



PAGES 2025

7th OPEN SCIENCE MEETING
5th YOUNG SCIENTISTS MEETING

Earth System Changes
*from the Past towards
the Future*

PAGES 2025 ABSTRACT BOOK

7th OPEN SCIENCE MEETING

21-24 May 2025 | Shanghai, China



中国科学院
CHINESE ACADEMY OF SCIENCES



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Welcome Message

From the Chairs of Scientific Committee

Dear participants,

Welcome to the PAGES 7th Open Science Meeting. This meeting will focus on “Earth System Changes from the Past towards the Future”. We are honored to host this distinguished gathering of researchers, scholars and professionals dedicated to advancing our understanding of past global changes and their implications for the future.

This conference serves as a vital platform for interdisciplinary dialogue, bringing together experts from diverse fields to share the latest scientific findings, innovative methodologies and emerging perspectives. As we face unprecedented environmental and climatic challenges, fostering collaboration and knowledge exchange has never been more crucial.

Beyond the scientific program, we encourage you to take advantage of the opportunity to connect with colleagues, engage in thought-provoking sessions, and explore the local culture and surroundings. We are committed to creating an enriching and stimulating environment for all participants, and we sincerely appreciate your contributions to making this conference a success.

Warm regards,

Chairs

Martin Grosjean
Zhengtang Guo



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1 Scientific Committee

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2 General Information

Introduction

The PAGES Open Science Meeting (OSM) is the PAGES flagship event held approximately every four years and is a much anticipated fixture on the paleoscience calendar.

Just before the OSM, PAGES will conduct the 5th PAGES Young Scientists Meeting (YSM) from 19-20 May 2025.

The 7th OSM will focus on “Earth System Changes from the Past towards the Future”. This conference aims to promote interdisciplinary scientific exchange and international collaboration, and to strengthen the connections among PAGES communities.

By integrating various spheres of the Earth's system, this conference will illustrate the changes in the key components of the Earth's surface system (air, water, ice, land, life, society, etc.) across timescales, with the ultimate goal of improving predictions for future climate and environment.

Themes

Earth System Changes
from the Past towards the Future

Location Shanghai, China

Dates 21-24 May 2025

Email

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Official Website

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PAGES 2025



Organizers and Sponsors



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Marine Geology



中国大洋发现计划
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DISCOVERY PROGRAM, CHINA

20 May (Tuesday)		Venue	21 May (Wednesday)	22 May (Thursday)	23 May (Friday)	24 May (Saturday)	
			Opening Keynote 1	Keynote 3	Keynote 5	Keynote 7	
08:15-08:30 (21 May)	On-site Registration /Check-in (12:00 - 20:00 on 20 May, 08:00 - 18:00 on 21-24 May)	Plenary Room	Opening Ceremony				
08:30-10:00 (22-24 May)			<i>Thomas Felis</i>	<i>Daniela Kröhling</i>	<i>Nathalie Dubois</i>	<i>Thomas Laepple</i>	
			<i>Ran Feng</i>	<i>Qing Pei</i>	<i>Nikita Kaushal</i>	<i>Benjamin Horton</i>	
10:00-11:00			Coffee				
		Poster Hall	Posters (Session 20, 31 half)	Posters (Session 30, 31 half)	Posters (Session 09)	Posters (Session 15, 06)	
			Oral Presentations 1		Oral Presentations 3	Oral Presentations 5	Oral Presentations 7
11:00-12:30		Room 1	Session 04	Session 27	Session 09	Session 02	
		Room 2	Session 19	Session 07	Session 15 (1)	Session 15 (2)	
		Room 3	Session 31 (1)	Session 31 (3)	Session 03 (1)	Session 21	
		Room 4	Session 18 (1)	Session 28 (1)	Session 24 (1)	Session 16 (1)	
		Room 5	Session 01 (1)	Session 23 (1)	Session 22 (1)	Session 22 (3)	
12:30-14:00			Lunch				
		Poster Hall	Posters (Session 04, 19, 18)	Posters (Session 28, 23)	Posters (Session 03, 24)	Posters (Session 16, 21)	

- Poster Presentation Schedule: Each poster will be displayed for either 21-22 May or 23-24 May. Authors presenting posters are required to be present at their respective posters during the designated poster session times for discussion.
- (1), (2), (3), (4): Time slot numbers indicate the first, second, third, and fourth sessions of the respective topic. Each time slot is 90-minutes long and includes six oral presentations. Sessions with only one time slot will not be marked with a time slot number.
- The meeting will start at 8:30 daily from 22 May. Note that the first day will commence at 8:15.

20 May (Tuesday)	Venue	21 May (Wednesday)	22 May (Thursday)	23 May (Friday)	24 May (Saturday)		
		Oral Presentations 2	Oral Presentations 4	Oral Presentations 6	Oral Presentations 8		
14:00-15:30	On-site Registrations /Check-in (12:00 - 20:00 on 20 May, 08:00 - 18:00 on 21-24 May)	Room 1	Session 12	Session 29	Session 06	Session 05	
		Room 2	Session 25	Session 14	Session 17	Session 15 (3)	
		Room 3	Session 31 (2)	Session 31 (4)	Session 03 (2)	Session 08	
		Room 4	Session 18 (2)	Session 28 (2)	Session 24 (2)	Session 16 (2)	
		Room 5	Session 01 (2)	Session 23 (2)	Session 22 (2)	Session 13	
15:30-16:30			Coffee				
		Poster Hall	Posters (Session 01, 12, 25)	Posters (Session 29, 14, 07, 27)	Posters (Session 17, 22, 02)	Posters (Session 11, 26, 05, 08, 13)	
			Keynote 2		Keynote 4	Keynote 6	Panel Discussion on IPCC Closure
16:30-18:00		Plenary Room	Haowen Dang	Kaustubh Thirumalai	Laurie Menviel	16:30-17:30 Thomas Stocker Fabrice Lambert Aditi Dave	
			Asfawossen Asrat	Chenxi Xu	Massanobu Yamamoto	17:30-18:30 Closing Ceremony	
18:30-20:30	OSM Icebreaker	Fuyue Hall		Conference Dinner			

Legend Notes



Sessions include 1 slot



Sessions include 2 slots



Sessions include 3 slots



Sessions include 4 slots



Keynote

Program at a Glance



4. Plenary Talks

Wednesday, 21 May

08:30-9:15

Time scales of climate change and environmental stress across the tropical oceans

Thomas Felis¹, Jessica A. Hargreaves¹, Hana Camelia¹, Oliver Knebel¹, Andrew M. Dolman², Alyssa R. Atwood³

¹MARUM-Center for Marine Environmental Sciences, University of Bremen, Germany

²Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, Germany

³Department of Earth, Ocean, & Atmospheric Science, Florida State University, USA

The last two years were characterized by record global temperatures and regional weather extremes, further amplified by an El Niño event in the tropical Pacific. Surface temperatures of the world's oceans reached unprecedented levels, leading to marine heatwaves that severely stressed vulnerable ecosystems such as tropical coral reefs. On the continents, heatwaves, droughts, extreme rainfall and floods led to the destruction of lives and infrastructure. The interaction between the tropical ocean basins plays a key role in modulating climate variability on interannual to decadal timescales. These timescales are of strong relevance to societies and ecosystems, because they control the time interval for recovery between extreme events. The PAGES 2k Network provides critical context for our understanding of anthropogenic forcing of climate, as well as information about Earth's natural climate variability over the past 2000 years. Building on key findings around the response of the global water cycle to temperature changes by the Iso2k project, the focus of ongoing 2k research is the reconstruction of hydroclimate over the past two millennia. Hydroclimatic changes are a key parameter in projections of the regional impacts in a warming climate. Throughout the tropical oceans, a key archive for reconstructions of temperature and hydrology are massive shallow-water corals. Annually to monthly resolved coral records, archived in the CoralHydro2k database, are critical for our understanding of tropical ocean-atmosphere interactions. Discrepancies between



proxy reconstructions, instrumental observations, and model simulations on longer timescales highlight the need for ongoing research in this area. The new CoralHydro2k seawater oxygen isotope database will be essential in calibrating reconstructions of surface ocean hydrology, providing additional avenues to resolve discrepancies. Finally, tropical corals not only provide information about the thermal and hydrologic history experienced during their lifetime, but also insights into the response of ecosystems to past and ongoing environmental stress.

Biography: Thomas Felis is the head of the Coral Paleoclimatology Group at MARUM-Center for Marine Environmental Sciences, University of Bremen. In 2017, Thomas co-initiated the PAGES CoralHydro2k Project, which aims to reconstruct tropical ocean hydroclimate and temperature from coral archives. Within this project, together with many early-career researchers, the CoralHydro2k Database was compiled, a global, actively-curated compilation of coral oxygen isotope and Sr/Ca records covering the Common Era. Thomas has been involved in three IODP expeditions to Tahiti, the Great Barrier Reef and Hawai'i to recover fossil corals from the last deglacial, glacial and beyond. Currently, Thomas coordinates the Priority Programme "Tropical Climate Variability & Coral Reefs" of the German Research Foundation (DFG), which aims to improve our understanding of tropical marine climate variability and its impacts on coral reef ecosystems in a warming world, and which involves more than 40 interdisciplinary researchers from 15 institutions across Germany.

Wednesday, 21 May

09:15-10:00

Integrating geological archives and climate models to understand the Pliocene and inform the future

Ran Feng¹, Alan Haywood², Heather Ford³, Harry Dowsett⁴, Erin McClymont⁵

¹Department of Earth Sciences, University of Connecticut, Storrs, CT, US

²School of Earth and Environment, University of Leeds, Leeds, UK

³School of Geography, Queen Mary University of London, London, UK

⁴Florence Bascom Geoscience Center, United States Geological Survey, Reston, VA, US

⁵Department of Geography, Durham University, Durham, UK



The Pliocene Epoch (~5.3–2.6 Ma) was the most recent geologic interval with CO₂ levels similar to present-day. Consequently, this interval has been widely studied to understand how the earth system operates in a warm climate and to what extent climate models can simulate past warm intervals. During the past few years, three community-wide projects, called PRISM4, PlioVAR, and PlioMIP2, have studied Pliocene climate. These projects targeted the mid-Piacenzian time interval (3.205 Ma) for data synthesis and experimental design. The proxy and model data generated from these projects fueled a wide range of research on Pliocene climate, covering topics such as the global mean and spatial patterns of temperature, state and drivers of the hydrological cycle, ocean circulation and heat transport, high latitude climate and ice sheet extents, and sensitivity to CO₂ forcing, among others.

Looking ahead, in addition to the standard mid-Piacenzian experiments, PlioMIP3 will incorporate an early-Pliocene experiment and an experiment featuring minimal land-sea configuration changes. Furthermore, new sensitivity experiments have been designed to explore uncertainties in orbital and greenhouse gas forcings, East Antarctic Ice Sheet topography, and vegetation coverage. In parallel, two early Pliocene time slices (4.474 and 4.870 Ma) have been identified for proxy data syntheses. Together, these ongoing projects will facilitate the next round of studies on Pliocene climate evolution, which will provide valuable insights into future climate change.

Biography: Ran Feng received a BS in atmospheric sciences from Nanjing University and a MS in meteorology from the Chinese Academy of Sciences. Following an interest in Earth history, she went on to obtain a PhD in paleoclimate modeling from the University of Michigan. She was introduced to the Pliocene Model Intercomparison Project as a postdoc working with Dr. Bette Otto-Bliesner at the National Center for Atmospheric Research and has since focused her career on investigating the mid-Pliocene and other warm intervals of the Cenozoic. Ran is currently an assistant professor at the University of Connecticut, a recipient of the US National Science Foundation Early CAREER award, and a steering committee member of the Pliocene Model Intercomparison Project.

Wednesday, 21 May

16:30-17:15



Western tropical Pacific as the heat and moisture engine: From late Quaternary to deeper and recent times

Haowen Dang¹, Zhimin Jian¹, Lijuan Sha², Yue Wang¹, Hai Cheng², Chen Li¹, Mahyar Mohtadi³, Yair Rosenthal⁴, Franck Bassinot⁵

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⁵Laboratoire des Sciences du Climat et de l'Environnement/IPSL, CEA-CNRS-UVSQ, University Paris-Saclay, Gif-sur-Yvette, France

The western tropical Pacific, often known as the West Pacific Warm Pool, plays a pivotal role as one major source of heat and moisture in the Earth surface system. By developing novel proxies of planktonic foraminifera, including Ocean Heat Content calculated from Mg/Ca thermometer and atmospheric humidity estimated by triple oxygen isotopes, we have revealed a coherent precession-dominated feature in the upper-Ocean Heat Content and moisture convergence over the Warm Pool during the Late Quaternary. Such results uncover that, under the orbital insolation forcing, the upper Ocean Heat Content of the Warm Pool waxes and wanes, thereby drives the moisture cycling from the oceanic evaporation sources to surrounding landmasses via meridional and zonal atmospheric circulations. A tight (thermo)dynamic connection from tropical oceanic heat budget to hydroclimatic cycling is therefore proposed, from the perspective of energetics, to propel a deeper understanding of the driving force of low-latitude processes in the global climate system. Our ongoing work with Plio-Pleistocene sediment records from ocean drilling and cold-water corals collected by deep diving are extending these findings from Late Quaternary to deeper and more recent times. In a warmer world like early Pleistocene and Pliocene, the obliquity-driven inter-latitudinal thermal contrast plays a central role in driving the thermal and hydroclimatic variations in the Warm Pool. Combining with the reconstructions of cold-water corals, it is implied that under the current global warming, a projected increase in the volume and heat-content of the Warm Pool would possibly trigger fundamental changes in the climate regime, therefore the Warm Pool, given its



role of heat and moisture engine, serves as an underemphasized “tipping point” in the Earth’s future.

Biography: Dr. Dang started his paleoenvironmental studies since his undergraduate years at Peking University, and then threw himself into paleoceanography during his pursuing for Master’s and Doctorate degrees at Tongji University and working as a postdoc at LSCE in Gif-sur-Yvette, France. He mainly studies the paleo-reconstructions of the upper-ocean thermal structure and hydroclimate of the West Pacific Warm Pool, using geochemical proxies of foraminifera, sediment and cold-water corals, for the time intervals from the Pliocene, Quaternary to recent millennia. His research, published on Nature, Science Advances, EPSL, GRL, etc., have revealed several key findings such as the modulation effect of subsurface heat on Walker Cell since the Last Glacial Maximum, regulation of Warm Pool heat content on sea-land moisture transport, and the orbital-induced moisture convergence dynamics over the Warm Pool.

Wednesday, 21 May

17:15-18:00

Rain or Shine: Hominin evolution and dispersal in response to environmental shifts – insights from a ~620 kyr climate record from Lake Chew Bahir in eastern Africa

Asfawossen Asrat^{1,2}, Verena Foerster³, Henry Lamb^{4,5}, Frank Schaebitz³, Martin H. Trauth⁶

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The East African Rift System (EARS) has long been recognized as a hotspot of hominin evolution. Since the discovery of some iconic Upper Miocene–Pleistocene hominid and



anatomically modern human fossils in the 1960s and 1970s, the region has become a focus of substantial paleoanthropological and archaeological research. With the discovery of more hominin fossils and cultural remains, the focus of research in the region progressively developed towards constraining the environmental context of hominin evolution and dispersal. The role of climate variability in human evolution and dispersal has become an overarching theme. However, long and continuous paleoenvironmental records from the region were lacking, hindering the establishment of the regional environmental context. The Chew Bahir Drilling Project (CBDP), part of the Hominin Sites and Paleolakes Drilling Project (HSPDP) initiated in the late 2000s, made a major breakthrough by providing a ~620 kyr environmental record. This record spans the period of key events in hominin evolution and their cultural transformation including the separation of modern human ancestors from archaic hominin groups and the subsequent appearance of anatomically modern humans as well as global dispersal of *Homo sapiens*.

The Chew Bahir climate record shows a complex relationship between climate variability and hominin evolution. Stable humid conditions between 620–275 kyrs BP favoured high anatomical diversity of hominins while more arid and pronounced climate variability between 275–60 kyrs BP coincided with the appearance of *H. sapiens* in the region accompanied by habitat transformation, and key human cultural innovations. Global human dispersal after 60 kyrs BP occurred during regionally dry but pronounced, high frequency climate cyclicity between arid and humid phases. In this plenary, this complex relationship between climate variability and hominin evolution will be discussed with particular emphasis on the response of human societies to shifting climate regimes.

Biography: Asfawossen Asrat is Professor of Geology at the School of Earth Sciences and Engineering of the Botswana International University of Science and Technology in Botswana and the School of Earth Sciences of the Addis Ababa University in Ethiopia. He received his PhD from the University of Nancy in France, and he is a geochemist and petrologist by training. His main research focus is Quaternary paleoenvironmental and paleoclimate reconstruction of eastern Africa. He worked on various archives, particularly on lake sediments and speleothems, using geochemical and stable isotope proxies. He has been leading and participating in several successful lake drilling projects in Ethiopia during the last two decades, including leading the ICDP-sponsored Chew Bahir Drilling Project in southern Ethiopia, as part of the Hominid Sites and Paleolakes Drilling Project (HSPDP) in eastern Africa. His research aims at understanding the impact of climate variability on



human evolution, expansion and innovation.

Thursday, 22 May

08:30-9:15

Quaternary geology of South America at multiple scales: A key to understanding hydroclimatic extreme events

Daniela M. Kröhling¹

¹Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) and Universidad Nacional del Litoral (UNL), Santa Fe, Argentina.

Unique geological features and the diverse climatic zones of South America highlight its potential for Quaternary palaeoenvironmental reconstructions. From the Andes Cordillera to the Atlantic Coast and throughout tropical to high-latitude areas, some regions are critical for understanding the complex interplay between exogenic and endogenic processes driving landscape evolution. However, some palaeoclimatic inferences on a regional or sub-continental scale based on multi-proxy data were generated without considering the morphotectonic settings. Local factors could produce spatiotemporal inconsistencies between different proxy reconstructions. Particularly, sedimentary basins allow the analysis of the interactions between tectonics, dominant surface processes, and sea/base-level changes across a range of spatial and temporal scales. They have significant implications for both paleoenvironmental reconstructions and future climate change scenarios. Large fluvial basins of South America (i.e. the Amazon and Paraná) developed along the main lowland depositional (intracratonic) basins. Extensive floodplains, wetlands, swamps, lakes, and deltas, represent vulnerable and changing quaternary depositional environments on these basins. Furthermore, Late Quaternary megafans constitute extensive distributive fluvial systems (DFS) of the Central Andean foreland basin, providing high-resolution records with potential as climate proxies of the Chaco aggradational lowlands. Focusing on terrestrial and near-shore marine sedimentary archives in typical sedimentary realms of the continent, the role of geology in reconstructing past hydroclimate variability is discussed. The occurrence of droughts from aeolian domains (represented by loess, sand dunes and salt lakes) and their relationship with large fluvial systems, the development of highly avulsive processes on DFS, the



complex dynamics of the Paraná Delta since the Holocene sea-level highstand, among others, will be addressed. As the frequency/severity of hydroclimatic extreme events is increasing, enhancing geomorphic processes and landscape responses such as flash floods, fluvial and coastal floods and droughts, a deeper understanding of the dynamics of geomorphic systems at multiple scales is critical to risk mitigation strategies.

Biography: Dr. Daniela M. Kröhling is a Senior Researcher at CONICET (National Research Council of Argentina) and a Full Professor of Geomorphology at Facultad de Ingeniería y Ciencias Hídricas (UNL-Universidad Nacional del Litoral), located in Santa Fe, Argentina. Her main research focuses on reconstructing climate and environmental changes based on Quaternary Geology in key regions of South America along different tectonic settings. From 2011 to 2019, she served as the Secretary/Webmaster of the TERPRO Commission of INQUA. Currently, she is part of the coordinator team for the 3rd phase of the PAGES Floods Working Group (2024-2026).

Thursday, 22 May

09:15-10:00

History of climate and society: Climate reconstruction and impact based on archives of societies in China

Qing Pei¹

¹Department of Land Surveying and Geo-Informatics, Department of Chinese History and Culture, The Hong Kong Polytechnic University, Hong Kong, China

Current global warming highlights the need to investigate history as a reference for contemporary climatic change and its challenges. A growing body of research in the history of climate and society has demonstrated the usefulness of “archives of societies”—including early instrumental records, descriptions of weather and seasons, and artefacts such as high-water marks—to work in conjunction with natural climate proxies and provide a more complete picture of past weather and climate as well as societal impacts and adaptations. With its unique wealth of historical documents, China has made significant contribution in this field. Nevertheless, the rich documentation on the history of climate in China has remained largely unfamiliar to non-Chinese scholars. To bridge this



gap, features of historical documents from China, which has been an important element of the CRIAS working group project, will be introduced with basis of various spatiotemporal scales. Based on Chinese historical documents, critical works by Chinese scholars on climate reconstruction and social responses to climate change across different scales will be explained. The presentation will consider how this scholarship may help us search for successful modes of transformation and resilience to climate change. Furthermore, it will discuss how work in the history of climate and society helps to bridge interests of different PAGES working groups and different methods and perspectives from the natural and social sciences and humanities.

Biography: Dr. Qing Pei is working at the Hong Kong Polytechnic University as Associate Professor with a joint appointment between the Department of Land Surveying and Geo-Informatics, and the Department of Chinese History and Culture. Before joining PolyU, he used to work at the Education University of Hong Kong, the University of Cambridge, the University of Zurich, and the University of Hong Kong. His research interests traverse both physical and social sciences, including historical geography, history of climate and society, and social-ecological resilience. He has published more than 70 papers and 1 monograph. He also has got many awards, such as Humanities and Social Sciences Prestigious Fellowship Scheme of Hong Kong Research Grants Council; Higher Education Outstanding Scientific Research Output Awards, Second-class Award in Natural Sciences, the Ministry of Education, China; Carson Fellowship, Ludwig Maximilian University of Munich, Germany; Swire Scholarships; and Li Ka Shing Prize.

Thursday, 22 May

16:30-17:15

Future increase in extreme El Niño supported by past glacial changes

Kaustubh Thirumalai¹

¹Department of Geosciences, University of Arizona, USA

El Niño events, the warm phase of the El Niño/Southern Oscillation (ENSO) phenomenon, amplify climate variability throughout the world. Uncertain model predictions limit our ability to assess whether these climatic events could become more extreme in response



to greenhouse warming. Paleoclimate records provide estimates of past changes, but it is unclear if they can constrain mechanisms underlying future predictions. Using numerical simulations, we uncover a mechanism driving consistent changes in response to past and future forcings allowing model validation against paleoclimate data. The simulated mechanism is consistent with the dynamics of observed extreme El Niño events, which develop when warm pool waters expand rapidly eastward due to strongly coupled ocean currents and winds. These coupled interactions slow down under glacial conditions due to a deeper mixed layer driven by a stronger Walker circulation. The resulting decrease in ENSO variability and suppressed genesis of extreme El Niño is supported by a series of paleoceanographic reconstructions showing reduced glacial temperature variability in key ENSO-sensitive locations. The model-data agreement for past variability, together with the consistent mechanism across climatic states, supports the prediction of more frequent extreme El Niño under greenhouse warming due to a shallower mixed layer in response to a weaker Walker circulation.

Biography: Dr. Kaustubh Thirumalai is a faculty member at the Department of Geosciences, University of Arizona. His main research interests are centered on (paleo)climate dynamics, paleoceanography, and biogeochemistry. Dr. Thirumalai and his research group use a combination of carbonate geochemical measurements, climate simulations, and statistical models to help constrain climatic variability and its impacts across seasonal to million-year timescales. Originally from Bangalore, Dr. Thirumalai holds a chemical engineering degree from the National Institute of Technology Karnataka, after which he obtained his M.S. and Ph.D. at the University of Texas at Austin. He was then awarded a Presidential Postdoctoral Fellowship at Brown University in 2017, after which he joined the Geosciences faculty at the University of Arizona in 2019. Dr. Thirumalai has authored/co-authored more than 65 peer-reviewed journal articles and is the recipient of the 2022 American Geophysical Union's Nanne Weber Early Career Award.

Thursday, 22 May

17:15-18:00

Impact of global warming on the Asian summer monsoon

Chenxi Xu¹, Wenling An¹, Junbo Ren¹, Qingyu Zhao¹, Ru Huang¹, Yaru Zhao¹, Yucheng Liu¹, Zhengtang Guo¹



¹Key Laboratory of Cenozoic Geology and Environment, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China

The impact of global warming on the Asian summer monsoon has garnered significant attention due to its implications for regional hydroclimate. However, high-resolution monsoon records in the low-latitude monsoon region of Asia remain scarce. Tree ring oxygen isotope can not only solve the problem of cross-dating for trees in low latitudes, but also is a promising proxy summer hydroclimate.

In this study, we utilized tree ring oxygen isotopes to reconstruct the history of the Asian summer monsoon over the past few hundred years. Our findings reveal two key insights: Firstly, the South Asian summer monsoon has weakened in response to global warming, leading to a notable increase in the frequency of extreme drought events. Secondly, global warming has strengthened the relationship between the Asian summer monsoon and the El Niño-Southern Oscillation.

These results underscore the potential for more frequent and severe extreme events in monsoonal Asia in the future. To evaluate impacts of higher temperature in future on the Asian summer monsoon, future research should focus on investigating seasonal to interdecadal monsoon changes using high-resolution records from deep time such as the Miocene and Pliocene.

Biography: Chenxi Xu is the Deputy director of Key Laboratory of Lithospheric and Environmental Coevolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China, where he also holds a Professorship. Dr. Xu received his PhD from Nagoya University Japan. After 2 years as a postdoc at the Research Institute for Humanity and Nature, Japan, he moved to the Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China.

His research focused on high-resolution Asian summer monsoon variations in the past using tree ring oxygen isotopes. He will introduce Asian summer monsoon variations in the past several hundred years and deep time.

Friday, 23 May



08:30-9:15

Societal impacts on the Earth System - from the past towards the future

Nathalie Dubois¹ & the Human Traces WG Steering Committee

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Department of Earth Sciences, ETHZ, Zürich, Switzerland

Society has become a key component of the Earth system in the last Century, modifying the atmosphere, oceans, cryosphere, land surface, and biosphere. But the interactions between human societies and the environment have a long, complex history spanning many millennia. Stratigraphic archives but also archeological sites and societal archives such as those investigated by the CRIAS working group serve as long-term records of natural variability and human-induced changes to the Earth system, allowing us to get an integrated understanding of Earth system dynamics which includes anthropogenic drivers and societal responses to change on various timescales.

The PAGES Human Traces working group aims to place contemporary anthropogenic impacts in a long-term, global perspective by synthesizing existing records of human traces, when possible, from different archives. Our first supra regional synthesis in Latin America involved for instance not only paleolimnologists, but also archeologists and anthropologists. Our first global synthesis, on the other hand, focusses on the record of lead (Pb) pollution in stratigraphic archives around the globe. In this presentation I will highlight key findings from these efforts and suggest ways forward to achieve a truly global synthesis of the long legacy of human impacts.

An integrated understanding of Earth system dynamics is critical to navigating towards a sustainable future. Therefore, quantifying both natural variability and the slow-evolving, low-intensity pre-Anthropocene human perturbations is essential if we are to improve predictions of future environmental dynamics and inform strategies for sustainability. These also serve as a way of defining reference conditions for ecosystem management and conservation by providing a longer-term perspective for recent global changes in the context of the Anthropocene.



Biography: Nathalie Dubois is a paleolimnologist who's research focusses on the human-environment-climate nexus. She is a Group Leader at Eawag, the Swiss Institute for Aquatic Science and Technology and an Adjunct Professor at ETH Zurich, with collaborations around the World. A paleoceanographer and paleoclimatologist by training, she is the current President of the Commission for Oceanography and Limnology of the Swiss Academy of Sciences. She was an active member of the former PAGES Aquatic Transition working group, and is now leading the Human Traces working group. Her research interests include the development of freshwater paleothermometers, but focus mainly on anthropogenic impacts in lakes and swamps, from detecting early human traces in Oceania, to assessing the impact of soil erosion in the Roman Era or Industrial Pollution in the 20th Century.

Friday, 23 May

09:15-10:00

SISAL the speleothem and cave monitoring database: Enabling modern karst water estimates to understanding past rapid climate changes

Nikita Kaushal¹ & PAGES-SISAL Working Group

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Global distribution, precise age control through absolute chronologies and multiple proxies for climatic and environmental parameters make speleothems an excellent natural archive for understanding climate changes. Researchers using the speleothem archive have made significant advancements in recent years. These include estimating temperatures that cause permafrost melting using U-Pb dating, gaining a deeper understanding of under-investigated Southern Hemisphere climate changes, reconstructing absolute rainfall amounts in the Holocene using recently developed calcium-isotope proxies, increasing the understanding of atmospheric dynamics during past Terminations and millennial events enabled by speleothem database, enhancing our comprehension of proxies for paleo-fires and development of models for karst water estimations. These achievements have been made possible by advances in multiple tools and techniques. Significant development has been made in the 'length' of speleothem



records through the addition of the U-Pb dating technique. Tighter control on the time period of events has been facilitated by age-depth model standardisation and layer counting using confocal and trace element methods. Big data methods enabled by the SISAL speleothem database are improving isotope ($\delta^{18}\text{O}$, $\delta^{13}\text{C}$, Sr isotopes, $^{234}/^{238}\text{U}$) and trace element (Sr/Ca, Mg/Ca, Ba/Ca, U/Ca) proxy interpretations through systematic reviews, isotope-enabled model data comparisons and the use of geostatistical tools like isoscapes. An increased focus on present-day cave monitoring (rain and drip water oxygen isotopes, modern carbonate) allows us to evaluate and use karst models, proxy system models and process models for semi-quantitative to quantitative reconstructions of modern karst water estimates and past climate and vegetation changes. In this presentation, we highlight some of these recent achievements of the field as well as provide a perspective on ongoing community research and future directions.

Biography: Nikita Kaushal is a trained Geologist from India. She works in the fields of paleoclimate and biogeochemistry on a range of spatial and temporal scales, ranging from regional to global, and centuries to half a million years. She uses natural archives such as speleothems and corals, and multiple approaches including field and lab work, and database techniques. Her goal is to understand the drivers, pathways and responses of the climate and carbon cycles during different climate states in order to, ultimately, inform our understanding of future changes.

Friday, 23 May

16:30-17:15

Role of the Southern Ocean in changes of past atmospheric CO₂ and implications for the future

Laurie Menviel¹

¹Climate Change Research Centre, University of New South Wales, Australia

The Southern Ocean (SO) has been identified as a crucial region modulating the concentration of atmospheric CO₂. The sustained upwelling of carbon-rich deep waters and inefficient nutrient utilization at the surface of the SO leads to an outgassing of CO₂. Changes to the SO circulation, resulting from both dynamic and buoyancy forcing, can



alter the rate of upwelling, as well as formation and subsequent transport of Antarctic bottom and intermediate waters. This impacts the air-sea CO₂ exchange in the SO and the carbon content of these water masses. In this talk, I will discuss the processes that might have led to changes in SO circulation over the last glacial period and deglaciation, as well as the impact of these changes on the marine carbon cycle and atmospheric CO₂. I will further discuss how recent and projected climate change might impact SO circulation and the capacity of the SO to uptake CO₂.

Biography: Laurie Menviel is a Scientia associate Professor at the Climate Change Research Centre, the University of New South Wales, Sydney, and a chief investigator of the Australian Centre for Excellence in Antarctic Science. Her research focuses on understanding the role of oceanic circulation in past and future abrupt climate change, including changes to the global carbon cycle and atmospheric CO₂ concentration. She explores these themes by performing numerical experiments with Earth system models and comparing with proxy records or observations. She is a co-editor in chief of *Climate of the Past*.

She obtained a PhD in oceanography from the University of Hawaii, USA, held post-doctoral positions at the University of Hawaii, University of Bern and the University of New South Wales, and obtained two Australian Research Council fellowships.

Friday, 23 May

17:15-18:00

Pleistocene CO₂ variability inferred from the Bay of Bengal leaf-wax carbon isotopes

Masanobu Yamamoto¹

¹Faculty of Environmental Earth Science, Hokkaido University, Japan

Atmospheric CO₂ and polar ice volume have been strongly coupled over the past 805,000 years. We reconstructed the atmospheric CO₂ concentration over the entire Pleistocene by taking advantage of the unique relationship between CO₂ concentration and leaf-wax δ¹³C resulting from changes in the extent of C₃ and C₄ vegetation in East India. Notably,



reconstructed interglacial CO₂ concentrations (CO₂FA) in the early Pleistocene were lower than the preindustrial level, which agrees with the new result of Antarctic blue ice gas analysis. The CO₂FA variation consistently covaries with benthic oxygen isotope variation throughout the Pleistocene, indicating a strong coupling of CO₂ and continental ice volume. The CO₂FA variation shows the amplitude modulation at the ~400,000-year cycle; the amplitude is larger when the long-term eccentricity is lower. This variation is harmonious with variations in the Antarctic Circumpolar Current strength and the rain ratios (CaCO₃/OC, CaCO₃/opal, etc.) in subpolar and tropical oceans. We suppose that the ice-CO₂ interaction, Southern Ocean upwelling, and biological production regulated CO₂ variability in the Pleistocene.

Biography: Masanobu Yamamoto graduated from the master's course at Tohoku University in 1988 and started work in petroleum geology and organic geochemistry in the Geological Survey of Japan as a researcher. Masanobu Yamamoto was awarded a PhD from Nagoya University and moved to Hokkaido University in 2000 as an Associate Professor in paleoceanography and paleoclimatology before becoming a Full Professor. Masanobu Yamamoto worked on SST reconstruction in the Pacific Ocean using UK37 and TEX86 in the 2000s. He then shifted to the Arctic and Indian Oceans for paleoenvironment and vegetation reconstructions using various biomarkers and their isotopes and works on reconstructing atmospheric CO₂ during the last several million years, as well as understanding the global carbon cycle.

Saturday, 24 May

08:30-9:15

The space-time structure of climate variability

Thomas Laepple¹

¹Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung & MARUM—Center for Marine Environmental Sciences and Faculty of Geosciences, University of Bremen, Bremen, Germany

Since 2016, the PAGES CVAS (Climate Variability Across Scales) working group has been dedicated to unraveling climate variability across different spatial and temporal scales.



While climate variability spans a wide range of scales, the decadal to millennial timescales are particularly significant. At these scales, natural variability overlaps with anthropogenic forcing, influencing our understanding of the industrial era and future climate projections. Paleoclimate records reveal strong variability at these longer timescales that cannot be fully explained by low-frequency orbital forcing. Further, many climate models appear to underestimate centennial to millennial variability, particularly on regional scales—suggesting potential deficiencies in internal variability, responses to external forcing, or inaccuracies in paleoclimate-based variability estimates. A deeper understanding of climate variability also emerges from its spatial structure. Observations and physical principles indicate an intrinsic link between temporal and spatial scales: fast variations, like weather, are regionally confined, whereas slower phenomena, such as glacial-interglacial cycles are globally coherent. While models suggest a strong reduction in the climate system's degrees of freedom over longer timescales, many proxy records point to persistent regional variations even at centennial to millennial scales. However, proxies provide only indirect representations of climate variability and also contain non-climatic signals with distinct spatial and temporal structures. Understanding and accounting for these influences is crucial for accurately reconstructing the space-time structure of climate variability. In this presentation, I will discuss recent advances in understanding the origins and spatial-temporal structure of both proxy-based and climate variability, along with their implications for refining future climate projections.

Biography: Thomas Laepple is a Professor of Earth System Diagnostics at the University of Bremen and MARUM – Center for Marine Environmental Sciences, and a research group leader at the Alfred Wegener Institute, Helmholtz Center for Polar and Marine Research in Potsdam, Germany.

He received his Ph.D. in Physics in 2009. Following a research stay as Feodor Lynen Fellow at Harvard University, he led a Helmholtz Young Investigator research group at the Alfred Wegener Institute and was awarded a prestigious ERC Starting Grant in 2017. He is an active member of the PAGES CVAS (Climate Variability Across Scales) initiative, which he led from 2020 to 2023. His current research interest lies in the quantitative synthesis and explanation of paleoclimate data with a focus on sediment and ice-cores. By bridging the gap between geological data and climate models, his working group develops a quantitative approach to using paleoclimate observations to reconstruct climate variability and to constrain estimates of future climate change.



Saturday, 24 May

09:15-10:00

Sea-Level Science in Singapore and Southeast Asia

Benjamin P. Horton¹, Yudhishthra Nathan², Fangyi Tan³, Benjamin Grandey⁴, Tanghua Li³, Tim Shaw³

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No matter how quickly nations lower emissions now, the world is looking at about 15 to 30 centimeters of sea-level rise through the middle of the century, given the long-drawn impact of climate change on the oceans and ice sheets. Even under a stable climate, sea-level rise is expected to continue slowly for centuries. Beyond 2050, sea-level rise becomes increasingly susceptible to the world's emission choices. If countries choose to continue their current paths, greenhouse gas emissions will likely result in ~3°C of warming by 2100, and a sea-level rise of up to 0.8 meters. Under the most extreme emissions scenario, rapid ice sheet loss from Greenland and Antarctica could lead to a sea-level rise approaching 2 meters by the end of this century and over 5 meters by 2150.

Here we illustrate the ways in which current methodologies and historical and geological data sources from Southeast Asia can constrain future projections, and how accurate projections can motivate the development of new sea-level research questions to mitigate and adapt to climate change.

1. We showed periods of rapid ice melting accelerated sea-level rise ~14,500 and ~11,500 years ago that significantly reduced land area and forced early human migration across the region. During these periods, thresholds of coastal habitat survival were also surpassed resulting in large-scale losses. Singapore became an island at approximately 9,000 years ago.



2. We ran an ensemble of Glacial Isostatic Adjustment (GIA) models that highlight how Southeast Asia experienced sea levels higher than present-day between 7,000 and 4,000 years ago, producing a mid-Holocene highstand. Variability in the high stand magnitude is controlled by solid Earth parameters while the timing is controlled by ice sheet melting history.

3. We developed a new fusion method for estimating high end sea-level rise, providing a more reliable assessment of scientific uncertainty. We estimate that by 2100, global sea levels will likely rise between 0.3-1.0 m under low emissions and 0.5-1.9 m under high emissions.

4. We focus on the implications of rising sea levels for coastal ecosystems. Under high emissions, nearly all salt marshes, most mangrove forests, and a considerable number of coral reef islands would be beyond their sea-level rise tipping point for survival.

Biography: Professor Benjamin Horton is the Dean of the School of Energy and the Environment at City University of Hong Kong. His research concerns sea-level change. He aims to understand the mechanisms that have determined sea-level changes in the past, which will shape changes in the future. Professor Horton has won research awards from European Geosciences Union, American Geophysical Union and Geological Society of America. Professor Horton was an editor for the Intergovernmental Panel on Climate Change (IPCC) 6th Assessment Report. Professor Horton has published over 280 articles in peer-reviewed journals, including Science, Nature and Proceedings of the National Academy of Sciences. He has been awarded US\$50 million in research funding.

Saturday, 24 May

16:30-16:45

IPCC Session

The role of paleo in IPCC assessments, game-changing paleo contributions to IPCC assessments since FAR

Thomas Stocker¹



¹Climate and Environmental Physics at the University of Bern, Switzerland

Biography: Thomas Stocker obtained a PhD in Natural Sciences of ETH Zürich in 1987. He did research in London, Montreal, New York and Honolulu. From 1993 to 2024 he was Professor of Climate and Environmental Physics at the University of Bern. Thomas Stocker has authored or co-authored more than 260 peer-reviewed papers in the area of climate dynamics and paleoclimate modeling and reconstruction. From 2008 to 2015 he served as Co-Chair of the UN Intergovernmental Panel on Climate Change (IPCC) that provided the scientific foundation of the Paris Agreement. Thomas Stocker holds two honorary doctorates of the University of Versailles and ETH Zürich, is member of several academies and was awarded numerous national and international awards.

Saturday, 24 May

16:45-16:55

IPCC Session

Plans for AR7: How you can contribute to AR7

Fabrice Lambert¹

¹Climatology at the Pontificia Universidad Catolica de Chile, Chile

Biography: Fabrice Lambert is a Professor of Climatology at the Pontificia Universidad Catolica de Chile, and a Chilean governmental delegate to the IPCC.

He received his Ph.D. in Climate Physics in 2007 at the University of Bern in Switzerland. Following a postdoc in South Korea he moved to Chile and became a professor there in 2015. Fabrice Lambert has been continuously involved with PAGES since his PhD. He has been a PAGES SSC member since 2022 and is an EXCOM member since 2025. His research interest span from paleoclimate dynamics and proxies to urban contamination and future climate change. His research group investigates using both empirical methods and climate model simulations.

Saturday, 24 May



16:55-17:00
IPCC Session

The opinion of the ECR network at large

Aditi Dave¹

¹University of Lausanne, Switzerland

Biography: Aditi Dave is a postdoctoral researcher at the University of Lausanne. Her research aims at understanding the interplay between climate and tectonics, and its role in shaping the earth's surface and dictating human-environment relationships over Quaternary timescales. Aditi's expertise lies in the application and development of trapped charge geochronological techniques of luminescence and Electron Spin resonance, not only as a dating method for the Quaternary, but also as a novel tool for applications in low-temperature thermochronology and provenance studies.



5. Abstracts

Session 01. Hydroclimate of the Common Era (The 2k Network)

Conveners: Alyssa Atwood, Georgy Falster, Benjamin Henley, Matthew Jones, Lukas Jonkers, Nikita Kaushal, Anaïs Orsi

【A0858】 -Poster

Reconstructing Hydroclimatic variability in western China and northern Pakistan through tree-ring records

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Global warming has had an unprecedented impact on human life; nevertheless, in the northern hemisphere, mid/high-latitude changes are more pronounced. Understanding of historical patterns of droughts and wet periods, providing insights into long-term climate variability in a climatically sensitive region. This study used tree-rings climate reconstruction to unravel climate variability. A tree ring width chronology developed from *Sabina tibetica*, covers the period from 1349 to 2014 and 563-y minimum temperature with reliable coverage from 1451 to 2014 was reconstructed. The temperature reconstruction shows six major warm periods (1490–1623, 1713–1729, 1784–1812, 1868–1877, 1918–1954, 1989–2014) and six major cold periods (1451–1489, 1624–1712, 1730–1783, 1813–1853, 1878–1917, 1955–1988). The major dry periods of northern Pakistan coincide with warm periods of west China during 1593–1623, 1785–1800, 1870–1877, 1918–1923, and 1989–1995). Similarly, wet periods are in close agreement with major cold periods of 1663–1675, 1687–1708, 1771–1773, 1806–1814, 1844–1852, and 1955–1969.



The most obvious common dry–wet periods were observed between the PDSI of northern Pakistan and west China during 1973-1968, 1933-1923, 1920-1913, 1893-1888, 1820-1815 1748-1740, 1680-1683 and 1620-1603, while contrary period's exits during 2003-1998, 1993-1988, 1981-1970, 1973-1948, 1913-1890, 1878-1848, 1828-1821, 1803-1750 and 1740-1693. A total of 9 dry–wet episodes (206-y) were found with a complete distinction from 1603 to 2003. The peculiar behaviors worth mentioning were the onset–offset nature of wet and dry episodes. When dry episodes centered over the north Pakistan, wetting periods were likely found in west China. Similarly, when wetting condition was noticed in northern areas in Pakistan, dry conditions were more prominent over west China. In addition, no such large coincidence was found in the timing and magnitude of dry and wet episodes between two PDSI reconstructions. So, it is assumed that no pronounced large-scale oscillation regulates the mechanism simultaneously.

However, additional proxies are crucial for reconstructing climate variability, addressing this research gap, and providing deeper insights into the study.

Keywords: Tree-ring, Climate reconstruction

【A0862】 -Poster

Persistent wetting trend in the northwestern China since 1700s

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The recent wetting trend in northwestern China and central Asia has caused wide and extensive attention. However, the characteristics and potential mechanisms remain unclear. Here, we established a 508-year annual tree-ring $\delta^{18}\text{O}$ chronology (1511-2018 CE) for *Picea schrenkiana* from the southern Tianshan Mountains in northwestern China. Climate response analyses revealed that the precipitation was the primary factor limiting tree-ring $\delta^{18}\text{O}$ fractionation. Based on our analysis, tree-ring $\delta^{18}\text{O}$ can be used to reconstruct the February to June precipitation based on both a reasonable mechanism of tree-ring $\delta^{18}\text{O}$ fractionation and a statistically significant regression model. We find that the regional precipitation shows a wetting trend since 1700s. Compared with moisture



reconstructions from adjacent areas, we find this wetting is probably caused by natural variability, including the solar activity, phase changes of North Atlantic Oscillation and associated northward shift of early summer polar jet stream. These findings highlight the importance of natural variability in driving the of the wetting trend in mid-latitudes, specifically in the context of global warming.

Keywords: Northwestern China, Tree-ring oxygen, Wetting trend, Natural variability

【A0526】 -Poster

Mg/Ca, $\delta^{18}\text{O}$, and $\delta^{13}\text{C}$ of different species of planktonic foraminifera from offshore northwest Africa.

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The northwest African upwelling region is one of the most productive marine ecosystems in the world. This study investigates marine climate variability and coastal upwelling dynamics off northwest Africa during the late Holocene, using sediment cores GeoB8601-3 and GeoB4223-1. Located near Cape Ghir and southwest Morocco, stable isotopes ($\delta^{18}\text{O}$ and $\delta^{13}\text{C}$) and Mg/Ca ratios of foraminifera (*Globigerina bulloides* and *Globorotalia inflata*) were used to reconstruct sea surface temperatures (SSTs), salinity, and productivity.

The results suggest SST warming during the Medieval Climate Anomaly (MCA, ~950–1250 CE) and cooling during the Little Ice Age (LIA, ~1300–1850 CE). High $\delta^{13}\text{C}$ values during the MCA suggest intensified upwelling and increased productivity, while the LIA indicates



reduced productivity and cooler SSTs, indicative of weaker upwelling. The 20th-century record highlights intensified upwelling, reflecting increasing alongshore winds and a strengthened land-sea thermal gradient. Species-specific differences reveal that *G. bulloides* captures signals of nutrient-rich, shallower upwelling waters, whereas *G. inflata* reflects conditions from deeper, more stable water masses. Additionally, recent $\delta^{13}\text{C}$ trends suggest the influence of the Suess effect, linked to anthropogenic CO_2 contributions. These results align with a neighboring core GeoB6008-1, which also suggests similar millennial-scale SST variability and 20th-century cooling linked to increased upwelling.

Keywords: Northwest African upwelling, Foraminiferal proxies, Sea surface temperature (SST), Late Holocene

【A0515】 -Oral

Transient simulation of past 2000 years with the isotope-enabled Earth System Model MPI-ESM-wiso

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The Common Era (CE, i.e. the past 2000 years) is among the periods selected by the Paleoclimate Modelling Intercomparison Project (PMIP) for transient experiments contributing to PMIP4. For PMIP4, novel estimates and updates of external forcing have been compiled. In addition to the Tier-1 category simulation "past1000" for the period 850 CE to 1849 CE, the Tier-3 "past2k" experiment covers the entire CE, extending the possibilities to evaluate the models' response to natural external forcings like volcanic activity, anthropogenic forcing and internal climate variability.

Stable water isotopes (H_2^{16}O , H_2^{18}O and HD^{16}O) are widely used to reconstruct past temperature and precipitation variations in many regions of the over Earth. While the general physical processes of how isotope variations are controlled by temperature and



water amounts is well understood, quantifying past isotope changes as a proxy for temperature and precipitation is much more difficult. An explicit simulation of water isotopes in current Earth system models is one possibility to approach this problem.

In this study, we present new results of a transient fully-coupled simulation of the climate of the last two millennia, using the isotope-enabled model MPI-ESM-wiso. We analyze long-term trends, variability and extremes of the simulated isotope changes in precipitation, compare model results to available data compilations (e.g. PAGES Iso2k) and quantify the relations with associated temperature and hydrological changes.

Our analyses clearly show that for many regions of the Earth, the surface warming starting with the beginning of the industrialization period is clearly imprinted in the oxygen-18 isotope signal of precipitation, e.g., over Greenland, North America, and the Atlantic Ocean. However, in some regions, recent temperature, precipitation and isotope changes seem to be decoupled e.g., over Antarctica, Oceania, and the Indian Ocean. In our presentation, we will discuss this regional varying imprint of the Anthropocene on the water isotope signal in detail. Further analyses focus on changes in isotope variability in different regions over the last two millennia, as well as the possible detection of past climate extremes in different isotope records. Finally, the Past2k-iso simulation results may be utilized for the reconstruction of past climate changes over the past two millennia through proxy data assimilation. This is demonstrated in a separate presentation within the same session.

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Keywords: Water isotopes, Past2k, Earth system model, Anthropocene

【A0551】 -Oral

Reconstruction of climate variability over the Common Era with paleoclimate data assimilation

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Reconstructing climate over the past 2000 years (Past2k) is essential for understanding the interplay between external forcing, natural variability, and anthropogenic influences on the Earth's climate system. This period records significant climate events, including volcanic eruptions, solar variability, and the onset of industrialization, offering valuable insights into the mechanisms driving climate changes and their implications for our warming world.

In this study, we employ an offline paleoclimate data assimilation framework to produce a spatiotemporally resolved global climate reconstruction for the Past2k. Paleo observations were derived primarily from natural archives in datasets such as Iso2k, PAGES2k, and SISALv3. The prior states were generated using ensemble-based climate model outputs, such as MPI-ESM-wiso, IsoGSM2, and MIROC5-iso, enabling the reconstruction of climate variables including but not limited to temperature, precipitation, and pressure.

A key aspect of the assimilation process is the systematic evaluation of the proxy models, which translate climate model variables into the proxy observation space. We assessed the performance of process-based Proxy System Models (PSMs), linear statistical



models (with temperature and/or precipitation), and non-linear machine-learning models across different proxy types. By selecting the optimal model for each proxy type, we enhanced the reliability and accuracy of the reconstruction. This step ensures the effective integration of proxies with distinct characteristics and resolutions, addressing challenges in assimilating multi-types and multi-scale proxy archives.

Our reconstructed dataset includes both annual and seasonal scales, providing insights into climate variability across temporal resolutions. Furthermore, we evaluated the quality of the reconstructed data across different time periods (e.g., 1-500 CE, 501-1000 CE, 1001-1800 CE). Additional experiments were conducted by assimilating a constant number of proxies within these periods, particularly to assess the potential degradation in reconstruction accuracy caused by reductions in proxy coverage with time extended backward. We hope that our datasets will contribute to a more comprehensive understanding of how climate changed in the past and serve as a robust foundation for analyzing ongoing and future climate changes from a long-term perspective.

Keywords: Past2k, Climate reconstruction, Data assimilation, Water isotopes, Proxy system models

【A0623】 -Poster

Concurrent Pan-Pacific decadal hydroclimate extremes driven by Pacific decadal variability over the last millennium

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North America, South America, Asia, and Australasia contain a large portion of the global population, agriculture, and economic activities. Decadal-scale hydroclimate anomalies in these areas, especially when they occur concurrently, can have significant impacts on food supplies, the economy, and populations locally and globally. Although prior studies have investigated the drivers and characteristics of decadal-scale hydroclimate changes in these areas, they are often limited to assessments in individual regions or focus on interannual



changes. As such, whether the hydroclimate in these regions can change concurrently on decadal timescale and the drivers behind such anomalies remain elusive.

We analyze the Paleo Hydrodynamics Data Assimilation product (PHYDA) in the context of decadal synchronous hydroclimate anomalies in these regions, and their associated sea surface temperature (SST) patterns. We identify decadal coherent hydroclimate anomalies on these continents with a spatial expression that is distinct from anomalies on interannual timescales. We particularly note the opposite phasing of hydroclimate anomalies in India, Australia, the southwestern regions of North and South America, and subsequently use these regions to identify concurrent hydroclimate extremes. We find that these decadal concurrent extremes are associated with SST changes that resemble Pacific Decadal Variability (PDV). However, there are also periods where shifts in PDV do not result in coherent pan-Pacific hydroclimate extremes. We further explore the relative role of changing interannual and decadal variability of the Pacific in causing pan-Pacific hydroclimate extremes and in driving the inconsistent relationship between PDV and pan-Pacific hydroclimate over time. We also supplement these analyses with model simulations to better determine the dynamic causes, as well as other paleoclimate field reconstructions to assess the dependency of these results.

Keywords: Hydroclimate, Pacific, Concurrent extremes, Common Era, Decadal Variability

【A0662】 -Poster

Spatial patterns of Larch climate response in the Kamchatka peninsula

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Kamchatka is a large peninsula located in the east of Russia where larch (*Larix gmelinii* Rupr.) area extension confined to the Central Kamchatka Depression, forming together with spruce the so-called "coniferous core" of Kamchatka. Previous dendroclimatological studies used mostly larch tree-ring width as a parameter suitable for climate reconstruction. The main goal of the research is to analyze multiparameter tree-ring larch



chronologies in terms of their climate response. During the extensive fieldworks occurred in last several years, the vast tree-ring network have been developed (Shiveluch volcano region, slope of Mt. Tolbachik, Esso settlement region). Tree-rings sites are located in tree-ring limit ecotone (800-900 m asl), middle part of the slope (300-520 m asl) and at the lower river terrace (300 m asl). Width-based parameters like whole ring (TRW), latewood (LWW) and earlywood (EWW) as well as delta blue intensity (dBI) were measured to develop 4 chronologies for each site. Air temperature and precipitation time series were obtained from local weather stations (Esso, Klyuchi) as well from CRU TS data base. Climate response analysis revealed that the strongest signal is found in trees that are growing at the upper tree-limit vicinity. At this sites correlation varies from $R = 0.3-0.4$ and $R = 0.5 - 0.7$ for TRW and dBI, respectively. In all cases dBI chronologies are more sensitive to summer temperatures compared to TRW chronologies. Surprisingly that LWW chronologies showed almost the same strength of response to summer temperatures as for dBI chronologies achieving values of $R = 0.5-0.6$. Spatial patterns of the climatic signal differ depending on used parameter. Signal strength in width-based chronologies increases with increased altitudes. Climate signal in dBI chronologies show statistically significant correlation in all sites from lowland to upper tree-limit.

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Keywords: Climate response, Kamchatka, dBI, TRW, larch

【A0194】 -Poster

ITCZ and tropical rainfall in the Little Ice Age: Was it southward?

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Tropical rainfall is relevant for the water and food security of ca two billion people. Some studies – using mainly biogeochemical proxies – have interpreted a southward shift of the rainfall belt during the Little Ice Age (LIA). Recently, others have interpreted an expansion



of its width and changes in the neotropics precipitation rather than a location change, including an alternative hypothesis of weaker rainfall in the equatorial core rather than geographical shifts. On the other hand, some have also used climate modelling to seek ITCZ rainfall changes in the last millennium, finding e.g. half degree global southward shifts or an increment in the Indo-Pacific rain belt core plus weakening over southeast Asia and Australia.

Our work studies the dynamics of tropical rainfall and associated tropical circulation during the LIA (1450-1850). It uses results from a 60-member atmospheric model ensemble (ModE-Sim), and a 20-member reanalysis (ModE-RA), that as boundary conditions has an ensemble reconstruction of sea surface temperature and sea ice based on proxies and observations; it also includes the standard PMIP4 for radiative – volcanic – forcing . The reanalysis is based on a 20-member subset of ModE-Sim and uses an offline assimilation system for ingesting early instrumental data and documentary records. The datasets allow us to analyse features of the tropical atmospheric circulation, such as the tropical ascent of moist air or the general Hadley circulation (width, strength, etc); we also analyse humidity and its changes due to temperature.

Model zonal averages show changes in tropical humidity in the LIA, but they are not reflected in the precipitation amount, compared to the initial industrial period (1850-1900). Precipitation is just clearly affected after a reduction in radiation and its location does not show displacement or bulk amount sub-trends, just interannual variability associated with the internal system conditions. Features of the ITCZ, such as its width and strength, do not either show a discernible difference between the LIA and the 1850-1900. The strong ascent also does not show meridional trends before 1950s, but recurrent shifts in DJF towards the equator are apparently associated with El Niño events.

Considering the uncertainty in both models and biogeochemical proxies, we conclude that it is difficult to identify a clear shift or change in the position or amount of precipitation in tropical regions during the LIA. Our results suggest that there were no changes in large-scale tropical circulation, but they probably occurred just at a regional instead of a global scale; we expect to test this hypothesis in future work.

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Keywords: Precipitation, Circulation, Climate, History, Records

【A0386】 -Oral

Phase 5 of the PAGES 2k Network: Hydroclimate 2k

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The global water cycle is changing in response to global warming, with profound societal and ecological impacts. The Common Era provides a pre-Industrial ‘baseline’ against which to assess these human-caused changes. Phases 1-3 of the PAGES 2k Network provided unprecedented insights into long-term global temperature changes, through generation of regional and global Common Era temperature reconstructions. These reconstructions have far-reaching science and policy impacts; for example, the PAGES 2k Common Era global temperature reconstruction was featured in IPCC AR6 Summary for Policymakers.

However, our understanding of long-term variability in the global water cycle remains far less well developed. This is in part due to the complexity of the global water cycle, which—unlike global temperature—cannot be easily reduced to a single variable. Whilst there are many palaeoclimate proxy records preserving information about aspects of water cycle variability over the Common Era, these have yet to be fully synthesised across all archive and proxy spaces to provide a comprehensive spatio-temporal reconstruction of water cycle variability.

PAGES 2k Phase 4 therefore shifted focus to understanding the hydroclimate of the Common Era. We aim to develop a comprehensive understanding of the hydroclimate of the Common Era from local to global spatial scales and seasonal to multi-centennial time scales, and to develop a mechanistic understanding of these changes. This aim will be accomplished using a diverse array of proxy data and modeling tools—including a state-of-the-art multi-proxy multi-archive database of hydroclimate proxy data featuring comprehensive metadata to allow robust interpretations. This metadata is also designed to facilitate use of the database in a data assimilation framework.

Here we outline the structure and format of our new ‘Hydroclimate2k’ database. The database is one of the key objectives of Phase 5 of the 2k Network, and we share database compilation progress to date. The Hydroclimate2k database hosts hydroclimate proxy data from coral, lake sediment, speleothem, ice, tree wood, documentary, marine sediment, and terrestrial sediment archives. Data included in the new database are a combination of records from existing PAGES 2k databases (e.g., Iso2k, CoralHydro2k) and records that were not previously included in a compilation. The proxy data preserve information about a wide range of hydroclimate-relevant variables, including precipitation amount and intensity, the ratio of precipitation to evaporation, local relative humidity, seawater salinity, and many more. These in turn may relate to dynamical variables including monsoon



strength, moisture source, and the presence of atmospheric rivers. This information will be captured in the records' metadata. We will outline our current plans for scientific analyses to be performed with the database, and invite community suggestions and collaborations.

Keywords: Hydroclimate, Database, Global

【A0949】 -Oral

New evidence of the Little Ice Age in the tropical montane forests of South America

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Evidence of cold events associated with the Little Ice Age (LIA, circa 1300-1850 CE) is conspicuous in the Northern Hemisphere, but until recently it was not clear whether similar cold conditions or altered hydroclimatic patterns occurred over South America due to the lack of long paleoclimate records. Particularly for the tropical Andes, there is still a large information gap regarding the behaviour of the LIA. The LIA led to glacier expansion in the tropical Andes (north of 16°S) and increased variability of water availability in the Puna-Altiplano highlands. Between southern Bolivia and 28°S in Argentina/Chile, the highest peaks are rarely covered by ice, so other records must be used to reconstruct past climate conditions. Trees are one of the best natural archives of past climate fluctuations: trees record the environmental factors that influence tree-ring growth at different temporal scales, making them an invaluable tool for monitoring a variety of climatic events. The traditional method for determining climate-growth relationships has been the analysis of ring-width chronologies. However, anatomical features in tree rings provide an additional opportunity for inferring climatic and environmental fluctuations. Frost damage to annual rings is known to be an indicator of unusual subfreezing temperatures during the growing season. The phenomenon of "frost rings" has been primarily identified



in conifers, while less work has been conducted on deciduous trees in temperate regions. Currently, there are no records of frost rings in tropical regions. Frost rings provide the unique opportunity to construct long-term chronologies of extreme cold events. The aim of this study is to present unprecedented evidence of unusual spring temperature extremes at a high-altitude location in the tropical Andes of Argentina during the last decades of the LIA. A ring-width chronology was developed for the period 1796-2021 from *Cedrela angustifolia* trees (*Meliaceae*) at the Argentinean-Bolivian border (Santa Victoria range; 2036 m asl). Frost rings were identified in 13 out of 39 samples, with a notable frequency of frost injury during 1818-1853 CE. Correlations between the tree-ring chronology and monthly climatic variations indicate that temperature is the triggering factor that promotes radial growth. The action of intense and prolonged freezing temperatures at the onset of the annual growing season result in alterations to the cambial tissue, leading to the formation of distinct rings with cryogenic evidence. Indeed, the present frost ring chronology is the first ever developed in a tropical region, and shows frost events at the beginning of the growing season which are currently very uncommon in tropical zones. This novel evidence of cold events in montane forests may shed light on past temperatures conditions along the southern tropical Andes, contributing to a comprehensive interpretation of climate variations during the latter portion of the LIA in South America.

Keywords: LIA, Andean Yungas forests, Dendrochronology, Frost rings

【A0430】 -Oral

Four century long winter and spring season regional drought history reconstructions from western Nepal Himalaya using tree rings

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The Himalaya mountains, also known as the Third Pole and Asian Freshwater Tower, are highly affected due to the ongoing rapid climate change. The region is experiencing rapid increase in temperature, inconsistent precipitation pattern but an increase in the extreme



climate events including intense and frequent drought and flood events. Tree-rings, being a valuable and proven source of high resolutions climate proxy data of centennial to millennia scale for the data deficient regions, provide historical context of drought events in the Himalaya region where instrumental data are limited to past few decades. By analyzing a network of tree-ring width site chronology from the western Nepal, we developed a regional composite tree ring width chronology extending from 1442 to 2017 AD. Growth-climate response analysis revealed that the growth of the studied tree species in the western Nepal was mainly limited by the moisture stress during winter-spring months or season as we found positive correlation between chronology and scPDSI during most of the months and seasons, with strong relationship with winter and spring months and seasons. By using the robust calibration model of tree-ring chronologies and scPDSI that explains 45% variance in the actual data, four centuries-long (1610-2017 AD) winter-spring season (Jan-June) regional drought history for the western Nepal Himalaya was reconstructed. The reconstructions revealed several distinct wet and dry periods during past four centuries along with several extreme wet and drought years and an increasing frequency of extreme events during recent decades. Moreover, several historic mega-drought events that were recorded in Monsoon Asia region like Strange Parallel drought (1756-68), Chalisa famine (1783-84); East India drought, Late Victorian drought (1876-1877), and some unnamed drought events were recorded in our reconstructions. The power spectral analysis revealed short interannual (2.2-2.9, 4.3-4.5, 6.2-6.5 years) to medium frequency cycles (31.0-40.8 years) indicating influence of broader scale climate mode or phase. The study provides a scientific insight for the preparation for the anticipated warming and drying climate scenarios in the Himalaya and adjacent regions taking the historic drought intensity and their periodicities during past four centuries.

Keywords: Drought reconstruction, Himalaya, Extreme events, Hydroclimate, Climate change

【A0246】 -Poster

Deciphering the variability of East Asian Monsoon precipitation isotopes using an isotope-enabled atmospheric model

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The East Asian monsoon is one of the most significant climate systems in the low-mid latitudes, affecting more than half of the global population. Speleothem $\delta^{18}\text{O}$ is widely used to reconstruct past hydroclimate variability, particularly over East Asia. However, the interpretation of this proxy is still in debate. The classic explanation of monsoon precipitation isotopes is Dansgaard's (1964) "amount effect", which describes a negative relationship between oxygen isotopes in tropical precipitation and local rainfall. However, recent studies suggest that the "amount effect" alone cannot fully account for variations in precipitation isotopes. Changes in atmospheric circulation, upstream rainout, moisture sources composition, source locations largely influence precipitation isotopes. To better understand the signal preserved in speleothems over various time scales, this study employs the iCAM6 model, which integrates the water vapor tagging technique, to simulate atmospheric moisture isotope variations over the period 1940–2014. Nudging techniques are applied to enhance the reliability of model in simulating precipitation isotopes. The research aims to quantify the relative contributions of different moisture source regions to the interannual variability of oxygen isotopes in East Asian Summer Monsoon precipitation. Furthermore, we investigate the dominant moisture transport patterns and atmospheric circulation features influencing isotope variability. These findings will provide critical insights into the interpreting paleoclimate proxies.

Keywords: East Asian monsoon, ICAM6 model, Water vapor tagging, Nudging technique

【A0975】 -Poster

Late Holocene high-resolution sedimentary paleoflood reconstruction and hydroclimate changes in the lower Yangtze River

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Paleofloods refer to flood events before historic and modern observations and are often studied using geological and geomorphological markers. Paleoflood studies uncover long-



term flood sequences at centennial to millennial timescales and are critical for revealing the relationship between hydrological and climate changes. The Yangtze River basin has experienced frequent flood disasters since ancient times, and there are rich preservations of paleoflood sediments. However, continuous high-resolution paleoflood research is scarce, and the patterns of extreme flood and hydrological changes on decadal to centennial scales, as well as their climate mechanisms, require further investigation. In this study, we obtained a 12.5 m long core of oxbow lake sediments (WW2401) of the Yangtze River in Wuwei City, Anhui Province (31°12.904'N, 118°7.880'E) for a paleoflood study. The core is characterized by alternating clay and silty lake deposits, interbedded with numerous sandy flood layers. The density of flood layers shows distinct variation with depth in the core. We conduct sediment grain size analysis at a 1 cm resolution and will use end-member analysis to help identify paleoflood events. We also combine ¹⁴C and OSL to date the age of the sediments. Preliminary data suggest that WW2401 probably preserved a flood record of the Yangtze River in this region over the past 1500 years, offering the opportunity for continuous high-resolution paleoflood reconstruction. In the presentation, we will present detailed sedimentary paleoflood reconstruction data and discuss the climatic drives of regional hydrological evolution.

Keywords: Paleoflood, Sediment, Climate change

【A0944】 -Poster

Over 150 years of streamflow behavior inferred from freshwater pearl mussel shell oxygen isotopes in northern Sweden

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Global warming has a significant impact on snowmelt-driven runoff regimes in northern latitudes. Especially, changes in the timing and magnitude of spring snowmelt – often responsible for over half of annual streamflow – potentially alters summer drought vulnerability in northern rivers. To assess these changes, it is essential to analyze historical seasonal water budget dynamics. Oxygen isotopes in streamwater are powerful natural tracers to characterize critical components of hydrological budgets. Specifically, a combined record of $\delta^{18}\text{O}$ in precipitation and streamwater can help determine the relative contributions of winter vs summer precipitation to streamflow. However, the spatial and temporal coverage of instrumental $\delta^{18}\text{O}$ records limits the full exploitation of these proxies.

Here, we propose two innovative approaches to reconstruct pre-instrumental $\delta^{18}\text{O}$ series in both precipitation and streams: (I) Precipitation $\delta^{18}\text{O}$ based on empirical relationships with atmospheric circulation patterns; (II) Streamwater $\delta^{18}\text{O}$ using the long-lived freshwater pearl mussel (*Margaritifera margaritifera*) which forms its shell in oxygen isotope equilibrium with the ambient water. We present continuous shell-based estimates of the seasonal origin index (SOI) of streamwater in four northern Swedish catchments over the time interval of 1836 to 2023. The dataset includes over 2,700 isotope samples representing stream water conditions during the main growing season of the mussels (June to August).

Our findings indicate that the relative contribution of winter vs summer precipitation to stream water during the shell growing season (summer low flow conditions) varies with catchment size. The largest catchment is dominated by winter precipitation, while smaller catchments show a mix of winter and summer signatures. We observed a moderate negative correlation of the SOI with baseflow discharge (Pearson's R ranging from -0.38 to -0.65) and with groundwater levels in smaller catchments (R ranging from -0.54 to -0.85). From this correlation we conjecture that the shell-derived SOI could be used to infer changes in streamflow during the summer period (growing season) in boreal regions of the northern hemisphere. Understanding these patterns provides critical insights into catchment-specific low flow conditions, aiding in the assessment of watershed sensitivity to climate change.

Keywords: Seasonal Origin Index (SOI), Bivalve sclerochronology, Streamwater oxygen isotopes, Baseflow, Drought vulnerability



【A0186】 -Poster

Global temperature trends modulated by Pacific decadal variability back to pre-industrial times

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The Pacific Decadal Oscillation (PDO) plays a crucial role in global decadal climate variability, yet there is ongoing debate about its pre-industrial variability. In this study, we reconstructed the PDO variability for the period 1746–2003 using a network of annually resolved marine proxy records from the extratropical North Pacific. Our PDO reconstruction (PDO_{rec}) provides evidence for persistent decadal variability and tropical-extratropical interactions over the North Pacific. Superposed epoch analysis shows an insignificant response of PDO_{rec} to major volcanic eruptions, underscoring the dominant role of internal variability. Decadal shifts in global temperature trends were observed to correspond with phase transitions in PDO_{rec} for the period 1746–2003. The strong global cooling during the early 19th century was not only linked to two strong volcanic eruptions but also a strongly negative phase of PDO_{rec}. Combined with model simulations, our reconstruction shows that the PDO accounted for ~18% of the decadal-scale global temperature trends, indicating a significant modulation of decadal temperature variations by internal variability. Our findings highlight the important role of unforced variability superimposed on the human-induced global warming trend in projections of 21st century climate change.



Keywords: PDO, Global temperature, Coral, Bivalve, Coralline algae

【A0685】 -Poster

Evaluating simulated Arctic sea ice variability during the Last Millennium

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Arctic sea ice has undergone rapid decline in recent decades, yet current climate models struggle to fully capture the observed variability. Understanding the drivers of past and future Arctic sea ice changes is essential for improving these models and enhancing future projections. This study evaluates the performance of past1000 simulations from PMIP4/CMIP6 in reproducing Arctic sea ice variability during the last millennium. By comparing model outputs with sea ice records derived from modern observations, historical documentation, and proxy reconstructions, we assess the ability of models to simulate regional patterns of variability.

Our analysis focuses on regional features, with particular attention to the North Atlantic and North Pacific sectors. The observations show that these regions exhibit contrasting sea ice histories and dynamics, offering unique opportunities to explore the mechanisms driving variability. We investigate key processes influencing sea ice, including internal variability and external forcings, to understand how models represent the timing and extent of changes during significant climatic periods such as the Medieval Climate Anomaly and the Little Ice Age.

By identifying strengths and limitations in model performance, our study highlight gaps in current simulations and informs efforts to improve the representation of high-latitude processes. Our results contribute to reducing uncertainties in future model projections of Arctic sea ice change.

Keywords: Arctic sea ice, Regional variability, Last millennium



【A0394】-Poster

Exploring the potential of cold-water corals for reconstructing temperature changes in the upper ocean of the central South China Sea since the industrial revolution

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Since the Industrial Revolution, the continuous increase in atmospheric carbon dioxide concentration has led to global warming. Ice core and observational data, however, indicate that "global warming hiatus" happened in the mid-20th century and the early 21st century. This phenomenon is explained partly by changes in ocean heat storage. The deep ocean is a vast heat reservoir, thus changes in deep ocean heat content may result in short-term stabilization and even decreases in atmospheric temperature. Therefore, understanding historical changes and the mechanisms of deep ocean heat storage is of great practical significance for predicting future climate change and mitigating global warming, but it is limited due to the lack of instrumental and proxy records.

Cold-

water corals, due to their wide distribution, slow growth rates, and unique structure, can record various environmental changes over their lifespans. This study aims at reconstructing seawater temperature changes in the upper ocean of the South China Sea since the Industrial Revolution using two cold-water corals collected from water depths between 300 and 1200 meters in the central South China Sea. In this study, we dated the organic nodes of the corals in high resolution, using Accelerator Mass Spectrometry (AMS) ¹⁴C dating methods. The organic nodes of the corals recorded ¹⁴C bomb peak, allowing us to construct the age framework by improving a previously proposed non-linear age model. The results show that the ages of both samples are within one hundred years, and the radial growth rates ranged from several to tens of micrometers per year, high near the sample's central axis. By analyzing the elemental composition of the calcium carbonate skeleton using LA-ICP-MS, seawater temperature was reconstructed using the modern seawater Mg/Ca-



temperature calibration. Samples from different water depths show similar annual variations, but significant different average temperatures. The temperatures from the shallower sample closely matched those from the World Ocean Atlas 2023 (WOA23), while the deeper one exhibited nearly a 4°C difference from the WOA23 data, and exhibited larger temperature variations. Additionally, temperatures were also reconstructed by analyzing the carbon and oxygen isotopic compositions along two different growth rings of the sectioned calcium carbonate skeletons. Compared to the temperatures from LA-ICP-MS, these two reconstructed temperatures are closer to the WOA23 and the sample's average temperature respectively. Despite potential non-thermal effects such as vital effects on the elemental and isotopic compositions of corals, this study shows the potential of using cold-water corals to reconstruct seawater temperatures during their growth period.

Keywords: Cold-water bamboo coral, South China Sea, Radiocarbon dating, Carbon-oxygen isotopes, Mg/Ca-T proxy

【A0356】 -Oral

North Atlantic region isoscapes through the Common Era

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The North Atlantic Oscillation (NAO) and East Atlantic Pattern (EAP) are atmospheric modes of variability operating in the North Atlantic region that help in understanding thermo/hydro-climate variability across Europe and the Mediterranean. The impact of such recurring climate modes results in spatial and temporal patterns in contemporary regional climate space, including in the isotopic values of precipitation, precipitation amount, source, and temperature.

Here we use records from Europe and Greenland in the Iso2k database, consisting of hydrogen and oxygen isotope records from various archive types (i.e. ice, marine and lake sediments, speleothems and wood) spanning the last two thousand years, to investigate changes in the isoscape across the region through the Common Era. These patterns are used to identify possible links to shifting atmospheric circulation during key climatic periods such as the Medieval Climate Anomaly (MCA; ~950-1250 CE), the Little Ice Age (LIA; ~1300- 1850 CE) and the Post-Industrial period (PI; 1850-present).

To help interpret observed changes in the Iso2k time series and their resulting spatial patterns, we also examine outputs from multiple isotope-enabled General Circulation Models (GCMs) and compare them to measured patterns from GNIP. We also use Proxy System Models (PSMs) to isolate various potential controls on terrestrial isotope records, such as changes in temperature and the isotopic composition of precipitation.

Initial results show that in the Iso2k records, the MCA is characterised by generally more positive $\delta^{18}\text{O}$ values in Greenland, mixed values in southern Europe and negative values in northern Europe. The LIA is distinguished by negative $\delta^{18}\text{O}$ values in Greenland and northern Europe, and with positive values in southern Europe, suggesting a change in the N-S isotope gradient across Europe between the two time periods. GCM output suggests some of this changing gradient in the Iso2k records can be explained by differences in the isotopic values of precipitation between the LIA and MCA. There appears to be greater discrepancy between proxy data and GCM outputs for the post industrial period. We test if these changing spatial patterns can be attributed to varying intensities of the NAO and EAP during the last two millennia.

Keywords: NAO, Isotopes, Common Era



【A0214】 -Oral

Spatio-temporal variability of Indian Summer Monsoon in the Western Ghats of south-western India during the Common Era

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The Western Ghats, a mountain range and biodiversity hotspot in southwestern India, has been experiencing extreme rainfall events, floods and landslides frequently during recent years. These events have resulted in significant loss to the economy, in addition to fatalities, injuries, loss of life, and extensive infrastructural damage in the region. We have investigated lacustrine sediments from three lakes in the region to reconstruct past hydroclimatic changes during the Common Era, which may aid in understanding extreme climatic events and modelling future monsoonal variations. The three lakes, Madagadakere Lake (MK), Cheppandikere (CK) Lake and Vagamon (VG) Lake, are situated along different rainfall (760 mm, 1483 mm, and 2500 mm respectively) and latitudinal (13.49°, 12.47°, 9.67° respectively) gradients in Western Ghats mountains in south-western India. The chronology of the sediments was established based on AMS C-14, Pb-210 and Cs-137 dating. The paleorainfall reconstruction was carried out using multiple proxies like environmental magnetism, organic geochemistry (C/N ratio), inorganic geochemistry (major elements, elemental ratios and various chemical indices of weathering), sediment grain size, diffuse reflectance spectroscopy, Fourier transform infrared spectroscopy and isotopes ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$). The high-frequency fluctuations indicative of local perturbations in rainfall are different in the three lake records, indicating regional variability in the rainfall. However, long-term trends exhibited by the three lacustrine sediment records are broadly similar along with inherent global climatic signatures. The study shows that the monsoon in the Western Ghats has strengthened overall in the region (800 cal. years B.P. to Present) and responded to global climatic episodes like the Roman Warm Period (strong), Dark Age Cold Period (weak), the Medieval Warm Period (strong), and the Little Ice Age (weak). The Summer Monsoon was strong during 150 BC–50 AD, 350–700 AD, 900–1025 AD, 1270–1350 AD, and 1600–1680 AD, with weak monsoon during intervening phases. Both high and low-frequency cyclicities



(39, 41, 44, 48, 54, 101, 105, 164, 291) were obtained from the spectral analysis of proxy parameters. These periodicities are also recorded in other paleoclimatic records in the region, whose origin is attributed to changes in Total Solar Irradiance (TSI). The results indicate that the rainfall variability and extreme climatic events during the past 2000 years in southern India were regulated by both internal factors (El-Niño southern oscillation, Indian Ocean Dipole and shifting of Intertropical convergence zone) and external forcings (Total Solar Irradiance). The periods of strong Summer Monsoon in the Western Ghats aligned with the occurrences of a positive Indian Ocean Dipole (IOD), enhanced Total Solar Irradiance (TSI), diminished El Niño Southern Oscillation (ENSO) activity and northward shift of the Intertropical Convergence Zone (ITCZ). Additionally, three lake records document several global climatic signals, proving the teleconnection between internal forcing processes and various climatic systems.

Keywords: Indian Summer Monsoon, Lake sediments, Southern India, Western Ghats, Multi-proxy

【A0610】 -Poster

Climatic response of stone birch wood density records from Kamchatka peninsula derived from X-ray computed tomography

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Wood density of angiosperms is a potential source of high-resolution paleoclimatic information. However, due to the complex nature of their wooden tissue and related technical difficulties of data acquisition, wood density of angiosperms remained in the background of their gymnosperm counterpart for a long time.



Here for the first time, we present the results of acquisition of 15 μ -resolution density profiles of stone birch (*Betula ermanii*) cores from Kamchatka peninsula (Russia) from high-resolution X-ray computed tomography (X μ CT) and their dendroclimatic analysis. 33 samples from two sites near Petropavlovsk-Kamchatsky were used to develop chronologies (1847-2023 CE) of different density characteristics of tree rings, including maximum, minimum and average density for different sub-sections of tree rings. These chronologies were then correlated to monthly temperature and precipitation from the nearby meteorological station for the common period from 1967 to 2022.

The results show that many of the extracted density-based parameters show high enough R_{bars} ($R_{\text{bar}}=0.2-0.4$) to be cross-dated, the fact that also confirms a common climatic signal in these proxies. Dendroclimatic analysis showed that density-based chronologies surpass their tree-ring width (TRW) counterparts in terms of climatic response strength. From the investigated parameters, that average and maximum density of the third quarter of tree ring (MeanQ3, MxQ3) appeared to show the strongest response to temperature. It correlates significantly with early summer (June–July) temperatures of the previous year (up to $r = 0.45$, $p < 0.05$), while negatively with March and September temperatures of the current year ($r = -0.25$, $p < 0.05$). They also showed significant negative correlations with August precipitation of the current year (up to $r = -0.37$, $p < 0.05$). TRW chronology, at the same time, showed positive correlations with March, June, July, August and September temperatures of the current year (up to $r = 0.29$, $p < 0.05$), and no significant relationship with precipitation.

For now, the dendroclimatic response was only obtained for the discrete density characteristics of the four quarters of tree ring, but we are currently working on other density characteristics. The study demonstrates better dendroclimatic performance of stone birch tree-ring density chronologies in comparison to their TRW counterparts and suggests future work to extract the most climate-sensitive density-based parameters by refining density calculation windows within annual rings.

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Keywords: Wood density, Angiosperms, Dendroclimatology, X-ray computed tomography

【A0122】 -Poster

PDO influenced interdecadal summer precipitation change over East China in mid-18th century

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There have been few case studies of the relationship between the Pacific Decadal Oscillation (PDO) and East Asian climate before the pre-industrial era with limited anthropogenic impacts. Using CESM Last Millennium Ensemble (CESM-LME) simulation with reconstruction evidence, we showed that there was an interdecadal transition of the summer precipitation in East China, with the pattern of "southern flooding and northern drought" in the mid-18th century. The interdecadal transition was influenced by PDO, as suggested by both the reconstruction evidence and simulation. Corresponding to the positive PDO phase change, East Asia-Pacific pattern teleconnection wave train propagated northward and modulated the circulation and precipitation in East China, together with the southward movement of the East Asian westerly jet. The volcanic double or clustered eruptions are thought to have played a crucial role on the shift of the PDO phase and the decadal summer climate change over East China during the mid-18th century. Incorporating volcanic activity in a reasonable manner would likely improve decadal simulations of East Asian climate in the past and predictions in the future.

Keywords: Pacific Decadal Oscillation, Last millennium, East Asian monsoon, Volcanic activity



【A1043】 -Poster

Ostracode $d^{18}O$ values from Kiritimati Island reconstruct central tropical Pacific climate over the past 1700 years

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Understanding the patterns and mechanisms responsible for long-term changes in the tropical Pacific climate is necessary as natural decade-to-century scale variability in the state of the tropical Pacific and the emergence of anthropogenic trends remain uncertain. Here we present two new central tropical Pacific stable isotope ostracode valve records from the main lagoon of Kiritimati, Republic of Kiribati. We hypothesize that higher $d^{18}O$ values result from increased cooling and evaporation of lagoon waters, whereas lower $d^{18}O$ values reflect warming and lagoon freshening from increased precipitation and runoff. Preliminary results indicate increasing $d^{18}O$ values from 250-1000 CE, a period of high variability in $d^{18}O$ preceding a hiatus from 12-1400 CE, and a decreasing trend in $d^{18}O$ from 1700 CE-present. The lagoon sedimentation hiatus coincides with Kiritimati lake hiatus and Washington island salinity spike. This indicates a potential period of severe aridity ~1400CE, or other abrupt, regional event. These data indicate high potential for Kiritimati lagoon ostracode $d^{18}O$ values to provide a continuous record of past climate variability, offering a new and valuable perspective on low frequency fluctuations and recent trends in the tropical Pacific climate system.

Keywords: Paleoclimate, Ostracode, Tropical Pacific

【A0196】 -Poster

Global multiproxy ENSO reconstruction over the past millennium

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El Niño-Southern Oscillation (ENSO) is the leading mode of interannual climate variability that affects climate and society across the world. However, our understanding of ENSO variability is currently lacking due to short instrumental observations, which limit our confidence in predicting its future occurrence and impact. In this study, we use the nested principal component regression method to reconstruct the ENSO index based on a global-scale proxy network of stable oxygen isotopes ($\delta^{18}\text{O}$). We account for the teleconnection changes that influence proxy records corresponding to different ENSO phases by using the isotope-enabled Community Earth System Model. According to the precipitation $\delta^{18}\text{O}$ –ENSO relationship, we reconstruct the ENSO index over the last eight hundred years based on the first two leading modes of the selected proxy records. The skill of ENSO reconstruction improves with an increased number of $\delta^{18}\text{O}$ series distributed over the ENSO-affected regions. Our new reconstruction shows high consistency with existing ENSO reconstructions during periods of strong ENSO variability, indicating that the global proxy records capture enhanced teleconnection signals during the phase of strong ENSO amplitude. There is a weak El Niño response one year after the large volcanic eruptions in our reconstruction, and the amplitude of ENSO is significantly correlated with volcanic intensity. The strengthened energetic interactions between the ocean and atmosphere following large volcanic eruptions result in enhanced sea surface temperature (SST) variability.

Keywords: Global-scale proxy network, Stable oxygen isotopes, ENSO reconstruction, Volcanic eruption

【A1041】 -Poster

The “Medieval Climate Anomaly” and the “Little Ice Age” in the mid-latitudes of western South America: A summer temperature reconstruction based on chironomids from Laguna El Pillo

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The scarcity of quantitative paleoenvironmental information in the Southern Hemisphere impedes a thorough examination of past extreme climatic events (e.g., heatwaves, floods) and the contextualization of current and future events under climate change trends, which project increased temperatures and droughts in Chile. Chironomids (*Diptera: Chironominae*) are widely recognized as one of the most reliable biological indicators for quantitative paleoenvironmental reconstruction, given the strong relationship between atmospheric temperatures and the spatial distribution of species. Using a chironomid training set from over 70 lakes in Chile (south-central and north Patagonia) and Argentina (north Patagonia), a model of the warmest month temperatures (WMM; austral summer) was constructed using the WA-PLS technique. The model was applied to the chironomid record covering the last 900 years in Laguna El Pillo (intermediate depression, 37.27°S; 72.67°W, 64 m a.s.l., WMM 19.5°C). The results indicate that summer temperatures were relatively lower than present between 1120 and 1300 CE (up to -2.5°C). Subsequently, the Laguna El Pillo record shows positive and negative anomalies associated with the Medieval Climate Anomaly (MCA, 1300-1600 CE) and the Little Ice Age (LIA, 1600-1890 CE), respectively. While the MCA shows summer temperature values similar to the present, during the LIA the values decrease by 1 to 2.5°C. Comparing our record until 1600 CE, it presents a pattern and chronology more consistent with summer temperature reconstructions from western north Patagonia (41-42°S) than from central Chile (34°S). Later, the available records including El Pillo exhibited a high correspondence with temperature increases during the 17th and 19th centuries, and in the last 50 years in line with the current warming trend, interrupted by cold summers between the 19th century and the first part of the 20th century.

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Keywords: Quantitative reconstruction, Chironomid training set, Last millennia, South-central Chile

【A0113】 -Poster



Vegetational and climatic changes in the Ladakh Himalaya, India: Insights from stable isotope and pollen analysis of a ~3200 year sedimentary record

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A ~3200-year record of vegetation dynamics and climate conditions from the sediment profile of the Shakti wetland, Ladakh, was investigated using a multi-proxy approach, including pollen, non-pollen palynomorphs (NPP), stable isotopes ($\delta^{13}\text{C}_{\text{org}}$, $\delta^{15}\text{N}_{\text{bulk}}$), total organic carbon (TOC), and total nitrogen (TN). Six AMS ^{14}C dates provided the chronology for the sedimentary sequence. The multi-proxy data indicate moderately wetter conditions from 3230–3130 cal yr BP, aligning with the Minoan Warm Period, evidenced by increased TOC, TN, and non-arboreal pollen (NAP). NPP concentrations around Shakti peaked during periods of aridity from 3070–2890 cal yr BP and 1660–1280 cal yr BP. Warm and wet conditions were marked from 2890 to 2630 cal yr BP by the presence of pollen from alpine meadows, dry steppe, and marshy taxa, alongside relatively lower $\delta^{15}\text{N}$ values suggesting increased nitrification. The first appearance of Cerealia pollen, dating to around 2700 cal yr BP, suggests early human settlement or pastoral activity. Between 2630 and 2130 cal yr BP, a mixed forest-type vegetation emerged, with alpine taxa increasing further during the wet period from 1280–740 cal yr BP, corresponding to the globally recognized Medieval Warm Period (MWP). Spectral analysis of $\delta^{13}\text{C}$ revealed cycles of approximately 400, 150, 110, and 85 years, suggesting solar influence on regional climate over the last ~3200 years.

Keywords: Vegetation, Palynology, Ladakh, Stable isotopes, Palaeoclimate

【A0603】 -Oral

Last millennium changes in Mississippi River Basin hydroclimate as a framework for understanding future anthropogenic impacts

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Human activities, such as river engineering and land use changes, have altered the natural course of the Mississippi River, leaving the lower basin particularly vulnerable to future hydroclimate extremes. Extreme wet and dry events are expected to intensify in the 21st century as anthropogenic forcing compounds natural variations in seasonal circulation patterns. In particular, the strength and positioning of the Bermuda high and Great Plains low-level jet (GPLLJ) have important controls on moisture transport into the Mississippi River basin (MRB). However, considerable uncertainty remains about how these atmospheric dynamics will evolve over time and affect future MRB discharge. This uncertainty poses significant challenges for policymakers managing water resources, mitigating flood risks, and ensuring agricultural sustainability. To provide more robust constraints on future MRB hydroclimate, this study capitalizes on Community Earth System Model (CESM) ensembles (which explicitly include river routing) to determine the relative importance of greenhouse gases, land use changes, and atmospheric dynamics on hydroclimate extremes in the past, present, and future. The CESM1.2 Last Millennium Ensemble resolves long-term (multi-decadal to centennial-scale) controls on MRB hydroclimate, broadly extending the statistics afforded by observational data, while the CESM2 Large Ensemble offers improved streamflow estimates and a large ensemble with SSP3-7.0 forcing. Using previously-established indices for the Bermuda high and GPLLJ, we evaluate the changes in these large-scale atmospheric systems over the last millennium and 21st century. Our work indicates that a westward shift in the western flank of the Bermuda high and a stronger GPLLJ yields drier conditions in the lower MRB in the 20th and 21st centuries compared to the pre-industrial era. Although the MRB is generally projected to shift toward drier conditions in the 21st century, we find that the basin is wetter in the 20th century compared to the pre-industrial era, with land use changes driving elevated precipitation and soil moisture. By clarifying the historical and future roles of atmospheric dynamics and land use changes in the MRB, these results provide actionable insights for policy and planning. Improved understanding of hydroclimate variability can inform regional water resource management strategies to balance competing demands between agriculture, industry, and municipalities. Insights into the frequency and magnitude of past floods can support infrastructure design to reduce



vulnerability to high-risk areas and inform crop diversification strategies. Given the myriad of factors contributing to future changes in the MRB, this work provides a foundation for building resilience in the 4th largest watershed in the world, preparing communities and ecosystems for an uncertain future.

Keywords: Hydroclimate, Land use change

【A0630】 -Oral

What controls the summer hydroclimate in Japan? – Detailed comparisons of paleo-records between relative humidity, air temperature and sea surface temperature during last 2k

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Flood and drought disasters are now rapidly increasing due to the global warming. However, in order to predict near-future changes in precipitation precisely, it is necessary to understand mechanisms and impacts of natural multi-decadal hydroclimate variability underlying the present increases in disasters.

Recently, summer relative humidity (RH), the main controlling factor of summer precipitation, has been successfully reconstructed in central Japan for last 2,600 years at every time scales from 1 to 1000 years by combining tree-ring cellulose oxygen and hydrogen isotope ratios. According to the physical definition, RH must have negative and positive correlations with air temperature (AT) and vapor pressure (VP), respectively, and summer VP in central Japan has been proven to be determined by sea surface temperature (SST) around Japan. In fact, during last 2k, the reconstructed summer RH in central Japan shows the inverse variation roughly in sync with the land AT averaged over Northern Hemisphere, while the decadal and centennial discrepancies between the inversed RH and the AT variations can be well explained by the foraminifera-based reconstruction of SST and some coral ring-based reconstructions of SST in the Indo-Pacific regions, especially the area near the Japan. It means that the continental AT and the oceanic SST exclusively control the summer RH and precipitation in central Japan, which



can be actually confirmed by documentary climate records from various periods in Japanese history. Although this finding is not surprising at all in the viewpoint of climate physics, the coincidences between different proxies from atmosphere and ocean with high temporal resolutions suggest that we can discuss explicitly about the atmosphere and ocean interactions influencing the variation in regional hydroclimate during last 2k by direct comparisons between proxy-based records of AT, SST and RH.

So far, tree-ring AT and RH records have been seldom compared with coral-ring SST records partly due to the shortage of long continuous coral-ring sequences. However, recent development of U/Th dating for carbonate materials makes the direct comparison possible between tree-ring and coral-ring data for various periods in the past to demonstrate the decadal and centennial atmosphere and ocean interactions, which can be also elucidated by the past 2k climate modelling using atmosphere and ocean coupled general circulation models.

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Keywords: Tree ring, Oxygen isotope ratio, Humidity, Japan, Sea surface temperature

【A0024】 -Poster

Records of the Holocene paleoenvironmental changes in coastal sedimentary archives of Sri Lanka

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Sri Lanka is an ideal location for understanding regional and global paleoenvironmental changes. This study is focused to investigate late Holocene paleo socio-environmental systems in Sri Lanka. Samples were collected from coastal sedimentary archives. Methodology includes CHNS elemental ($n = 294$), gas chromatography-mass spectrometry ($n = 74$), X-ray diffraction ($n = 14$), and Fourier-transform infrared spectroscopy ($n = 59$) analyses. Chronological events were identified using accelerated mass spectrometry (AMS) ^{14}C data. The compiling of temporal geochemical variations in core samples suggested two sedimentary facies in coastal sedimentary archives. The lower sedimentary succession (i.e., from ca. 7.5 ky B.P. to 2.5 ky B.P.) can indicate deposition of marine-terrestrial organic matter under oxygen-poor to anoxic conditions. Paleoclimate of this facies can be identified as a period of mid-Holocene sea-level highstands. The upper sedimentary succession (from ca. 2.5 ky B.P. to the Recent) can indicate the burial of considerable level terrestrial organic matter under the late-Holocene sea-level lowstands. Sea-level change can be identified as the main triggering factor for geomorphological changes on the western coast of Sri Lanka which directly controls socio-environmental systems during the late Holocene. For example, geomorphological change is mainly characterized by the formation of beach rock ridges, headland barriers, and semi-closed aquatic systems. In contrast, molecular-level studies such as $n\text{-C}_{29}/n\text{-C}_{\text{all}}$ and $n\text{-C}_{37}/n\text{-C}_{\text{all}}$ alkane proxies suggested a gradual transition of Northern Hemisphere Summer Monsoon from wet to dry climate since middle Holocene along the western coast of Sri Lanka.

Keywords: Carbon sequestration, Holocene, Sea-level change, Paleoclimate, Summer Monsoon

【A0702】 -Oral

Climate change and human-environment interactions in the coastal loess area of Shandong Province, eastern China over the past 2000 years

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Systematic investigations on human-environment interactions in coastal loess areas are still rare in eastern China and thus require further study. Based on the high-resolution pollen records from the Xihao profile, Ren et al. reconstruct climate change and its relationship with human activities in the coastal loess area of Shandong Province, eastern China over the past 2000 years. Our pollen data indicate a warm and dry climate condition from 2000 to 1300 BP, which then switches to a warm and wet climatic condition during the Medieval Warm Period (~1200–700 BP). After 600 BP, the increase of the cold-tolerant taxa coincides well with the Little Ice Age. We analyze historical documents to demonstrate episodes of population increase and decline and to provide evidence for the climate change impacts and human resilience in the coastal loess area of Shandong Province over the past 2000 years.

Keywords: Climate change, Pollen, Coastal loess, Human-environment interactions, Shandong Province

【A1032】 -Poster

Understanding hydroclimate variability over the Indian sub-continent during the Common Era: A critical analysis of paleoclimate models and data assimilation products. (an evaluation)

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In the recent decade, paleoclimate models and data assimilation (DA) products (hereafter referred to as synthetic data) have increasingly been used to explore hydroclimate variability over the Indian subcontinent during the Common Era (0 – 2000 CE). These synthetic datasets, which incorporate proxy sites/networks that are unevenly distributed



across the globe, have been used extensively to document global-scale hydroclimate variability. Importantly, the global south is poorly represented in the proxy network(s) that are used to derive these synthetic datasets, resulting in large uncertainties in the model-based projections of future change in this region. The Indian subcontinent and the wider South Asian region remain one such historically underrepresented region. Here, we review the literature evaluating the performance of: newly introduced global synthetic data assimilation products, PHYDA and LMR; and global paleoclimate models from the Paleoclimate Model Intercomparison Project (PMIP). This review is supplemented by a comparative analysis of the hydroclimate reconstruction captured by PHYDA, LMR and PMIP with the existing proxy-based reconstructions for the region surrounding Mandu, Madhya Pradesh. Located in central India, Mandu has a rich archaeological record that is being used to study past society—environment relations and to identify resilient climate adaptation strategies for the region. However, site and region-specific hydroclimate reconstructions differ from global DA and model-based reconstructions, highlighting a critical challenge in the use of global synthetic datasets in this data shadow region. With this work, we emphasize the need for creating a more comprehensive and accurate regional hydroclimate reconstruction for central India.

Keywords: Intercomparison, Reconstruction, Regional change, Hydroclimate

【A0689】 -Poster

Ring width and blue intensity chronologies for the past 8 centuries from Solovetsky Archipelago used for the paleoclimatic reconstructions and dating of archeological monuments

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The Solovetsky Archipelago (65.07, 35.704) is located in the White Sea and belongs to the northern subzone of the taiga - the forest – tundra ecotone. Our pine and spruce ring width and blue intensity chronologies of living trees are up to 474 and 378 years long, respectively. The ring width of pine and spruce depends on the temperature of June-July, the blue intensity series correlate to the temperature of the entire warm period (June-



August), i. e. correspond to a larger time window. The correlation coefficients between climatic parameters and blue intensity are up to 0.7, while the correlation of monthly temperature with ring width is weaker (0.3 - 0.4). In order to extend the chronologies back in time we used the wood of the buildings of Solovetsky Monastery that was found in XV (5 church buildings and 10 residential and utility buildings). Both tree-ring parameters are suitable for dating purposes, but the most reliable dates are obtained using blue intensity. The series of ring width and blue intensity from architectural monuments significantly increased the replication of the Solovetsky master chronologies for ring width and blue intensity, and allowed to extend it up to 1185 CE. The chronology covering more than 8 centuries is used to assess the summer temperature variability of one of the poorly documented areas and discuss the magnitude of current warming at the background of the long-term summer temperature changes.

The study was supported by grant of the Ministry of Science and Higher Education of Russian Federation (agreement NO 075-15-2024-554 of 24.04.2024).

Keywords: The Solovetsky Archipelago, Tree-ring width response climate, Blue intensity, Dendrochronology

【A0653】 -Poster

Spatial summer precipitation reconstruction based on tree-ring $\delta^{18}\text{O}$ records from the south-eastern Tibetan Plateau

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The monsoon dynamics of Asia are controlled by several environmental factors such as regional topography, atmospheric circulation, cloud cover, relative humidity, etc. This further impacts billions of human populations dependent on the large river systems, watershed loads of which fluctuate as per monsoon precipitation variability. The feedback mechanisms causing the complex behavior of Asian Monsoons are lesser known. The



high-resolution proxy records from the south-eastern Tibetan Plateau, such as tree rings and ice cores, have well-established precipitation as one factor influencing the region's environmental variations. The $\delta^{18}\text{O}$ records from tree-ring cellulose have affirmed the negative relationship to precipitation, relative humidity, and cloud cover in the TP and EH, indicating the variations in the moisture source and spatio-temporal strength. However, inadequate long-term climate observation is insufficient for understanding climate dynamics and modeling and predicting climate scenarios. The strengthening of long-term quantification of hydrological changes under changing climate is significant for water managers and policy-makers to develop sustainable water resource strategies. With a view to this, we reconstructed gridded summer (June-August) precipitation totals for the south-eastern Tibetan Plateau encompassing the eastern Himalaya region using a network of tree-ring $\delta^{18}\text{O}$ records. This reconstruction of precipitation has characterized the hydroclimatic variability in terms of drought and pluvial since 489 CE. The reconstruction was assessed for its variability and strengths with special emphasis for major global climatic events i.e., medieval climate anomaly (MCA) and little ice age (LIA). The declining trends of moisture variability during mid 19th century to recent is observed which might be the serious concern for future sustainable hydroclimatic scenario of the region. The gridded precipitation reconstruction shows affinity with sea surface temperature of the Indian and Pacific Oceans.

Keywords: Precipitation, Drought, Pluvial, Indian Ocean dipole, Sea surface temperature

【A0258】 -Poster

A millennial context for the late 20th-Century drought in the Sahel

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Between the late 1960s and 1990s, the Sahel experienced a severe drought with a 20-30% decline in rainfall—arguably one of the most consequential hydroclimate anomalies in recent history. The underlying mechanisms of this drought remain debated, partly due to a lack of proxy records from the region that can provide a definitive assessment of its uniqueness in the context of the region's longer-term climate history. Using a paleoclimate



data assimilation product, we reconstruct the Sahel hydroclimate variability and find that droughts, comparable to the late 20th-century event, have occurred at roughly centennial intervals over the past millennium. These droughts are linked to quasi-centennial oscillatory variability in the extratropical North Atlantic sea surface temperatures and the Intertropical Convergence Zone dynamics. The late 20th-century drought exceeds past events in duration and possibly in severity, although the latter cannot be confidently assessed due to a progressive loss of variance back in time within our reconstruction. Nonetheless, the extended duration of the modern drought suggests that anthropogenic factors amplified the event beyond the range of natural variability over the past millennium.

Keywords: Sahel, ITCZ, Droughts, Past millenium

【A1024】 -Poster

Synchronous climate and civilization changes spanning the Common Era: High-resolution biomarker record from a mountain peat in East China

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Knowledge of climate changes over the past 2000 years can provide insights into the interplay between human activity and natural forcing, and improve projections of future changes in climate and the environment. Here, branched glycerol dialkyl glycerol tetraethers (BrGDGTs), total organic carbon (TOC), and total nitrogen (TN) proxies from a well-preserved Dahutang (DHT) peat core were used to reconstruct local paleotemperature and effective moisture. Our results indicated that changes in mean annual air temperature (MAAT) and effective moisture around the peat DHT were broadly synchronous since 200 CE, and had a colder and drier period during 200–750 CE, followed by a warmest and wettest stage during 750–1450 CE coincident with the Medieval Warm Period (MWP) and a coldest and driest period during 1450–1900 CE corresponding to the Little Ice Age (LIA). The regional biomarkers results suggested that there was a decrease in MAAT of 1–3 °C on the East Asian continent from the MWP to the LIA. A



regional collection of hydrology-sensitive paleorecords showed that there was a tripole mode of precipitation variations in the East China (north of 25 °N) during the LIA. A cooler and more variable hydroclimate during the LIA in East China could be the most important trigger for the collapse of Ming Dynasty by increasing the frequency of epidemics and wars. The unfavorable climate condition was probably triggered by low solar irradiance, and aggravated by sea surface temperature (SST) changes.

Keywords: BrGDGTs, MAAT, Hydroclimate, Common Era, East Asia

【A0323】 -Oral

Spatiotemporal drought variability in Europe over the past millennium

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Recent summer droughts in Europe have caused severe ecological and economic impacts. Droughts are intrinsically linked to temperature and precipitation, with an increased prevalence and severity of droughts in recent decades. However, the spatiotemporal changes in drought conditions across Europe over the past millennium remain unclear, limiting the ability to evaluate recent droughts within the long-term context of pre-industrial variability. Here, we present a physically consistent, multivariable paleoclimate gridded reconstruction using an off-line ensemble-based data assimilation approach. This reconstruction integrates constraints from five climate models with 105 moisture- and temperature-sensitive tree-ring records. It demonstrates high skill in reproducing surface



temperature, precipitation and drought index (Palmer Drought Severity Index, PDSI), with significant correlations ($p < 0.05$) against observation-based reanalysis datasets for the period 1901–2000 CE. Our analysis identifies extreme spatial patterns in PDSI, characterized by a dipole pattern between northwestern and southeastern Europe over the past millennium. Notably, regions experiencing compound hot and dry conditions have expanded and intensified since the mid-19th century. The anthropogenic warming trend partially explains this recent expansion and intensification, particularly over Scandinavia. The dynamics of the summer North Atlantic Oscillation (NAO) and jet stream are superimposed on the effects of the warming trend, leading to contrasting short-term patterns between southern and northern Europe. The contributions of anthropogenic warming and atmospheric circulation to the spatial variability of droughts have been further assessed, providing insights into their respective roles over the past millennium compared to recent decades.

Keywords: Summer drought, Data assimilation, Past millennium, Atmospheric circulation, Anthropogenic warming



Session 02. Scales and scaling in the climate system: Climate, macroclimate, megacclimate

Conveners: S. Lovejoy, R. Hébert, K. Rehfeld, C. Franzke, J. Fan, A. Spiridinov, F. Lambert

【A0554】 -Poster

The potential role of the Atlantic Meridional Overturning Circulation as an internal mechanism modulating the quasi-200-year Suess/de Vries climate cycle

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The paleoclimatic data indicate the widespread existence of a periodic variability of approximately 200 years in the climate system, which aligns with the quasi-200-year Suess/de Vries cycle observed in the cosmogenic radionuclide ^{14}C . Conventionally, this periodicity has been linked to solar spot activity, yet there is a lack of solid theoretical support and continuous observational evidence. The Atlantic Meridional Overturning Circulation (AMOC) has been confirmed to exhibit internal oscillations of similar scales in climate model simulations without external forcings, potentially influencing the atmospheric distribution of ^{14}C periodically through carbon cycle processes. Our study identifies the interplay between salinity advection feedback and vertical mixing in the subpolar North Atlantic as playing key roles in providing the continuous internal energy source to maintain this multi-centennial oscillation. The coupled model simulation datasets from the CESM iTraCE project are also used to analyze the temporal evolution patterns of abiotic atmospheric Delta ^{14}C in the ocean model output. This work identifies that variations in the AMOC have evident impacts on the vertical distribution of ^{14}C in oceans, indicating that the AMOC may play a non-negligible role in modulating the Suess/de Vries cycle. This study will enhance our understanding of Earth's climate evolution, providing crucial scientific evidence for both Holocene climate research and future long-term climate predictions.



Keywords: Multi-centennial climate variability, Suess/de Vries cycle, AMOC, Isotope simulation

【A0249】 -Oral

Astronomical forcing and climatic cycles in late Triassic (Norian) sedimentary records of the UK

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The Upper Triassic Norian stage, characterized by its long duration and relatively stable climate, provides a valuable window into the interactions between astronomical forcing and sedimentary processes. This study focuses on the St. Audrie's Bay section in the Somerset Basin (UK), which captures a well-preserved record of lacustrine and marginal marine deposition over ~6.3 million years (207.96–214.3 Ma). Utilizing high-resolution analyses of rock color parameters (L^* , a^* , b^*) and elemental geochemistry (e.g., Fe/Al), we investigate hydroclimatic variability, sedimentary dynamics, and astronomical forcing during this interval.

The results reveal sedimentation rates of 0.69–0.77 cm/kyr and identify dominant Milankovitch cycles (405 kyr, 100 kyr) as key drivers of climate fluctuations. Long-term cycles (~10 Myr and 3.3–3.5 Myr) highlight links between Mesozoic arid monsoon dynamics and Late Triassic lake level cycles. Paleolake levels indicate two major arid phases, with local variations in lake hydrology suggesting latitudinal progression of dry climates from low to mid-high latitudes during the Late Norian.



Elemental and rock color data reveal distinct relationships between depositional environments and climatic conditions. High calcium content corresponds to gray-green mudstone, reflecting arid conditions with limited sediment input, while silicon-rich layers suggest increased terrigenous influence. The Chemical Index of Alteration (CIA) correlates positively with lake levels, indicating that wetter climates, driven by increased precipitation, promoted higher lake stands. Sedimentation rates estimated at 0.69–0.77 cm/kyr align with cyclic climatic influences, revealing periodic shifts in depositional conditions.

This study underscores the interplay between astronomical forcing, regional sedimentary processes, and global climate trends during the Late Norian. The identification of long-term cycles and their connection to Mesozoic arid monsoons and Upper Triassic Lake level changes provide new insights into the mechanisms driving Late Triassic paleoclimate and sedimentation in mid-latitude settings.

Keywords: Climate cycle, Lake level, Age model, Late Triassic, Norian

【A0737】 -Oral

Spectral model from macroweather to climate: The half-order EBM and ENSO models

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The half-order energy balance equation (HEBE), a physically-based model for heat storage, has recently emerged as a promising tool for characterizing the temporal autocorrelation structure of temperature fields in the macroweather scaling regime. The HEBE captures long-range memory effects, integrating high-frequency forcing to generate slower temperature variations. Here, we demonstrate that the HEBE serves as a robust parametric model, effectively describing local temperature spectra with only two parameters using recent instrumental records, reanalysis data, and outputs from global



climate models. However, certain dynamical modes of variability, most notably the El Niño–Southern Oscillation (ENSO), exhibit features that extend beyond the scope of the simple two-parameter HEBE framework.

To address this, we propose a generalized spectral model by integrating the HEBE with ENSO theories. Specifically, we analyze how the ENSO spectral signal evolves under recharge and delay oscillator models. This approach enables a unified characterization of the background continuum of variability and the emergence of oscillatory modes across different climate models. Our results pave the way for spectral tuning of climate models, enhancing their representation of both background variability and distinct dynamical modes.

Keywords: Spectral analysis, Global climate models, ENSO, HEBE

【A0734】 -Poster

Synoptic regimes and climatic drivers of persistent low temperature, rain-snow, and freezing extremes over South China: A comparative analysis of 2008 and 2022

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Persistent low-temperature, rain-snow, and freezing (LTRSF) weather is a catastrophic extreme event resulting from interaction between weather systems from different latitudes across various spatial-temporal scales. However, distinct discrepancies in weather and climate regimes among LTRSF events remain poorly understood. In this study, we conduct a comparative analysis of the extreme LTRSF events of 2008 and 2022 in South China. The 2008 LTRSF was characterized by persistent freezing, while the 2022 LTRSF featured more frequent rain-snow occurrences. Both extreme LTRSF events exhibit the typical circulation pattern of a blocking high coupled with a deepened East Asia trough. However, significant differences in the intensity of cold air and moisture transport between the two events were observed. These differences were attributed to discrepancies in the India-Burma trough and mid-high latitude trough-ridge patterns, which were influenced by Rossby wave activity flux propagation over Eurasia. Furthermore, our results indicate that the joint influence of La Niña and the positive North Atlantic Oscillation favored the occurrence of both events. The frequent rain-snow in 2022 event could be attributed to the synergistic effects of high sea ice anomalies in the northeastern East Siberian Sea-northern Chukchi Sea and La Niña. This combination stimulated an anomalous cyclone around the Tibetan Plateau and an anomalous anticyclone over the northwest Pacific, leading to increased precipitation. But remarkably, the Arctic sea ice anomalies alone play a negligible impact on LTRSF. These results can enhance our comprehension of LTRSF occurrence in South China and identify potential climate predictors for forecasting extreme LTRSF.

Keywords: Cold events, South China, La Niña, North Atlantic Oscillation, Arctic sea ice

【A0664】 -Poster

Impact of meteorological-scale phenomena on paleoclimate reconstructions: Uncertainties in stable water isotope variations in Antarctic ice cores due to synoptic-scale atmospheric circulation

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Water isotopes measured in inland Antarctic ice cores enable the reconstruction of the temperature variations over the past several hundred thousand years. Although ice core studies have assumed that ice cores record the mean state of inland Antarctica, potential biases in the cores related to episodic warm and moist air intrusions from mid-latitudes and associated extreme precipitation events in inland Antarctica have been debatable. To examine the influence of mid-latitude atmospheric circulation on inland Antarctic precipitation isotopes, we adopted a Japanese isotope-enabled atmospheric general circulation model for the present and past climates (the Last Glacial Maximum; LGM; ~21,000 years ago). We found synoptic circulations (high/low-pressure system) were key in transporting moisture toward inland Antarctica in both climates. These circulations, especially during the austral winter, led to extreme precipitation events associated with abrupt warming. They significantly biased isotope signals weighted by precipitation amounts. We also found that daily variations in precipitation isotopes at Dome Fuji Station were primarily controlled by the Southern Annular Mode, an indicator of the westerly winds. Our results imply that such meteorological time-scale phenomena are crucial in determining inland Antarctic precipitation isotopes and may induce bias in interpreting ice cores. We will also discuss the applicability of the same methods to other regions.

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Keywords: Multi-time scale, Antarctica, Ice core, Westerly wind, Extreme weather

【A0901】-Poster

Hydroclimatic evolution of the southwestern Tibetan Plateau since the Last Glacial Maximum inferred from a multi-proxy lake record

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Hydroclimatic variations on the Tibetan Plateau since the Last Glacial Maximum (LGM) are still debated. Here, we reconstruct climatic and hydrological variability in the southwestern Tibetan Plateau since the late LGM using climate proxies based on molecular distributions of *n*-alkanes, hydrogen and carbon isotopic composition of terrestrial *n*-alkanes and $\delta^{18}\text{O}_{\text{carbonate}}$ at Lake Zabuye. Our findings indicate that the $\delta\text{D}-n\text{C}_{31}$ signal in this lake was primarily influenced by temperature from late the LGM to early deglaciation period, shifting to a predominance of precipitation influence from the Heinrich event 1 (H1) to the Holocene period. In contrast, the carbonate $\delta^{18}\text{O}$ was found to be primarily governed by evaporative processes. Through comprehensive analysis of all proxies, we suggest that Lake Zabuye was dominated by the mid-latitude Westerlies with cold and moist conditions from late LGM to early deglaciation. The H1 and Younger Dryas (YD) periods were characterized by low temperature and reduced precipitation due to the influence of the moderately intensified Westerlies. The Indian Ocean Summer Monsoon (IOSM) intensified during the Bølling/Allerød (B/A) period, and its strength was comparable to that of the Westerlies, resulting in plentiful rainfall and high evaporation. The IOSM was dominant during the Holocene, characterized by abundant rainfall and high evaporation.

Keywords: Tibetan Plateau, Lake Zabuye, *N*-alkane, Isotope, Indian Summer Monsoon, Westerlies

【A0721】 -Poster

Structure and changes of multivariate climate proxy variability during the last glacial period

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Earth's history has seen abrupt changes in the stability of different climate sub-system's steady states. When viewed as bifurcations, these changes are expected to be preceded by changes in the temporal variability of the systems. This principle is currently being exploited to warn about potential ongoing stability shifts in the climate system as a result of rising CO₂ concentrations, and the paleoclimate record is a key testbed for its validity.

Recent work has highlighted that the variability changes should affect only certain degrees of freedom that are directly related to the physical mechanism of the bifurcation. Thus, the analysis of individual climate records in order to find bifurcation precursors for past or ongoing stability shifts can be inconclusive or misleading. Indeed, past work on the abrupt climate changes during the last glacial period has focused on the analysis of individual proxy records, arguing both for and against the existence of precursors.

Here we present a multivariate analysis of climate proxies during the last glacial. We employ a dimension reduction method that is typically used to find a meaningful low-dimensional representation with a few collective variables of a high-dimensional system. Based on modeling work, we propose that such a technique can also be harnessed for the purpose of bifurcation precursors by observing qualitative changes in the structure of the reconstructed data manifold. Given the data set includes most relevant variables, this allows one to deduct not only whether a bifurcation was present, but to make inferences on the drivers of past abrupt climate changes by finding the relevant "reactive" coordinates.

Keywords: Glacial climate variability, Ice core records, Dansgaard-Oeschger events, Early-warning signals

【A0288】 -Oral

Scaling geochronologies

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Much of our knowledge of the Earth's past is gleaned by interpreting varying layers in outcrops, cores drilled through lake and ocean sediments, and sheets of rock and ice. These were laid down under highly variable conditions and their stratigraphy generally include gaps of all size. Since erosion, sedimentation, aggradation, denudation and progradation rates of sediment sources and sinks operate over wide ranges of scale, the simplest hypothesis is that they are scaling in accord with scaling Holocene and Quaternary climate records. In this study, we analyze chronologies and proxies from records spanning the Holocene, Quaternary, and Phanerozoic, focusing on the measurement density, the number of measurements per unit time, that we quantitatively characterize in a multifractal framework. This density is a new and distinct multi-scale proxy that can be used to understand the evolution of Earth's system history. Implicitly, it includes information on the absence of evidence, thus – paradoxically - providing positive information about the structure of non-recorded history, a significant phenomenon that can be quantified in its own right. We also analyze the scaling of the probability distributions of the inter - measurement time intervals and show that completeness of the records decreases with the number of measurements, thus quantitatively explaining the Sadler effect.

Keywords: Geochronologies, Scaling, Paleoindicators, Multifractals

【A0287】-Poster
Scaling geological time

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Geological time is punctuated by events that define biostrata and the Geological Time Scale's (GTS) hierarchy of eons, eras, periods, epochs, ages. Paleotemperatures and macroevolution rates, have already indicated that the range ≈ 1 Myr to (at least) several hundred Myrs) is a scaling (hence hierarchical) "megaclimate" regime. We use techniques from statistical physics including Haar fluctuations, structure functions and trace moment and extended self-similarity analyses, applied to the temporal density of the boundary events ($r(t)$) of two global and four zonal series. We show that $r(t)$ itself is a new paleoindicator and that it is scaling over ranges spanning ≈ 1 Myr to at least several hundred Myrs. We determine the three fundamental multifractal exponents: $H \approx -0.15$, $C_1 \approx 0.1$, $a \approx 1.2-1.5$ respectively characterizing the mean fluctuations, the intermittency and the degree of multifractality. By exploiting the strong intermittency, we determine the "outer" (largest) megaclimate scale finding it to be close to 1 Gyr. Finally, we analyze the probability distribution of the intervals ("gaps") between boundaries and find that its tail is also scaling with an exponent $q_D \approx 3.3$ indicating huge variability with occasional very large gaps such that its third order statistical moment barely converges.

This scaling characterization opens new doors to our understanding of life and the planet and it is needed for unbiasing many statistical paleobiological and geological analyses, including unbiasing spectral analysis of the bulk of geodata that are derived from cores.

Keywords: Geological time scale, Scaling, Paleoindicators, Paleotemperatures, Multifractals

【A0747】-Poster

Understanding the role of moisture transport in the interdecadal shift of East Asian Summer Monsoon precipitation variability

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Understanding the mechanisms of water vapor transport is crucial for elucidating the variability of precipitation. The dominant mode of interannual variability in the East Asian Summer Monsoon shifted in the 1990s from a tripolar structure to a meridional north-south pattern. Understanding this change in precipitation variability is of significant importance for improving precipitation predictions. Therefore, we used the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model to simulate air mass trajectories over East Asia of the Summer Monsoon to quantify changes in moisture pathways and sources. Further calculations permit us to determine the dominant moisture source areas and their contributions affecting the interannual variability of the leading mode of East Asian Summer precipitation.

Keywords: Moisture Transport, East Asian Summer Monsoon precipitation, HYSPLIT, Interdecadal shift

【A0026】-Poster

Detection of dust impact in a changing climate in small-scale insights to understanding Oak Forest decline (Case study: Kordestan province)

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Oak Forest decline induced by climate change is a global phenomenon that affects many trees, mainly in drought-prone areas as the Western region of Iran. During the last two decades, the phenomenon of oak decline has occurred the Zagros oak forests (*Quercus brantii*) in Kordestan province. The purpose of this study was to identify climatic parameters with high potential for oak decline and determine the most important climatic



factors affecting it. In order to detect the occurrence of climate change in the Zagros oak forests of Kordestan province, daily data of minimum temperature, maximum temperature and precipitation parameters were used. Data were analyzed for quality and homogeneity and prepared to enter into the climate model that reveals the occurrence of climate change. Warm temperature indicators for climate change detection were calculated, using ClimPACT software in R 2.10 programming environment for the period of (1991-2019). Trend change, trend slope error and significance of changes were extracted at $p = 0.05$. The results showed that at all monitoring sites, hot temperature indices, including 2TX2TN SU35, SU30, SU25, TN90p, TX90p, TX50p, WSDI6, WSDI2, had a significantly increasing trend. Changes in the slope of the trend of these indicators coincided with the beginning of the decline phenomenon and have been more intense in the last two decades. Due to the increasing trend of temperature, this increasing trend of indicators will continue in the coming years and the forests of the region will face more drought stress. The study of drought incidence in 3-month, 6-month and 12-month time scales showed that the frequency and severity of drought was higher in the second half of the time series used, but the highest continuity occurred in the first half and in the period 1999 to 2002. In all scales and in all degradation monitoring sites, the total frequency of drought occurrence based on SPEI index is higher than the frequency of drought occurrence based on SPI index. In all scales and in all decline monitoring sites, the longest drought continuity in 1999 to 2002 is the year of the beginning of the decline phenomenon (2001) in the whole Zagros and including the study area. The results of the calculations of dust occurrences in the range of synoptic stations of Kurdistan showed that the frequency of dust storms with a horizontal field of view of 100 to 200 meters in the Baneh station (area of oak forest deterioration sites) has occurred in a limited number of years. Drought and Climate changes findings illustrate complex responses to oak decline suggesting different tolerances to the combined effects of climate and biotic stressors under the forecasted warmer and drier conditions.

Keywords: Climate change detection, Drought stress, Dust impact, Warm temperature indices.

【A0844】 -Poster

Explanation of the regional conditions related to the danger of heat waves and dust in the Zagros forests in western Iran (Kurdistan province)

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The global rise in temperature is putting us all at risk, regardless of where we live. According to the Lancet Medical Journal, climate change is increasing the frequency, duration, and intensity of heatwaves. Unfortunately, Heat makes air pollution worse. This trend of more intense and frequent heatwaves isn't just a coincidence. Deterioration of Zagros forests may partly be related to changes in climatic parameters. In the present study, the trends of precipitation and temperature changes in relation to the trend of forest cover changes Kurdistan province, west of Zagros, was studied using 30 years' data (1988-2017) recorded at Baneh & Marivan Synoptic Weather Station. In order to reveal the effect of heat waves on the decline of Zagros forests in Kurdistan province in four decay monitoring sites, daily information of the nearest synoptic stations to decay sites for a complete climatic period (1991-2019) was used. Modeling was performed using ClimPACT software in R 2.10 programming environment and climatic indicators revealing climate change were extracted and analyzed. The year of onset of heat wave at the sites of decline and trend changes and trend slope error and significance of changes were extracted with P-value= 0.05. Among the output indicators to reveal the effect of heat waves on the decline of Zagros forests in Kurdistan province, the most important characteristics of heat waves include the frequency of the day with hot wave, the number of hot wave events and the persistence of hot waves in four monitoring sites. The decline of the Zagros was examined. The results showed that despite the onset of heat waves from 1994, but continuously since 2010 with the onset of decline with a steep upward slope and significantly increased the frequency and duration of heat waves. Examination of cold temperature indicators indicating climate change showed that all cold indicators indicating climate change showed a decreasing and significant trend and experienced the largest increase in the last decade, especially in 2017 and 2018. Some indicators in all deterioration monitoring sites, especially in the last decade, have been severely reduced to some extent and will probably be unrepeatable in the future due to the continued increase in temperature.

Keywords: Dust, Heat wave duration, Heat waves frequency, Kurdistan, Zagros forests



【A1054】 -Poster

Megaclimate and the scales and modes of mammalian macroevolution—a case of large mammals

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Terrestrial mammalian fossil record is a unique and rich source which can be used in understanding causal structure of evolutionary change. NOW (New and Old Worlds) database registers Cenozoic mammalian occurrences at the global scale with tens of thousands of observations. Using Bayesian diversity dynamics reconstruction approach applied to the NOW dataset, we've yielded the species level diversity curves of large terrestrial mammals, such as Carnivora (excluding Pinnidepia), Perissodactyla, and Artiodactyla (excluding Cetacea). The species level diversity curves show idiosyncratic and complex histories with multiple sudden transitions, and changes to significantly differing dynamical states. To test for the presence of external physical forcing in these highly nonlinear structures, we've used two state-of-the-art approaches for scale-by-scale analysis —i) joint recurrence plots and recurrence quantification analysis, and ii) the Haar fluctuation analyses. The first approach allowed us to detect coordinated quasi-stable diversity-megaclimate states, while the latter was used in revealing structure functions and scale-dependent correlations of diversity and the macro-to-megaclimate. Scaling patterns revealed complex interactions and crossover scales between diversity-dependence and synchronization of terrestrial large mammal diversity (Geo-Red Queen dynamics) and the external forcing.

Keywords: Megaclimate, Macroclimate, Macroevolution, Macroecology, Cenozoic

【A0990】 -Poster

Effects of permafrost stability changes on vegetation dynamics in the middle part of the Greater Khingan Mountains



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Permafrost in the middle section of the Greater Khingan Mountains is highly sensitive to climate change; however, the specific mechanisms by which its degradation affects vegetation dynamics remain unclear. This study utilized vegetation and climate data, along with 30-meter high-resolution frozen soil distribution data from 2003 to 2021, to investigate the impact of changes in frozen soil stability on vegetation dynamics and phenology. Analysis of satellite observations reveals significant changes in the spatiotemporal distribution of permafrost in the area, with the stability of permafrost in low-altitude regions being particularly affected. The area of stable and extremely stable permafrost has significantly decreased, while the area of transitional or unstable permafrost has increased annually, indicating a negative correlation between climate warming and frozen soil stability. The study also identified an overall greening trend in the region, with the proportions of increased normalized vegetation index (Gr-NDVI), advanced start of the growing season (SOS), and delayed end of the growing season (EOS) being 93.84%, 75.12%, and 68.83%, respectively. Ridge regression and partial correlation analyses indicated that frozen soil status, precipitation, and evapotranspiration are the primary factors influencing vegetation dynamics, accounting for 32.90%, 30.45%, and 27.15%, respectively. High-altitude areas are mainly influenced by permafrost stability and precipitation, while mid- and low-altitude areas are predominantly affected by evapotranspiration and precipitation. Vegetation dynamics exhibited spatial heterogeneity; some low-altitude areas maintained high growth vitality despite a shortened growing season, whereas Gr-NDVI decreased in other regions. These research findings underscore the critical role of changes in permafrost stability in shaping vegetation dynamics, which has significant implications for the carbon budget and ecological stability in the context of future climate warming.

Keywords: Permafrost degradation, Vegetation dynamics, Climate factors, Central Greater Khingan Mountains

【A0557】-Poster



A diagnostic method to decompose the throughflows into the wind-driven current and upwelling in the paleoclimate study

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The closure of the Seaways play a crucial role in the reorganization of global ocean circulation. However, there are significant uncertainties in the paleoclimate simulations and the interpretations derived from the proxy data. It indicates that the paleoclimate studies require the robust theoretical framework to validate the observation and simulation. In the study, we utilize a diagnostic method -- amended "island rule" that could decompose the throughflows into wind-driven currents and upwellings in the Pacific. This method is applied in the Miocene climate simulation and several sensitivity experiments that involved the runoff input and the successive closure of the Tethys Seaway and the Panama Seaway. The findings show that the closure of the Tethys Seaway and the Panama Seaway could not alter the wind in the South Pacific, but rather modify the upwelling in the Pacific basin, which in turn affects the throughflows in the Pacific boundary. It should be noticed that the wind-driven currents only contributed to the Indonesia Throughflow when the Panama Seaway closed. The results also indicate that the northward movement of the Australia-New Guinea plate could reduce the Indonesia Throughflow's wind-driven currents by approximately 4 Sv. These insights not only enhance our understanding of past ocean circulation but also underscore the intricate interplay between tectonic movements and oceanographic processes, providing a critical foundation for future paleoclimate research.

Keywords: Miocene, Seaways, Island rule

【A0573】 -Oral

Orbital modulation reveals the decoupling of millennial-scale climate changes in atmospheric methane and Asian monsoon



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Climate in Late Pleistocene is characterized by rapid fluctuations on a millennial time scale superimposed on the background of glacial-interglacial cycles. However, the driving mechanism of the variations of atmospheric methane concentration (CH₄) on a millennial-scale remains controversial. Here, we used the Holo-Hilbert Spectral Analysis (HHSa) method to explore the relationship between the changes of a CH₄ and East Asian monsoon intensity. Phase analysis was further used to correlate them with insolation and ice sheet changes. Benefiting from the high temporal resolution of HHSa, we found remarkable similarity in the frequency domain between the variations of CH₄ and the East Asian monsoon intensity. Both CH₄ and monsoon changes exhibit millennial-scale periodic changes of 1.5 kyr, 3 kyr, 5.5 kyr, and 10 kyr. However, their amplitude modulation varies at a millennial-scale, especially at the 5.5 kyr scale. At this timescale, CH₄ is modulated by precession, while the Asian monsoon is primarily modulated by obliquity. Phase analysis indicates that millennial-scale variability of CH₄ primarily driven by the Northern Hemisphere solar radiation, whereas millennial-scale variability of Asian monsoon is primarily modulated by ice sheet dynamics. This decoupling relationship indicates that the millennial-scales signals in atmospheric CH₄ mainly originate from the high latitudes of the Northern Hemisphere. This new approach effectively reveals the relationship between millennial-scale climate changes and orbital forcings, potentially providing new insights into the modulation relationship between orbital cycles and millennial-scale variations.

Keywords: Millennial fluctuations, Orbital modulation, Methane and monsoon, Nonlinear and non-stationary

【A0966】-Poster

Vegetation and climate changes in the western Chinese Loess Plateau since Marine Isotope Stage 5

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In order to evaluate the impact of global climate change on vegetation in the arid area of the Chinese Loess Plateau (CLP), two loess-paleosol sequences Wuwei and Jingtai were selected for pollen analysis in the western CLP. Results show that during the interglacial, Marine Isotope Stage 5 (MIS 5) and MIS 1, the vegetation in the studying area was desert-steppe, dominated by *Artemisia*, *Echinops-type*, *Aster*, *Taraxacum-type*, Chenopodiaceae and Poaceae, and very small amounts of conifers also occurred. During the glacial (MIS 4 and MIS 2), vegetation in Wuwei and Jingtai area was desert and desert-steppe, characterized mainly by *Echinops-type*, *Artemisia*, Chenopodiaceae in Wuwei, and *Artemisia*, *Echinops-type*, Chenopodiaceae in Jingtai. It was worth mentioning that, in Jingtai area, conifers, especially *Picea* and *Pinus*, increased during periods adjacent to MIS 3. During MIS 3, *Picea* increased dramatically, vegetation in Jingtai converted to forest-steppe. *Echinops-type* decreased in Wuwei area, the vegetation type was desert-steppe, dominated by *Artemisia* and Chenopodiaceae.

In the arid area of CLP, desert and desert-steppe vegetation developed during the interglacial and glacial periods, coniferous forests (mainly *Picea*) flourished in the cool and humid interstadial. In the interstadial, vegetation in the western CLP was characterized by dark coniferous forests in the bedrock mountainous areas and great river valleys, while by desert-steppe in loess areas. Therefore, temperature and effective humidity are important factors in controlling the distribution of *Picea* forest.

Keywords: Marine Isotope Stage 5, Loess-Paleosol sequences, Vegetation, Pollen, *Picea*



Session 03. Human traces of Earth system changes

Conveners: Guangjie Chen, Sakonvan Chawchai, Nathalie Dubois

【A0173】 -Poster

Palaeogeographical reconstructions of the Pattanam site: Insights into coastal geomorphology and ancient global maritime trade networks of Kerala, India

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The Pattanam archaeological site, located at the estuarine region of the Periyar River in Kerala, India, holds global significance for its rich archaeological finds, underscoring its role in ancient maritime trade through the Indian Ocean. Despite numerous studies confirming its archaeological importance, limited information exists on the site's paleogeography. This research aims to reconstruct the coastal landscape variations during the Holocene using Optically Stimulated Luminescence (OSL) dating of stratigraphic units. Central Kerala's coastal geomorphology reveals two distinct sets of beach ridges at the mouth of an ancient embayment, parallel to the current coast. The landward ridges date back to the mid-Holocene, while the western ridges are younger, formed during the late Holocene. Trenches were excavated on the Pattanam archaeological mound, which is located on the younger beach ridge sequence was studied using OSL dating for understanding the age of deposition. The PT TR-52 trench, located about 4 km from the coast, consists of medium to coarse sand at the bottom and clayey sand with pot-shreds and bricks up to a depth of 340 cm from the surface. The lower part of the trench has



medium to fine sand with parallel lamination. OSL dating of samples from various layers indicates that the bottom sand layer was deposited between AD 40-418. Samples from archaeological contexts provided ages of BC 81-AD 339 and AD 152-558. The uppermost sample from 140 cm depth dated between AD 1240-1388, marking the end of cultural deposits in this area. The five OSL samples collected from the other two trenches from the area had shown age of deposition between 1.7 to 1.3 ka. The ^{14}C dating of charcoal material collected from the area have provided ages of deposition between BC 115 and AD 25 (PT14 LI CHA 1338) and Cal AD 25 to 130 (PT14 LII CHA 1311) (Pattanam Excavations: Interim Report of the Eighth Season - 2014) giving good correlation of ages from OSL and ^{14}C method. The OSL ages of the samples from the studied section indicates that the Pattanam archaeological site and cultural deposits deposited during 1st century BC and early centuries of Christian Era (CE). The termination of cultural deposits in the trench may indicate the destruction of the settlement in the area due to the reported large catastrophic flood of AD 1341. The reconstructions of coastal landscape variation using OSL highlighting a general phenomenon of sea-level changes, deltaic progradation and sediment infilling during Middle to late Holocene.

Keywords: Pattanam archaeological site, Maritime trade, Paleogeography, Coastal landscape, Holocene, Optically Stimulated Luminescence (OSL), Sea-level changes

【A1029】 -Oral

Synthesizing human traces in Latin American paleoenvironments

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Latin America's diverse landscapes have long supported human activities, including agriculture, controlled burning, and water management, yet gaps remain in understanding the appearance and distribution of human traces in these environments. To fill this gap this study synthesizes published sedimentary records that trace human presence and associated activities using a combined expert-driven and algorithm-assisted review. We consider human trace (e.g. pollution, deforestation, vegetation shifts) as environmental changes induced by human activities (i.e. actions like agriculture, agro-pastoralism, mining, or settlement that alter natural systems) detectable through proxies in lake sedimentary records. Based on this framework we synthesized data from 336 peer-reviewed studies analyzing 416 sedimentary records. The records span from 54,000 (Northern Andes Mountains) to 1,500 cal yrs BP (Gran Chaco), documenting proxies (n=22), human traces (n=9), and activities (n=13). Key findings reveal early Holocene (10–14 kyrs BP) human traces, such as fire and vegetation changes, geographically concentrated in Mesoamerica and the Andes, while younger records (1–3 kyrs BP to 1900 CE) documented pollution and eutrophication through microfossil aquatic proxies (e.g., diatoms, chironomids), particularly in Patagonia and Gran Chaco. These results highlight the temporal and spatial variability of human traces, which if combined with archaeological data (in progress), will provide new, interdisciplinary insights into the environmental history of Latin America.

Keywords: Human traces, Paleolimnology, Latin America

【A0759】 -Oral

Sediment signals of early anthropogenic traces and lake ecosystem responses in Southwest China



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A large amount of research on different natural archives has been conducted internationally on the Holocene records of climate system change, but how to identify early human signals and define the stratigraphic boundaries of the Anthropocene epoch remains one of the challenging issues in Earth system research. In the context the study of paleoclimate change in the Holocene, quantitatively identifying the long-term trajectory of watershed development and conducting temporal analysis of driver-response patterns based on lake sediment records is a key scientific perspective for identifying early signals of the Anthropocene. The southwestern region of China is located in a low latitude plateau area, and its climate system is controlled by the Indian Summer Monsoon. Meanwhile, the region is known for a long history of watershed development and human civilization. A synthesis on the paleoenvironment and paleoecology of lakes in the region can provide an important perspective for detecting the temporal patterns of the southwest monsoon and historical signals of human activities. A comprehensive analysis of human influence, environmental forcing, and lake responses can help identify early signals and geological boundaries of the Anthropocene. This study selects multiple lakes in southwestern China for paleolimnological surveys, through establishing high-resolution sequences with reliable age control, and conducting comprehensive analysis of environmental proxy indicators with clear indicative significance. The aim is to apply multi-indicator methods that indicate human activities to analyze the long-term trajectories and main stages of algal changes and ecosystem responses in lakes under different scenarios of climate and human impacts. This study can provide sediment evidence and systematic perspective for detecting lake signals and processes driven by hydroclimatic changes and watershed development in this Asian monsoon region.

Keywords: Anthropocene, Paleolimnology, Human trace, Ecosystem, Asia

【A0435】 -Poster

Radionuclides composition and migration in thermal waters from artesian wells in the Eastern Black Sea region



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Groundwater sources are widely used for agricultural and recreational purposes in eastern Black Sea region. Some of them are of anthropogenic origin, such as deep artesian wells. In the 1970s, in the north-western part of the Colchis lowland pressure horizons of thermal water were discovered at depths of more than 2 km. The springs were not tamped down, and over several decades they continued to discharge hot water to the surface. In 2007, the construction of a thermal resort based on two springs near the village of Kyndyg was initiated. The thermal water containing radionuclides flows through the territory of the resort and then drains into the Dabakuara River, which flows into the Black Sea. In order to determine the origin of the thermal water of the Kyndyg springs and the concentration and dispersion range of the radionuclides present in it, geomorphological mapping was carried out, water and bottom sediment samples were taken (both at the thermal wells and in the river bed). Analytical work included the determination of the chemical composition of macro- and micro-components, pH and Eh, $\delta^{18}\text{O}$ and $\delta^2\text{H}$, gamma-emitting radionuclides (^{137}Cs , ^{238}U , ^{232}Th , and their respective daughter products). X-ray fluorescence analysis was also carried out.

It has been established that the thermal waters of Kyndyg springs are of the classic nitrogen-methane thermal type with a source fed by atmospheric precipitation in the adjacent mountainous terrain. The main factors influencing the geometry of the zones of varying thermal water influence on the surrounding environment are the gradient of the river channel and the sediment composition of the river bed. A decrease in the gradient from 0.009 to 0.004 leads to a reduction in the flow velocity of the river and the clay sediments accumulation, which have the capacity to sorb radionuclides. At the geochemical barrier, located 830-980 meters from the source, radionuclides accumulate in the clayey sediments of the waterlogged channel, with concentrations there three times higher than in the environment. The investigation demonstrates that when



outpouring from the source, the disturbance of the age-old equilibrium in the ^{238}U decay series is restored only at a distance of 426 m from the source. Three distinct zones have been identified on the basis of the level of environmental impact due to ionizing radiation.

The observed patterns underscore the multifaceted impact of the thermal spring on geomorphological processes, encompassing both localized changes in the immediate vicinity of the spring and prolonged effects affecting significant sections of the river system. These findings contribute to our understanding of the complex interactions between hydrothermal activity and landscape evolution in geothermally active regions.

Keywords: Thermal waters, Radionuclides, Water quality, Radium isotopes

【A1042】 -Poster

Anthropogenic impacts on western Mediterranean coastal lagoons: A multiproxy approach to historical and recent changes

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Coastal lagoons are iconic ecosystems of the Mediterranean region, and they have provided resources and services to humans for millennia. First impacts in the watersheds occurred during the Neolithic, followed by periods of more noticeable disruption during Roman, Medieval and the onset of industrial revolution times. Activities such as fishing, hunting, and salt extraction have historically coexisted in balance with these fragile natural environments. However, this equilibrium was drastically disrupted during the second half of the 20th century due to the accelerated evolution of economic activities. Traditional agriculture was replaced by intensive practices, natural adjacent areas were urbanized without proper planning, and in some cases, large industries were established in the drainage basins.



In this study, we analyze the direct impact of anthropogenic activities on coastal lagoons in the western Mediterranean. We examined emblematic cases such as the Albufera of Adra, the Mar Menor, and the Albufera of Valencia in the Iberian Peninsula, along with s'Estany des Peix and s'Estany Pudent in Formentera (Balearic Islands). We used short sediment cores with robust age models based on ^{137}Cs , ^{210}Pb , and ^{14}C dating. Through a multiproxy approach, we analyzed chemical, sedimentological, multispectral images and C, N and S isotopic ratios enabling us to reconstruct past conditions in these lagoons and identify the timing and evolution of the impacts they have experienced over recent decades.

Our results reveal that the exponential growth of human activities in the last century has left an unmistakable footprint across all the studied sites. Increases in organic carbon accumulation rates are a constant, accompanied by higher inputs of heavy metals such as mercury and lead.

Although these ecosystems have coexisted with human presence for millennia, sedimentary records do not reflect events of comparable magnitude to the changes observed today. This study highlights the urgent need for sustainable management to preserve these unique and fragile environments.

Keywords: Great acceleration, Paleolimnology, Global change, Eutrophication

【A0875】-Poster

Linked molecular and isotopic indicators of fire history, population, vegetation and climate change in the Maya lowlands

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Understanding past societal responses to climate change requires proxy indicators of human population, climate and land-use change. We apply a range of proxies to a lake sediment core from Laguna Itzan, a cenote adjacent to the ancient Maya population centre of Itzan, in order to examine the response of the lowland Maya to climatic and environmental change, which remains poorly understood. By combining molecular proxies for population (faecal stanols) and biomass burning (polycyclic aromatic hydrocarbons or PAHs) with isotopic analyses of plant wax n-alkanes as proxies for vegetation change ($\delta^{13}\text{C}$) and palaeohydrology ($\delta^2\text{H}$), we show the complex interplay of environmental and societal changes over 3300 years.

Faecal stanols suggest at least three periods of significant population decline associated with precipitation change, including between 3300 and 2900 cal yr BP and 1860-1670 cal yr BP, as well as the widely documented Terminal Classic drought (1220-1050 cal yr BP). The use of PAHs provides a record of fire history from both hearths as well as from vegetation burning associated with hypothesised slash and burn land clearance, or swidden, agriculture. Fire history can be linked with records of vegetation change inferred by $\delta^{13}\text{C}$ of n-alkanes, which fluctuate between more negative values associated with forest (C_3) vegetation and more positive values associated with maize (C_4) agriculture.

Our data show that population and land use appear to be variable, with a transition from generally more intense fire use and C_4 plant agriculture during the Preclassic (3500-2000 BP) to dense populations and reduced fire use during the Classic period. This is consistent with other evidence for a more urbanised and specialised society in the Classic (1600-1000 BP), and less changing land use over time. We do not find evidence extreme drought in the hydrogen isotope leaf wax record ($\delta^2\text{H}_{\text{lw}}$) at this site, implying that climate change was not a primary driver of observed variability in land use or population. This suggests that climate change was not a major control on Maya societal development, and undermines the hypothesised link between drought and Classic Maya “collapse” since collapse is inferred to have begun in the southwest lowlands.

Keywords: Maya lowlands, Plant wax isotopes, Faecal stanols, Polycyclic aromatic hydrocarbons, Palaeoclimate

【A0304】-Poster



Late Holocene humidity changes and extreme drought/dust events in the central Tianshan Mountains

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Global warming may lead to the increased frequency of drought and dust events in arid Central Asia, seriously threatening the development of ecological and economic systems, and human health. We used pollen assemblages and Ti element content of a sediment core from Xiannv Lake in the central Tianshan Mountains, to reconstruct changes in regional humidity and droughts/dust events during the late Holocene, and to explore their implications for regional human activity. The results show that the regional climate was slightly dry during 4.3–3.7 ka, and that humidity remained high from 3.7 ka to the present, with the interval of 2.5–1.8 ka being the wettest. The sedimentary Ti content is significantly correlated with the total pollen concentration and the pollen A/C (*Artemisia*/Chenopodiaceae) ratio. Peaks in Ti at ~2.6 ka, ~1.75 ka, ~1.1 ka, and ~0.25 ka likely reflected aeolian dust inputs from the deserts of low altitude, which were response to a rapidly drying climate. However, the relative humidity did not reach the level of extreme drought at ~2.6 ka, ~1.1 ka and ~0.25 ka, suggesting that wind dynamics were also an important factor in dust activity. The humid climate during 2.5–1.8 ka contributed to the flourishing of civilization in the lower oasis. While, the severe drought and dust event at ~1.75 ka, led to land degradation, which may have been important factors leading to the demise of the Loulan Kingdom in the southern Tianshan Mountains.

Keywords: Vegetation evolution, Climate change, Human activities, Drought/dust events, Tianshan region

【A0443】-Poster

Significant shifts in lake seston C:N and trophic stoichiometry along the phosphorus and temperature gradients

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Plankton, a major component of seston (suspended matter) in the pelagic zones of inland waters and oceans, can play a vital role in biogeochemical cycling and ecosystem stability from a stoichiometric perspective. Both nutrient availability and balance are important factors in affecting seston stoichiometry. With increasing anthropogenic P supply to freshwaters (i.e. eutrophication), the elemental composition of plankton in inland waters can be strongly altered, with important ecological consequences in the Anthropocene. Here, we collected water quality and suspended matter samples of different grain sizes (including phytoplankton and zooplankton of three grain sizes) from 44 lakes in Yunnan during summer and spring, to uncover the effects of nutrient and temperature variations on plankton stoichiometric signal. The results showed that at the community level, higher nutrients led to faster growth rates and lower C/N of both phytoplankton and zooplankton, while the effect of temperature was more complex. Higher temperatures favoured a decrease in phytoplankton C/N in shallow lakes, whereas an increase was observed in deep lakes. From a stoichiometric point of view, and a critical C/N ratio of 7.73 ± 0.25 was found for phytoplankton in low-latitude plateau lakes in Yunnan. In addition, the trophic stoichiometric ratio (TSR) decreased significantly and the energy transfer efficiency of the food chain increased with rising nutrient levels. However, high temperatures do not lead to a decrease in TSR. In deep-water lakes, higher temperatures cause an imbalance in nutrient uptake, leading to an increase in TSR and a decrease in the efficiency of energy trophic transfer. Our results suggest that in the context of global warming, deep lakes may experience weaker trophic transfer of nutrients that can have detrimental effects.

Keywords: Carbon and nitrogen, Stoichiometry, Trophic stoichiometric ratio, Spatio-temporal variation, Yunnan lakes

【A0731】-Oral

A millennium history of ancient zinc metallurgy linked to cooper coinage technological transition in Central China

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China is one of the important cradle of zinc smelting in the ancient world. Zinc is the last major metal produced by the ancients, mainly because the reduction temperature of zinc is higher than the boiling point, and it is easy to reoxidises after vaporization. Although based on the analysis of historical records and archaeological evidences, some more consistent understanding of origin and evolution of the ancient brass alloy have received, but the date of the earliest use of zinc and the origins of metallic zinc in China is still uncertain. Sedimentary evidences from two lakes in central China provide a continuous record about the utilization and technology transition of zinc in ancient China, and revealed that: 1) changes of Zn in the sediment core correspond to the records of exploiting and smelting activities in regional, affirm that the use of zinc (probably calamine ore) in the middle-lower reaches of the Yangtze River was no later than the early 13th century, and the use of metallic zinc was no later than about 1621 CE. 2) changes of Zn in the sediment core is well correlated with the changes of alloy composition in Chinese coins, suggest that the copper coinage casting in ancient China drove the use of zinc/calamine ore and the technological innovation in metallic zinc production.

Keywords: Zinc metallurgy, Brass, Lake sediment records, Central China

【A0712】 -Oral

Large sediment methane production potential in reservoirs compared to lakes and rivers

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Inland waters emit a globally significant amount of methane (CH₄) into the atmosphere. Measurements of potential CH₄ production rates (PMP) can help constrain the magnitude of CH₄ sources and time-averaged emission rates. We explored the magnitude, variability, and drivers of sediment PMP, based on compiled measurements (238 sediment cores from



72 systems) following a standardized laboratory incubation procedure. The data reveal more than five-fold higher PMP in reservoir sediments compared to lakes and rivers. Sediment organic carbon content and depth below the sediment-water interface are universal drivers for PMP across freshwater ecosystems. The disproportional high CH₄ production rate in sediments from human-made waterbodies calls for more comprehensive monitoring of their CH₄ emissions and their consideration in the assessment of carbon footprints of reservoirs. This first meta-analysis of PMP in sediments from different types of freshwater aquatic systems may help to constrain basin-scale CH₄ budgets of individual water bodies in larger-scale assessments.

Keywords: Carbon cycling, Greenhouse gas emissions, Inland waters, Freshwater

【A0300】 -Oral

The signal of agropastoral activities in sedimentary DNA and pollen records since 3.7ka BP in the Ili River Basin, Central Asia

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The combination of agriculture and animal husbandry within the mountain-basin system forms a crucial economic foundation for human civilization in Central Asian. Here, we present a high-resolution record of sedimentary DNA and pollen from the eastern Ili River Basin, spanning the past 3.7 ka. We aim to identify agropastoral activities signal in sediment and explore the evolution of human-environment relationships. The results show that the concentration changes of pollen from dominant herbaceous and woody plants are synchronous, showing higher concentration at intervals of ~3.6-3, 2.2-1.8, and 1.4-1.2 ka BP. Local paleo-fire exhibits relative high intensity at ~3.6-3 and 2.2-1.7 ka BP, while regional fire intensity show an overall declining trend. There is a continuous increase in the signal of domestication animals and plants in sediment DNA since 3.6 ka BP. During



the period of 2.1-1.7 ka BP, the species diversity, species evenness and the intensity of paleo-fire all reach the highest values, with the only decreasing signal being that of sheep. Thus, the significant ecological changes observed during this period appear to be associated with the increase in crops, and the animals that require more human management, such as *bos* and *Equus*. By comparing regional archaeological and paleoclimatic records, we suggest that in the natural state, temperature variation dominated the vegetation condition and paleo-fire activity in the Ili River Basin. Our research further reveals that the impact of agropastral activities on the ecological environment is influenced by the transformation of subsistence patterns, with agriculture tends to have more profound and intricate effects.

Keywords: Central Asian, Agropastral activities, Han dynasty, Sediment DNA, Pollen

【A1030】 -Oral

Disentangling the climate and human footprints in the past two millennia in south-central Chile: Lake sediment evidence from the coast to the Andes

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In this study, we analyzed five sedimentological records from lakes located between 37° and 38°S in western South America, using a multi-proxy approach to investigate landscape evolution and infer the main forcing mechanisms associated with climate and anthropogenic activities. The lake survey spans an east-west transect with an elevation range from 1400 m (western Andes) to 8 m a.s.l. (Pacific Coast). Samples were obtained using Uwitec gravity and Livingstone piston corers, with core lengths ranging from 100 to 430 cm and basal ages between 1000 and 1800 years before present. We examined sedimentological parameters (texture changes, X-ray fluorescence, organic matter and



nutrient contents, age models) and biological indicators (pollen, charcoal, chironomids, and diatoms) to reconstruct environmental changes over the past 1800 years. These findings were then discussed in the context of archaeological background, paleodemographic studies, and the main regional climate patterns.

Preliminary results reveal contrasting scenarios between the pristine Andean ecosystems and the lowland and coastal areas. Charcoal and pollen records suggest that the nomadic lifestyle in the Andes played a key role as an ignition agent for wildfires during favorable climatic conditions in pre-Hispanic times. In this regard, hydroclimatic drivers are mainly related to the El Niño Southern Oscillation and the Southern Annular Mode. In contrast, the climate signal in lowland and coastal areas is less pronounced due to human activities associated with agricultural practices (*Zea mays*), suppressed fire activity, and a mosaic landscape of native forest and open areas. Erosional processes and changes in water productivity have also been identified, though the triggers of these changes are still under investigation. Major changes in biological assemblages occurred after the arrival of the Spaniards in 1540 CE, albeit at different times. While coastal and inland areas experienced rapid landscape anthropization in the second half of the 16th century, this event occurred in the Andes only after 200 years. The most important changes in land use and land cover were recorded in all sediment records after the 1950s, indicating native forest loss and the increase in nutrients leading to lake eutrophication. Here, the main trigger of the ecosystem impairments is linked to the intensive exotic tree plantations in south-central Chile.

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Keywords: Antropocene, South America, Lacustrine records, Late Holocene

【A0951】 -Oral

Droughts and social conflict in the Andes of Capricorn during the Late Precolumbian Period (1000-1500 CE)

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Before the Inca expansion (13th-15th centuries), the Central Andes (~10°-25°S) experienced endemic warfare, a phenomenon often linked to severe droughts. Archaeologists propose that water scarcity, reduced agricultural productivity, and resource competition were triggers for social conflicts among neighboring communities, though the specific mechanisms connecting climate and conflict remain underexplored. Paleoclimatic records from the South American Altiplano (18°S-22°S) reveal recurrent droughts over the past 700 years, with significant regional variations in water availability due to the area's complex topography. These differences shaped local adaptation strategies and influenced the resilience of societies to environmental challenges. During the Late Precolumbian Period (LPP; 1000-1450 CE), the population of the Andes of Capricorn (20°-24°S) concentrated in Altiplano basins and mid altitude valleys, where they relied on diversified agropastoral economies.

This study integrates paleoclimatic data from the South American Drought Atlas (SADA) with archaeological evidence in order to analyze the impact of climatic fluctuations on the economies of different regions of the Andes of Capricorn and the potential relationship between economic failure and interregional conflict. With this goal, the archaeological indicators of conflict from three regions (Northern Lipez -NL-, Rio Grande de San Juan -RGSJ- and Quebrada de Humahuaca -QH-) are reviewed, putting emphasis on the chronology in which the signs of violence appear for the first time in each place. Then, this information is compared with the climatic data in order to assess relative correlations between droughts and the onset of conflict in each region.

The results reveal six significant drought events during the 1200-1500 (CE) period expressed in all three regions: three prolonged droughts lasting nearly 20 years and three shorter ones lasting between 5-6 years. The drought of 1222-42 is very pronounced with respect to its historical variability, mainly in QH and RGSJ. For NL, much of the second half of the 14th century (~1350-1400) shows water deficit. On the other hand, the transition to defensive settlement strategies, likely prompted by the onset of conflicts, took place around 1205-1261 ($p < 0.95$) in RGSJ, 1236-1311 in QH, and 1271-1340 in NL. Among the three regions considered, Northern Lipez was the most vulnerable to prolonged droughts,



given its strong dependence on dry farming. The pressure of Northern Lipez communities on the fertile valley lands to the east and south, where they could practice irrigation, would explain why the earliest evidences of conflict appear in the RGSJ. Subsequently, conflicts spread to QH and NL, reflecting both environmental stress and the perpetuation of inter-ethnic rivalries.

In conclusion, environmental deterioration affected the three regions differently, depending on available resources and the vulnerability of their economies. Adaptive responses such as labor intensification, expansion of productive areas, irrigation, and redistribution required new political agreements and institutions capable of securing cooperation and redistribution at broad geographical scales. No such agreements were reached at the inter-regional level, however, leading to violent conflicts that persisted for 200 years, until integration was achieved under Inca rule.

Keywords: Droughts, Social conflict, Andes of Capricorn

【A0725】-Poster

Chronology, environment and early modern human activities in the Lower Barakar-Damodar Plain, Eastern India

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The Lower Barakar-Damodar basin occupies the western margin of the Ganga plains belonging to a different stratigraphic order of sedimentation of the Vindhyan system, forming its own mini-delta. The Barakar (BK) archaeological site is one of the few localities in Eastern India where a partial microlithic toolkit of paleolithic hominin and several loose teeth and bones of Bovidae family animals have been discovered from the Barakar-Damodar Quaternary sediments. The present research synthesise records of environmental magnetism (χ_{lf} , χ_{ARM} , IRM), archaeology, and chronology (OSL,



AMS) for a late Quaternary fluvial archive from the western Gangetic Plain, India, to determine the hominin age and to reconstruct Pleistocene environmental change and compare our data with other published results. Based on the field observation and chronology data (OSL, AMS). The study reveals that i. We constrain occupations of the microlithic site between ~17 and 16 thousand years ago; ii. the first appearance AMS age of *Boselaphus tragocamelus* from the BK Quaternary sediments is younger (13570-12060 BP) than the human occupation; iii. incision prevailed during ~17-18 ka after the swampy conditions during Last Glacial Maximum (LGM ~21-23 ka). iv. The remanence coercivity ($B_{(0)CR}$) depicts a shift from mixed antiferromagnetic mineralogy of LGM to detrital ferrimagnets during post-LGM. The other environmental magnetic proxies (χ_{lf} , χ_{ARM} , SIRM/ χ_{lf} , S-Ratio, and HIRM) show higher-order variability in sediment records, indicating stronger Indian Summer Monsoon (ISM) seasonality in response to climate change. These findings suggest that there is a large depositional gap between the ash bed and the cultural layer in the BK region, and its subsequent erosion had local hydro-ecological effects. The discovery of the ash bed and palaeolithic assemblages in the Barakar-Damodar valley expands our understanding of Late Pleistocene depositional environments, hominin occupations, and possible human movement toward the Eastern coastal region.

Keywords: Bengal River, Last Glacial Maximum, Quaternary deposit, Human settlement

【A0474】 -Poster

How much sediment is enough? A methodological test to determine the necessary amount of sediment to access microplastics in marine sediment cores

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Microplastics (MPs), synthetic polymer particles with a size fraction of 1 μ m to 5 mm, are dispersed throughout the Earth's Interior and represent an urgent societal problem. These microtechnofossils can potentially be anthropogenic signatures for recent and future sediment strata and can be applied to date the present and future human-impacted



sedimentary strata. Nevertheless, there is no consensus regarding the amount of sediment necessary to reconstruct historic MP input to the marine environment, with studies using various amounts (i.e., 3g of dry sediment, 10 or 50 mL of wet sediment, to 1 or 2 cm (from different core diameters). Considering the limited amount of sediments retrieved with coring techniques, this study aims to determine the ideal sediment mass for future studies to reconstruct this human activity marker and its impact on the Ocean. For this, four surface sediment samples from the Admiralty Bay (King George Island) were split into five mass quotas (5, 10, 20, 40, 60g); each quota was spiked with known amounts of microplastics and subjected to MP extraction via density separation, using a NaI solution ($\rho \sim 1,65 \text{ g mL}^{-1}$), and filtration of the supernatant (GF/F; 2μ pores). MPs were identified and categorized with a stereomicroscope (80x amplification). Our results show that the sediment mass analyzed is vital for modern and past MP input studies. Overall, samples with a mass between 40 and 60g resulted in lower MP abundance and dry sediment concentration per gram. Meanwhile, in the 5 and 10g quotas, MP abundance and concentration were between 2.4 and 36 times higher. Therefore, our preliminary data suggests that high-mass samples may underestimate MP concentration in sediments, which is most likely associated with the interference of particles in the flotation step. However, samples with less than 10g will overestimate MP concentration. Although additional tests are needed, our preliminary results suggest that studies focusing on reconstructing human impacts in the marine environment via MP input over time should aim to use samples with a sediment mass of 20 to 40g of dry sediment.

Keywords: Microtechnofossils, Anthropic markers, Method

【A0919】 -Oral

Holocene climate and human impact in the Mediterranean: Evidence from the semi-enclosed Mar Piccolo basin (Southern Italy)

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During the Holocene, the Mediterranean region underwent significant environmental transformations driven by rapid climatic changes and growing human activities. High-resolution palynological analyses on 492 samples (pollen, dinocysts, Non-Pollen Palynomorphs) of a 30-meter-thick sediment core and 15 surface sediment samples from the Mar Piccolo basin (Southern Italy) provide a comprehensive record of climate and environmental changes from the latest Pleistocene to recent times, enabling the identification of both natural climatic shifts and anthropogenic impacts. Global climatic amelioration marked the beginning of the Holocene, driving significant hydrological changes across the Mediterranean region. In the Mar Piccolo basin, these changes were reflected by increased freshwater input, which allowed the development of freshwater marshes (e.g., Cyperaceae) to replace the saltmarshes (e.g., Amaranthaceae) and steppes (e.g., *Artemisia*) that dominated under the arid conditions of the late Pleistocene. Marine spillovers, suggested by foraminiferal organic linings and halophytes, culminated in a major marine ingression at 10.3 ka BP, marked by the presence of full marine dinocysts (*Impagidinium patulum*). Simultaneously, the expansion of mixed semi-deciduous oak forests, reflected a climatic improvement driven by shifts in global circulation following the retreat of the Northern Hemisphere ice sheet. Palynological record documents 22 rapid climatic changes, including the 8.2 ka BP and 4.2 ka BP events, characterized by expanding open vegetation and the decline of thermophilous oak forests. Between 11.8 and 7.2 ka BP, these arid events align with North Atlantic cooling linked to a slowdown in the Atlantic Meridional Overturning Circulation. After the complete melting of the ice sheets around 6.8 ka BP, solar insolation variations drove rapid climatic changes, though vegetation shifts were less pronounced, except during the notable 4.2 ka BP event. The Mar Piccolo is a pivotal site for studying the complex interplay between climatic changes and human activity, reflecting its long-standing role as a cultural crossroads since the Neolithic. Evidence of early settlements around the basin dates to 5.4 ka BP, as indicated by the recovery of resting eggs from human intestinal parasites (e.g., *Diphyllbothrium*) and Cerealia-group pollen, consistent with archaeological data. Human impact intensified during the Greek period (foundation of *Taras* in 706 BC), Roman period and Middle Ages, as evidenced by *Olea* percentages, which also reflect historical events such as agrarian reforms, famines, and wars. Modern and contemporary times have seen a marked increase in anthropogenic activity, evidenced by extensive agricultural activities and urbanization. Palynological analyses of surface sediment samples reveal that the vegetation is currently highly degraded as results of agricultural activities, monospecific



reforestation, urban expansion, and the introduction of exotic taxa (e.g., *Eucalyptus*). Additionally, a significant loss of vegetal biodiversity is testified by the composition of Mediterranean and Sub-Mediterranean assemblages.

The results of this research underscore the importance of tracing human impacts on environments by integrating both paleoenvironmental and present-day data. This integrated approach is crucial for developing mitigation strategies to address the challenges posed by ongoing Global Warming and increasing environmental degradation due to anthropogenic activities.

Keywords: Palynology, Vegetation, Flora, Pollen, Dinocyst

【A0930】-Poster

The lagoon of Venice (Italy) during the latest Holocene: Insights into settlement dynamics, adaptive behaviours, and palaeoenvironmental reconstructions

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This interdisciplinary research project (PRIN 2022 – funded by the Italian Ministry for University and Research), integrates historical, archaeological, geomorphological, palaeoecological, and palaeoclimatic data to assess the interplay between climate changes and human activities in the Lagoon of Venice (Italy) during the latest Holocene, with a particular emphasis on the Roman period. Palynological (pollen, dinocysts and other Non-Pollen Palynomorphs) and geoarchaeological analyses (e.g., geophysical surveys, coring) are currently underway at key sites within the Northern Venice Lagoon (Lio Piccolo) and in the archaeological site of *Altinum*. In particular, palynological analyses



at *Altinium* traced floral, vegetational and climatic changes with decadal resolution, from 4.2 to 1.4 cal ka BP. This provided valuable insights into environmental changes induced by human activities, such as deforestation, agriculture and urban wastewater management, starting from the foundation of *Altinium* to its decline. The discovery of non-native species (e.g., *Cucumis sativus*, *Citrus*) testify the role as an important commercial hub of this ancient city. In addition, ongoing palynological analyses of two sedimentary cores, retrieved from inside and beneath an oyster cultivation tank in the Roman Villa of Lio Piccolo are contributing to a more detailed assessment of environmental changes and human impact in the lagoon. Combined with other proxies, such as dinocysts and foraminifera, these analyses have enabled the reconstruction of variations in lagoon palaeohydrology and its connections to the sea. This multidisciplinary approach sheds light on the palaeogeography of the lagoon, highlighting the responses of transitional environments to sea-level rise and providing valuable insights into settlement dynamics, human adaptation and resource exploitation strategies in the Venice lagoon and comparable settings.

Ultimately, all this work will culminate in the development of an innovative digital storytelling platform, designed to share the project's findings in an accessible and captivating way, bridging the gap between science and the public. By collaborating with key institutions such as the "Museo di Storia Naturale di Venezia", the "Museo Archeologico Nazionale di Altino", and the forthcoming "Museo Nazionale della Laguna di Venezia," the project will also strengthen cultural tourism and support educational initiatives.

Keywords: Palynology, Flora and vegetation, Non-native taxa, Agricultural practices, Geoarchaeology

【A0713】-Poster

Post glacial landscape of the central highlands of Kenya: Unveiling ancient life and cultures

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The Central Highlands of Kenya (CHK) have emerged as a significant region in the study of human origins and traces. Recent archeological and paleontological investigations at Ngobit 1 (0° 3'32.56 "S, 36°48'6.18"E) and Oltaveta (0° 3'35.04" S, 36°48'44.62" E) which are approximately one kilometer from each other have yielded evidence supporting a potential tropical Quaternary refugia. Palynological evidence shows that landscape has been stable from the Pliocene creating a suitable habitat for a variety of fauna species including hominins. The sites have yielded a rich fossil assemblage that includes a fossilized tooth of a pig, two kinds of extinct elephant, giant long-horned wild cattle, small antelopes and archaic homosapiens. This research focuses on the stratigraphic relations of the fossils initially deposited in plio-pleistocene sedimentary layers before they were reworked and into moraine deposits. By examining the interplay of glacial geomorphology, archeology and palaeontology CHK offers new contributions to understanding the importance of moraine deposits in the human origins and traces story.

Keywords: Central Highlands of Kenya, Moraine, Hominin, Human traces, Sediments

【A0508】 -Oral

Early human impacts in the Tibet-Yi corridor: Sedimentary evidence of soil erosion from two alpine lakes

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Human activity and related land use change are the primary causes of accelerated soil erosion, which affects long-term soil sustainability and threatens future agricultural yields. Soil erosion has also received increasing attention regarding carbon fluxes because it is a source of increased carbon emissions into the atmosphere. Unfortunately, the magnitude and scope of anthropogenic impacts on soil erosion have only been systematically observed for the past few centuries, so the long-term human effects on soil erosion have yet to be well evaluated and constrained, which also hinders the prediction of soil erosion evolution under global environmental change. China has a long history of agricultural civilization, and anthropogenic soil erosion dates back thousands of years. Our study site is located in the central part of the eastern Tibetan Plateau, a region with complex and diverse natural environments, which was also a key region for the Southern Silk Road and the Tibetan-Yi Corridor during the historical period. Based on sedimentary cores from two alpine lakes, we reconstructed changes in the natural environment and the history of human activities in this area over the past 2000 years by using XRF element data, loss on ignition, magnetic susceptibility, and grain size. We also explored the differences in soil erosion under different conditions of land use by comparing the records from the two lakes. The results reveal that anthropogenic soil erosion around Lake Shayema started around 620 cal a BP, with noticeable increases in erosion intensity. Whereas soil erosion around Lake Xiaoshayema began around 280 cal a BP with sustained intensive erosion. It is hypothesized that soil erosion in this region is associated with the large-scale Han immigrants and land reclamation during the Ming-Qing dynasties according to historical records. Considering the topography of the watershed and modern land use, we may posit that soil erosion around Lake Shayema is primarily attributable to deforestation, while agricultural cultivation is the predominant factor around Lake Xiaoshayema. The result of the organic carbon accumulation rate (OCAR) in the Lake Shayema region indicates that OCAR increased after 620 cal a BP, primarily attributed to accelerated sedimentation rates linked to the intensification of soil erosion. Our findings indicate that there are notable variations in the extent and persistence of soil erosion under diverse land use practices. Furthermore, we conclude that soil erosion plays a key role in the lake carbon burial. This study presents a geologic record of historical human activities on the eastern Tibetan Plateau and provides a crucial foundation for comprehending and predicting the evolution of anthropogenic soil erosion and lake carbon burial.



Keywords: Soil erosion, Carbon burial, Lake sediment, Eastern Tibetan Plateau, Human activity

【A0259】-Poster

Effects of human activities on mountain forest in northern China during the middle Holocene

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China has a long history of civilization and agriculture, and its terrestrial ecosystems have long been subjected to anthropogenic impacts. However, we lack detailed knowledge of the nature and timing of human impacts on the development of vegetation ecosystems in the mountain region of northern China during the Holocene, especially during the middle and late Neolithic periods. In this study, we used pollen and charcoal data, combined with the biomization method, from a sediment core from Mayinghai Lake to reconstruct the Holocene vegetation history of a mountain region in northern China. Considering the relatively warm and wet climatic conditions indicated by independent paleoclimate reconstructions, we conclude that our results provide a record of human impacts on the natural landscapes of the study region since ~4.8 ka (1 ka=1000 cal yr BP), which are mainly indicated by a decrease in the coverage of temperate deciduous forest (based on biomization scores), higher sedimentary charcoal concentrations, and an increase in the number of archaeological sites, both in the vicinity of the study site and throughout the whole of northern China. Our results provide new insights into the role of humans in the ecological evolution of this mountainous region during the Holocene, and we suggest that



the impact of prehistoric humans on vegetation succession was potentially significant, which needs to be considered when using pollen records for paleoclimatic reconstruction.

Keywords: Holocene, Mayinghai lake, Mountain forest, Vegetation succession, Human activities

【A0330】 -Poster

Human Traces in Lake Ladoga records during Holocene

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Lake sediments are very important natural archive of paleoenvironmental changes, including early anthropogenic impact on aquatic systems. Reconstruction based on cores of a large lake allow us to obtain data on changes in the vast territory of the lake's catchment area. The catchment area of Lake Ladoga is 17,765 km². Ladoga is the largest lake in Europe and lies between 60 and 62 N in northwestern Russia. We studied several cores in different parts of Lake Ladoga. Multi-proxy studies of the sediments of the studies of the European largest lake makes it possible to obtain results of natural and anthropogenic changes for the lake and its catchment area. The same set of methods that was applied to all the sediment sequences of Lake Ladoga we studied, makes it possible to compare the conditions of sedimentation for Holocene in different parts of the lake.

We studied a new continuous record of sedimentation in the eastern part of the lake allowed to reconstruct paleoenvironmental over the past 11 thousand years. The samples were investigated using lithological, pollen, macrocharcoal, phosphorus, metals, and radiocarbon analyses. The content of metals V, Mn, Fe, Co, Ni, Zn, Sr, Pb, Si, Ti, Al, Mg, Ca and K was determined. New data of changes in total, organic and inorganic phosphorus during the Holocene dated by the radiocarbon method were obtained. An increase in phosphorus and the Fe/Mn ratio was recorded in different periods of Holocene. This may indicate the influence of both natural and anthropogenic factors in the pre-industrial period. Even more this can be asserted because during these same periods we often note



the appearance of ruderal plants pollen in the pollen spectra. The age of Cerealia first appearance in the new core dates the beginning of the Subboreal period. In the new core we also discovered a unique find of a preserved in situ wood. The wood was identified as *Populus tremula*, radiocarbon dating showed an age of 11078-10588 cal. years ago. The maximum of macrocharcoal concentration occurs in the Preboreal.

Our long-term studies of Lake Ladoga show that, Human Traces have a little impact in the large lakes during Holocene, but Human Traces are there.

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Keywords: Paleolimnology, Lake sediments, Pollen, Macrocharcoal, Geochemistry

【A0932】-Oral

Early human impact on Canary Island environments: A paleolacustrine perspective

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The Canary Islands, a volcanic archipelago in the central North Atlantic, were among the few islands colonized in prehistoric times in the Macaronesian region. Archaeological evidence suggests the settlement occurred around 3 - 2 ka BP, but the timing of the first occupation and the nature of the early impacts remain unclear. This early occupation of the territory offers a unique opportunity to investigate human-induced environmental changes during the prehistoric period in the Macaronesian region. To assess timing and intensity of early settlement we have conducted a survey of lake basins in Tenerife and La Gomera islands. This study presents a multi-proxy analysis of sedimentary records including magnetic susceptibility, XRF geochemistry, lipid and faecal biomarkers, faecal spherulites, and new age models. To further contextualize our findings, we integrated these natural archives with archaeological and ethnoarchaeological evidences.

In northern Tenerife, the lacustrine sequences from La Laguna (551 m a.s.l.) reveal a phase of increased sediment delivery to the central basin around 3-2 ka BP coinciding with the chronology of the initial aboriginal settlement in the Canary Islands (c. 3-2 Ka). A more intense phase of erosion occurred with the European colonization in the 15th century, driven by deforestation, agriculture, and urbanization, culminating in the drainage of the lake in the 19th century. In southern Tenerife (Malpaís de La Rasca, 20-50 m a.s.l.), the use of land for livestock during both aboriginal and historical times is evidenced by the presence of fecal biomarkers and spherulites in archaeological and ethno - archaeological records. However, evidence of human impact on the lacustrine sequences is scarce. The sedimentary sequence from La Laguna Grande (1240 m a.s.l.) in Garajonay National Park (La Gomera) reveal that human impact on high-elevation areas has been relatively limited since initial settlement. This is consistent with the general trend of later colonization and higher impact in high-elevation settings.

By integrating multi-proxy analyses and inter-island comparisons, we provide an assessment of pre-human and post-human environmental conditions in the Canary Islands. This study offers insights into the timing, nature, and magnitude of human influence on the insular environments. However, further research is necessary to refine our understanding of the synergies between regional climate and local factors and to assess the varied human signatures in the different islands of the archipelago.



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Keywords: Anthropocene, Human impact, Canary Island, Lake records

【A0991】 -Poster

The alteration of environmental magnetism by human activities in the sediments of the Yellow River since 1855

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As an important intersection area of the interaction between rivers and the sea, the delta is affected by both natural and human activities in the basin, and its sediments record in detail the influence of human activities on the exchange of sea and land materials and sediment transport processes in the surrounding areas. In this paper, the sediments of cores JC-1201 and YRD-1101 were studied before and after the diversion of the Yellow River Delta in 1855. The results show that the magnetic minerals in the sediments of the two boreholes are mainly ferromagnetic minerals. According to the κ -T curve, the magnetic minerals are mainly magnetite, which may contain a small amount of magnetic hematite. They contain superparamagnetic particles, but the sediments in section B of hole JC-1201 contain almost no superparamagnetic particles. The results show that the types of magnetic minerals are the same before and after the Yellow River diverted into Bohai Sea in 1855, and the contents of magnetic minerals are basically the same. However, the variation range of magnetic minerals in sediments after the diversion is significantly greater than that before the diversion, and the content of superparamagnetic particles increases significantly. Combined with the characteristics of heavy metal content changes, it is found that their change trend is consistent, and the influence of human activities on the sediments of YRD-1101 core since 1855 is mainly divided into three stages. Therefore, we believe that environmental magnetism can better record the historical process of



sediments in the delta area, and can reflect the changes of sediments caused by human activities, which provides a new research idea for further exploring the influence of human activities on modern sediments.

Keywords: Environmental magnetism, Human activities, Yellow River Delta, Modern sediments

【A0836】 -Poster

Radiocarbon fingerprinting black carbon source history in the himalayas

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Black carbon (BC) is considered as an important contributor to the Himalayan glaciers melt in the past few decades. However, the long-term source apportionment of BC remains unclear. Here we present the first radiocarbon (¹⁴C)-based annual variation of BC source apportionment in an ice core spanning the period of 1959-2012 drilled from the Southeastern Tibetan Plateau, a receptor site of South Asia outflow. We find fossil fuel combustion is a major contribution (73±5%), yet the biomass burning fraction (f_{biomass}) has grown from 24±4% to 30±4% since 1990. Intriguingly, we further find the f_{biomass} demonstrating a robust correlation with South Asian wildfires linked to climate oscillations. Thus, for mitigating BC impacts on Himalayan glaciers, South Asia's transition from fossil fuels to clean energy is a more efficient and urgent strategy than reducing residential biomass burning.

Keywords: Ice core, Tibetan Plateau, Radiocarbon, Black carbon

【A0454】 -Poster

Human-induced prehistoric and historical soil erosion: Sedimentary evidence from Lake Jian, southwestern China



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The escalating soil erosion has become a pervasive phenomenon in global environmental changes during the Anthropocene, posing significant challenges to the ecological environment. Long-term records can help to further clarify the processes, patterns and variability of human impacts on the natural environment. Here we present a sedimentary record from Lake Jian in Yunnan Province, southwestern China, which indicates that anthropogenic land-use changes have influenced the lake as early as 2900 cal a BP. Increases in C/N ratios and positive anomalies in organic matter carbon isotope suggest that human activities between 2900 cal a BP and 2606 cal a BP led to a rise in the proportion of terrestrial organic matter, likely associated with increased soil erosion caused by the clearing of agricultural land. Published archaeological data indicate that the absence of cultural layers at the Haimenkou site from 3050 to 2750 cal a BP. During this period, the lake level of Lake Jian was high, suggesting that ancient humans may have migrated to higher ground and cultivated land to meet their subsistence needs. However, since 2606 cal a BP, as lake level of Lake Jian decreased, human resettlement at the site, and carbon isotopes of sediments shifted to more negative values. During the Yuan Dynasty, increased regional immigration intensified human disturbances in the watershed, leading to a significant rise in soil erosion, exceeding historical and prehistoric periods. Subsequently, after the mid-20th century, anthropogenic impacts increased further, accompanied by changes in the type and intensity of human activities. Therefore, this study contributes to a better understanding of the Anthropocene and its historical background.

Keywords: Southwestern China, Lake Jian, Human activities, Soil erosion, Anthropocene

【A0935】 -Poster



Climate and cultural evolution drove Holocene cropland change in the Huai River Valley, China

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As an important way of maximizing land productivity by growing more than one crop type in the same field, mixed cropping has been an effective option for sustaining population growth under different climatic conditions since prehistoric period. We used a combination of archaeological data and an improved prehistoric land use model to quantitatively reconstruct spatiotemporal changes in cropland types and areas in the Huai River Valley of China, a core region of mixed cropping during the Holocene. The total cropland area increased more than 25 times during 8–2 ka BP, with northward expansion of rice-dominated cultivation during 5–4 ka BP and southward expansion of dry-dominated cultivation after 4 ka BP. Temperature and precipitation determined cropland types distribution, while that of cropland area was controlled by cultural development. The interplay between past climate, culture, and cultivation potentially provides useful insights into mitigating future population pressures with climate change.

Keywords: Human activity, Land use, Holocene, Climate change, Culture development



Session 04. Transdisciplinary approach to address environmental issues

Conveners: Qiaoyu Cui, Charuta Kulkarni, Laurent Marquer, Estelle Razanatsoa, Michal Slowinski

【A0698】

Ecology of economically important teak *Tectona grandis* and sal *Shorea robusta* informed by palaeo-data

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In managing ecosystems, it is important to understand the ‘natural’ regime in an ecosystem, wherein what is ‘natural’ means the variation in ecosystem traits and properties as a function of climate variables and disturbance regimes across time. Components of ecosystems may be very dynamic and be formed by historical legacies of disturbance regimes. However, modern scientists are unable to understand the underlying dynamism in ecosystems because they only have access to present-day distribution of species and ecosystem traits. Long-term ecological research stations are at best <200 years old and may not be able to provide the necessary length of time in which ecosystem dynamics play out. The problem of understanding what is natural is further compounded in the case of economically important timber species as their present-day distribution may far exceed their natural range due to past efforts in creating and managing plantations of these species. The current distribution of many timber species may not be due to natural dispersal, or natural affinity for the environmental conditions in that area, but due to silvicultural imperative. Using only present-day distribution for understanding species also may under-estimate their tolerance for different environmental conditions. This is particularly true for teak (*Tectona grandis*) and sal (*Shorea robusta*), two of the most economically valuable timber species in India. At present, they cover large tracts of India (~40%), but their future persistence and resilience under future climate change scenarios is uncertain. We create a paleo-dataset for Central India that includes climate, species



composition and human disturbance across space (15 sites across the region) and time (across the Holocene) and use it to understand long-term factors associated with dispersal and extinction of teak and sal. We create spatially-explicit models for teak and sal dispersal and extinction across space and time, and parameterize these models using greenhouse experiments. We find that Sal occurrence is significantly explained by periods of higher temperature and sites with higher precipitation and temperature, while teak occurrence is explained by significantly higher temperature. Role of fire appears weak despite being considered important in modern literature. Using this approach, we are able to successfully model teak and sal expansion and extinction, and understand the interaction between climate, disturbance and demography. This approach may be used to create more accurate species distribution models than those using only contemporary distribution data, and thus predict future climate risk and resilience.

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Keywords: Central India, Sal-teak distribution, Meta-analysis, Plant traits

【A0199】-Poster

Parasites in rodent middens as indicators of ecological and environmental dynamics during the Late Quaternary in the Atacama Desert

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Paleoparasitology, the study of parasites in archaeological and paleontological contexts, provides valuable insights into paleoecological, evolutionary, and cultural dynamics. Parasites serve as robust indicators for reconstructing past environments, offering information on climate, diet, hygiene, demography, host-parasite relationships, and paleoepidemiology. By studying their presence in ancient contexts, research in this field infers environmental conditions and ecological interactions that shaped past ecosystems. Primary sources for paleoparasitological studies include coprolites, rodent middens, pellets, sediments, and other remains from diverse organisms. Rodent middens, in particular, consist of plant macrofossils, coprolites, pollen, and sediments encased in hardened urine, forming deposits that can remain intact for millennia. In South America, these deposits have been central to paleoenvironmental and paleoclimatic studies spanning the last 50,000 years, specially in the Atacama Desert, characterized by prolonged hyper-arid conditions. Early research focused on plant remains and pollen, but advancements in recent decades expanded the scope to include proxies such as arthropod assemblages and heavy metal concentrations. These deposits have emerged as significant archives for paleoparasitological evidence in arid ecosystems, particularly in Argentina and Chile, where they are recognized as bioindicators of environmental conditions, offering new dimensions to paleoecological reconstructions. The present study aimed to explore the paleoparasitic diversity within rodent middens of the Atacama Desert and assess their potential as indicators of environmental changes during the Late Quaternary. The analysis encompassed 150 rodent middens distributed across latitudinal (18°S to 25°S) and altitudinal (2,000 to 6,600 m a.s.l.) gradients, with dating ranging from hundreds of years to 12,000 years cal BP. Using coprological and molecular methodologies, including ancient DNA techniques, hosts and their parasites were identified. Strict protocols were implemented to avoid contamination and ensure data integrity. Multivariate statistical analyses revealed patterns of parasite abundance, diversity, and intensity linked to environmental variability over time and space, as well as parasite adaptations to extreme conditions. Results identified a high diversity of parasites, including nematodes, cestodes, and coccidia, with distinct assemblages across spatial and temporal scales. Latitudinal and altitudinal variations in parasite communities, particularly in more recent samples, aligned with current environmental productivity gradients, providing new insights into parasite-host spatial dynamics and the environmental factors that have dominated the desert in recent years. In contrast, parasites in ancient samples varied in response to fluctuations



in environmental conditions in the region over the last several thousand years. These findings highlight the resilience and adaptation of parasites and their rodent hosts to the Atacama Desert's extreme conditions, as well as the influence of fluctuating environments on parasite assemblages. This study underscores the utility of parasites as proxies for reconstructing past environmental conditions. It expands the geographic and temporal scope of paleoparasitological research, integrating this field with other paleoecological proxies, enriching our understanding of ancient parasitic infections. This research offers innovative contributions to paleoecology and paleoenvironmental studies. Expanding this approach will enable deeper reconstructions of ancient environments and provide insights into how past societies and wildlife adapted to environmental changes, with implications for ecological and health challenges in arid regions.

Keywords: Paleoparasitology, Ancient ecosystems, Coprolites, South America, Environmental change

【A1009】 -Poster

The differences of tree species and tree ring width were used to identify old landslides in the degraded permafrost area of Northeast China

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The degradation of permafrost caused by climate warming accelerates the infiltration and evaporation of water, destroys the hydrological system, and the permafrost in Northeast China, which is located in the south margin of permafrost area in Eurasia, has gradually degenerated, resulting in an increased incidence of landslides. At present, research on the occurrence mechanism, movement process characteristics and evolution trend of landslides in permafrost area, is limited and lacking in detail. It is difficult to identify landslides that have cured within the last hundred years as movements have been relatively small during this time period. In addition, the lack of written records, the unusual geological environment and land forms and the surface coverage, as well as the landslide mechanisms mean that accurate identification is difficult using existing technology. A large number of studies have confirmed that the width of tree rings is



restricted by environmental factors, and there is a good correlation between the width and environmental factors. It can record the growth status of trees and environmental changes that affect tree growth, gradually becoming an important means of studying environmental changes. This paper selects the Bei-hei Expressway located in the permafrost degradation area of Northeast China as the research area. Field investigation, 3D modeling of UAV image, high-density electrical survey, geological drilling and other methods are used to study the distribution of new and old landslides in the area. There was a significant difference in the distribution of tree populations outside the landslide mass. By adding tree core sampling and utilizing relevant theories and methods of dendrochronology, statistical analysis is conducted on tree species distribution, differences in tree rings, and tree ring width to estimate the occurrence time of old landslides. Based on previous research results, the relationship between landslide movement process and permafrost degradation in the study area was analyzed. This method can effectively locate and reconstruct old landslides on a short-term scale, and has important theoretical and practical significance for the early warning and treatment of landslides in permafrost degradation areas.

Keywords: Climate change, Old landslides, Trees population, Tree ring

【A0367】 -Poster

Wooden coffin remains reveal popularization tendency of imperial China

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China hosts the world's richest repository of coffin remains, an indicator of the socio-economic, cultural, and forest resource transformations throughout history. In this study, we developed the most comprehensive coffin database currently available for China, based on our newly identified coffin remains and published literature, including 1,446 coffin samples from 377 sites through the entire Chinese history from the Xia to Qing dynasties (2070BCE-1911CE). The center of coffin remains shifted from central China to the southeast, mirroring the historical movement of China's population and economic centers. The lowest point in the U-shaped distribution of coffin remains coincides with the



period of Buddhism's spread. Buddhism's advocacy for cremation likely led to a significant decline in the use of wooden coffins, while simultaneously fostering the widespread adoption of stone burial implements. Coffins became smaller and cheaper towards the end of imperial China in Ming and Qing dynasties (1368–1911CE), coinciding with a sharp rise in commoner burials. The trend of popularization and the accompanying rise in autocracy are related to the growth of a market economy in southeastern China. Prolonged resource exploitation in southeastern China depleted natural forests by the Ming and Qing dynasties, making plantation species like Chinese fir the main material for coffins. This study tested the use of coffin remains to trace the evolution of China's social structure and offers new perspectives on contemporary social stability and sustainable development.

Keywords: Coffin remains, Tree species identification, Socio-economic transformation

【A0845】 -Poster

Environmental and ecological impacts of European colonialism in South Asia

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South Asia is one of the most densely populated regions in the world and is on the frontline of efforts to balance rapid urbanisation, agricultural expansion, water resource management, and economic development with the increasingly unpredictable effects of climate change. The complexities of this balancing act underscore the urgent need to understand the long-term interactions between human societies and their environments. In particular, developing detailed historical records of land use changes and their impacts on ecosystems and socioeconomic systems is crucial for addressing contemporary challenges.



A crucial threshold in this historical narrative is the arrival of European colonial powers, starting in the 15th century, which marked a profound turning point in land use and settlement patterns in South Asia. However, compared to other parts of the world, the impacts of colonialism on land use, environmental systems, and demography in South Asia remain relatively understudied, especially from a multidisciplinary perspective. This gap in knowledge is especially apparent when considering the complex legacies of British colonialism in the region. The transformation of South Asia's landscapes and social systems during this period had long-lasting consequences that continue to shape the region's ecological and socioeconomic conditions today.

In this study, we synthesise evidence from a range of disciplines, including archaeology, environmental history, historical ecology, and palaeoecology, to explore the environmental and societal impacts of European colonialism in South Asia, with a particular focus on India and Sri Lanka. We examine the introduction of non-native plant and animal species, shifts in land use tied to colonial land tenure systems—such as the establishment of plantations—and changes in urban structure and dynamics. We also analyse climate data on temperature and precipitation from 1300-2000 CE, as well as the social tensions, famines, and economic disruptions that accompanied these environmental changes.

We argue that the colonial legacies of land use and resource management in South Asia have significantly shaped the region's current vulnerabilities to climate change. For example, widespread deforestation, the replacement of biodiverse ecosystems with monoculture plantations, and the degradation of traditional water management systems during the colonial period have contributed to the ecological fragility and socioeconomic inequalities that persist today. At the same time, evidence of traditional land use practices that predate colonial interventions offers valuable insights into how sustainable and resilient systems might be revived or adapted for modern contexts.

Keywords: South Asia, Colonialism, Land Use, Environment

【A0552】 -Poster

Impact of climatic and anthropogenic factors on the content of biogenic elements in the small rivers of Tyumen Region, Russia



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Recently, the relevance of the problem of eutrophication of water bodies has significantly increased due to climate warming and the growth of anthropogenic activities. The increase in average annual temperature contributes to the intensification of eutrophication processes. This can lead to the vegetation overgrowth in small rivers, resulting in a decrease in biodiversity and taxonomic congruence.

The aim of this research was to assess the degree of eutrophication in the tributaries of the Ishim River (Tyumen Region, Russia, southern West Siberia). For this purpose, nitrogen (by capillary electrophoresis) and phosphorus (by the spectrophotometric method) compounds were determined in the 68 water samples collected from 13 tributaries of the Ishim River, located in three terrestrial ecosystems – taiga, forest steppe, and steppe. Comparing the results of the analysis conducted in 2020 with the data from 1991, the largest increases in phosphate (by 40 and 8 times in the Maly Ik River and the Ik River, respectively) and nitrate (by 3000 times in the Barsuk River) content were observed in rivers located in the taiga zone of the Tyumen Region, away from big cities. The increased content of biogenic elements in the taiga zone is associated with increased general humidity within the terrestrial ecosystem, as well as landscape features. The phosphate content exceeds the norm (0.6 mg/L) by 5-8 times in these rivers, while nitrate does not exceed the norm (40 mg/L). Additionally, significant increases in phosphate (by 9 and 6 times in the Karasul River and Loktinka River, respectively) and nitrate (by 517 times in the Loktinka River) content were observed in rivers located in the forest-steppe zone near the city of Ishim. The high content of elements is due to the impact of agricultural enterprises in the territory of the city. The phosphorus content exceeds the norm by 3-4 times in these rivers. To assess the toxicity of the waters in small rivers, the ratio of nitrogen to phosphorus content was calculated. The optimal ratio is considered to be $N/P = 16$. In the studied rivers, this ratio ranges from 1 to 7, indicating a disrupted balance with a predominant influence of phosphate ions on the eutrophication process of small rivers.



The tributaries tend to become overgrown with blue-green algae, making their waters unsuitable for domestic use without specialized treatment.

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Keywords: Eutrophication, Small rivers, Western Siberia, Climate change, Biogenic elements

【A0401】-Poster

Anthropogenic forcing and Pacific internal variability-determined decadal increase in summer precipitation over the Asian water tower

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The increased precipitation in the Asian water tower has prompted the abrupt lake expansion and increased runoff, significantly reshaping the water resource redistribution in the Inner Tibetan Plateau (ITP). However, the dynamic attribution behind this decadal increment remains unclear. Here, analysis of observations, large ensemble simulations, and pacemaker experiments indicates that this decadal increase was mainly attributed to the synergistic effects of the external forcing (anthropogenic greenhouse and aerosol emissions) and the Pacific internal variability, while the Atlantic and the Indian Ocean play a secondary role. Observations and simulations show that thermodynamic and dynamic effects work collaboratively to this increase. Remarkably, the upper-level dynamic



convergence over the ITP would be enhanced through teleconnection and atmospheric dynamic feedback when involving the Pacific internal variability, resulting in more precipitation occurrence. Further analyses show that the enhanced stationary Rossby wave propagation over Eurasia and strengthened transient eddy activity over North Pacific could contribute to the anomalous cyclone over the ITP and weakened East Asian westerly jet, which built a pathway for the external forcing and Pacific internal variability collaboratively impacting the decadal increase in precipitation in the ITP. These results can improve our understanding of ITP summer precipitation attribution and can be applied to emergent constraints on future decadal precipitation prediction.

Keywords: Anthropogenic forcing, Pacific internal variability, Summer precipitation, Asian water tower

【A0092】 -Oral

Pollen-based reconstruction of Holocene plant diversity changes in southern Sweden

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Understanding the changes of plant diversity and their driving mechanisms in the Holocene can provide references for future landscape management and biodiversity conservation strategies. Based on the pollen records from the sediments of Stavsåkra (STAV) and Storasjö (SSJ) in southern Sweden, we used biomization and plant diversity indexes, including palynological richness, evenness, Simpson diversity, Shannon-Wiener diversity and turnover, to reconstruct the history of vegetation and plant diversity changes during the Holocene. The possible mechanism of Holocene plant diversity changes in the region was revealed.



The results show that the two sites have similar background of vegetation evolution over the Holocene. In general, the vegetation was temperate mixed forest, except for some short periods during the early Holocene, when cool-temperate coniferous forest developed. At the beginning of the Holocene (~10500–9000 cal yr BP), all indexes of palynological richness, Simpson, Shannon-Wiener and evenness at STAV and SSJ sites indicate that the plant diversity in southern Sweden was at a low value, which corresponds to the low fire frequency during this period. Low temperatures and less precipitation may account for the low fire frequency and plant diversity. In the early and middle Holocene (~9000–6100 cal yr BP), the plant diversity was high, with an overall increasing trend. During this period, the temperature in Europe increased rapidly and reached its maximum at ~7 ka BP. The warm climate induced the high fire frequency, and consequently increased the plant diversity. In the middle and late Holocene (~6100–1000 cal yr BP), the plant diversity at SSJ site was still high, which is associated with the decreasing intensity, but still frequently-occurred local fire. However, the plant diversity of STAV decreased sharply at ~6100–3300 cal yr BP, which may be related to the very low local fire frequency caused by the rapid increase in precipitation. In the late Holocene, plant diversity began to decline gradually at ~1000 cal yr BP at the SSJ site and rapidly at ~200 cal yr BP at the STAV site, which may be related to the intensive human disturbance.

In summary, changes in plant diversity in southern Sweden recorded by STAV and SSJ profiles during the Holocene are closely related to fire frequency. Higher plant diversity is associated with higher fire frequency, which in turn is influenced by both climate change and human activities. Moderate fire frequency can develop diversified habitats such as "forest hollow", thus improving plant diversity. Our results show that the "intermediate disturbance hypothesis" in modern ecology is also applicable to paleoecological changes, providing key evidence for a comprehensive understanding of the driving mechanisms of Holocene biodiversity changes.

Keywords: Pollen, Plant diversity, Holocene, Paleo-vegetation reconstruction, Southern Sweden

【A0408】 -Poster

Investigation of the cold-water coral ecosystem on a mound at the northern South China Sea using in-situ observations by Manned Submersible



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Deep-sea biosphere plays a crucial role in climate regulation, carbon cycling, and ecosystem services. However, its remoteness hinders a full understanding of its ecological dynamics and environmental responses. Manned submersibles offer precise *in situ* observations and targeted data collection to overcome these challenges. This study examines the abundance of cold-water coral (CWC), a key indicator of benthic ecosystems, on a mound in the northern continental shelf of the South China Sea, using video footage taken by manned submersible dives combined with high-resolution multibeam bathymetric data. An active benthic CWC ecosystem is identified, with an average density of 15.11 ± 2.25 individuals per 100 m², supporting a flourishing benthic community. Through *in situ*, non-invasive investigations, a comprehensive database was developed, integrating biological abundance, spatial distribution, substrate types, and hydrological parameters. The workflow and database established by this work enables further analyses of materials collected by submersible dives on benthic ecosystems and the surrounding environments, offering critical tools for studying and protecting deep-sea ecosystems.

Keywords: Cold-water corals, South China Sea, Benthic ecology, Bottom currents

【A0818】-Oral

Immigrations of war refugees leads to significant land cover changes in subtropical mountainous areas of southeastern China

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In Chinese history, the subtropical mountainous regions of South China have served as destinations for refugees from wars in the Central Plain. Fujian Province, for instance, has witnessed numerous waves of war-induced migration from the north. It is generally



accepted that these incoming populations have significantly influenced the subtropical mountain landscapes, yet the exact process remains unclear. In this study, we conduct high-resolution pollen and charcoal analyses of Holocene sediment obtained from a subalpine peat bog in Youxi County, aiming to investigate the fire histories and the historical impacts of human activities on the mountainous landscape of central Fujian.

Our study shows high proportions of arboreal pollen and low charcoal influxes between 8 and 1.3 ka, demonstrating dense subtropical evergreen broadleaved forests with very few signs of human activities such as deforestation and agriculture in the study region. However, through precise ^{14}C dating, a notable transition emerges around 1300 cal. yr BP., characterized by a sudden increase in charcoal particles. Subsequent pollen result demonstrates severe landscape changes, including the notable decrease of arboreal pollen and increase of in pioneer taxa such as *Dicranopteris* and herbs, indicating the onset of deforestation, as well as an overwhelming rise in the frequency of Poaceae, attributed partly to the expansion of rice cultivation the onset of large-scale agricultural development. This environmental transformation revealed by our records coincides with the timing of the establishment of nearby Lianhe Terraces, ancient agricultural terraces documented to have been first constructed during the early Tang Dynasty by military migrants. Integrating our pollen records with historical evidence, we demonstrate that this period of war-induced migration had profound human impacts on the subtropical montane forests of the study area. Furthermore, our charcoal record subsequently reveals three additional peaks, signifying intervals of elevated forest fire frequency. Remarkably, these charcoal peaks coincide temporally with significant influxes of war refugees during pivotal historical events, including the An-Shi Rebellion (755 CE), the tumultuous era of the Five Dynasties and Ten Kingdoms, and the Jingkang Incident (1127 CE), indicating growing impact of human activity on the subtropical mountains area, particularly during periods of war-induced migration from the north.

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Keywords: Migration, Pollen, Fire, Terraced field

【A0081】 -Oral



Dendrochemical potential of *brachystegia longifolia* benth unravels reduced copper smelting-induced sulphur dioxide emissions in Mufulira, Zambia

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High levels of Sulphur dioxide (SO₂) emanating from a copper smelter in Mufulira, Zambia has been reported around the year 2000, exceeding environmental quality guidelines. This study investigated the dendrochemical potential of *Brachystegia longifolia* in detecting environmental change induced by variations in industrial pollution load. *B. longifolia* wood discs were extracted at breast height, air dried and sanded until transverse surface and annual rings were clearly visible. μ -XRF spectrometer was used to determine the distribution of Sulphur by scanning and exposing samples along the bark-pith transverse surface to the X-ray beam, obtaining X-ray transmission intensity values of counts per second (cps) for Sulphur. Finally, the same radial slices were then scanned with a cellulose acetate calibration scale using an X-ray densitometry chamber. Digital images were then analysed with Windendro® program to determine wood density. The mean Sulphur distribution in tree rings at the beginning (2007) and completion (2014) of the smelter upgrades were 15.41 cps and 17.51 cps, respectively. By 2019, the highest Sulphur content in *B. longifolia* wood had significantly ($p<0.05$) reduced to 13.28 cps. Furthermore, a significant reduction in wood density with increasing tree age was observed after the installation of the new smelter. 0.78 g/cm³ and 0.75 g/cm³ mean wood density were recorded in annual rings at the beginning and completion of the upgrades, respectively. However, the mean wood density had significantly ($p<0.05$) reduced to 0.67 g/cm³ by 2019. The significant variations in the distribution of sulphur and wood density in tree



rings formed before and after upgrading an obsolete copper smelter demonstrates the dendrochemical potential of *B. longifolia* and possibly other miombo woodland species, offering an opportunity to biomonitor the impact of industrial activities in the miombo landscapes which are extensively distributed across sub-Saharan Africa.

Keywords: Copper smelter, Sulphur dioxide, *Brachystegia longifolia*, Annual rings, Sulphur distribution, Wood density

【A0165】 -Poster

Using climate reanalysis to signal glacial lake outburst floods in the central Himalaya

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Glacial lake outburst floods (GLOFs) are catastrophic events triggered by the sudden failure of moraine dam, releasing massive amount of water that devastates downstream communities and infrastructures. These events have resulted in the loss of thousands of lives, particularly in the Himalayas, where remote and under-developed villages at high risk with limited access to rescue resources. Climate change exacerbates the frequency and severity of on GLOFs through two primary mechanisms: (1) rising temperature accelerates the melting of ice cores within moraine dams, weakening their structural integrity, and (2) increasing extreme precipitation events lead to fluctuation in lake volume, causing overtopping and eventual dam failure.

Understanding the relationship between past climatic conditions and historical GLOFs events is essential for improving predictions and early warning systems. However, in-situ meteorological data from GLOFs-prone regions are often unavailable due to their remote and inaccessible locations. Climate reanalysis data, such as ERA5, provide a valuable alternative, offering high-resolution temperature and precipitation estimates in



mountainous regions. Despite its potential, the robustness of reanalysis data in signaling past GLOFs has not been thoroughly evaluated.

This study examines the latest ERA5 reanalysis data to investigate the climatic conditions preceding two historical GLOFs events in 2015 and 2016 in Yindapu region, Central Himalaya. By analyzing temperature and precipitation anomalies associated with these events, we aim to assess the reliability of reanalysis in identifying climate signals linked to GLOFs. The results contribute to enhancing the accuracy of GLOFs early warning systems, supporting efforts to protect critical infrastructures and safeguarding vulnerable communities in high-risk regions.

Keywords: Glacial lake outburst floods, Climate reanalysis, ERA5, Climate signals, Central Himalaya

【A0203】 -Oral

A geohistorical and remote sensing assessment of urbanization and climate impacts on the wetland 'Bahía Serena' enclosed in the city of Bariloche (Patagonia)

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Patagonian wetlands, specially the so-called “mallines” are key areas for local and regional biodiversity. Despite providing a wide range of services such as nutrient cycling, water storage and purification, food production, and recreation they are still far from meeting global ecosystem-service conservation goals as only a 3% of these patagonian wetlands are currently protected. There is an urgent need to preserve the Patagonian mallines, as



they are important 'carbon sequestrators' of the world. Detecting natural carbon storage in protected land is a practical climate stabilization strategy.

The urban mallin Bahia Serena located in the city of San Carlos de Bariloche (North Patagonia - Argentina) has been systematically threatened by multiple stressors, specially by the rapid urbanisation in the peripheric areas which has led to the loss of natural habitats and recreational areas. In addition, as climate change exacerbates these challenges, urgent action is needed to preserve these ecosystems.

Water changes in the Mallín Bahía Serena over the past decade were assessed using Copernicus SAR data through Google Earth Engine. A water mask was generated to identify inundated pixels in each image, and a total of 298 images were analyzed to determine seasonal variations. A simple linear regression analysis was applied to quantify the temporal trend of inundation. These results, combined with urbanization indicators and meteorological data allowed us to visualise spatial and temporal changes in the wetland related to anthropic and climatic changes.

Preliminary results indicate a concerning decline in the mallín moisture levels over the past decade. This suggests that urban expansion plays a significant role in altering the hydrological balance of the mallín.

By integrating geospatial sciences with ecological research and palaeoclimatic and palaeoecological modelling, we can harness the power of spatial, descriptive, and temporal data to better understand these complex interactions. This transdisciplinary approach, combining satellite imagery and historical data, offers valuable insights for developing adaptive management strategies to safeguard wetland ecosystems in the face of growing pressures.

Keywords: Patagonian wetlands, Urbanization impacts, Climate change adaptation, Geospatial analysis

【A0184】-Poster

New inventory and spatiotemporal changes of glacial lakes in Alaknanda River Basin, Uttarakhand, India from 1990 to 2020: A multi-temporal landsat analysis



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Glacial lakes are critical components of high-altitude mountainous regions in the Himalayas. In recent years, glaciers have rapidly receded due to climate change, resulting in the formation of glacial lakes with substantial risks for downstream communities and infrastructure. The present study uses Landsat satellite data to create a comprehensive glacial lake inventory in the Alaknanda Basin, focusing on spatiotemporal changes between 1990 and 2020. The study has recorded 73 glacial lakes ($\geq 0.003 \text{ km}^2$) with a total surface area of $2.538 \pm 0.037 \text{ km}^2$ in 2020. The mean depth and volume of glacial lakes were assessed as 7.17 m and 0.432 m^3 , respectively. During 1990-2020, the total glacial lake area has increased from $0.748 \pm 0.020 \text{ km}^2$ to $2.538 \pm 0.037 \text{ km}^2$ with a growth of $\sim 1.790 \text{ km}^2$ (239%; $7.97\% \text{ y}^{-1}$). Additionally, 15 common glacial lakes have shown significant growth rates of 91.24% ($3.04\% \text{ y}^{-1}$). Among all the glacial lakes, tiny lakes ($< 0.02 \text{ km}^2$) have shown the maximum growth in both numbers (+33) and area (477.92%; $15.93\% \text{ y}^{-1}$). Moraine-dammed lakes have expanded more rapidly in terms of number (+27), while supraglacial lakes have exhibited a higher rate of areal (1771.71%; $59.06\% \text{ y}^{-1}$) expansion. Based on the current inventory, flood hazard studies in the Alaknanda Basin can be carried out for a better understanding of glacial-climate related dynamics.

Keywords: Glacial Lakes, Inventory, Alaknanda Basin, Landsat imageries

【A0218】 -Poster

Pollution history and anthropogenic-induced increase in the transport of toxic metals from Australia to Sub-Antarctic islands

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Mercury (Hg), is a volatile toxic metal, with a large atmospheric emission and transport capacity. The biogeochemical cycle of Hg is sensitive to changes in climate, yet our understanding of the impact of climatic factors on the Hg cycle remains limited. A primary challenge in Hg research involves distinguishing alterations in Hg levels resulting from human activities from those driven by climatic variations. This research focuses on examining how industrialisation and climate change have increased toxic metal pollution in the Australia-Pacific region, a distinctive and underexplored area where Hg deposition fluxes are often extrapolated from global models. Studies have found Hg in remote areas of Australia, the Southern Ocean, and Antarctica, with increased deposition occurring with the great acceleration. Here we use a multi-proxy framework to differentiate climatic events from anthropogenic factors in Southern Australia, and sub-Antarctic islands (Macquarie and Campbell) over the past 8,000 years. We aim to reconstruct and disentangle impacts of anthropogenic emissions, feral animals and those caused by climate change, such as the intensification of the southern hemisphere wind belt on the deposition of toxic metal pollution to understand the biogeochemical processes governing Hg behaviour in lacustrine ecosystems. Using a multi-proxy framework facilitates the precise quantification and interpretation of Hg deposition sources and accumulation rates in the context of a changing climate. This research will inform contamination amelioration strategies, and support Australia's efforts to meet its international obligations under the Minamata Convention on Mercury. This research is in collaboration with the Australian Nuclear Science and Technology Organisation, the British Antarctic Survey, and the University of Tianjin, China.

Keywords: Mercury, climate, Paleolimnology, Ecology

【A0987】-Poster

Steppe development and mammalian adaptation in the middle Miocene, North Junggar Basin, Central Asia

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The Central Asian (CA) steppe ecosystem and its fauna experienced a marked transition during the Miocene Climatic Optimum (MCO), though the specific process and dynamics remain elusive. We selected the Duolebulejin (DLB) section within the Junggar Basin to reconstruct vegetation and climate changes, using proxies such as particle size, mammalian fossils, and previously reported data including pollen, $\delta^{13}\text{C}_{\text{TOC}}$, and magnetic susceptibility. The results reveal three distinct phases of transformation in regional vegetation and fauna from 18.8 to 13.2 Ma. During the pre-MCO (18.8–17.0 Ma), the landscape was dominated by desert scrubland, primarily inhabited by rodents. The MCO (17.0–14.5 Ma) witnessed a shift towards steppe vegetation, initially with herbaceous taxa followed by the establishment of C_4 plants, alongside a diversity of large mammals adapted to open habitats. This suggests the emergence of savanna-like woodland steppes. In the post-MCO (14.5–13.2 Ma), the region transitioned to a dry steppe, accompanied by a decline in animal populations, although a significant proportion of species remained adapted to steppe environments. These findings underscore a co-evolutionary relationship between the development of steppe ecosystems and mammalian adaptations, driven by global MCO warming and subsequent cooling, with regional hydroclimatic changes acting as a modulating factor. The steppe-fauna biome emerged in the Junggar Basin during the MCO warming, with mechanisms resembling those of tropical savannas in the late Miocene. These insights enhance our understanding of early steppe ecosystem evolution through past warming periods, shedding light on the pathways to modern steppe formation.

Keywords: Steppe ecosystem, Mammalian adaptation, Miocene Climatic Optimum, Central Asia, C_4 expansion

【A0967】-Poster

Winter warming revealed by pollen records in the northernmost mountain regions of China during the Holocene

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East Asian monsoon system is the most significant factor of climate and vegetation change in the vast East Asian region. Compared with the East Asian Summer Monsoon, the study of East Asian Winter Monsoon (EAWM) is seriously insufficient. Especially in the Holocene, the time span is short, the sample resolution is high, and the Holocene variation trend of the EAWM reconstructed by different proxy indexes is inconsistent, which restricts the understanding of the East Asian monsoon as a complete system. Therefore, this study is intended to reveal intensity trend of the EAWM in the northernmost mountains of China during the Holocene, and the regional vegetation change responded to the intensity change of the EAWM. The results of palynological analysis of lake sediment boreholes in Lake Moon, Lake Woniupaozi located in the Great Khingan Mountains and Lake Shuang in Altai Mountains show that the content of temperate forest components, mainly *Pinus* and deciduous *Quercus*, has increased significantly since about 6 ka BP, indicating that the distribution of temperate forest has shifted northward, the winter temperature has increased, and the EAWM has weakened. The results combined with the simulation results from TraCE-21ka show that the increase of solar radiation and atmospheric CO₂ concentration in winter are the external factors that lead to the weakening of the EAWM in Holocene. The results of periodic analysis show that the effect of El Niño-Southern Oscillation (ENSO) on the EAWM increases after ~6 ka BP.

Keywords: Pollen, Holocene, Winter warming

【A0299】-Poster

Chronology of the urban evolution of ancient Loulan city

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Understanding the historical development of civilization in the western regions of China requires a detailed and precise chronology and knowledge of the development dynamics of Loulan Ancient City (LA). However, due to the lack of systematic chronological investigations of specific archaeological sites within LA, the construction and occupation dates of many of its sites, as well as the overall extent and development phases of the



urban area, remain unclear. To address this we established the “Loulan Radiocarbon Dating Database” and applied the Summed Probability Distribution (SPD) method to reconstruct the chronology of different sites and the urban development process of LA. Our results indicate the following: 1) from ~BCE 500 to ~BCE 200, only site units LA-I and LA-VIII existed, indicating a developing village phase; 2) from ~BCE 200 to ~AD 100, the construction of LA-IV marked the transition to a city phase, and abundant plant and animal dating materials revealed a mixture of agricultural and pastoral practices; 3) from ~AD 100 to ~AD 400, all the remaining site units were constructed, occupied, and utilized, defining an urban phase. Complex social divisions emerged, with monks, soldiers, officials and blacksmiths that shaped the urban fabric. Our chronological evidence provides novel insights into the urban development process of LA.

Keywords: Loulan radiocarbon dating database, ^{14}C , Summed probability distribution, Western regions, The ancient Silk Road

【A0056】 -Oral

Millennial-scale dynamics of cyanobacterial communities and their driving mechanisms in Huguang Maar Lake, South China

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Cyanobacteria can proliferate massively in freshwater under suitable temperature and nutrient conditions, forming dense and often toxic blooms. These blooms pose severe threats to the diversity and ecological functions of aquatic food webs due to toxin production and oxygen depletion. With the intensification of eutrophication and climate change, the frequency and intensity of cyanobacterial blooms have significantly increased. However, existing studies primarily focus on short-term annual field observations or controlled cultivation experiments, while the mechanisms governing how cyanobacterial communities respond to long-term climatic changes and extreme events (e.g., typhoons, earthquakes) remain poorly understood. Huguang Maar Lake, a closed volcanic crater lake in southern China, offers an ideal setting for studying the long-term evolution of



cyanobacterial blooms under multifaceted influences. The lake's favorable sedimentary environment preserves a continuous record of the past millennium, encompassing climatic changes, human activities, and natural disasters. This study establishes a high-resolution chronological framework using ^{210}Pb , ^{137}Cs and ^{14}C dating techniques, and integrates multi-proxy analyses including sedimentary ancient DNA (sedaDNA) and diatom assemblages. By combining these results with historical environmental records, our study reconstructs the ecological evolution of the lake over the past millennium. The study aims to reveal the dynamic adaptations of cyanobacterial communities driven by climatic changes and environmental disturbances, providing critical insights into the ecological responses of cyanobacterial blooms to long-term environmental changes.

Keywords: Cyanobacteria blooms, Sedimentary ancient DNA, Biodiversity, Millennial-scale, Huguang Maar Lake

【A0198】 -Poster

Fire activities in the northern Tianshan of China over the past 400 years

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Reconstructing the historical fire events and exploring the relationships between past fire incidents, environmental factors (climate and vegetation), and human activities is crucial for accurately understanding regional fire evolution patterns, managing vegetation effectively, and assessing regional fire risk. Xinjiang, located in the arid northwest, has a population that is relatively concentrated in areas with rich vegetation like oases. In the context of global warming, the fire risk in this region is elevated, potentially posing threats to both ecosystems and human communities. Given that the mechanisms of fire evolution in this area remain unclear, we selected a peat-marsh sediment profile from Sichanghu, in the northern Tianshan, to conduct microcharcoal measurement and statistical analysis and reconstructed a high-resolution fire evolution history over the past 400 years. By comparing published paleoclimate and paleovegetation data, we conducted a



comprehensive analysis of the potential mechanisms of fire occurrence on centennial to decadal timescales. The main findings include: (1) Since 1550 AD, the fire evolution in the Sichanghu area has undergone three distinct phases: a high-frequency fire occurrence period from 1550 to 1740 AD, a low-frequency fire occurrence period from 1740 to 1900 AD, and a period characterized by frequent and highly variable fire events since 1900 AD; (2) The L/W (length/width) ratio of charcoal indicates that the primary fuel source for fires from 1550 to 1780 AD was predominantly woody plants, whereas from 1780 AD onwards, the fuel composition shifted to being primarily herbaceous; (3) A comprehensive analysis of regional fire-vegetation-climate data over the past 400 years suggests that the Sichanghu area is more vulnerable to fire under arid environmental conditions, and the combustibles are closely related to the composition of regional vegetation. The impacts of human activities on fire history in this region needs further study.

Keywords: Xinjiang, Charcoal, Fire events



Session 05. Understanding drivers of paleo sea-level changes through proxies and modeling

Conveners: Juliet Sefton, Matteo Vacchi, Tamaro Pico, Roger Creel, Holly Han

【A0193】 -Poster

Exploring the potential use of shallow marine sediment cores for paleoenvironmental investigation of the Yellow Sea glacial land bridge

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The last glacial period was marked by a global scale drop in sea level, exposing many continental shelf areas where land bridges may have existed. The Yellow Sea, located between mainland China to the west and the Korean Peninsula to the east, is currently a shallow sea with an average depth of about 45 m, connected to the Pacific Ocean via the East China Sea to the south. Prior to the last deglaciation and subsequent rise of sea level during the Holocene, this area would have been subaerially exposed, potentially serving as a regional land bridge for Pleistocene animals and Paleolithic humans. However, to date, this area has not been the focus of detailed paleoenvironmental investigations, despite the many interesting research questions it may raise. For example, was the exposed shelf merely a migration route, or did it function as a coastal marine or lake-rich plain that supported large Pleistocene mammals and ancient hunter-gatherers, as suggested by a model-based sea-level reconstruction study? Moreover, although much research on paleoenvironmental changes during the Holocene, including centennial scale sea-level fluctuations, monsoon climate evolution, and human cultural development, has been conducted using estuary, lake, and wetland sediment cores from the current inland area of the Korean Peninsula, studies on late Pleistocene records remain relatively scarce. This scarcity is attributed to the predominantly erosional conditions believed to have prevailed across much of the peninsula's current inland regions during the last glacial period. Investigating the currently submerged Yellow Sea offers an opportunity to address this gap by providing access to long, possibly not severely interrupted sediment cores spanning



the last glacial-interglacial cycle, as has been recently investigated off the coast of South Australia and on the Jeju Strait shelf. This presentation will share my preliminary examination of available bathymetric data from the Yellow Sea, focusing on finding local topographic settings that may have retained depositional conditions since the last glacial period. These findings will be compared with known sediment coring locations from previous resource explorations to assess the potential for utilizing the upper sections of archived sediment cores in detailed palynological and paleoceanographic research.

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Keywords: Last Glacial Period, Sea Level Change, Continental Shelf, Land Bridge, Yellow Sea

【A0061】-Poster

Terrestrial and marine palynomorphs record as a tool for paleoenvironmental reconstruction during the Holocene in the coastal plain of Paraty, Brazil

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Continental and marine palynomorphs were performed by collecting two sediment core (JBS1 and JBS2) in the coastal plain of Paraty, southeastern Brazil associated with ^{14}C dating. The main objective was to integrate the data obtained to establish the paleoenvironmental dynamics surrounding Paraty Bay during the Holocene. The drillings were carried out with a manual auger and the sediment were subsampled every 10 cm. The samples were subjected to standard processing for palynomorphs. The sediment core JBS1 presented the oldest age between 5585-5329 cal years BP at 580 cm depth and the sediment core JBS2 presented the oldest age between 7836-7674 cal years BP at 750 cm depth. The integrated analysis indicated a tendency of increasing accumulation of dinoflagellate cysts from the base to about half of the sediment core, confirmed by ^{14}C dating indicating a transgressive movement within the bay. The cysts that stood out were *O. centrocarpum*, *L. machaerophorum* and *Spiniferites* sp. Continental palynomorphs were less frequent at the base of core JBS2, with an increase in their concentration observed from the beginning of the transgressive phase. The JBS1 sediment core presented a higher concentration at the base close to the maximum transgressive. After the transgressive phase and with the beginning of the regressive phase, a decrease in the presence of marine palynomorphs was observed in JBS2 and a slight increase in the concentration of continental palynomorphs in JBS1. The influence of the transgression and subsequent marine regression observed during the Holocene in this coastal have initially favoured the establishment of an oligotrophic environment, allowing the establishment and subsequent deposition of marine palynomorphs. In the regressive phase, the reduction of previously flooded areas allowed the establishment of different plant formations.

Keywords: Palynomorphs, Sea-level variation, Quaternary, South America

【A0191】 -Oral

Sea levels since the Last Glacial Maximum from the Atlantic coast of Africa and Southeast Asia

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Reconstructions of relative sea-level (RSL) change from far-field regions since the Last Glacial Maximum (LGM) provide fundamental constraints to global ice volumes. Here, we present two new databases that quantify the magnitudes and rates of sea-level changes along the Atlantic coast of Africa and Southeast Asia from the LGM to present.

(1) Along the Atlantic coast of Africa, a database of 341 sea-level index points reveal RSL dropped from -99.4 ± 5.2 m at 26.7 ± 0.5 ka BP to -103.0 ± 0.8 m at 19.9 ± 0.8 ka BP at -1 mm/yr. From ~ 15 to ~ 7.5 ka, RSL show phases of major accelerations with rates up to ~ 25 mm/yr and a major deceleration triggered by the ~ 8.2 ka cooling event. In the mid to late Holocene, data indicate the emergence of a sea-level highstand, which varied in magnitude (0.8 to 4.0 m above present mean sea level) and timing (5.0 to 1.7 ka BP).

(2) In Southeast Asia a database of 113 sea-level index points show RSL rose from a lowstand of -121.1 m at 20.7 ka BP to -112.3 m at ~ 19 ka BP at rates of RSL rise up to ~ 7 mm/yr. Between ~ 16 ka and ~ 13 ka BP, RSL rose to -70 m with a cluster of SLIPs associated with the Meltwater Pulse 1A. The average rate of RSL rise reached ~ 15 mm/yr. In the Holocene RSL rose from -20.6 m at 9.4 ka BP to -0.25 m at ~ 7 ka BP at a maximum rate of 15 mm/yr. The rate of RSL rise subsequently slowed as RSL continued to rise and reached a mid-Holocene highstand of ~ 4.6 m at 5.2 ka BP. SLIPs constraining the mid- to late-Holocene transition suggest RSL fell below present level to -2.2 m between ~ 2.5 and ~ 0.25 ka BP at a rate of -1 mm/yr.

Keywords: Sea level, Southeast Asia

【A0525】-Poster

Lambert Glacier-Amery ice shelf system and solid earth response since last Deglaciation: Evidences from Lake sediments

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The East Antarctic Ice Sheet (EAIS) is vulnerable to future climate change and global sea level rise. However, significant uncertainties remain regarding its dynamics, particularly its response to sea level changes and interactions with the solid Earth. Understanding the past dynamics of the Ice Sheet is crucial for assessing ongoing glacial isostatic adjustment (GIA) and its potential impacts on both sea level and solid earth response. This knowledge gap arises from a lack of understanding of the past relative sea level (RSL) changes and their causal factors, particularly after the last glacial maximum (LGM). Low-elevated lakes of coastal oases viz., Larsemann Hills, Vestfold Hills and Rauer Group record RSL changes in their sedimentary sequences. In particular, for Larsemann Hills (LH), the low-elevated coastal lakes record such signatures. Here, we analyzed two radiocarbon-dated sediment cores (DL2 and DL3) from freshwater Lake Discussion (5 m above sea level (asl)), Larsemann Hills. DL2 spans 6–17.1 cal. kyr BP and DL3 covers 0–6 cal. kyr BP. Combined diatom analysis showed marine species dominance from 17.1 to 2.8 cal. Kyr BP suggested the lake was a marine basin. A brackish-water diatom revealed a transition occurred between 2.7 and 2.3 cal. kyr BP, followed by freshwater diatoms from 2.3 cal. kyr BP to present, indicating isolation from marine influences. Based on nearby Mochou Lake's (10m asl) lack of marine phases from deglaciation to recent, we hypothesize RSL in the LH ranged from 5 to 10 m asl from the Last Deglaciation to 2.7 cal. kyr BP. The persistence of Discussion Lake as a marine basin during the 123 m rise in eustatic sea level (ESL) and its transition to freshwater at 5 m asl since 2.7 cal. kyr BP suggests 128 m of isostatic uplift in the Larsemann Hills since the last deglaciation. During the deglaciation period, the highest upliftment rate occurred between 14.5 and 14 cal ka BP, which coincided with the $\delta^{18}\text{O}$ records of ice cores, exposure dates at the Rauer Group, and melting flux proxies indicating an increased retreat of the Lambert Glacier-Amery Ice Shelf system. During the Holocene, the highest isostatic upliftment rate was recorded from 11.2 to 9 cal. kyr BP, coinciding with the timings of accelerated retreat of the Amery Ice Shelf and EAIS, as evidenced by marine and proglacial lake records. The mechanism driving the retreat of the Amery Ice Shelf grounding line, which triggers rapid isostatic uplift of the EAIS, is believed to be the southward shift of the Southern Hemisphere Westerlies during Meltwater Pulse 1A and the early Holocene. This shift likely brought warm Circumpolar Deep Water closer to Antarctica. Our findings highlight the dynamic interplay between GIA, glacial retreat, and oceanic forcing, with significant regional variations throughout the deglaciation and Holocene.



Keywords: East Antarctic ice sheet, Last deglaciation, Relative sea level changes, Prydz Bay, Amery ice shelf

【A0049】 -Poster

Multidisciplinary analysis of Pleistocene beach ridges unveiling sea-level and environmental conditions during glacial-interglacial cycles in the Thai-Malay Peninsula

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Beach ridges, as relict coastal landforms, preserve subsurface deposits that are crucial for reconstructing past sea-level and environmental changes. However, beach ridges that formed during the Pleistocene are particularly vulnerable to modifications due to post-depositional processes, which are influenced by sea-level changes and climatic events occurring during glacial-interglacial cycles. This study utilizes a multidisciplinary approach including ground-penetrating radar (GPR) surveys, sedimentological analysis, and luminescence dating to examine the evolution of beach ridges in relation to sea-level fluctuations and past environmental conditions on the Thai-Malay Peninsula. Our findings reveal evidence of beach progradation that highlights the deposition of coarse-grained sediments in a high-energy environment on the beach face. Subsequently, these beach ridges were covered by aeolian layers that were likely reworked at the surface themselves. Luminescence dating indicates that the formation of the beach ridges commenced during the interglacial period of Marine Isotope Stage 5e, with sea levels of < 4.3 m above present mean sea level. Following this period, aeolian activity further modified the ridges during the last global glacial phase, resulting in vertical accretion of the beach ridges. The presence of aeolian deposits suggests a period of climate aridification and reduced vegetation cover in Sundaland.

Keywords: Beach ridges, Pleistocene, Aeolian deposit, Sea level, Luminescence dating, Ground-penetrating radar



【A0116】 -Oral

Underestimated vertical land motion signal in sea-level projections in the Oka estuary, northern Spain: Insights from paleo RSL data and GIA model

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Vertical land motion (VLM) is an important component in sea-level projections, but difficult to derive because of a lack of long-term instrumental records. Geological data offer an alternative solution to determine VLM by comparing RSL data with Glacial Isostatic Adjustment (GIA) models.

Here, we present a case study from the Oka estuary, northern Spain. We compare two GIA models (ICE-6G_C and ANU-ICE) with late Holocene relative sea-level (RSL) data along the Atlantic coast of Europe, showing good fit (misfit < 1.5) at all regions of Europe except for the Oka estuary (misfit > 4.5), which indicates local subsidence. We derive a VLM rate of -0.88 ± 0.03 mm/yr (subsiding) using the residuals between the late Holocene RSL data and GIA model predictions in the Oka estuary. The derived subsidence rate is further validated by nearby GPS (station SOPS, > 15 years) data showing a VLM rate of -0.85 ± 0.14 mm/yr and differenced altimetry-tide gauge data (Bilbao tide gauge, ~30 years) showing a VLM rate of -0.80 ± 0.32 mm/yr. In contrast, the VLM rate incorporated in Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6) projections in Oka estuary is -0.2 mm/yr, which is an underestimation of ~77% compared to the derived VLM rate of -0.88 ± 0.03 mm/yr using longer-term geological data.



Incorporating our VLM rate in IPCC AR6 RSL projections under a moderate emissions scenario increases the rate of RSL rise by 15% by 2030, 11% by 2050, and 9% by 2150 compared to the original IPCC AR6 projections, and also increases the magnitude of RSL rise by over 40% by 2035 and 2090 compared with projections from the Spanish National Climate Change Adaptation Plan. Our study demonstrates the importance of accurate VLM estimates for sea-level projections.

Keywords: Sea-level projection, Vertical land motion, Glacial Isostatic Adjustment, Late Holocene, Subsidence

【A0626】 -Oral

Reconstructing Pliocene-Pleistocene sea-level change through drilling on the tropical Sunda Shelf

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Sea-level variations are crucial for understanding the building-up of the boreal ice sheets and the marked atmospheric cooling events at the Pliocene-Pleistocene transition. However, only the last 0.5 Ma sea level has been documented using several independent methods, while the reconstruction of the earlier part is largely dependent on indirect evidence and interpretations. As the largest tropical shelf in the world, the Sunda Shelf provides particularly well-suited conditions for studies of the Pliocene-Pleistocene sea-level history because of: (1) its equatorial far-field position providing a clear eustatic signal, (2) its flat physiography and large lateral extension sensitively leading to a laterally



expanded signal of sea-level imprints, and (3) extremely high sedimentation rates and relatively continuous sequences particularly of high-level stands during interglacial periods.

Therefore, we proposed through IODP Proposal 1007-Full to drill on tectonically stable sedimentary basins on the Sunda Shelf for reconstructing Pliocene-Pleistocene sea-level change. The scientific objectives of the drilling proposal further include: (1) to reconstruct the development of major river systems in the Sunda Shelf region, the erosional response to tectonic activity in the hinterland, and the flux of weathering products on the shelf, and (2) to evaluate the contribution of the glacial exposure of this major tropical shelf region as a massive sink for carbon and source for atmospheric greenhouse gas emissions, and to assess its role in regulating and shifting global climate.

Keywords: Sea level change, Paleo-river system, Carbon cycling, Pliocene-Pleistocene, Sunda Shelf

【A0571】 -Poster

Evidences of Late-Quaternary sea-level changes in central Kerala, south India and its implications on global records

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The coastal sediments in Kerala are preserved in two distinct geomorphological settings; in palaeo-mudflat/ coastal swamp deposits occurring inland, which are bordered by medium to fine sandy beach-ridge sequence, sub-parallel to the modern shore. While the palaeo-beach ridges generally devoid of shells, the equivalent ancient low energy tidal flats and coastal lagoon deposits show well preserved shells, mostly autochthonous. The study aims to understand the change in palaeo-environments using the abundance of species assemblage of shells in the sediments and radiocarbon and OSL dating to constrain the age of deposition. The samples were collected from five different locations of Thrissur



district, Kerala, located 5-10 km inland from the present shoreline. The sections display lenticular bedding within the mudflat sediments and fossil shells where embedded in the grey sandy clay to clayey substratum at variable depth (between 2-10.5m). In the invertebrate macro-fauna, bivalves and gastropods make up the majority of the specimens, according to the taxonomic compilation of the shells. These organisms have a characteristic range of environments, including marine, marginal marine, and estuarine situations. Planktic and benthic foraminifers were identified from varying depths in the core indicating marine conditions during middle Holocene and late Pleistocene times. Radiocarbon ages constrain the timing of distinct periods of shell accumulation during 6870 ± 220 , 7080 ± 200 , 3350 ± 160 yrs. BP and >40 ka BP. The OSL dating of clastic sediments of younger beach ridge sequence bordering the lagoons/ mudflats largely show age of deposition between 0.5 ± 0.1 ka and 4.0 ± 0.1 ka. The sand units from the palaeo mudflat units at varying depth between 4.6m to 9.2m had shown age of deposition between 40.0 ± 2.0 ka and 55.0 ± 2.0 ka. The shell deposit displays an abundance of well-preserved Holocene shell specimens and slightly altered shells due to the effect of differential taphonomic conditions during late Pleistocene. The marine influence in the species assemblage and the formation of these landforms as a consequence of late-quaternary sea-level fluctuations at distinct time period and associated environmental response is deduced.

Keywords: Quaternary, Sea-level changes, Marine shells, Radiocarbon age, OSL dating

【A1031】 -Poster

Centennial-Scale Variability in Antarctic Surface Mass Balance and its Linkages to Tropical Oceans

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The Antarctic Ice Sheet is a major source of uncertainty in projections of global sea level rise. Understanding the processes governing past mass changes in the Antarctic Ice Sheet is critical for improving these projections. Past mass fluctuations are primarily driven by changes in the ice sheet's surface mass balance (SMB)—the balance between snowfall accumulation and mass loss through melting and sublimation. Using ice core measurements and reconstructed SMB data from the past centuries, we investigate the main driver of the changes in both regional and continental SMB across Antarctica. Our analysis, supported by proxy data and sea surface temperature (SST) reconstructions, identifies centennial-scale changes in tropical ocean conditions as a key contributor to Antarctic SMB variability. Numerical experiments further demonstrate that SST changes in the tropical Pacific and Atlantic significantly influence centennial to multi-centennial variability in snowfall rates over the Antarctic Ice Sheet. This tropical-polar linkage operates through atmospheric teleconnections, particularly via Rossby wave dynamics. While atmospheric teleconnections between the tropics and higher latitudes are well-documented on interannual to decadal timescales, our findings highlight the existence and importance of centennial-scale teleconnections, which have been largely absent from the existing literature. Additionally, investigations using observations and proxy data from both tropical and polar regions suggest that similar mechanisms may also operate on millennial and longer timescales.

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Keywords: Sea level, Antarctic Ice Sheet, Surface mass balance, Tropical oceans, Atmospheric teleconnection

【A0598】-Poster

Modelling Antarctic margin response to Pleistocene like warming

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The Antarctic ice sheet is potentially the largest but most uncertain component of sea level rise under anthropogenic warming. With the twelve months to January 2024 the first to average $> 1.5^{\circ}\text{C}$ warming above pre-industrial, determining how the ice sheet responds to prolonged moderate warming is key to understanding sea level change and coastal impacts in the coming decades to centuries. Warm Pleistocene interglacials, $1\text{-}2^{\circ}\text{C}$ above pre-industrial, are a natural analogue for Antarctica under moderate warming. However, where and how much Antarctica retreated during these periods remains uncertain. Determining whether collapse mechanisms were triggered under moderate Pleistocene warming, and in which regions, is key to improved projections of how the ice sheet will respond to ongoing and future warming.

The GEO-ICE project aims to improve our understanding of Pleistocene glacial-interglacial Antarctic retreat dynamics, by combining numerical ice sheet models with sediment core data – including new cores from the Ross Sea. We present new simulations that explore Antarctic retreat under late Pleistocene interglacial warming. Using physically comprehensive ice sheet model experiments, we simulate Pleistocene Antarctica under idealised forcing scenarios. These experiments resolve key grounding line and ice stream processes, and capture how these respond to Pleistocene-like ocean and atmosphere forcing. We combine novel ice-proximal geochemical proxy records and ice sheet model outputs, to constrain uncertain model processes and improve our modelling framework. This allows us to explore how the Antarctic ice sheet responds to moderate Pleistocene-like warming, which can inform predictions of the ice sheets near-future.



Keywords: Antarctic ice sheet, Ice sheet modelling, Late-Pleistocene, Sea-level rise

【A0686】 -Poster

Holocene sea level dynamics and sediment distribution shaped by geomorphic transformations along the southwest Kerala coast, India

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The marine transgression during the Mid-Late Holocene has resulted in significant geomorphic changes along India's west coast. However, the variations in sea level and sediment input in the coastal marine areas of southwestern Kerala are rarely studied. This study investigates the differences in lithology and texture within a sedimentary sequence of 3.4 meters long deposited over the past 8200 YBP. It provides a complete record of sedimentary evolution in the coastal lowland of the Koduvally region, associated with the Kuyyali River in Kerala, India. The sedimentary layer rests on a lateritic basement, indicating primarily fluvial sediment deposition from early to mid-Holocene. Decomposition of sediment grain size distribution data (GSD) into end Members with End-Member Analysis (EMA) demonstrates deposition of coarser sediment EM6 (mean size 867.95 μm), which consists of very coarse sand to granules, representing components derived from the lateritic basement. Higher fractional abundances of EM3 (EM3; 102.45 μm ; fine sand), EM4 (EM4: mean size 210.75 μm ; medium sand), and EM5 (EM5; mean size 362.82 μm ; coarse sand), particularly between 8200 to 6000 cal yr BP suggest deposition of coarser fluvial flux in the section. The grain size characteristics of this sediment and EM3-EM5 on an M (Median, 50 percentile) and C (coarser, 99 percentile) bivariate diagram demonstrate that sediment of fine to coarse sand domain represents the deposition of river axial facies from rolling, saltating to graded suspension grain populations. Whereas, deposition of dominantly finer, EM1 (EM1; mean size 6.08 μm ; fine silt) and EM2 (EM2; mean size 48.01 μm ; coarse silt) demonstrate a gradual decrease in the coarser fluvial flux since 5800 cal yrs BP and transformation into a low-energy estuarine environment towards the top of the sedimentary section. CM size



characteristics of EM2 and EM1 and sediments deposited between 5800 to recent represent deposition of fluvial suspension to settlement in still water conditions such as those found in estuarine or backwater settings. Deposition of coarser fluvial materials from around 8200 to 5800 cal yrs BP corresponds with a period of rapid changes in the sea level along the western Indian coast. During this period, relatively lower sea levels created space for fluvial deposits to accumulate at the site. On the contrary, the sea-level high-stand since 6000 cal yr BP slowly transitioned into a shallow water estuarine setting, accumulating finer suspension deposits. However, the occasional intercalation of coarser fluvial sediment, along with finer sediment deposited from 5800 to the present, suggests that there were episodes of increased river discharge possibly linked to strong hydroclimatic conditions in the catchment area.

Keywords: Holocene, End Member Analysis, CM Plot, Southwest Indian coast, Palaeoclimate

【A0687】-Oral

Impact of global mean sea level on past and future climates

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The sea level rise is generally understood as a consequence of ice sheet melting during large transient warming at scales from ten to thousand years, as for instance for the last deglaciation and for the on-going anthropic period. Here, we investigate the role of global mean sea level (GMSL) as a driver of climate change in these two different contexts.

A first appropriate period is the Last Interglacial (LIG 130- 115ka), during which the sea level was higher from 3 to 9 m than in the preindustrial period. Idealized general circulation models (GCM) simulations account for this important feature. Superimposed to the classical forcing factors, orbital and green house gases (GHG), usually used to simulate LIG-127ka , a sensitivity simulation to a GMSL of 5 to 10 m has been provided by NORESM-F1 and IPSL-CM6 GCMs (both part of the LIG MIP). These models depict a large sensitivity to GMSL increase. They also present common features on the pattern of mean annual temperature response. Moreover, there is an improvement of model data comparison, especially for NORESM, concerning South hemisphere sea surface temperature. For IPSL, the GMSL increase leads to a cooling over North Atlantic, intensified compared to NORESM, mainly due to a weaker AMOC for preindustrial IPSL simulations. At regional scales, there are also important differences between the two models, especially over the Bering straits, mainly due to the different bathymetry, as well as over Artic Ocean. These results speak for accounting GMSL in modeling LIG.

Interestingly, the impact of GMSL increase from preindustrial simulations has also been investigated for both models using 0.625 and 5 m that corresponds to expected values for the end of this century and next century, respectively.

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Keywords: Sea level, Driver of climate change, Ocean and atmospheric dynamics

【A0993】-Poster

New Common Era sea-level reconstructions from southeastern Australia

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Since the around the 1860s, global sea level has been rising – and accelerating – at a ‘unprecedented’ rate. This rise has been recorded by tide gauges and organic coastal sediment archives worldwide, and advances to understand how this rise manifests at regional to local scales are underway, particularly in the North Atlantic region. In Australia, the tide gauge record is short (mostly since 1950) and there are a limited number of sedimentary records that provide information on sea-level change. The records that do exist indicate the rate of rise in southeastern Australia exceeds the global average in the 20th century. We present two new sea-level reconstructions from southeastern Australia developed from saltmarsh foraminifera at King Island (Tasmania) and Venus Bay (Victoria). We develop chronologies for both sediment records using radiocarbon and lead isotopes. The fossil foraminifera assemblages at both sites indicate local sea-level rise over the past



~150 years. Spatial-temporal modelling of geological sea-level data highlights the contribution of local, regional, and global processes through space and time. This work fits into a larger effort to build a network of sedimentary sea-level records to determine a sea-level 'budget' in southeastern Australia.

Keywords: Sea level, Australia, Saltmarsh, Holocene

【A0358】 -Poster

Mid-Holocene hydro-ecological evolution and human adaptation on the Fenghua River Plain, eastern China

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Sea-level fluctuations have significantly impacted coastal environments and human activities, manifesting as coastal erosion, saltwater intrusion, and storm surges. Although ancient populations exhibited adaptive strategies to coastal environments, their vulnerability remained evident. This study investigates the hydro-ecological evolution and human adaptation at the Xiawangdu site during 6300-4000 cal. yr BP through multi-proxy analyses including chronology, grain size, alkaline earth metals, organic carbon compositions, and pollen and spore. Results indicate that the region experienced marine transgression from 6300 to 5900 cal. yr BP. From 5900 to 5300 cal. yr BP, falling sea levels and progradation of the alluvial plain facilitated the transition of the environment from a low-salinity marsh to a freshwater wetland. Around 5300 cal. yr BP, when sea levels stabilized and a marsh land was formed, the Hemudu people started rice agriculture at the site. Freshwater environment prevailed at the site during 5300 to 5000 cal. yr BP, contrasting the salinity intrusion induced by storm events reported from other sites. It is suggested that the levee of the Fenghua River possibly maintained by the Hemudu people protected the backswamp from salinity intrusion during the storm events. This study



provides valuable insights into ancient human-environment interactions and dynamic adaptation strategies.

Keywords: Backswamp, Sea level, Hydro-ecological Environment, Coastal wetland, Human adaptation

【A0390】 -Poster

Early Holocene sea-level changes along the western Bohai Sea coast: Far-filed responses to meltwater pulses

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Meltwater Pulses (MWP) from the last deglaciation are highly relevant today, as they provide insight into ice sheet melt history and its global impacts, which is vital for improving future sea-level rise predictions. The western Bohai Sea coast (WBSC), located deep within the Asian continent and far from major glaciation centers and subduction zones, exhibits sensitive relative sea level (RSL) responses to meltwater influx, offering valuable data to refine the chronology and magnitude of MWPs. This paper presents 24 high-confidence early Holocene sea-level index points (SLIPs) from high marsh peaty samples, generated through analysis of sediments, microfossil foraminifera, and radiocarbon dating of 14 cores from the WBSC. The altitudes of SLIPs were adjusted for factors such as self-compaction, long-term tectonic subsidence, and water extraction. The early Holocene RSL history in the WBSC reflects a rapid rise in sea level during ~9800–7100 cal a BP, with an average rate of ~7 mm/a, occurring within the global context of global sea-level rise. During ~9800–8100 cal a BP, the RSL rise was faster, averaging ~8 mm/a, characterized by two distinct stepwise increases. A MWP before ~9400 cal a BP was supported by a sharp RSL rise of 14.2 mm/a, despite uncertainties regarding the magnitude and timing onset. The second MWP during 8500 and 8100 cal a BP, adding a total rise of 3.07 ± 1.05 m on the top of background RSL rise, with a two-phase structure



where the main phase produced $2.81 \pm 0.77\text{m}$ occurring in the first phase. After ~ 8100 cal a BP, the RSL rise slowed to ~ 4.5 mm/a, though a minor MWP of 1.06 ± 0.95 m. occurred during 7590 ± 80 cal a BP.

Keywords: Early Holocene, Sea-level changes, Bohai Sea, Melt water pulse

【A0531】-Oral

Holocene geomorphological evolution of a sediment-starved coastal embayment in response to sea level change: Insights from the Qing'ao Embayment, southern China

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Aiming to gain a better understanding of the response of sediment-starved coastal systems to the climate-driven sea level change, this study examines the Holocene evolution history of Qing'ao Embayment, southern China, as a case study. Results suggest three distinct stages of the evolution history: Stage 1 (8400–6000 cal yr BP) records an initial sedimentation phase associated with the early Holocene marine transgression into the embayment. Stage 2 (6000–3000 cal yr BP) records early sediment deposition under relatively strong hydrodynamic inshore/open- bay environment during early marine regression. Stage 3 (3000 cal yr BP to present) records two substages: Stage 3a relates to the semi-enclosed bay, intertidal and lagoonal salt marsh facies between 3000 and 1300 cal yr BP, and Stage 3b records the final infilling of the embayment into a lagoonal plain. This evolution model suggests that the rates of sea level change and sediment accretion are the two major controlling factors for the Holocene geomorphological evolution of



sediment-starving coastal systems. Comparison of the evolution of Qing'ao embayment with sediment-supply rich large-river estuary/deltas reveals unique features in the response to Holocene sea level change of this sediment-starved embayment: During the early Holocene marine transgression, sediment starts to accumulate in the small embayment around 8400 cal yr BP, hundreds of years later than in large river estuaries. During 8400–6000 cal yr BP, sediment accretion rate remains dramatically lower than sea level rise rate, which results in the quick growth of sediment accommodation space during this stage. Around 6000 cal yr BP, though sea level has remained relatively stable and large-river deltas have been growing for about 1000 years, the sediment-starved embayment was still under shallow marine and/or open bay conditions. At 3000 cal yr BP, shoreline started to prograde in sediment-starved embayment, which is about 3000 years later than large river deltas. Finally, agricultural activity started around 1300 cal yr BP in the embayment, thousands of years later than large river deltas. Limited or minimal fluvial sediment supply to the small embayment has constrained the land expansion during the sea level stabilization since mid-Holocene, and the limited living space might result in the much later agricultural activity in such coastal system. Due to the different balances between sea level change and sediment flux, sediment-starved coasts are expected to be under higher risks than large river deltas. However, earlier and more extensive human activities in large river basins have resulted in the reduction of sediment discharge that heighten the risks of large river deltas against future sea level rise. Thus, more attention should be paid to the coastal sediment supply budgets in the context of the background of rising sea level.

Keywords: Sediment-starved coastal embayment, Sedimentary environment, Sea level change, Holocene, Sediment supply

【A0962】 -Poster

Diatom-inferred water depth changes since 1850s in Pinqing Lagoon, a typical coastal lagoon in South China

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Coastal lagoon is a typical wetland whose ecological characteristics influenced by both land and sea, and is an important window of global change. In this study, we chose the largest lagoon in inland China, Pinqing Lagoon, and investigated the diatom communities in 21 surface sediments on the characteristics of lake environmental variables (water chemistry and sediment characteristics). Results showed that the lagoon was dominated by the planktonic diatom *Thalassionema nitzschioides*, the benthic species *Nitzschia granulata*, *Diploneis smithii* and other marine genera, and some freshwater species *Amphora*. Ordination analysis revealed that water depth as the most important variable affecting diatom distribution, explaining 71.8% of diatom variability alone. Therefore a diatom-water depth transfer function model was developed using partial least squares weighted mean regression, which provided strong prediction ability ($R^2 = 0.82$) and low derivation error (RMSE = 0.088). Combined with the diatom records in a sedimentary core (PQ2) and the model, the water level change in Pinqing Lagoon over the past 150 years were quantitatively reconstructed: 1864 - 1945, the water depth decreased from 2.98 m to 1.06 m. and the oceanic influence was weakened; 1945 - 2007, the water depth showed a clear upward trend, rising to 4.20 m, synchronized with the fluctuation of the sea level, and the oceanic influence was strengthened; 2007 - 2019, the declining water levels, weakening marine influence, natural climate change dominates water level changes, and the lagoon is at risk of siltation. The results provides important reference for regional global sea level change, which can provide important data for coastal management and the development of climate change adaptation strategies.

Keywords: Pinqing Lagoon, Diatom community, Water depth, Redundancy analysis, Transfer function



Session 06. Reconstructing marine responses: Oxygen and pH dynamics through time

Conveners: Helena L. Filipsson, Xiaoyi Guo, Babette Hoogakker, Dominik Hülse, Katrin Meissner, Sha Ni, James Rae, Jimin Yu, Shuzhuang Wu

【A0612】-Poster

Foraminifera-bound Nitrogen isotope ratio measurements from the Arabian Sea oxygen-deficient zone over the last 150 thousand years

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The Arabian Sea and the eastern tropical Pacific host the major oxygen-deficient zones (ODZs) of the global ocean. Denitrification in the suboxic sediment porewaters and in the functionally anoxic ODZ water columns is the dominant fixed nitrogen removal mechanism from the ocean. The $\delta^{15}\text{N}$ content of shallow subsurface nitrate increases due to water column denitrification, the upwelling of which produces sinking particulate matter with a similarly high $\delta^{15}\text{N}$ enrichment. Bulk sediment $\delta^{15}\text{N}$ ($\sim \delta^{15}\text{N} / \delta^{14}\text{N}$) measurements from both the Arabian Sea and the eastern equatorial Pacific (EEP) ODZs have indicated glacial-interglacial variability in water column denitrification, with low glacial $\delta^{15}\text{N}$ values commonly followed by a deglacial $\delta^{15}\text{N}$ maximum and subsequently reaching Holocene $\delta^{15}\text{N}$ values that are higher than those of the Last Glacial Maximum (LGM). Lower LGM bulk sediment $\delta^{15}\text{N}$ values were interpreted as lowered denitrification rates during cold periods due to contracted ODZs. However, recently made $\delta^{15}\text{N}$ measurements on foraminifera shell-bound organic matter (FB- $\delta^{15}\text{N}$) from the EEP have indicated comparable LGM and Late Holocene $\delta^{15}\text{N}$ values, suggesting similar water column denitrification strengths between the LGM and the middle to late Holocene. Here we present FB- $\delta^{15}\text{N}$ measurements from two core sites (Sites RC27-24 and RC27-61) located within the Arabian Sea ODZ back to 150 kyr. Preliminary Arabian Sea FB- $\delta^{15}\text{N}$ measurements suggest similar LGM and Late Holocene $\delta^{15}\text{N}$ values, suggesting comparable denitrification rates and ODZ extents between these periods. Our findings so



far suggest analogous Arabian Sea ODZ variability to that observed from the EEP, indicating that the ODZ extents were similar between glacial and interglacials, despite the difference in global climate.

Keywords: Oxygen minimum zone, Oxygen deficient zone, Nitrogen isotopes, Denitrification

【A0516】 -Oral

Imprints of Atlantic Multidecadal Oscillation on pantropical seawater pH inferred from coral $\delta^{11}\text{B}$ records

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Understanding natural variability in seawater pH (pH_{sw}) is crucial for predicting future ocean acidification. Coral boron isotopes ($\delta^{11}\text{B}$) offer an alternative method to extend pH_{sw} records back centuries, shedding light on how pH_{sw} varies over time. This study compiles both new and existing coral $\delta^{11}\text{B}$ records from pantropical oceans to investigate multidecadal pH_{sw} variability and its connection to climate variability. A notable finding is the pronounced influence of the Atlantic Multidecadal Oscillation (AMO) on pantropical coral $\delta^{11}\text{B}$ -pH variations. This is primarily interpreted as the effects of AMO-associated climate changes on reef pH_{sw} , rather than influencing coral physiological processes related to calcifying fluid pH. Key factors like wind speeds and hydrological variability related to Intertropical Convergence Zone (ITCZ) shifts are identified as potential drivers of the AMO's impact on pH_{sw} . This study thus provides valuable insights into the broader effects of the Atlantic climate on pantropical seawater CO_2 system.

Keywords: Multidecadal pH variability, Boron isotopes, Coral

【A0631】 -Poster

Boron Incorporation in coral skeletons: Biomineralization mechanisms and potential for seawater carbonate chemistry reconstructions



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The concentration and isotopic composition of boron in biogenic carbonates (B/Ca and $\delta^{11}\text{B}$) are becoming increasingly popular as proxies for the reconstruction of seawater carbonate chemistry. Empirical calibrations of $\delta^{11}\text{B}$ with seawater pH and B/Ca with $\Delta[\text{CO}_3^{2-}]$ in foraminifera shells have been successfully applied to seawater carbonate chemistry reconstructions during the late Pleistocene glacial cycles. Corals are another important climate archive with the potential for high-resolution paleoceanographic reconstructions, yet the B/Ca and $\delta^{11}\text{B}$ proxies in coral skeletons are not as widely used. This is partly due to our incomplete understanding of the incorporation mechanisms of boron in corals, as strong “vital effects” are observed in many species. Bulk measurements of B/Ca and $\delta^{11}\text{B}$ in scleractinian coral skeletons suggest that the internal $[\text{CO}_3^{2-}]$ and pH in the calcifying fluid of the corals are significantly elevated relative to the ambient seawater, a potential universal mechanism that causes the observed vital effects. To further understand the incorporation mechanism of boron in coral skeletons, we made observations of B/Ca and $\delta^{11}\text{B}$ together with other isotopic ($\delta^{13}\text{C}$ and $\delta^{18}\text{O}$) and elemental proxies in different types of corals, including aragonitic surface and deep-sea corals, as well as calcitic deep-sea octocorals, with a combination of bulk measurements and different in-situ analytical techniques (SIMS, LA-ICP-MS). Our results show strong B/Ca variability following the growth bands of aragonitic coral skeletons, while B/Ca in calcitic corals is more homogeneously distributed. Most notably, the centers of calcification (COCs) in aragonitic coral skeletons show strong depletions in B/Ca as well as $\delta^{11}\text{B}$ compared to the surrounding aragonitic fibers. Seasonal cycles of B/Ca and $\delta^{11}\text{B}$ observed in surface corals could be related to biological manipulation of the skeletal structures in response to environmental changes, as is also inferred from the correlations between B/Ca and other trace elements (e.g. Mg/Ca, Sr/Ca, U/Ca). Overall, B/Ca in corals is significantly positively correlated with seawater $\Delta[\text{CO}_3^{2-}]$, while $\delta^{11}\text{B}$ in corals seems to track ambient seawater pH. Robust reconstruction of past seawater carbonate chemistry with B/Ca and $\delta^{11}\text{B}$ requires better understanding of the biomineralization mechanisms of corals through a combination of geochemical observations and numerical modeling.



Keywords: Corals, Boron, Trace elements, Seawater carbonate chemistry, Biomineralization

【A0005】 -Oral

Orbital-timescale deep Southern Ocean CaCO_3 saturation state variabilities during the Miocene Climate Optimum

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The role of the Southern Ocean played in regulating the marine carbon cycle during past warm periods is uncertain. Here, we present a 2 million-year-long reconstruction of carbonate chemistry in the deep Southern Ocean based on boron to calcium ratios in benthic foraminifera during the Miocene Climate Optimum (MCO) period, when atmospheric CO_2 levels ranged between about 400 and 800 ppmv, and the ocean was 4 to 10 degrees warmer than the present. Our record shows orbital timescale variabilities in the amount of carbon stored in the deep Southern Ocean, indicating that the Southern Ocean carbon cycle was coupled with Earth's climate during the MCO. Additionally, the gradients in carbon storage between relatively warm and cold intervals during the MMCO appear to be smaller than that between glacial-interglacial periods during the late Pleistocene, which might imply a different climate-carbon cycle feedback related to the Southern Ocean during MMCO from the late Pleistocene.

Keywords: Miocene, Carbon cycle, Southern Ocean

【A0437】 -Poster

Imaging the past: μCT analysis of foraminiferal morphology to trace marine environmental changes

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Marine environments are currently facing three major environmental challenges: warming, ocean acidification, and deoxygenation. Understanding the severity and long-term impacts of these changes requires context, which geological records can uniquely provide. By examining the environmental conditions of the past, we can gain insights into the processes driving these changes, their potential impacts, and the resilience of marine ecosystems. Paleoceanography has traditionally relied on the distribution of species as proxies for interpreting past marine conditions, with geochemical methods later augmenting this approach. However, as new technologies emerge, we have the opportunity to study past coastal environments through a different lens.

In this study, we investigate the use of foraminiferal shell morphology to reconstruct historical environmental conditions in coastal zones. Specifically, we apply synchrotron-based X-ray microcomputed tomography (SR μ CT) to capture highly detailed 3D images of calcareous foraminifera from various sites and time periods across the Baltic Sea region. This imaging allows us to quantify shell properties—such as volume, thickness, and pore density—which serve as proxies for environmental parameters like temperature, acidity, and oxygen availability. By organizing these properties into time-series, we generate a robust dataset that traces morphological changes over time, revealing shifts in environmental conditions in a way that complements traditional faunal analysis.

In addition to presenting our findings, we discuss both the advantages and limitations of using μ CT and 3D imaging in paleoenvironmental research, including the challenges associated with analyzing and managing large datasets. Our work represents a step forward in applying advanced imaging techniques in environmental science, showing how morphological data can enhance our understanding of climate and environmental change in coastal ecosystems. This approach can potentially deepen our understanding of ecosystem resilience and variability, especially under the current pressures of anthropogenic change.



Keywords: Deoxygenation, μ CT, Morphology, Microfossils, Foraminifera

【A0427】-Poster

The east Pacific Oxygen Minimum Zone during the Pliocene

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Global climate during the Pliocene (5.33-2.58 Ma) was similar or even warmer than today's climate such that this period provides a potential analog on how future global climate change may look like. Although the Pliocene has been studied extensively, major gaps in our knowledge are still existing, specifically in the east Pacific. During the early Pliocene the east Pacific was likely warmer than today, the equatorial cold tongue did not exist yet and the Oxygen Minimum Zones (OMZ) may have been less intense or even absent. This overview attempts to look at the history of the OMZ in the east Pacific both on a long-term timescale, i.e. from the early Pliocene to after the onset of Northern Hemisphere Glaciation (NHG), and on a shorter, glacial-interglacial timescale. We reconstruct variability potentially related to the OMZ from (I)ODP sites U1338, 1236 and 1241 using different foraminifera-based proxies. Changes in the stratification of the water column, related to upwelling intensity and ventilation, are reconstructed by temperature (Mg/Ca) and relative salinity ($\delta^{18}\text{O}_{\text{sw}}$) analysed on *Trilobatus sacculifer*, *Neoglobobulimina dutertrei*, and *Globobulimina crassaformis* representing different water depths. Nutrient utilization in the water column related to the upwelling of nutrients is reconstructed by nitrogen isotopes ($\delta^{15}\text{N}$) determined on the shells of *T. sacculifer* and may be related to changes in the OMZ. Specific changes in the OMZ are reconstructed via the planktic foraminifer *Globobulimina hexagonus*. Changes in its abundance, in the porosity of its tests, and the Mn/Ca of the tests show a strong affinity with the intensity of the OMZ. Our results suggest a strong control of OMZ variability by low-latitude insolation as expressed by clear precession cyclicity in both the $\delta^{15}\text{N}$ and *G. hexagonus* records before the



intensification of NHG, while after onset of the NHG a strong obliquity component is present in the records related to high latitude influence.

Keywords: Oxygen minimum zone, Foraminifer geochemistry, Pliocene, Porosity, Eastern equatorial Pacific

【A0070】 -Poster

Proxies of hypoxia and Submarine Groundwater Discharge in the coastal ocean: Foraminiferal shell chemical perspectives

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Coastal marine settings are important in terms of geochemical cycles and biological productivity. Climate change is predicted to affect coastal environment via hypoxia and Submarine Groundwater Discharge (SGD). Appropriate proxies could help to better understand oxygenation history and the role of SGD in regulating hypoxia. This would also benefit prediction of potential outcomes of future environmental changes. The sensitivity of benthic foraminiferal shell chemistry to environmental conditions opens the possibility to use them as proxies of coastal hypoxia and SGD. We report here that the average Mn/Ca ratios in tests of living benthic foraminiferal shells in the Changjiang River Estuary (CJE) is 2.3 times higher during hypoxia periods than under well-mixed conditions. In addition, Ba/Ca ratios in living benthic foraminiferal shells co-varied well with radon-inferred SGD signals. Fluctuations of Mn/Ca and Ba/Ca ratios in tests of a single foraminiferal shell along successive chambers corresponds well with seasonal-scale variations of hypoxia and SGD. We suggest that Mn/Ca and Ba/Ca ratios within intra-tests of benthic foraminifer can provide a reliable proxy for past hypoxia and SGD trends.



Keywords: Benthic foraminifera, Coastal hypoxia, Submarine groundwater discharge, LA-ICP-MS, Mn/Ca and Ba/Ca ratios

【A0558】 -Poster

Paleoproductivity and deep-sea oxygenation in Cosmonaut Sea since the Last Glacial Maximum: Impact on atmospheric CO₂

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The paleoproductivity in the Southern Ocean plays an important role in controlling the atmospheric CO₂ concentration. Here we present a sediment record of ANT37-C5/6-07 gravity core, which was retrieved in the Cosmonaut Sea (CS), Indian Ocean sector of the Southern Ocean. We found that the change of oxygen concentration in CS bottom water is tightly correlated with atmospheric CO₂ fluctuation since Last Glacial Maximum (LGM). Combined with the change of export production, we reconstruct the evolution history of deep-water ventilation /upwelling in the studied area. During LGM, a large amount of respiratory carbon was stored in the bottom of deep Southern Ocean, caused by low export production and restricted ventilation. The oxygen concentration was low at the same time. Despite the increase of paleoproductivity, the "biological pump efficiency" maintained a low level during the Last Deglaciation. Vast quantities of "aged" CO₂ was released into the atmosphere by enhanced upwelling. The recovery of the ventilation also supplied oxygen-rich surface water to deep ocean. Moreover, signals are identified during the transition of HS1, ACR and YD periods. During the early Holocene, the slow increase in paleoproductivity, coupled with a drastic reduction of preformed carbon reservoir, resulted in a rapid increase in the oxygen content of the CS bottom water to the peak. In the late Holocene, productivity increased overall, and oxygen in the bottom water was consumed but still at a high level. It may be caused by the enhanced ventilation and/or the prevalence of East Cosmonaut Polynya (ECP) near Cape Anne, which needs to be proved with more evidence.



Keywords: Paleoproductivity, Oxygenation, Last Glacial Maximum, Carbon cycling, Cosmonaut sea

【A0805】-Poster

Did the deep subpolar North Atlantic lose its breath during glacials of the Mid-Pleistocene Transition?

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The Mid-Pleistocene Transition (MPT; 1250–700 kyr) is a key interval for understanding the Earth's climate evolution over the Pleistocene. As The transition from 41-kyr to 100-kyr climate cycles occurred in absence of any significant shift in orbital forcing. The increase of carbon storage in the deep ocean between MIS 24–MIS 22 has been suggested as a main internal factor leading to the transition to 100-kyr glacial cycles. The subpolar North Atlantic is a region of deep-water convection today. This process driven by physical (density) gradients between surface and deep ocean provides oxygen to the deep ocean. Here we present sedimentary redox proxies and benthic foraminifera data that demonstrate persistent dysoxic conditions during the MPT at IODP Site U1314 (58.36°N; 27.88°W, 2800 m depth), in the subpolar North Atlantic. Specifically, during cold intervals between 950 and 860 kyr, benthic foraminifera species sensitive to the high pore-water oxygen concentration disappeared, and concentrations of Mn oxides and reactive P mineral phases, both influenced by redox state, showed reductions larger than 50%. This interval coincides with the delivery of large amounts of fresh water during ice-rafted delivery events, and higher abundance of polar planktonic microfossils with an ice-related habitat. We hypothesize that changes in the density of the surface ocean and extended sea-ice cover caused a reduction in the deep-water convection, which decreased bottom-



water oxygenation and favored carbon storage in the subpolar North Atlantic. Coeval changes in surface ocean and bottom oxygen conditions are observed in the Southern Ocean, suggesting a connection between internal climate amplifiers from both polar regions contributing to the decrease $p\text{CO}_2$ during the MPT.

Keywords: Mid-Pleistocene transition, Oxygenation, North Atlantic, Benthic foraminifera, Redox

【A0998】 -Poster

Deep water oxygenation changes in the Northwest Pacific Ocean during the Pliocene-Pleistocene climate transition

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Global ocean oxygen loss is projected to persist with warming climates in the future, but Earth system models have not yet provided a consistent picture of how it will influence the deep ocean. In this study, we present a deep water oxygenation record based on redox-sensitive elements from ODP 1208 on the Shatsky Rise in the North Pacific from the middle Pliocene to early Pleistocene (2.5-3.6 Ma). During this period, the deep Pacific consistently exhibited lower oxygen concentrations during glacial periods, in contrast to enhanced oxygenation during interglacial periods. A long-term decline in oxygenation from the middle Pliocene to the early Pleistocene, coinciding with global cooling and decreasing atmospheric CO_2 levels, is also observed. This trend is most likely associated with reduced deep ocean ventilation due to a weakened North Atlantic Overturning Circulation.

Keywords: Bottom water oxygen, Glacial-interglacial cycles, The Pliocene-Pleistocene transition, Northwest Pacific

【A0910】 -Poster

Magnetofossil reconstruction of late Quaternary oxygen evolution in the Bengal Fan



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Reconstructing past oceanic oxygen levels is crucial for understanding the dynamics of global climate change. In this study, we use magnetofossil proxies to reconstruct oceanic oxygen conditions. By analyzing modern sediment samples from the Bengal Fan, we assess the reliability of magnetofossil-based oxygen indicators. Our findings reveal a negative correlation between magnetofossil morphologies and bottom water oxygen concentrations (BWO): higher oxygen concentrations are associated with a lower proportion of elongated magnetofossils. This indicator is then applied to two sediment cores from the middle and lower Bengal Fan. We observe that during the Last Glacial Maximum (LGM), the proportion of elongated magnetofossils was significantly higher than during the Holocene, indicating reduced BWO during the LGM. We suggest that the influx of Antarctic Bottom Water and weak ocean ventilation during the LGM may have contributed to the observed oxygen decline. This study highlights the potential of magnetofossils as a valuable tool for reconstructing past oceanic oxygen conditions and provides insights into the mechanisms driving oxygen fluctuations in the past.

Keywords: Magnetofossil, Environmental magnetism, Redox conditions, Northern Indian Ocean

【A0952】-Poster

Possible feedback mechanisms in alkalinity transport during glacial-interglacial cycles

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Glacial-interglacial cycles may be accompanied by shifts in alkalinity inputs to the ocean, driven by fluctuations in rivers, groundwater discharge, mid-ocean ridge hydrothermal circulation, and other sedimentary and water-rock interaction processes. This study explores how these processes influence alkalinity sources and sinks using a multi-element Monte Carlo simulation. By analyzing the distinct impacts of each process on the ocean's major ion ratios, we identify scenarios that align with the current ocean composition, including steady-state conditions.

Our sensitivity analyses reveal several plausible scenarios, such as increased riverine and mid-ocean ridge hydrothermal fluxes, decreased carbonate precipitation, and reduced low-temperature circulation through oceanic crust. Building on these scenarios, we investigated feedback mechanisms involving sea-level changes, $p\text{CO}_2$, pH, and CaCO_3 preservation during glacial-interglacial transitions.

For example, enhanced saline groundwater flux during cooling may moderate the rate of temperature decline during glacials, while reduced flux during warming may dampen the rate of temperature rise during interglacials. These findings provide valuable insights into the dynamic interplay between alkalinity fluxes and climatic feedbacks over geological timescales.

Keywords: Ocean chemistry, Carbon ocean cycle, Alkalinity ocean fluxes

【A0483】-Poster

Redox records in the northernmost Arabian Sea: implications of the deep circulation in Indian Ocean

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The Arabian Sea hosts the largest OMZ (Oxygen Minimum Zone) in the world and strong denitrification occurs throughout the entire Arabian Sea. Previous studies found different sedimentary $\delta^{15}\text{N}$ records in the Arabian Sea and inferred the spatial difference in the evolution of OMZ was caused by monsoon and the ventilation of intermediate waters. In order to evaluate the influence of ventilation on OMZ strength, the deep circulation in north Indian Ocean were analyzed using geochemical records of multiple cores from intermediate waters to deep waters in north Arabian Sea. All $\delta^{15}\text{N}$ records indicate consistent variations of OMZ strength in north AS and large-amplitude millennial changes mirror climatic changes recorded in Greenland ice cores $\delta^{18}\text{O}$ and stalagmite $\delta^{18}\text{O}$. Low $\delta^{15}\text{N}$ values during Dansgaard-Oeschger (DO) stadials suggest inactive or weak OMZ during cold periods, while OMZ strengthened during warm interstadials. Vertical profiles of Sr/Ca ratios indicate the variability of Antarctic Intermediate Water (AAIW) since last glaciation. The strongest AAIW was found during H1 and it can increase the preservation of aragonite in sediments above 2200 m. The redox record of cores below 2500 m is consistent with other deep water records in Indian Ocean and Pacific Ocean, suggesting sluggish circulation during Last Glacial Maximum and increasing ventilation since H1.

Keywords: Arabian sea, Redox conditions, Antarctic intermediate water, Deep circulation

【A0154】 -Oral

Reconstructing the oxygen depth profile in the Eastern Equatorial Pacific during the last glacial period

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Reconstructing the strength and depth boundary of oxygen deficient zones (ODZs, oxygen < 50 $\mu\text{mol/kg}$) in the glacial ocean advances our understanding of how ODZs respond to climate changes. While many efforts have inferred better oxygenation of the glacial Eastern Equatorial Pacific (EEP) ODZ from qualitative and quantitative indices, oxygenation and vertical extent of the glacial ODZ is not well quantified, and sometimes controversial. Here we reconstruct the oxygen depth profile in the glacial EEP using two independent



paleo-oxygen proxies (benthic foraminiferal surface porosity and benthic foraminiferal carbon isotope gradient), from six sediment cores with water depths ranging from ~600 to ~3200 m. We find that compared to modern, the glacial oxygen concentrations were approximately ~10 $\mu\text{mol/kg}$ higher in the upper ocean (at ~ 600 m), the lower ODZ depth boundary deepened to ~2.2 km, and oxygen was 20 – 80 $\mu\text{mol/kg}$ lower at greater depths (~1.5 – 3.2 km). Comparison with Arabian Sea glacial oxygen reconstructions suggests that glacial oxygen loss at intermediate depths (1 – 2 km) was larger in the EEP than the Arabian Sea, with implications for glacial ocean circulation and carbon storage. These emerging semi-quantitative reconstructions of glacial oxygen are valuable targets for future data-model comparison.

Keywords: Oxygen, Pacific, Glacial

【A0595】 -Oral

Multiproxy reconstructions for bottom water oxygenation dynamics in the Gulf of Cadiz during the Early to Middle Pleistocene Transition (EMPT)

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The Early to Middle Pleistocene Transition (EMPT, 1200-700 kyr) marked a change in how Earth's climate system responded to orbital forcing. Throughout the EMPT, the frequency of glacial-interglacial cycles shifted from ~ 41 kyr to ~100 kyr, which resulted in more intense and longer-lasting interglacial periods. While the EMPT has been studied worldwide, the impacts of those changes in the Gulf of Cadiz, a transition zone between



the Mediterranean Sea and the Atlantic Ocean, are still mostly unknown. High-resolution records from the Gulf of Cadiz, provide insights into variations in bottom water conditions during this interval. By analyzing the sediment sequence from IODP Site U1387 (559m water depth), which is currently influenced by Mediterranean Outflow Water (MOW), we reconstructed bottom water oxygen conditions from Marine Isotope Stage (MIS) 32 to MIS 19 (1100-761 kyr). In this study, we provide reconstruction of relative oxygen concentration changes, based on benthic foraminifera assemblage data, carbon isotope gradients between epifaunal and deep-infaunal benthic foraminifera species, and U/Mn ratios in authigenic coatings of planktonic foraminifera. Our results indicate that periods of reduced bottom water ventilation along with reduced MOW flow strength during interglacial intervals are marked by decreases in oxygen levels, as reflected in all the proxy records. This signal is fully decoupled from the strong interglacial Atlantic Meridional Overturning Circulation and associated well-oxygenated North Atlantic waters. The decrease in diversity during low-oxygen intervals further supports the interpretation of stressing environmental conditions and highlights the impact of reduced MOW flow. The lower diversity might also reflect an increase in food supply, which favors specific benthic foraminifera species adapted to nutrient-rich, low-oxygen environments. Conversely, periods of higher oxygen levels are characterized by more diverse fauna, consistent with U/Mn ratios that indicate lower oxygen fluctuation and reduced environmental stress. This pattern highlights the impact of oxygenation and nutrient availability on benthic foraminiferal communities. Therefore, we hypothesize that longer periods of low oxygen levels as recorded by both geochemical proxies are likely attributed to reduced ventilation of the MOW in consequence of sapropel formation in the eastern Mediterranean Sea and increased rainfall and river run-off in southern Iberia. Short episodes of low oxygen levels, indicated by the carbon isotope gradient but not reflected in the U/Mn data, could be related to increased surface productivity. This scenario is exemplified during MIS 25, when seasonal upwelling is indicated by *Chaetoceros* spores. Our multiproxy approach for reconstructing past oxygenation provides a more robust interpretation compared to relying on a single proxy. Incorporating diversity indices and assemblage data further allows distinguishing between signals of productivity and low-oxygen conditions.

Keywords: Early to Middle Pleistocene Transition, Gulf of Cadiz, Benthic foraminifera, Mediterranean outflow water, Bottom water oxygenation

【A0327】 -Poster



Tracking the Oxygen Minimum Zone in the Arabian Sea during the Holocene

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Understanding the development of oxygen minimum zones (OMZs) in interglacial oceans is crucial for deepening our knowledge of their potential responses to ongoing climate change. The Arabian Sea contains the world's thickest OMZ, characterized by suboxic intermediate waters composed of distinct water masses that are integral to global ocean circulation. Despite extensive efforts using qualitative indicators to infer past oxygenation changes within this OMZ, the severity and spatial extent of deoxygenation during the Holocene remain poorly constrained. This study integrates foraminiferal morphology and geochemistry as complementary proxies to reconstruct past seawater conditions. By analyzing the porosity, trace element ratios (Mg/Ca and U/Ba), and stable isotopes ($\delta^{13}\text{C}$ and $\delta^{18}\text{O}$) of the benthic foraminifer *Uvigerina peregrina* from various water depths and locations in the Arabian Sea, we aim to reconstruct the distribution of the OMZ and its relationship to water mass composition during the Holocene. We employ the state-of-the-art Earth system models, including the Max Planck Institute Earth System Model (MPI-ESM) and the Model for Interdisciplinary Research on Climate, Earth System version 2 for Long-term simulations (MIROC-ES2L), to explore mechanisms governing oxygen dynamics in the Arabian Sea. These simulations provide a framework to assess the temporal evolution of the Arabian Sea OMZ and its sensitivity to changes in ventilation, biological production and remineralization of organic matter. The integration of proxy data and transient simulations allows us to generate a comprehensive evolution map of the Arabian Sea OMZ during the Holocene, underscoring the significant role of water mass variability, circulation dynamics, and the monsoon-driven upwelling system in modulating oxygen levels. This study also highlights the uneven distribution and temporal variation of oxygen



concentrations across the Arabian Sea, driven by complex interactions between local and global processes.

Keywords: OMZ, Arabian sea, Benthic foraminifera, Oxygenation, Holocene

【A0465】-Poster

Fe availability drove biogenic magnetite production in the early Eocene proto-Mediterranean region

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Biogenic magnetite is produced by magnetotactic bacteria in marine environments with elevated Fe and low oxygen (O₂) concentrations. These conditions are common during geological global warming events, which have motivated generation of biogenic magnetite content records that have been used as proxies for O₂ variability. However, the specific controls of Fe and O₂ availability in biogenic magnetite production have not been identified separately; hence, it is still unclear if magnetotactic bacteria biomineralization products reveal either Fe inputs to marine settings or reduced marine O₂ levels. To better understand the paleoenvironmental significance of biogenic magnetite, we present geochemical, rock magnetic and electron microscopy data from the proto-Mediterranean Contessa Road section (Gubbio, Italy). This marine sedimentary section contains records of early Eocene global warming events, which were characterized by enhanced Fe inputs from continents to oceans and widespread marine deoxygenation. Our new datasets reveal that biogenic magnetite content variability correlates with detrital mineral input indices, which suggests that biogenic magnetite contents are not suitable for studying O₂ variability directly. Alternatively, at the Contessa Road section, these minerals indicate enhanced Fe availability as a result of warming-induced



hydroclimate shifts. Our observations reveal that the geological significance of biogenic magnetite may change according to different local paleoenvironmental conditions, which suggests that its use as a Fe and O₂ variability index should be complemented with other proxy data.

Keywords: Biogenic magnetite, Fe And O₂ availability, Early Eocene global warming

【A1022】 -Oral

Weakened ocean circulation and increased river runoff as the main drivers of deglacial strengthening of the oxygen minimum zone off the Angolan margin

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Recent research has shown a strengthening of the oxygen minimum zone (OMZ) off the Angolan margin over the last 43 kyr BP, driven primarily by long-term warming in the subtropical South Atlantic. In accordance with these authors, the mean temperature over the last 20 kyr was *ca.* 1.7°C higher than during the glacial period (20–93 kyr BP). However, despite this overall warming, temperature variability (especially the relative cooling of the thermocline during the Holocene)—did not improve oxygen conditions in the region. This suggests that additional processes likely contributed to decreased oxygen levels since the last glacial maximum (LGM). In this study, we applied a multiproxy approach to high-resolution core ODP-1078C (11°92'S, 13°4'E; 426 m water depth), collected within the OMZ off the Angolan margin, to investigate the role of African monsoonal precipitation and ocean circulation in the dynamics of this shallow OMZ over the last 30 kyr BP. We used the carbon isotopic difference between epifaunal and deep-infaunal benthic foraminifera (Dd¹³C) and the sediment Mn/Ca ratio (X-ray fluorescence – XRF) to reconstruct bottom-water oxygenation. The Fe/K and Fe/Al ratios in the sediment were used to track changes in the intensity of chemical weathering and increases in river runoff associated rainfall



over West Central Africa respectively, and Zr/Rb as a proxy for bottom-current strength. High Dd^{13}C values indicate well-oxygenated waters ($150\text{--}250\ \mu\text{mol kg}^{-1}$) during the glacial period, which decreased to $50\text{--}70\ \mu\text{mol kg}^{-1}$ during the deglaciation, suggesting an intensification of the OMZ off Angola over the last 20 kyr BP. Increased Mn/Ca values support this pattern during the same period. Additionally, increasing values of Fe/K and Fe/Al ratios indicate wetter conditions in Central Africa and enhanced river runoff since the LGM, while a decrease in Zr/Rb values points to weakened ocean circulation during the same time. Increased river runoff likely intensified upper-ocean stratification, thereby reducing vertical mixing with central waters. This, combined with an enhanced supply of terrestrial organic matter, led to greater remineralization and oxygen consumption. Reduced subsurface ocean circulation likely exacerbated bottom-water oxygen depletion at the core site and the region. We will discuss whether the reduction in surface/subsurface ocean circulation over the last 20 kyr BP was caused by weaker trade or by increased river discharge that amplified stratification and inhibited vertical mixing.

Reference

Portilho-Ramos, R.C., Hebbeln, D., Hoogakker, B., Titschack, J., and Wienberg, C. Warming-driven intensification of the Angolan oxygen minimum Zone over the last 43,000 years. (under internal revision)

Keywords: Southeastern Atlantic, Angola OMZ, Glacial-interglacial, Oxygenation proxies

【A0814】-Poster

Accurate LA-ICP-MS calibration for B/Ca in coral skeleton with matrix-matched standards: A potential proxy for seawater carbonate chemistry

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As one of the primary climate archives, carbonates in different geological settings can record multiple facets of the climate system with their isotopic and elemental compositions. Geochemical measurements of carbonates at high spatial resolution have the potential to generate climate records at annual, seasonal or even higher temporal



resolution, yet such measurements are often costly and limited in analytical precision. The accuracy of *in-situ* measurements of trace elements in carbonates can be additionally complicated by the availability of homogeneous and matrix-matched calibration standards. Here we present a calibration method for multiple element-to-calcium (Me/Ca) ratios in carbonates using LA-ICP-MS. This method is based on a set of commercially available carbonate standards comprising homogenized nano-pellets of natural coral, foraminifera, clam, speleothem, and limestone materials. To our knowledge, this is the first attempt to conduct LA-ICP-MS measurements using calibration lines with up to five matrix-matched external standards. We also systematically evaluate the precision, accuracy, and resolution limits of this calibration method and develop corresponding data reduction codes in MATLAB.

By implementing the aforementioned method, the Li/Ca, B/Ca, Na/Ca, Mg/Ca, P/Ca, K/Ca, Mn/Ca, Fe/Ca, Sr/Ca, Cd/Ca, Ba/Ca, Nd/Ca, and U/Ca of the biogenic carbonate could be determined within a single experiment session with basic instrument setup. Me/Ca ratios in several coral samples (stony coral, bamboo coral, and shallow-water coral) were analyzed through single-point measurements, linear scanning, and 2D mapping. Our preliminary results demonstrate variations in Me/Ca across different regions of the coral skeleton. Combined with the bulk sample Me/Ca by solution ICP-MS and the environmental parameters of the coral samples' seawater surroundings, we discovered the B/Ca in the coral skeleton has a notably strong and significant linear relationship with the seawater $\Delta[\text{CO}_3^{2-}]$ showcasing its potential as a proxy for seawater carbonate chemistry.

Keywords: B/Ca, LA-ICP-MS, Coral, Carbonate chemistry, Matrix-matching

【A0150】 -Poster

The Southern Ocean's role in the global carbon cycle over the last 800 kyr constrained using reconstructions of the CO₂ system

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The Southern Ocean is thought to play a key role in the regulation of atmospheric CO₂, both in the past and into the future. However, owing to sampling difficulties, it has been challenging to obtain the estimates of Southern Ocean (SO) carbonate chemistry required to better constrain this region's role in major carbon cycle change. Here, we present a new planktic $\delta^{11}\text{B}$ record from sediment core PS1506 (68.73°S, 5.85°W) that tracks the pH and surface pCO₂ of the Antarctic Zone (AZ) over the last 8 glacial cycles, providing a testbed for understanding the SO carbon cycle over intervals of major change in ocean-atmosphere CO₂ exchange. These data are complemented by benthic B/Ca and carbonate preservation indices; due to the location of this core on the continental margin of the eastern Weddell Sea, these data allow us to track the source CO₂ chemistry of the dense Antarctic waters that feed the ocean's lower overturning cell. We find coherent CO₂ change between surface and deep waters, indicating persistent formation of AABW that transfers Antarctic surface water signals to depth. Critically, we discover major AZ pCO₂ decline during glacial inception conditions, coinciding with initial atmospheric CO₂ drawdown, highlighting the AZ's key control on glacial-interglacial CO₂ change. After evaluating the proposed drivers, our findings suggest that shifts in Southern Ocean circulation—linked to changes in sea ice and perhaps also influenced by the Southern Hemisphere westerlies—played a key role in this glacial inception CO₂ change. In contrast, the effects of productivity, solubility, and the sea ice 'lid' appear either insignificant or counterproductive in this region and time interval. Overall, these reconstructed CO₂ system dynamics provide critical insights into Southern Ocean carbon cycling and its critical influence on the atmosphere.

Keywords: Antarctic southern ocean, Foraminiferal boron isotope, pH and pCO₂ reconstruction

【A0221】-Poster



Ferromanganese nodules as archives: Unravelling the paleoceanographic variations on the archipelagic aprons of seamounts in Northwestern Pacific Ocean

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The archipelagic aprons of the large deep-sea seamounts of the northwestern Pacific Ocean (NWPO) show potential areas for significant reserves of ferromanganese nodules (FMNs). This study used methods such as mineralogical, element geochemical, Sr-Nd-Pb isotopic, and chronological analyses of FMNs of the Suda Guyot (SG), which was located on the central area of the Marcus-Wake seamounts, in the NWPO. The results indicated current mineralization of the deposit has been ongoing for ~10 Ma yrs. Continuous weakening of the Antarctic Bottom Water (AABW) resulted in a gradual decrease in bottom water oxygen contents around the SG. This in turn resulted in a decrease in cryptocrystalline Fe-vernadite (δ -MnO₂) and elemental contents associated with δ -MnO₂ of FMNs, such as Mo, Te, and Tl. Meanwhile, the contribution of Asian dust to the study area increased, leading to increased Fe, which in turn increased amorphous ferrihydrite (FeOOH), and FeOOH-associated elements such as Ti, Pb, and Th. Productivity gradually increased to its peak value around 4-5 Ma yrs ago, leading to similar trends in REY, Ba, and U. REY contents exhibited a certain correlation with water depth around the SG. The results of this study suggest that the deepening of the Carbonate Compensation Depth (CCD) resulted in higher content of REY of the FMNs in the shallower apron.

Keywords: Ferromanganese nodules, Paleoenvironment, Northwestern Pacific Ocean, Suda guyot

【A0043】-Poster

Evolution of ocean oxygen-deficient zones and nitrogen cycling during the Paleocene-Eocene Thermal Maximum



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Over recent decades, the ocean has experienced substantial oxygen loss, affecting marine ecosystems and fisheries. However, the future response of ocean deoxygenation to global warming remains controversial. The history of ocean deoxygenation can offer important mechanistic insights into its future evolution. Of particular interest is the Paleocene-Eocene Thermal Maximum (PETM), where the magnitude of carbon emission is analogous to the RCP8.5 scenario. Recent studies suggest that the impact of global warming on ocean deoxygenation during the PETM is more complex than previously understood, highlighting the need for further investigation into the extent and spatial distribution of oxygen-deficient zones (ODZs). Here, we present coupled records of foraminifera-bound nitrogen isotopes, marine barite sulfur isotopes, and ocean productivity from the same cores in the South Atlantic. Integrated into isotope-enabled box models, these data suggest the development of “ammonium-type” ODZs and increasing N₂ fixation during the PETM. Simulations of cGENIE support the expansion of ODZs from suboxia to anoxia in the subsurface Atlantic, which is a combined effect of global warming and enhanced productivity. Our findings highlight the potential spatial variability of ocean deoxygenation in a warming world - while the Pacific might experience different oxygenation conditions, parts of the Atlantic thermocline water likely became anoxic during the PETM.

Keywords: Ocean deoxygenation, Oxygen deficient zones, Nitrogen cycle, Marine barite, Paleocene-Eocene Thermal Maximum

【A0228】-Poster

Variations in Mediterranean thermohaline circulation since the Last Glacial Maximum

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The Mediterranean Sea has an active thermohaline circulation system, similar to that of the global oceans. This circulation is highly sensitive to climate change, as evidenced by the rhythmic deposition of organic-rich sapropel layers, which signify anoxic deep-water phases. However, many aspects of the complex interactions between climate and the paleoceanography associated with circulation dynamics, surface hydrology, and sea-level change remain unclear. Here, we present a deep-water record of Nd isotope composition (ϵ_{Nd}) for the eastern Mediterranean Sea (EMS) over the last ~30,000 years, based on the reliable archives of fish teeth/debris and foraminiferal shells. By combining our record with published authigenic- ϵ_{Nd} data and applying a refined box model of the Nd budget, we constrained the Mediterranean circulation variations since the Last Glacial Maximum (LGM), including sapropel S1. During the Last Glacial Maximum (LGM), the unradiogenic ϵ_{Nd} values ranging from -7.4 to -6.5 corresponded to a decline of $44\% \pm 12\%$ in water exchange between the EMS and WMS, due to lower global sea level. Despite the active deep convection, the circulation modes are different and relatively isolated between the EMS and WMS. During the last deglaciation, the increasing trend of EMS deep-water ϵ_{Nd} can be mainly attributed to enhanced Nile runoff. The offset between the stepwise increase in deep-water ϵ_{Nd} and the Nile records is likely due to the potential reservoir effect of EMS deep water in response to surface freshening. This is primarily caused by the increased inflow of fresher, unradiogenic Atlantic water driven by deglacial sea-level rise. During the S1 period, the consistent and radiogenic ϵ_{Nd} ranging from -5.0 to -4.7 indicated a widespread stagnant condition in the EMS below 800 m. This stagnation coincided with a 50% reduction in the EMS-WMS exchange, which was confined to upper waters, featuring an outflow of intermediate water originating from the Adriatic Sea. The deep-water stagnation began approximately 1,000 years before S1 formation, gradually diminished after approximately 8.2 kyr, and concluded with a complete renewal of deep water.

Keywords: Nd isotopes, Mediterranean circulation, Nile river, Sea level, Last Glacial Maximum (LGM)

【A0636】 -Poster

Extremely poleward shift of Antarctic Circumpolar Current by Eccentricity during the Last Interglacial



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The Antarctic Circumpolar Current (ACC) exerts substantial control on the physical, chemical and biological properties of the Southern Ocean, potentially modulating the global carbon cycle and climate. Forcing on the past and future changes in the strength and position of the ACC during warm periods remains little known. Here, we reconstruct the history of ACC extending back to the Last Interglacial (LIG) for two cores in the Scotia Sea. Based on high-resolution sortable silt mean grain size, we find that the bottom current speed is synchronized with eccentricity, superimposed with precession cycles. During the LIG when both eccentricity and precession reached the maximum and global annual mean temperature was 1.0-1.5 °C higher than preindustrial, the current speed reached the maximum to the south of the Southern ACC front, exceeding that in the Holocene by over three-fold, suggesting that the Polar Front shifted ~5° southward. We suggest that eccentricity-driven Antarctic ice sheet retreat/advance dominates the low-frequency ACC frontal migration, while precession-driven shifting of the Southern Hemisphere Westerlies plays the secondary role. Results imply that natural forcing prompts the ACC to shift northward in future, yet, we speculate that anthropogenic warming may counteract such northward migration.

Keywords: The Antarctic Circumpolar Current, Last interglacial, Southern Hemisphere Westerlies, Antarctic ice sheet, Front

【A0360】-Poster

Oxygenation conditions of Pacific intermediate and deep waters during the mid-Miocene

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Earth's climate transitioned from warm to cool during the mid-Miocene, with significant changes in the carbon cycle. A recent study suggests that the remineralization rate of organic matter in the open ocean increased during the mid-Miocene (17-11 Ma), which likely consumed more oxygen and led to lower dissolved oxygen concentration (DO) in the whole ocean. However, there are only few records that directly reflect seawater DO concentration during this time interval. In this study, we combine foraminifera-bound trace element proxy I/Ca with sediment magnetofossils to reconstruct redox conditions of the Pacific Ocean over the mid-Miocene. Consistently high benthic I/Ca data ($>5 \text{ } \mu\text{mol/mol}$) suggest that Pacific intermediate and deep waters were likely highly oxygenated, even though it was much warmer in the mid-Miocene than at present. Both I/Ca and sediment magnetofossil data at various sites were generally invariant, suggesting that the DO in the deep ocean did not change significantly over the mid-Miocene. The southeast Pacific (SEP) record is an exception, where sediment magnetofossil data suggest an enhancement of DO during the Miocene Climatic Optimum (MCO) and a following decrease after that in the intermediate water. This is consistent with a recent study reporting a shrink of oxygen deficient zone in the eastern equatorial Pacific during the MCO. Similarly, the DO in the deep water in the SEP was slightly higher during the MCO than during the Middle Miocene Climate Transition, but the magnitude of change was smaller and the peak of the DO also appeared later than in the intermediate water of SEP. This implies that the redox condition of the deep water was much less affected than the upper and intermediate waters during the mid-Miocene climate change.

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Keywords: Mid-Miocene, Deep ocean, Redox condition, I/Ca proxy, Magnetofossil

【A0125】-Oral

Fish-teeth cerium anomaly evidence for bottom water oxygen in the Paleocene-Eocene Thermal Maximum

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The Paleocene-Eocene Thermal Maximum (~56 Ma) is an analog of ongoing global warming caused by massive carbon emissions, characterized by global temperature rise, ocean acidification, and seawater chemistry perturbations. Despite extensive studies on ocean oxygen changes during the PETM, the concentration and evolution of bottom water oxygen (BWO) in the global open ocean remain poorly constrained due to proxy limitations. Here, we present modern core-top fish teeth Ce anomalies (Ce/Ce*) and assess their relationship to BWO measurements from the Eastern Equatorial Pacific, Arabian Sea, and California margin. The fish teeth Ce/Ce* show a strong semi-quantitative correlation with modern BWO values. We, for the first time, apply this calibration to the PETM, reconstructing BWO from 8 DSDP/ODP/IODP sites in the Pacific, Atlantic, and Indian Oceans. Our results show a rapid increase in fish teeth Ce/Ce* across all sites, but the magnitude is considerably different among



ocean basins and water depths during the PETM. This pattern is further supported by the cGENIE Earth System Model results, depicting a global picture of BWO in the PETM ocean. Our findings demonstrate the fidelity of this novel proxy for paleo-BWO estimates, which can be applied to other geological times and also provide implications for future ocean oxygen changes under climate warming.

Keywords: Paleocene-Eocene thermal maximum, Bottom water oxygen, Fish teeth, Cerium anomaly



Session 07. The end of the '41-kyr world' and the transition to the '100-kyr world'

Conveners: Daniel Baggenstos, Laurie Menviel, Joel Pedro, Chronis Tzedakis, Xu Zhang

【A0924】-Poster

Mediterranean vegetation and climate dynamics across the Early-Middle Pleistocene Transition: A palynological perspective

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Between approximately 1,250 and 650 thousand years ago (ka), Earth's climate underwent a profound transformation as glacial–interglacial (G/I) cycles shifted from ca. 41-thousand-year (ky) intervals to ca. 100-ky cycles, accompanied by more intense glacial periods. This Early Middle Pleistocene Transition (EMPT) occurred without significant changes in Milankovitch astronomical climate forcings, suggesting that the primary climatic shifts were driven by nonlinear interactions within the ocean–atmosphere–cryosphere system. While some studies attribute the transition to long-term processes spanning multiple glacial cycles, others highlight an abrupt shift between Marine Isotope Stages (MIS) 24 and 22 (ca 930–870 ka), often referred to as the "900-ka event". Palynological analyses from the Mediterranean offer critical insights into EMPT, providing a detailed terrestrial perspective that enriches the broader discussion. This study integrates palynological data from the Southern Italian sites of Montalbano Jonico (marine succession: MIS 31 to 18) and Santarcangelo (lacustrine succession: MIS 31 to 21). New high-resolution analyses focus on the critical MIS 26–22 interval at Santarcangelo, which falls within a period of major ocean circulation weakening between MIS 25 and 21 (ca 950–860 ka) marking the onset of the first ca. 100-ky interglacial–glacial cycle and a significant intensification of Northern Hemisphere glaciation. Both sedimentary successions are characterized by high sedimentation rates and exceptional stratigraphic continuity, making them ideal for investigating the timing and nature of environmental responses at both millennial and orbital scales. Their geographical proximity provides a



unique opportunity for integrated analyses, allowing direct comparisons of terrestrial and marine settings across overlapping intervals. This approach is instrumental in examining potential taphonomic biases caused by differing depositional environments and processes. It also facilitates the evaluation of the stratigraphic distribution of taxa no longer present in Italy, such as *Taxodium/Glyptostrobus*, *Cathaya* and *Liquidambar*, enhancing the reliability of inferred climatic and ecological dynamics. Pollen data document significant variations in vegetation structure, effectively capturing G/I cycles and millennial-scale fluctuations, including episodes of heightened climatic variability (e.g. the transition from MIS 25 to MIS 24). G/I cycles are delineated by shifts in vegetation patterns characteristic of Mediterranean littoral environments, i.e. fluctuations between open vegetation and thermophilous forests. Subtropical taxa, such as *Taxodium/Glyptostrobus*, are already in a relict status. In contrast, taxa like *Tsuga*, *Cedrus*, and *Carya* show more consistent representation, although over time, they progressively decline, eventually disappearing from Italy. A comparative analysis along a west-east transect - including palynological data from the Iberian margin, ODP Core 976 (Alboran Sea), Tenaghi Philippon (Greece), and Lake Ohrid (Balkans) - is also presented. This integrative approach underscores the regional variability in vegetation dynamics and hydrological responses across the Mediterranean. It provides valuable insights into the spatial heterogeneity of climate during the EMPT, demonstrating how local environmental transformations were driven by large-scale shifts in atmospheric and oceanographic circulation, including the reorganization of monsoonal systems and the North Atlantic overturning circulation. These processes profoundly influenced precipitation patterns, oceanic temperatures, and the stability of Mediterranean ecosystems during this critical phase.

Keywords: Pollen, Flora, Glacial/Interglacial cycles, Millennial fluctuations, MIS26-21

【A0411】 -Oral

Plio-Pleistocene climate and environmental evolution from 6 million year old ice at Allan Hills, Antarctica

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There is great international interest in extending the ice core record through the mid-Pleistocene Transition into the 40-ka world, and possibly beyond into the warmer climate of the Pliocene. Reconstructions of Antarctic climate and atmospheric composition, uniquely enabled by such cores, would greatly aid in understanding this period of the geologic record. COLDEX (www.coldex.org) is an NSF Science and Technology center that is exploring Antarctica for the oldest possible ice samples, with the goal of reconstructing climate and environmental parameters through the Pleistocene and into the Pliocene. This presentation will review recent results from ice coring at the Allan Hills Blue Ice Area, Antarctica, where basal ice naturally outcrops at the surface. Ice core drilling, and dating with the $^{40}\text{Ar}_{\text{atm}}$ chronometer, have discovered ice samples as old as 6 Ma. Age vs. depth profiles in these cores show complex and in some cases overturned stratigraphy. Dated sections provide “snapshots” in time that we are analyzing for a range of climate parameters, including greenhouse and major gases, proxies for mean ocean temperature, dust, ice chemistry, and the isotopic composition of water. We present a new record of water stable isotope ratios, a proxy for local site temperature, going back 6 Ma and showing long-term cooling across the Plio-Pleistocene. Gas-phase records of atmospheric CO_2 , CH_4 and noble gas ratios (a proxy for mean ocean temperature) have been extended to 3Ma, with implications for our understanding of the Mid-Pleistocene Transition.

Keywords: Mid-Pleistocene Transition, Carbon dioxide, Antarctica, Ice core, Pliocene

【A0215】 -Poster

Changes in South Atlantic deep ocean ventilation during the mid-Pleistocene transition



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The mid-Pleistocene transition (MPT—1250ka to 700ka) marked a fundamental change in the global climate system, characterized by modifying the glacial-interglacial cycle rhythm from a 40kyr to 100kyr period. Because no significant changes in orbital forcing were observed, it is proposed that an internal modification in the ocean-atmosphere-continental-ice system must be the fundamental forcing. Based on studies in the Atlantic Ocean, it has been suggested that a decrease in glacial $p\text{CO}_2$ atmospheric concentrations during the MPT, possibly due to a reduction in ocean ventilation, contributed to the growth of larger ice sheets in the Northern Hemisphere, and increasing the duration of the glacial cycles. However, the expression of changes in deep ocean ventilation during the MPT event and its mechanisms on the Brazilian margin are not fully comprehended, due to the lack of long-term and high-resolution records. In order to fill these gaps, the present work aims to investigate the deep ocean ventilation changes in the South Atlantic across the MPT. For that, we provide records from a composite from two cores MD23-3677Q and MD23-3678 (3°14.35 S, 36°11.87 W, 1988 water-depth), collected on a seamount at the northeastern Brazilian margin during the AMARYLLIS AMAGAS II scientific expedition. We conducted $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ analysis on benthic foraminifera (*Uvigerina* sp.) at a 4-cm resolution and an X-ray fluorescence scanning at a 1-cm resolution to obtain the ratio Mn/Ti. An age model covering the Mid-Pleistocene was built based on the $\delta^{18}\text{O}$ results aligned with a deep sea $\delta^{18}\text{O}$ stack. The $\delta^{13}\text{C}$ and Mn/Ti results showed a glacial-interglacial variability for the entire record, with peaks during interglacial periods indicating a more ventilated ocean. A modification in both proxies variabilities and mean values is observed after the MPT, suggesting changes in deep circulation patterns and deep ocean ventilation across this period. Our records will improve the understanding of MPT climatic mechanisms and their influence on global climate.

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Keywords: South Atlantic, Deep ocean ventilation, Mid-Pleistocene Transition, Deep ocean circulation

【A0212】-Poster

Orbital forcing and cyclic variations in agglutinated benthic foraminifera abundance: Implications for productivity changes in the Central South Pacific over the last 1.6 Ma

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Understanding the influence of orbital dynamics on long-term productivity variations in the Central South Pacific (CSP) remains a key research challenge. While precessional forcing is known to influence atmospheric systems, including the South Pacific jet stream and Antarctic Circumpolar Current (ACC), its specific effects on marine benthic communities and biogenic productivity remain unclear. Agglutinated benthic foraminifera, thriving in organic-rich environments, provide a valuable proxy for reconstructing productivity changes, yet their response to orbital forcing during key climatic transitions, such as the mid-Pleistocene Transition (MPT; ~0.9–0.7 Ma), is not fully understood. Sediment samples from International Ocean Discovery Program Sites U1539, U1540, and U1541 reveal agglutinated foraminifera abundance records with significant cyclicities of ~94 kyr, ~42 kyr, ~33 kyr, and ~29 kyr. Wavelet and spectral analyses identify shifts in dominant cycles, with a 41 kyr obliquity-driven cycle prominent from 1.4 to 1.1 Ma and a



~100 kyr eccentricity-driven cycle characterizing the last 0.6 Ma. Additionally, notable peaks of ~29 kyr, ~41 kyr, and ~100 kyr reflect orbital forcing mechanisms influencing the productivity changes as suggested by the agglutinated foraminiferal abundance. The periodic increase in biogenic productivity, marked by higher opal content and increased diversity of agglutinated foraminifera, follows a cyclic trend from the Pleistocene to the Holocene. Also, a periodic fluctuation of calcareous agglutinated benthic foraminifera *Siphotextularia* spp. records a significant cyclicity of ~94 kyr after 0.6 Ma suggests that 100 kyr cycle influenced hydrographic conditions during significant glacial-interglacial changes after the MPT. These findings highlight the pivotal role of orbital cyclicity in driving CSP marine productivity and climatic transitions over the last 1.6 Ma.

Keywords: IODP, Middle Pleistocene Transition, Orbital cyclicity, Antarctic Circumpolar Current

【A0684】 -Poster

Planktonic foraminifera and temperature records highlight climatic changes on the southern Portuguese margin during the Early-to-Middle Pleistocene (1.54–0.75 Ma)

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The Pleistocene was marked by major changes in glacial-interglacial cycles, with a significant transition between 1.25 and 0.7 Ma. Prior to 1.25 Ma, 41-kyr obliquity cycles dominated, resulting in shorter and less intense glacial periods. After the Mid-Pleistocene



Transition (MPT), 100-kyr cycles became dominant, leading to longer and more pronounced glacial-interglacial cycles. These changes reorganized temperature gradients, influencing planktonic foraminifera distributions and abundances.

Here, we provide evidence of millennial scale climate variations and their effects on planktonic foraminifera assemblages at IODP Site U1387 (36°48.32'N 7°43.13'W, 559 water depth), located on the southwestern Iberian margin. The aim is to reconstruct sea surface temperature (SST) trends, based on the foraminiferal fauna and lipid biomarkers, and analyze ecological changes from MIS 52 to MIS 18 (1.54–0.75 Ma), spanning the transition from the 41-kyr to 100-kyr climate regime.

During the 41-kyr world, subtropical and transitional species dominated. Subtropical symbiont-bearing foraminifera, including *Orbulina universa*, *Globigerinoides ruber*, and *Globigerinella siphonifera*, exhibited abundances of 20–40%, although with *G. siphonifera* peaking only during MIS 47. *O. universa* and *G. ruber* reached maxima between MIS 51 to MIS 39 when SSTs were as warm as ~23°C in summer. The same pattern was observed in the transitional species *Globoconella inflata*, with abundances up to 60%, particularly during MIS 43. Subtropical species, including *Globigerina falconensis* and *Globigerinella calida*, and tropical species like *Globorotalia crassaformis*, also peaked during these periods but declined sharply during MIS 45, signaling a weaker interglacial with cooler SSTs (~21°C in summer; 16°C in winter).

During glacial periods (e.g., MIS 48, MIS 44, MIS 42, and MIS 40), species related to high nutrients, like *Globigerina bulloides*, reached percentages between 30% and 60%. The species *Globigerinita glutinata* also contributed up to 15%, pointing to upwelling and well-mixed waters. In contrast, after 1.25 Ma, during MIS 35 to MIS 18, *G. bulloides* and *G. glutinata* showed reduced abundances (<25% and <15%, respectively). This decline coincided with the emergence of thermocline dwellers like *Globorotalia scitula* and *Globorotalia truncatulinoides*. These species increased in abundance (5–8%) during glacials such as MIS 28, MIS 24, and MIS 18, potentially indicating weaker upwelling. *G. truncatulinoides* surpassed 5% abundance only after 1.25 Ma, whereas *G. scitula* followed a similar trend, linked to a southward shift of the Azores Front impacting nutrient availability during glacial times.



In contrast, during interglacial periods MIS 31, MIS 25, and the beginnings of MIS 21 and MIS 19, the subtropical species with a strong affinity to the warm and oligotrophic surface waters had a consistent abundance of >40%. Maximum SSTs rose to ~24.7°C in summer and 13.4°C in winter and 23.3°C as annual SST. The expansion of the subtropical gyre during interglacials likely influenced these assemblages and SST fluctuations.

Our results highlight dynamic shifts in oceanographic conditions before and after 1.25 Ma. The coupling of biological and climatic changes suggests enhanced altered nutrient availability, upwelling intensity, and subtropical water influence shaping marine plankton ecosystems during the Pleistocene.

Keywords: Iberian margin, Paleotemperature, Nutrient availability, EMPT

【A0351】-Poster

A climate-driven human genetic bottleneck in Africa 900 thousand-years ago

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Mid-Pleistocene transition (MPT), a climate state underwent low temperature and dry condition, has been suggested as a candidate for a massive genomic bottleneck in African hominins ~0.9 million years ago (Ma). However, no sufficient evidence supports such attribution to climate deterioration for the genetic bottleneck. Here, we use an agent-based model forced by realistic time-evolving climate conditions to investigate the population and genetic changes of African hominins. With our climate-driven model simulations, population collapses are found before and during the MPT due to reductions of atmospheric CO₂ concentrations. The corresponding climate changes and vegetation loss enhance the difficulty of habitation for African hominins in northern and southern Africa. The regional extinctions create population refugia in eastern and southern Africa serving as the remaining genetic pool for the emergence of *Homo sapiens*. Furthermore,



culture evolution is suggested to reinforce the expansion and dispersal of African hominins during the climate recoveries after MPT and to enhance the chance of admixture of African genetic information.

Keywords: Mid-Pleistocene Transition, Genetic bottleneck, Agent-based model, African hominin, Culture evolution

【A0755】 -Poster

AMOC modulates ocean heat content during the last four deglaciations

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Deglaciations are the largest natural global warming events across the Quaternary. During these large-scale reorganizations of the climate system, the planet takes up vast amounts of energy, about half of which warms the global ocean. Thus, global ocean heat content (OHC), which is directly linked to mean ocean temperature (MOT) through the heat capacity of sea water, is a key metric for the determination of Earth's energy budget during the Quaternary.

Several climate modelling studies suggest that OHC not only changes in response to orbital-scale changes in ice-sheet extent and greenhouse gas concentrations, but that it is also modulated on millennial timescales by ocean circulation. Here, we present the first OHC record that covers the last four glacial terminations, the glacial maximum conditions prior to them, and their subsequent interglacials, based on noble gas ratios in the EDC ice core in better than 1000-year resolution.

Our record reveals significant millennial-scale OHC variability across all studied terminations. Comparison to AMOC proxy records reveals that these millennial-scale OHC



changes are anti-correlated with AMOC strength, suggesting that the AMOC modulates OHC during the last four deglaciations. In our record, the millennial-scale OHC variability most prominently manifests itself in the form of OHC maxima at the end of Terminations II–IV, when MOT was up to 1.9 ± 0.2 °C warmer than the Holocene. Given the magnitude of these maxima, AMOC-induced millennial-scale OHC variability may be an important control of early-interglacial atmospheric CO₂, sea level, and climate.

Keywords: Ocean heat content, AMOC, Millennial variability, Deglaciation, Noble gases

【A0779】 -Poster

Identifying oldest ice employing an isochronally calibrated ice sheet model

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The Antarctic Ice Sheet (AIS) contains invaluable archives of past climate, offering a transient record of historical changes in the climate system. This study aims to identify suitable sites for extracting the oldest ice from the AIS, which is crucial for understanding long-term climate variability, particularly the Mid-Pleistocene Transition (MPT). Such knowledge is essential for improving our comprehension of the climate system and projecting future changes in a warming world influenced by human activity.

We calibrate a state-of-the-art ice sheet model using radar observations of internal ice layering (isochrones) to locate potential oldest ice sites on the AIS. Our methodology employs a refined climate index approach, combining ice-core records of past climate and regional accumulation changes with Regional Atmospheric Model snapshots to simulate the AIS over paleo timescales. Isochrones are computed online via an isochronal model or through Lagrangian tracers in postprocessing. By minimizing discrepancies between observed and modeled isochrones, we optimize ice flow parametrization, refine paleoclimate forcing, and better constrain geothermal heat flux.

We first apply our methodology on a regional scale, focusing on well-mapped sectors of the AIS isochronal structure, such as the area around Dome C in East Antarctica. The



observed traced and dated layers in this region cover approximately the last 200ka years, allowing us to identify suitable oldest ice sites near existing drilling stations. Continental-scale simulations provide insights into potential new sites for the oldest ice, as well as locations for younger but valuable ice cores.

This research seeks to identify the oldest ice in the AIS using an isochronally calibrated ice sheet model, which is essential for advancing our understanding of the climate system. By extending the current 800ka-year record, we aim to shed light on the MPT and other significant climate events, ultimately contributing to more accurate projections of future climate change.

Keywords: Oldest ice, Ice sheet modelling, Isochrones, Ice core

【A0815】-Poster

Transient simulation of the orbital periodic transition in equatorial Pacific sea surface temperature since the Pliocene

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Changes in Earth's orbital parameters are considered a primary driver of glacial cycles. However, during the Mid-Pleistocene Transition (MPT), the dominant period of glacial cycles shifted from the 40,000-year obliquity cycle to the 100,000-year eccentricity period, without corresponding changes in orbital parameters. This phenomenon suggests that the sensitivity of the climate system to external forcing underwent significant modifications. According to the "ocean dynamical thermostat" hypothesis, the decline in atmospheric CO₂ over the past 3 million years resulted in the expansion of Northern Hemisphere ice sheets, cooling at high latitudes, and an increase in the equatorial-to-polar temperature gradient. These changes altered the upper ocean's thermocline circulation, strengthening upwelling in the equatorial eastern Pacific (EEP) and enhancing the zonal temperature gradient in the tropical Pacific. Concurrently, stronger air-sea interactions in the mid-to-low latitudes modified the sensitivity of the climate system to orbital forcing at different periods, indicating that long-term climatic background changes likely drove the transition



in orbital-scale climate periods. To test this hypothesis, this study employs the "ocean dynamical thermostat" 4-box" model and a two-dimensional energy balance model (EBM). Using orbital parameters and atmospheric CO₂ concentrations over the past 3 million years as external forcing, transient accelerated simulations were performed to explore the relative contributions of external forcing and internal feedback mechanisms to long-term EEP sea surface temperature (SST) changes and the cycle transition. Results indicate that water vapor feedback is the primary factor influencing average temperature. Regarding the cycle transition, when ice albedo and water vapor feedback are turned off and atmospheric CO₂ is held constant, SST changes in the EEP are primarily driven by meridional solar insolation gradients, showing a dominant 40,000-year obliquity cycle. When ice albedo feedback is activated, a significant 20,000-year precession signal emerges but remains insufficient to replicate the cycle transition observed in reconstructed records. Only with realistic transient atmospheric CO₂ concentrations and the simultaneous activation of ice albedo and water vapor feedbacks does the 100,000-year eccentricity period become pronounced, resembling the characteristics of the observed period transition. This study highlights the critical roles of external forcing and internal feedback mechanisms in the MPT.

Keywords: Equatorial eastern pacific sea surface temperature, Mid-Pleistocene transition, Thermocline circulation, Transient numerical simulation

【A0229】-Poster

The precession cycles in East Asian stalagmite records before the MPT constrained by carbonate U-Pb dating

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Carbonate U-Pb geochronology has demonstrated immense potential in the field of geosciences. The Isotope Laboratory at Xi'an Jiaotong University has innovatively developed a U-Pb dating method by combining Laser Ablation and Isotopic Dilution (LA&ID-MC-ICPMS), based on research into Quaternary secondary carbonate geochronology from caves. This method integrates the high spatial resolution and rapid



analysis capability of laser techniques with the precision and controllable sample requirements of isotopic dilution, establishing an efficient and accurate system for carbonate U-Pb geochronology.

Based on the robust, high-precision LA&ID techniques, a new stalagmite record from Sanbao Cave in Shennongjia, Hubei is obtained, we determined that SB20 grew between 1.25 and 1.50 million years ago, capturing approximately eight orbital cycles of $\delta^{18}\text{O}$ variation. This study represents the first $\delta^{18}\text{O}$ record established in East Asia's monsoon region predating the Mid-Pleistocene Transition (MPT). The stalagmite record highlights the dominant role of low-latitude monsoons, driven by solar radiation forcing, in shaping the East Asian climate and reveals distinct precession cycles.

Furthermore, through comparative simulations of climate differences between the Last Glacial Maximum (LGM) and the Pre-Industrial (PI) period, as well as between climate extremes (Pmin-Pmax), we found that summer (JJA) wind field intensity and precipitation in the East Asian monsoon region are primarily influenced by solar insolation. By correlating this with $\delta^{18}\text{O}$ records from stalagmites across the MPT, we conclude that the large-scale monsoon circulation reflected in stalagmite $\delta^{18}\text{O}$ is not directly controlled by ice sheet or greenhouse gas radiative forcing but rather by the combined effects of the Atlantic Meridional Overturning Circulation (AMOC) and seasonal insolation changes.

With global climate change research gaining increasing attention, our study synthesizes past scientific achievements to reveal the interaction between thermodynamic circulation systems dominated by high-latitude ice volume and dynamic circulation systems regulated by low-latitude monsoons. This work establishes a multi-faceted geoscientific framework and provides critical evidence for exploring the "high-low latitude" climate circulation theory within the context of orbital-scale climate dynamics.

Keywords: Carbonate U-Pb geochronology, MPT, Stalagmite records, Precession cycles

【A0613】 -Poster

Extending accurate chronology of the Dome Fuji ice core, Antarctica to 720,000 years and its implications for the 100-kyr cycles

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Accurate ice-core chronologies are essential for identifying the timing and duration of polar climatic changes with respect to orbital forcings as well as their phasing with the changes in other parts of the globe. We originally constructed the chronology for the past 360 kyr through orbital tuning of the O₂/N₂ ratio of trapped air in the Dome Fuji ice core with local summer insolation, and recently improved the dating methodology and resulting chronology for the past 207 kyr through the combination of new gas measurements (O₂/N₂, d¹⁵N of N₂, CH₄), an inverse firn densification model, and a Bayesian dating model. We are currently extending the O₂/N₂ data towards the bottom of the core (~720 kyr) to establish a new Dome Fuji chronology (uncertainty <~1 kyr) and constrain the timing and duration of the past climatic changes. Our chronology is independent of the U-Th Chinese speleothem chronology, which has widely been used to constrain marine sediment cores and EPICA Dome C ice-core chronologies. Preliminary comparison between our and speleothem chronologies shows differences (beyond uncertainty) for some periods with possible implications for the timing and duration of climatic events and cycles. In the presentation, we will show the newest extension of the O₂/N₂-based Dome Fuji chronology, precisely compare our chronology with some marine and speleothem chronologies using abrupt climatic event signatures, and discuss the relative importance of precession and obliquity for generating the 100-kyr cycles. We will also discuss the quality of the O₂/N₂ record in the deep part of the existing Dome Fuji core, and the potential of the method for dating an older ice core from the ongoing 3rd Dome Fuji deep ice core project, which aims to obtain the ice from the 40-kyr world within the next few years.

Keywords: Ice core, Dome Fuji, Chronology, Termination, Glacial cycles

【A0314】-Poster

Early Pleistocene (MIS 42-45) climate dynamics and oceanographic changes reflected in the benthic foraminifera assemblages from the southern Portuguese margin (Gulf of Cadiz)

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Pleistocene climate variability and glacial cycles are well-studied phenomena, but less is known about the climate dynamics that preceded the Middle Pleistocene transition, known as the "41 kyr world", and its impact on benthic foraminifera assemblages. The benthic foraminifera assemblages are sensitive to changes in factors such as nutrient flux, pore water oxygenation and bottom water conditions, as well as changes in the Mediterranean Outflow Water (MOW). To explore their relationships, we studied the IODP drill core U1387 (36°48.321'N 7°43.1321'W), drilled during IODP Expedition 339 in the Faro Drift off the southern Portuguese margin (Gulf of Cadiz) in 559 m water depth, to investigate the early Pleistocene glacial/interglacial cycles between MIS (Marine Isotope Stage) 42 and MIS 45 (1.33-1.39 Ma). In addition to the benthic foraminifera assemblage data, we also obtained $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ epibenthic stable isotope data derived from *Cibicides pachyderma* and *Planulina ariminensis* species compared with $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ deep infaunal stable isotope data derived from *Globobulimina affinis* and *Globobulimina turgida*, and calculated $\Delta\delta^{13}\text{C}$ values as the difference of the epifaunal and deep infaunal $\delta^{13}\text{C}$. Insolation data of 21 June at 65°N, organic carbon and sand weight percent (wt%), sapropel and red layers from the Mediterranean Sea, and abundance of the planktonic foraminifera *Neogloboquadrina pachyderma* was used to provide context for the data interpretation.

A total of 30 samples from the IODP site U1387 were analysed in two size fractions (>250 μm and >125 μm), relative abundance, diversity indices, elevated epifauna, benthic foraminifera oxygen index (EBFOI) were calculated, and principal component analysis was performed on the data set. A total of 123 species of benthic foraminifera were identified during the course of the study, with 26 species exhibiting significant abundance. The most dominant species were *Sphaeroidina bulloides*, *Cassidulina laevigata*, *Uvigerina celtica*, *Cibicides pachyderma*, and *Globocassidulina subglobosa*. Diversity indices, especially the Shannon-Wiener and Fisher alpha indices, showed correlations with the oxygen stable isotope data and the $\Delta\delta^{13}\text{C}$ curve as well, suggesting variations in the bottom water



oxygen levels and/or strong temperature variations. A significant decrease in diversity coincided with abrupt changes in $\delta^{18}\text{O}$, especially in MIS 44, which are likely related to cooling events in surface waters and may be a consequence of weakening of the Atlantic Meridional Overturning Current (AMOC), based on *N. pachyderma* data. Changes in the assemblages, particularly the high abundance of certain species, can be associated with changes in $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$. Our results also highlight the influence of environmental factors, such as the percentage of sand (wt% sand), on the abundance of certain foraminifera species, indicating the impact of MOW on the bottom current intensity.

Keywords: Early Pleistocene, Gulf of Cadiz, Benthic foraminifera, 41 kyr world, MOW

【A0172】 -Oral

Long-term stability and episodic intensification of Pacific deep circulation during the Mid-Pleistocene Transition

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We present three new neodymium isotope (ϵ_{Nd}) records from fossil fish teeth recovered at meridionally separated sites along the full flow path of the Pacific Deep Western Boundary Current (DWBC), spanning the Mid-Pleistocene Transition (MPT; 600–1300 ka) with an average temporal resolution of ~ 10 kyr. The data reveal that a reduced north–south ϵ_{Nd} gradient in the Pacific DWBC was a persistent feature of glacial periods relative to interglacials. This pattern likely reflects enhanced DWBC transport and/or shoaling of the Pacific Deep Water (PDW)–Lower Circumpolar Deep Water (LCDW) interface during glacial periods. In contrast, non-conservative processes—including increased Asian dust deposition and enhanced benthic fluxes of volcanogenic material—appear to have remained stable or induced only minor positive shifts in ϵ_{Nd} gradient during glacials, as indicated by a series of sensitivity experiments using a Nd cycling model. The amplitude of glacial–interglacial ϵ_{Nd} gradient variability remains consistent between the early and late MPT, suggesting no major reorganization of deep Pacific circulation across the transition. However, an anomalously reduced ϵ_{Nd} gradient during Marine Isotope Stage (MIS) 22 indicates an exceptional circulation event, likely linked to DWBC strengthening



and/or upward migration of the PDW–LCDW water mass boundary. These findings support a scenario in which the MPT was shaped by the combined influence of episodic ocean circulation changes and intensified chemical weathering. In particular, a circulation shift triggered by insolation-driven sea ice expansion during MIS22 may have enhanced carbon storage and global cooling, promoting glacial persistence. The resulting regolith erosion by expanding ice sheets could have enabled the development of larger and more stable Northern Hemisphere ice sheets, facilitating the emergence of longer and more intense glacial cycles after the MPT. While our results provide new constraints on deep ocean circulation and climate evolution during the MPT, further work is needed to fully resolve the mechanisms driving this major climatic transition.

Keywords: Mid-Pleistocene Transition, Neodymium isotope, Pacific deep western boundary current, Deep ocean circulation

【A0950】 -Poster

Precession-induced tipping of the Atlantic Meridional Ocean Circulation implies the appearance of the 100-kyr glacial cycle during the Late Pleistocene

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Orbital forcing could have facilitated glacial inceptions during the Pleistocene by triggering a substantial weakening of the Atlantic meridional overturning circulation (AMOC). However, no such changes of AMOC have been observed in the atmosphere-ocean general circulation models (AOGCMs). Here we show that the precession is indeed able to trigger an almost full collapse of the AMOC, during the phase when the Northern Hemispheric summer insolation (NHSI) is low. This collapse occurs only under high eccentricity and relatively low atmospheric CO₂ concentration (*p*CO₂). Therefore, the precession was inefficient in triggering glacial inception before the mid-Pleistocene transition and certainly will not induce a sudden weakening of AMOC in the future due to high *p*CO₂. Moreover, it takes multiple millennia for the AMOC to fully respond to



precession-induced low NHSI, so that orbital acceleration, a technique commonly adopted in AOGCM simulations, will cause such abrupt changes of AMOC to be missed.

Keywords: Precession, Glacial inception, Meridional overturning circulation, AMOC, Tipping

【A0404】-Poster

The million year ice core, Australia's oldest-ice project

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The Million Year Ice Core (MYIC) Project is an Australian Antarctic Program initiative to recover a continuous ice core spanning the mid-Pleistocene Transition (MPT; 700–1,250 kyr). During the MPT global ice volume increases and the pacing of glacials changes from 41-kyr cycles phase-locked with obliquity, to quasi-periodic 100-kyr cycles. The MYIC project, along with other international oldest ice projects, are targeting records of past climate and atmospheric composition needed to test hypotheses on the carbon, ocean-atmosphere and ice-sheet processes involved in this major shift in Earth's climate state.

The drilling location for MYIC is in the Dome Concordia North (DCN) region at 75.04220S, 123.63120E, ice depth 3064 m. This target is ca. 45km NE of the European Beyond EPICA Oldest Ice site at Little Dome C. MYIC was initially also planning to drill at Little Dome C,



but recent work indicates older and more highly resolved ice at the new DCN location. Modelling indicates 1.5 Myr old ice at ca. 100 m above the bed and a potential bottom age of up to 2 Myr, which would provide access to multiple cycles in the pre-MPT 41 kyr world. The 2024-25 season is focused on moving from LDC to the new site, camp construction and pilot drilling.

The project is developing and testing new gas and impurities labs for the specific challenges of analysing old highly-thinned ice as required to test hypotheses on the MPT. The gas lab combines a small sample sublimation-extraction system coupled to an Aerodyne Quantum Cascade Laser spectrometer and dual inlet mass spectrometry for CO₂, δ¹³C-CO₂, CH₄, and N₂O, as well as the main air isotopes. The Continuous Flow (CFA) lab currently supports measurements for conductivity, particles and soluble ions and will be configured for continuous water isotope and methane measurements along with discrete samples collection for cosmogenic ¹⁰Be.

Reference

Chung, A., Parrenin, F., Steinhage, D., Mulvaney, R., Martín, C., Cavitte, M. G., Lilien, D. A., Helm, V., Taylor, D., Gogineni, P., 2023. Stagnant ice and age modelling in the Dome C region, Antarctica. *The Cryosphere*, 17(8), 3461-3483.

Keywords: Ice core, Oldest ice, Mid-Pleistocene Transition

【A0027】-Poster

Extreme Drought around 900ka in Southwestern Iberia: Insights from IODP pollen records

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The Middle Pleistocene Transition (MPT) marks a key period in Quaternary evolution, with a shift in glacial-interglacial cycles from ~40 kyrs to ~100 kyrs, increased global ice volume, land aridity, and lower sea surface temperatures. While the driving mechanisms of the MPT remain unclear, the most likely hypotheses are related to ice-sheet dynamic feedbacks, such as ice albedo, precipitation at ice margins, elevation-temperature, the regoliths, and the decrease of CO₂ concentration. Here we focus on the "precipitation at the ice margins" hypothesis. To test this hypothesis, appropriate proxy reconstructions and paleoclimate simulations are needed.

The Southwestern Iberian margin is directly influenced by the westerlies, which play a crucial role in delivering moisture to the Northern Hemisphere ice sheets. Here we present new pollen records from the International Ocean Discovery Program (IODP) Sites U1386 and U1385, capturing vegetation dynamics and winter rainfall fluctuations in Southwestern Iberia during the MPT. Our results reveal a long-term decline in Mediterranean forest (MF) coverage during MIS 31-22 (1200-870 ka), closely aligned with the gradual reduction in boreal summer insolation at 65°N. This trend culminated in a period of extreme aridity between 930 and 870 ka. This period of strongest dryness coincides with the highest North Atlantic Ice Rafted Debris (IRD) concentration, weakest Atlantic Meridional Overturning Circulation (AMOC) and highest dust input from north Africa to the Mediterranean Sea during MIS 24-22, and coeval with the southward migration of the thermocline water source, related to the position of the moisture source, lower than the Iberian margin. After 870 ka, the trend was reversed and the MF thrived again during MIS 21, associated with the increase in insolation and AMOC and the



northward shift of the moisture affecting Iberia. During MIS 20, the strong reduction of the MF during this glacial reflects the second extreme regional drought, probably due to the maximum ice volume, supported by the heaviest benthic foraminifer $\delta^{18}\text{O}$ ($\delta^{18}\text{O}_b$) values, and the southernmost position of thermocline water source at around 830 ka. From MIS 19 to MIS 18, the insolation remained low, but the MF increase concomitant with the northward migration of the moisture source that bring precipitation to Iberia through the Westerlies. The increase in insolation, the decrease in ice volume and the optimal position of the moisture source close to Iberia, led the maximum expansion of the MF during MIS 17. A pronounced contraction of the MF after 700 ka suggests the north shift of the westerlies, leading to the strong 100-kyr cycles. Furthermore, the wavelet analysis on the MF, $\delta^{13}\text{C}$ and $\delta^{18}\text{O}_b$ records has showed the dominant cyclicity is in the 80-kyr band between 1200 ka to 1050 ka, and faded away from 1050 ka to 840 ka including the mega drought period. After 840 ka, the obliquity and precession cyclicities emerged, and even the 5.5-kyr cyclicity can be found in the MF. Our data suggest the strong IRD-derived freshwater fluxes blurred the predictable North Atlantic orbital climate cyclicity during 930-840 ka.

Keywords: The Middle Pleistocene Transition, Mediterranean forest, Extreme drought, Moisture source, Iberian margin

【A0775】 -Oral

Continuous CO_2 reconstruction across the MPT from boron isotopes informs mechanisms of glacial CO_2 change

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The Mid-Pleistocene Transition (MPT) represents a fundamental shift in the operation of Earth's climate system, yet as this interval extends beyond the current reach of continuous ice core records, the role of CO₂ in this transition is uncertain. Prior to the MPT, the climate system was paced by the ~40 kyr obliquity cycle, with available CO₂ reconstructions, temperatures, and ice volume all coupled to orbitally forced changes in solar energy at high latitudes. Following the MPT, this relationship breaks down, with Northern Hemisphere ice sheets persisting through obliquity maxima in a series of "skipped terminations", leading to longer glacial periods with larger ice sheets. Here we examine the role of CO₂ over the MPT, using high resolution boron isotope data from 3 sediment cores, spanning the Atlantic, Pacific, and Indian Oceans. These records show excellent agreement with the ice core record in their younger portions, and striking consistency between sites, supporting the robustness of our reconstruction of atmospheric CO₂. We find that CO₂ and ice volume remain largely coupled through the MPT, with limited CO₂ rise during the skipped terminations around MIS 36 and 34, low CO₂ during the deep glaciation of MIS 22 (the "900 ka event"), and elevated CO₂ during the "super-interglacial" of MIS31. This underscores the key role of CO₂ in glacial and interglacial climate states. In addition, it highlights that the mechanisms governing glacial-interglacial CO₂ change, which are thought to be largely centred on the Southern Ocean, are not forced by orbital changes alone, but must be linked to land ice volume, as the only feature of the climate system with the inertia to persist through orbital insolation peaks. This implies the existence of teleconnections between Northern Hemisphere ice volume and Southern Ocean CO₂ storage, and we outline two potential mechanisms by which this might be achieved.

Keywords: CO₂, MPT, Glacial, Ice sheets, Oceans

【A0700】 -Oral



The shift to the 100-kyr world: Insights from 1.5 Ma Iberian margin SST record

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The Iberian Margin provides an exceptionally accurate record of millennial-scale climate variability, making it a crucial site for deciphering historical shifts in climate and oceanography. The region's exceptional sensitivity to high-latitude processes, such as the discharge of meltwater into the Northeast Atlantic, exerts a significant influence on ocean dynamics, nutrient supply and the effects of climate change. These processes are central to understanding the complex interactions between the ocean, ice and climate systems.

IODP 339 Site U1385, also known as the "Shackleton Site", was drilled at a water depth of 2582 meters below sea level (mbsl), reaching a total depth of 155.9 meters below the seafloor. The oxygen and carbon isotope records show that Site U1385 was continuously covered by hemipelagic sediments from the Holocene to 1.45 million years ago (Marine Isotope Stage 47), providing a benchmark record of millennial-scale climate variability. This paper presents a high-resolution sea surface temperature (SST) record that reveals climate variability over the past 1.45 million years. This dataset provides a comprehensive record of millennial climate variability, including major climatic perturbations such as the Mid Brunhes Event and the Mid Pleistocene Transition (MPT). It reveals a clear shift in SST driven by obliquity orbital forcing from 1200 to 800 thousand years ago (ka), improving our understanding of the underlying mechanisms at glacial/interglacial and centennial to millennial scales.



Furthermore, the SST record indicates that extreme cold events occurred not only after the MPT, but also during and after this enigmatic period. The highest temperatures in the entire record were observed during interglacial periods and coincided with maximum insolation (precession minimum), suggesting an orbital dependence of SST over the past 1.45 million years.

Keywords: SST, Iberian margin, MPT, Millennial-variability

【A0362】 -Poster

The evolution of the Wilkes Subglacial Basin from the mid Pliocene Warm Period until today

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The middle Pleistocene transition (MPT) played a large role in the long-term evolution of the Antarctic Ice Sheet with potential regional transitions from predominantly land based ice sheets to the marine ice sheets we know today. Up until now, modelling these regional dynamics has proven challenging as computational costs to run an 3D ice sheet model on the necessary resolution can be prohibitive. Here we present transient simulations of the Wilkes Subglacial Basin across the MPT on an 8 km grid-resolution using the Parallel Ice Sheet Model (PISM) allowing us to investigate grounding line dynamics and marine ice sheet dynamics before and after the MPT. The simulations are calibrated against late-Quaternary internal reflection horizons (IRHs) as well as present day observations guaranteeing a robust representation of ice dynamics.

Our simulations suggest that the Wilkes Subglacial basin can exhibit similar collapse-regrowth episodes as the West Antarctic Ice Sheet remaining in a largely retreated configuration throughout much of the pre-MPT period before accommodating both advanced and retreated configurations depending on the climate state during and after the MPT.



Situated close to current bottom water formation sites a major reorganization of the Wilkes Subglacial Basin as we have shown here might have influenced larger ocean circulation patterns affecting the MPT.

Keywords: Antarctica, Ice sheet dynamics, Sea level, Middle Pleistocene Transition

【A0638】 -Poster

The evolution of Southern Ocean paleoproductivity under the combined influences of ice sheet dynamics and oceanic circulation during the Mid-Pleistocene Transition

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Paleoproductivity records are well documented in high latitude regions of the Northern Hemisphere and tropical areas during the Middle Pleistocene Climate Transition (MPT). In contrast, there is a relative scarcity of long-term paleoproductivity studies in the Southern Ocean over the past million years.

Furthermore, the relationship between changes in paleoproductivity in the Antarctic zone of the Southern Ocean and ocean circulation and ice sheet dynamics during the MPT remains poorly understood.

In this study, we analyzed sediment samples from the International Ocean Drilling Program (IODP) Site U1537, dated back to 2.6 million years ago, using X-ray fluorescence core scanning (XRF) for elements such as Fe, Si/Al, Zr/Rb, as well as natural gamma radiation (NGR) and reflectance measurements (b^*). We also assessed opal content and the mean sortable silt grain size of the terrigenous sediment fraction (10-63 μm , denoted as SS). Our findings reveal a significant increase in iron (Fe) deposition during the MPT transition in the Southern Ocean. Multiple paleoproductivity proxies, including Si/Al ratios, NGR, and reflectance b^* , indicate a marked decline in paleoproductivity throughout the MPT, with a minimum observed around 0.9 million years ago, which aligns with trends in



opal content. These results suggest an inverse relationship between changes in paleoproductivity and fluctuations in Fe levels in the Antarctic zone of the Southern Ocean. Additionally, the mean sortable silt grain size (SS) exhibited a slight decrease between 0.7 and 1.25 million years ago. Combined with Zr/Rb elemental analysis, this indicates a weakening of the Antarctic Circumpolar Current (ACC) during the MPT.

Potential mechanisms underlying the significant decline in productivity during the MPT may include a substantial decrease in sea surface temperatures in the Southern Ocean starting around 1.25 million years ago, a synchronous increase in the Antarctic ice sheet (as evidenced by a rise in ice-rafted debris), and an expansion of sea ice coverage. These changes likely contributed to the weakening of the ACC, a reduction in nutrient upwelling, and limited light availability, all of which are detrimental to diatom bloom growth. Consequently, this resulted in markedly low productivity levels and a reduction in atmospheric CO₂ concentrations.

Keywords: MPT, Southern Ocean Antarctic Zone, ACC, Antarctic ice sheet, Paleoproductivity

【A1035】 -Poster

The evolving morphology of glacial-interglacial cycles over the course of the Middle Pleistocene Transition: Results from the Portuguese Margin

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In the Early Pleistocene, glacial-interglacial cycles appear symmetric with smaller ice volumes and a period of ~41 kyr. Over the course of the Middle Pleistocene Transition (MPT; 1.2-0.8 Ma) these cycles became longer, stronger and more 'saw-tooth' shaped. Here we examine changes in the morphology of a set of glacial-interglacial cycles



from this interval, representing key stages in the evolution of climate variability. We present results from a suite of climate proxies in deep-sea core U1385 on the Portuguese Margin, a prime location for investigating orbital- and millennial climate variability, interhemispheric coupling and land-sea correlations. A key aspect is that the Site U1385 is near enough to the continent to derive a terrestrial signal, but deep enough to generate high-quality palaeoceanographic records that are pertinent to basin-wide phenomena.

Keywords: Glacial cycles, Middle Pleistocene Transition, Portuguese Margin

【A0106】 -Oral

Stepwise synchronization of Antarctic and global climate across the Mid-Pleistocene Transition

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As an integral part of Earth's climate system, the Antarctic Ice Sheet (AIS) impacts global sea level and interacts with Southern Ocean climate on a variety of timescales. A lack of long and continuous records of AIS variability on orbital timescales, however, has challenged our understanding of the complex interplay between the AIS, ocean, atmosphere, and biogeochemical cycles and its contribution to the evolution of Plio-Pleistocene climate. Here we use well-dated, high-resolution sediment records from Iceberg Alley Site U1537 (IODP Expedition 382) from the Antarctic Zone of the Southern Ocean in combination with climate and ice-sheet model simulations to show that key



components started to synchronize with orbitally-paced global climate change since ~1.5 million years ago (Ma), 0.3 Ma before the Mid-Pleistocene Transition (MPT) started. Since ~1.5 Ma, productivity (upwelling) and dust proxies of Site U1537 covaried on orbital time. From ~1.5–~0.9 Ma, a long-term trend of Southern Hemisphere sea-ice increase was accompanied by a similar long-term decrease in sea-surface temperature. During that period, modeled Antarctic ice volume also increased. Since ~0.9 Ma, all climate components show increased synchronization with global climate and higher amplitude variability on orbital time scales. A final step-change in synchronization is documented for the Mid-Brunhes event (~0.45 Ma). Since then, all components of the Antarctic climate and ice-sheet system were locked into an orbital rhythm with high-amplitude, glacial-to interglacial variability. The weak response of this system to orbital forcing prior to 1.5 Ma indicates sensitivity thresholds for the Southern Ocean and the AIS. Specifically, the sea-ice increase and sea-surface temperature decrease in combination with Antarctic ice-sheet growth played an increasing role in regulating the carbon cycle across the MPT.

Keywords: Antarctic ice sheet, Carbon cycle, Ocean productivity, Dust deposition

【A0561】 -Oral

Unravelling abrupt transitions of Antarctic Ice Sheet dynamics during the mid-Pleistocene transition

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A mechanistic understanding of the main drivers of Quaternary climate variability, especially during the mid-Pleistocene transition (MPT; around 1.2–0.8 million years ago) remains a significant challenge in paleoclimate research. Climate changes during that time include a pronounced shift from 41-kyr to 100-kyr periodicity of glacial cycles as imprinted on sea level reconstructions, and the emergence of much larger ice sheets. While several modeling studies have focused on the interplay between the climate system and northern



hemispheric ice sheets during the MPT, the role of Antarctica in driving and responding to climate change at that time remains largely unknown.

Here, we use the Parallel Ice Sheet Model (PISM) to simulate the transient evolution of the Antarctic Ice Sheet throughout the last 3 million years. PISM is forced by a climate index approach that is based on snapshots of climatic conditions in the past. Climate snapshots are derived from the Community Earth System Models (COSMOS), a general circulation model that simulates atmosphere, ocean, sea ice and land vegetation in dependence of reconstructions of paleogeography, orbital configuration, and greenhouse gas concentrations. Interpolation in times between snapshots is linear and based on a convolution of the EPICA Dome C record and the Lisiecki-Raymo benthic isotope stack.

Our simulations indicate that between 1.9 Ma and 800 ka BP, several Antarctic drainage basins crossed critical thresholds at different times, for example leading to the formation of a stable marine-based West Antarctic Ice Sheet. We further examine the characteristics of these thresholds and their associated state transitions. Additionally, our findings suggest that these thresholds, and their interplay, amplified eccentricity-driven climate variability both before and during the MPT, providing new insights into the complex interactions between Antarctic ice sheet dynamics and climate during this period.

Keywords: MPT, Antarctic ice sheet

【A0129】 -Poster

Intermediate water dynamic recorded by authigenic Nd isotope in the north Atlantic across the mid-Pleistocene transition

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The Mid-Pleistocene Transition (MPT, ~1250 ka to 700 ka) is characterized as a period of intense changes in the Earth's climate system resulting in a switch from a ~40 kyr to a ~100 kyr glacial-interglacial cyclicity without an external change in orbital forcing. Several mechanisms including regolith erosion beneath the ice sheets, gradual atmospheric CO₂



decline, deep ocean circulation reorganization and the asynchronous development of hemispheric ice sheets, have been proposed to explain the emergence of the ~100-kyr cyclicity characteristic of the post-MPT world. Regarding to the key role of intermediate water masses in modulating ocean heat and atmospheric pCO₂ levels, they may play a pivotal role initiating the MPT, however, their dynamics are not well constrained. Here, we present new authigenic neodymium (Nd) isotope record from ODP 982 sediment (1134 m) across the MPT. Before the MPT, unradiogenic ϵ_{Nd} signatures (-13.5 to -12.5) dominate during interglacial periods with a small but visible trend. In contrast, glacial periods yield an increase of ϵ_{Nd} signatures from -11 (1.4 Ma) to -9 (1.2 Ma). Hence, a radiogenic component appears during glacials prior to the MPT. On first order this may reflect a dominant influence (>50%) of Iceland Scotland Overflow Water (ISOW) at intermediate depths, which are continuously becoming more radiogenic when approaching the MPT. Post 1.1 Ma, interglacial climate yield more unradiogenic ϵ_{Nd} (-14) and glacial periods yield more radiogenic ϵ_{Nd} signatures as high as -8. This finding advocate, for an enhanced decoupling of radiogenic Iceland Scotland Overflow Water (ISOW) and unradiogenic Labrador Sea water, or significant endmember changes. Notably, a regolith erosion signal around 950 ka, as suggested previously, is not recorded here. These novel authigenic Nd isotopes thus indicate a reorganization of intermediate ocean circulation, and the strong correlations between ϵ_{Nd} and $\delta^{18}\text{O}$ (LR04) appeal that the ice-sheet may control the intermediate water production and re-circulation in the north Atlantic. However, other factors potentially influencing the Nd isotopic composition, such as boundary exchange and sensitivity to leaching strength (sediment composition) need to be further assessed.

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Keywords: Mid-Pleistocene transition, Authigenic neodymium isotope, Intermediate water, North Atlantic



【A0406】-Poster

Enhanced cross-hemisphere upper-ocean heat transport since the Mid-Brunhes Event

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The Mid-Brunhes Event (MBE), occurring around ~430,000 years ago, signifies a crucial transition in glacial-interglacial cycles with enhanced inter-hemispheric thermal contrast, but its underlying mechanism remains elusive. Here, records of deep and bottom thermocline temperatures (DTT and BTT), derived from Mg/Ca ratios of two subsurface-dwelling planktonic foraminifera from IODP Site U1489 at the center of Indo-Pacific Warm Pool (IPWP), are reconstructed over the last 670,000 years. The results reveal a gradual decrease in DTT and a significant BTT warming since the MBE. We argue that the deep thermocline of IPWP gradually cools in tandem with the mid-latitude Northern Hemisphere via shallow subtropical cell due to increasing trade winds. The sustained warming of the bottom thermocline, in contrast, is associated with enhancing subduction of the Subantarctic Mode Water[HD1], which is forced by strengthening westerly winds and thereby a thickening of the mixed-layer between the southern Subtropical and Subantarctic Fronts. Consequently, the upper- to intermediate-ocean circulation from south to north Pacific may have been accelerated, thereby exacerbated the inter-hemispheric thermal asymmetry and amplified the interglacial warming since the MBE. Such a scenario provides an empirical analogue of the near- future implications of upper-ocean circulation dynamics for the polar amplification, given the comparable effects of the ongoing Southern Ocean and Antarctic warming.

Keywords: Subantarctic mode water, Upper-ocean circulation, Hemispheric asymmetry, The Mid-Brunhes Event





Session 08. Leveraging paleoecology for sustainable ecosystem restoration in the Anthropocene

Conveners: Ke Zhang, Estelle Razanatsoa, Ondřej Mottl, Lindsey Gillson

【A0586】 -Poster

On the applicability of combinatorial landscape-specific spatial assessment of CO₂ emissions on the peatlands of Polistovsky Nature Reserve (Russia)

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Global climate change and multi-scale anthropogenic impacts have led to significant CO₂ emissions from peatlands, transforming some of them from carbon sinks into sources of greenhouse gases (GHG). This highlights the need for accurate assessments of net ecosystem exchange (NEE), particularly for pristine and protected peatlands. NEE can be comprehensively evaluated by linking specific vegetation and soil parameters with GHG fluxes.

This study was conducted in the southern part of the Polistovsky Nature Reserve (Pskov region, Russia), which covers a significant portion of the Polistovo-Lovat peatland system, one of the largest raised bogs in Europe. We analyzed the vegetation cover and compared its structure with CO₂ soil emission values.

Geobotanical investigation resulted in description of 28 plant species, mapping of vegetation cover and associated microrelief forms (hummocks, hollows, ridges, and forested bogs). Peat water pH and water table level were measured at each site. CO₂ emissions were measured using a portable sensor (HT-HZ510) in triplicate, with 15-minute exposure periods.

The mapping covered 21 ha, identifying 16 types of peatland vegetation. The most common types included pine-sphagnum, heath, and ridge-hollow bogs. These data were



classified using the GEST (Greenhouse Gas Emission Site Types) approach, based on vegetation, soil, microrelief, and water table characteristics. Values of CO₂ emissions, after the on-site measurements, were recalculated into the flux units of CO₂ over the studied area, for the five identified GEST units as the following: Very moist bog heath (10% of the area) - 0 - 0.64 t CO₂/ha/year, Wet small sedges, reeds mostly with moss layer (20%) - 0.18 - 29.90 t CO₂/ha/year, Wet peat moss lawn (17%) - 2.54 - 51.94 t CO₂/ha/year, Wet peat moss lawn with pine trees (46%) - 0 - 28.37 t CO₂/ha/year, Wet peat moss hollows resp. flooded peat moss lawn (7%) - 15.96 - 22.24 t CO₂/ha/year.

Comparing measured CO₂ soil fluxes with literature reference values showed substantial discrepancies. For example, the “Wet peat moss lawn” unit showed a difference of up to 54.94 t CO₂/ha/year, and the “Wet peat moss hollows” had a 26.84 t CO₂/ha/year difference. Emission variability was significant across landscape microforms, indicating using vegetation structure alone without other landscape proxies is insufficient. Presence of wood stand also affected emissions, with low-density pine spots showing higher emissions than medium-density ones. Spots of very moist quaking bogs and eutrophic areas also contributed to higher emissions.

These findings give evidence for implementing an ecosystem-based approach in peatland management, focusing not only on species diversity but also on functional ecosystem integrity. The GEST approach requires correction for regional biogeographic specifics, ensuring more accurate emission assessments and aiding paleoclimate reconstructions from peat cores.

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Keywords: Peatlands, GEST approach, CO₂ emissions, Protected areas

【A0857】-Poster



Mediterranean archives of biodiversity variability and human impact: Past, present (and future) trends

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The Mediterranean Basin is a hotspot for environmental change, and is expected to undergo significant shifts in biodiversity compared to other regions, driven by factors such as global warming and human pressure. The roots of this trend can be traced back to long-term plant diversity, spanning from multi-decadal to multi-millennial scales.

Mediterranean coastal areas have been extensively colonised by civilisations in different prehistoric and historical periods, up to today's extremely high population densities in low-lying coastal areas, with the trend expected to continue to increase. In this context, Mediterranean coastal wetlands are among the most sensitive natural archives.

In this study, we selected two coastal lagoons in the central Mediterranean Basin (Burano and Orbetello sites, Italy), to investigate Holocene and current biodiversity variability through palynological analysis. We sampled both deep and surface sediments, the latter being used for site-specific pollen signal calibration.

The composite record we obtained spans the last 8000 years. Diversity and dominance indices were applied on pollen data [Shannon's Diversity (H) and Evenness ($e^{H/S}$)]. In addition, direct anthropogenic-indicator pollen types (i.e., crops and woody cultivated species) as well as other indirect indicators (e.g., *Rumex acetosa*-type and *Plantago lanceolata*), were used to infer human impact. Results were compared with independent archaeological evidence.

Four main time frames, defined by historical and regional archaeological periods, were compared: Late Mesolithic/Early Neolithic, Late Copper/Early Bronze Age, Historical, and Modern times. A noticeable change in biodiversity occurred during the Late Copper/Early Bronze Age, with H index increasing from 2.46 (Late Mesolithic/Early Neolithic) to 3.21. Closed temperate woodlands (AP up to 85%) gave way to open woodlands. The



occurrence of croplands (e.g., cereals, *Vitis*) is corroborated by regional archaeological data, indicating a consumption of cereals during the Early Bronze age. The continuous presence of *Olea* pollen can be associated with wild populations (*Olea europaea* var. *oleaster*), as observed in other Mediterranean sites during the Neolithic. During historical times, i.e., the '20th century, the spread of intensive farming (vineyards, olive groves and artificial meadows) favoured by new mechanized agricultural practices, is reflected in a strong anthropogenic-indicators pollen signal (up to 20%). A further shift is observed in the modern pollen data (i.e., the most recent years), which show a decline in biodiversity indices compared to historical times (H index from 3.3 to 2.89). The recent loss of biodiversity is linked to the degradation of habitats, including the release of microplastics and metal trace elements, and the spread of exotic species, particularly *Ailanthus*.

What is the next step? In the near future, plant diversity in the Mediterranean is likely to undergo a significant shift, displacing native plants which have dominated the region's landscapes for thousands of years. To deal with this scenario, we emphasise the importance of developing context-dependent conservation and restoration strategies which incorporate palaeoecological data.

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Keywords: Palaeoecology, Mediterranean Basin, Biodiversity, Human impact, Coastal wetlands

【A0204】 -Oral

Protecting the future by learning from the past: Salmon nursery lake ecosystem reconstruction through sedimentary DNA

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Long-term data are crucial for understanding past environmental changes, establishing restoration baselines, and identifying stressors. Sedimentary DNA (sedDNA) has emerged as a powerful proxy in paleoecology, offering an expanded taxonomic scope compared to traditional methods. In this study, we used sedDNA to reconstruct ecosystem changes in salmon nursery lakes in British Columbia, Canada, spanning centuries to millennia. Using digital PCR (dPCR), we present the first DNA-based reconstruction of Sockeye Salmon biomass dynamics, uncovering distinct trends across the study lakes. DNA metabarcoding, targeting the 18S ribosomal RNA gene, was used to track shifts in microeukaryote communities, including phytoplankton, zooplankton, and other groups. Most lakes exhibited notable changes in algal communities, such as a relative increase in diatom abundance, a decline in chlorophytes, and fluctuating chrysophyte and dinoflagellate populations. Among diatoms, we observed a pronounced increase in planktonic species in surface sediments, likely reflecting longer open-water periods and/or enhanced thermal stratification. Additionally, we detected dynamic changes in potential fish parasites, such as nematodes and ichthyosporeans. Nematode reads displayed a consistent upward trend across all lakes, possibly indicating increased fish infection rates in recent decades. Network analysis identified novel indicator taxa, including *Pirsoniales* (diatom parasitoids), *Desmodesmus* (green algae), and *Glissomodida* (bacterivorous protists), and their historical abundances were reconstructed. Our findings demonstrate that sedDNA captures diverse taxa, enabling comprehensive ecosystem reconstructions and offering critical insights into aquatic ecosystem health. In collaboration with Fisheries and Oceans Canada and local Indigenous Peoples, these results inform conservation strategies to protect these vital salmon nursery lakes.

Keywords: Sedimentary DNA, Salmon, Digital PCR, Metabarcoding

【A0200】 -Oral

Sedimentary DNA reveals historical Cyanobacterial responses to environmental and anthropogenic changes

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The Masurian Lake District in north-east Poland, contains more than 2000 lakes with diverse morphologies, land-use histories and varying trophic states, in an area of outstanding beauty and significant touristic value. Many of these lakes experience frequent cyanobacterial algal blooms during the growing season, suffer from low water transparency, and undergo anthropogenic eutrophication.

Using a metabarcoding approach, we reconstructed up to 250 years of cyanobacterial history using 16S rRNA amplicons and algal pigments extracted from sediment cores from three lakes with differing catchment morphologies and histories. Building on our earlier research that identified shifts in toxigenic cyanobacteria through the analysis of *mcyE/ndaF* genes involved in microcystin and nodularin biosynthesis in one of these lakes, we linked changes in the cyanobacterial community to historical environmental and anthropogenic factors.

Our findings demonstrate the utility of sedimentary DNA analysis in understanding long-term cyanobacterial dynamics. These insights can inform contemporary restoration efforts by identifying historical baselines and assessing how anthropogenic impacts and environmental changes have influenced cyanobacteria over time.

Keywords: Microcystins, Metabarcoding, Environmental change, Eutrophication

【A0982】-Oral

Integrating dendroecology into restoration practice and policy

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As we tackle the triple crises of climate change, desertification and biodiversity loss, strategic tree planting becomes a cornerstone of restoration. However, not all trees are equally equipped to endure and adapt to changing climates. Dendroecology provides the



data needed to select species that are not only native but also resilient to shifts in temperature, precipitation, and other environmental factors. This helps avoid the pitfalls of reforestation efforts that use non-native or less adaptable species, which may fail to establish, negatively impact local ecosystems, or exacerbate ecological imbalances.

A major knowledge gap exists regarding how tree species grow in response to climate variability and how they might adapt to future climatic changes. These responses can be explored through studies that span large-scale climate gradients, examining plant reactions at various temporal scales (both inter-annual and intra-annual) and integrating multi-parameter measurements. Tropical dendroecology advancements are driving progress in this area, but further scaling and investment and integration into practice and policy of restoration are needed. This presentation will explore how tools like tree-ring analysis, quantitative wood anatomy, and stable isotopes have been used to assess drought tolerance and water-use efficiency in tree species and forests, with implications for climate-resilient restoration particularly in the tropics—to support nature-based solutions and inform policy decisions that enhance the resilience of both ecosystems and human livelihoods in the face of ongoing climate change. We will also discuss the establishment of African Tree Ring Network (ATRN) to inform policy.

Keywords: Restoration, Dendroecology, ATRN, Africa, Climate change

【A0986】 -Poster

Agricultural development has not necessarily caused forest cover decline in semi-arid northern China over the past 12,000 years

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Forest cover significantly affects the global carbon cycle, biodiversity, and human welfare, but is seriously threatened by human activities. Here we found that anthropogenic forces did not necessarily lead to forest cover decline in the marginal agricultural region of



northern China based on a quantitative reconstruction of 12,000-years forest cover changes using modern analog technique and random forest. The forest cover was strongly affected by human activities in the core agricultural region, as indicated by the high independent effects of archeological sites (38.3%) and burning area (42.3%). In contrast, climate impacted the forest cover in the marginal agricultural region, where the annual precipitation and summer mean temperature contributed 52.4% and 27.4%, respectively. Agricultural development in the marginal agricultural region likely occurred in the river valley or sunny slopes, not overlapping with zonal forests growing on shady slopes. This study implies much less afforestation potential than previously expected in the marginal agricultural region.

Keywords: Forest cover, Agricultural development, Holocene, Afforestation potential

【A0245】-Poster

Extreme hydroclimatic events trigger asymmetric shocks and recovery trajectories across multitrophic levels of Tibetan Plateau lakes

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Increasing extreme climatic events threaten the functioning of lake ecosystems, especially the highly sensitive alpine lakes in the warming Anthropocene. Whether the asymmetric effect of climate extremes on the distinct aquatic communities to is less explored. Here, we investigated the dynamics of aquatic communities across multitrophic levels before the extreme precipitation event and afterwards, based on the sedimentary ancient DNA and phototrophic pigment records from an endorheic lake Paiku Co on the southwestern Tibetan Plateau. We found the phytoplankton and zooplankton communities can gradually recover to predisturbance levels, but reassembly of zoobenthos and fish took up a longer time due to the habitat destruction. Our results highlight the distinct resilience of aquatic communities at different trophic levels and the greater risk of collapse in the zoobenthos community, when facing the frequently hydroclimatic extremes in a warming world. These findings advance the understanding of the response of aquatic communities



to extreme climatic events and seriously potential ecological ramifications, providing insights for making general predictions of the ecosystem function and biodiversity of alpine lakes.

Keywords: Hydroclimatic extremes, Tibetan Plateau, Ecological resilience, Aquatic biodiversity, Sediment ancient DNA

【A0418】 -Poster
Centennial evolution and influencing factors of wetland landscape patterns in Jiangnan Plain

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Global wetlands have experienced great loss over the past century. It is of great significance for wetland ecological restoration and protection to accurately restore wetland change process and reveal its evolutionary mechanism. On the basis of previous studies, our research enriches the types of wetland reconstruction, and takes small wetlands into consideration. The Jiangnan Plain, which has experienced the most typical wetland changes during the past past century, was selected as the study area. Combined with the 1:50,000 topographic map of the Republic of China and the interpretation results of modern remote sensing images, the centennial evolution process of wetland landscape in the Jiangnan Plain was investigated. Then the response of wetland changes to natural and human-induced factors was analyzed. The results show that the total area of wetlands in the Jiangnan Plain in the 1920s was about 11613km². In the past hundred years, the wetland area of Jiangnan Plain has shown a process of first decreasing and then increasing, and the total wetland area in 1985, 2000 and 2020 is equivalent to 57.3%, 62.6% and 63.6% of the 1920s, respectively. In the 1920s century, lakes, marshes, rivers and mudflats accounted for 52.8%, 32.0%, 12.8% and 2.4% of the total wetland area, respectively, and the proportion of marshes in the total wetland area decreased significantly. The weighted average area of wetland landscape patches decreased rapidly before 1985 and gradually increased after 1985. The distribution of wetland landscapes tended to be discrete over the past 100 years. The shape complexity and spread of wetland landscape continued to



lose from the 1920s century to 2000, and slowly increased after 2000. During the past century, the wetland landscape pattern of the Jiangnan Plain has been affected by both natural and man-made factors, among which human factors such as cultivated land reclamation and national policies are the most critical factors leading to wetland loss. The results of this study can provide a reference for re-understanding the reclamation and wetland loss of the Jiangnan Plain in the past 100 years, as well as the current wetland protection and restoration.

Keywords: Jiangnan Plain, Wetland landscape patterns, Centennial dynamics, Influencing factors, Historical maps

【A0675】 -Poster

Quantitative contributions of different atmospheric circulation systems to Holocene aeolian activity in northwestern China: Evidence from a closed interdune lake in the Tengger Desert hinterland

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The aeolian deserts of northwestern China are major landscape types in the arid regions of the Northern Hemisphere, and collectively they are one of the largest dust source regions on Earth. However, owing to occurrence of sedimentary hiatuses within aeolian deposits in the deserts, we lack clear knowledge of the history of Holocene aeolian activity and the interaction between aeolian processes and their potential drivers. In this study, we extracted an environmentally sensitive grain-size component from the sediments of a closed interdune lake in the hinterland of the Tengger Desert. Our methodology included the application of End Member Analysis (EMA) of different modern sediment types from catchment to regional scales. We reconstructed aeolian activity over the past 13 cal ka BP and quantified the contributions of environmental factors. The results indicated that the EM 2 fraction of the interdune lake sediments is mainly transported by local winds and reflects changes in the intensity of aeolian activity. Based on EM 2 the strongest aeolian activity occurred during 13.0–7.0 cal ka BP, especially during 8.0–7.0 cal ka BP, and the weakest activity occurred during 7.0–3.5 cal ka BP. Aeolian activity increased after 3.5 cal



ka BP, but with a gradually weakening trend. The occurrence of the weakest aeolian activity in the Tengger Desert during the Middle Holocene differs from that on the Asian Summer Monsoonal Boundary and in the area influenced by the Westerlies-dominated climate regime. Thus, there was a clearly defined spatio-temporal differentiation of Holocene aeolian activity across the deserts and dune fields of northern China. Quantitative analysis of the contributions of the potential drivers indicated that wind activity forced by different atmospheric circulation systems, rather than changes in vegetation cover, were the most important driver of regional aeolian activity, although their relative effects varied during the Holocene.

Keywords: Aeolian activity, Interdune lake, Tengger Desert, Holocene, Quantitative contribution

【A0103】-Poster

Late Pleistocene vegetation succession, climate change and hominin adaptation in Sandinggai site, central South China

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The paleoenvironmental changes and adaptation strategies of hominins during the Late Pleistocene are crucial for understanding the evolution, dispersal, and behavioural shifts of early modern humans. South China, an essential region for the dispersal of early modern humans and handaxe technology, has lacked quantitative paleoenvironmental research on this topic. The Sandiniggai site (96.6-13.3 ka BP) in central South China, with its well-preserved stratigraphy and rich lithic artefacts, is notable for offering valuable insights. In this study, a quantitative reconstruction was conducted on the vegetation succession and climate change sequences at the site using palynological and



isotopic data. The results indicated a shift from a warm-temperate evergreen and deciduous broadleaf mixed forest to a temperate deciduous broadleaf forest, with the climate transitioning from warm and humid to cooler and drier conditions. During the early phase, increased lithic production suggested favourable conditions for hominin survival. In the later phase, decreased lithic production and the replacement of large handaxe tools by smaller flake tools, indicated that hominins adapted to the cooler, drier climate and more open landscapes through lithic miniaturization. These findings highlight the environment-driven adaptation of lithic technology and hominin behaviour, shedding light on human survival adaptation strategies.

Keywords: Hominin, Paleolithic, Living environment, Environmental adaptation, Lithic miniaturization

【A0247】-Poster

Transformation in the forest ecosystem of northeastern China driven by human factors over the past 1600 years

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Human-driven degradation of forest ecosystems has profoundly altered land cover, disrupted ecosystem functions, and contributed to climate variability. Understanding long-term changes in forest composition and resilience is crucial for developing effective, evidence-based restoration strategies. This study presents a 1600-year paleoecological reconstruction of forest dynamics in northeastern China, based on sedimentary pollen records from Sihailongwan Maar Lake. The findings reveal that from 480 to 1930 CE, natural factors primarily governed forest dynamics, allowing for a stable adaptation of mixed coniferous and broadleaved species to climate fluctuations. However, since 1930 CE, human activities have become the dominant force, leading to significant shifts in forest structure, reduced coniferous populations, and a substantial decline in ecological resilience. By using forest dynamics driven primarily by natural factors as an ecological baseline, this study provides essential guidance for restoration efforts aimed at



reestablishing a resilient mixed coniferous-broadleaved forest structure. Furthermore, these recommendations emphasize the importance of strengthening forest protection, limiting logging, and engaging local communities in conservation efforts. However, as global warming continues to accelerate, the ecological baseline derived from historical dynamics may become less applicable. This necessitates the establishment of new baselines that take future ecological changes into account.

Keywords: Forest ecosystem, Climate change, Human activity, Ecological resilience

【A0799】 -Oral

Problems and prospects in the application of palaeoecology to managing ecosystems in the Anthropocene: examples from Africa and China

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The idea of using long-term palaeoecological data to inform conservation management decisions first emerged in the 1990s when John Birks reflected on the idea of an ‘applied palaeoecology’. Employing the most suitable and sustainable ecosystem management interventions in the context of a rapidly shifting physical and social environment in the face of climate change and economic development is challenging, and is strongly constrained by the fact that Anthropocene ecosystems are typically highly altered and have only short-term data available relating to their dynamics. While longer-term palaeoenvironmental information is therefore of great potential value to ecosystem management and restoration, there are theoretical and practical constraints to its application. In this paper, using case studies from Africa and China, I reflect on the challenges and opportunities of using information from the past to guide more sustainable ecosystem management.

Keywords: Applied palaeoecology, Ecosystem management, Africa, China

【A0254】 -Poster



Using multi-proxy to reconstruct the vegetation in northwestern Madagascar throughout the mid-Holocene and its relevance to biodiversity conservation

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The most threatened ecosystem in Madagascar is the western dry tropical forest. Human activities have significantly impacted the loss of vegetation cover and erosion, particularly in sedimentary areas and regions with prolonged dry seasons, such as the northwest region. These assumptions have led to policies of general tree planting to restore degraded land and combat soil erosion. However, the vegetation dynamic and the interactions between human and climatic drivers over time are still unclear and debated. This study uses fossil pollen and stable carbon isotopes (C) from two sediment cores from northwestern Madagascar dated ca. 5400 cal years BP and six decades, respectively, to understand the vegetation dynamics. Major and trace elements (MTE) such as Si, K, Ti, Fe/K ratio, and Sr/Ca ratio, as well as charcoal and spores, help explain the signs of climate change, fire, and herbivory activity.

The findings highlighted that bushland, wooded savanna, and grassland have been categorized as open vegetation and have existed in the northwest region even before the human settlement (ca. 2000 BP). During this period, the values of $\delta^{13}\text{C}$, fire records, and herbivory activity were low. From ca. 2000 years PB, we detected a past erosion signal through an increase in Si and K values which correlated with the increase of fire records and herbivory activity. Between 2000 and 1000 cal BP, $\delta^{13}\text{C}$ values declined at the same time as Fe/K and Sr/Ca ratios. This showed that the hydroclimate variability was low and was linked to a drought period. Human activity has impacted the vegetation cover, which had increased from 1000 cal BP during a drier climate with low Fe/K and Sr/Ca ratios. Human settlement has intensified this impact, leading to erosion, particularly in the last six decades. Those findings can be used for conservation management of the dry ecosystem in the western region of Madagascar and across Africa, with a particular focus on erosion prevention, reforestation, and climate change.



Keywords: Mid-Holocene, Dry forest, Pollen, Geochemical, Conservation

【A0311】 -Oral

Palaeoecology as a guide for restoration: Case of the open and mosaic ecosystems of the Central Highlands of Madagascar

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Reforestation initiatives are actively promoted to address climate change. This is the case in the Central Highlands region of Madagascar, where the vegetation is dominated by open and mosaic ecosystems. At present, little is known about the origin of these ecosystems and whether or not they are ancient or anthropogenically derived mosaics. This research, based on palaeoecological records from Lake Dangovavy in the Central Highlands, provides new insights into the environmental history and drivers of change over the past 6000 years and offers guidance for reforestation projects. Our results suggested that open and mosaic ecosystems have been present in the landscape for at least 6000 years i.e., 4 cal. ka BP before human settlement (2 cal. ka BP). Between 6.3–2 cal. ka BP landscapes were characterized by a mosaic ecosystem dominated by a matrix of open montane grassland and ericoid shrubland with extent forest patches, associated with seasonal variation of rainfall, and fire. A matrix of ericoid shrubland remained abundant in the landscape despite an increase in fire regime and herbivory activities between 2 and 1.1 cal. ka BP. Major changes in the vegetation were recorded during the last millennium with a shift towards a more open C₄-dominated grassland associated with high fire frequency and herbivory activities, most likely linked to human influence. Our findings support the notion of the natural presence of open ecosystems on Madagascar island. This insight into the landscape history should be taken into account when



establishing conservation goals, particularly in areas designated for tree plantations and fire restrictions, such as the Central Highlands of Madagascar.

Keywords: Holocene, Vegetation dynamics, Drivers of change, Open and mosaic ecosystems, Madagascar

【A0850】 -Poster

A Quantitative Holocene Climatic Record and Human impact in Majuli Island (world's largest river island), northeast India: A multiproxy assessment

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Majuli's wetlands area is a vital part of the island's ecosystem, providing food and livelihoods for many people. However, the wetlands are shrinking due to several factors, including erosion, lack of natural floodwater circulation, and the expansion of agriculture and infrastructure. Thus, to develop a better understanding of the rapid climatic changes (RCCs) and anthropogenic influence in this part of the Indo-Burma region and their response to the regional vegetation, an extensive multiproxy investigation has been performed during post-Meghalayan to Little Ice Age (LIA) from a sedimentary section of Majuli Island (upper Brahmaputra valley of Assam). The Mean Annual Temperature (MAT) and Mean Annual Precipitation (MAP) during different pollen phases have been inferred through the Coexistence approach. From 2150 to 320 BCE, tropical mixed deciduous forest was observed under warm and humid climate with maximum seasonality. The recovery of extra-local arboreal taxa like *Rhododendron*, *Magnolia*, *Castanopsis*, and Rosaceae in the pollen assemblage was suggestive of the flood activity in the region. The average maximum MAT and MAP values were highest recorded during this phase ($\approx 30^\circ\text{C}$; ≈ 3000 mm). Thus, the Roman Warm Period (RWP) synchronicity during the terminal part of pollen phase I was quite apparent. During 320 BCE to 480 CE, the gradual conversion of a mixed deciduous forest to open-dry vegetation was witnessed as evidenced by the decline in moist tree cover under a relatively less warm and humid climate, the flood activity was comparatively low compared to the preceding phase. Subsequently, during 480 to 860 CE,



the open savanna forest was evident with a further decline in tree cover under a relatively dry climate, corresponding to the Late Antique Little Ice Age (LALIA). LALIA was a long-lasting global cooling period in the 6th and 7th centuries CE. The gradual revival of moist and dry deciduous tree elements was detected during 860 to 1450 CE, under increased humid climatic conditions with the advancement of fluvial activities. This pollen phase was highly corroborated with the Medieval Climatic Anomaly (MCA). During this period, the average value of maximum MAP was elevated (≈ 2750 mm). The abundance of anthropic and arboriculture marker pollen suggests the enhancement of human habitation on the island. The non-pollen palynomorph (NPP) data supports the anthropogenic impact in the region. The dominance of *Helminthosporium*, *Telitia*, and spores of coprophilous fungi like, *Ascodesmis* and *Podospora* (45%) indicate agricultural, grazing activity and domestic settlement around Majuli Island. In addition, the sediment texture record analysis shows low to high mixed-energy conditions since the post-Meghalayan age. Thus, this multidisciplinary quantitative approach to understand climate change since the last four millennia in Majuli Island and its impact on society will aid in developing mitigation strategies for climate change issues.

Keywords: Palynology, Palaeoecology, Anthropogenic, River Island

【A0413】-Poster

Sedimentary record of primary productivity changes in a crater lake in Northeast China since the Last Glacial Maximum

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Seasonal ice-covered lakes are sensitive to anthropogenic warming and undergoing widespread species changes and ecological reorganizations. To recognise and assess anthropogenic effects on lake ecosystems above and beyond natural variability, it is essential to establish a baseline of palaeolimnological trends, in addition to understanding how lakes have responded to past environmental changes on longer timescales. Using multiple proxies of lake primary productivity including biogenic silica content, the carbon



preference index of short-chain *n*-alkanes, and sterol-based geochemical proxies, we reconstruct primary productivity changes in a seasonally ice-covered crater lake (Lake Tuofengling) in northeast China since the Last Glacial Maximum. Results show that primary productivity was lower during the cold and dry glacial period, whereas it was higher during the warm and humid Holocene. During the last deglaciation, primary productivity experienced a ~1.5-kyr lagged response to BøllingAllerød warming, and multiple oscillations during the Younger Dryas. Additionally, the peak productivity of the entire profile also occurred during this period. These fluctuations and the highest primary productivity are suggested to be the result of the combined influences of increased summer temperatures and regional permafrost melting. The current state of primary productivity in Lake Tuofengling is moderate but has been increasing since the abrupt increase in diatom productivity after ~3 ka B.P. This stage is associated with increased dust deposition and longer ice-free periods under winter-warming conditions. We suggest that longer seasonal stratification under the current warmer winters and increased nutrient concentrations caused by decreased lake level will increase the risk of lake ecosystem degradation in the future.

Keywords: Lake primary productivity, Biogenic silica, Short-chain *n*-alkanes, Sterols, Northeast China

【A0532】-Poster

Transient social-ecological dynamics reveal signals of decoupling in a highly disturbed Anthropocene landscape

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Understanding how interconnected social and ecological systems (SES) change over time is crucial for tackling sustainability challenges in the Anthropocene. However, identifying critical transitions in these systems remains a complex task. In this study, we introduce a framework to trace the evolution of SES over long historical periods. Using decades of data, including socioeconomic trends, paleoenvironmental evidence, and advanced



sedimentary ancient DNA records, we focus on China's Yangtze River Delta—a region known for its dense population and extensive environmental changes.

Our findings highlight two major transitions in the region's SES. The first, spanning centuries, shows a loosely connected system that maintained ecological balance. However, starting in the 1950s, rapid industrialization and urbanization created a highly interconnected system, leading to tipping points marked by severe soil erosion, water pollution, and ecosystem damage. The second transition, around the 2000s, saw a remarkable shift: socioeconomic development began to decouple from environmental degradation. This positive reconfiguration offers valuable lessons for balancing growth and sustainability.

By examining these transitions, our study provides critical insights not only for the Yangtze River Basin but also for other regions facing similar challenges. The findings demonstrate the importance of using coevolutionary approaches to better understand and manage the dynamic relationships between society and the environment.

Keywords: Anthropocene, Tipping point, Resilience, Lake ecosystem, Regime shift

【A0746】 -Poster

The characteristics of the space-time change of the carbon accumulation rate of the peatland in the Changbai Mountains in the Anthropocene

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Peatland is the ecosystem with the largest carbon density in terrestrial ecosystems. Although the area only accounts for 3% of the land, it stores about 1/3 of the carbon in the soil and occupies an important position in the global carbon cycle. With the warming of the climate, there is no clear answer to the question of whether the carbon sink function of mid-latitude peatlands will increase or decrease. This paper selects a total of 11 peat cores from 7 peatlands in the Changbai Mountain region located on the southern edge of the boreal peatlands. With the support of ²¹⁰Pb/¹³⁷Cs and AMS¹⁴C technology, it



analyzes the temporal and spatial changes of carbon accumulation rate in the peatlands in the Anthropocene and to explore its impact mechanism. The results show that the carbon accumulation rate of the peatlands every 30 years gradually increased from 1850 to its peak around 1950, and then continuously declined. The peak of the carbon accumulation rate around 1950 coincided with the inflection point of the global CO₂ concentration and rapid increase in temperature. This indicates that an appropriate increase in temperature helps to promote the primary productivity of local peatland, resulting in an increase in carbon accumulation. However, when the temperature exceeds a certain threshold, the decomposition of plant residues dominates and the carbon accumulation rate decreases. This suggests that the peatland in the region may turn from a carbon sink to a carbon source as the climate warms further. In terms of spatial distribution, the highest value of carbon accumulation rate in high-altitude peatland lags behind that of low-altitude peatland and lasts longer. This further shows that when the carbon accumulation rate is at a high value, the temperature should be within a certain threshold range, and too low or too high temperature is not conducive to the carbon accumulation in the peatland. There is a significant difference in the rate of carbon accumulation in different habitats of the same peatland, which is speculated to be related to the hydrological conditions caused by micro-landforms. Comparing the plant composition with carbon accumulation, it is found that moss plants and small shrubs are abundant during the period when the carbon accumulation rate is high. Based on above comprehensive analysis, we speculate that temperature and mire surface wetness affect the carbon accumulation rate of peatland by affecting the combination of plant growth and peat decomposition. This research is conducive to an in-depth understanding of the complex relationship among climate, plant and carbon accumulation, and provides a basis for predicting the carbon sink function of mid-latitude peatland in the future.

Keywords: Peatland, Carbon accumulation, Anthropocene, Changbai Mountains, Plant residue

【A0102】 -Oral

Accelerated ecological shifts in a Tibetan alpine lake reveal ecosystem sensitivity to climate change

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Remote lakes have been recognized as ideal sentinels for global changes due to being far away from direct human intervention and being able to record the natural variabilities of lake ecosystems in sediments. Over the past century, biodiversity loss and ecological regime shifts have been documented globally in response to climate warming, yet high-altitude regions and aquatic micro-organisms remain underrepresented in current research. In this study, we investigate a remote alpine lake above the treeline on the southeastern margin of the Tibetan Plateau, analyzing its biodiversity and ecosystem stability over the past two centuries. Using paleolimnological proxies, including geochemical elements and diatom assemblages, we reconstructed terrestrial inputs and diatom community composition, calculating temporal rates of change in species diversity and multifaceted stability indices. Under the impact of climate change, the lake environment has changed directionally after the 1920s and led to a stark shift in community structure around 1990 CE. This shift coincided with a near doubling of species richness, increased pairwise similarity, and marked declines in ecological stability and structural heterogeneity. Compared to the Arctic lake ecosystems from 1850 to 2000 CE, the Tibetan alpine lake exhibited smaller yet steadily rising compositional turnover rates. These findings highlight the pronounced sensitivity of mid-latitude headwater ecosystems to climatic and environmental drivers, underscoring their potential to influence downstream water quality and biodiversity. Enhanced long-term monitoring of remote ecosystems, particularly in high-elevation regions, is critical to understanding their role as an early indicators of global change impacts.

Keywords: Alpine lakes, Global change, Biodiversity, Diatom community, Tibetan Plateau



Session 09. Pleistocene to Common Era climate reconstructions and insights from speleothem and allied archives

Conveners: Jun Hu, Haiwei Zhang

【A0576】 -Poster

Climate and tectonic imprints in tufa records from Northwest Africa over the past 600 kyr: Insights from petrography and stable isotopes of microbialites

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This research investigates groundwater-fed tufa deposits spanning the Middle Pleistocene to Holocene in northern Morocco, focusing on a depositional system characterized by a multi-story wedge of barrage-cascade and dammed-area deposits. Through process-oriented facies analysis and ^{230}Th dating, along with stable oxygen and carbon isotope analysis ($\delta^{18}\text{O}$ and $\delta^{13}\text{C}$) and petrographic examination conducted on laminated microbialites, the study identifies significant tufa growth during MIS 14. This suggests a warm, humid 'extra-long interglacial' during MISs 15–13, likely supporting late Acheulean hominin occupation and the emergence of early modern humans around 300 ka. The findings point to the possible influence of the Mid-Brunhes Event (MBE) on tufa deposition via CO_2 -climate feedback mechanisms, emphasizing the sensitivity of tufa to global climate shifts. Insights from stable isotopes and microfabric analysis reveal distinct seasonality patterns across tufa stages, further underscoring the impact of the MBE. Additionally, regional tectonic imprints in the late Middle Pleistocene are suggested by counterclockwise rotation and northward tilting of MIS 14 deposits. These features are likely driven by left-lateral strike-slip tectonics and seismic events that disrupted the



hydrogeological balance, influencing both tufa growth and degradation. Differential karstic dissolution and tectonic forces further contributed to deposit tilting, indicating a bookshelf faulting mechanism.

Keywords: Tufas, Climate and tectonics, Pleistocene and Holocene, Northwest Africa

【A0547】 -Oral

Deciphering climate patterns across the last glacial-interglacial transition in Northwest Africa: Insights from speleothems

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We conducted a high-resolution paleoclimate record from a stalagmite sample in Northwest Africa to capture hydroclimate variability over the past 34,000 years. The age model, constructed with over 80 ²³⁰Th dates and 2076 $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ datapoints, reveals periods of mineralogical transitions aligned with significant climatic phases, such as the Last Glacial Maximum (LGM) and Holocene. $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ records show a long-term decline with a significant positive correlation ($r = 0.82$, $p < 0.001$). Data cluster into three groups across key intervals (Holocene, Younger Dryas, B/A-MIS 3), with $\delta^{18}\text{O}$ amplitude of 1.72‰. On a multimillennial scale, $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ exhibit opposite trends in some key intervals, notably during the Last Termination and part of MIS 3. Additionally, variations in Sr/Ca and Mg/Ca in the calcite interval (YD-LGM) hint at the role of water-rock interactions and effective rainfall with minimum contribution from prior carbonate precipitation. Comparisons with regional paleorecords reveal the record sensitivity to orbital and millennial-scale climate oscillations, highlighting a response to both global boundary



conditions, such as radiative forcing and AMOC variability, and local factors, including the influence of Mediterranean-derived moisture, typically during the LGM. The study presents the first high-resolution speleothem record from Northwest Africa to offer insights into regional hydrological responses to broader climate dynamics during the Last Glacial-Interglacial Transition.

Keywords: Speleothems, Late Glacial Maximum, Last Termination, Northwest Africa

【A0074】 -Poster

Pronounced and variable typhoon landfall imprints in a Holocene precipitation isotope record from coastal South China

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Typhoon-induced heavy rainfall significantly impacts the society and economy of the South China coast, yet forecasting its future trajectory remains a formidable challenge. Historical typhoon records are crucial for deciphering the mechanisms behind typhoon variability, but they seldom span the entire Holocene epoch. Given the distinctively negative isotopic signatures of typhoon precipitation, this study examines a Holocene precipitation isotope record derived from the hydrogen isotope composition (δD) of leaf-wax *n*-alkanes in a sediment core from a coastal lake in South China, to assess its potential for reflecting past typhoon activity. The reconstructed precipitation δD are less negative ($-46 \pm 8\text{‰}$) between 9.2 and 3.5 thousand years ago (ka) and more negative approaching -96‰ during the intervals of 11.2–9.2 ka and 3.5–0 ka. This pattern diverges from the typical $\delta^{18}O$ stalagmite records in the East Asian monsoon region, and the -96‰ value matches the extreme negative δD values observed in recent typhoon precipitation. Consequently, we infer that our δD record mirrors the relative contribution of typhoon-induced rainfall to the overall precipitation, suggesting a substantial reduction in typhoon-related rainfall during 9.2–3.5 ka. Notably, this Holocene typhoon history pattern aligns



with the Northern Hemisphere autumn insolation and appears to be influenced by the mean thermal conditions in the tropical Pacific. On a shorter time scale, several negative δD excursions at millennial scale are identified and correspond well with the Bond events, suggesting a possible modulation of local typhoon events by meltwater fluxes in the North Atlantic.

Keywords: Huguangyan Maar Lake, South China coast, Holocene precipitation isotope, Typhoon precipitation, EASM region

【A1025】-Poster

Paleoclimate changes inferred from speleothems in Qinba area during the past 100,000 years

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The Qinba region in Shaanxi Province, situated at the climatic divide between northern and southern China, is home to the highest latitude Tiankeng (sinkhole) group in the country. The Qinling Mountains, known as the "Central Water Tower," play a pivotal role in regulating precipitation across the north and south, halting the advance of Siberian cold fronts and serving as a battleground for large-scale weather systems from opposing directions. Paleoclimatic research in the Qinba area is crucial for the security of the central route of the South-to-North Water Diversion Project and for adapting to climate change. The Last Glacial Period, the most recent ice age in the Quaternary, experienced dramatic climate fluctuations on orbital-millennial scales. A series of abrupt millennial-scale events have been identified, such as Heinrich Stadials (HS) and Dansgaard–Oeschger cycles (DO), which provide valuable patterns for future climate forecasting. There has been a scarcity of research reconstructing monsoon variations across orbital, suborbital, and millennial scales. Moreover, the Qinba region's position at the intersection of the Indian and East Asian monsoons makes the paleoclimate records from stalagmites there instrumental in understanding the phase relationships between the two Asian monsoon subsystems.



Building upon prior research, this study synthesizes the reported paleoclimate studies on stalagmites in the Qinba region and conducts a paleoclimate investigation spanning the last 100,000 years using high-quality stalagmites from the recently discovered Hanzhong Tiankeng group. Utilizing uranium-series dating and carbon and oxygen isotope analyses, we reconstructed the Asian monsoon variations over the past 100,000 years with two stalagmites, DDH-B15 and DDH-B1, from the Didonghe cave in Hanzhong, Shaanxi. Three key findings emerged: First, the stalagmite oxygen isotope records from three regions—the Indian Monsoon region, the East Asian Monsoon region, and the Qinba region—exhibit similarities on millennial and centennial scales but differ on orbital and suborbital scales. The oxygen isotopes in stalagmites from eastern China tend to become more negative, while those from the Indian Monsoon region become more positive, indicating that changes in moisture sources significantly affect the oxygen isotopes in Chinese stalagmites. Second, the hydrological changes represented by the carbon isotopes in stalagmites and other indicators in the Qinba region are highly consistent with the monsoon intensity indicated by oxygen isotopes on a millennial scale. Third, there are subtle differences between the oxygen isotope records of Didonghe stalagmites and Hulu-Sanbao records. During the 60-30kyr BP period, the oxygen isotopes in Hulu Cave stalagmites remained stable without the positive shift observed during the 50-40kyr BP period, and the precession cycle was not evident in this interval, unlike the Didonghe stalagmites, which showed a pronounced expression. This suggests that the Asian monsoon is primarily controlled by the variations in summer insolation at low latitudes in the Northern Hemisphere, with a significant 23,000-year precession cycle. Changes in boundary conditions such as ice volume and carbon dioxide levels can also modulate the amplitude of the precession cycle.

Keywords: Speleothem, Qinba region, Last Glacial, Oxygen isotope

【A0119】 -Oral

Reconstructing drought and climate variability in Semi-Arid Brazil through speleothem records

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Understanding the climate variability and aridity patterns of the São Francisco River Basin (SFRB) over the last millennium is critical to interpreting the processes that shape the semi-arid Northeast of Brazil. This region, which sustains vital economic and social activities, is increasingly affected by extreme drought events, challenging the resilience of ecosystems, agricultural systems, and water resources. However, the limited number of high-resolution paleoclimate studies in this area leaves significant gaps in understanding the historical climate dynamics that have influenced aridification. Identifying natural versus human-induced climate trends in such environments remains complex, as the interactions between oceanic-atmospheric patterns—such as the El Niño-Southern Oscillation (ENSO) and the Atlantic Multidecadal Oscillation (AMO)—and regional precipitation are not fully resolved.

Speleothems, secondary mineral deposits formed in caves, offer a promising proxy for addressing these gaps. With their ability to record long-term environmental changes through isotopic and geochemical signatures, speleothems from the SFRB provide critical data on past hydrological conditions. These records capture fluctuations in precipitation, which reflect shifts in climate modes over centuries. High-resolution analyses of isotopic ratios, such as $\delta^{18}\text{O}$, and trace element composition reveal rainfall patterns and extreme dry periods across different temporal scales. This approach is essential for reconstructing the historical climate of the SFRB, enhancing understanding of the region's hydrological variability, and enabling refined comparisons between historical and modern aridity trends.

Here, a new project is introduced to address this knowledge gap in one of Brazil's most climate-sensitive regions. By analyzing speleothems, abundant yet underutilized in the SFRB, this study aims to reconstruct past drought patterns and improve the understanding of climatic drivers that have historically influenced water availability. These insights are valuable not only for reconstructing past climate regimes but also for informing future climate adaptation strategies in this critical region.



Keywords: Speleothems, Drought Patterns, São Francisco River Basin, Semi-Arid Brazil, Paleoclimate Reconstruction

【A0947】 -Poster

Evolution of Late Cenozoic paleovegetation reconstructed from silica phytoliths preserved in paleosols and its association with climatic oscillations in the Southern Pampas, Argentina

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The late Cenozoic pedosedimentary sequences of southeastern Buenos Aires Province, exposed in coastal cliffs between the cities of Mar del Plata and Miramar, represent one of the most important continental mammal records in South America. These deposits form an extensive mantle of pedogenized loessoid siltstones covering more than 1,000,000 km². Reconstructing the paleoenvironmental conditions under which these sequences were deposited is challenging due to their mineralogical homogeneity and the limited preservation of depositional features caused by intense post-depositional processes (pedogenesis, bioturbation, and high groundwater activity). In particular, the evolution of pre-Holocene paleovegetation is poorly understood, as plant macrofossils and pollen are not preserved. Other bioindicators, such as silica phytoliths produced by vascular plants, have been documented since the earliest microscopic descriptions of these sequences but have only been superficially examined. Recently, a taphonomic evaluation of microfossils in this record highlighted the relevance of silica phytoliths as bioindicators to reconstruct paleovegetation and, indirectly, pedogenesis intensity and paleoclimatic conditions. This study describes and analyzes phytolith assemblages from two historical sections with established chronological control and adequate temporal resolution: Escalera Barranca Los Lobos (PEBL) and Punta San Andrés (PPSA). We analyzed 72 samples, describing their phytolith content both qualitatively and quantitatively using optical microscopy. The results were contextualized within the latest allostratigraphic framework, while previous magnetostratigraphic studies provided indirect chronological control. In the PEBL section, an average of 6,600 phytoliths per mg of sample was



estimated, enabling the reconstruction of paleovegetation during the late Pliocene to early Pleistocene. The phytolith record indicates four shifts in vegetation cover. Assemblages from the Playa San Carlos Alloformation suggest paleovegetation dominated by Arecaceae and grasslands similar to modern temperate humid prairies (“flechillar”). In the Punta Martínez de Hoz Alloformation, an internal transition was detected: from semi-arid, temperate/cold grasslands (Pooideae) in the lower section to more humid conditions in the upper section (Stipoideae), supported by the presence of diatoms and chrysophycean cysts. In PPSA, an average of 4,250 phytoliths per mg of sample was estimated, allowing for a detailed paleoenvironmental reconstruction of the Punta San Andrés Alloformation (Pleistocene). Two intervals with unusually low phytolith content, a condition previously unreported at both local and regional scales, suggest arid conditions with sparse vegetation cover, alternating with periods of well-developed grasslands resembling those of the present day (Stipoideae and Pooideae). These findings reinforce earlier interpretations of arid conditions in the southeastern Pampas around 2.5 Ma during MIS 82–78, previously inferred solely from the presence of arid-adapted taxa in the *Ctenomys chapadmalensis* biozone. The observed changes in phytolith assemblages support interpretations of climatic oscillations influenced by glacial and interglacial periods throughout the Late Cenozoic in Patagonia, affecting humidity conditions in the Southern Pampas. Overall, this study offers new insights into the paleovegetation and paleoenvironmental evolution of the area, and contributes to the understanding of Pliocene and Pleistocene climate at a regional scale.

Keywords: Paleovegetation, Phytoliths, Paleoenvironmental reconstruction, Southern Pampas

【A0500】-Poster

The stable isotope records of stalagmite fluid inclusions from central China and their climate significance during the last glacial period

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Stalagmite calcite oxygen isotope compositions are commonly used to infer paleoclimate changes. However, the $\delta^{18}\text{O}$ values of stalagmite calcite are influenced by multiple factors, including precipitation oxygen isotope compositions, temperature, in-cave physicochemical processes, and potential kinetic fractionations under disequilibrium deposition conditions. In contrast, the stable isotopes ($\delta^{18}\text{O}$ and δD) in fluid inclusions within stalagmites are more robust to infer the stable isotope composition of drip-water, i.e., paleo-precipitation. To compare $\delta^{18}\text{O}$ variations between calcite and fluid inclusions and to reconstruct climate change, in particular, the temperature changes, during the last glacial period ($\sim 100\text{--}30$ ka B.P.), we analyzed fluid-inclusion $\delta^{18}\text{O}$ and δD values from a stalagmite collected from Didonghe Cave, central China. The results show that while calcite and fluid-inclusion stable isotopes covary on orbital timescales, they diverge on millennial timescales. Temperature reconstructions based on fluid-inclusion and calcite $\delta^{18}\text{O}$ indicate a slight overall decrease in annual temperature during the last glacial, with particularly low temperatures occurred during $\sim 75.2\text{--}72.7$ ka and $\sim 50\text{--}47.6$ ka, indicating significant temperature changes in these events.

Keywords: Speleothem, Fluid inclusion, Stable isotope, Last glacial, Palaeotemperature

【A0517】-Poster

Stalagmite records of Holocene climate change on the Chinese Loess Plateau

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The speleothems in northern China are excellent archives for studying changes in the East Asian Summer Monsoon climates, as monsoon precipitation contribute the major fraction of the annual precipitation and is highly sensitive to the advancement and retreat of the Summer Monsoon front. Based on 32 U-Th dates, 826 sets of carbon and oxygen isotope measurements, and 181 sets of trace element analyses (Mg/Ca, Sr/Ca, Ba/Ca) attained from two stalagmites, this study presents multi-proxy stalagmite records from the northern margin of the Chinese Loess Plateau, primarily covering the period from 9.6 to 5.9 ka BP (before present, referring the years before 1950 AD). The deposition of the stalagmites from Yixi Cave exhibits significant episodic variability, very likely reflecting changes in regional hydroclimates determined by both the precipitation and temperature. The main growth phases correspond to periods of high stalagmite cumulative growth frequency in Longfeng Cave, which align with the high lake-level periods in northern China, providing constraints on the timing of the Holocene optimum in the study area. The amplitude of the "8.2 ka BP event" is not prominently defined and other centennial-scale fluctuations with similar amplitude are also observed in the $\delta^{18}\text{O}$ record of this cave, suggesting that multiple processes influenced the $\delta^{18}\text{O}$ variations in stalagmites from the monsoon margin regions in northern China. Additionally, a comparison of multi-proxy indicators in the stalagmites, especially the centennial-scale component of $\delta^{18}\text{O}$, reveals a significant regime shift around 7.8 ka BP, implying that different stages within the Holocene optimum were governed by distinct primary factors.

Keywords: The northern China monsoon margin, Holocene Optimum, Speleothems, East Asian Summer Monsoon

【A0885】-Poster

Speleothem evidence of solar modulation on the south Asia monsoon intensity

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The influence of solar variation on climate has long been debated, with some studies expressing conservative views. Here, we utilize a published decadal-resolved speleothem $\delta^{18}\text{O}$ record from Vietnam, spanning 32.5 to 27.5 kyr BP, as a proxy for regional precipitation levels, and compare it to Total Solar Irradiance (TSI) proxies. Our results show a general coherence between TSI and regional precipitation, supporting a positive climate response consistent with conventional monsoon theory. Spectral analysis on the Vietnamese datasets reveals an approximately 180-year periodicity coinciding with the de Vries cycle of solar activity. Further comparing our record with 35 other speleothem records, we demonstrate the importance of sufficient age control points in capturing solar-related periodicities. Model simulation shows that TSI could enhance monsoonal circulation and regional precipitation. Also highlighted are the implications of chronology control for detecting climate events in proxy records. The new findings underscore the significance of relatively minor radiative forcing in regional climate dynamics over monsoonal Asia on decadal to centennial timescales.

Keywords: Solar influence, Asian Summer Monsoon, Multi-linear regression analysis

【A0429】-Poster

The stalagmite-inferred interplay between the westerlies and the Indian Summer Monsoon on centennial to decadal scales over the south-western Tibetan Plateau during the last interglacial

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Climate variability on centennial to decadal scales during the Holocene has been well investigated in various records. However, whether such variability exists in older interglacial periods remains elusive, hindering our understanding of climate variability on these short time scales and thus diluting the capability to project future climate change in a warming world. Here, we present a precipitation $\delta^{18}\text{O}$ record from ~124.73–121.57 ka BP, inferred from a stalagmite with clear annual lamination from Qiongguo Cave,



southwestern Tibetan Plateau. The $\delta^{18}\text{O}$ values of stalagmites are rather negative and vary from -17.8‰ to -22.9‰, consistent with the fluctuation range and trend of $\delta^{18}\text{O}$ values of stalagmites in Tianmen Cave in the south-central Tibetan Plateau, indicating that water vapor conveyed by the Indian Summer Monsoon can still reach the southwestern Tibetan Plateau during this period. Modern observations show that precipitation $\delta^{18}\text{O}$ in regions (seasons) affected by westerlies is positively correlated with temperature, while precipitation $\delta^{18}\text{O}$ in regions (seasons) influenced by the Indian Summer Monsoon is inversely correlated with temperature and monsoonal water vapor transport, implying that the precipitation $\delta^{18}\text{O}$ fluctuations recorded by the Qiongguo stalagmite can reflect the interplay of these two climate regimes. The long-term variation of stalagmite $\delta^{18}\text{O}$ record closely tracks the 65°N solar insolation changes, confirming the dominant control of solar insolation on the Indian Summer Monsoon. EEMD, spectral, and wavelet analyses reveal multi-decadal (~60-year) and centennial (~230-year, ~580-year, etc.) periodic variations. Unlike the ~60-year cycles, which persist throughout the whole record, the fluctuations at centennial scales are apparent only at the late portion of the record. The study affirms that the ~60-year periodic variation of the Indian Summer Monsoon observed in the Holocene also exists in the last interglacial, demonstrating that solar activity and the Atlantic Multidecadal Oscillation may be the main factors regulating the ~60-year variability of the Indian Summer Monsoon in the warming world.

Keywords: Last interglacial, Tibetan Plateau, Annual laminae, AMO, Solar activity

【A0160】 -Poster

In-phased rainfall pattern in northern and central China on millennial-scale timescales revealed by multi-proxy speleothem records

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The interactions of the East Asian Summer Monsoon (EASM) and Westerly Jet (WJ) are essential to the rainfall anomalies on the Chinese Loess Plateau (CLP), which is ambiguous during the last glacial period. Using 230Th/U dating, stable isotope and trace metal data from a stalagmite, we reconstructed palaeoclimate changes on central CLP during



the Marine Isotope Stage 3. Consistent with Dansgaard-Oeschger (DO) events captured in $\delta^{18}\text{O}$ record (a proxy of EASM intensity), $\delta^{13}\text{C}$ and trace metal records also show in-phased millennial-scale variations. The $\delta^{13}\text{C}$ proxy is possibly related with the terrestrial biomass controlled by local hydrothermal conditions, and trace metal ratios might reflect the effects of water-rock interactions and prior calcite precipitation and thus an indicator for humidity. A principal component derived from $\delta^{13}\text{C}$ and trace metal ratio records show good similarity with loess-based reconstructed summer precipitation. Local precipitation changes consistently with rapid status shifts in the EASM and the WJ at DO onsets, but decouples from the EASM during long-lived DO events, indicating potential impacts of the WJ. The position and strength of the WJ could modulate the CLP rainfall in two ways: the rapid switch from low- to high-level rainfall at DO onsets related to the fast backward-jump and quick recession of the WJ, and the strong impediment on water vapour transported by the monsoonal circulation from low-latitudes. Therefore, millennial-scale rainfall amount patterns on the CLP are likely resulted from the relative intensity and position of the WJ and EASM.

Keywords: East Asian summer monsoon, Chinese stalagmite, Westerly Jet

【A0540】 -Oral

Seasonal monsoon variations and collapse of Late Brone Age civilization in China

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While the decline of complex societies has been linked to natural climatic changes, the specific impacts of seasonal climate variability on resource management and society stability remain insufficiently underexplored. Here, we present micron-scale isotopic and geochemical analyses of an annually laminated stalagmite in northern China, offering detailed records of seasonal climate during Shang to Western Zhou dynasties (~1600-771 BCE) - pivotal periods in the origin and evolution of Chinese civilizations. The results reveal that the East Asian Summer Monsoon (EASM) dissipates from northern China for decades in the late Shang and late Western Zhou, coinciding with the global 2.8-ka event. We



suggest that the consecutive multi-decadal occurrences of rare, unexpected extreme climatic events, marked by severe aridity and decreased precipitation predictability in both summer and winter season, significantly reduced the millet-based agricultural productivity, triggering conflict over essential resources and thus contributing to the collapse of these agrarian societies. Additionally, we propose that the climate-induced agricultural stress may have driven a significant shift in dietary from millet to wheat, highlighting the broader implications of climate variability on society resilience.

Keywords: Stalagmite, Precipitation Seasonality, Micron-scale analyses, Early China, Societal transformations

【A0874】 -Poster

A decade of tracing hydroclimate shifts in Northwest Africa from speleothems: Bridging the Holocene and Late Pleistocene Divide

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Northwest Africa, a region of critical climatic and archaeological importance, has seen considerable advances in understanding its Holocene hydroclimate variability. However, insights into the Late Pleistocene remain limited, creating a significant knowledge gap. This study synthesizes Holocene speleothem-based hydroclimate records from Morocco, integrating high-resolution isotopic ($\delta^{18}\text{O}$, $\delta^{13}\text{C}$) and trace element data. These records highlight the influence of major atmospheric circulation modes, including the North Atlantic Oscillation (NAO) and the Atlantic Meridional Overturning Circulation (AMOC), in driving regional precipitation variability.

Key findings reveal pronounced hydrological shifts during the Holocene, including periods of enhanced winter precipitation associated with negative NAO phases and millennial-scale cooling events. The results emphasize the interplay between westerly winds and the Azores High, which modulated moisture delivery to the region. Furthermore, these findings provide context for the socio-environmental impacts of climate variability, such as shifts in human occupation patterns and the extent of Green Sahara conditions.



While these records offer valuable insights into Holocene climate dynamics, the Late Pleistocene remains poorly understood due to the paucity of well-dated, high-resolution archives. Addressing this temporal gap is essential for refining our understanding of orbital-scale forcings and the climatic drivers of human dispersal in Northwest Africa. This work underscores the need for extended datasets covering the Late Pleistocene to establish a comprehensive view of regional climate evolution and its global teleconnections.

Keywords: Speleothems, North Atlantic Oscillation, Green Sahara, Holocene hydroclimate, Northwest Africa

【A0510】 -Poster

Prior calcite precipitation systematics in stalagmites with detrital inputs

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One of the key hydrological processes recorded in stalagmites is the shift in the infiltration water regime from dissolution to precipitation within the epikarst, known as Prior Calcite Precipitation (PCP). This process is particularly noteworthy for its significant impact on specific trace element-to-calcium ratios and stable isotope profiles. PCP can be traced using the Mg/Ca ratio, and occasionally the Sr/Ca and/or Ba/Ca ratios, in combination with $\delta^{13}\text{C}$ values. Recent studies have focused on isolating PCP signals to distinguish the contributions of soil and vegetation respiration in the $\delta^{13}\text{C}$ values. However, caution is needed when interpreting proxies from samples with detrital inputs.

In this study, we present new data from *Gaea* stalagmite, Ejulve cave (NE Spain), characterized by significant detrital Mg inputs, providing an ideal case for investigating PCP processes in a detrital-rich sample from this cave. The correlations observed between Mg/Ca and Al/Ca, Y/Ca, Si/Ca, and ^{232}Th , alongside the lack of correlation between Mg/Ca and Sr/Ca, highlight the influence of detrital inputs on Mg/Ca. Moreover, the strong



correlation between Sr/Ca and $\delta^{13}\text{C}$, contrasted by the absence of this relationship with Ba/Ca, suggests that Sr/Ca is a reliable proxy for tracing PCP processes, provided potential growth rate effects on Sr/Ca variability are ruled out. Consequently, Sr/Ca is applied in *Gaea* to explore the original respired- $\delta^{13}\text{C}$ signal set up by vegetation and soil processes.

This stalagmite exhibits high sensitivity in capturing the terrestrial response contemporaneous with sapropel deposition events—periods associated with organic-rich sediment accumulation and seafloor anoxia in the Mediterranean Sea. Notably, the signal varies across these events, reaching the highest $\delta^{13}\text{C}$ values, high variability, and pronounced PCP during the “glacial” S6 (~165–178 ka). In contrast, sapropels formed during interglacials, such as S7 (~192–198 ka), S8 (~209–224 ka) and S9 (~239 ka), show much more moderate PCP signals and lower $\delta^{13}\text{C}$ values.

Keywords: Speleothems, PCP, Detrital inputs, Soil respiration

【A0416】 -Oral

Reconstructing MIS3 climate during Neanderthal extinction in Iberia using speleothems from Spain

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The Iberian Peninsula served as one of the final refuges for Neanderthals, where they survived and likely interbred with *Homo sapiens*. Evidence suggests a staggered timeline for their disappearance across Iberia: Mousterian industries, attributed to Neanderthals, ended around 44-45 ka BP in northern Spain and 36-37 ka BP in the south. While hypotheses such as climate and ecosystem shifts, along with competition from *Homo sapiens*, have been proposed to explain their extinction, the issue remains under debate.



This study presents two stalagmite records from eastern Spain, spanning 59 to 31 ka BP, covering MIS3, the period of Neanderthal extinction in Iberia. The stalagmites were collected from semi-arid zones with distinct climatic regimes: one from the continental Mediterranean region of the Iberian Range, with an annual precipitation of 431 mm, and another from the maritime Mediterranean climate of the Balearic Islands, which is slightly wetter.

The $\delta^{13}\text{C}$ profiles of these records closely track sea surface temperature variations in the nearby Atlantic, reflecting vegetation and soil respiration responses to Dansgaard-Oeschger (DO) oscillations identified in Greenland ice core records. A key observation is the varying amplitudes seen in the $\delta^{13}\text{C}$ responses to DO events, contrasting with the more uniform patterns seen in Greenland, suggesting differences in sensitivity and intensity in the $\delta^{13}\text{C}$ response across DO events.

The new proxy data offers high temporal precision, with age uncertainties around 170 years at the MIS4 to MIS3 transition and less than 100 years between 35 and 31 ka BP, in the more recent portion of MIS3. Crucially, our record captures the precise timing of Heinrich Stadial 4 and Heinrich Event 4, as the $\delta^{18}\text{O}$ in one of the stalagmites is particularly sensitive to shifts in the $\delta^{18}\text{O}$ composition of the nearby ocean, reflecting meltwater discharges in the Atlantic. This robust chronology provides a framework for reconstructing ecosystem disruptions linked to Heinrich 4 and evaluating its potential impacts on hominin populations in Iberia.

Keywords: Speleothems, MIS3, Neanderthals

【A0732】-Poster

Holocene climatic and environmental changes on the NE Tibetan Plateau from sedimentary records

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Alpine ecosystems are particularly sensitive to climatic and anthropogenic change. The Qinghai-Tibetan Plateau is located near several deserts and drylands and is under the influence of various wind systems including the Westerly Jet and the East Asian winter monsoon (EAWM), which may affect mineral dust supply to the Plateau. As such this region is an important study area of past changes in climate and earth surface processes, and hence the Asian dust cycle.

Sediment cores from lakes and wetlands on the NE Tibetan Plateau were collected to reconstruct climatic variability and landscape evolution during the Holocene. This project aims at reconstructing climatic/environmental changes and anthropogenic activities during the Holocene using sedimentary, biological and geochemical proxies from wetland archives. Dunes nearby the study sites were also sampled. Samples from the sediment cores and dune samples were analyzed for elemental inorganic geochemistry (major and trace elements) in order to determine the composition of the mineral matter of the wetlands and to infer potential environmental and climate changes.

A 3.0m core was collected at Xing Cuo wetland, and the base was dated to 13.0ka cal BP. The core displays several changes between lacustrine sediments and peat ca 4.0ka cal BP, when the wetland was fully established. The timing of the inception of peat accumulation is similar in the other sampled wetlands (3.0-4.0ka cal BP) and suggests a climatic influence over autogenous processes. Results on rare earth elements suggests the mineral matter in the Xing Cuo wetland is a mixture of local sources such as the dunes surrounding the site, and the deserts of northeastern China. From 4.0ka to 1.5ka cal BP, the REE flux is relatively high and then displays a gradual decrease from 1.5ka onward. Along with the increase in mineral material, a sharp increase in charcoal fragment and particle grain size is observed during the same period in different wetlands, suggesting a change either in local environmental conditions or a broader climatic change (potentially changes in WJ or EAWM intensity). Dune activity display a similar tendency, with increased activity around 11.2ka during a period interpreted as dry in the Xing Cuo record, and a second period, with more extensive dune activity after 4.0ka corresponding with other evidence of drying conditions in the regions. The Younger Dryas display more humid conditions and a subsequent drying during the early Holocene in disagreement with the speleothem records, while the Mid- and Late Holocene display similar tendencies as the speleothem records. The reason for these discrepancies remains to be explored.



Keywords: Holocene climate, Asian Monsoon, Sedimentary archives, Elemental geochemistry, Charcoals

【A0859】 -Poster

Characterizing composition of stalagmites- A non-destructive approach

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Stalagmites are best-recognized carbonate deposits, providing continuous and precisely dated records of climate and environmental history within continental settings. In our study, we used hyperspectral imaging (HSI) and microXRF (Itrax core scanner)- a relatively non-destructive techniques to remotely characterize the mineral and elemental composition of stalagmites. The wide spectrum HSI was initially tested on a sample, named Stalagmite MAJ-4 from Madagascar. The results were cross validated using petrographic analysis of oversized thin sections and X-ray diffraction (XRD) analyses on selected layers.

To automate the mineral identification and classification across the entire sample, we developed a machine learning algorithm. For relative quantification of mineralogy across various depths, we use spectral indices method. This technique offers us faster mineral detection and mapping as well as thier quantification. Current study also addressed the effect of elemental substitution on the index profile of carbonate minerals, offering a less destructive and time friendly method of analyzing stalagmites.

To evaluates the reproducibility of this approach, we are extending the analysis to stalagmite samples from Trapia and Furna Nova caves in Brazil. The finding obtained from this study can provide a guide for subsequent mineralogical and geochemical analysis for paleoenvironment reconstruction.



Keywords: Stalagmites, Carbonates, Hyperspectral imaging, Machine learning, Paleoenvironment

【A0704】-Poster

A speleothem record of precipitation and temperature in the Russian Plain (Samara region)

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The central part of the Russian Plain represents an area of abrupt climate change during the Quaternary period, with a strong correlation to climate variations in the North Atlantic. Furthermore, climatic changes within the Russian Plain have a significant impact on the volume of the Volga River's run-off, due to the repeated glaciations and fluctuations in precipitation that have characterized this region. Consequently, this has had an impact on the level of the Caspian Sea.

For example, two periods of change in the Volga River runoff have been reconstructed since the last glacial maximum. The initial period (18-12 ka) is distinguished by relatively low temperatures and high runoff. The second period (8.5-5.5 ka) is characterised by temperatures higher than those of the present day and low Volga runoff. It is important to note, however, that these reconstructions have a relatively low resolution. The speleothem records from the Volga River basin have the potential to provide insights into precipitation and temperature changes in the region, and consequently, into runoff changes and their impact on Caspian Sea level changes.

In 2024 three flowstones and two stalagmites were collected from the Samara region. The cave was located within the confines of the upper Permian carbonate rocks. It is not



possible to monitor the cave in its current state, as it has been destroyed by quarrying activities.

Two samples of stalagmites (PD-1, PD-2) demonstrate two distinct generations of calcite growth. ICP-MS analysis reveals fluctuations in Sr, Mg, and their ratio with Ca. It is expected that $\delta^{18}\text{O}$ would also show at least two periods, reflecting different precipitation and temperature conditions. U-Th dating will help us to tie these changes to chronology. As it looks quite young, we expect to cover part of the Late Pleistocene and the Holocene.

Stable-isotope analysis of a flowstone in the area, similarly exposed by local faulting and collected in 2019, yielded d^{18}O from -13.5 to -12.5 per mil and d^{13}C from -9.5 to -7, comparable to early Holocene values in the Ural Mountain records. Preliminary dating suggests that speleothem growth occurred as early as MIS-11/13. Given the relative condition of the samples/sites, this age is plausibly an upper limit for speleothem preservation in the area.

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Keywords: Volga River, Holocene, Precipitation

【A0073】-Poster

Implications of synoptic-scale stable water isotope modelling in East Asia

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The isotope-enabled climate models have been widely applied to simulate the variability of stable isotopes in meteoric water and climate proxies at various time scales. It is



necessary to understand the difference in climate controls of water isotopes from daily and synoptic scales to annual and longer scales. The models show better skill for warm and humid backgrounds, which corresponds to the monsoonal regions with lower latitudes in East Asia. The daily modelling has good potential to investigate the short-term climate details behind water isotopes. The air regimes controlling the annual isotope variability may be not the same as those controlling the synoptic variability, as suggested by modelling and observations. The findings are useful for understanding the time scales of possible climate factors related to water isotope variability in East Asia.

Keywords: Stable water isotopes, East Asia, Time scale

【A0739】 -Oral

Grand dipole response of Asian Summer Monsoon to orbital forcing

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The coherent continental-wide speleothem water isotope records are accompanied by regionally inconsistent moisture patterns within the Asian Summer Monsoon (ASM) region, leaving a disputed explanation of monsoonal hydroclimate variability at the orbital timescale. Here, the transient simulation forced by orbital parameters during the past 300,000 years in an isotope-enabled fully coupled model shows that the complex ASM response can be understood as a grand dipole pattern of oxygen isotope and rainfall between South Asia and Japan, with South China lying in a hybrid transition region. While the dipole monsoon rainfall change between South Asia and Japan is related to the large-scale circulation adjustment in response to Northern Hemisphere summer insolation, the dipole oxygen isotope pattern is associated with the changing contribution of moisture sources. Our results provide new clues to reconcile ASM hydroclimate patterns at orbital timescale as revealed by the water isotope records and other hydrological proxies.



Keywords: Orbital scale, Speleothem oxygen isotope, Asian Summer Monsoon

【A0297】 -Poster

Asynchronicity of deglacial permafrost thawing controlled by millennial-scale climate variability

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Permafrost is a potentially important source of deglacial carbon release alongside deep-sea carbon outgassing. However, limited proxies have restricted our understanding in circumarctic regions and the last deglaciation. Tibetan Plateau (TP), the Earth's largest low-latitude and alpine permafrost region, remains underexplored. Using speleothem



growth phases, we reconstruct TP permafrost thawing history over the last 500,000 years, standardizing chronology to investigate Northern Hemisphere permafrost thawing patterns. We find that, unlike circumarctic permafrost, TP permafrost generally initiates thawing at the onset of deglaciations, coinciding with Weak Monsoon Intervals and sluggish Atlantic Meridional Overturning Circulation (AMOC) during Terminal Stadials. Modeling elaborates that the associated Asian monsoon weakening induces anomalous TP warming through local cloud–precipitation–soil moisture feedback. This, combined with high-latitude cooling, results in asynchronous boreal permafrost thawing. During the last deglaciation, however, anomalous AMOC variability delayed TP and advanced circumarctic permafrost thawing. Our results indicate that permafrost carbon release, influenced by millennial-scale AMOC variability, may have been a non-trivial contributor to deglacial CO₂ rise.

Keywords: Permafrost, AMOC, Glacial-interglacial cycle, CO₂, Stalagmite

【A0868】 -Poster

A speleothem GDGT-based reconstruction of temperature changes through the Last Glacial Maximum to early Holocene in central China

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Reconstructing the characteristics of temperature changes from the Last Glacial Maximum (LGM) to the warmer early Holocene provides an opportunity for a comprehensive understanding of Earth's climate dynamics in response to polar ice loss, and a better evaluation of climate model simulations. Temperature reconstructions based on the abundance and distribution of Glycerol Dialkyl Glycerol Tetraethers (GDGTs) in geological materials have been successfully applied to marine and lake sediments, loess and peats. However, few studies have attempted to extract and quantify GDGTs from speleothems. Here, we present a paleotemperature reconstruction from the LGM to the early Holocene based on GDGT analysis of a 40 cm-long stalagmite from Xianglong Cave in central China. The TEX₈₆ values of the stalagmite range from 0.38 to 0.78, underlining the potential for



speleothem archives to sensitively record changes in temperature. Our results suggest that the cave air temperature, as derived by TEX₈₆ and reflecting the local mean annual air temperature at the time of deposition, was ~6.4°C during the LGM (~6.6°C lower than the present-day cave temperature). Temperatures during the Heinrich 1 and Younger Dryas stadials were ~10.5 °C and ~11.6 °C, respectively. Interestingly, our record does not indicate a change in temperature during the Bølling–Allerød warm period. This observation potentially implies that during periods of intensified Asian Summer Monsoon activity, such as the Bølling–Allerød, the TEX₈₆ proxy might be subject to influences beyond just temperature variations.

Keywords: Speleothem, GDGTs, Last Glacial Maximum, Early Holocene, Temperature

【A0152】 -Poster

Chinese speleothem evidence of Holocene atmospheric circulation transitions

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It remains unclear how the Holocene Asian Summer Monsoons (ASM) were related to changes in ice volume and shifts in the Intertropical Convergence Zone (ITCZ) under the forcing of Northern Hemisphere Summer Insolation (NHSI). Here, we provide a high-resolution record of monsoon changes, with measurements of 14 230Th/U dates and 706 δ¹⁸O values of a stalagmite from Shima Cave, Hunan Province, central China, covering the past 14.6 ka. Our record shows a gradual monsoon intensification from the end of YD to ~8 ka BP, which is supported by many of the published cave and other archive records. This observation, along with prominent events including the 8.2 ka, 9.2 ka and the Preboreal Oscillation (PBO) during the early Holocene, suggests that the early Holocene ASM changes were controlled by NHSI and variations of northern high-latitude climates during the process of ice-sheet retreat. Furthermore, the general pattern and transition in our record agree well with the ITCZ record, and an integrated



cave record of long Chinese cave $\delta^{18}\text{O}$ records which can represent the overall changes in precipitation $\delta^{18}\text{O}$ compositions over the monsoonal region of China. Both our and the integrated $\delta^{18}\text{O}$ records demonstrate a prominent transition at ~ 8 ka BP, coinciding with worldwide reorganizations of oceanic and atmospheric circulations including a pronounced southward shift in ITCZ, implicating forcing from external insolation and internal feedbacks (e.g., ice sheets). When placing the Chinese stalagmite record in the context of the last four interglacial periods, we find that the inner-interglacial transitions are likely controlled by an insolation threshold and that features and dynamics in climatic transition are exceptional during the Holocene.

Keywords: Stalagmite, Asian Summer Monsoon, Holocene, Atmospheric transition

【A0953】-Poster

Water source variability in the Dead Sea Basin since the last deglaciation: Insights from uranium isotopes of authigenic minerals

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The Dead Sea basin, located at the intersection of the Mediterranean climatic zone and the Sahara Desert belt, provides a sensitive archive of past hydroclimate dynamics in the south Levant, a region vulnerable to drought under ongoing climate warming. Paleoclimate reconstructions from the Dead Sea Deep Drilling Project (DSDDP) reveal a detailed lithological record of regional climate variability, characterized by wetter glacials and drier interglacials. This record captured dry intervals that are not evident in the Soreq Cave speleothem, offering a more comprehensive view of the region's paleoclimate. Here, we analyzed $^{234}\text{U}/^{238}\text{U}$ activity ratios of authigenic minerals (aragonite, halite, and gypsum) from the DSDDP core to track shifts in water source to the Dead Sea since the last deglaciation. During the hyperarid Bølling–Allerød and the beginning of Holocene, marked by thick halite deposition, the $^{234}\text{U}/^{238}\text{U}$ activity ratios of authigenic minerals decreased from ~ 1.5 to $1.1\text{--}1.3$. The notable declines indicate a shift in water sources from the north and west (Jordan River and Mediterranean-sourced rainfall, $^{234}\text{U}/^{238}\text{U}$: $\sim 1.5\text{--}1.7$) to the eastern and southern catchments along with flash floods ($^{234}\text{U}/^{238}\text{U}$: $\sim 1.0\text{--}1.2$). Given that



Mg^{2+} in the Dead Sea is conservative and its concentration ($[Mg^{2+}]$) is directly proportional to the lake volume, water budgets of different sources were estimated based on porewater $[Mg^{2+}]$ and a two-component uranium isotope-mixing equation. Our results suggest a dramatic reduction in the Jordan River's runoff, the primary freshwater source in the south Levant, by one to two orders during the arid periods (Bølling–Allerød and the beginning of Holocene) compared to the modern level. This is probably driven by a decrease in wintertime cyclonic activities. Additionally, a doubling in the southeasterly runoff during the Younger Dryas–Holocene transition and the relatively wet period (9.5–8.3 ka) coincided with the Mediterranean sapropel event (S1). This increased southeasterly source may be related to the resumption and intensification of the African Summer Monsoon.

Keywords: Dead Sea, Uranium isotopes, The last deglaciation and Holocene, Authigenic minerals

【A0489】 -Oral

Reconstructing sub-annual variations in hydroclimate and temperature on the Chinese Loess Plateau based on clumped isotopes of modern and glacial fossil land snail shells

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Currently available reconstructions of past East Asian Monsoon (EAM) variability reach an average temporal resolution of ~100 years at best. Although insightful for orbital and millennial scale changes in EAM climate, our understanding of seasonal variations in precipitation and temperature requires quantitative reconstructions at a higher resolution. Here we present sub-annual scale reconstructions of temperature and precipitation variability based on carbonate clumped isotope (D_{47}) and stable oxygen isotope ($\delta^{18}O_{\text{shell}}$) measurements on modern and glacial fossil land snail shells collected from the western



(Yuanbao, YB) and eastern (Lingbao, LB) edge of the Chinese Loess Plateau (CLP). Whole-shell D_{47} -derived temperatures (T_{47}) from different modern snail species are consistent with land surface temperature during their growing season (mid-April to September at YB and mid-March to October at LB). Fossil snail shells indicate that glacial growing season conditions were $\sim 7^\circ\text{C}$ cooler than today. Notably, within-shell variations in T_{47} are most often not significant, which suggests that variability in $\delta^{18}\text{O}$ within the same shell is predominantly related to changes in the body water composition of the snail ($\delta^{18}\text{O}_{\text{bw}}$) and thus hydroclimate. The $\delta^{18}\text{O}_{\text{bw}}$ obtained for modern snails is $\sim 3\text{--}6\text{‰}$ less negative than the average $\delta^{18}\text{O}$ of precipitation during the modern growing season, suggesting that $\delta^{18}\text{O}_{\text{bw}}$ is influenced by low relative humidity (RH) and related evaporation. The within-shell variations in $\delta^{18}\text{O}_{\text{bw}}$ in fossil snails from LB (LGM) and YB (last deglaciation) show a larger amplitude compared to in the modern shells, which is primarily induced by more negative $\delta^{18}\text{O}$ of precipitation in wet season and stronger evaporation effect in dry season resulting from potentially a longer water vapor transport pathway and low RH during glacials, respectively. The high-resolution Δ_{47} and $\delta^{18}\text{O}_{\text{shell}}$ records demonstrate that sub-annual scale variations in hydroclimate were enhanced during glacial conditions. Our data further support the potential of using land snail shells for reconstructing sub-annual scale variations in past EAM climate.

Keywords: EAM system, Snail shells, Clumped isotope, Absolute temperature, Seasonal precipitation $\delta^{18}\text{O}$



Session 11. New horizons for paleosciences outreach

Conveners: Boris Vannière, Iván Hernández-Almeida

【A0132】 -Poster

Preserving Klang Cave: 3D virtual tourism for sustainable development in Thailand

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Over 5,000 caves have been discovered in Thailand, drawing tourists with their stunning natural beauty, and providing a vital source of income for local communities. However, caves are fragile ecosystems, susceptible to damage from natural disasters and human activities. This underscores the importance of long-term monitoring, effective management, and sustainable development of cave resources. Klang Cave, located in Southern Thailand, is regarded as one of Southeast Asia's most beautiful caves. Formed within Permian karst tower limestone, it features remarkable speleothems that offer valuable insights into Earth's geological history, making it an ideal site for scientific research and education. This study focused on creating a 3D model of Klang Cave using laser scanning technology to provide guidelines for developing it as a geological tourism destination in Krabi Province. To enhance public awareness, a virtual tour of the cave was created, featuring 360-degree images and detailed audio commentary in both Thai and English. The virtual tour highlights the cave's intricate formations and unique features, accessible at <https://www.geo.sc.chula.ac.th/virtual/klangcave>. This research serves as a case study in collaboration with local communities and government authorities, emphasizing the preservation of caves while promoting sustainable tourism development.

Keywords: 3D mapping of the cave, Virtual tour, Cave preservation and management, outreach product, Thailand

【A0772】 -Poster



Bridging the past and present: Integrating art, paleoecology, and local knowledge in volcanic Socio-Ecological systems

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Volcanic territories are complex Socio-Ecological Systems (SES) shaped by geological, ecological, and cultural processes that unfold over multiple time scales. These systems are often characterized by interdependencies between nature and culture, which influence resilience and adaptation to volcanic hazards. The integration of paleoecology, which reconstructs long-term environmental histories, and art, which evokes emotional connections and memories, offers a unique approach to understanding and communicating these dynamic systems.

In this context, we explore how art can complement paleoecological research to bridge the gap between past and present volcanic landscapes. Using case studies from the Doña Juana volcano in southwestern Colombia, we examine the role of fire and plant memory in volcanic ecosystems. By combining art techniques such as fire-based wood preservation and cyanotypes, we engage local communities in the reconstruction of ecological memories. These artistic methods serve as tools for recalling intergenerational knowledge of plants and volcanic hazards, fostering a deeper connection between local traditions and scientific research.

Our research highlights the value of integrating art and paleoecology to enrich both the understanding of past volcanic events and the communication of this knowledge to modern societies. This approach not only enhances scientific reconstructions of past environments but also facilitates the co-construction of knowledge between local communities and researchers, closing gaps between scientific and traditional ecological knowledge in volcanic SES.

Keywords: Art and science, Socio-ecological systems, Volcanic settings, Northern South America, Traditional knowledge



【A0860】 -Poster
Visualising ancient Maya environmental change

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The ancient Maya civilisation of Mesoamerica responded to various socio-political and environmental challenges throughout their history. Yet, the environmental history of these societies, including response to drought, is poorly constrained, with gaps in understanding how landscapes were transformed over millennia by both natural forces and human activities. By combining organic geochemical and archaeological data from an interdisciplinary palaeoenvironmental study of the lowland Maya site of Itzan, located present-day Guatemala, "Itzan" seeks to communicate the insights of a multi-proxy study through visualising in video format the changing environmental conditions that shaped the site over the last 6,000 years.

At the heart of the project is the use of digital modelling using Unreal Engine to reconstruct the shifting landscapes of Itzan, from its initial settlement in the Preclassic period (around 1000 BCE) through to the height of its Classic period prominence (250–900 CE) and eventual decline in the Terminal Classic period (around 1000 CE) based on quantification of fecal stanols, polycyclic aromatic hydrocarbons, and plant wax hydrogen and carbon isotopic analyses. Drawing from the extensive research compiled on environmental change in the Maya lowlands, including studies of forest cover, agricultural practices, water management, and climate variability, the project creates a dynamic visual timeline that integrates multiple data sources to depict both the human and natural influences on the site. The project's visualisations are rooted in data extracted from a range of sources, including sediment cores and archaeological surveys, which provide insights into long-term trends in climate and water availability vegetation, soil erosion, and urban development.

Central to the Itzan project is its emphasis on communicating palaeoenvironmental science to a broad audience, including scholars, students, and the general public. By presenting complex environmental data in accessible, interactive visual formats, the



project aims to foster a deeper understanding of the long-term relationships between the lowland Maya and their environment. These visualisations also offer a powerful tool for understanding how past societies adapted to and influenced their landscapes, and has been well received by the public and archaeologists. It has been shown at over 15 festivals and galleries internationally, including the Festival del Cinema di Cefalù and Sardinia Film Festival (Italy), the 28th International Symposium on Electronic Art (France), the Athens Digital Art Festival and Balkan Can Kino (Greece), the Global Science Film Festival (Switzerland), and the Earth Futures Festival (Australia).

The methodologies used in the Itzan project will be presented, highlighting the challenges of integrating multiple types of palaeoenvironmental data into a cohesive visual narrative. It will also discuss the importance of visual storytelling in communicating the results of palaeoecological research, and the potential of digital reconstructions to engage new audiences in the study of ancient environments.

Keywords: Data visualisation, Outreach, Palaeoclimate, Sediment core, Science communication

【A0365】-Poster

Connecting science and society: Outreach in paleosciences through SPP 2299

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Climate change, particularly the rise in tropical sea surface temperatures, is the greatest threat to coral reef ecosystems today. The IPCC's AR6 Summary for Policymakers anticipates that coral reefs will decline by 99% at 2°C global warming. Further impacts on tropical coral reefs have the potential to impact global food supply, coastline protection, economic revenue and the livelihoods of up to one billion people. Assessing how future warming will influence coral reef ecosystems and tropical climate variability is therefore of extreme urgency, and conveying scientific understanding is of great importance.



Outreach plays a pivotal role in ensuring that scientific discoveries resonate beyond academia, fostering public understanding and engagement with critical issues like climate change. This is especially true as we enter a period littered with misinformation. Within the framework of the Priority Programme "Tropical Climate Variability & Coral Reefs – A Past to Future Perspective on Current Rates of Change at Ultra-High Resolution" (SPP 2299 - <https://www.spp2299.tropicalclimatecorals.de/>) of the German Research Foundation (DFG) we have been establishing a trusted platform to approach the communication of scientific principles to diverse audiences.

Through this programme, we employ several approaches to overcome the challenges of communicating complex, data-driven collaborative research conducted across the 18 projects of the programme. Our approach to outreach efforts aims to bridge the gap by making research findings relatable, relevant, and impactful by tailoring different approaches to audiences and promoting them across numerous platforms. These include leveraging digital platforms like Instagram, Bluesky and YouTube for visual storytelling and engagement, writing accessible blog posts to explain key scientific concepts, and trying to foster dialogue through workshops and public events. The benefit of diverse methods is the ability to focus and tailor outreach to various important audiences. For instance, social media facilitates real-time engagement with younger audiences, while long-form blog content and events provide deeper insights for educators, stakeholders and others within the scientific community. Each medium offers a unique way to address the inherent intricacies of paleosciences, such as the multi-scale nature of climate data, the interplay between models and observations, and the relevance of past environmental changes to the current climate crisis.

We will highlight the philosophy adopted by the SPP 2299 Programme, and associated with these actions taken to help achieve some of the goals of the programme. Outreach is not only a tool for education but a critical responsibility for scientists to ensure that research has a tangible impact on society and empowers communities to make informed decisions for a sustainable future. Ultimately, our goal is to empower future generations with the knowledge and understanding they need to address the challenges of a changing planet.

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Keywords: Science communication, Visual Storytelling, Digital Platforms, Trusted Sources

【A0807】 -Poster

Paleoscience comics for young adults: the future of PAGES Horizons journal

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The PAGES Horizons journal was launched in 2021 with the goal of communicating science to the general public. The topics of each of the three issues published up to now (“Paleoscience” -in general-, “Warm worlds” and “Wet vs dry climate”) wanted to raise awareness about the importance of paleoscience in understanding future societal challenges. That is why, contributions were designed to fit visual and written language of teenagers and young adults who are interested in learning more about paleoscience, past global changes, and science in general. More than 40 comics and photo reports is the result of the work by paleoscientists (serving as authors and editors) and artists involved in these three years of publication. PAGES IPO acknowledges the importance of science outreach, and that is why is asking the paleoscience community of new topics and ideas which can be incorporated to the PAGES Horizons journals from 2026 and onwards. A new editorial model is going to be used, in which new issues will be chosen among proposals submitted to PAGES IPO. These should include a topic, and a list of authors and guest editors (together with a potential list of articles and an estimation of the required graphical support) will be evaluated by the PAGES IPO to receive support (logistical and funds). If you have new ideas on how to communicate science or want to participate in PAGES Horizons organizing upcoming issues, come and share your thoughts with us!

Keywords: Science communication, Magazine, Teenagers, Comic



【A0976】 -Poster

Detailed investigation of pretreated *Arundo donax* L. biomass for efficient glucose production

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Arundo donax, being potential alternate energy crop for biofuel production, receiving increased interests around the world mitigating energy crisis besides shortage of fossil fuels and climate change worsening. The objective of current research was to evaluate chemical and enzymatic hydrolysis for investigating bioethanol potential using *Arundo donax* biomass. Effect of 1%, 3%, 5% and 7% concentration of sodium hydroxide (NaOH), hydrogen per oxide (H₂O₂) and sulfuric acid (H₂SO₄) coupled with physical pretreatments and steam explosion were evaluated prior to enzymatic hydrolysis at 0, 24, 48 and 72 h. 7% NaOH followed by 7% H₂O₂ and 7% H₂SO₄ pretreated biomass at 72 h showed highest reducing sugar yield ($360.6 \pm 0.25 \text{ mg g}^{-1}$, 325.8 ± 1 and $306.05 \pm 0.5 \text{ mg g}^{-1}$) respectively significantly higher than untreated ($111.8 \pm 0.17 \text{ mg g}^{-1}$). Structural analysis; scanning electron microscopy (SEM), X-ray diffraction (XRD) and Fourier transform infrared (FTIR) revealed disintegration and disruption in pretreated biomass. Investigation of spatiotemporal variation pattern of reducing sugar yield was carried out by 7% of each chemical. Highest glucose yield was found in October followed by January, July and April from Kallar Kahar Lake with slightly higher yield when compared to same months of Kottli Sattian. *Arundo* crop of October from Kallar Kahar suggested an idea; optimal harvest time for achieving highest yield of fermentable sugars after alkaline (NaOH) pretreatment.

Keywords: *Arundo donax*, Pretreatments, Structural characterization

【A0703】 -Poster

Hands-on paleoscience: Inspiring future generations through interactive learning

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Paleoclimatology, through the analyses of natural archives such as sediments and ice cores, provides vital insights into the long-term evolution of Earth's environment. Its unique interdisciplinary approach, integrating spatial and temporal scales for systematic analysis, offers valuable references for sustainable development. However, the abstract nature of its temporal scales and the complexity of its multidisciplinary methodologies make it challenging for the public, especially the students in basic education stage, to access and comprehend. Innovative approaches are urgently needed to enhance public awareness and engagement in paleoscience. To address this, we have developed original marine science teaching tools and courses to help participants intuitively understand the principles of survey instruments through hands-on operations, making the learning process more engaging and enjoyable. Using real-world case studies, we designed a cognitive pathway linking environmental issues, modern observations, and paleoscience. This pathway guides participants to explore the profound implications of paleoscience via modern observational data and contemporary environmental problems, fostering a systematic understanding of temporal scales. Over the past year, this course has been widely implemented in schools, libraries, and even extended to research-based learning on research vessels, yielding remarkable outcomes. It has sparked a strong interest in science among students and received high praise from educators and the public. In the future, we aim to further expand this practice to broader educational contexts, deepen public understanding of paleoscience, and inspire early interest in related scientific and engineering fields, laying a foundation for cultivating interdisciplinary talents to address future global challenges.

Keywords: Paleoclimatology, Interactive learning, Temporal scales, Environmental issues, Educational innovation



Session 12. Arctic to sub-Arctic climate evolution during the Quaternary and their impact on modulating paleoclimate and paleoceanographic change worldwide

Conveners: Harunur Rashid, Matt O'Regan, Wenshen Xiao, Li Wu, Min Zeng

【A0354】 -Poster

Unusual changes in East Asian winter monsoon during MIS 8 as recorded in Chinese loess and the implications for ice age dynamics

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One of the basic shapes of the marine $d^{18}O$ records of the last million years is “saw-toothed” form, characterized by the gradual cooling to full glacial conditions and then terminated by very rapid deglacial transitions. Understanding such a basic shape is crucial to improve our knowledge of global glacier dynamics.

In this study, we present high-resolution grain-size and magnetic susceptibility records of East Asian monsoon from three typical loess-paleosol sections in central and western Loess Plateau, and make an integrated study on global terrestrial and marine records, to understand the regional and global implications of abnormal MIS 8-7 monsoonal climate (Hao et al., 2024). The result show grain-size records of East Asian Winter Monsoon



(EAWM) from all the three sections exhibit a weakening trend through MIS 8, interrupted by a low-amplitude strengthening in a very short interval corresponding to MIS 8.2. It is well known that variations in Northern Hemisphere ice sheets influence the Siberian High (an atmospheric pressure system), so variations in the EAWM can serve as a useful proxy of Arctic climate variability (Hao et al., 2012; 2015). We argue that the weakening trend of EAWM through MIS 8 reflect trend of shrinkage of Arctic toward the termination, contrasting with the trend indicated by the $d^{18}O$. To confirm this, we make an integrated study on the global paleoclimate records. The results show that there are numerous lines of evidence distributed from high-northern latitudes to middle-southern latitude to support our inference. We also find that it is the Antarctic Bottom Water (AABW) sourced from the sinking water around the Antarctica that leads to “abnormal changes” in deep water of the global ocean. In other words, the changes in $d^{18}O$ during the MIS 8 was seriously overprinted by signals of the deep-sea temperature. Our above explanations are supported by alignment of obliquity and local precessional summer insolation maxima in both Polar regions. Our results highlight the complexity of global paleoclimate reference curve of benthic $d^{18}O$, and need a multidisciplinary study on MIS 8 to understand the high-latitude forcing from both Polar regions and how they interact in modulating the buildup of the ice sheets and the deglacials.

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Keywords: East Asian Winter Monsoon, MIS 8, Glacial climate trend, Southern forcing, Saw-toothed form



【A0801】 -Poster

Holocene sequestration of permafrost carbon along the East Siberian Arctic Shelf: Implications for terrestrial carbon release under a warming climate

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Permafrost thaw in the Arctic represents a potential tipping point in the Earth system, releasing vast amounts of terrestrial organic carbon (OC) that could accelerate the rise of atmospheric CO₂. However, our understanding of past permafrost destabilization, particularly in comparison to current warming trends and its impact on long-term permafrost carbon dynamics, remains limited. This is especially true for the release of carbon from Siberian permafrost into the continental shelf throughout the Holocene epoch. In this study, we utilize a well-dated, high-resolution sediment core (LV77-36-1) from the East Siberian Arctic Shelf (ESAS), spanning 8.3 ka BP. Carbon isotopes ($\delta^{13}\text{C}$ and $\Delta^{14}\text{C}$) and molecular proxies are employed to identify permafrost contributions to the carbon pool. Our findings reveal high sedimentation rates and carbon contents during the transgression period, reflecting the massive remobilization and deposition of land-derived permafrost carbon, driven by enhanced hydrodynamic processes. This is characterized by depleted stable and radiogenic carbon isotopic compositions ($\delta^{13}\text{C} = -26\text{‰}$, $\Delta^{14}\text{C} = -841\text{‰}$), as well as lower concentrations of biomarkers, indicating that the Ice Complex Deposit (ICD) was the dominant source of organic carbon during the transgression period. In contrast, during High Sea-level Period (HSP), there exhibited distinct conditions with dual-carbon isotope composition. Furthermore, OC fluxes from permafrost-derived ICD were five times higher ($105.9 \text{ g}\cdot\text{C}\cdot\text{m}^{-2}\cdot\text{year}^{-1}$) during the transgression compared to the high sea level period ($21.1 \text{ g}\cdot\text{C}\cdot\text{m}^{-2}\cdot\text{year}^{-1}$). This suggests that historical PF-OC sequestration in the ESAS exceeded current state, implying more extensive coastal erosion and carbon release in the Holocene time-scale.



Keywords: Permafrost carbon, Sediment records, Source apportionment, Arctic shelf, Holocene

【A0923】-Poster

Ancient tunnel valleys: A snapshot into the Quaternary glacial dynamics

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The influences of Antarctic Ice Sheet fluctuations in the Quaternary history of global climate, after initiation of major glaciations in the Northern Hemisphere, are not yet well understood. Subglacial and marine records from adjacent to continental ice sheets reflect climate changes, ice sheet dynamics, the intensity of erosion, and the effect of uplift and subsidence in onshore and offshore catchment areas. The glacial activity was responsible for major erosion and deepening of the shelf and the accumulation of eroded sediments along glaciated continental margins. In this study, we analyze and compare the spatial pattern and morphometry of a number of tunnel valleys and associated glacial landforms from North Sea, Barents Sea, and west Antarctica, where these features have been previously observed. Detailed mapping of the tunnel valley morphology and the geometry of the infill based on high resolution of the bathymetric and seismic data indicates that subglacial meltwater was responsible for incising the valleys and depositing at least some of the infill. The tunnel valleys are further interpreted to be formed through a combination of steady-state drainage and outburst floods close to the ice margin, as a result of increased melting within a periods of rapid climate warming. We further use a numerical model of bedrock erosion to quantify the major controls on formation of the target regions, and elucidate how they interact with the subglacial hydrological system and paleo-ice sheet dynamics regionally and the linkages between Northern and Southern Hemisphere ice sheet developments during the Quaternary.

Keywords: Tunnel valley, Glaciated margin, Quaternary, Arctic, Antarctica

【A0688】-Poster

Sedimentary record of sea ice rafting in the Laptev Sea during the Holocene



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Variations in sea ice have important implications for climate and local ecosystems, as well as the sediment budget in the Arctic Ocean, and reconstructing the evolutionary history of sea ice is currently a subject undergoing intense study. Extracting credible sea ice signals from complex sedimentary records is key to accurately reconstructing sea ice variability. Although the coarse sediment fraction is commonly used to reconstruct the variability of sea ice, relying on the coarse fraction alone in the Arctic shelf region poses challenges because of the drastic changes in the depositional environment that followed deglaciation. Here, we conduct chronological, sedimentary, and geochemical analyses of two sediment cores from the eastern central Laptev Sea and Lena River–Yana River estuary. We propose the “anomalous” pattern—an increasing coarse fraction content in the sediment with a negative skewness—as an indicator of sea ice deposits. We then apply this proxy to reconstruct the history of sea ice rafting deposits during the Holocene in the Laptev Sea.

Keywords: Arctic sea ice, Grain size, Sediment transport

【A0426】 -Oral

Influences of pre-aged terrigenous organic carbon on deep-sea ventilation reconstruction

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Abrupt warming shown by rapid atmospheric pCO₂ rise is suggested to be related to the resume of Southern Ocean ventilation during the last deglaciation, which is influenced by weak AMOC intensity in the poor-ventilated North Atlantic though circulation bipolar seesaw. However, palaeoceanographic reconstructions documenting changes in deep-ocean ventilation using ¹⁴C dating, may bear multidimensional explanations, obfuscating the roles of ocean ventilation played on atmospheric CO₂ rise. For example, there is extremely old ventilation ages of intermediate (>5000 ¹⁴C years) and deep water (>10000 ¹⁴C years) in the high latitude North Atlantic during Heinrich Stadial 1 (HS1), indicating weak AMOC intensity, but this extremely old ventilation ages seem incredible. Here, we show that previously inferred poorly ventilated conditions in the North Atlantic were linked to enhanced pre-aged organic carbon (OC) input during HS1. The ¹⁴C age of sedimentary OC was approximately 13,345 ± 692 years older than the coeval foraminifera in the central North Atlantic during HS1, which is coupled to a ventilation age of 5,169 ± 660 years. Old OC was mainly of terrigenous origin and exported to the North Atlantic by ice-rafting. Remineralization of old terrigenous OC in the ocean may have contributed to, at least in part, the anomalously old ventilation ages reported for the high-latitude North Atlantic during HS1.

Keywords: Deep-ocean ventilation, AMOC intensity, North Atlantic, Radiocarbon age

【A0669】 -Oral

Glaciation dynamics and challenges in Northeastern Siberia

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The study of glaciation and interglacial cycles is an important tool for understanding the functioning of the Earth's climate system and the factors that control it. However, many aspects of the scale and chronology of Quaternary glaciations, as well as the dynamics of climate change and natural landscapes in Northeastern Siberia, remain insufficiently understood. This is primarily due to the region's remoteness, inaccessibility, and limited study.



This research analyzes the major glacial complexes of Northeastern Siberia using data from published sources and new studies in which the author participated. The primary studies on the glacial complexes of Northeastern Siberia are known for Central Chukotka, the Koryak Highlands, the Chersky Range, and the Verkhoyansk Range. These studies indicate that the glacial stages occurred during the Middle and Late Pleistocene. Thus, for Central Chukotka, cosmogenic ^{36}Cl exposure ages from glacial boulders indicate glaciation during Marine Isotope Stage (MIS) 4 and the Last Glacial Maximum (Brigham-Grette et al., 2003). According to studies on the Chersky Ridge, cosmogenic ^{10}Be exposure ages indicate deglaciation stages corresponding to MIS 6, MIS 4-5, and MIS 2 (Nørgaard et al., 2023). For the Verkhoyansk Range, the oldest moraines dated using the IRSL method correspond to MIS 6, while the most recent glaciation occurred prior to 50 ka (Stauch and Lehmkuhl, 2010). Our recent studies in the Verkhoyansk Range, based on cosmogenic ^{10}Be exposure ages from glacier boulders, indicate glacier deglaciation during the LGM. This contradicts the conclusions of previous researchers (Stauch and Lehmkuhl, 2010). Thus, it can be concluded that during this period, the climatic conditions in the mountains of Northeastern Siberia were highly conducive to glaciation, characterized by cold temperatures and significant solid precipitation. Nevertheless, despite the vast area, chronological data remain scarce.

A comparison of the analyzed and obtained data revealed a consistent reduction in the extent of glaciation in Northeastern Siberia since MIS 6. The observed reduction in glaciation extent is associated with the highly continental climatic conditions characteristic of the Eurasian interior. The progressive decrease in glacier area reflects increasing aridification and declining humidity during the Late Pleistocene. In addition, studies of the aeolian covers of Central Yakutia also indicate aridization conditions during the last glaciation (MIS 2) (Lukyanycheva et al., 2024). These results are consistent with the paleoclimatic history of the region, as recorded in various natural archives, including continuous sequences of lake sediments (Elikchan-4, El'gygytgyn), ice complexes (East Siberian and Laptev Sea coast, Lena Delta), and marine deposits. Based on these studies, a synthesis of paleoclimatic records and glacial stages in Northeastern Siberia was developed. The study was provided as part of a state assignment FMGE-2019-0005 (0148-2019-0005).

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Keywords: Quaternary glaciation, Pleistocene, Northeastern Siberia, Moraines

【A0914】-Poster

Reconstruction of the North Atlantic subpolar dynamics during MIS 7 based on micropaleontology and sediment geochemistry

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Marine Isotope Stage (MIS) 7 hosts the weaker interglacial substages 7e, 7c, and 7a than the MIS 5e or 11e and is separated by weak ice ages sub-stages 7d and 7b. The MIS 7e-7d-7c sequence is considered to represent a faster ice-sheet build-up and retreat of the last 800 ka. Paleoclimate records suggest iceberg rafting and meltwater pulses from the eastern North Atlantic (Singh and Singh, 2024). However, the extent to which the subpolar North Atlantic changed during MIS 7 due to iceberg rafting and the ensuing meltwater supply is poorly understood. Here, we report foraminiferal census and ice-rafted detritus (IRD) count, oxygen isotopes, and bulk sediment geochemical data at 2-cm continuous



intervals from the Integrated Ocean Drilling Program (IODP) Site U1314 (56.219°N; 27.533°W; 2820 m water depth) and piston core Hu9007-08 (44.8881°N; 40.6425°W; 3522 m water depth) from the subpolar North Atlantic for the first time. IRD events and the consequent rise in the planktonic foraminifera *Neogloboquadrina pachyderma* suggest the appearance of polar water mass. However, the abundance of *Turborotalia quinqueloba* is approximately anticorrelated with % *N. pachyderma* in addition to the infrequent matching of high % *Globorotalia inflata*. This turnover in foraminiferal species suggests a seasonal replacement of the subpolar water masses by the warm and salty North Atlantic Current. We have applied the Genetic Algorithm Optimized Backpropagation Artificial Neural Network (GA-BP-ANN) using the foraminiferal census count to calculate temperature at 10 m, 100 m, and 200 m water depth. The reconstructed temperatures at 100 m and 200 m water depths appear too cold to be realistic given the semi-quantitative temperature proxy, i.e., % *N. pachyderma*, do not show substantial variability. Therefore, we hypothesize that the reconstructed temperature at 10 m water depth most likely represents the plausible in-situ temperature reflected by the foraminiferal census count. High temperature and high *Globigerina bulloides* $\delta^{18}\text{O}$ values suggest a high salinity interval during MIS 8, whereas low temperature but low *Globigerina bulloides* $\delta^{18}\text{O}$ values suggest a low salinity period during MIS 7e. Moreover, low and high $\delta^{18}\text{O}$ *Globigerina bulloides* intervals during MIS 7d and 7b are concordant with the reconstructed water column temperatures. These are the first data and consequent past sea-surface reconstruction from the subpolar North Atlantic that highlights intricacies between subpolar water masses and the North Atlantic Current during MIS 7.

Keywords: Subpolar gyre, Planktonic foraminiferal census, Ice-rafted detritus and meltwater, Artificial Neural Network, Water column temperatures

【A0276】-Oral

Sediment transport dynamics in the deep western Arctic Ocean basins during the middle to late Pleistocene

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Continuous cooling throughout the Pleistocene led to ice sheet growth and sea ice expansion in the Arctic Ocean. Studying the impact of different transport mechanisms and sorting processes on Arctic seafloor sediments can provide insights into changes in the sedimentary environment related to past climate variability. This study first utilizes the latest coccolith biostratigraphy to recalibrate the age framework of a series of sediment cores from the western Arctic Ocean, and then analyzes the grain size data of cores from the Canada Basin (ARC7-LIC) and Makarov Basin (ARC5-ICE6) based on the recalibrated age framework. By comparing to earlier published records, this study aims to explore the evolution of sediment transport dynamics in the western Arctic Ocean and further reveals the evolution of iceberg, sea ice, ocean current transport in the Arctic Ocean during the Pleistocene on long-term and glacial-interglacial time scales.

The grain size data were processed by End Member Modeling to distinguish different transport and sorting processes, including icebergs, currents, and sea ice. The data show that sediment input by icebergs generally peaks during glacials, while sea ice primarily transports clay-sized and poorly sorted sediments. Iceberg transport in the Canada Basin shows a gradual increase since the Middle Pleistocene Transition (MPT), in contrast to a delayed increase in cores from the Makarov Basin and Lomonosov Ridge. This indicates Beaufort Gyre-dominated sediment transport in the Canada Basin, compared to Transpolar Drift-dominated in the Makarov Basin and Lomonosov Ridge, reflecting the dynamics of ice sheets on North American and Eurasian margins, respectively. Sea ice transport shows an inverse trend relative to iceberg transport which generally peak during interglacials, suggesting more dynamic sea ice formation and transport during periods of high sea level and relatively open seas. The poor correlation between the sortable silt percentage and the mean size of sortable silt in the two cores indicates that sortable silt cannot represent the strength of ocean currents but is influenced by other transport mechanisms, such as icebergs or anchor ice. The latter is more active during interglacials. Near-bottom currents primarily transport fine silt sediments. The strength of near-bottom currents in the Canada Basin gradually decreases throughout the Pleistocene, indicating weakened ventilation in response to climate cooling.



Keywords: Western Arctic Ocean, Quaternary stratigraphy, Grain size, EMMA, Transport mechanisms

【A0837】 -Poster

Chronostratigraphy and paleoclimate implication of the Core ARC9-21B from the Alpha Ridge

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Palaeomagnetic investigation and Mn-cycle of a 3.5-m-long sediment core ARC9-21B from the Alpha Ridge were performed to better constrain the regional chronostratigraphy. Palaeomagnetic analyses reveal that the sediments are characterized by low-coercivity ferrimagnetic minerals (magnetite), mainly in the pseudo-single domain grain-size range. Alternating field demagnetization experiments on the 5-mm resolution samples were carried out to obtain the characteristic remanent demagnetization. By comparing the GPTS, the B/M boundary is located at 3m. A high-resolution age model derived from comparing the Mn variations with previously published sedimentary marine records of Core 08B85-D from the study area. Under the constraints of the chronological framework, we reveal the arctic ice sheet and circulation changes since MIS8 using the anisotropy index of magnetic susceptibility, which indicated that the ice sheet extent increased in MIS8 and reached its maximum in MIS 5/6.

Keywords: Magnetostratigraphy, Paleoclimatology

【A0118】 -Poster

A decrease in river discharges in the recent past in the Arctic

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The Arctic territory in Siberia and Alaska is characterized by the presence in river valleys of numerous local traces of a decrease in river discharges in the recent past. The main ones include: 1) the presence of fragments of ancient ox-bows on the floodplains with a meander wavelength and channel width greater than the modern ones; 2) the narrow modern channel at the bottom of large ancient meandering river and the presence of a low floodplains in the bottoms of such large bends with the width, which corresponds to the large bend wavelength; 3) the chains of ponds in narrow modern channel, which reflect a former existence of the large channel. On the Yamal Peninsula (the West Siberia, Russia), all these signs of a decrease in river discharges are characteristic for in several river basins, and the secondary cryogenic relief on fluvial relief surfaces indicates that they originated in the relatively recent past (200 - 1000 years ago). One area with well-preserved signs of reduced runoff have been identified in the Mordy-Yakha River basin. In the upper reaches of the river the channel width and meander wavelength decreased about 1.5 times in comparison with the ancient channel width in the ox-bows, in the middle reaches – more than 2 times and in the lower reaches of the river – by approximately three times. The calculations with the use of the relationship between the channel width and the mean maximum discharge shows that the latter has decreased in the lower part of the river basin by approximately 4.5 times. This reduction in maximum discharges nearly completely ceased the floodplain inundation during the spring flood, which allowed to use the territory of the floodplain of the Mordy-Yakha River for the construction of infrastructure facilities of Bovanenkovskoye gas field. The second area cover the river basins of the southeastern Yamal, where the Novoportovskoye oil and gas condensate field is located. The sizes of meander wavelengths of the rivers do not changed significantly, following the regional relationships with the basin area. The widths of the channels at the lower reaches also follow the regional relationships and the meander wavelength/width ration is not more than 10 for these reaches. In the upper reaches of these rivers the channels widths decrease dramatically, so that the meander wavelength/width ration is about 50. These narrow channels bear all signs of their width decrease, being shaped by the chains of ponds and are bounded by low floodplain, which reflect the size of the former channel width. Examples of this kind can be found throughout the Arctic. Such river basins do not have territorial development. They are local, neighbouring basins often bear no signs of a decrease in river flow in the recent past. In this respect, this stage differs from the well-studied period at the boundary of the Late



Glacial – the Holocene, when a decrease in flow affected river basins on all lowlands of the Northern Hemisphere.

Keywords: River channel morphology, Hydrological indicators, Safety of infrastructure facilities

【A0153】 -Oral

Upper ocean variability during MIS11 and its impact of deep water ventilation

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In this multiproxy study, we used new isotopic data on planktonic foraminifera to highlight the strong instability that characterized surface conditions in the Iceland Basin during Marine Isotope Stage 11 (MIS 11). We produced new oxygen isotope data on the planktonic species *Neogloboquadrina incompta* and *Turborotalita quinqueloba*, foraminifera-bound nitrogen isotope data on *Neogloboquadrina incompta*, and calcareous nannofossil data at coring site IODP U1314. The multiproxy record displays two distinct upper ocean regimes: a relatively stable pre-climate optimum and an unstable post-climate optimum with high amplitude variations in nutrient utilization and seasonality proxies, and strong enrichment in oxygen isotopes suggesting colder and/or saltier upper waters. The latter regime was concomitant with a resurgence in ice-rafted debris. Interestingly, this surface instability is not observed in cores from sites affected by the North Atlantic Current. Moreover, deep water ventilation is reconstructed to decrease throughout the eastern North Atlantic, while remaining rather constant in the Labrador Sea. The evidence presented here indicates that deep-water formation was unstable throughout MIS 11, and that peak periods of deep-water formation varied across high latitude North Atlantic basins, depending on the prevailing surface conditions in each region. These findings suggest that reconstructing deep-water formation and ventilation require a comprehensive approach that accounts for the interconnectivity between different components of the overturning circulation system.



Keywords: Paleoceanography, Stable isotope, MIS 11

【A0711】 -Poster

Dynamics of environmental evolution in the Sea of Okhotsk since the last glacial period

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The Sea of Okhotsk, influenced by the East Asian Summer Monsoon, is a critical region for studying environmental changes due to its sensitivity to global climate shifts. It marks the southern limit for perennial sea ice and serves as a source for North Pacific Intermediate Water (NPIW). Despite significant environmental changes during the late Quaternary, comprehensive understanding has been limited. This study synthesizes data from 30 sites, reconstructing the last 30,000 years of sea surface temperatures, sea ice, productivity, and Okhotsk Sea Intermediate Water (OSIW) ventilation. Two conceptual models—"glacial type" (ice-dominated) and "interglacial type" (ice and currents dominated)—were proposed. Cross-correlation analyses with global climate records reveal that during the last glaciation (30-14.7 ka), the area experienced low temperatures, expanded sea ice, weak OSIW ventilation, and reduced productivity. In contrast, the late Holocene (<6 ka) was characterized by warmer temperatures, retreating sea ice, strong OSIW ventilation, and increased productivity, with sediments primarily composed of siliceous ooze. The Bølling-Allerød (14.7 - 13 ka) and Pre-boreal (11 - 9.7 ka) periods resembled the interglacial model but featured anoxic intermediate waters, while Heinrich Stadial 1 (17.5 - 14.7 ka) and the Younger Dryas (13 - 11.7 ka) were more glacial-like, with enhanced OSIW ventilation. Over 30,000 years, the environment's evolution was shaped by high-latitude insolation, the East Asian monsoon, and atmospheric CO₂ levels.

Keywords: Sea Surface Temperature, Paleoproductivity, Sea Ice, Ventilation, the Sea of Okhotsk

【A0261】 -Poster



Sea ice history in the western Arctic Ocean over the past 600 ka: Reconstruction based on foraminifera and ostracod indicators

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Sea ice is an essential component in the Arctic climate system and plays an important role in regional and global climate changes. Sea ice is also one of the main factors controlling the sedimentary environment in the Arctic Ocean. Recognizing sea-ice variabilities on long-term time scales is critical to understand the rapid sea-ice decline in recent decades and to predict future Arctic changes. A variety of sea ice proxies, such as microfossils, biomarkers and grain size components in sediments have been developed to reconstruct past sea ice variability in the Arctic Ocean. Among which, the thriving of certain microfossils species provides efficient and direct indications of past sea ice conditions.

In this study, sea ice indicator species of benthic foraminifera and ostracods have been investigated in three cores collected by the Chinese Arctic Expedition from the Mendeleev and Alpha ridges. By combining with previous published results, our records reveal the temporal and spatial sea ice changes over the past 600 ka in the western Arctic Ocean. In the cores from the central Arctic Ocean to the southern Mendeleev Ridge, the percent/abundance of perennial sea ice indicator species benthic foraminifera (BF) *Bolivina arctica* and ostracod *Acetabulastroma arcticum*, BF sea ice transition zone indicator *Epistominella arctica* and seasonal sea ice indicator species *Epistominella exigua* showed obvious spatio-temporal variabilities. At MIS 11, *B. arctica* and *A. arcticum* appeared north of about 80°N and increased significantly in subsequent interglacial periods, indicating an increase in perennial sea ice since the Mid-Brunhes Event (MBE), marking the onset of perennial sea ice north of about 80°N. While *E. exigua* is dominant in the south of about 78°N, suggesting presence of seasonal sea ice. At MIS 8/7, in areas south of 78°N, the increase of *E. arctica* and decrease of *E. exigua* suggest a further cooling and expansion of sea ice transition zone. Since MIS 3 in the Chukchi Plateau, the presence of ostracod species *Rabulimilis mirabilis* indicates seasonal sea ice in this region.



Keywords: Arctic Ocean, Sea ice, Pleistocene, Microfossils

【A0915】-Poster

Pre-aged terrigenous organic carbon biases ocean ventilation-age reconstructions in the North Atlantic

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Over the last deglaciation, ventilation of ocean circulation has been key regulators of deep-sea carbon release, controlling climate change on centennial to millennial time scales. However, paleoceanographic reconstructions documenting changes in deep-ocean ventilation using ¹⁴C-foraminifera dating, may bear multidimensional explanations, obfuscating the roles of ocean ventilation played on climate evolution. Here, we show that previously inferred poorly ventilated conditions in the North Atlantic were linked to enhanced pre-aged organic carbon (OC) input during Heinrich Stadial 1 (HS1). The ¹⁴C age of sedimentary OC was approximately $13,345 \pm 692$ years older than the coeval foraminifera in the central North Atlantic during HS1, which is coupled to a ventilation age of $5,169 \pm 660$ years. Old OC was mainly of terrigenous origin and exported to the North Atlantic by ice-rafting. Remineralization of old terrigenous OC in the ocean may have contributed to, at least in part, the anomalously old ventilation ages reported for the high-latitude North Atlantic during HS1. This study provides a new organic geochemical explanation for anomalous deep-water ventilation ¹⁴C ages, and provides unique insights for global carbon cycle under extreme climatic events.

Keywords: Pre-aged OC, Ventilation, North Atlantic, Heinrich Event

【A0175】-Oral

Productivity and upwelling changes in the northwest Pacific over the last five glacial cycles and implications for CO₂ changes

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The polar oceans play a vital role in regulating atmospheric CO₂ concentrations during the Pleistocene glacial cycles. However, despite being the largest modern reservoir of respired carbon, the impact of the subarctic Pacific remains poorly understood due to limited records. Here, we present high-resolution, ²³⁰Th-normalized export productivity records from the subarctic northwestern Pacific covering the last five glacial cycles. Our records display pronounced, glacial-interglacial cyclicity superimposed with precessional-driven variability, with warm interglacial climate and high boreal summer insolation providing favorable conditions to sustain upwelling of nutrient-rich subsurface waters and hence increased export productivity. Our transient model simulations consistently show that ice sheets and to a lesser degree, precession are the main drivers that control the strength and latitudinal position of the westerlies. Enhanced upwelling of nutrient/carbon-rich water caused by the intensification and poleward migration of the northern westerlies during warmer climate intervals would have led to the release of previously sequestered CO₂ from the subarctic Pacific to the atmosphere. Our results also highlight the significant role of the subarctic Pacific in modulating pCO₂ changes during the Pleistocene climate cycles, especially on precession timescale (~20 kyr).

Keywords: Productivity, Upwelling, North Pacific, Global CO₂

【A0087】-Poster

Provenance evidence for the Late Pleistocene East Siberian ice sheet

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The timing and extent of the East Siberian Ice Sheet (ESIS) are pivotal to understanding Arctic ice-ocean interactions and their climate feedbacks. Evidence of glaciogenic landforms along the East Siberian continental margin indicates the presence of the ESIS, but its development during the Late Pleistocene, particularly during the last glacial period, remains highly debated. In this study, we analysed the cyclic variations and spatial distributions of provenance indicators—including ice-rafted debris (IRD), clay minerals, and Sr-Nd isotopes—to reconstruct regional glacial activity and environmental responses across the Mendeleev Ridge, Chukchi Basin, Chukchi Plateau, and Northwind Ridge. The results reveal that "ice cavity-like" depositional environments, characterized by the absence of IRD and biogenic shell material, occurred along the East Siberian continental margin during both Marine Isotope Stage 4 (MIS4) and MIS2. Under such restricted hydrodynamic conditions, fine-grained clay minerals from northern Europe and Arctic Canada were also blocked. These environmental fingerprints support the existence of the ESIS and its extended ice shelf during MIS4, with its maximum extent approaching the limits delineated by previous studies using glaciogenic lineation. However, during MIS2, the northern boundary of the ice shelf retreated southward, while its eastern extent expanded onto the Chukchi Shelf. Our findings enhance the understanding of the episodic evolution and variable extents of the ESIS during the Late Pleistocene and establish a foundation for evaluating the mechanisms driving Arctic iceberg outbursts and their broader climatic impacts.

Keywords: East Siberian Ice Sheet, Provenance, Arctic Ocean, Late Pleistocene

【A0449】-Oral

The subpolar surface water masses dynamics of the North Atlantic since the last glacial cycle

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Understanding the interaction between the Polar and subpolar water masses is crucial, given that the ongoing rise in atmospheric temperature is predicted to increase freshwater transport to the subpolar gyre of the North Atlantic. This study analyzed planktonic foraminiferal census and ice-rafted debris (IRD) count, foraminiferal $\delta^{18}\text{O}$, and bulk sediment geochemistry in the Integrated Ocean Drilling Program (IODP) Site U1314 (56°21.8'N, 27°53.3'W) and piston core Hu90-08 (44°53.291'N, 40°38.551'W) retrieved from the subpolar North Atlantic to reconstruct the sea surface dynamics during the last glacial cycle. We used the abundance of polar foraminiferal species *Neogloboquadrina pachyderma*, subpolar species *Turbotalita quinqueloba*, and transitional species *Globigerinita glutinata*, *Globorotalia inflata*, *Globigerina bulloides*, and *Neogloboquadrina incompta* to infer migration of the polar, arctic, subarctic, and North Atlantic Transitional water (NATW) masses and North Atlantic Current (NAC) within the subpolar gyre (SPG). These paleo-proxies were also used to assess changes in the oceanic fronts (polar front (PF), Arctic front (AF), and Subarctic front (SAF)) within the SPG. Our data suggest that the SPG shrank northward during the MIS 5e peak (128-120 ka) and Holocene. As a result, the NATW primarily impacted the SPG; consequently, the SAF was located north of the SPG. Six millennial-scale cooling events, in which the *N. pachyderma* ranges from 50 to 100% in the eastern SPG Site U1314, suggest a high-frequency variability of subpolar to polar water masses during MIS 5d-5a. In contrast, only one cooling event during MIS 5b (C21) and 5d (C24) was found in the western SPG, indicating that the NAC moved into the SPG but stayed longer than the eastern SPG. Our data further suggest that the PF and AF moved to eastern SPG more frequently. There are differences in the variation trends of planktonic foraminifera assemblages between eastern and western SPG cores during the mid-MIS 3 (49-38 ka). *N. pachyderma* gradually increased to 90% at Site U1314, but the transitional species were high in core Hu90-08, indicating that the northward migration of the NAC at this time has a greater impact on the western SPG than on the eastern SPG. During MIS 4 and MIS 2, the polar species at the eastern SPG and the western SPG were relatively high (80-90%), reflecting the influence of polar/Arctic waters on the SPG; PF and AF both migrated southward to the mid-latitude of the North Atlantic. In the Heinrich event of core Hu90-08 and the equivalent IRD event of Site U1314, the PF migrated south of U1314, AF migrated south of Hu90-08, and the southward movement of PF and AF led to the invasion of polar and subpolar water masses towards SPG.



Keywords: Subpolar gyre, Surface water masses, Foraminiferal assemblages, Oceanographic fronts, Last glacial cycle

【A0710】 -Poster

Paleomagnetism and rock magnetism in Quaternary Arctic Ocean sediments: Implications on stratigraphy and environmental reconstructions

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As a commonly used method for establishing stratigraphic chronology, paleomagnetism faces limitations in its application to the Arctic Ocean sediments. The reasons for the frequent geomagnetic reversals observed in sediments from this region have been widely questioned. This study analyzed paleomagnetic and rock magnetic parameters from gravity cores collected from the Alpha and Mendeleev ridges, western Arctic Ocean, and aimed to examine the preservation mechanisms and origins of magnetostratigraphic signals. Our results show frequent geomagnetic reversals in the core records and confused anisotropy of magnetic susceptibility. Differences in the composition of magnetic minerals were observed between the upper and lower parts of the cores. Secondary remanent magnetization carried by high-coercivity magnetic minerals, which are commonly present, is likely one of the reasons for the frequent fluctuations in geomagnetic signals obtained through alternating field demagnetization. Redox environmental changes of the Arctic Ocean bottom water may play a key role in causing the observed differences in magnetic minerals and anomalies in remanent magnetization recorded.

Keywords: Paleomagnetic, Rock magnetic, Arctic Ocean



Session 13. Assessing plants diversity in time and space may help conservation approaches

Conveners: Rachid Cheddadi, Kangyou Huang

【A0560】 -Poster

Estimation of phytomass changes on the Kamchatka Peninsula

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Kamchatka peninsula (55°N 158°E) is located at the Far East periphery of Eurasia. The temperate climate benefits to the larch dominated forests covering the central part of the Peninsula. The aim of this study was to determine the phytomass of Kamchatka trees and their carbon sequestration rate basing on the dendrochronological method and the remote sensing data. In the fields (2023-2024) we collected cores of poplar, birch, and larch and measured the diameters of all trees at each site at 4 locations. Unfortunately, there are no phytomass measurements available for the Kamchatka Peninsula, therefore we used coefficients for allometric coefficients from the nearest regions (Magadan Oblast and Sikhote-Alin Mountains). Reconstruction of phytomass values is based on data of annual ring widths of poplar, birch, larch trees and trunk's diameters. That variations of phytomass of these species in Kamchatka correlate with summer air temperature, but the processes of biomass accumulation are also affected by anthropogenic stresses. The correlation between phytomass of all tree species and temperature weakened in the 1940s and 1960s. According to the local information at that time massive logging and several severe fires occurred in the area of Esso settlement. These impacts led to the more intense tree growth due to increased access to the sunlight. The series of reconstructed phytomass and the net primary production (NPP) revealed from MODIS images are highly correlated for the whole 22-year period of MODIS operation. The combination of the two independent methods also allows to reconstruct the spatial changes of the phytomass variations in Kamchatka up to four centuries.



The study was supported by grant of the Ministry of Science and Higher Education of Russian Federation (agreement NO. 075-15-2024-554 of 24.04.2024).

Keywords: Phytomass, Dendrochronology, Remote sensing, Kamchatka

【A0920】-Poster

Human activities have reduced plant diversity and net primary productivity of vegetation in eastern China over the last two millennia

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Understanding the history and regional singularities of human impact on vegetation is key to developing strategies for sustainable ecosystem management. In this study, fossil and modern pollen datasets from China are employed to investigate temporal changes in pollen composition, analogue quality, pollen diversity and net primary productivity (NPP) reconstructions during the Holocene. Anthropogenic disturbance and vegetation's responses are also assessed. Results reveal that pollen assemblages from non-forest communities fail to provide evidence of human impact for the western part of China (annual precipitation less than 400 mm and/or elevation more than 3000 m a.s.l), as inferred from the stable quality of modern analogues, principal components, and diversity of species and communities throughout the Holocene. For the eastern part of China, the proportion of fossil pollen spectra with good modern analogues increases from ca. 50% to ca. 80% during the last 2 millennia, indicating an enhanced intensity of anthropogenic disturbance on vegetation. This disturbance has caused the pollen spectra to become taxonomically less diverse over space, highlighting a reduced south–north differentiation and divergence from past vegetation between regions in the eastern part of China, together with a significant decrease in NPP and increase of vegetation variability. We recommend that care is taken in eastern China when basing the development of ecosystem management strategies on vegetation changes in the region during the last 2000 years, since humans have significantly disturbed the vegetation during this period.

Keywords: Holocene, Human impact, Pollen, Land-use



【A0945】 -Oral

Come rain or come shine, the species richness will decline in the Moroccan mountains

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Plant species richness in mountainous regions generally follows a unimodal distribution with lower values at both low and high altitudes in relation to precipitation. In the Atlas Mountains, Morocco, plant species richness is currently highest at 800–1200 m elevation, but the extent and altitudinal limits of this species-rich belt have shifted in the past with climate change.

Here, we trace the evolution of pollen taxonomic richness (PTR) as a proxy for plant species richness, with the aim of understanding the relationship with climatic changes over the past 19,000 years, and make some assumptions about future changes in species richness. Past PTR was inferred through an analogy with an extensive modern pollen dataset, and past climatic variables were reconstructed from a fossil record collected in the Middle Atlas, Morocco.

We found that the current PTR distribution in Morocco is more closely associated with precipitation than with temperature. During the last glacial period, both PTR and annual precipitation were low, and the analogs were located at lower altitudes than the altitude of the fossil record. During the early Holocene, the PTR increased by approximately 15%, and the modern analogs were found approximately 600–800 m higher than the analogs of the last glacial period.



After 6000 years BP, we observe a steady decline in annual precipitation of approximately 30%, resulting in a species richness loss of approximately 18% and a retreat of the upper boundary of the species-rich belt.

Climate projections suggest that annual precipitation in Northwest Africa will decrease by 20–30% over the next 50 years, an annual amount comparable to that of the last glacial period, but under much warmer conditions and in a significantly shorter time. Such a decline in precipitation could result in an unprecedented loss of plant species richness of approximately 15% in just a few decades and put 35% of the protected areas at risk. The forested mountains above 1600 m could then resemble the treeless and less diverse steppes found at higher altitudes above today's tree line.

Keywords: Plant species richness, Protected areas, Conservation, Mountains, Past climate change

【A0301】-Poster

Savanna/rainforest dynamics and hydroclimate changes in northern boundary of tropical Asia over the past 150 kyrs

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How tropical hydroclimate and ecosystems in Asia have varied on orbital timescales has been an important topic for decades. The northern boundary of tropical Asia under strong influence of monsoon system has been highly sensitive to global climate changes on orbital timescales. Among the available proxy data, limited terrestrial evidence of glacial-interglacial variation of vegetation impedes the understanding of tropical climate dynamics. Here, we report a lacustrine record covering the last 150 kyrs from a tropical maar paleolake located between the Asian landmass and the South China Sea. Our pollen



and $\delta^{13}\text{C}$ results consistently show strong glacial-interglacial variability of vegetation changes between savanna dominated by C_4 herbs and rainforest characterized by C_3 trees over the past 150 kyrs. The glacial/stadials with C_4 herb dominance during MIS6, 4 and 2 corresponded to drier conditions with rainfall amounts <650 mm/yr, which has been considered as the climatic threshold for the growth of savanna biome. The vegetation variations in relation to large-amplitude variations of regional hydroclimate were tightly coupled with the internal glacial forcings (e.g., global ice volume) in addition to external insolation, and coincided with changes in sea level/continental shelf exposure and sea surface temperature in the northern South China Sea. These significant correlations suggest a more important role of glacial forcings than insolation in controlling tropical hydroclimate and vegetation changes, which is transmitted and amplified by tropical warm pool environments (i.e., spatial extent of shelf exposure and water temperature).

Keywords: Tropical vegetation, Glacial cycle, Hydroclimate, Savanna, Southern China

【A0181】 -Poster

Oak pollen infrageneric classification-based winter temperature reconstruction since the Marine Isotope Stage 5 in Southeast China

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Quantitative reconstructions of Quaternary land temperature in the western Pacific are relatively rare, resulting in a gap in synchronous comparisons between marine and terrestrial paleoclimate proxies. This study reconstructs winter temperatures along the southeastern coast of China since late Marine Isotope Stage (MIS) 5 using Oak (*Quercus* L.) pollen—a dominant broadleaved taxon in East Asia (EA). The analysis employed infrageneric classification of oak pollen, with 861 grains extracted from topsoil samples across 15 latitudes and examined under a scanning electron microscope. Five distinct ornamentation types—rodlike, rodlike-vertical, rodlike-masked, verrucate, and scattered verrucate—were identified, representing four taxonomic sections. Detrended correspondence analysis revealed strong links between ornamentation type ratios and the Mean Temperature of the Coldest Quarter (MTCQ). A MaxEnt species distribution model



further validated the correlation between MTCQ and the distribution of deciduous oak. By applying the Transformation Function Method, relationships between modern oak pollen and MTCQ were used to reconstruct past winter temperatures from 967 fossil oak pollen grains retrieved from two coastal drilling cores in southeastern China. Results show that MTCQ has fluctuated over time, with an average reconstruction error of approximately 1.9 °C since the last glaciation. Compared to present conditions, the late MIS5 was slightly cooler, while early and middle MIS3 were marginally warmer. A notable cooling event (-3.6 °C) occurred during late MIS3, with another cooling period in the early Holocene. These fluctuations during MIS3 closely correspond to changes in the Atlantic Meridional Overturning Circulation (AMOC), highlighting the sensitivity of EA winter temperatures to AMOC variability. Additionally, shifts in temperature and humidity from early to late MIS3 align with changes in the tropical western-to-eastern Pacific temperature gradient, suggesting significant influence from tropical climate processes. These findings underscore the intricate teleconnections between high- and low-latitude climate systems and provide valuable insights into past climate dynamics.

Keywords: Oak pollen, Paleoclimate, Scanning electron microscope, Marine isotope stage 3, Southeast China

【A0278】 -Poster

Pollen atlas of sub-tropical southern Africa (Pollen and Spores of KwaZulu-Natal)

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The correct identification of pollen and spores allows for palaeovegetation reconstruction and inferences of past climate. Identification of fossil pollen and spores is usually done by comparing the recovered pollen with reference materials which can be difficult to access, as the reference materials are spread across the different University palynology laboratories and due to the level of preparation and preservation issue, these materials



are susceptible to decay. Hence, the need to document these reference materials in southern Africa to have a central repository that is easily accessed. Photographs and videos of the reference materials from the University of KwaZulu-Natal have been captured using a Leica microscope camera at 1000 magnification, and over two hundred different species consisting of Gymnosperms, Angiosperms, and Pteridophytes have been captured and converted to digital images, accessed through the internet, hence aiding in delimiting species during pollen identification and in turn contributing to the understanding of the Quaternary Palaeoenvironment of southern Africa.

Keywords: Pollen analysis, Drakensberg, Pollen identification, Paleoclimate and Paleo-vegetation

【A0766】 -Oral

Volcanic influences on biodiversity in the Northern Andes: Bridging paleoecology and ecology

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The Northern Andes region is a key biodiversity hotspot, playing a crucial role in maintaining ecosystem health and resilience. The exceptional biodiversity in this area results from a complex interplay of steep elevation gradients, varied geological processes, and fluctuating climatic conditions. Volcanic activity, a persistent force in the region for millennia, is a major driver of landscape transformation, influencing both ecological succession and biodiversity distribution. This study aims to bridge paleoecological and ecological perspectives to understand the role of volcanism in shaping contemporary biological diversity in the Northern Andes.

We investigate how volcanic processes, such as eruption styles and the volume of volcanic products from tectonic collapses, affect plant diversity and vegetation distribution across volcanic landscapes. Specifically, we explore whether volcanic events create heterogeneous habitats that foster ecological diversity by disrupting the landscape, or whether they lead to environmental homogenization, potentially reducing biodiversity.



To address these questions, we combine spatial analyses of plant diversity and habitat heterogeneity with observations from vegetation plots. Our comparative approach contrasts plant diversity between Late Pleistocene-Holocene composite volcanoes in the Northern Andes and non-volcanic landscapes, focusing on volcanoes with well-documented eruption histories. Additionally, we explore how palynological records from volcanic settings can provide deeper insights into successional pathways and long-term ecological dynamics.

Ultimately, this research seeks to clarify the interactions between volcanism, habitat diversity, and plant distribution in volcanic ecosystems, offering valuable insights for conservation and ecosystem management in these unique landscapes.

Keywords: Volcanism, Art and science, Spatial-temporal dynamics, Pollen, Holocene

【A0769】 -Poster

Climatogenic expansion of woody vegetation in the mountain tundra of the southern part of the Urals: Models, predictions, consequences

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In recent decades, in response to shifts in environmental conditions, particularly climatic, there has been a rapid shift of woody and shrub vegetation in the tundra and alpine ecosystems of the highlands. Mountain tundra is a unique natural system, a dry and cold habitat situated above the forest zone. The area of mountain tundra communities of the Southern Urals is negligible in comparison to other mountainous regions within the Urals and across the globe. It has already been established that the area of mountain tundra in



the highlands of the Southern Urals is undergoing a rapid decline as a consequence of the expansion of woody vegetation at higher altitudes. In this regard, it is necessary to understand the current state and quantitatively assess the possible threat of reduction or disappearance of mountain tundra in the Southern Urals in the future.

For the first time, a diffusion model of probable changes in the altitude of the treeline in the 21st century was developed and tested on Dalniy Taganay Mountain and Poperechnaya Mountain, and methods for accurate quantitative assessment of changes in forested areas were improved, which can be applied in other regions. Using data on phytomass from permanent sample plots, the rate of overgrowth of slopes of various exposures from 1959 to 2022, and local growing conditions, diffusion models of population distribution were developed based on the logistic population growth curve and the principle of distribution of tree phytomass from areas of high concentration (forest) to areas of low concentration (tundra). The obtained predictions of future changes in the distribution of forested areas indicate that within the next 35-45 years, the Dalniy Taganay may be entirely covered by a closed forest. Mountain tundra will be preserved on the higher peak of Poperechnaya in the next century. It has been shown that mountain tundra could disappear from 32 other peaks in the Southern Urals in the next century.

Since 2008, the monitoring of species diversity and abundance of ground-dwelling invertebrates has revealed a notable decline in the number of certain insect species at the summit of Dalniy Taganay, and the ground beetles *Carabus karpinskii* Kryzhanovskij et Matveev and *Pterostichus mannerheimii* (Dejean, 1831) have not been recorded since 2022. During the same period, the number of red ants *Formica aquilonia* Yarrow in the tundra increased almost fourfold. The typical forest dendrobionts have been observed, namely the weevil *Hylobius (Callirus) pinastri* (Gyllenhal, 1813) and the bark beetle *Hylastes cunicularius* Erichson, 1836.

The results obtained demonstrate convincingly that, in the context of modern climate change, not only are forests moving higher into the mountains, but also that the vegetation cover and invertebrate communities in the mountain tundra are undergoing transformation, and that local extinction of individual species is occurring.

The study was supported by the Russian Science Foundation grant 24-27-00338.



Keywords: Treeline, Mountain tundra, Prediction models, Spatiotemporal modeling, Invertebrates

【A0320】 -Poster

Charcoal analyses: Assessing climate and vegetation history of the eastern Lesotho Highlands during the Late Holocene

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The Polihali Cultural Heritage Management Plan project was conducted in the basaltic eastern Highlands of Lesotho, situated about 2000 meters above sea level (masl). Several archaeological sites, which were at risk of being submerged by the construction of the Polihali Reservoir on the Senqu River, were excavated. One of these sites, designated as D08, revealed a continuous late Holocene deposit dated to 2000 cal BP, which included substantial charcoal samples. Analysing these charcoal samples can provide invaluable insights into the vegetation and climate of the interior montane region during the Late Quaternary period. Furthermore, the charcoal may shed light on how the people living in the area utilized and managed the woody plant species that were present near the shelter.

The preliminary data identifies several species, including *Passerina montana*, *Leucosidea sericea*, *Euclea* sp., *Rhamnus prinoides*, *Salix* sp., *Cliffortia* sp., *Scolopia* sp., *Buddleja* sp., *Ziziphus mucronata*, *Searsia* sp., *Grewia flava*, etc. These species suggest a cold, dry, and open environment. Additionally, the data indicate that there have been either shifts in plant diversity and abundance or changes in resource preferences over the past 2000 years. The identified plants have ethnographically recorded uses, including fuel for fires, artefact manufacture, and various medicinal and magical applications. Such uses may have been relevant to local inhabitants and could have influenced plant diversity during the Late Quaternary period. Understanding the vegetation history of the eastern highlands allows conservationists to track changes in species diversity and if this is due to climate change or woody resources use and management, hence making informed decisions.



Keywords: Conservation, Charcoal, Palaeoenvironment reconstruction, Plant diversity, Human plant uses

【A0302】-Poster

Two general patterns of subalpine peatland development since the Last Glacial Maximum in subtropical China

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Peatlands interact significantly with the global carbon cycle and climate changes. A comprehensive understanding of the development of peatlands is extremely important to help address future climate challenges. Here, we combine three total organic carbon content records with seven published records from subalpine peatlands in the monsoonal region of subtropical China, aiming to reveal the general pattern of peatland development since the Last Glacial Maximum (LGM) in this region. The synthesis showed that organic carbon contents significantly increased at approximately 16 cal kyr B.P. These ten records clearly display two distinct patterns since that time: pattern one showed three intervals of high carbon contents at ca. 16–12 cal kyr B.P., 9.5–7.5 cal kyr B.P. and 6–4 (or 4–1) cal kyr B.P., whereas pattern two reached the maximum in the early Holocene and remained high and relatively stable during the Holocene. Through comparison with pollen indicators and climate reconstructions, we demonstrated that local hydrology linked to monsoonal climates (especially precipitation) was the dominant factor controlling carbon accumulation and the development of subalpine peatlands since the LGM in subtropical China. However, two dynamic patterns that occurred under the same climatic conditions were attributed to the significant modulation of local topography, i.e., intermontane basin (pattern one) or montane (pattern two) settings. The hydrology and development of peatlands are functions of the changes in monsoonal climate and local site-specific topography. These findings provide a comprehensive understanding of past long-term development of peatlands under monsoonal climates.

Keywords: Peatland development, Organic carbon contents, Monsoonal climate, Subtropical China, Last Glacial Maximum



【A0898】-Poster

Pollen evidence of eco-environment changes in the South Yellow Sea since the early Pleistocene

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Quaternary sediment of the South Yellow Sea (SYS) is usually assumed to record climatic changes, tectonic activities and major river evolutions. However, as an important terrigenous indicator, a long sequence of pollen proxy in the SYS lacks for studies of river provenance and climate changes. In this study, we focused on a 150-m pollen record in the SYS since the early Pleistocene. The most significant changes of pollen assemblage were caused by river provenance, that high pollen percentages of broadleaved trees such as *Castanea/Castanopsis* reflect a dominant provenance of the Yangtze River since ca. 1.8 Ma, with a decline trend during the Middle Pleistocene Transition (MPT) mainly between 1.1 and 0.8 Ma. The sharp increase in coniferous pollen, particularly *Picea*, originated from the Yellow River drainage areas, suggesting a major alteration in terrigenous pollen source from the Yangtze River to the Yellow River at ~0.8 Ma, which agrees well with the timing of the final integration of the modern Yellow River. The high pollen quantities of *Artemisia* and *Ephedra* also shows the enhanced Yellow River provenance where most landscape was covered by semi-arid open vegetation (e.g. steppe). The alternate appearances of marine foraminifera and dinoflagellate cysts, and freshwater wetland plants (*Cyperaceae*, *Poaceae*) through the interglacial intervals from MIS 19/21 demonstrate different estuary sedimentary environments and diverse salinity, associated with the sea-level fluctuations. The pollen concentration suggests an increase in terrigenous materials towards the interglacial MIS 11 and the preliminary delta formation of the Yellow River. We propose that the terrigenous input from the Yellow River accelerated after the MPT, and combined effects of tectonic movement drove the evolution of the river delta plains in eastern China. Our data also reveal some secondary periodic changes in evergreen broadleaved forest



during the past 1.8 Ma and cold-tolerant coniferous forest after particularly the MPT, which are generally linked with the 400-ka long eccentricity cycle and the variability of monsoon climate.

Keywords: South Yellow Sea, Pollen and spores, Wetland evolution, Provenance shift, Orbital change

【A0964】 -Poster

Modern pollen–plant relationships for reliable pollen-based reconstruction of past plant diversity—insights from southwest China

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Sedimentary pollen diversity has been commonly used to estimate past long-term changes in plant diversity. However, interspecies differences in pollen production, pollen diffusion/deposition make the relationship between pollen diversity and plant diversity unclear. To accurately interpret fossil pollen diversity in terms of past plant diversity, it is crucial to improve our understanding of the relationship between modern pollen and plant diversity. Yunnan Province, located in a subtropical highland monsoon climate zone with diverse vegetation types, offers an ideal region to explore pollen-plant relationship. In this study, we collected surface soil and moss samples from the northeast of Yunnan and conducted a detailed vegetation survey. We calculated taxonomic and functional diversity indices to examine the relationship between pollen and plant from different spatial scales. Furthermore, we analyzed the correlations between pollen and plant diversity with their potential driving factors. This study will provide a theoretical basis for reconstructing historical dynamic of plant diversity in subtropical regions and provide insights into biodiversity conservation and of ecosystem restoration in this and adjacent areas.

Keywords: Pollen, Pollen diversity, Plant diversity, Functional diversity, Yunnan



【A0183】 -Poster

Pollen evidence of enhanced Yellow River provenance into the South Yellow Sea after the Middle Pleistocene Transition

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The Quaternary sediments of the South Yellow Sea (SYS) serve as important archives of climatic fluctuations, tectonic processes, and riverine evolution. Palynological analysis of marine sediment sequences enables tracing of not only paleovegetation evolution along the continental margin but also sea-land climatic process and sediment provenance. However, long-term pollen records from the SYS have been underutilized in studies of river provenance and paleoclimate changes. This study examines a 150-m pollen record spanning most of the Quaternary period (~1.7 Ma). Eight pollen zones (I-VIII) with 9 subzones (IIa-IIb, IVa-IVb, Va-Vc, and VIIa-VIIb) were identified. The most significant changes in pollen assemblage were influenced by river provenance, that high pollen percentages of broadleaved trees such as *Castanea/Castanopsis* reflect a dominant provenance of the Yangtze River since ca. 1.8 Ma, with a declining trend during the Middle Pleistocene Transition (MPT) mainly between 1.1 and 0.8 Ma. The sharp increase in coniferous pollen, particularly *Picea*, originating from the Yellow River drainage areas, suggests a major shift in terrigenous pollen source from the Yangtze River to the Yellow River at ~0.8 Ma. This timing aligns with the final integration of the modern Yellow River. Enhanced Yellow River contributions are further supported by increases in *Artemisia* and *Ephedra* pollen, indicative of semi-arid open vegetation (e.g. steppe). Alternations in foraminifera, dinoflagellates, and freshwater plants (e.g., *Cyperaceae* and *Poaceae*) during MIS 19/21 reflect dynamic estuarine conditions and salinity variations driven by sea-level fluctuations. Pollen concentration during MIS 11 suggests heightened terrigenous input, marking the onset of Yellow River delta formation. We propose that the terrigenous input from the Yellow River accelerated after the MPT, and the combined effects of tectonic movement drove the evolution of the river delta plains in eastern China. Our findings also reveal some secondary periodic changes in evergreen broadleaved forests during the past 1.8 Ma and cold-tolerant coniferous forests, particularly after the MPT, which are



generally linked with the 400-ka long eccentricity cycle and the variability of monsoon climate.

Keywords: Pollen, South Yellow Sea, The Middle Pleistocene Transition

【A0723】-Poster

Forest and mosaic vegetation cut off savanna corridors during the Last Glacial Maximum in Southeast Asia recorded by marine pollen

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During the Last Glacial Maximum (LGM), Southeast Asia was characterized by the exposure of a vast landmass known as Sundaland, which emerged from the continental shelf. This newly available area may have facilitated the proliferation of vegetation, potentially enhancing carbon dioxide (CO₂) uptake. The ongoing debate regarding previous interpretations of “savanna corridors (C₄-rich grassland corridors)”, “mosaics vegetation” and “forest” in Southeast Asia necessitates further evidence to substantiate the presence of forests and grasslands. Pollen serves as a crucial proxy for reconstructing paleovegetation; however, pollen data from the central region of Southeast Asia, specifically the Indo-China Peninsula, is lacking for the LGM period. In this study, we present a new marine pollen record (NS2007-8) from the western South China Sea, which provides insights into the paleovegetation of the eastern Indo-China Peninsula, including the drainage basins of the paleo-Mekong River and the paleo-Red River. These rivers encompass both ancient rivers on the exposed shelf and modern rivers. We establish a standard for savanna (C₄-rich grassland) by comparing modern pollen data from savanna sediments and soils in Africa and South America. Our findings indicate that Poaceae-dominant tropical grasslands experienced a rapid decline in the eastern Indo-China Peninsula during the LGM, coinciding with the expansion of *Pinus* and evergreen *Quercus*-



dominant lower montane rainforest. Furthermore, using the established savanna standard, we find that the exposed northern Sundaland during the LGM supported an incomplete savanna mixed forest, resulting in a landscape characterized by forest-seasonal savanna mosaics. These results lend support to the concepts of “forest” and “mosaics vegetation”, challenging the hypothesis of “savanna corridors”.

Keywords: Vegetation mosaics, Biogeography, Last Glacial Maximum, Southeast Asia, the western South China Sea, Pollen

【A0522】-Poster

Paleoecological changes in Russian Altai during the Late Holocene based on pollen data in a Zolotoe Lake core

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Palynological data provide information about the distribution and abundance of plant species, as well as the climate condition in the past. This allows a comprehensive analysis of climate changes and their impact on ecosystems over time and across different spatial scales. This study presents vegetation changes in the Russian Altai region over the last 1700 years and reveals the possible causes of these changes. Thirty-two pollen samples from a 64-cm long core from Zolotoe Lake (51°51.479' N, 080°15.986' E) were studied. Zolotoe Lake is situated in the southern part of the West Siberian Plain, near the foothills of the Altai. The region is dominated by sagebrush-grass steppes with isolated pine and birch forests growing on the hills. The core sediments were dated by AMS ¹⁴C dating on total organic carbon, ²¹⁰Pb and ¹³⁷Cs dating in NTUAMS Lab at the Taiwan University. The pollen analysis revealed moderately high pollen concentration and generally good preservation of pollen grains. Based on the palynological data, five main stages of



vegetation changes can be identified. I: ~1690-1500 cal yr BP, a dominance of coniferous forests suggested the existence of a relatively warm and humid climates during the Roman climatic optimum. II: ~1500-1180 cal yr BP, an expansion of steppe communities indicated cooling and drying climates during the cold Dark Age. III: ~1180-700 cal yr BP, an expansion of coniferous forests and a reduce of steppe components revealed warmer and wetter climate conditions during the Medieval climatic optimum. IV: ~700-280 cal yr BP, a further expansion of broadleaf species reflected a relatively warm and humid climate during this period which was different from the general cold/dry conditions during the Little Ice Age. V: After ~280 cal yr BP, a trend toward aridization of climatic conditions is noticeable. The sharp peaks in the concentrations of coprophilous, parasitic, and saprotrophic fungi spores around ~1300-1180 cal yr BP, and -14 cal yr BP (1964 CE), most likely indicated human impacts. Based on the pollen record, we conclude that in the southern part of the West Siberian Plain, forest vegetation was reduced and replaced by steppe vegetation during the past 1700 years. Larisa Frolova was supported by grant of the Ministry of Science and Higher Education of Russian Federation (agreement No 075-15-2024-554 of 24.04.2024).

Keywords: Vegetation, Reconstruction, Climate

【A0171】 -Oral

Changes in plant diversity in the Altai Mountains during the Holocene: Trends, patterns and drivers

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Situated at the boundary of several climatic zones, the Altai Mountains are the most important site for the study of Holocene biodiversity and environments in North and Central Asia. The high-resolution palaeorecords from the Altai lakes allow a detailed study of the past biodiversity dynamics of the region.



A standard set of methods is used to reconstruct past alpha and beta plant diversity from pollen and sedimentary DNA data, albeit with some limitations. Moderate anthropogenic disturbance of landscapes ('intermediate' disturbance hypothesis) is known to increase diversity (Beek et al., 2018), but intensive agriculture and urbanisation in recent decades have negatively affected floristic diversity (Seppa, 1997; Meltsov et al., 2012). At the same time, semi-open landscapes show greater plant diversity than fully open or fully afforested landscapes (Billeter et al., 2008).

In community ecology, compositional turnover refers to the quantification of the replacement of one species by another in a community over time or space, or both (Birks, 2007). Temporal compositional turnover is the change in community composition over time, expressed as a quantification of the dissimilarity between each time step for a single point in space. In pollen analyses, beta diversity is typically defined by the sum of compositional changes of all pollen taxa within a single stratigraphic sequence, i.e. relative to a temporal gradient. Pollen records provide a reliable means of investigating compositional changes in assemblages over long periods of time (Felde et al., 2020).

Based on the analysis of alpha-diversity for pollen and plant sedaDNA records from 15 lakes located in different types of landscapes in the Altai Mountains, the following conclusions can be drawn. For lakes located in zones of insufficient moisture, phytodiversity is strongly positively correlated with increasing forest cover and precipitation (the latter only for basin lakes).

The phytodiversity indicators obtained for both basin and highland lakes in the arid zone show the same regularities: plant diversity increases with increasing forest cover. In the arid highlands, plant diversity responds positively not only to afforestation, but also to an increase in the area of different types of non-steppe highland formations. Conversely, phytodiversity calculated for lakes in mountainous areas with high forest cover increases with increasing open areas occupied by steppe or tundra communities.

Based on the calculation of beta-diversity, we can assume that no abrupt changes in the level of plant diversity were observed in the Altai during the Holocene, even during the period of highest humidities ("Holocene optimum"). The maximum restructuring of the taxonomic composition of Altai plant communities occurred only at the turn of the Holocene and Pleistocene.



It was found that the total phytodiversity of the Altai increased during the last millennium, despite a decrease in total precipitation. This may be due to increasing anthropogenic pressures on the landscape, the emergence of a greater number of diverse habitats, and an increase in the overall mosaic of vegetation cover.

The studies were supported by grant of the Ministry of Science and Higher Education of Russian Federation (agreement № 075-15-2024-554 of 24.04.2024).

Keywords: Plant biodiversity, Altai, Holocene, Biodiversity changes, Anthropogenic pressure

【A0445】 -Poster

Climate-driven coastal disparity hypothesis for mangroves

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Mangrove ecosystems along the Indian coastline face increasing threats due to climate change, making their conservation and restoration an acute priority. However, there is a gap in understanding region-specific climate impacts and conservation needs for these ecosystems under future scenarios. This study aims to identify the key environmental drivers of Indian mangrove distribution, map their spatial and temporal range, and determine priority sites for conservation and restoration. Using an ensemble modeling approach, we assessed baseline, past (~6000 years ago), and projected future distributions (for the years 2040, 2060, 2080, and 2100) of 20 Indian mangrove species under SSP1-2.6 and SSP5-8.5 climate scenarios. Our results indicate that environmental variables, particularly temperature and precipitation, significantly affect mangrove habitat suitability, with considerable variability between the east and West Coasts of India. Under the SSP1-2.6 scenario, regions of high mangrove species richness are primarily maintained on the West Coast but are projected to decline by 2100 due to shifts in temperature and salinity. Conversely, the SSP5-8.5 scenario initially predicts an expansion of species richness along parts of the East Coast but ultimately projects severe biodiversity loss by



the end of the century, driven by increased sea surface temperatures, intensified salinity, and greater coastal erosion. The analysis underscores the need for region-specific conservation strategies: for the West Coast, efforts should focus on reducing salinity intrusion and limiting coastal development, while on the East Coast, enhancing cyclone protection and sediment management is essential.

This study provides crucial insights for targeted mangrove conservation policies that can be integrated into the national climate action plans of India. By identifying vulnerable regions and prioritizing conservation actions, this research supports the long-term resilience of India's mangrove ecosystems amid accelerating climate change.

Keywords: Mangroves, Habitat suitability, Climate change, Ensemble modelling, Conservation prioritization

【A0115】-Poster

Evidence of 458-445 million-year-old land plants in India

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The emergence of plants on land marked a crucial macro-evolutionary event in life's history, with bryophyte-like plants initiating terrestrialization in the Early Palaeozoic in a step-wise manner. Since no definitive macrofossils of early land plants predate the Silurian period, evidence relies primarily on fossilized microfloral remains, notably dispersed spores (cryptospores). These microfloral records precede the macrofossil records of embryophytes, tracing back their origins at least to the Ordovician, and probably also the Cambrian, if not the Precambrian. Cryptospores provide the earliest evidence of terrestrial flora. Although sporomorphs from the late Proterozoic have been reported, most pre-Ordovician organic-walled microfossil records remain cryptic. The earliest cryptospore assemblage is documented from the Dapingian (470-467 mya) strata of Argentina; evidence of early land plant life can be found in fine-grained clastic sediments from various Ordovician and Early Silurian environments, both continental and marine, in



the form of sporomorphs and cuticles. This global evidence indicates cosmopolitan vegetation during the Early Palaeozoic.

Despite the well-exposed Early Palaeozoic sediments at various Indian localities, particularly in the Kumaon-Garhwal Himalayas and the Tethyan zones of Kashmir, Ladakh, and Lahaul-Spiti, India's contribution to this field remains minimal compared to extensive global research. There is a report of cryptospore-like microfossils from the Cambrian Kunzum La (Parahio) Formation, Parahio Valley of the Spiti region, which mentions the occurrences of cryptospores like microfossils as monads, dyads, and tetrads without taxonomic identification. Plant macrofossils older than the Silurian have not been found in India, with only two questionable records of macroplant remains, *Psilophyton princeps* and *Taeniocrada* sp., from the Early Silurian and Early Devonian sequences of the Spiti region.

The search for microfloral remains in India's Ordovician-Silurian strata has been largely neglected. Recent efforts in this direction included maceration of shale/siltstone from the lowermost Takche Formation in the Takche locality of the Indian Tethys Himalaya. This yielded a microflora assemblage alongside phytodebris and marine palynomorphs. The miospore assemblage includes cryptospores (monads and dyads) and trilete spores, characterized by species such as *Chelinospora* sp., *Chelinospora?* sp., *Chelinohilates* sp., *Didymospora luna*, *Didymospora* sp., *Didymospora luna?*, *Didymospora fucosogranulata?*, *Gneudnaspora* sp., *Laevolancis divellomedium* (Chibrikova), *Rugosphaera cerebra*, *Rugosphaera* sp. *Rugosphaera* cf. *cerebra*, *Dyadospora murusdensa*, *Segestrespora rugosa?*, *?Sphaerasacus glabellus* and *Sphaerasacus glabellus*. The phytodebris comprises laevigate tubes, tracheid-like and cuticle-like sheets. This microflora likely originated from terrestrial plants of the Gondwana mainland and was transported by air/wind into near-shore shallow marine settings, as the palynomorph-yielding horizon is truly marine. This discovery supports the idea of cosmopolitan middle-late Ordovician terrestrial vegetation and the hypothesis that embryophytes first emerged in Gondwana. However, further detailed studies are needed to firmly establish evidence of early land plants from the early Palaeozoic sequences of the Indian subcontinent.

Keywords: Ordovician, Tethyan Himalaya, Cryptospore, Phytodebris, Marine palynomorphs



【A0305】 -Poster

Identification of conservation sites for endangered arid tree *Tecomella undulata* in highly evolving drylands of India

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Climate change profoundly impacts species across different ecosystems and forces them to shift their habitat or migrate to survive. Like other regions, drylands, which constitute 40% of the total geographical land, are also highly impacted by environmental factors due to climate change. North-western India, a major dryland, is severely impacted, affecting the ecosystem and the residing population, which is higher than other drylands. *Tecomella undulata* is a keystone endemic species in the region with high ecological, economic, medicinal, and aesthetic value. It is widely utilised for furniture, timber, and fodder. The once widely distributed species in the region is currently endangered owing to climate change and anthropogenic influences. In our study using Species Distribution Modelling (SDM), we determine the role of environmental variables in reducing the habitat distribution of the species.

For the study, we collected 111 occurrence records, 19 bioclimatic variables, seven edaphic variables and two topographical variables. These environmental variables are analysed to find 16 variables that significantly influence the distribution of the species. We modelled the distribution from the Last Glacial Maximum (LGM) (~20000 ybp) to 2100 to obtain a history and prediction of the distribution of the species. The study identified bio12, bio8, altitude, total nitrogen, Cation Exchange Capacity (CEC), and bio15 as the variables that have a crucial role in distribution. The models showed a limited distribution in the past during wet periods when the temperature was lower and its subsequent increase until the present state as the region got drier and hotter. In the future, the number of suitable habitats for the species will increase owing to the rise in temperature (especially bio8) and erratic rainfall in the region, which is a positive sign in the conservation efforts of the endangered species. Even though environmental factors favour the species' habitat suitability, we must find individuals with superior genes, avoid



inbreeding depression and provide suitable surroundings with limited human disturbances for the species to survive. In our study, we compared the suitable habitats predicted by our models for the future and the existing conservation sites and identified Priority Conservation Areas (PCAs) for the species. Most of the identified PCAs fall in regions of human habitation, necessitating the development of novel conservation strategies for *Tecomella undulata* involving the participation of the people.

Abbreviations: LGM – Last Glacial Maximum, SDM – Species Distribution Model, CEC – Cation Exchange Capacity, bio12 – Annual Precipitation, bio8 – Mean temperature of wettest quarter, bio15 – Precipitation seasonality (Coefficient of variation), PCA – Priority Conservation Areas.

Keywords: Maxent modelling, Desert teak, Habitat suitability, Fossil pollen, Priority Conservation Areas (PCAs)

【A0512】-Oral

Fagus diversification in China in relation to East Asian monsoon evolution

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When and how the extraordinary species diversity in subtropical East Asia formed is intensely debated, and the available evidence is often inconsistent. In this study, we evaluate the effects of pre- and post- Quaternary events on the evolutionary and biogeographic history of Chinese beech (*Fagus* species that now occur in China) to gain new insights into the historical establishment and future fate of the East Asian subtropical forest (EASF). A series of approaches and datasets were used to reconstruct biogeographic and evolutionary history of the Chinese beech. They include phylogeography based on the polymorphisms of the complete chloroplast genomes, species distribution models, and a



large palaeobiogeographic dataset including 59 pre-Quaternary fossil records, 296 Quaternary fossil records and 3515 modern pollen records. Our multidisciplinary approach suggests that (i) Chinese beech has dispersed to subtropical East Asia and diversified in the early Miocene when the Asian monsoon (AM) intensified; (ii) the last post-glacial warming resulted in limited poleward displacement but significant contraction at southern and lower elevations; (iii) the poleward dispersal of Chinese beech was limited by drought in the early growing season in temperate China, controlled by the East Asian Summer Monsoon. Our results support the hypothesis that the establishment of the EASF is closely related to the evolution of the AM. More importantly, we suggest that with continued climate warming (e.g., during the last post-glacial period or under current climate change), the monsoon probably hindered rather than promoted the persistence of deciduous beech species, resulting in a decline in species richness.

Keywords: Biodiversity, Fagus, Global warming, Postglacial, Spring drought

【A1018】 -Oral

Modern pollen–plant diversity relationships for reliable pollen-based reconstruction of past plant taxonomic and functional diversity: A case study in southwest Shandong, China

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Pollen diversity provides insights into our understanding of past plant diversity, a wide variety of diversity indices have been used to characterize plant diversity from sedimentary pollen. However, studies reported inconsistent associations between pollen–plant taxonomic diversity, this could be partly accounted for by biases due to interspecies differences in pollen production, pollen diffusion/deposition, and poorly specified dispersal distance of pollen-source plants. It is therefore crucial to improve the interpretation of the sedimentary pollen diversity by systematic studies of palynological and floristic diversity associations in contemporary landscapes.



To test the reliability of pollen assemblages as a proxy of plant diversity, we collected pollen and vegetation from 36 surface sites in southwest Shandong. We detected the correlation between pollen-plant taxonomic and functional diversity indices from different spatial scales.

Our results show pollen-plant correlations vary in spatial scales for different indices, the Spearman correlation analysis indicates significant and the strongest correlations between pollen-plant Shannon index around the RSAP ($0.399 < p < 0.520$), while the Pielou's evenness shows significant and the highest correlations ($0.411 < p < 0.425$) around and beyond the RSAP, but only weak positive relationships can be detected between pollen-plant richness. Functional composition based on whole plant height and specific leaf area and functional dispersion based on combined traits of whole plant height, specific leaf area, seed mass, and leaf dry mass shows significant positive pollen-plant associations, indicating that functional diversity may improve the pollen-plant link.

Our results confirm that pollen data performs well in presenting plant taxonomic and functional diversity, which provides a solid theoretical basis for quantitative reconstruction of the long-term plant diversity dynamics and response of ecosystem functions to the environment in the future. Furthermore, the results demonstrate that the spatial scale of vegetation survey plays an important role in the representation of pollen diversity.

Keywords: Palynological diversity, Floristic diversity, Community weighted mean abundance, Functional dispersion

【A0983】-Oral

Mangrove dynamics and coastal environmental changes from Northern Hainan Island, China

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Mangrove ecosystems are most threatened by relative sea-level rise in the context of



global climate warming. An 8000-year history of mangrove development and coastal environmental changes based on multi-proxy sedimentary records from the northeast coast of Hainan Island, aiming to assess the impact of past environmental changes on the evolution of mangrove ecosystems. Palynological, foraminiferal, loss on ignition, and grain-size data for two 650 cm sedimentary cores indicate four stages of ecosystem development in Bamen Bay, Qinglan Port. Pollen analysis was also conducted on samples of surface sediment from various mangrove communities in Qinglan Port, and the results show that the mangrove species found in the core samples are similar with those of the modern environment, and exhibit a consistent vegetation succession sequence. Around 8400 cal yr BP, study area was transformed into an estuarine environment due to sea-level rise. Mangrove began to presence, initially dominated by *Bruguiera/Ceriops* and *Excoecaria agallocha*, and gradually replaced by the more salt-tolerant species *Rhizophora* and *Sonneratia alba*. When the mangrove sediment did not keep pace with rapid rising sea level, mangrove forest disappeared from study area for several centuries, while foraminiferal abundance increased relatively. The second occurrence of *Rhizophora*, accompanied by other mangrove species, suggested that the study area was transformed back into an intertidal zone, supporting a prosperous mangrove community. Sea-level were relatively stable during the mid-Holocene in southern China. Between 6000 and 2500 yr BP, the extremely slow sedimentation rate in both two cores may suggested the possible occurrence of land subsidence or sediment loss, which may have allowed the continued survival of mangrove community by providing sufficient space for their persistence from at least 6000 years. The future adjustment of mangrove communities will also vary in response to changes in local topography and sediment supply.

Keywords: Mangrove, Holocene, Hainan Island, Palynology



Session 14. Atmospheric paleo-particles and global environmental impacts

Conveners: Steve Pratte, François De Vleeschouwer, Zhiwen Dong, Gaël Le Roux, Weijun Li

【A0451】 -Poster

Anthropogenic and climatic impacts in southwestern China over the last 1300 years recorded in an alpine wetland

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Climate change and anthropogenic activities are two key factors influencing regional environmental changes, with effects spanning millennia to centuries. In this study, we present the potentially harmful trace elements (PHTEs) and stable isotopes (Pb and Hg) records combine with the radiometric profile of a sediment core from Jiulongchi wetland in Fanjing Mountain, southwest China. We calculate the chemical index of alteration and enrichment factors, and conduct multivariate statistics (factor analysis followed by clustering of the factor score matrix). This study aims to reconstruct the mass accumulation rate and the atmospheric deposition history for the last 1300 years, link the geochemical records to historical and climatic events, and find out the source of contamination. The up-to-date data of sediment core is a review of the regional development and a supplement of local database, which provide policymakers with scientific evidence to formulate effective environmental management and adaptation strategies, mitigate the negative impacts of climate change and human activities on regional environments, and promote sustainable development.

Keywords: Trace metals, Anthropocene history, Lead isotopes, Hg isotopes, Alpine wetland

【A0691】 -Oral

Stratospheric and tropospheric aerosol forcing from volcanic eruptions



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Volcanic sulfate aerosols play a key role in forcing climate, and past records of this aerosol forcing are reconstructed from sulfate concentrations in polar ice cores. It is typically assumed that all of the sulfate deposited on the ice sheet comes via the stratospheric overworld, and thus can be scaled into a stratospheric sulfate loading. Here I will present sulfur isotope evidence that shows that a substantial proportion of ice core sulfate is oxidized in lower altitudes, calling into question how we should scale these ice core sulfate fluxes into atmospheric sulfur loadings. I will investigate the magnitude of this complication across many of the major eruptions over the last several thousand years, including eruptions from the Katmai/Novarupta, Aniakchak, Mazama, and Okmok volcanoes, and will discuss the implications of these findings for stratospheric aerosol forcing records currently used in climate models.

Keywords: Volcanic aerosols, Ice cores, Sulfate, Isotopes

【A0942】-Poster

Simulated evolution and controlling factors of the dust cycle during the Phanerozoic

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Atmospheric dust is crucial in Earth's radiation balance, cloud and precipitation formation, and marine biogeochemistry. Simulations of paleo-climatic dust cycles provide important



information about how dust cycles interact with the deep-time evolution of the Earth. This study employed the climate model CESM1.2.2 in combination with the vegetation model Biome4 in order to systematically explore the evolution of the global dust cycle and its governing factors over the last 540 million years.

The main conclusions are as follows: Before the colonization of land plants, the global dust cycle is significantly greater than in the pre-industrial (PI) and supercontinent periods, with atmospheric dust loading 1.5-2.4 times that of the PI (24 Tg). Nearly every terrestrial surface has the potential to produce dust, and the sources of dust depend on the size of the continent. After the colonization of land plants, the subtropical land area becomes the main control factor for the dust cycle, with climate playing a secondary role and the land plant evolution having a relatively minor impact. The size of the subtropical land area, by affecting the extent of bare soil, determines the strength of dust emission, with dust loading variations ranging from 1 to 35 Tg in different periods. During the supercontinent periods (240Ma), dust loading peaks at about 1.5 times that of the PI.

The spatial distribution of dust source regions and dust deposition simulated in our study is supported by extensive geological records. It is worth noting that a portion of dust emitted from land is eventually deposited into the ocean. The iron content within this dust serves as an essential nutrient for oceanic primary productivity, significantly influencing marine primary production and the carbon cycle. We have simulated the evolution of the flux of dust deposition into the ocean over the past 540 million years, which shows a strong correlation with continental fragmentation. This is because as continents break up, dust is transported across shorter distances to reach the ocean, thereby increasing the proportion of dust that ends up in the ocean.

Keywords: Dust cycle, Climate simulation, Phanerozoic

【A0062】 -Oral

Iron variability reveals the interface effects of aerosol-pollutant interactions on the glacier surface of Tibetan Plateau

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Iron (Fe) as a limiting nutrient has profound impacts on ecosystems and the global biogeochemical cycle. Field observations were made at the atmosphere–snowpack interface in various glaciers of the Tibetan Plateau. The form and chemical properties of the Fe detected were investigated in laboratory using TEM-EDX measurements, to obtain insights in the content and sources of Fe in aerosol pollutants in glaciers, as well as micro-structure changes and their environmental effects, as well as interface transformation dynamics. We find that Fe occurs in forms of aggregated and single particulates with diameter $d < 5 \mu\text{m}$. The Fe particulates collected from different locations show clear spatial heterogeneity, with fly ash and soot constituting the major components of anthropogenic Fe. The concentration of Fe aggregates with pollutants (e.g., sulfate and nitrate) is dominant in regions close to the areas of human activity. Moreover, in the remote areas of the interior plateau, an increased concentration of mineral Fe particles is found in the aggregates. These observations are crucial to elucidate the evolution processes of pollutant-Fe mixing, from generation or emission through anthropogenic activities to accumulation in remote areas and modification of Fe occurrence form during transportation. Our results also show that, during interface deposition, soluble Fe particle concentration increased by 13.8% on average, as Fe solutes with sulfate-coating enhances the dissolution of Fe in fly ash-soot and minerals—a process that produces large quantities of ultrafine Fe particle under reductive dissolution in snowpack. Overall, these changes significantly contribute to enhancing the bioavailable iron content in the study areas affecting thereby the glacier ecosystem.

Keywords: Fe particulates, Glacier surface, Tibetan Plateau, Pollutant mixing states, Source

【A0459】 -Oral

Reconstructing atmospheric sea salt aerosol variability over 800,000 years



using the EPICA Dome C Ice Core

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Sea salt aerosols play a critical role in the climate system, influencing the Earth's radiative balance both directly by scattering incoming radiation and absorbing outgoing radiation, and indirectly by acting as cloud condensation nuclei. In the polar regions, both the open ocean and sea ice are sources of sea salt aerosols. However, the evolution of these sources on glacial-interglacial timescales, and how this controls the atmospheric concentrations of sea salt aerosols remains poorly understood.

We use a continuous record of sea salt sodium (ssNa^+) from the EPICA Dome C (EDC) ice core to investigate the long-term evolution of sea salt aerosols. This record is the oldest continuous ice core record, covering the past 800,000 years. High-resolution measurements of chemical impurities preserved within the ice were made using a continuous flow analysis (CFA) system, which allows for the reconstruction of the ssNa^+ and other chemical impurity records in 1 cm resolution. Even for the deepest sections of ice, where thinning reduces the time resolution, the high resolution of the measurements allows for the preservation of multi-decadal-scale variability (Röthlisberger, R et al., 2008).

The EDC ice core record shows a 2-4 fold increase in ssNa^+ concentrations in glacial periods compared with interglacials. This variability arises from the interplay of local accumulation changes, changes in source strength, and aerosol losses during transport through wet and dry deposition. For example, due to temporal changes in precipitation on top of the ice sheet the local atmospheric sea salt concentration/sea salt deposition flux changed only by a factor of 2-3. Moreover, during glacial periods, colder temperatures led to a reduction in the integrated precipitation and, thus, aerosol loss during transport. In turn, this leads to increased atmospheric concentrations at the ice core site, and consequently, higher concentrations preserved within the ice core.



We use a simple conceptual transport model to correct for atmospheric losses during transport, enabling the reconstruction of past atmospheric concentrations of sea salt aerosols (Markle, B. R et al., 2018). Using the model, we investigate how changes in the temperature gradient during glacial-interglacial periods impact aerosol atmospheric lifetimes and the inferred source region for sea salt aerosols being deposited at the EDC site. This approach provides insights into changes in source strength and the variability of sea salt aerosol concentrations in high-latitude climates over glacial timescales. Here, we present a reconstruction of atmospheric sea salt aerosol concentrations spanning the past 800,000 years. Model results indicate that much of the variability in ssNa^+ in the EDC ice core can be explained by reduced aerosol rainout during cold periods, however reconstructed atmospheric concentrations also suggest that source strength was increased 1-2 fold during cold periods.

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Keywords: Ice cores, Sea salt aerosols, Glacial cycles

【A0840】 -Poster

Insight into radionuclide ^{235}U deposition in multiple-environmental media in Muztagh Ata Glacier Basin of the eastern Pamirs

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This study concerns the $^{235}\text{U}/^{238}\text{U}$ ratios in environmental samples collected in the Pamir region (Central Asia). Cryoconite (a supra-glacial sediment), soil and river water were sampled in the Muztagh Ata Glacier Basin, a secondary basin belonging to Gaizi River watershed. The aim of the research is to assess the impact of anthropic nuclear activities in such a remote area, being the $^{235}\text{U}/^{238}\text{U}$ ratio highly sensitive to anthropogenic disturbances. Results indicate that the $^{235}\text{U}/^{238}\text{U}$ atomic ratio in the region ranges from 0.007256 to 0.007263, with an average of 0.007259 ± 0.000002 . Such values are slightly higher than the natural isotopic reference (0.007256) (Hiess et al., 2012), suggesting a modest enrichment of ^{235}U . This is related to the input of uranium with an anthropogenically modified isotopic signature. The $^{235}\text{U}/^{238}\text{U}$ ratios are higher in cryoconite compared to that of surface soil and river water, reflecting differences in the release, transmission and retention of ^{235}U across various environmental media in the Pamir region. The variability of the isotopic ratio was also explored in relation to some key geographic parameters and compared with data from a wider geographic context. The altitude distribution of the $^{235}\text{U}/^{238}\text{U}$ ratio indicates that the deposition of ^{235}U in the Muztagh Ata area primarily results from upper atmospheric deposition sources of the global fallout of radionuclides, which were probably released by historical human nuclear activities of global range, but without clear evidence of local uranium contamination. A conceptual model for interpretation of the $^{235}\text{U}/^{238}\text{U}$ ratios and profile distribution in eastern Pamir is provided. Comparative analysis of the $^{235}\text{U}/^{238}\text{U}$ ratios in our samples and in samples from other locations in the northern hemisphere shows that the level in the environment of the Muztagh Glacier area is cleaner, with subtle enriched uranium and not contaminated by depleted uranium. Therefore, this work is of importance in providing a complete view on the migration, dispersion, and removal of radionuclide ^{235}U in the atmosphere and cryospheric glacier watershed of the remote Pamir region, thus offering new insights into the distribution and behavior of radionuclides in the Pamir.

Keywords: $^{235}\text{U}/^{238}\text{U}$ radionuclide, Muztagh Glacier basin, Pamir Plateau, Anthropogenic nuclear activities, Atmospheric pollutants

【A0326】-Poster

Late Holocene atmospheric dust variability inferred from an ombrotrophic peatland in Southwest Patagonia

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Paleoclimatic reconstructions in Patagonia have for a long time relied on palynology and pollen proxy reconstructions. Alongside lake sediments, peat bogs provide reliable records of past atmospheric variability. In particular, dust concentrations and fluxes provide a record of past atmospheric dust variability as they depend solely on the deposition of airborne dust particles. Atmospheric dust variability in Patagonia depends on both atmospheric winds and precipitation. They therefore complement pollen-based paleoclimatic records that depend mostly on precipitation and temperature. Here, we measured dust concentrations in the well-known Rio Rubens peatland based on geochemical analyses. The calculated dust fluxes for the past 3000 years indicate that a similar multi-centennial variability exists as seen in pollen-based proxies from south-Patagonian lakes, with similar phasing. However, the amplitude of these oscillations in the dust flux is very subdued compared to the pollen data. As an initial interpretation, this would indicate that temperature may be a more important driver of local climate variability than precipitation. However, this contradicts the interpretations of many other studies and sites in the region, and may be due only to a low sensitivity of this particular site to past dust changes.

Keywords: Dust, Patagonia, SWW

【A0641】-Poster

Contrasting effects of road dust and atmospheric dust on carbon accumulation in ombrotrophic peatlands

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Limited research has been conducted on the role of atmospheric dust as a nutrient source for peatlands, and none of them have studied the effects of localized and intense road dust on peatland carbon (C) accumulation. To compare the effects of dust deposition from these two sources on peatlands, we examined three ombrotrophic peatlands adjacent to unpaved (gravel) roads in eastern Canada. We find that road dust deposition increases the ash content of peat and decreases its stoichiometric ratios of C, nitrogen (N), and phosphorus (P), with the greatest changes occurring at the site having the highest road dust deposition. The reconstruction of the dust record since 5500 cal BP reveals six dust events, with the most recent one being predominantly from road dust having a dust flux 19-95 times higher than the background atmospheric dust flux (varying based on the reference element for the dust flux). The atmospheric dust flux exhibits a significant positive linear correlation with the accumulation rates of C, N, P, and potassium in the catotelm of the peat profile, but a negative linear correlation with the ratios of C:N and C:P. In contrast, the C accumulation rate is lowest closest to the road and increases with distance away from the road as a result of changes in vegetation composition, nutrient availability, and water levels. The different effects of the atmospheric dust and road dust suggest that there may be a threshold effect of dust or nutrient inputs, especially P, on peatland C accumulation.

Keywords: Road dust, Atmospheric dust, Carbon accumulation, Nutrients, Peatlands

【A0046】-Oral

Distribution, composition and risk assessment of PAHs and PCBs in cryospheric watersheds of the eastern Tibetan Plateau

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Polycyclic Aromatic Hydrocarbons (PAHs) and Polychlorinated Biphenyls (PCBs) are significant components of persistent organic pollutants (POPs) and pose a threat to both ecosystems and human health. To explore their spatial distribution, origins, and risk assessment, we collected 25 glacial meltwater and downstream river water samples in the eastern Tibetan Plateau (including the Qilian Mountains in the northeast) during the summer of 2022 (June–July). Our results showed that Σ PAHs and Σ PCBs were present in a wide range from ND-1380 ng/L and ND-1421 ng/L, respectively. Compared to other studies worldwide, the Σ PAHs and Σ PCBs in the Hengduan Mountains were at high levels. The PAHs and PCBs mainly consisted of low-molecular-weight homologs, including Ace, Flu, Phe, and PCB52. Phe was the primary component of PAHs. Glacial meltwater samples generally exhibited low concentration of PAHs and PCB52, whereas downstream river water samples typically showed high concentration of PAHs and PCB52. We attributed this characteristic to the influence of pollutants physicochemical properties, altitude effect, long-range transport (LRT), and local environmental conditions. In the eastern Tibetan Plateau glacier basin (especially in the Hailuoguo watersheds), the concentration of PAHs and PCB52 in runoff generally increased with decreasing elevation. We believe that the primary factor affecting the concentration of PAHs and PCB52 in the region is the difference in local human activity inputs from various altitudes. The composition characteristics of PAHs and PCBs suggested that incomplete coal combustion and coking discharge mainly caused PAHs, while the combustion of coal and charcoal and the release of capacitors primarily caused PCBs. We assessed the carcinogenic risk of PAHs and PCBs in the glacier basin of the TP and found that the potential threat of PAHs was stronger than that of PCBs. Overall, this study provides new insights into the ecological security of water resources in eastern Tibetan Plateau. It is significant for controlling PAHs and PCBs emissions, assessing the ecological environment of the glacier watershed, and regional human health.

Keywords: PAHs, PCBs, Risk assessment, Eastern Tibetan Plateau, Glacier basin

【A0385】-Oral

Atmospheric dust in peatlands: Innovative method for paleoclimate



reconstruction

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Peatlands are globally distributed ecosystems with a key role in climate regulation through carbon storage, along with water provision and regulation. In Chile, they are widely distributed throughout the Patagonian region. This southernmost continental landmass is directly influenced by the Antarctic Circumpolar Current and the core of the southern westerly winds. Due to their acidic, anoxic conditions and incomplete organic decomposition, peatlands preserve proxies of atmospheric and ecological signals, making them invaluable paleoclimatic archives.

Mineral atmospheric dust is one of the proxies measured in peat cores, with a pivotal role in understanding past changes in the radiative balance and the biogeochemical cycles of the atmosphere. Dust concentrations in peat have traditionally been estimated through geochemical elemental analyses and average crustal concentrations. To reduce uncertainties, we have developed an innovative method for measuring dust particle concentrations in peat cores using direct particle counting. This method includes four main steps: sampling, freeze-drying, digestion, and particle measurement. A key feature is the preservation of grain size during the digestion process, allowing simultaneous analysis of dust size and concentration.

We applied the new method to a core obtained from the El Sapo peatland (51°16'22.87"S, 72°51'57.86"W), located southeast of Torres del Paine National Park. We validate the new method's effectiveness by comparing its results with those obtained using established protocols based on geochemical measurements and crustal average concentrations.

Keywords: Atmospheric dust, Peatlands, Paleoclimate, Methods



【A0745】 -Poster
Characterization of eolian dust in surface moss samples of northeastern China and its potential environmental implications

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Dust can affect the nutrient balance of terrestrial ecosystems by supplying minerals that may contain significant amounts of nutrients. Peatlands play a significant role in the global carbon cycle and store approximately one third of the global organic carbon pool. Nutrient supply and availability are factors controlling peatland productivity and carbon burial. Northeast (NE) China is at the eastern edge of the desert and drylands of northern China and is located in the area of influence of Asian dust storms making it an ideal area to study recent records of dust evolution.

Surface moss samples (mainly *Sphagnum*) were collected in various peatlands (six until now) of northeastern China between 2018 and 2024 (still ongoing). The mineral fraction of in the moss, was isolated and the acid-soluble and acid-insoluble fractions separated. This study will combine geochemical, mineralogical and grain-size analyses on present-day dust and the mineral fraction of peat. Major elements in the acid-soluble fraction of the dust in the *Sphagnum* moss and in peat will be used to evaluate the potential bioavailability of nutrients (P, Cs, Mg, K, S, Fe and Mn) and estimate their release rate in peatlands. The geochemical composition of the acid-insoluble fraction is used to help identify the source of the dust over the recent years.

Preliminary results on the acid-insoluble fraction of the dust in two peatlands indicate that the rare earth element geochemical composition is similar to that of samples from the Holocene and that the main source of eolian dust in the region remains the drylands of northeastern China, namely the Hunshandake, Horqin and Hulun Buir drylands. The acid-soluble fraction of the mineral matter displays higher major elements content than the insoluble fraction and their concentration in the bulk samples (including both acid-soluble and acid-insoluble fraction) is higher in the surface *Sphagnum* samples than in the deeper



peat samples for some major elements (Ca, P, K, Mg, etc.). This suggests that an important part of the nutrients in terrestrial ecosystems of northeastern China could originate for eolian dust. However, the number of samples (n=38) and the number of study sites (n=2) remains too limited to draw any clear conclusion at the moment. Further analyses will be undertaken on other sites for which samples are already available.

Keywords: Eolian dust, Surface moss, Geochemistry

【A0839】 -Poster

Zn isotope tracing unveils primary anthropogenic Zn sources in glacial cryoconite of the high Asian mountains

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Zinc (Zn) exerts a significant influence on the global environment, terrestrial ecosystems, and human health. The application of Zn isotopes ($\delta^{66}\text{Zn}$) has been suggested as a potent tool for tracing environmental contamination. However, studies focusing on Zn isotope tracing within the cryosphere areas are notably limited. Here we present the first dataset on Zn isotopes in glacial cryoconite, based on observations over a large regional scale in High Asian Mountains (including Tibetan Plateau (TP) and its surroundings of western China). The results showed that glacial cryoconite had a general heavy Zn isotopic signature in various TP locations, with $\delta^{66}\text{Zn}$ values ranging from -0.22‰ to +0.87‰. Employing the MixSIAR model, the overall Zn contribution source to the cryoconite was



mineral dust (36%) > coal burning (33%) > non-exhaust traffic emissions (22%) > industrial smelting (10%). We ascertained that anthropogenic sources account for the primary contribution (about 60-73%) of Zn inputs in all glacial locations, with coal burning emerging as the foremost anthropogenic contributor (mean 33%). Anthropogenic Zn in various TP locations was primarily derived from Zn emissions resulting from coal combustion, though it is also predominantly influenced by industrial smelting source in cryoconite of the Tianshan Mountains. Our results aligned with coal combustion data from the energy inventory of western China, suggesting that regional coal burning likely represents the foremost source of atmospheric Zn pollutant emission and deposition in the High Asia mountain glaciers.

Keywords: Zinc isotopes, Source tracing, Anthropogenic emissions, Glacial cryoconite, Tibetan Plateau

【A0213】-Poster

Air-transported contaminant composition in peat soil at different distance from the objects of metallurgic industry

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Peat soil chemical composition at raised bogs is not linked with bedrock, and is greatly determined by the compounds income via atmospheric precipitation. A number of complex geochemical barriers are known for raised bogs (Glazovskaya 1988). Geochemical sorption and acid barriers contribute to the accumulation of trace elements in peat deposits, which affects their migration ability. This process is important for purification of peat water from pollution. It is especially relevant for industrial regions, with metallurgical production contributing greatly to the air pollution. A zone of technogeneuous anomaly eventually can appear around the industrial objects, causing a range of negative effects in ecosystems, i.e., chlorosis of plants, vegetation structure transformation etc. (Gruzdev



2020).

Main goal of this research is investigation of factors that determine pollution rate of peat soil by air-transported contaminants over an area adjacent to metallurgical industry.

The objects of the study are three bog sites in the Vologda region, located in the north of the East European Plain. The “Bolshoy Mokh” peatland is located 65 kilometers south of the metallurgical complex and is suggested as a geochemical near-background reference for the research. This site is part of the Darwin Natural Biosphere Reserve. Two other peatlands (“Solntseвка” and “Pustynskoye”) are located 10 kilometers from the metallurgical industry. Peat deposits with a depth of at least 50 cm were collected at each site, including the central and regional ones. Samples were taken every 5 cm and the top layer consisted of living plants.

Composition of total and acid-soluble forms of Fe, Ca, S, Mn, Cr, Ni, Zn, Cd, Al was measured using inductively coupled plasma optical emission spectroscopy (ICP-OES). Highest values of Fe (172533 ppm), Mn (3297 ppm) and Zn (294 ppm) were obtained for the samples from “Pustynskoye”. These numbers are 64, 8.3 and 6.2 higher than maximum concentration values for the same elements from “Bolshoy Mokh”. The coefficient of technogeneous transformation for the studied elements increases in the order $\text{Fe} > \text{Mn} > \text{Zn} = \text{Cr} > \text{Ca} > \text{Al} > \text{Ni} > \text{S} > \text{Cd}$.

Concentration variation between spots within a peatland site was investigated. Difference in Fe, Ca, Mn and Ni content was proved to be statistically significant ($\alpha < 0,05$) for the central and edge spots of peatlands under industrial impact, while for the near-background site such difference was observed only for Fe and Al.

For the “Bolshoy Mokh” sections, Mn, Cr, Zn and Ni concentration values tend to decrease with depth, while Fe, S, Al and Ni opposite increasing trend with depth. At the “Solntseвка” site, content of elements for Cr, S, Al and Ni a notable rise of concentration (2-4 times) was denoted in the middle layer (depth 20-30 cm) at the central spot. Unequal vertical distribution of elements is likely to be conditioned by the difference of elements’ biological uptake and sorption, in particular within the layers of higher peat decomposition state.



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Keywords: Peat, Soil contamination, Air pollutants

【A0211】 -Oral

Significant change in atmospheric oxidation capacity driven by warming and wetting over Tibetan Plateau

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Under the context of climate change, the Tibetan Plateau (TP) has experienced a significant warm-wet trend in recent decades, potentially impacting atmospheric oxidizing capacity (AOC), which regulates the removal rates of pollutants and greenhouse gases (GHG) like methane (CH₄). While past research has focused on the TP's hydrological and ecological systems, the effects on AOC remain largely unknown. Here, we use nitrate isotopic records ($\delta^{15}\text{N}$, $\delta^{18}\text{O}$, $\Delta^{17}\text{O}$) in an ice core collected in Anemaqen (34.798°N, 99.463°E, 6200 m.a.s.l.) and GEOS-Chem simulations to investigate AOC changes over the past two decades (2002-2023). The synchronous rise in the records of Na⁺ and SO₄²⁻ deposition fluxes, aligned with lake expansion, suggests an accelerated internal hydrological cycle over the study period. Through nitrate isotopes and numerical simulation analysis, we find an increase in hydroxyl radical (OH) concentrations, driven by rising humidity and enhanced microbial NO_x emissions linked to warming and wetting trends. Our study reveals that climate-induced shifts in hydrology and microbial activity are reshaping the TP's AOC, with implications for atmospheric oxidation chemistry.



Keywords: Ice core records, Atmospheric oxidizing capacity, Warming and wetting, Nitrate isotopes

【A0831】 -Poster

The increasing anthropogenic sources in the 21st century recorded by Tibetan ice core

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Previous studies of ice core glaciochemistry on the Tibetan Plateau (TP) have discussed anthropogenic impact from South Asia and Central Asia. There was limited knowledge about the impacts of industrial and agricultural activities. Here, we have reconstructed the high-resolution glaciochemical records (Ca^{2+} , K^+ , Mg^{2+} , Na^+ , NH_4^+ , NO_3^- , SO_4^{2-} , and Cl^-) of the Bugyai kangri (BK) ice core retrieved from the south TP, covering 1950–2020, and used Positive Matrix Factorization (PMF) model to distinguish anthropogenic sources from natural sources. The lake sources indicated by Factor 1 and crustal sources indicated by Factor 2 in PMF model were decreasing. In contrast, the anthropogenic sources of NO_3^- and NH_4^+ by Factor 3 in PMF model were increasing, and the trend has exceeded the previous levels since the 21st century. This is attributed to enhanced emissions from industrial production and agricultural activities associated with the rapid growth of economic development in South Asia. This study improved the understanding about the influence mechanisms on increasing anthropogenic sources of glaciochemistry on the TP.

Keywords: Anthropogenic sources, Major soluble ions, Ice core, Tibetan Plateau

【A0618】 -Poster

Reconstructing stratospheric sulfur aerosol loading for extratropical volcanic eruptions: New insights from sulfur isotopes in Greenland ice cores

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Volcanic sulfate aerosols have a significant cooling effect on Earth's climate by reflecting incoming solar radiation, with their climate impact largely determined by the altitude of sulfur dioxide (SO₂) injection. While tropical volcanic eruptions are typically more effective at producing global cooling, extratropical eruptions can also have outsized climatic impacts¹. The current 'transfer function' used to scale sulfate deposition in polar ice cores to high-latitude stratospheric sulfur injection is solely based on model simulations of the Laki (1783-1784) and Katmai (1912) eruptions using the GISS-E model². However, significant variability has been observed in simulated sulfate deposition when using different aerosol models³, which highlights the need for empirical calibration to refine the model-based 'transfer function'.

Sulfur isotope measurements (d³⁴S and d³³S) have recently emerged as a powerful tool for constraining the fraction of stratospheric sulfate in ice cores¹. Specifically, stratospheric sulfur undergoes photochemical reactions when exposed to intense UV radiation, imparting a mass-independent fractionation (MIF) of sulfur isotopes. Here, we apply this technique to Greenland ice cores to quantify the stratospheric sulfur flux from the 1912 Katmai eruption. This provides, for the first time, an empirically derived 'transfer function' for Northern Hemisphere extratropical eruptions based on the most recent major high-latitude event. By comparing this newly developed 'transfer function' with existing and updated estimates from aerosol chemistry-climate models, we will assess whether current reconstructions of climate forcing from extratropical volcanic eruptions are appropriate, with implications for understanding the apparent greater sensitivity of climate to extratropical eruptions than tropical eruptions for a given stratospheric sulfur loading.

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Keywords: Volcanic forcing, Transfer function, Extratropical eruptions, Sulfur isotopes, Mass-independent fractionation



Session 15. Climate and environmental changes in permafrost regions: Paleoecological perspectives

Conveners: Olga Solomina, Elena Novenko, Xiaolin Hou, Yukun Fan, Natalia Kuzmenkova

【A0149】 -Poster

Quantitative pollen-based reconstructions of climate characteristics and forest coverage for the permafrost zone of central Siberia: Evaluation of different techniques

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The aim of this study was to provide quantitative pollen-based reconstructions of climate characteristics and forest coverage for the poorly investigated region of northern Central Siberia. The training set consists of 246 pollen assemblages from tundra, forest-tundra and taiga biomes. 144 pollen spectra were derived from the Eurasian Modern Pollen Database-2 and 102 were collected from different areas in the study region.

We developed regional calibration models for mean January temperature (T_{Jan} , °C), mean July temperature (T_{Jul} , °C), mean annual temperature (T_{ann} , °C), mean annual precipitation (P_{ann} , mm) and forest coverage in radii of 50, 20, 10, and 5 km from sampling plots. The performance of Modern Analogue Technique (MAT), weighted averaging (WA), partial least squares (WAPLS), and Random Forest (RF) were cross-validated, and the best model parameters were chosen. The results show that MAT calibration provided the highest R^2 (0.79-0.88 for forest coverage and 0.90-0.94 for climatic characteristics); RF performance is somewhat lower (0.65-0.75 for woody cover and 0.61-0.84 for climate), and WA and WAPLS performed considerably poorer, with R^2 ranging from 0.25 to 0.35 for woody cover and 0.29-0.52 for climatic characteristics. Despite MAT providing the best performance, we argue that our training set is prone to spatial autocorrelation, and therefore MAT calibration is not reliable.



Applying the different techniques for reconstructing climate and forest cover using pollen data from the peat core of the Nizhnyaya Tunguska mire (Tura area, Krasnoyarsk Krai, Russia; 64.167884N, 100.533927E), accumulated over the last 110 years, only RF showed statistically significant results for T_{ann} , P_{ann} and forest coverage. Comparison of the climatic reconstruction using RF models with the instrumental record from the Tura weather station for 1928-2019 showed poor correlation for both sets; the Welch bootstrap t-test (9999 cycles) characterized instrumentally measured and fitted by model P_{ann} values as having similar means ($p = 0.02$). Despite these findings, the reconstructed values are visually very similar to the instrumental record, with the same trends and low residuals, except for the annual temperature increase since 1990. The models of forest coverage simulation demonstrated the lower fitted values compared to modern woody area. However, the models showed deforestation trends in 1950-1970 and 2010-2019 that correspond to the peak of anthropogenic activity and intensive forest fires in the region.

The study was supported by grant of the Ministry of Science and Higher Education of Russian Federation (agreement № 075-15-2024-554 of 24.04.2024).

Keywords: Training set, Random Forest, Transfer functions

【A0368】 -Poster

Changes in the structure of atmospheric precipitation in NUUK (SW Greenland) from the late 19th to early 21st centuries

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Precipitation is key to characterizing climatic conditions. Variability in amounts and structure of precipitation in the Arctic is increasingly important, especially in the recent global warming (Przybylak 2016). This is related to the influence of precipitation on the mass balance of glaciers and the Greenland ice sheet. Cryospheric behaviour is extremely important to the evolution of the global climate system.

The analysis is based on daily precipitation sums at Nuuk station (SW Greenland) for the late 19th to early 21st centuries. Due to large data gaps, 15 years' worth of data (sometimes discontinuous) from four subperiods were selected for comparative analysis: A: 1875–83, 1886–91 (initial precipitation observations in Nuuk; Little Ice Age), B: 1925–27, 1929–32, 1934, 1936–1942 (the Early Twentieth-Century Warming); C) 1970–84 (transition from cooling to contemporary warming); and D: 2000–14 (major contemporary warming).

Daily precipitation totals from periods A and B were digitised from Danish meteorological yearbooks (*Meteorologisk Aarbog*). Precipitation for periods C and D was obtained from the Danish Meteorological Institute database. Daily precipitation totals were used to calculate monthly, seasonal and annual totals. Daily precipitation intensity was analysed using the Olechnowicz-Bobrowska classification (1970): very light 0.1–1.0 mm, light 1.1–5.0 mm, moderate 5.1–10.0 mm, moderately heavy 10.1–20.0 mm, heavy 20.1–30.0 mm, very heavy >30.0 mm. Seasons were also analysed: spring (March–May), summer (June–August), autumn (September–October), winter (December–February). Particular attention was paid to extreme precipitation and its causes by analysing the synoptic situation for selected days using the 20th Century Reanalysis (https://psl.noaa.gov/data/20thC_Rean/).

Precipitation in Nuuk is highly temporally variable. Annual precipitation totals can differ by up to 600 mm, year-on-year. In the studied periods, precipitation was highest (>1000 mm) in 1983, 2000, 2001, 2005 and 2013 and lowest (<400 mm) in 1882, 1927, 1930 and 1931. The driest years occurred in period B and the wettest in period D, when average annual totals were 517.5 and 900.9 mm, respectively. In the annual cycle, in the 60-year period, average totals were lowest (37.7 mm) in January and highest (96.9 mm) in September.

In Nuuk, over the 60-year period, no precipitation was recorded on ~60% of days. On



precipitation days, intensity was most commonly light (38.3%) or very light (33.7%). The share of days of specific precipitation intensities in the total annual number of precipitation days continued to decline with increasing precipitation intensity (i.e., 14.5%, 9.0%, 2.8% and 1.7%, respectively, for moderate, moderately heavy, heavy and very heavy). The structure of precipitation differed among periods. Very light precipitation was most frequent (37.9%) in period A, while, e.g., very heavy precipitation occurred most frequently (2.6%) in period B.

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Keywords: Precipitation, Climate change, Greenland, Nuuk

【A0539】 -Oral

Long-Term evolution of Yakutian Lakes: Climate-Driven changes in permafrost-associated ecosystems since the last glacial maximum

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Arctic and subarctic warming rapidly transforms freshwater ecosystems, including lakes in the Republic of Sakha (Yakutia), vital to local communities. In Yakutia, thermokarst and alaa lakes—formed in permafrost—hold ecological, cultural, and environmental



importance. Yet, their long-term development and response to climate change remain poorly understood. This research investigates the temporal evolution of two different Yakutian lakes (Lake Satagay and Lake Khamra), since the Last Glacial Maximum, highlighting lake development and its relationship to vegetation changes using a multi-proxy approach. Sediment cores were analyzed to reconstruct past aquatic and terrestrial ecosystems, combining metabarcoding of diatoms and plants from sedimentary ancient DNA (*sedaDNA*) with microscopic analyses of diatoms and pollen, biogeochemistry, and XRF profiles. Key findings at Lake Satagay indicate that thermokarst lake development included three stages since the Early Holocene, each corresponding with an associated diatom and macrophyte community. An extended shallowing stage may suggest the addition of a previously unrecognized stage in an *alaas* lake evolution. Paleoenvironmental analyses further provide insights into how vegetation dynamics and ecological changes shaped the lake deepening and shallowing displayed by the compositional turnover of diatoms from epiphytic to planktonic in the Early-Holocene and back from planktonic to epiphytic in the Mid-Holocene. In contrast, Lake Khamra showcases a stable intermontane lake unaffected by thermokarst processes, but rather its large catchment which impacts changes in lake depth. By examining changes in terrestrial and aquatic ecosystems, we can trace how climatic shifts, including periods of rapid warming and cooling, first affected conditions in southwestern Yakutia and then, a millennium later, Central Yakutia. This study highlights the importance of integrating aquatic and terrestrial records to advance understanding of paleoclimate, paleoecology, and the long-term dynamics of permafrost-associated lake systems in eastern Siberia, which is already affected by rapidly changing climate conditions.

Keywords: Lake sediments, SedaDNA, Permafrost, Thermokarst, Alaas

【A0338】 -Poster

Mysteries of the frozen peat bog in the northern taiga of Western Siberia

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Peat-lacustrine deposits of the frozen palsa bog located in the north of Western Siberia on the border of the northern taiga zone and forest-tundra near Nadym (65°18'56"N, 72°52'27"E) were studied using complex palaeoecological methods, including spore-pollen, diatom and NPP analysis, macrofossil analysis of peat, measurement of the degree of peat hummification, radiocarbon dating and two methods of quantitative paleoecological reconstructions (the biomization method and the information-statistical method of paleoclimate reconstruction). Studies have shown that these 1050 cm thick deposits have a complex genesis. Two possible hypotheses can be used to explain the obtained facts: the hypothesis of a long interruption in sedimentation in the period preceding the Holocene and the hypothesis of a warm and humid late glacial period in the north of Western Siberia. Based on the first hypothesis, the deposits of the Nadym section were formed both in the Holocene and in much older interglacial period. At the same time, the absence of glacial deposits in the section was noted. The authors explained the latter by the hypothesis of glycioisostatic compensation, according to which during the Glacial period the studied area was elevated and ancient lake sediments underwent secondary diagenesis in subaerial conditions. Holocene lake sedimentation began around 10,000 cal yrs BP. However, these lake sediments were enriched with redeposited pollen and diatoms of Neogene age. Exclusively syngenetic sedimentation is confined only to peat-bog deposits aged 8000 cal yrs BP. For this time, the dynamics of vegetation cover and quantitative changes in paleoclimate were reconstructed using biomization methods and the information-statistical method of V.A. Klimanov based on palynological data. It was found that in most cases, periods of sharp decreases in average January and average July temperatures reconstructed from pollen data coincided with episodes of low solar activity. A conclusion was made about the decisive influence of solar activity on the formation of permafrost in the soils of the study area, to which the vegetation cover responded.

Keywords: Pollen, Western Siberia, Palsa bog, Climate, Sediments

【A0177】 -Oral

Reconstruction of landscape and climatic conditions of the last interglacial-glacial macrocycle in north-eastern Siberia based on palynological studies of mammoth fauna remains

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Palynological studies of sediments filling the bone remains of mammoth fauna animals provide a new source of paleoecological information.

Pollen analysis was carried out on samples of sediment extracted from the roots of a *Mammuthus primigenius* tooth found near the coast of the East Siberian Sea (ca. 70° N, 155° E), where modern vegetation is represented by grass-shrub and moss tundra with rare dwarf birches and willows. The composition of the pollen spectra shows that at the time of the animal's burial, this territory was covered with larch-birch forests with an undergrowth of shrubby alder, birch, willow and dwarf pine, wet meadows and swamps. Finds of pollen from aquatic plants and algae indicate sediment accumulation on the lake's margin. Analysis of modern ranges of fossil flora species shows that the mean July temperature was at least 8°C higher than today. Therefore, the time of the mammoth habitation corresponds to the Last Interglacial (MIS 5e).

Palynological studies of sediments filling the brain cavities of two skulls of cave lions (*Panthera spelaea*) and one skull of a woolly rhinoceros (*Coelodonta antiquitatis*) found in the middle reaches of the Indigirka River (ca. 68°30'N, 146°20'E) were also carried out. At present, the area is occupied by open larch forest. The northern tree line formed by *Larix dahurica* crosses the Indigirka River basin at 70°N.

The radiocarbon age of the cave lion skull F-4304 (>48,800 yr BP, IGAN-7601) is beyond the limits of the method. The pollen assemblage indicates the development of larch forests with shrub willow, birch and alder in the undergrowth, with a wide distribution of meadows and sedge-grass mires in the depressions. The abundance of microscopic fragments of coniferous wood in this sample suggests that the site is close to a larch copse. The high content of *Artemisia* pollen indicates the presence of cryoxerotic communities similar to the modern cold steppes of Yakutia. These features point to a more continental and drier climate with higher summer temperatures compared to the modern climate in MIS 3. The relatively high *Larix* pollen content and the presence of larch stomata in the woolly rhinoceros skull sample F-61 support the significant role of larch in the vegetation during MIS 3.



The skull of cave lion F-4302 has been radiocarbon dated to $20,130 \pm 60$ yr BP (IGAN-7599). The predominance of pollen from dwarf birch and other shrubs, rare finds of larch and tree birch pollen in the sediment filling this skull indicate vegetation similar to the southern tundra, but with a complex mosaic structure combining forest, shrub, tundra, meadow, mire, and cryoxerotic "tundra-steppe" communities. The greater proportion of the latter compared to MIS 3 can be explained by the greater continentality of the climate and the significant decrease in temperatures, especially in winter, due to lower sea levels and a greater width of exposed shelf during the Last Glacial Maximum.

Keywords: Pollen analysis, North-East Siberia, MIS 5e, MIS 3, LGM

【A1005】-Poster

Holocene swamp carbon burial in the southernmost high-latitude permafrost region in Northeast China: Processes and influencing factors

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The southernmost high-latitude permafrost region in Northeast China is scattered with numerous swamps, serving as an important buried carbon reservoir in terrestrial ecosystems, and is greatly threatened by permafrost degradation under global warming. Accurately quantifying the sedimental organic carbon accumulation rate (CAR), and exploring the influencing factors, can contribute to revealing the swamp carbon burial mechanism. Three swamp sedimentary profiles in Northeast China were selected to establish the temporal and spatial dynamics of CARs through empirical formulas. We show that the CARs of three swamp profiles were $1.68 \text{ g C m}^{-2} \text{ yr}^{-1}$ (HEIHE profile), $1.14 \text{ g C m}^{-2} \text{ yr}^{-1}$ (HUMA profile), and $7.80 \text{ g C m}^{-2} \text{ yr}^{-1}$ (TAHE profile), respectively. The HEIHE and HUMA profiles exhibited relatively high values of early and late Holocene CAR and were mainly influenced by sedimentation rate with prominent local factors regulated. Conversely, the TAHE profile exhibited a relatively high CAR in the middle to late Holocene, which was mainly controlled by organic carbon content and was well consistent with regional staged superior hydrothermal conditions and vigorous vegetation. We stress the dominant influences of climate and vegetation on the varied carbon burial dynamics in the wetland



system, while the local factors might lead to more heterogeneity. The diversity of wetlands conditions should be taken into account when estimating inland carbon stocks and predicting future carbon dynamics.

Keywords: Carbon accumulation rate, Sediments, Holocene, Climate change, Northern Northeast China

【A0588】 -Poster

Westerlies and Asian Summer Monsoon modulated the iodine sink in Tibetan Plateau recorded in Zoige peatland

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Wetlands and permafrost can store large amounts of iodine, making them major iodine reservoirs in terrestrial environments. Against the backdrop of global warming, the iodine storage capacity of these environments could have potential impacts on terrestrial atmospheric ozone depletion and cloud formation processes, thereby influencing the Earth's surface solar insolation balance. Understanding the sources and input mechanisms of iodine in wetlands and permafrost is thus crucial for assessing future changes in their iodine storage. Located in the interior of the continent, the Tibetan Plateau's vast high-altitude terrain creates a unique ecological environment. The extensive wetlands in the northeastern plateau serve as important archives for studying climate change. In this study, we analyzed the iodine content of Holocene peat deposits in the Zoige region of the northeastern plateau. The obtained records differ from the patterns of any other climatic proxy indicators. Through detailed comparisons and segmented analysis, we found that the iodine records during the early to mid-Holocene resemble changes in the intensity of the Asian Summer Monsoon, while those in the mid- to late Holocene align with variations in the strength of the westerlies. Moreover, the pattern is well-validated by events such as the 4.2 ka and 8.2 ka cold events, as well as other centennial-scale cooling events. This coupling feature aligns with the previously identified westerlies-monsoon interaction in the Qinghai Lake region. This finding further indicates that



atmospheric iodine deposition is the primary source of iodine in wetland environments. Iodine released into the atmosphere from large oceanic regions such as the North Atlantic, Indian Ocean, and Pacific Ocean likely contributes to iodine deposition in the special region of the northeastern plateau through long-distance transport via the westerlies and monsoon. This study not only provides scientific evidence for understanding iodine deposition and storage mechanisms in the unique environment of the Tibetan Plateau but also offers important insights into the large-scale geochemical cycling of iodine.

Keywords: Iodine, Peat, Tibetan Plateau, Holocene

【A0562】 -Poster

Environmental conditions in the Laptev Sea coastal region during the Last Interglacial based on the analysis of aquatic invertebrate communities

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Fossil cladoceran (Crustacea, Branchiopoda) and chironomid (Diptera, Insecta) records of lacustrine thermokarst deposits of the Krest-Yuryakh sequence (Marine Isotope Stage 5e, MIS5e; Last Interglacial, LIG) exposed at the southern coast of Bol'shoy Lyakhovsky Island and the Oyogos Yar coast along the Dmitry Laptev Strait (Arctic Russia) were investigated. The vegetation of the study area is currently represented by Arctic tundra. The mean air temperature of the warmest month of the year (MTWA) is 3.5 °C for Bol'shoy Lyakhovsky Island and 6.9 °C for Oyogos Yar. Age information of the Krest-Yuryakh lacustrine deposits is based on infrared-stimulated luminescence (IRSL) dating. The obtained ages range from 127.3±6.1 ka to 117.6±6.0 ka (Schirrmeister et al., in review). For the chironomid-based paleotemperature reconstruction, we inferred the TJuly (MWTa) by using a temperature inference model, based on a modern calibration data set of 193 lakes and 162 taxa from northern Russia (Nazarova et al., 2015). For the cladoceran-based reconstruction, we



applied a mutual climatic range (MCR) method (Buckland, 2007, 2014).

The studied fossil aquatic invertebrate remains of the Krest-Yuryakh deposits are exceptionally well preserved. The cladoceran assemblages are dominated by littoral shallow-water taxa, such as *Chydorus* cf. *sphaericus*, *Alona guttata* / *Coronatella rectangula*. The cladoceran records on Oyogos Yar are more diverse and have much higher concentrations. The reconstructed climatic conditions were more favorable for cladocerans on Oyogos Yar than on Bol'shoy Lyakhovsky. The cladoceran assemblages of Oyogos Yar indicate lacustrine habitats with well-developed vegetated littoral zones as well as pelagic open-water zones in the paleo-lakes. Discoveries of cladoceran taxa significantly north of their modern ranges allow the reconstruction of warmer climatic conditions during the LIG. Presumably, on Oyogos Yar the cladoceran-based MTWA is 11.4 °C; and thus at least ~4.5°C higher than today.

The semi-terrestrial *Limnophyes*, *Smittia* and the acidophilic *Psectrocladius sordidellus*-type dominated in the chironomid assemblage from Oyogos Yar. Phytophilic taxa indicative for temperate shallow lakes or littoral conditions are less abundant (*Cricotopus laricomalis*-type, *Tanytarsus pallidicornis*-type, *Endochoronomus albipennis*-type). The chironomid-based MTWA was also much warmer than today and varies between 9.4±1.7 and 15.3±1.5 °C on Bol'shoy Lyakhovsky Island and amounts to 12.9±0.9 °C on Oyogos Yar. Our results are supported by independent proxy-based temperature reconstructions such as plant macro-fossils, pollen and sedimentary DNA, as well as by climate modeling simulations (Schirrmeister et al., in review).

Keywords: Cladocera, Paleotemperature, Chironomids, MIS5e, LIG

【A0527】 -Oral

Holocene wildfire dynamics and their drivers in Central Yakutia, Siberia: A regional composite of paleofire data based on charcoal in lake sediments

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The Republic of Sakha (Yakutia), the coldest permanently inhabited region on Earth, is characterized by unique ecological relationships between larch forest, permafrost, and wildfires. Together, they can stabilize each other, preserving the larch-dominated biome. Abundant thermokarst lakes have important cultural and subsistence-related functions and are dynamically connected to warming permafrost processes, sometimes also initiated by wildfires. Recently intensified wildfire seasons, however, raised questions regarding the causes and impacts of fire regime changes. Despite recent progress, eastern Siberia is still sparsely covered by reconstructions of long-term fire history. This limits an evaluation of past drivers, both natural and anthropogenic, and impacts of fire regimes on centennial to millennial timescales.

Here, we present the first composite curve of biomass burning throughout the Holocene, based on a combination of eight new records of macroscopic charcoal from lake sediments and previously published data. The newly studied lakes are located in the Lena-Amga interfluvium of the Central Yakutian Lowlands, the southern Verkhoyansk Mountains, and the Oymyakon Highlands. We find high fire activity in the Early Holocene (c. 10,000 years BP), likely facilitated by a combination of warm climatic conditions and post-glacial shrub and open woodland vegetation. Fire activity decreases around 6000 years BP, fluctuating on a lower level until pre-industrial times. Simulations of forest development and climate-driven fire disturbance independently reproduce reconstructed trends in the Early to Mid-Holocene, but fail to do so during the Late Holocene. This may indicate that fire regimes during that period were not driven by climatic changes or shifts of vegetation. Instead, a potential explanation could be the initial settlement of the Sakha people around 800 years ago, introducing a semi-sedentary, pastoralist culture based on horse and cattle breeding, which also included cultural burning practices. The new data shows the potential of comparisons between paleoecological and modeling data, while highlighting the need to understand the human component of past fire regime changes in eastern Siberia.

Keywords: Wildfire, Siberia, Boreal, Charcoal, Yakutia



【A0519】 -Oral

Towards the reconstruction of Arctic coastal landscapes dynamics in Pechora and Kara seas during Holocene

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Tidal marsh deposits are important place for carbon stock and also natural archives that are able to provide evidences on landscape dynamics, sea level and climate changes in the past (Engelhart and Horton, 2012; Shennan, 1989; Vink et al., 2007). We studied the composition of deposits of the marshes in two Arctic sites, the Kuznetsk Bay of the Pechora Sea and the Baydaratskaya Bay of the Kara Sea.

Peat deposits at the Kuznetsk Bay had low overall thickness. Moreover, organic interlayers were detected in the bottom sediments of the bay at a depth of 4 m below the modern level. This indicates that the sea level in the region was rising continuously during the Holocene. Thus, the absence of highstand in the mid-to-late Holocene indirectly confirms the presence of a sinking glacioisostatical forebulge, leading to a faster rise in the Pechora Sea level compared to the world average.

At the western coastal ledge of the Baydaratskaya Bay the peat deposits with a total thickness of 114 cm were extracted. Radiocarbon dating showed peat formation during 150 years (from 6857±35 to 7109±35 BP). This indicates favorable conditions for vegetation growth and peat accumulation during the period of the stable Arctic Ocean



level.

The data obtained contribute to understanding the paleogeographic conditions of the Holocene in the Arctic. Detailed analysis of other proxies will bring additional data for reconstruction of paleoclimate and landscape dynamics in the Arctic coastal area.

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Keywords: Arctic coastal dynamic, Carbon dating, Marsh deposits

【A0441】 -Poster

Lithological features of Lama Lake sediments (Russia)

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Lake Lama is one of the largest lakes in Krasnoyarsk Krai (Russia). The lake is of tectonic origin. It is situated in the northwestern part of the Putorana Plateau, bordered to the north by the slopes of the Mikchangda Mountains and to the south by the Lama Mountains, with predominant elevation of 500-800 meters. The lake itself lies at an altitude of 53 meters above sea level.



In 2024, researchers from Kazan Federal University extracted three sediment cores, with the longest measuring 33 cm. The samples have been sent to the Taiwan University for detailed age determination. However, according to Stefanie K. Harwart, average accumulation rate is 0.65 mm/year, in this case the age of studied core approximately 500 years.

Magnetic parameters of dry sediments (magnetic susceptibility and hysteresis parameters) were analyzed, and the chemical composition of the 33 cm core was determined.

Magnetic susceptibility (MS) was found to range from $3,99 \cdot 10^{-6}$ to $5,56 \cdot 10^{-6}$ kg/m³, with maximum values observed in the lower part of the core. The ferromagnetic component (k_{ferro}) was identified as the primary contributor to MS (up to $32,78 \cdot 10^{-5}$), while the paramagnetic component (k_{para}) and the superparamagnetic component (k_{super}) showed little contribution, with the former varying between $(1,27-1,34) \cdot 10^{-5}$ and the latter reaching the maximum value of $0,28 \cdot 10^{-5}$.

X-ray fluorescence analysis was performed to determine the chemical composition of Lake Lama sediments, providing data on major and minor oxides. The sediments were found to be enriched in Fe₂O₃, MnO and CaO compared to clay shales, while being depleted in Na₂O.

Statistical analysis was conducted using through multiple approaches. Factor analysis of the selected variables from the geochemical dataset identified two factors with significant loadings greater than 0,7. Factor 1, accounting for 26% of the total variance, displayed a bipolar structure, indicating an increase in LOI (Loss on Ignition) and a decrease in K₂O, CaO and ZrO₂ content. Factor 2 pointed to a decrease in TiO₂ and Fe₂O₃ content. The correlation matrix of the selected variables from the geochemical dataset and the paramagnetic component showed a positive correlation between k_{para} and CaO, and also revealed correlations among CaO, SiO₂, and TiO₂, reflecting the allothigenic nature of these elements. Spearman's rank correlation coefficient was also calculated to detect and describe statistical dependencies, further confirming the allothigenic nature of CaO, SiO₂, Cr₂O₃, and magnetic parameters.

Magnetic and geochemical studies of Lake Lama samples revealed that the cores collected approximately 1,5 km apart were generally similar in measured parameters, likely indicating comparable sedimentation conditions. However, core #2 exhibited a sharp



change in magnetic parameters at a depth of 25-33 cm.

Obtained data allow us to reconstruct the character of lake sedimentation and its relation to climatic changes over the last centuries.

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Keywords: Magnetic studies, Geochemical composition, Statistical analysis, Climatic changes

【A0694】 -Poster

Features of distribution and forms of presence some metals in the bottom sediments of lakes with different anthropogenic load

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One of the most important problems of our time is the rational use and protection of water resources, and solving this problem is impossible without a multidimensional study of water bodies (Kükrer S et al., 2014). The assessment of permissible anthropogenic impact on water bodies includes not only the determination of concentrations and forms of toxic elements in the water column but also the content of pollutants in the bottom sediments of surface water bodies. The purpose of this study was to identify the patterns of distribution of some geochemical indicators (pH, calcination losses, C(Fe), C(Mn), etc.) according to the depth of the section of the bottom sediments of small lakes with different anthropogenic loads located in different climatic zones of Western Siberia (Maslennikova S et al., 2012).

A layer-by-layer granulometric analysis of the bottom sediments of several lakes was carried out. General geochemical indicators (pH, electrical conductivity, calcination losses



(CL)) were determined. The distribution of these indicators according to the depth of the bottom sediments makes it possible to identify several areas that differ in a number of geochemical indicators (Aleshina O et al., 2011). In most lakes, the CL reaches maximum values in the upper layers, and then the organic matter content gradually decreases. The content of iron and manganese in the samples is distributed extremely unevenly. In each fraction, several extremes can be determined, characterized by the maximum value of the content of the elements. The content of iron and manganese, determined in fractions of different sizes, was correlated with the gross content of these elements (XRF method).

The conducted studies made it possible to establish patterns and interrelations of geochemical indicators, to identify geochemical barriers characterized by extreme values of a number of indicators, as well as to suggest possible forms of finding elements in lake sediments.

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Keywords: Lakes, Bottom sediments, Layer-by-layer analysis, Western Siberia, Anthropogenic load



【A0771】 -Poster

Holocene and modern ice wedges at the southern limit of their distribution in the North-West Siberia

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Ice wedges are found in the north of the permafrost zone. However, local conditions vary by region. Holocene ice wedges occur near the surface, making them vulnerable to climate change. Thermal erosion and thermokarst typically develop as the active layer increases. They are greatly enhanced in areas where ice wedges exist. To foresee hazards to engineering infrastructure, it is vital to investigate the form and direction of ice wedge development, particularly near the southern limit of their distribution. Ice wedges store paleogeographic information, allowing us to reconstruct winter temperatures (Vasil'chuk, 1991).

In 2024, we conducted studies of ice wedges in two locations: in the Labytnangi town area on the Lower Ob River region (66°45.5' N, 66°24.5' E), near the southern limit of their distribution in northwestern Siberia, and in the Yary village area on the Baydarata Bay southern shore (68°51.5' N, 66°52' E). We analyzed the isotopic composition of ice and its cryostructure. The ice wedges width is up to 1 m, and their height exceeds 1 m. They are located at a depth of 0.6–0.9 m. The ice continues to grow in the Labytnagi area as we observed elementary veins in the active layer ($\delta^{18}\text{O} = -17.6\text{‰}$). The ice-wedge ice yielded average $\delta^{18}\text{O}$ values of $-17.9 \pm 0.3\text{‰}$ and $-18.5 \pm 0.5\text{‰}$ from two sampled ice wedges exposed crosswise in one outcrop. It is possible that the ice wedges formed during the freezing of peatbog after the Holocene Optimum. The ice wedges were exposed in a thermoerosional gully near the lakeshore. Congelation ice lies above and to the side of the ice wedges. It differs sharply in its isotopic signature and marks the processes of partial degradation and thawing. This indicates the input of a large amount of surface water, which has frozen and formed congelation ice. In the Yary village area, the ice wedges occur in the deposits of the laida (marsh) and the first marine terrace of 6-10 m high. The ice



wedges width is up to 0.4 m, their height exceeds 0.7 m, and they are located at a depth of 0.7 m. No signs of modern growth were found in either ice wedge, although they are located much further north than the ice wedge from the Labytnangi area. The ice wedge in the laida lies in peat deposits. The average $\delta^{18}\text{O}$ value of ice wedge is $-18.4 \pm 1.3\text{‰}$. The ice wedge in the first marine terrace lies under peat 0.7 m thick and interposes into high-ice gray sandy loams. The average $\delta^{18}\text{O}$ value of ice is $-17.4 \pm 0.4\text{‰}$.

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Keywords: Ice wedges, Holocene, Isotopic composition, West Siberia

【A0331】 -Poster

Genesis of massive ice beds and host sediments of the coastal plains of Western Siberia and Eastern Chukotka

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Although Eastern Chukotka and Western Siberia are located far from each other, they have some distinct similarities in permafrost phenomena. For example, in both regions, massive ice beds have been found in the Pleistocene sediments of marine terraces. Massive ice beds are ice bodies with a thickness from 0.5 m to several tens of meters and a length from 2-5 m to several kilometers. The genesis of massive ice beds is controversial and still the subject of ongoing scientific discussions. Some researchers consider them to be buried remains of Pleistocene glaciers. The other scientists suggest their intrasedimental origin, but associate them with meltwater from ice sheet glaciations. Still



other researchers consider them to be intrasedimental formations that formed during the freezing of marine or coastal-marine sediments. Determining the genesis of massive ice beds in the studied regions are necessary for verification their origin during the Pleistocene.

During the field investigation in 2016-2024, eight massive ice beds in the north of the Western Siberia (Amderma, Yary, Marre-Sale, Vas'kiny Dachi) and in Eastern Chukotka, near the Lavrentiya community were investigated. For analyzing massive ice beds cryolithological, geochemical (X-ray fluorescence analysis - XRF), oxygen isotopic, methane content in air inclusions and size of the ice crystals analyses were performed. We also compared the geochemical data of the mineral impurities in massive ice beds with covering and underlying sediments.

Methane analysis allowed us to determine the origin of the air inside the massive ice: if the methane concentration is low (1-5 ppmV), then the air inside the ice is from the atmosphere and the massive ice is a buried snowfield or glacier. Otherwise (methane concentration >100 ppmV), the massive ice probably has an intrasedimental genesis.

In Eastern Chukotka, the methane concentration in three massive ice beds is low (2-18 ppmV). This indicates their atmospheric origin. In one massive ice, the methane concentration is 432 ppmV. It is probably intrasedimental.

Geochemical analysis showed that in Marre-Sale, the massive ice beds occur in coastal marine sediments. On the Ural coast of the Baydaratskaya Bay (Yara), the massive ice beds are covered by fluvial and lacustrine sediments.

This study was supported by State Assignment project #121051100167-1 "Evolution, current state and forecast of the development of the Russian Arctic coastal zone".

Keywords: Massive ice, Pleistocene, West Siberia, East Chukotka, Methan

【A0750】-Poster

Quantitative reconstruction of permafrost and climatic conditions of the periglacial zone of Western Siberia in the late Quartery



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Complex paleogeographic studies of late Pleistocene periglacial cover deposits and paragenetically related relief within the Tobol-Ishim interfluve (540-570 n.lat.) made it possible to carry out a quantitative reconstruction of the permafrost and climatic conditions of their formation.

Integumentary loess deposits are represented mainly by clay sand and are characterized by a yellowish-brown color, the presence of carbonates, high hardness in the dry state, the presence of vertical individuals and are well distinguished by morphological, geological-stratigraphic, granulometric, lithochemical signs. At the base of the cover layer of sediments, there is often a buried network of small wedge-shaped cracks and veins (depth up to 0.5-1.5 m, width 5-15 cm) of paleocriogenic genesis, which are primary ground veins, pseudomorphoses along ice-soil veins and fragments of their polygonal networks (Alekseeva et al., 2022; Larin et al, 2020, 2024). They are developed on different elements of the ancient relief and sediments of very different composition, origin and age. Crack cavities are usually filled with fine-grained siltstone and silt sand of aeolian genesis, usually identical in color and composition of the lower part of the overlapping sediments.

In the course of further accumulation of the cover layer, cryoaride temperature-humidity conditions abruptly changed to more humid and moderate ones. The uppermost parts of the sections of the integumentary stratum, in contact with the day surface, were formed under more humid conditions, with greater exposure to weathering processes. The climatic conditions for the formation of cover deposits are noticeably reflected in their material composition. According to the morphoscopy of quartz grains, the ensemble of the cover layer is dominated by particles that have experienced transport in aeolian flows.

In the thicknesses of individual sections of the mane, 2-3-4 sharp cold snaps are recorded. Calculations show that during these periods the southern taiga was replaced by the middle, northern taiga, southern tundra and even the Arctic tundra, and the seasonal



permafrost was transformed into island, massively island and continuous permafrost. Thus, during the formation of periglacial integumentary deposits and the network of cracks and veins buried at their base, a significant role was played by aeolian-cryogenic factors.

Acknowledgements

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Keywords: Periglacial cover deposits, Reconstruction, Permafrost-climatic conditions, Morphoscopy, Geochemistry

【A0726】 -Poster

Geochemistry of buried peatlands of the Ishim-Irtysh interfluvium (Russia)

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Upper peatlands are currently actively used for the reconstruction of conditions during the period of their formation (Larina et al., 2013, 2014). Less often, buried peat strata are



used for these purposes. The problem of their origin and informativeness is debatable. This paper presents the results of a layer-by-layer chemical analysis of a section located in the lower part of the floodplain of the Barsuk River (Vikulovsky District, Tyumen Region, Russia), containing a buried peat deposit. Radiocarbon dating data indicate that the peat bog existed in the range from 7120 ± 60 l.p. (7940 ± 60 cal. years) to 3140 ± 50 l.p. (3350 ± 60 cal. years). The results of the distribution by section of general geochemical indicators, various forms of organic matter, as well as the gross content of some macro- and microelements are given; statistical processing of measurement results is carried out. Layer-by-layer chemical analysis of the section revealed some geochemical features of its composition and evolution.

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Keywords: Ishim region, Buried peatlands, Layer-by-layer analysis, Chemical composition, Radiocarbon age

【A0753】 -Poster

Hydrological response of the Kolyma River Basin to climate change in the XXI century



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The Kolyma River, the largest river with a basin entirely located within the continuous permafrost zone, has experienced significant changes in its hydrological regime due to contemporary climatic variations. This study investigates the river's response to past, ongoing, and projected climate changes using the physically-based hydrological model ECOMAG (ECOLOGical Model for Applied Geophysics).

From 1979 to 2013, the mean annual air temperature within the Kolyma River basin rose by 1.3°C, with substantial increases exceeding 2.5°C in spring and autumn months. Annual precipitation increased by 8.3%. These climatic shifts have led to notable hydrological changes, including a 5.2% rise in annual water flow near the Kolymskoe point (283 km from the river's mouth), an increase in summer-autumn runoff, and a reduction in the duration of winter low-flow periods.

The ECOMAG model, calibrated and validated for key sections of the Kolyma River and its tributaries (Bolshoy Anyuy and Yasachnaya rivers), demonstrated high accuracy in reproducing observed water discharges and intra-annual flow patterns. Sensitivity analysis of the water regime to changes in air temperature and precipitation revealed that a 5% increase in precipitation has a more pronounced impact on water discharge than a 1°C rise in temperature.

Future projections were conducted using an ensemble of global climate models under four Representative Concentration Pathway (RCP) scenarios. Numerical experiments for the periods 2020–2039, 2040–2059, 2060–2079, and 2080–2099 predict an increase in annual and summer-autumn runoff under all scenarios, along with changes in peak water discharges, spring flood volumes, and the duration of winter low-flow periods.

The study highlights the significant role of physically-based hydrological modeling in understanding and predicting hydrological processes in permafrost regions. By integrating detailed meteorological and geophysical data with ECOMAG, this research enables the



exploration of the mechanisms driving the Kolyma River's water regime changes.

Keywords: River runoff, Model of runoff formation, Kolyma, ECOMAG, Climate change

【A0980】 -Oral

Field-Scale distribution of permafrost in Northeast China

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Permafrost in Northeast China (NEC) has been consistently degrading over the past decades. While the large-scale distribution of permafrost in NEC is well understood, its field-scale distribution characteristics remain unclear. Using survey data from multiple highways, this study investigates the spatial stratification heterogeneity and distribution characteristics of permafrost at the field scale. It summarizes the relationships between key environmental variables and permafrost distribution and identifies the major contributing environmental factors in different regions. Based on these findings, an algorithm was developed to create an indicator that represents the relative distribution probability of permafrost. The indicator is simple in form and matches well with field survey results. This research can provide valuable references for local highway construction and environmental studies.

Keywords: Permafrost distribution, Northeast China, Field scale

【A0328】 -Poster

Surface pollen assemblages and their interpretation: A case study of the north-western Putorana Plateau (northern Central Siberia, Russia)

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Many palaeoecological studies rely on palynological data, making it essential to understand how surface pollen assemblages correlate with modern vegetation. These relationships are region-specific; however, the Putorana Plateau remains unexplored in this context. We present new data that contribute to palaeoecological reconstructions in this area.

The study area is located in the north-western Putorana Plateau, at the north of Central Siberia (Krasnoyarsk Krai, Russia). This region is characterized by Siberian subarctic climate and a continuous permafrost. *Betula*, *Picea*, and *Larix* forests prevail in this area, which are replaced by shrub and tundra communities with increasing altitude. During the fieldwork, samples were collected from 27 plant communities, including forests of varying stand composition and crown density, peatlands, shrub thickets, and tundra. Samples for pollen analysis were prepared following Moore et al. (1991).

Our results show that most of the pollen assemblages are dominated by arboreal pollen (80-90%, with a minimum of 55%), primarily from *Betula nana* and *B. alba*-type, *Alnus fruticosa* that can be abundant even in assemblages from sampling plots, where they are absent from the plant cover. Another tree pollen is represented by *Picea*, *Larix*, and *Pinus*. The amount of *Picea* pollen increases in sampling plots where this species is more abundant, while the pollen value of *Larix* is always underestimated. *Pinus*, which does not grow in this region, is likely transported by wind from distant regions. Moreover, the percentage of *Pinus* pollen increases in open areas. Non-arboreal pollen is represented by a variety of taxa, including Ericaceae, *Artemisia*, Asteraceae, Poaceae, *Thalictrum*, and others. Among spores, *Lycopodium annotinum* is particularly abundant (up to 60-80%). The composition of herb pollen and spores in assemblages is influenced by the local vegetation. Pollen spectra from peatlands tend to show a higher ratio of non-arboreal pollen (Ericaceae, Cyperaceae, etc). Although sampling plots in tundra have extremely sparse vegetation cover, their pollen assemblages are characterized by higher proportion of herbs and a greater diversity (e.g., *Apiaceae*, *Artemisia*, Asteraceae, *Brassicaceae*, *Caryophyllaceae*, *Papaveraceae*, *Poaceae*, *Rosaceae*, *Rumex*, *Saxifraga*).

The study was supported by grant of the Ministry of Science and Higher Education of Russian Federation (agreement № 075-15-2024-554 of 24.04.2024).

Keywords: Pollen analysis, Central Siberia, Subfossil spectra



【A0195】 -Oral
Effects of climate change and fire on the middle and late Holocene forest history of Yenisei Siberia

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The study presents the long-term forest history in the forest-tundra ecotone of the Low Yenisei River basin. The new pollen and macroscopic charcoal data were inferred from two peat cores taken from the perennial frost mound and thawed hollow in the peatland near the town of Igarka (Krasnoyarsk region, Russia). These high-resolution peat archives covering the last 6300 years provide a unique opportunity to investigate the mid- to late Holocene forest and fire history in this very remote and poorly documented area of Yenisei Siberia. Climate reconstructions are based on the application of the Best Modern Analog technique using pollen data.

Our findings suggest several phases of vegetation change between 6320 and 2700 cal yr BP, influenced by climatic fluctuations and fire occurrence. During the Holocene Thermal maximum and the periods of warming (6320 – 5360, 4465-4200 and 3600-2700 cal yr BP) the eastern margin of the West Siberian Lowland was occupied by middle taiga larch forests with a high proportion of *Abies sibirica*, *Picea obovata*, and *Pinus sibirica*. Climate warming caused a northward shift of the vegetation zone boundaries in the Yenisei Siberia. The area of distribution of *Abies sibirica* expanded by 200 km northward compared to its modern range. Fire frequencies and biomass burning increased during the warming periods. We suggest that the frequent fires may encourage the melting of the local permafrost, thereby enhancing tree growth and re-generation, and likely favouring the expansion of *Abies sibirica* and *Picea obovata* farther to the north.

Climate deterioration at 5400-5480, 5075-4940, 4670-4550 and 3860-3670 cal yr BP led



to a degradation of the dark coniferous forests in the study area. This was caused by the expansion of sparse larch-birch woodlands with an admixture of *Picea obovata* and *Pinus sibirica* and shrub communities dominated by *Betula nana* and *Alnus fruticosa*. The cooling of the climate was accompanied by a decrease in the frequency of fires.

The vegetation pattern of the region became close to the modern one at around 2700 cal. yr BP. Based on the comparison of modern environmental processes with periods of climate warming and increased fire activity in the past, we suggest a potential increase in suitable habitats for tree growth in Yenisei Siberia in the future, and further studies are needed to test this hypothesis.

The study was supported by grant of the Ministry of Science and Higher Education of Russian Federation (agreement № 075-15-2024-554 of 24.04.2024).

Keywords: Permafrost, Pollen, Larch forests, Holocene

【A0240】 -Oral

Microelement composition of the bottom sediment of lake Nizhnee Multinskoe (Altai Russia) as a basis for paleoclimatic reconstructions

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Bottom sediments in mountain lakes record both regional and global environmental changes. For freshwater high-mountain lakes of the Altai region, the main sources of bottom sediment material are terrigenous debris from the adjacent territory and organic material of allochthonous and autochthonous origin. Weather and climate changes affect the elemental composition of sediments depending on the ratio of the incoming material. Analysis of variations in the elemental composition along the core section of lake sediments can provide information on changes in key climatic parameters of the region over the past millennia with a high degree of detail. To create climatic reconstructions with high temporal resolution, the method of scanning X-ray fluorescence analysis using



synchrotron radiation (XRF-SR) was used, which allows obtaining continuous series of elemental composition along the core depth with the required spatial resolution.

The use of scanning μ XRF-SR for studying bottom sediment cores allows obtaining a detailed set of geochemical data for creating transfer functions that quantitatively link regional weather and climate parameters with the elemental composition of dated sediment layers and constructing paleoreconstructions with high time resolution.

The studies were supported by grant of the Ministry of Science and Higher Education of Russian Federation (agreement № 075-15-2024-554 of 24.04.2024).

Keywords: Lake sediments, XRF-SR, Temperature reconstructions

【A0142】 -Poster

Application of an incubation experiment as a method for assessing organic carbon decomposition rate on permafrost degradation in peat plateaus

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A laboratory experiment of peat artificial incubation was carried out to analyze the organic carbon sustainability of peat plateaus to decomposition. The mineralization rate of peat organic carbon and the CO₂ and CH₄ emissions were calculated under artificial aerobic and anaerobic conditions at a temperature of +4° C during the incubation for 1300 days in mixed peat samples of a hummocky bog taken from active (AL), transitional (TL) and permafrost (PL) layers. The $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isotopes and C/N, O/C, and H/C ratios were determined as indicators of changes in the decomposition rate of organic carbon. The study shows that by the 1300th day of the experiment under aerobic conditions, the total CO₂ production released per 1 g of carbon in the analyzed sample was 10.24–37.4 mg C C⁻¹ (on average 25.76 mg C C⁻¹), while under anaerobic conditions, – only 2.1–3.38 mgC C⁻¹ (average 3.15 mgC C⁻¹). CH₄ emission was detected only in the transition layer and in extremely small quantities.



The cumulative amount of CO₂ and CH₄ production in peat samples from thawed organic carbon during the main experiment (1300 days of incubation experiment) were used to calibrate a model of organic carbon decomposition and to simulate GHG formation from the thawed permafrost peat plateaus until 2100. Projections of CO₂ aerobically production for 80 years represent 6.31±0.47 % of initial permafrost carbon from the samples of key site. But under anaerobical conditions estimates are close and indicate insignificant amounts 0.30-1.90 % of carbon release over a period of 80 years.

The incubation experiment results support the hypothesis that peat plateaus are resilient, especially under anaerobic conditions, regardless of ongoing climate warming.

Funding for the study was provided by the RSF № 24-27-00056 “Vulnerability of permafrost peatlands as a result of the linear facilities construction on current climate warming in the Arctic: assessment of economic and irreversible natural risks”.

Keywords: Peat, Mineralization, Carbon, Dioxide, Methane

【A0496】 -Poster

Main indicators and features of Late Pleistocene-Holocene sediment accumulation in Sosednee glacial Lake, North-Eastern Siberia.

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Lake Sosedneye is located in the North-Eastern Siberia. The lake is 1,400 m long and 600 m wide. The max water depth reaches 13.4 m in the western part of the lake, while in the eastern part the average depth is 2-6 meters where 424 cm core was raised using a modified Livingstone piston sampler. Sosednee Lake was formed after a glacial retreat during the Late Pleistocene around 22,500 cal. BP. Lake sediments provide of record of cold, transitional and warm climate. Three units are distinguished in the lake sediments according to lithological features: unit 1 - olive-gray massive organic rich silt with a layer



of volcanic tephra dated to 8400 cal. year; unit 2 - unclearly layered brownish-gray silt; unit 3 - gray-grey laminated silts. According to the age model the boundary between units 1 and 2 coincides with the boundary of the Pleistocene and Holocene (11,700 cal. years), and the boundary between units 2 and 3 mark the boundary of marine isotope stages 1 and 2 (14,700 cal. years). The terrigenous clastic sedimentation dominated in the lake during the Late Pleistocene, as indicated by increased contents of the major elements. The low SiO_2 content and low $\text{SiO}_2/\text{TiO}_2$ ratio indicate the absence biogenic silica accumulation, which is confirmed visually in smear slides. The presence of ice in the central part of the lake impeded wind-induced water mixing and oxygen enrichment, creating anoxic conditions in the bottom waters and upper sediment layers that are favorable for the formation of iron sulfides including pyrite and magnetic single domain greigite and pyrrhotite. The high concentrations of sulfides are found at 6 levels and are distinguished by high values of magnetic susceptibility. The $\text{Fe}_2\text{O}_3/\text{MnO}$ and V/Cr ratios were used to determine the redox conditions. According to pollen data open landscapes with herbaceous vegetation dominated in the vicinity of the lake at that time. A noticeable climate warming began about 14,700 cal. years ago. It impacted the terrestrial and aquatic components of the natural environment. Intensive accumulation of biogenic silica and organic matter affected the rock magnetic and geochemical parameters of sediments, reducing the concentration of detrital clastic matter.

The transition from glacial to interglacial conditions is marked by increase in tree and shrubs pollen. Multiscale variations in biotic and abiotic proxies show unstable climate and sedimentation conditions during the Holocene. About 9000 years ago, forest vegetation was established around the lake area. The percentage of *Pinus s/g Haploxylon* increases noticeably in pollen spectra, and the *Larix* pollen spectrum becomes almost continuous. Sediments from upper part of the unit 2 show similar rock magnetic characteristics as glacial sediments. They were formed 12,900 – 11,700 cal. years ago, which corresponds to the Younger Dryas. This event in the North-East is practically not distinguished by spore-pollen data. Rock magnetic data can become a mark for this interval.

Keywords: Lake sediments, Holocene, Pleistocene, Magadan region, Paleoecology

【A0493】 -Poster

Carbon and nitrogen stable isotope ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) records in peat mosses



of the Central Siberia

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The ratios of stable carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotopes are commonly used in ecological research tracing physiological and biogeochemical processes. The climatic fluctuations occurred during the Holocene affected both the plant community composition of peatlands and stable isotope composition of plant species itself. Thus, in last decades, an analysis of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ recorded in peat deposits throughout the Northern hemisphere become a powerful tool for the paleoclimatic reconstructions of past hydrothermal conditions. Nevertheless, the natural variability of stable isotope composition of peat plants in Siberia, as an important prerequisite for adequate interpretation of paleoclimatic records, remains poorly described. Particularly, there are still scarce data on *Sphagnum* and *Hypnum* mosses, the key plant species of peatlands. The aim of our study was to fill this gap analyzing the spatial variation of isotopic composition of most abundant peat mosses and, thus, reveal their response to hydrothermal regimes on local and regional scale.

The study has been conducted in 8 sites within the latitudinal gradient of Central Siberia: middle taiga (60.3 and 60.8°N), northern taiga (64.3 and 65.8°N), forest–tundra ecotone (67.4 and 69.3°N) and tundra (72.5 and 73.5°N). Moss sampling was arranged in contrasting ecotopes of every peatland (i.e. mounds and hollows) and surrounding forests. In total, we analysed 20 species of *Sphagnum* and 12 species of feathermosses. The collected samples were subjected to elemental and stable isotope (C and N) analysis with TOC Macro cube (Elementar, Germany) connected to an Isoprime 100 IRMS (Isoprime Ltd., UK).

The bulk $\delta^{13}\text{C}$ values of *Sphagnum* mosses demonstrated significant variation among species and habitats: from -26.34‰ (e.g. *Sph. obtusum*) to -34.44‰ (e.g. *Sph. viride*). Despite species-specific variation, there were also site-specific effects: ^{13}C enrichment occurred due to the well-known "water film" effect, which appeared more pronounced



on mounds, and ^{13}C depletion primarily found in water-logged troughs likely due to absorption of dissolved lighter C originating from peat decomposition. Relative to *Sphagnum* spp., the major feathermoss species more abundant in forested areas have slightly lighter isotopic C composition (from -28.05‰ in *Aulacomnium turgidum* to -35.33‰ in *Brachythecium rivulare*), which is likely also driven by assimilation of isotopically lighter CO_2 originating from soil respiration. For both moss types we found an enrichment of their tissues by ^{13}C from southern to northern sites (0.2 and 0.4‰ for *Sphagnum* and feathermosses, respectively), suggesting a decreasing share of soil respiration in photoassimilated C in a colder environment. The $\delta^{15}\text{N}$ varies among *Sphagnum* and feathermoss species from -5.60 to $+3.38\text{‰}$ with the maximum values surprisingly occurred in both moss types in the region between 64 and 67°N , that might be an effect of changes in interactions with N_2 -fixing cyanobacteria, playing critical roles in terrestrial carbon and nitrogen cycling processes.

This study was supported by a grant of the Ministry of Science and Higher Education of Russian Federation (agreement No. 075-15-2024-554 of 24.04.2024).

Keywords: $\delta^{13}\text{C}$, $\delta^{15}\text{N}$, Peat, Mosses, Central Siberia

【A0569】-Poster

Climate change affecting sedimentary and fluvial processes in Arctic River deltas

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The present-day impact of climate change on the hydrological regime, sediment dynamics and fluvial processes in Arctic River deltas. There have been notable alterations in air and permafrost temperatures and solar radiation at the beginning of the 21st century. These changes have the potential to exacerbate new processes of thermal erosion and thermal denudation of permafrost riverbanks. It has been demonstrated that riverbank degradation driven by thermal processes, which are in turn related to increases in air and



permafrost temperatures, represents the primary factor responsible for the accumulation of sediment from deltas to the sea. In order to describe the warming rates of air temperature, solar radiation, precipitation and wind speed for the period of global warming that commenced in 1979, we have applied the ERA5-Land reanalysis data. In this research, innovative remote sensing methods were developed to model suspended sediment. Additionally, semi-automatic and manual methods were developed to explore channel change and the impact of climate change due to erosion of permafrost banks. The results contribute to our understanding of suspended sediment dynamics and channel changes from the largest Russian river deltas to the Arctic Ocean.

Keywords: River deltas, Remote sensing methods, Permafrost degradation, Sediment transport, Fluvial processes

【A0490】 -Poster

Climatic changes in stable isotope ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) records of palsa peat deposits in Central Siberia

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Palsa (permafrost bogs) occupy 14.6% of all wetlands in Russia and contain a huge carbon pool, which is vulnerable to climate change. At present, despite the availability of information on the properties of hummocky permafrost bogs, the theoretical and methodological aspects of the problem of their formation remain controversial. A comprehensive analysis of the genesis and current state of the soil-geocryological complex of palsa at different levels of their organization is needed - from the vegetation and soil cover to the molecular level, revealing the specifics of the structure and formation of organic matter in peat. In this regard, such geochemical properties of peat as elemental (organic carbon and nitrogen, their ratio) and stable isotopic composition, reflecting changes in vegetation and the degree of humification (transformation and mineralization) of plant residues, are widely used as indicators of climate change, including permafrost processes (i.e. degradation and aggradation). However, the stable isotope composition of



Siberian palsa remains poorly studied, which limits our understanding of their formation and further development. The aim of our study was to fill this gap analyzing the spatial variation of isotopic composition of palsa peat deposits developed in diverse climatic conditions in Central Siberia. The study has been conducted in three model territories located in Central Siberia: Igarka (67.4°N), Tura (64.3°N) and Vanavara (60.3°N). The results of elemental and isotopic analysis indicate that peat composition changes with depth due to several interrelated allogenic and autogenic factors: 1) climate-induced plant community changes and vegetation succession characterized by stable isotope fractionation patterns (e.g. bryophytes versus vascular plants), 2) climate influencing ^{13}C uptake during wet and dry periods, 3) nitrogen cycling disturbances causing ^{15}N enrichment or depletion, 4) organic matter decomposition and humification responsible for enrichment in heavier isotopes, and 5) permafrost-mediated processes such as cryoturbation altering the hydrothermal regime in the soil profile. The complexity of interactions of these factors is discussed to illustrate likely responses of permafrost-affected peatlands to climatic changes and fixed in their stable isotope ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) records of peat deposits.

This study was supported by a grant of the Ministry of Science and Higher Education of Russian Federation (agreement No. 075-15-2024-554 of 24.04.2024).

Keywords: Stable isotopes, $\delta^{13}\text{C}$, $\delta^{15}\text{N}$, Palsa, Peat, Central Siberia

【A0981】 -Poster

Study on the spatial heterogeneity and driving factors of geological disasters susceptibility in the permafrost regions of Northeast China

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Global climate change may accelerate the degradation of permafrost, thereby exacerbating the occurrence of geological disasters such as slope instability, landslides, debris flows, and ground subsidence in permafrost regions. This study focuses on the distribution characteristics of geological disasters in the permafrost regions of Northeast



China. By employing the information value method and logistic regression, it establishes a susceptibility evaluation system for geological disasters in permafrost regions, considering environmental, permafrost, and geological factors. Furthermore, the study analyzes the impacts of permafrost changes on the types and distribution of hazards. High-hazard zones for geological disasters are distributed in the permafrost degradation areas of the eastern Greater Khingan Mountains and the southeastern Lesser Khingan Mountains. Approximately 9.8% of the Lesser Khingan Mountains region falls into very high-hazard zones, with the main types of geological disasters being landslides and ground subsidence. Soil type and rainfall are the primary factors contributing to the spatial clustering and distribution differences of geological disasters in the Greater Khingan Mountains region. Atmospheric temperature and surface frost number (SFN) are the main influencing factors for the spatial distribution of geological disasters in the Lesser Khingan Mountains region. In this area, the geological disaster risk level shows a highly significant negative correlation with SFN. The research results can provide important scientific support for environmental protection and sustainable development in cold regions, as well as a theoretical foundation for formulating effective disaster prevention and mitigation measures.

Keywords: Permafrost degradation, Geological disaster susceptibility, Spatial heterogeneity, Driving factors, Cold region sustainability

【A0023】-Poster

Characteristics of tropical lowland peatlands (Mangrove Swamps) in South Asia

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Tropical peatlands occur mostly in coastal lowlands, and it can be considered as larger sinkers of carbon and important ecosystem services for water resources, bio-resources, and biodiversity. Tropical peatlands cover about 11% of the global peatland resource (441,025 km² in area) and the estimation value can be changed by including all histosols and shallow organic soils. However, tropical low-altitude coastal peatlands in South Asia



are poorly investigated yet. The objective of this ongoing study is to characterize tropical lowland peatlands (mangrove swamps) in South Asia. Accordingly, a database was developed to cover all available peat records in South Asia, including India, Sri Lanka, Bangladesh, Maldives, Nepal, and Bhutan. Results show that the area distribution and organic matter content are not high as Southeast Asian peat records. In addition, this study considered CHNS elemental data ($n > 1000$) to estimate organic matter burial, sources, and depositional environments of South Asian mangrove swamps. Geochemical proxies such as total organic carbon (TOC, range mainly 10–20% but enhance up to 40%), C/N ratio (mainly 15–20), and C/S ratio (mainly 5–1000) suggest the muck to very high ash peat, organic matter sources mainly from mangrove roots, and anoxic to oxic dominant depositional environments, respectively. Hydrology is a fundamental factor in the formation and function of tropical peatlands. Carbon loss through water (prominent fluvial activities) and carbon emission by microorganism degradation are the main factors in the loss of carbon content in South Asian mangrove peats. A lack of impermeable substrates such as clay is the main factor in draining surface water from mangrove swamps. In contrast, the author compared the distribution of *n*-alkanes in mangrove sediments and mid- to high-latitude peat bogs. The *n*-alkane distributions are rather similar in those environments. Consequently, constructive mixings of various terrestrial organic matter in the sedimentary succession are typically controlled by growth habitats of local environment conditions, though *n*-alkane compositions depend on intra- and inter-species variability. Tropical coastal peatlands in South Asia were predominantly developed during the middle to late Holocene (between 3,500 to 6,000 years BP) under the wet conditions generated after the stabilization and regression of middle Holocene sea-level highstands. Tropical mangrove swamps/peats in South Asia store abundant organic matter. However, recent anthropogenic activities enhance the emission of stored carbon as greenhouse gasses such as CH₄ and CO₂.

Keywords: Carbon accumulation, Groundwater level, Peatland disturbance, Database

【A0761】 -Poster

The palynospectra from surface sediments of different genesis from two small arctic islands within the Lena River Delta (East Siberia) - do they adequate to modern vegetation?

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The main goal of the study is to collect data on the composition of sub-recent spore-pollen spectra and to clarify the features of their formation in various facial environments of the islands Samoilovsky and Matvey-Aryta located within the Lena River delta, arctic East Siberia. We thicked to obtain a reliable actualistic basis for the interpretation of fossil pollen spectra and reconstructions (including numerical) of vegetation changes both in the Lena Delta and in its basin. The study in this hard-to-reach area was conducted for the first time. Data were obtained from peaty bottom sediments of thermokarst terrace hollows, silty bottom sediments of the small lake, sandy-detrital sediments of the towpath, peats of a high non-flooded terrace and a low laida.

The palynospectra of all the studied samples are dominated by pollen, which is transported by wind and water from remote taiga zone, mainly pollen of Siberian and Scots pine, birch, both tree and shrub; sporadically - spruce and alder. At the same time, the predominance of pollen from both polar and grey willow, as well as dwarf birch, shrub alder, sedges and grasses among the local components of the palynospectra allows us to conclude that subrecent palynospectra generally reflect the composition of modern phytobiocenoses of islands included in the typical tundra subzone. At present, the low floodplain bordering the vegetated beaches is inhabited by sparse horsetail-grass psammophyte plant communities turning into willow thickets while the middle floodplain, the largest area within the Island of Samoylovsky, is occupied by willow thickets with *Salix glauca*.

The lowest concentration of microfossils is characteristic of towpath deposits, the highest - in the peatlands of the high floodplain and laida. Testate amoebae *Assulina muscorum* were also found in abundance in the sediments of laida.

Keywords: Sub-recent spore-pollen spectra, Modern vegetation, Islands within the Lena River delta, East Siberia, Russian Arctic

【A0592】-Poster



Holocene environmental changes in the southern Barents Sea based on a ^{14}C dated palynological record from the Kola Trough

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We present a record of lithology, pollen, spores and aquatic palynomorphs in sediment core PL96-110 from the Kola Trough, southern Barents Sea. Based on seven AMS ^{14}C dates, obtained in Arizona AMS Laboratory (USA), the core represents a continuously deposited sedimentary record for the last ~11.8 cal. ka with approximately century-scale resolution.

Three sedimentary units identified in Core PL96-110 contain palynomorph assemblages assigned to 6 palynological zones (PZ).

Unit 3 (~11.8-11.1 cal. ka) is composed of diamict sediment with a fine-grained matrix and numerous coarse terrigenous debris characterizing proglacial environments. This sediment contains only rare reworked microfossils of mainly Mesozoic age (PZ-1; *Pinus*, *Picea*, *Ginkgo* sp., *Podocarpus unica*, Taxodiaceae/Cupressaceae, *Cycas glabra*, *Bennettites* spp., numerous spores of *Gleichenia* spp. and Polypodiaceae). The final deglaciation time is characterized by a gradual lightening of the $\delta^{18}\text{O}$ isotopic composition, a high proportion of the fraction > 63 μm and abundance of redeposited pollen and spores of pre-Quaternary age. The absence of younger microfossils indicates harsh environmental conditions with likely suppressed or degraded vegetation on land.

The lithological features of Unit 2 (~11.1–10.4 cal. ka), represented by clayey silts, and the characteristic palynospectra extracted from it indicate deposition under still cold and dry climatic conditions, likely representing distal glaciomarine environments. Pollen spectra are characterized by extremely low concentration of microfossils and a predominance of *Betula nana*-type pollen and *Sphagnum* spores (PZ-2). The fact that the group of aquatic palynomorphs is represented only by freshwater colonial algae of the genus *Pediastrum* indicates low salinity of the basin, probably due to significant meltwater runoff.



Soft sandy muds of Unit 1 (~10.4 cal. ka to present) accumulated under normal marine conditions. Palynological assemblages of this unit are grouped into four successive, distinctly different PZs (PZ-3-PZ-6). Overall, these assemblages reflect the succession of the costal vegetation cover under an increasing temperature and moisture supply.

According to lithology, the time span of 7.1-4.5 cal. ka is the period of activation of currents, which is presumably associated with an increase in the influx of Atlantic waters. In the spore-pollen spectra of PZ-5, which characterizes this time span, In addition to the largest amount of damaged and torn pollen of *Pinus silvestris* and an abundance of Polypodiaceae spores and *Picea* pollen, probably brought into the sediment by water, the spectra contain up to 6% of “exotic” pollen of broad-leaved plants (*Quercus*, *Ulmus*, *Corylus*, *Carpinus* and *Tilia*), probably produced by mixed broad-leaved forests of Western Europe. Along with this, the increase in the proportion of the autotrophic species *Operculodinium centrocarpum* among the cysts of marine dinoflagellates and the presence of single *Spiniferites elongatus* and *S. ramosus* may also reflect increased influx of transformed Atlantic waters into the Barents Sea. Over the adjacent land, tundra communities were at this time displaced by sparsely forested birch communities («birch time») with a significant admixture of spruce and pine.

Keywords: Sedimentary unit, Pollen, Spores, Aquatic palynomorphs, Holocene, Kola Trough

【A0033】 -Oral

Constraining the little ice age moraines in the Western Himalayas

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In Himalayan glacier chronology, it is generally believed that moraines located within two



kilometers of contemporary glaciers belong to the Little Ice Age. This understanding is primarily based on relative dating and comparisons with the timing and patterns of glacier advances observed in Europe from 1300 to 1850. However, we present findings from the Lahaul, Zaskar, and Kargil Himalayas that suggest these moraines are significantly older than previously thought. Using Cosmogenic Radionuclide (^{10}Be) dating of rock samples from several glaciers, including Bara Shigri (29 km) in Lahaul Himalaya, Drangdrung (12 km) and Padum (4 km) in Zaskar Himalaya, and Parkachik (8 km) in Kargil Himalaya, our study indicates that the ages of these moraines range from 6 to 70 Ka years ago. Large glaciers, such as Bara Shigri from Indian Summer Monsoon dominated regions of Lahaul Himalaya suggest that these moraines formed between 11.6 Ka to 12.3 Ka years ago. Similarly, medium-sized glaciers like Drangdrung and Parkachik from Westerlies dominated precipitation regime show ages between 6.6 -18.7 Ka and 13.8-17.1 Ka, respectively and constrain these moraines to the Younger Dryas Stage in Europe. However, the Padum glacier in Zaskar Himalaya returned much older dates, ranging from 41.3-74.4 Ka years ago, suggesting these moraines parallel to the Batal Stage in the Lahaul and Zaskar Himalayas, a stage corresponding to Marine Isotope Stage 4. The substantial variations in the ages of these moraines can be attributed to several factors, including glacier size, topography, landscape preservation, and the dominant precipitation mechanisms in the region. This study refutes the relative association of these moraines with the Little Ice Age and advocates for further geochronological investigations across the area to more accurately define the Little Ice Age moraines in the Himalayas.

Keywords: Cosmogenic radio nuclide, Little ice age, Himalaya, Indian Summer Monsoon

【A0749】-Poster

Traces of ancient permafrost of the upper Angara region: The Late Paleolithic site malta-most 3

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In 2020–2021, conservation and rescue archaeological work was carried out at the Malta-



Most 3 site under the leadership of G.V. Turkin and A.S. Kozyrev. This site is located on the right bank of the Belaya River in the Usolsky district of the Irkutsk region. The Malta-Most 3 site belongs to the group of Upper Paleolithic sites of the Maltese type, the first of which, the Malta site, was studied for the last 90 years.

We have studied five Late Pleistocene–Early Holocene sections that form the terrace-like surface of the Belaya River at an altitude of 436–441 meters. In these sections, the thickness of water-sedimentary and subaerial sediments (aeolias) separated by several buried soils has been revealed. Various traces of relict cryogenic processes are widespread in them: cryoturbations and frost fissures structures (soil wedges of primary infilling and epigenetic wedges, small wedge-shaped cracks with vertical extent, sand wedges and sand veins) of several generations. The intensity of cryogenic disruptions varies from the bottom to the top of the section, indicating an apparently progressive formation in the layers containing the cultural finds. Traces of relict cryogenesis in the distribution area of modern sporadic permafrost in the Upper Angara region represent a perspective source of paleogeographic and paleoclimatic data for reconstructing Late Paleolithic environmental conditions.

Radiocarbon dating, granulometric analysis and scanning electron microscopy (SEM) have provided data on the genesis and age of the studied sediments. Fractions of 0.315–0.125 mm and 0.5–0.63 mm were used to study the surface (SEM) of grains of sand, where traces of cryogenic destruction of quartz/potassium feldspar and traces of aeolian processing are most reliably manifested.

Consequently, it was determined that the visible part of the alluvial sediments of this terrace was found to be between 22600 to 17200 cal BP. From this, we can conclude that the formation of alluvium with buried soils and interlayers of subaerial sediments took about 5500 years. During this period, according to the traces of relict cryogenesis, only seasonal or sporadic permafrost spread was observed, while a strong cooling with the spread of permafrost and the formation of ice wedge polygons occurred somewhat later–17200 cal BP. Later (14100 cal BP), there was a marked deterioration of environmental conditions – climate cooling and aridisation is fixed by the formation of subaerial sediments (the cultural layer of Malta), where frost fissures structures originate.

Keywords: Late Neopleistocene, Quaternary sediments, Frost fissures structures,



Palaeoclimatic conditions

【A0789】 -Poster

Investigations of the morphology of deep scour holes in the Anadyr River within the depression of the glacier-dammed lake: First field results

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This study investigates the morphology and formation of deep scour holes (pits) in the Anadyr River, which can reach depths of up to 45 meters. These pits are located both in the main river channel and in floodplain tributaries. The recent fieldwork conducted in 2024 focused on 239 overdeepened pits, incorporating advanced methods such as echosounder depth measurements, ADCP for velocity and flow direction analysis, and soil and water sampling within the pits to examine sediment composition and hydrochemical properties.

Ice-Related Phenomena Hypothesis: The pits may have formed due to ice accumulation and the hydraulic action of under-ice flow, which causes erosion. Frazil ice accumulation beneath the ice cover could restrict the cross-sectional area of the channel, leading to increased flow velocities. This higher velocity may generate whirlpools and abrasion, eroding the riverbed and forming the pits. Similar features have been observed in the Mackenzie River Delta, where ice and the movement of ice masses under the ice cover were identified as key drivers of pit formation. Erosion of sediments from ancient thermokarst lake basins, combined with buried ice under the riverbed, may contribute to the overdeepening of these areas.

Methane Explosion Sinkholes Hypothesis: Some pits might have formed by methane explosion sinkholes. These explosions could be triggered by the release of methane from thawing permafrost or methane hydrate layers beneath the riverbed. The release of gas under pressure could cause the ground to collapse, forming sinkholes with near-vertical walls. This is supported by the regular, circular shapes of some pits, which are characteristic of sinkholes formed by explosive processes rather than gradual erosion.



Additionally, the presence of methane flux in the water column and the appearance of fresh pits with distinct morphology lend further support to this idea.

Geological and Hydrological Conditions Hypothesis: The pits could also be a result of the unique geological and hydrological conditions of the area. The region's depression, filled with fine-grained sediments (such as silt and clay), organic matter, and older lake sediments, might be prone to differential erosion. The presence of buried ice and variations in sediment properties could contribute to the formation of depressions that deepen over time into pits. The geological history of the area, influenced by past glaciations and interglacial periods, suggests that fluctuating water levels and seasonal changes in river discharge might lead to cyclical erosion, allowing the pits to form in response to changing hydrological conditions and variable sediment erodibility.

Although each of the proposed hypotheses presents a plausible explanation for the formation of the overdeepened pits, the study concludes that the precise cause is still uncertain. The pits' formation likely results from a combination of factors, including ice-related processes, methane explosion sinkholes, and the region's unique geological and hydrological conditions. The ongoing integration of field data into a hydrodynamic model will help further test these hypotheses and clarify the mechanisms responsible for the pits' formation.

The work is being carried out under the RSCF project 24-27-00149.

Keywords: Anadyr, River scour hole, Vortex zone, Gas blowout crater

【A0909】 -Poster

Reproduction and restoration of data on average annual soil surface temperature in the Yamal-Nenets Autonomous Okrug according to CMIP6 models

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This study examines the impact of climate change on the Arctic permafrost zone, focusing on trends such as permafrost degradation, which includes a reduction in the coverage area, an increase in depth and an in soil temperature. Only 6 models out of 46 CMIP6 models were selected for the study, namely: TaiESM1, BCC-ESM1, FGOALS-G3, HadGEM3-GC31-LL, GFDL-CM4, GISS-E2-1-G-CC, which meet the criteria for the quality of reproducing surface air temperature. In the island permafrost zone, under conditions of near-zero temperatures of permafrost rocks, the models on average satisfactorily reproduce the temperature of rocks at the surface and at depth in comparison with borehole data. The model that best reproduces these parameters and can be used to predict the soil temperature of the southern cryolithozone on the Yamal's meridian is: GFDL-CM4. By using the GFDL-CM4 climate model, this study addresses an important issue of data accuracy gaps in the Arctic region, especially in the Yamalo-Nenets Autonomous Okrug.

To address these gaps, a computational model is developed using statistical methods - regression and standard deviation analysis to reconstruct missing data. By integrating information from more than 40 boreholes and climate model projections, the study aims to improve the quality of the model's data and the accuracy of the analysis. The data used include monthly average soil temperatures at a depth of 1 meter from the GFDL-CM4 climate model, calculated up to 2014 using the SSP 2-4.5 scenario, which is chosen due to its practical indistinguishability from the calculated scenarios up to 2030-2040.

The following parameters were calculated during the study: reproducibility of the GFDL-CM4 model for the average monthly permafrost temperature values by the coordinates of the boreholes of urgent and one-time observations, correspondence of the well group cells by coordinates and the lowest RMSE, a set of correction factors for each month and year of measurements in boreholes of repeated measurements, the proportion of days in a month when the average monthly permafrost temperature was in the range between the difference and the sum of the average monthly value and the standard deviation.

Calculation of the proportion of days in a month when the average monthly permafrost temperature was in the range between the difference and the sum of the average monthly value and the standard deviation showed that some wells have a percentage of compliance with the range of more than 70% for 5 or more months of the year. Only one well shows a percentage of compliance with the range exceeding 68% for all 12 months in



2020. The longer the period of recording observation data, the higher the compliance with the above range.

This study makes it clear that addressing the gaps in the accuracy of climate data is essential to improving our understanding of permafrost dynamics and its implications for climate change. Using advanced statistical methods and integrating data from climate models and observational sources, this study aims to provide valuable insights into the complex interactions between climate change and permafrost in subpolar regions.

Keywords: CMIP6, Permafrost degradation, Soil temperature, Reproducing

【A0111】 -Oral

Vegetation succession driven by permafrost thawing in Semi-Arid Regions: Pollen evidence from Northeast China

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Permafrost plays a crucial role in maintaining forest ecosystems in semi-arid regions. It prevents water from penetrating deep into the ground, while its seasonal melting provides moisture critical for vegetation growth. Recent studies have documented significant vegetation changes in southern Siberia linked to permafrost thawing. However, the limited time span of these studies restricts our understanding of the long-term ecological impacts of permafrost degradation. The northern part of the Khing'an Range experienced significant permafrost thawing during the Late Glacial to Holocene transition, making it an ideal region for investigating the long-term effects of permafrost thawing on vegetation dynamics.



In this study, we analyze three Late Glacial pollen records from sites near the modern permafrost boundary. These sites are geographically close and share similar precipitation patterns but differ in temperature conditions. This allows us to isolate the effects of permafrost thawing on vegetation from the influence of precipitation. Using the Landscape Reconstruction Algorithm (LRA), we reconstructed the relative vegetation coverage for each site. Our results show that larch forest declined after the Younger Dryas, accompanied by an increase in steppe species. Furthermore, variations in birch appear to correspond to specific local temperature. These findings shed light on the responses of different vegetation types to historical permafrost thawing, and provide a valuable basis for predicting how vegetation in southern Siberia might respond to ongoing warming and permafrost degradation.

Keywords: Pollen-based vegetation reconstruction, Permafrost thawing, Younger Dryas, Northern Khing'an Range

【A0616】-Poster

Paleochannels as indicators of climate-induced changes in runoff in the Volga river basin (East European plain)

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On the floodplains of Northern hemisphere rivers, traces of ancient channels—known as paleochannels—are frequently discovered. These include oxbow lakes, meander scars and cirques, etc. Paleochannels vary in size and location within the floodplain, indicating their formation at different times. The Volga basin features notable examples of both large late Pleniglacial and small Holocene paleochannels (Panin et al., 1999). The characteristics of these paleochannels, specifically channel width and meander wavelength, correlate with the mean maximum flood discharge of the rivers that created them. This correlation enables a reconstruction of historical river runoff parameters based on paleochannel dimensions (Sidorchuk et al., 2021). By dating the channel alluvium from both the largest



and smallest paleochannels, we can establish the timelines of high and low river runoff epochs. This is particularly significant for the Volga basin, which serves as the primary water supplier to the Caspian sea, where the dynamics of the coastline were notably high in the past.

To investigate the traces of varying river runoff levels within the Volga basin river valleys, we utilized satellite images (Bing, ESRI, etc.) and the ALOS 3D digital elevation model. In areas with prominent paleochannels, channel width and meander wavelength were measured at several locations within both ancient and modern channels. Employing an enhanced methodology (see Sidorchuk et al., 2012; 2021), we reconstructed bankfull and mean annual discharges and subsequently calculated the paleorunoff depth for both large and small paleochannels. Based on this data, paleorunoff depth maps were created for both stages. Some of the identified paleochannels were drilled to collect channel facies samples from the paleochannel alluvium for radiocarbon dating.

Evidence of high river runoff primarily appears in the southern half of the Volga basin, whereas small paleochannels are predominantly found in the northern half. On average, large paleochannels are 2-3 times larger than modern channels, while small paleochannels are 1.5-2 times smaller. The reconstructed runoff for large paleochannels exceeds contemporary levels by approximately 1.7 times, whereas for small paleochannels, it is about 0.7 times. The compiled maps of the paleorunoff depth for both stages demonstrate that the overall spatial structure of paleorunoff aligns with the modern configuration, suggesting that the conditions for river runoff formation have remained stable over time.

The age of large paleochannels is estimated to be around 17-14.5 cal. kiloyears ago, indicating their formation during the late Pleniglacial and early Lateglacial periods. In contrast, small paleochannels are dated to approximately 7-3 cal. kiloyears ago, corresponding to the Holocene climatic optimum and Subboreal stage. Therefore, based on the hydraulic geometry of paleochannels, we can conclude that there was an epoch of high river runoff in the Volga basin during the late Pleniglacial, followed by a period of lower runoff in the middle of the Holocene.

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Keywords: Small oxbows, Macromeanders, Lateglacial, Holocene, Paleorunoff

【A0621】-Poster

Early-Middle Holocene environmental changes as recorded in the C-N ratio of the Lorino high-centered peatlands, eastern coast of Chukchi Peninsula

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Predictive climatic and geochemical scenarios for areas with permafrost require an understanding of global carbon (C) and nitrogen (N) cycles. The content of C and N, as well as the isotopic characteristics of these elements, are actively used in the study of peatlands to identify the degree and intensity of peat decomposition during the degradation of permafrost due to climate warming. The study of permafrost peatlands has allowed us to establish that their nitrogen content is significantly lower than that of thawed peatlands. This has been the basis for using nitrogen content as a marker for the existence of permafrost in peatlands. The aim of this study is to determine the time of peat accumulation, study the carbon and nitrogen content, and analyze variations in stable carbon and nitrogen isotopes in peat from a flat-sided polygonal peat bog located in the upper part of a remnant of the third marine terrace near the Lorino village on the eastern coast of Chukotka (65.30° N, 171.43° W). The peat is located in an area with continuous permafrost distribution. Ice wedges are deposited in the peat with a thickness



of 2–5 m, and radiocarbon dating (^{14}C) was obtained for peat samples containing ice wedges, ranging from 9.9 to 14.2 years ago (Vasil'chuk et al., 2025). Variations in the content of carbon (C) and nitrogen (N), as well as their isotopic ratios ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$), in peat show pronounced synchronicity. Four cycles are distinguished. The average C content in the entire peat is 19.8% and the average N content is 0.9%. The minimum values of $\delta^{13}\text{C}$ (-28.37%) and C (8.16%), as well as the maximum value of N (0.53%), were noted for the earliest cycle with the depth interval of 4.50-3.90 meters. The maximum $\delta^{15}\text{N}$ value of 2.57% was also recorded for this cycle. The second cycle is characterized by average C content of 16.4% and the N of 0.8% in the range 3.8-3.0 m, with average $\delta^{13}\text{C}$ value of -27.9% and $\delta^{15}\text{N}$ value of 1.8%. In the third cycle, the C content increases in the 2.9-2.1 m depth range, with an average of 24.9% C and 1.1% N. The average $\delta^{13}\text{C}$ value is -27.3%, and the $\delta^{15}\text{N}$ value is 1.5. The upper part of the peat bog, between 2.00 and 1.60 meters in depth, is characterized by an increase in carbon content. The average carbon content is 27.7%, with an average nitrogen content of 1.1%. The average C/N ratio is 30.4 and the $\delta^{13}\text{C}$ value is -27.3, while the $\delta^{15}\text{N}$ value is 1.5.

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Keywords: Holocene, Peat, Isotopes, Nitrogen, Carbon

【A0481】 -Oral

Paleoecological environmental changes in the polygonal peatlands near Novyi Port in the southeast Yamal Peninsula over the Holocene

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Polygonal peatlands are widespread on the Yamal Peninsula. We studied polygonal peatlands on the first and second lagoon-marine terraces in the shrubby tundra near the Novyi Port settlement on the southeastern Yamal Peninsula. We have measured the radiocarbon age of the two studied peatlands (4 and 8 ^{14}C conventional dates), organic carbon and nitrogen content, as well as the isotopic compositions of these elements. The chronology of peatland formation is established: it occurred during the Greenlandian and Northgrippian stages of the Holocene, between 8,840 and 7,050 cal BP on the second terrace and 9,820 to 7,670 cal BP on the first terrace. This means that the peatland on the first lagoon-marine terrace is slightly older than that on the second one. Inversions in the radiocarbon dating we obtained are due to repeated transitions of peat between thawing and freezing states. According to ^{14}C dating, the rate of peat accumulation ranged from 0.6 to 1.9 mm/year. Paleoecological environmental changes during the 8.2k global cooling are recorded mainly as a decrease in nitrogen mineralization due to low temperatures in the winter and transitional seasons, which is confirmed by the minimum $\delta^{15}\text{N}$ values (-0.01‰) and middle $\delta^{13}\text{C}$ values (-28.5‰), and it was practically not recorded for the summer season in the southern part of the Yamal Peninsula as indicated by denrochronological data. The boundary between the Greenlandian and Northgrippian stages, corresponding to the event 8.2k in the peat of the second terrace, is determined at a depth of 0.4 m, and in the peat in the first terrace at a depth of 0.7-0.8 m. On the second terrace, the average carbon content was 47.18%, nitrogen was 2.64%, and the first terrace had 44.14% and 1.51%. The increased carbon content (close to 50%) corresponds to periods of relatively rapid transition of peat to permafrost state. The boundary between the acrotelm and catotelm (mesotelm) in the peat on the second terrace is fixed by the transition to a practically stable state of the C/N values (about 20) at a depth of 0.2 m. The position of the mesothelm in the peat on the first terrace is determined on the basis of a decrease in the C/N values and a local peak of the $\delta^{15}\text{N}$ values in the range of 0.25-0.3 m. The depth of the active layer in the peatlands of Novyi Port as a result of global warming has exceeded the depth of the transition layer. This has led to the disappearance of the transition layer; therefore, the buffer function of the transition layer is not performed in the region.



This research was supported by the Russian Science Foundation (grant N 23-17-00082).

Keywords: Polygonal peatlands, Carbon, Nitrogen, 8.2k event, Holocene

【A1000】 -Oral

A vertical profile study of permafrost microbial community structure and metagenome in Arxan region, Greater Khingan Mountains

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Permafrost stores large amounts of organic carbon and serves as a habitat for microbial communities. Normally, microbes decompose organic carbon in permafrost, producing greenhouse gases such as carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) that are released into the atmosphere. However, as permafrost thaws, the microbial community composition changes. This may allow certain more adaptable microbes to thrive, potentially evolving more efficient mechanisms for breaking down organic carbon in the soil. Moreover, with the ongoing warming of the climate, permafrost thawing intensifies, leading to the release of large amounts of ancient organic carbon, which further accelerates the decomposition of organic carbon and the emission of greenhouse gases. However, current mechanistic studies lack sufficient evidence to fully support this process.

16S rDNA technology provides classification information on microbial communities, while metagenomics can reveal the functional characteristics and ecological roles of microorganisms. The combined use of these two technologies can track changes in microbial community structure over time and identify which microbial groups in permafrost are likely to become active in response to environmental changes. This approach offers insight into the role of permafrost microbes in the degradation of organic carbon. Therefore, we aim to use these methods to investigate the vertical differentiation of soil microbial structure and function in the Arxan area of the Greater Khingan Mountains (A typical permafrost distribution area). We expect to obtain data on the



distribution and functional characteristics of microbial communities in the permafrost vertical profile in this area, providing valuable evidence for the study of permafrost ecosystems.

Microbial communities in permafrost play a critical role in the degradation of organic carbon, and thawing permafrost will significantly alter this process, which in turn affects the global carbon cycle and greenhouse gas emissions. In the context of global warming, in-depth research into the relationship between microbial activity and organic carbon decomposition in permafrost is of great significance for predicting the dynamics of future climate change and the carbon cycle.

Keywords: Permafrost, Microorganism

【A0955】-Oral

Moisture shifts in permafrost regions of inland Northeast Asia controlled by westerlies during the last millennium

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Previous paleoenvironmental data synthesis indicates that arid central Asia (“westerlies Asia”) and mid-latitude East Asia (“monsoonal Asia”) show anti-phased moisture variations over the last millennium. However, there are very few records from inland Northeast Asia, which obscures the spatial extent of or the boundary between the two domains and hinders the assessment of climate change impacts and consequences across the region. Here, we present a multi-proxy record that combines peat properties, plant macrofossils, and isotopic ratios of *Sphagnum* moss cellulose from a unique precipitation-fed peatland in northern Northeast China to fill this critical data gap. The results show major centennial-scale moisture anomalies at this site, with drier and wetter conditions during the Medieval Warm Period and the Little Ice Age, respectively, which resemble the pattern of moisture changes in “westerlies Asia”. During the period of rapid anthropogenic warming, the site is much drier, with isotopic evidence for threshold-like summer desiccation of peat-forming *Sphagnum* mosses. We provide the long-term context and



identify the large-scale pattern of moisture variability in an inland region home to carbon-rich peatlands, forests, and permafrost soils, highlighting their potential vulnerability to future warming-enhanced drying and westerlies-transmitted expansion of Asian drylands.

Keywords: Northeast Asia, Peatland, Sphagnum, Paleoenvironmental reconstruction, Stable isotopes

【A0504】 -Oral

Climate-induced water table drawdown reduced carbon and nitrogen sequestration in a Kobresia-dominated peatland on the central Qinghai-Tibetan Plateau

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Peatlands on the Qinghai-Tibetan Plateau (QTP) represent one of the world's largest reservoirs of soil organic carbon (C) and nitrogen (N), yet their future stability under a changing climate remains uncertain. This study utilizes high-resolution multi-core records of C and N contents, stable isotopes, and infrared spectroscopy to reconstruct water table depths and their impacts on C and N accumulation and decomposition over the past 2.7 kyr in a slope peatland from central QTP. Our paleo records reveal that increased decomposition in the surface oxic layer has led to decreased C and N accumulation rates over the last millennium, primarily due to water table drawdown driven by climate warming and drying. Evidence from nearby records suggests that this trend of surface drying may be widespread across QTP peatlands. Despite this, QTP peatlands retain some of the highest 1-m C and N densities globally, with values of $54.1 \pm 18.9 \text{ kg C m}^{-2}$ and $3.2 \pm 1.5 \text{ kg N m}^{-2}$. These findings highlight the vulnerability of QTP peatlands' substantial C and N reservoirs and sequestration functions to continued water table declines in a warming and drying climate.



Keywords: Peatland, C&N sequestration, Climate change, Qinghai-Tibetan Plateau, Paleo ecohydrology

【A0520】-Poster

Chemical weathering throughout the Yarlung Zangbo river system on the Tibetan Plateau

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Chemical weathering has been considered to regulate the Earth's climate by removing CO₂ from the atmosphere over long timescales. However, whether the weathering-climate feedback can operate on shorter timescales remains controversial. Here, we investigate major and trace elements of both silt (<63 μm) and clay (<2 μm) fractions of surface sediments collected at high spatial resolution along the course of the Yarlung Zangbo river system on the Tibetan Plateau to study the sensitivity of silicate weathering intensity to climate. We isolate the true weathering signals by defining the $\delta\alpha^{Al}E$ indices and δCIA to quantify the elemental fractionation between the clay and silt fractions. The results show increasing trends in $\delta\alpha^{Al}Ca$, $\delta\alpha^{Al}Na$, $\delta\alpha^{Al}Sr$, and δCIA downstream (eastward) along the 1700-m-long river course of the Yarlung Zangbo. These findings reveal an increase in silicate weathering intensity in response to increasing temperature and precipitation from the interior to the eastern edge of the Tibetan Plateau. Combined with correlation analysis, we believe that temperature is the primary controlling factor of silicate weathering intensity on the Tibetan Plateau, whereas precipitation plays a secondary role. Our study shows that silicate weathering intensity can respond sensitively to temperature changes in a low-temperature environment on the Tibetan Plateau at the present-day timescale. It implies that the Tibetan Plateau, with abundance of highly reactive materials, inevitably holds great potential to buffer against the warming climate and elevated atmospheric CO₂ concentration exacerbated by human activities through enhancing chemical weathering.

Keywords: River sediments, Elemental geochemistry, Chemical weathering, Yarlung Zangbo river system, Tibetan Plateau



【A0989】-Poster

Simulation of spatiotemporal distribution and variation of 30m resolution permafrost in Northeast China from 2003 to 2021

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The high-resolution permafrost distribution maps have a closer relationship with engineering applications in cold regions because they are more relative to the real situation compared with the traditional permafrost zoning mapping. A particle swarm optimization algorithm was used to obtain the index with 30 m resolution and to characterize the distribution probability of permafrost at the field scale. The index consists of five environmental variables: slope position, slope, deviation from mean elevation, topographic diversity, and soil bulk density. The downscaling process of the surface frost number from a resolution of 1000 m to 30 m is achieved by using the spatial weight decomposition method and index n. We established the regression statistical relationship between the surface frost number after downscaling and the temperature at the freezing layer that is below the permafrost active layer base. We simulated permafrost temperature distribution maps with 30 m resolution in the four periods of 2003-2007, 2008-2012, 2013-2017 and 2018-2021. Direct and indirect verification shows that the permafrost temperature distribution maps after downscaling still have high reliability, with 83.2% of the residual controlled within the range of $\pm 1^{\circ}\text{C}$ and the consistency ranges from 83.17% to 96.47%, with the identification of permafrost sections in the highway engineering geological investigation reports of six highway projects. The maps are of fundamental importance for engineering planning and design, ecosystem management, and evaluation of the permafrost change in the future in Northeast China.

Keywords: Land surface temperature, Surface frost number, Permafrost temperature, Downscaling, Northeast China

【A0342】-Oral

Insights into the Holocene peatlands carbon dynamics based on high-



altitude and high-latitude peatland studies

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Peatlands store about 1/3 of the world's total soil organic carbon (OC), making them the most important terrestrial carbon reservoirs on Earth. Understanding the mechanisms of peatland carbon deposition in response to climate change is crucial for predicting peatland carbon fate in the future. Alpine peatlands are formed in high-altitude mountains and high-latitude plains with waterlogging conditions. Whether these peatland carbon reservoirs act similarly in the context of global warming is not clear. In this study, we provided peat sediment records from the Altay Mountains in Central Asia and Kondinsk Lake in New Siberia, Russia. We measured ¹⁴C, Total Organic Carbon (TOC), and carbon isotope ratios ($\delta^{13}\text{C}$) to establish the history of carbon accumulation and palaeoclimate change. Our findings reveal that the Holocene peatlands in the Altay Mountains experienced periods of high organic carbon accumulation rates (OCAR) between 10.5-8.4 and 4.0-2.0 kyr (one thousand years), with a decline during 8.4-4.0 kyr. While analyses of peat carbon deposition and decomposition, and the potential responses of organic carbon accumulation rate (OCAR) to climatic in Siberian peatlands are in progress. This will provide important scientific data for the sustainable carbon storage study in peatlands in the context of global warming.

Keywords: Holocene, Carbon dynamics, Peatlands, Central Asia, Western Siberia

【A0870】-Poster

Recent climate change has driven divergent hydrological shifts in high-latitude peatlands

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High-latitude peatlands are changing rapidly in response to climate change, including permafrost thaw. Here, we reconstruct hydrological conditions since the seventeenth century using testate amoeba data from 103 high-latitude peat archives. We show that 54% of the peatlands have been drying and 32% have been wetting over this period, illustrating the complex ecohydrological dynamics of high latitude peatlands and their highly uncertain responses to a warming climate.

Keywords: Peatlands, Testate amoebae, Permafrost, Hydrology

【A0889】 -Oral

Cyclic activity of Muztagh Ata glacier in the East Pamir and potential North Atlantic climate forcing during the mid-Holocene: Evidence from continuous glaciolacustrine sediment records

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Satellite observations reveal that, over the past 60 years, most glaciers on the Tibetan Plateau (TP) have been losing mass at accelerated rates, with the exception of glaciers in the Karakoram, West Kunlun, and East Pamir, where have shown balanced to slightly positive glacier budgets (known as the Karakoram Anomaly). Reconstructing long-term glacier fluctuations and their climatic drivers beyond the satellite era is crucial for fully understanding this regional disparity, and accurately predicting future glacier changes. However, glacier reconstructions on the TP are mainly based on moraine sequences, providing only discrete snapshots of glacier activities. Here, we construct a continuous high-resolution (annual to decadal) 7.5-thousand-year record of glacier activity for Muztagh Ata in the East Pamir, using glacial and environmental indicators (dry bulk density, magnetic susceptibility, grain size, elements, and total organic carbon) in alpine lake



sediments. Our results show a general contraction trend of the glacier extent over the past 7500 years, with the glacier extent exhibiting persistent 580- and 1000-1400-year cyclic oscillations. These oscillations generally follow the North Atlantic drift ice variations with approximately a 500-year delay. This delayed glacier response in the East Pamir to pronounced cyclic changes in North Atlantic climate suggests that recent Karakoram Anomaly is possibly the ongoing manifestation of the last Bond event.

Keywords: Glacier, Karakoram Anomaly, Lake sediment, Mid-Holocene

【A1012】 -Oral

Vegetation succession under permafrost degradation: A case study of Northeast China

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Northeast China is a region experiencing permafrost degradation and serves as a transitional zone for both climate and vegetation types. The complex water-thermal conditions and climate environment jointly influence vegetation changes. Current research on vegetation change mainly focuses on field surveys or the response of vegetation to climate change, with less emphasis on the relationship between vegetation succession and permafrost degradation. This study examines the spatiotemporal changes in permafrost stability in Northeast China from 2000 to 2024 and develops five vegetation type transition matrices. The study reveals the direction of vegetation succession in permafrost areas with different stability types and clarifies the spatiotemporal relationship between permafrost type transformation and vegetation evolution trends. It focuses on the geographic distribution and changing trends of the conversions between forest, shrubland, grassland, and sparse vegetation. Additionally, the kNDVI index is used to quantitatively assess vegetation change trends in typical change areas, summarizing the potential impacts of various environmental factors at different stages of vegetation succession and highlighting the varying intensities of permafrost changes.

Keywords: Permafrost degradation, Vegetation succession, Northeast China





Session 16. Emerging physical and geochemical proxies in sedimentary paleoclimate studies

Conveners: Nazik Ogretmen, Stergios Zarkogiannis, Sonal Khanolkar, Charlotte Prud'homme, Yama Dixit, Stephen Obrochta

【A0774】 -Poster

Powerful proxies of change: Deterministic rules of assembly guide the composition of diatom communities as observed in ancient Lake Towuti, Indonesia

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Diatoms are among the most powerful microfossils to use when analyzing deep sediment cores. Their capacity for long-term preservation and their classification as primary producers makes them strong tools for tracking major ecological changes. Many paleolimnological studies use diatoms as proxies for changes in primary production. Despite this, there is a gap in the identification of the drivers which guide the composition of diatom communities through geological time. Tracking diatom communities over long, geological time frames is essential in identifying whether deterministic or stochastic mechanisms are the primary drivers for diatom community assembly as this will determine the strength of diatoms as environmental indicators in sediment records. The fossil diatom record from ancient Lake Towuti, Indonesia (~1.2 My) shows two long-term periods of planktonic growths (i.e. planktonic maxima; ~40 kyr – 60 kyr in duration each), dominated by taxa of *Aulacoseira*, and separated by ~100 ky of absence and perturbations. We investigated whether the *Aulacoseira* assemblages of the two planktonic maxima were guided by deterministic or stochastic processes. In this study, we reconstructed the



Aulacoseira assemblages of each of the two planktonic maxima from two deep drilling cores, core 1F and 2A. We counted diatoms from sediment samples throughout the planktonic maxima for relative abundances and total cell densities. We used stratigraphically constrained hierarchical clustering analysis (CONISS) to identify zones within the sediment cores with similar diatom assemblages and used nonmetric multidimensional scaling (NMDS) to identify shifts in *Aulacoseira* composition over time.

Our results show that all planktonic maxima from both cores show similar shifts in community assembly, despite their separation of ~100 kyr, suggesting that deterministic processes strongly influence diatom community assembly. Our results show that earlier layers, which are also the lower sections of both planktonic maxima, were dominated by *A. sumatrana* (*A. sumatrensis* var. *rectangularis* (64.5%±26.7%) in the upper planktonic maxima of both cores and *A. sumatrensis* var. *elongata* 56.0%±14.7) in the lower planktonic maxima of both cores. The later and upper layers of each planktonic maxima were all dominated by *A. towutiensis* (67.9%±16.9). Our results from the CONISS and NMDS analyses confirm the shifts in the patterns of assemblage in both upper and lower planktonic layers. This repeated structure and progression in composition suggests that diatoms are sensitive to their environment; and since deterministic mechanisms strongly drive them, they signify the power of diatoms as indicators of small and long-term ecological and environmental changes.

Keywords: Ancient lakes, Microfossils, Diatoms, Fossils, Ecology

【A0277】 -Poster

Hyperspectral imaging and high-resolution biogenic sedimentary proxies of the mid-elevation lake Khorlaket (Western Caucasus)

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Hyperspectral imaging of sediment cores is an emerging analytical method capable of providing an array of high-resolution sedimentary proxies. The method is based on spectral signatures of different sedimentary components and accumulation processes.



Here, we investigate the potential of an industry-standard hyperspectral camera coupled with a custom developed software package to provide indirect data on past changes in sediment accumulation conditions of a mid-elevation lake in the Western Caucasus. We study the sediment core from Lake Khorlaket (43°29'36"N; 42°13'05"E, 2063 m a.s.l.) as our pilot study object for hyperspectral imaging basing on its varied lithological composition and thus diverse spectral properties.

The camera Specim FX10e works in visible and near infrared range (VNIR, 400-1000 nm); the spatial resolution is 229 $\mu\text{m}/\text{px}$ and mean spectral resolution is 5.5 nm. The specialized Matlab-based software package developed in the Laboratory of Environmental Paleoarchives of the Institute of Geography RAS allows for a range of tasks including calibration, automated core fragment stitching, crack removal and spectral analysis. The preprocessed raw data is a hyperspectral data cube with first two dimensions corresponding to length and width of the sediment core and a third spectral dimension of 448 bands; thus each image pixel is characterized by a 448-point spectral curve.

Variations of spectral properties of a sediment can manifest themselves as absorption features or sections with diminished reflectance in a spectral curve. In order to trace such features, we used a technique of wavelength correlation mapping. This approach vividly shows only one absorption feature around 670 nm wavelength that marks a characteristic distinction between organic-rich and organic-poor sections of the studied sediment core. This part of the spectrum corresponds to absorption of electromagnetic radiation by chlorophyll *a*, a pigment characteristic for all photosynthetic organisms. The abundance of chlorophyll *a* allows to connect its variations in the sediment with bulk organic matter.

We used different techniques (depth and area indices) with various spectral spans to calculate the chlorophyll *a* derived index. We argue that the selected spectral index $\text{RABD}_{660;670}$ (Rein and Sirocko, 2002) can be used as a high-resolution proxy for downcore variations of organic matter content in the sediment core. The results are supported by correlation and multivariate analyses with independent biogenic proxies – total organic carbon (TOC) and loss-on-ignition (LOI 550). Noteworthy is the concordance of the $\text{RABD}_{660;670}$ and XRF-derived concentration of bromine in the sediment that we previously used as a high-resolution biogenic marker in the Caucasus (Alexandrin et al., 2023). We argue that taking into consideration such issues as sedimentary matrix effect, the resultant curve provides a basis for reconstruction of lake productivity at the resolution of



around 1 year for Mid and Late Holocene.

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Keywords: Hyperspectral imaging, Lake sediments, High-resolution proxies, VNIR spectroscopy, Caucasus

【A0242】-Poster

Cautionary tales in paleoproductivity reconstruction: A case study from the Bay of Bengal

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By comparing the paleoproductivity proxies from the Bay of Bengal, we infer that constraining productivity through a single proxy might lead to overestimation/underestimation. As a critical climate modulator, primary productivity controls the exchange of CO₂ between the ocean and the atmosphere (Broecker, 1982). Many factors, including nutrient availability, turbidity, and light and wind intensity, influence the oceanic primary productivity. Therefore, primary productivity signatures are often used to assess the changes in hydroclimate variability in a particular region. This makes the paleoproductivity records an essential aspect to understand the climate change in different boundary conditions. The past productivity changes have been constructed by using different proxies like planktic foraminifera, benthic foraminifera, biogenic opal, organic proxies and carbonate content. However, due to different regional biases



associated with different proxies, the inferences obtained from a single proxy often result in misinterpretation. To address this, we will present a carbonate based multiproxy record of glacial-interglacial productivity changes from IODP Site U1446 in the northern Bay of Bengal which is characterized by a river runoff driven productivity. This study aims to untangle the complexities associated with different proxies used to assess glacial-interglacial productivity changes on a regional scale. For this we have used the absolute abundance of planktic foraminifera, the ratio of *Globigerina bulloides* to *Globigerinoides ruber*, Eutrophic assemblage based on planktic foraminifera species population and Cd/Ca in surface dwelling *G. ruber*. The Li/Ca values of *G. ruber* have been used to differentiate the signature of carbonate preservation from productivity. We also compared our productivity record with the published record of seawater $\delta^{18}\text{O}$, $\delta^{13}\text{C}$ of leaf wax, Rb/Ca and $p\text{CO}_2$ from the same site. The data for the last ~ 1.45 myr shows increased productivity during interglacials and increased carbonate preservation during glacial periods. Our proxy comparison infers differential control of hydrodynamic conditions on different productivity proxies. So, we suggest caution should be exercised while interpreting single proxy based paleoproductivity changes on a regional scale.

Keywords: MPT, Primary productivity, Indian Ocean, Glacial-interglacial, Foraminifera

【A0666】 -Poster

Reconstruction of weathering history in Himalayan foreland basin since 12 Ma: Links to global cooling and Himalayan uplift

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The Himalayan-Tibetan Plateau (HTP) upliftment and global cooling have long been considered critical controlling factors of climate dynamics during the Late Miocene in the Himalayan Foreland Basin (HFB). However, the dominant influence between these factors is still debatable. To enhance our understanding of climate change and its driving forces in the HFB, we analyze the clay mineral assemblages and geochemical compositions



(major, trace and REEs) in siliciclastic sediments from the Tanakpur-Sukhidang section of the HFB. The present study aims to identify the source rock composition and reconstruct of palaeoweathering in the basin over the past 12 Ma. Selected elemental ratios (Cr/Th, Th/Sc, Th/Co and La/Sc) and chondrite-normalized REE patterns with enriched LREE and negative europium anomaly indicate a felsic source rock composition. Relatively high proportions of primary clay minerals (illite and chlorite) and low values of weathering indices (CIA, CIW and PIA) indicate that the source region experienced intense physical erosion associated with high monsoonal rainfall from ~12 to 8 Ma. Subsequently, lower proportions of primary clay minerals and high weathering indices values suggest decline in physical erosion and increase in chemical weathering attributed to low monsoonal rainfall in the source region between 8 to 4 Ma. Hence, the change in the weathering regime associated with a decreased monsoonal rainfall around 8 Ma ago is possibly linked with global cooling.

Keywords: Himalayan Foreland Basin, Himalayan-Tibetan Plateau, Global cooling, Clay mineralogy, Chemical weathering index

【A0673】-Poster

Glacier and glacial lake changes: Linking the present to the last glacial maximum climate in North Sikkim, Eastern Himalaya

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Glaciers are critical barometers of climate change, and the sediment-landform associations within glacial valleys provide valuable proxies for understanding paleo-glacier dynamics in response to past environmental changes. Glacier dynamics across the Third Pole are not uniform but exhibit consistent regional-scale patterns along the Himalayan axis. However, the paucity of paleoclimate and glacier-glacial lake data from North Sikkim, a part of the Eastern Himalaya, has prompted investigations in the Changme Khangpu (CK) valley. This north-south trending valley receives precipitation from the Indian Summer



Monsoon (ISM) and the Northeast Monsoon.

This study explores present glacier and glacial lake variability, glacial lake breaching events, and paleoclimate variability in the CK basin. Sedimentary geochemistry serves as a proxy for paleoclimate reconstruction. A combination of remote sensing, GIS techniques, AHP analytical tools, and field expeditions provides robust data and methods to analyze present-day glacier and glacial lake changes. Investigations of paleo-glacier and glacial lake changes involve field-based landform mapping, sedimentary and facies analysis, and reconstruction of glacier and lake extents. Intermediate climate variability is reconstructed using sediment grain size analyses and geochemistry, with chronological placement achieved via ^{14}C Accelerated Mass Spectrometry (AMS) dating.

A glacier and glacial lake inventory identified 99 lakes in the CK basin, covering an area of $4.57 \pm 0.175 \text{ km}^2$. The AHP-derived analysis of Potentially Dangerous Glacial Lakes (PDGLs) highlighted seven lakes as highly hazardous, with evidence of three GLOF events over the last 49 years. A reconstructed lake breaching event during the pre-LGM period (ca. 27.32 ka Cal BP) occurred under relatively humid conditions. The lake, with an area of 0.2 km^2 and an approximate volume of $3 \times 10^6 \text{ m}^3$, breached during an intense ISM phase, characterized by annual precipitation 94 mm higher than present levels. An extensive advance of the CK glacier (Phase-II) occurred under a cooler climate ($\Delta T = -1.73^\circ\text{C}$) during late MIS 3. This led to the formation of a breached ablation valley lake, offering insights into glacier-lake dynamics in response to past climatic shifts.

Keywords: Glacier, Eastern Himalaya, Last Glacial Maximum, Accelerated Mass Spectrometry, Geochemistry

【A0361】-Poster

Reconstructing the past shifts in Southern Ocean fronts using the planktonic foraminiferal assemblages

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The Southern Ocean plays a vital role in regulating Earth's climate due to its unique hydrography, shaped by distinct water masses and frontal regimes. These fronts, characterized by rapid changes in physical properties such as temperature and salinity, are influenced by the eastward-flowing Antarctic Circumpolar Current (ACC), the largest ocean current in terms of volume and speed. Planktonic foraminifera inhabiting the upper water column are highly sensitive to such environmental variations and serve as valuable indicators for studying these dynamic systems. This study focuses on sediment core SK200/23, retrieved from the Polar Frontal Zone in the Indian sector of the Southern Ocean from the intermediate water depth (~1423 m). By analyzing the downcore abundance of planktonic foraminifera, the research aims to reconstruct shifts in hydrological fronts and variations in calcareous production during glacial and interglacial periods of the Late Quaternary. The variability in dominant foraminiferal species, such as *Neogloboquadrina pachyderma* and *Globigerina bulloides*, is used to track shifts in hydrological fronts during glacial-interglacial cycles. During the last glacial period, the northward shift of the Antarctic Polar Front (APF) is marked by a higher abundance (~80%) of cold-water species like *N. pachyderma* at the core site. In contrast, the Holocene is characterized by the dominance of the subtropical-subpolar species *G. bulloides* (~20%) and a decline in *N. pachyderma*, indicating a southward shift of the APF. Since the current core site is at intermediate water depth, the planktic foraminiferal concentration variability represents their water column production changes. Despite significant shifts in hydrological fronts during glacial and interglacial periods, the total planktonic foraminiferal concentration exhibits limited variability, except for a pronounced decline during the Last Glacial Maximum (LGM). This stability in planktonic foraminiferal production across climatic transitions suggests that carbonate production remained relatively stable across the climatic transitions. This observed stability in planktonic foraminiferal production may be attributed to the Antarctic Polar Front (APF) position, which consistently remained south of the core site. As a result, the region remained within the Polar Frontal Zone (PFZ) across both glacial and interglacial periods. However, the sharp decline in planktonic foraminiferal concentration during the Last Glacial Maximum (LGM) likely reflects the northernmost position of the APF, coinciding with an increased diatom- or opal-rich sediments that diluted the foraminiferal concentration. The results highlight the utility of planktonic foraminifera as a sensitive indicator of past environmental changes, offering valuable insights into subpolar hydrological variability. By analyzing foraminiferal assemblages from sediment core SK200/23, this study highlights the dynamic nature of frontal systems and their response to climatic fluctuations. Furthermore, the findings emphasize the Southern Ocean's pivotal role in regulating



glacial-interglacial biological productivity and carbon cycling during the Late Quaternary.

Keywords: Southern Ocean, Palaeoceanography, Planktonic foraminifera

【A0045】 -Oral

What lipid biomarkers and sedaDNA tell us about the marine primary production variations on the Iberian Margin over the last millennium?

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To assess variations in marine primary production (PP) and phytoplankton community composition at the Iberian Margin (IM) over the last 1000 years, we compare lipid biomarkers with sedimentary ancient DNA (sedaDNA) from three sites under the influence of different environmental conditions: off the Douro River in northern Portugal (colder waters, strong river flow and upwelling events), off the Tagus River in the central area (relevant river flow and upwelling events) and the south, on the Algarve continental shelf (sporadic upwelling and low river contribution). Although not in perfect agreement, preliminary results from lipid biomarkers and sedaDNA show similarities with respect to trends in phytoplankton groups, revealing consistent PP differences between the three sites and between the main climate intervals of the last millennium, namely: the Medieval Climate Anomaly (MCA: 850-1300 CE), characterized by warm condition; the Little Ice Age (LIA: 1350-1850 CE), characterized by a decrease in SST in the order of 1°C; and the Industrial Era (after 1850 CE), characterized by a new rise in seawater temperature.



The contribution of marine lipids (Mar.Lip; sum of C27, C28, C30 ste, phytol, C37 and C38 alkenones) is indicative of higher marine primary production at the Algarve site throughout the millennium, except for the higher concentrations at the Douro after 1980 CE. sedaDNA sequences also show an increase for all groups since 1980, confirming the observation of lipid biomarkers and reinforcing the increasing trend of primary production on the IM over the last 40 years.

Regarding the phytoplankton community, lipid biomarkers and sedaDNA analyses reveal spatial differences along the millennium. Lipid biomarkers show a higher contribution of coccolithophores (alkenone C37:2) at all sites throughout the millennium, with a change in this pattern occurring around 1880 CE when diatom sterol (28d5.22) become predominant in the Douro and dinoflagellate sterol (30d22) in the Algarve. Significant diatom sterol also occurs in the early MCA at all sites and specific IE ages. sedaDNA sequences, on the contrary, point to diatom dominance at all sites throughout the record, with notably higher values at the Tagus site. Nevertheless, the highest diatom peaks in sedaDNA sequences are also assigned by diatom sterol.

Keywords: Lipid biomarkers, SedaDNA, Marine primary production, Iberian Margin

【A0470】 -Oral

Morphological attributes of coccoliths as a new proxy for carbonate saturation in the South China Sea in the last 200 kyr

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Using paleoproxies in the geological record sensitive to variations in ocean carbonate chemistry provides insights into the biogeochemical changes that pCO₂. Higher dissolution of CO₂ in seawater leads to ocean acidification, reducing pH, [CO₃²⁻], and calcite saturation



state (Ω_{Ca}). The Ω_{Ca} is central in driving changes in ocean alkalinity, mediated through the precipitation and dissolution of $CaCO_3$. The shape factor (ks) has been validated as a reliable and stable proxy for reconstructing Ω_{Ca} variations at depths between 600 and 3800 meters in the South China Sea (SCS). Here, we applied the ks factor derived from coccoliths of the Noëlaerhabdaceae family (*Emiliania huxleyi* and *Gephyrocapsa* spp.) to track changes in Ω_{Ca} . Samples were retrieved from three sediment cores in the northeastern SCS sub-basin at different depths: ODP 1146B (19°27' N, 116°16' E, 2092 m water depth), ODP 1147B (18°50.11' N, 116°33.28' E, 3245 m water depth), and MD12-3437 (18°39' N, 116°46' E, 3840 m water depth), spanning the past 210, 185 and 140 kyr, respectively, with a temporal resolution of ~1.5–1.7 kyr per sample for Sites ODP1146B and ODP1147B and ~2 kyr for MD12-3437. Coccolith images were processed to extract morphological parameters—length, volume, area, and mass using the C-Calcita software from cross-polarized images (Zeiss AX10 microscope), and thickness and ks were then calculated. Key marine isotope stage (MIS) transitions, from MIS 6 to MIS 5 and from MIS 2 to MIS 1, recorded increased mean ks , reflecting enhanced Ω_{Ca} conditions during interglacial periods. Notably, the ODP1146B core recorded an overarching decline from MIS 7 to MIS 1 with the most pronounced decrease in mean ks values during the Last Glacial Maximum (LGM), reaching 0.019, suggesting strong carbonate dissolution under intensified glacial conditions. The Ω_{Ca} based on coccolithophore ks of the shallowest core (ODP1146B, 2092 m) is generally higher than the two deeper ones (at 3245 and 3840 m depth) during MIS 6 and Termination II, indicating high $[CO_3^{2-}]$ at intermediate depths in the SCS. However, during MIS 4 and Termination I, Ω_{Ca} at ODP 1146 was much lower than the deeper sites. This gradient in Ω_{Ca} with higher carbonate preservation at depths larger than 3000 m compared to the shallower site indicates the penetration of a water mass with a higher concentration of regenerated CO_2 . We suggest that the reorganization in the water mass geometry during these intervals contributed to enhanced carbon storage at intermediate depths in the Western Pacific.

Keywords: Coccoliths, Calcite saturation state, Carbonate dissolution, South China Sea

【A1037】 -Poster

Exploring coccolith morphology proxies for assessing carbonate saturation changes

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The shape factor k_s and its normalized variation ($\sigma/\text{mean } k_s$), derived from the morphological attributes of coccolithophores from the Noëlaerhabdaceae family (*Emiliania huxleyi* > 2 μm and small *Gephyrocapsa* spp.), have emerged as innovative proxies for tracking changes in carbonate saturation (Ω_{Ca}). To explore this relationship and examine how coccolithophore calcification and preservation influence fossil morphology, we analyzed coccolith mass, length, thickness, and k_s through laboratory dissolution experiments and surface sediment samples retrieved in a depth gradient (629 – 3809 m water depth). Using redundancy analysis (RDA), we investigated potential links between coccolith morphological attributes (length, volume, thickness, and k_s shape factor) and environmental variables, including mean annual seawater temperature, salinity, nutrients, total alkalinity, total carbon dioxide, pH, carbonate partial pressure at 50 m depth, and Ω_{Ca} at bottom depth from the study area surface samples. The results have demonstrated that mean k_s correlates strongly with Ω_{Ca} at bottom depths, explaining up to 47% of its variance. Furthermore, $\sigma/\text{mean } k_s$ enhances the sensitivity of dissolution assessments by capturing variability in the degree of size-selective dissolution and assemblage composition. The RDA confirms that Ω_{Ca} primarily drives morphological variations in coccoliths. Importantly, $\sigma/\text{mean } k_s$ complements mean k_s by accounting for variations in coccolith size and morphology, providing a more nuanced understanding of dissolution processes. Applying these proxies not only quantifies dissolution intensity but also enables the reconstruction of changes in the carbonate system over time. While traditional carbonate chemistry proxies often face challenges due to ecological and physiological variability, k_s and $\sigma/\text{mean } k_s$ offer a direct link to the saturation state of carbonate. This makes them particularly suitable for studying environments with complex carbonate dynamics or limited preservation of other calcifiers. Overall, the mean k_s and $\sigma/\text{mean } k_s$ proxies provide a reliable framework for interpreting past and present carbonate dissolution, improving our capacity to understand the role of oceanic carbonate chemistry in the global carbon cycle. Their potential applications include evaluating dissolution processes across depth gradients and reconstructing past changes in carbonate saturation.



Keywords: Coccolith, Paleoproxy, Carbonate saturation, Carbonate dissolution

【A0095】 -Poster

Incorporation of trace metals into land snail shell on the Chinese Loess Plateau as proxies for paleo-precipitation

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The loess-paleosol sequence on the Chinese Loess Plateau (CLP) serves a unique archive that records climate change in monsoonal East Asia since early Quaternary, yet absolute reconstruction of rainfall amount in the past is still challenging due to the lack of suitable proxy records. In this study, the trace metal compositions of land snail shell (*Cathaica sp.*) on the CLP were systematically explored in order to establish their correlations with mean annual precipitation (MAP). We found that shell Sr/Ca and Ba/Ca ratios are characterized by limited intra- and inter-shell variations. Significant spatial variations of and positive correlation between shell Sr/Ca and Ba/Ca ratios were observed, which can be explained by the Rayleigh distillation. Distinct negative correlations can be drawn between MAP and the Sr/Ca and Ba/Ca ratios of snail shell, suggesting that snail shell Sr/Ca and Ba/Ca ratios may record paleo-precipitation by reflecting the degree of the Rayleigh distillation.

Keywords: Chinese Loess Plateau, Land snail shell, Sr/Ca, Ba/Ca, Mean annual precipitation

【A0052】 -Oral

Responses of Tibetan antelope population to environment changes during the Holocene

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Tibetan antelope is the only genus of large mammal endemic to the Tibetan Plateau. In the past decades, the antelope population has been significantly affected by human activities, including massive illegal hunting, followed by strict protection policies and establishments of natural reserves. Various techniques and many efforts have been devoted to monitoring antelope population fluctuation and migration in past decades. However, it remains unclear how the antelope population changed in the past, and how it varied with climate and environment. Here, we presented sedimentary records at Lake Zonag, one of the major calving grounds for the Tibetan antelope, to study past changes in antelope population and its response to environment in past 9000 years. The sedimentary fecal sterols, produced by antelopes, captured the sudden decrease in antelope population due to illegal hunting in 1980s, as well as the recent recovery because of protection. The antelope population varied significantly during the past 9000 years, generally following environment changes revealed by geochemical elements in the same sediment core. Large antelope population likely lived in environment with relatively warm and humid condition, while small antelope population occurred in adverse environment with relatively cold and dry condition. Two periods with notably low antelope population were observed at 5.1-4.5 and 4.1-3.7 ka. The increase in antelope population in the past 400 years likely resulted from wildlife protection from early Tibetans. This study provides a promising method to reconstruct past changes in antelope population, to study its response to environment changes, and to provide historical comparison for wildlife protection.

Keywords: Tibetan antelope, Fecal steroids, Holocene, Antelope population

【A0432】-Oral

Nd isotope compositions: A proxy to reconstruct past ocean circulations and lithogenic Nd input from continental erosion

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The neodymium isotope composition (expressed as ϵNd) is a proxy extensively used in paleoceanography to determine the origin of water masses and weathering input, but some aspects regarding the impact of detrital materials on the dissolved ϵNd distributions remain unclear. In order to better constrain the processes of Nd exchange between seawater and detrital material in the past in a context of marginal sea influenced by strong lithogenic inputs. We have analyzed Nd isotopic compositions of planktonic foraminiferas collected from two marginal seas, the South China Sea (SCS) and the Bay of Bengal (BoB).

Past seawater ϵNd records during the past 35 kyr were extracted from foraminifera samples in the core MD01-2393 in southern SCS. During glacial times, the site witnessed large terrigenous fluxes of poorly altered minerals resulting from pronounced physical erosion of the highland of the Mekong River basin, these fluxes are not associated with obvious change of water masses originated ϵNd values. While foraminiferal ϵNd displays significantly unradiogenic values during the deglacial interval from 18 to 8 cal kyr BP, this is associated with intensification of monsoon rainfall and river input of detrital material characterized by strongly altered minerals (high illite chemical index and kaolinite/illite ratio) deriving from tropical plain soils of the Mekong River basin. We have also analyzed the foraminiferal ϵNd values in the BoB (core MD12-3412) spanning the last two glacial-interglacial cycles (past 200kyr). Our ϵNd data indicate relatively homogenous and radiogenic values (from -8.4 to -7.5) during glacial periods in the BoB, similar to the composition of glacial water masses of the Southern Ocean. In contrast, interglacials were characterized by more unradiogenic ϵNd and a pronounced north-south gradient of ~ 4.5 ϵNd units (from -12.9 to -8.5) in bottom water, similar to the present-day distribution in the BoB, pointing to a strong lithogenic control by seawater-particulate interactions. Notably, this significant decoupling of the local Nd isotope signature from the Southern Ocean composition occurred when Himalayan riverine inputs were dominated by the erosion of Indo-Gangetic plain soils during interglacial periods, whereas the preferential delivery of fresh primary mineral assemblages during glacial periods appears to have had little impact on Nd exchange with seawater.

Both results suggest that pedo-genetic minerals from tropical plain soils are more efficient



in terms of Nd exchange with the seawater than primary minerals produced by intense physical erosion during the glacial period. In conclusion, the state of chemical weathering of sediment delivered by rivers is the main factor controlling the detrital modification of past seawater Nd distributions in the marginal sea of the SCS and BoB. This finding sheds light on the utility of the ϵ Nd proxy for fingerprinting weathering inputs in marginal seas.

Keywords: Neodymium isotope composition, Marginal sea, Weathering input

【A0580】 -Poster

First evidence for the reappearance of *Globigerinoides ruber* (pink) in downcore sediments of the northeastern Indian Ocean since 120 kyr BP

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Globigerinoides ruber is a mixed-layer planktic foraminiferal species cosmopolitan to the tropical–subtropical oceans, extant since the Miocene. *G. ruber* has multiple morphotypical variants with distinctive white and pink chromotypes. Today, the pink variety is exclusively found in the Atlantic Ocean and its nearby basins. For the past few decades, it was believed that pink-pigmented *G. ruber* disappeared from the Indo-Pacific Oceans at about 120 kyr BP. A recent study from the northwestern Bay of Bengal documented the presence of *G. ruber* (pink) in surface sediments. Hitherto, there was no evidence of *G. ruber* (pink) in downcore sediments from the Indian Ocean since 120 kyr BP. In this study, for the first time, we document the re-appearance of *G. ruber* (pink) in downcore sediments from the northern Indian Ocean since 120 kyr BP. Gravity core MGS30/GC-03 was retrieved from the eastern BoB from a water depth of 1883 m, and its chronology was established using eight AMS radiocarbon dates. We documented the relative abundance of *G. ruber* (pink) and selected planktic foraminiferal species in the



core, reflecting centennial-millennial scale fluctuations in salinity and productivity. The relative abundance of *G. ruber* (pink) was highest during the Last Glacial Maximum (LGM) and Heinrich Event 2 (H2), followed by a gradual decrease during the deglaciation and early Holocene, until it disappeared after ~8 kyr BP. We compared variability in the relative abundance of *G. ruber* (pink) with the ratio of mixed-layer eutrophic to oligotrophic species (MLES/MLOS) and the low-salinity indicator species *N. dutertrei*. We observed that salinity was generally higher during the Holocene compared to the Last Glacial period, except for the time interval 6-10 kyr BP, where lower salinity was indicated by a high abundance of *N. dutertrei*. The high abundance of *N. dutertrei* indicate reduced sea surface salinity (SSS) in the eastern BoB, and a strong stratification of upper water column as a result of strong Indian Summer Monsoon (ISM). Additionally, principal component analysis (PCA) revealed significant species associations, notably a strong positive correlation between *G. ruber* (pink) and *N. dutertrei*, suggesting similar environmental preferences. The presence of *G. ruber* (pink) during glacial stages and the early Holocene suggests that it has not entirely disappeared from the Indian Ocean since 120 kyr BP and that its turnover may be driven by changing hydrographic conditions.

Keywords: Globigerinoides ruber (pink), Indian Ocean, Chromotypes, Indian Monsoon, Salinity

【A0109】-Poster

Two millennia precipitation reconstruction in northeast Brazil using luminescence sensitivity of quartz

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The São Francisco River Basin (SFRB) is the largest in eastern South America, stretching



across three distinct Brazilian biomes. The headwaters are located in a humid region dominated by the Atlantic Forest, where rainfall reaches up to 2000 mm per year. However, the majority of the basin drains the Cerrado, the Brazilian Savanna (1200 mm/year), and Caatinga (500 mm/year), which are characterized by drier conditions. Since the 18th century, the region has experienced an increasing frequency of drought events, so understanding historical rainfall trends is essential for assessing the region's vulnerability. The SFRB precipitation pattern is shaped by two main climatic systems: the South American Monsoon, which affects the southern part of the basin, and the seasonal migration of the Intertropical Convergence Zone (ITCZ), which influences the semi-arid northern area. Here, we present a precipitation record covering the last two millennia based on the sensitivity of the 110°C thermoluminescence (TL110°C) peak of quartz recovered from the marine sediment core M125-115-4 (10°41'S, 36°27'E), collected off northeastern South America. It receives terrigenous sediments from the adjacent SFRB, making it an ideal location to track variations in past precipitation if an appropriate proxy is available. The quartz TL110°C sensitivity method is based on the intensity of light (luminescence) emitted per unit mass per unit of radiation dose, which has allowed to track the grains transported by rivers and deposited in marine environments, serving as a proxy for changes in continental precipitation. Quartz TL110°C sensitivity is particularly useful for tracking continental sediment sources, as quartz is an abundant and persistent mineral in soils and surface sediments, even under tropical weathering conditions. The main advantages of this method include its fast response to precipitation changes, the absence of post-depositional biases, and its independence from effects related to rainfall isotopic fractionation or changes in relative sea level, which can influence other paleoclimate archives. The SFRB has a specific pattern seen by surface samples where the headwaters provide quartz with higher TL110°C, so we interpret that higher TL110°C sensitivity values suggest greater influence from the southern, wetter portion of the basin, while lower TL110°C values indicate a more substantial contribution from the northern, semi-arid region. The comparison between our TL110°C results and ITCZ proxy from Cariaco Basin shows that precipitation in the northern, semi-arid portion of the basin has varied proportionally and synchronously with shifts in the ITCZ position. During periods when the ITCZ shifted southward, such as the Little Ice Age (LIA), we observed a reduction in quartz TL110°C sensitivity (between 1630 - 1800), indicating a wetter climate in the semi-arid region. This finding supports the hypothesis that precipitation in the SFRB is linked to the latitudinal movement of the ITCZ, with wetter conditions in the semi-arid part of the basin during periods of a southward ITCZ displacement. Our study demonstrates the potential of luminescence-based proxies to reconstruct past



precipitation in the SFRB, providing new insights into the region's hydroclimatic history and its response to variability.

Keywords: Hydroclimate, Intertropical Convergence Zone, Continental precipitation proxy, Marine sediment core, Little Ice Age

【A0657】 -Oral

Ecosystem structure and biologic carbon pump efficiency: New insights from compound-specific amino acid $\delta^{15}\text{N}$

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The ocean's ability for "absorbing" carbon from the atmosphere is determined not only by the primary productivity but also by the efficiency of this biologic carbon pump, which is closely tied to the structure of the upper ocean ecosystem. Previous paleoceanography studies have primarily focused on biogenic composition of sediments, lacking a comprehensive picture of past ecosystem structure changes.

This study generates sedimentary compound-specific nitrogen isotope ($\delta^{15}\text{N}_{\text{AA}}$) records from a western equatorial Pacific site (MD10-3340), covering the last 140 kyr. Sedimentary $\delta^{15}\text{N}_{\text{AA}}$ provides isotopic information about the source nitrogen and $\delta^{15}\text{N}$ variations associated with trophic processes, allowing us to infer the average trophic position of the upper ocean ecosystem. Our results demonstrate higher average trophic position during the glacial periods, especially during Marine Isotope Stage 2-4, coinciding with glacial-interglacial shifts in carbonate percentage. We propose that glacial ecosystems characterized by a greater proportion of predators relative to producers likely generated more fecal pellets that rendered degradation of organic matters as they precipitated through the water column. Such a complicated ecosystem structure suggests a higher potential for carbon burial in deep reservoirs, supporting the role of the western equatorial Pacific as a carbon "sink" during glacials.

Keywords: Biologic carbon pump, Nitrogen cycle, Compound-specific amino acid nitrogen



isotope, Trophic processes

【A0099】 -Oral

Quaternary climate change in East Asia as recorded by microcodium on the Chinese Loess Plateau

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The soil carbonates in Chinese loess, preserved by continuous dust accumulation, provide a rare opportunity to explore the potential of using their geochemical compositions as paleo-proxies for paleoclimate reconstructions. In the last decade, we systematically examined the geochemical compositions (Sr/Ca, Sr, and O isotopes) of microcodium, which is of purely authigenic origin due to the replacement of bio-cells by the calcite in the loess deposits, and their environmental controlling factors on the Chinese Loess Plateau. Calibrations based on Holocene paleosol demonstrate that microcodium Sr/Ca is linked to local precipitation amount while microcodium oxygen isotope records the oxygen isotopic composition of monsoonal rainwater. The microcodium-based multi-proxy reconstructions have provided several key insights into the climate change in East Asia across time scales, including 1) the prolonged intensification of the East Asian Summer Monsoon (EASM) since early Quaternary as documented by microcodium oxygen isotope record and its implications to the trigger of Mid-Pleistocene climate transition; 2) orbital-scale variability of EASM as documented by microcodium Sr/Ca ratio record, which highlight the obliquity-driven variations of summer precipitation that originate from the gradient of boreal insolation that modulates the thermal contrast between the Asian continent and surrounding oceans; 3) millennial-scale variability of EASM at the interglacial-glacial transitions and the last glaciation as documented by microcodium Sr/Ca ratio, Sr and oxygen isotope records, which emphasize the key role of ice volume in modulating the response of the EASM to insolation-triggered North Atlantic cooling and the modulation of low-latitude insolation on the millennial-scale Summer Monsoon variability, respectively.



Keywords: Loess, Proxy, Monsoon, Soil carbonate, Microcodium

【A0157】 -Poster

Phosphorus cycling in the eastern equatorial Pacific during the Middle Miocene Climate Optimum

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The Middle Miocene Climate Optimum (MMCO), spanning between 17 and 14.5 million years ago, represents the warmest interval of the Neogene. With a moderately high atmospheric CO₂ concentration (400-700 ppm), the MMCO provides a plausible analog for future climate warming. During the MMCO, the global mean surface temperature was 5-12°C higher than preindustrial level, with a weaker equator-to-pole latitudinal temperature gradient. The benthic foraminifera $\delta^{18}\text{O}$, $\delta^{13}\text{C}$ and CaCO₃ records show variations in 100-kyr cycles, with an additional 400-kyr rhythm superposed on the $\delta^{13}\text{C}$ and CaCO₃ records, indicating eccentricity forcing was an important driver of climate and carbon cycling during the MMCO. However, how ocean productivity and nutrient recycling correspond to eccentricity cycles during the MMCO remains unclear. In this study, we present sedimentary records of phosphorus fractions (i.e., adsorbed phosphorus (P_{ex}), iron-bound phosphorus (P_{Fe}), authigenic phosphorus (P_{auth}), organic phosphorus (P_{org}), detrital phosphorus (P_{detri})), total organic carbon mass accumulation rate (TOC MAR), and opal and marine barite accumulation rate (BAR) from IODP Leg 321, Site U1337 in the eastern equatorial Pacific. Our new records assess carbon export efficiencies in the water column and sediments during the MMCO. The Long-term Ocean-atmosphere-Sediment Carbon cycle Reservoir (LOSCAR) model reconstructs the evolution of marine carbon and phosphorus cycles, supporting the influence of 100-kyr eccentricity cycles on the biological pump and carbon isotope variations during the MMCO. These findings provide new insights into the response of marine biological pump to climate change.



Keywords: Miocene, Phosphorus cycle, Eccentricity, Productivity, Carbon cycle

【A0467】 -Poster

Climate of the last 2500 years in the central Andes of Peru based on peatland deposition

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The high central Andes have experienced significant hydroclimatic changes in recent decades, impacting ecosystems through glacier retreat, temperature variations, and altered precipitation seasonality. Andean peatlands are crucial to water and biogeochemical cycles and are sensitive to climate change. To infer past climatic and environmental conditions, we analysed X-ray fluorescence (XRF) core scanning data, principal component analysis (PCA) with clr-transformation, and total organic carbon (TOC) on the APA01 peat core (basal age ~2500 years). PCA-clr explained 88.8% of variance, revealing interactions between organic matter (OM) content, accumulation dynamics, and climatic influences. The correlation between Log [S/Ti] and PC1-clr highlighted the interplay of OM concentration and erosion intensity. Environmental proxies such as Ln [Si/S] and Ln [Zr/Ti] ratios provided insights into accumulation processes and climatic impacts. Analysis of carbon accumulation rates (CAR) and mineral accumulation rates (MAR) from 507 BCE to 1565 CE indicated distinct phases of organic and mineral accumulation, reflecting climatic changes.

Comparative analysis with regional climate records (Quelccaya and Illimani ice cores, Pumacocha Lake sediments) during the Medieval Climate Anomaly (MCA) and Little Ice Age (LIA) demonstrated broader climatic influences on peatland dynamics. Decreased OM accumulation during the MCA was linked to drier conditions, while increased accumulation during the LIA corresponded to wetter climates. Warming phases such as



the MCA, post-LIA, and recent decades showed high clastic mineral input without necessarily wetter conditions, likely due to glacier and permafrost melting and increased snow-to-rain proportion.

Our data indicate a decline in peatland growth and OM accumulation since 2010, emphasizing the need for careful monitoring and future restoration efforts.

Keywords: Andes, Peatland dynamics, Climate change, XRF core scan, Carbon accumulation rate

【A0148】-Poster

Best practice to extract Na/Ca data from epibenthic foraminifers for paleoceanographic reconstructions – a cleaning reagent comparison

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Foraminiferal Na/Ca has been gaining importance as a proxy for salinity and/or seawater calcium concentration, as revealed by trace element measurement on planktic and shallow-water benthic foraminifers. Traditional foraminifer cleaning methods use NaOH at the oxidative step, which may result in overestimating Na/Ca values. Therefore, it is necessary to test different cleaning reagents to find the most effective way to determine the correct Na/Ca values. In this study, we compared benthic foraminiferal Na/Ca values, obtained by ICP-MS trace element analyses, for three oxidative cleaning reagent protocols: 1) NH₄OH buffered; 2) NH₄Cl buffered; and 3) NaOH buffered following the reductive cleaning step. We concentrated on deep-sea epifaunal benthic foraminifers *Planulina ariminensis* and *Cibicides pachyderma* due to their direct contact with the ambient water mass, hence assumed to be not biased by the pore waters. The samples are from water depths ranging from 380 to 820 m, the water depth of the core of the high salinity



Mediterranean Outflow Water (~37) in the Gulf of Cadiz and its diluted counterparts (~35.5-36) along the Portuguese margin. We later tested the measured foraminiferal Na/Ca values for their relationship with the ambient seawater salinities. The salinity data was compiled from online databases such as GLODAP and WOA in addition to direct measurements (i.e., CTD) during the sampling campaigns.

Keywords: Benthic foraminifers, Proxy, Paleosalinity, Mediterranean Outflow Water, Trace element analysis

【A0015】 -Poster

Reconstructing the past functioning of the biological carbon pump: A sedimentary ancient DNA approach

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Sedimentary ancient DNA (*sedaDNA*) is revolutionizing our understanding of marine ecosystems by offering a window into past biodiversity and its response to environmental and climate change. Over geological timescales, sediment layers accumulate, forming a record of past planktonic and benthic biodiversity, including non-fossilizing taxa. Recent findings have suggested that *sedaDNA* holds potential as a proxy for past particulate organic carbon (POC) flux (Cordier et al., 2022), a key process for carbon sequestration in the oceans that is yet to be quantified from the geological record.

We have reconstructed eukaryote biodiversity from a 19.5-meter-long Calypso core retrieved from the Eirik Drift in the Labrador Sea using DNA metabarcoding targeting the ribosomal 18S-V9 region. The record spans the last ca. 150,000 years, encompassing key interglacial and glacial climate intervals, such as the Holocene, Last Glacial Maximum, Marine Isotope Stage (MIS) 3-4 and Last Interglacial. Using a modern global scale surface-to-seafloor DNA dataset (>100 locations worldwide), we have separated sinking plankton



DNA signatures from that of benthic taxa along the sediment core samples. This approach enabled the first reconstruction of planktonic eukaryotes reaching the seafloor and directly contributing to carbon export over geological timescales. In our sediment core, we identified diverse planktonic marine taxa including radiolarians, cercozoans, diatoms, dinoflagellates, opalozoans, fungi, apicomplexans and ciliates, alongside benthic organisms such as polychaetes. Our first results reveal shifts in the relative abundance of both plankton and benthic communities in response to past climate variations, possibly reflecting changes in POC export dynamics.

We are currently developing a predictive model trained on a large collection of surface sediment samples, linking modern DNA signatures to current POC flux estimates. This calibrated model will be applied to our sediment core samples to reconstruct past POC fluxes. By providing the first quantitative assessment of POC export up to the Last Interglacial, we aim to predict the future behaviour of the biological carbon pump in warmer climates.

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Keywords: Sedimentary ancient DNA, Biological carbon pump, Biodiversity, Proxy

【A0543】-Poster

Late-Pleistocene short-term climatic and environmental oscillations in the Mologa-Sheksna Lowland (northern East European plain): State-of-the-art

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Chronologies representing rapid climate or environmental alterations take special place in palaeoclimatic and palaeogeographical reconstructions. Investigation of short-term oscillation (STOs) is particularly relevant, at highest temporal resolution level possible (sub-millennial, centennial, decadal), in order to outline frames and response patterns of the environment, similar to the contemporary climate change. On the one hand, detailed insight into STOs can be reached by improved technologies (e.g., continuous core logging). On the other hand, more advanced data should be obtained from new sections containing high-resolution records. Original palaeoclimatic STO investigations from the Mologa-Sheksna Lowland (MSL) are reviewed in this work, with the use of both abovementioned approaches, and their significance for the palaeoenvironmental reconstructions is discussed.

The Mologa-Sheksna Lowland is one of the least investigated areas of the northern East European Plain in terms of Late Glacial palaeogeography. Its present-day plain boggy relief is known as heritage of the large postglacial lakes, drained during the Holocene onset.

In the central MSL, a buried peat layer (5-30 cm thick) of presumably Allerød age has been discovered at 9 spots, mainly overlain by fine sand deposits (supposedly, aeolian), 1.5 – 5.0 m thick. At one site this peat section is perfectly exposed at the river Mologa bank, available for visual research, whereas at other 6 sites it was uncovered from boreholes, and at 2 sites it underlies muddy bottom lake sediments. At seven studied sites the peat layer age was determined as ~12.5 – 13.4 cal. ka BP, which corresponds to the late Allerød interstadial and early Younger Dryas stadial, also approved by pollen studies for one of the sections. These results represent an outstanding finding of a single Allerød-aged stratum as a separate lithological body, different from many reported Allerød-aged deposits which could be identified only by pollen investigation.

Interstadials Allerød, Bølling, stadials Older and Younger Dryas were described for the bottom sediment sequences of small relic lakes in the northern and central MSL, using high-resolution (2 mm) X-ray fluorescence core logging (XRF). Elemental composition of lacustrine sediments enabled to obtain Late Glacial record of palaeohydrological dynamics for the first time for the MSL, which can be correlated with regional palaeoclimate reconstructions, using supplementing multiproxy data. The following correspondence with palaeoclimatic chronology of the Late Glacial environmental dynamics was suggested for the northern MSL: Bølling ~14.0 cal. ka BP, Older Dryas ~13.5 cal. ka BP, Allerød ~13.3 –



12.9 cal. ka BP, Younger Dryas ~12.9 – 11.7 cal. ka BP. These alterations also can be traced in respective changes of palaeosedimentation, palaeoecology and palaeovegetation in the lake basins, which largely agree with the earlier regional reconstructions. Also, as reported, postglacial MSL large palaeolake level drop occurred within three stages: ~12.8 – 12.7, ~11.8 – 11.7, ~11.0 – 10.7 cal. ka BP, eventually transforming into the peatlands.

Knowledge on the Late Glacial STOs in the MSL was significantly enriched lately. Late Glacial palaeoclimatic and palaeoenvironmental alterations are in agreement with the global stratigraphy, although, some time lags were discovered due to the local MSL hydroclimatic specifics.

Keywords: Short-term oscillations, Allerød, XRF, Late Glacial

【A0322】-Poster

Recognition of the sedimentary record of tropical storm deposits from granulometric characteristics from the Bichitrapur coastal area of the Bay of Bengal, India

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The analysis of sediments deposited by prehistoric tropical storms is constrained by the absence of contemporary analogues, especially in the Bay of Bengal, India. The examination of the prehistoric records of land-falling tropical storms contributes to our comprehension of the tropical storm activity in this region and its correlation with global tempestological records. In order to accomplish this, we have analysed the stratigraphy and sedimentology of the subsurface sedimentary core deposits in the Bichitrapur back barrier coastal wetland of the Bay of Bengal, India. In this study, high-resolution granulometric analysis of a sediment core from the wetland is utilised for the paleoclimatic reconstruction. Along with the conventional plotting and analysis of particle size datasets, visual analysis and categorisation of particle size distribution curves (PSDCs) have been utilised for understanding the catastrophic depositional processes and changing environmental conditions. This study shows massive to parallel laminated,



normally graded sand (Unit B) overlies the bluish grey mud unit (Unit A), exhibiting a sharp erosional contact. The unimodal light brown sand that dominated the base of the overlying sand unit grades into bimodal olive-grey sandy silt in the upper part of the deposits. The underlying muddy unit shows symmetrically skewed silt and clay deposits that were deposited in the back barrier wetland from the tidal current flow. The granulometric distribution of the light brown sand exhibits similar characteristics to the modern intertidal and beach regions of the adjacent coastal barrier in the seaward direction. These overlying sandy deposits were eroded by Cyclone Yaas and re-deposited on the back barrier wetland as washover deposits.

Keywords: Tropical Storm, Particle size distribution curves, Washover, Wetland, Bay of Bengal

【A0495】-Poster

Holocene warming and seasonal stratification of the Arabian Sea

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Holocene sea surface temperature (SST) changes in the Arabian Sea reveal critical links between regional monsoon dynamics and global climatic change. Using a multi-proxy approach, we reconstruct a ~1.4 °C SST increase in Arabian Sea surface waters since the early Holocene. The early Holocene featured strong upwelling and weak stratification due to intensified monsoon winds. In contrast, the late Holocene exhibited enhanced stratification, diminished upwelling, and weaker monsoon activity. During the early to middle Holocene (10–6 ka), Arabian Sea surface water temperature increased from south to north, contrasting with the regionally varying patterns observed in modern SST trends. Our results indicate that the Arabian Sea was cooler during the early Holocene compared



to the late Holocene—a consistent finding supported by both models and proxy records. Notably, the surface ocean warming was accompanied by monsoon weakening, low productivity, and increased stratification. Our findings underscore the Arabian Sea's sensitivity to climatic shifts, providing critical insights into past transitions and future changes in a warming world.

Keywords: Holocene warming, Arabian Sea SST, Ocean stratification, Monsoon dynamics, Individual foraminiferal analysis

【A0417】 -Poster

Holocene to anthropocene burial of organic carbon in the Yangtze Delta

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Holocene organic carbon (OC) burial in mega-deltas is considered to played a crucial role in modulating long-term atmospheric CO₂ levels, but this role should have been significantly altered by human activities during the Anthropocene. The lack of precisely estimating the Holocene deltaic OC burial rates limits a comprehensive understanding of carbon cycle evolution. This study, using data from 50 Holocene boreholes and 216 modern surface sediment samples, examines changes in OC sources, their controlling factors, and quantifies OC burial rates in the Yangtze Delta (YD) from the mid-Holocene to the Anthropocene. The results reveal three distinct stages of OC burial evolution in the YD. From 8 to 2 ka, the weakening East Asian Summer Monsoon reduced terrestrial OC contributions, but the YD maintained slow progradation and stable OC burial rates (~0.79 Mt/yr). After 2 ka, human activities became the dominant driver, leading to a 78% increase in OC burial (1.40-1.44 Mt/yr). Following the impoundment of the Three Gorges Dam, the YD entered an erosion-driven destruction phase, with OC burial rates declining by 59%. Accounting for subaqueous delta erosion, the YD has shifted from a carbon sink to a source, contributing ~0.81 Mt/yr of OC to the Zhejiang-Fujian mud belt. These findings underscore the pivotal role of sediment burial rates in governing OC burial in mega-deltas and highlight the global consequences of human-induced sediment dynamics, as deltas



worldwide may similarly transition from carbon sinks to carbon sources.

Keywords: Yangtze Delta, Organic carbon burial, Holocene, Anthropocene, Terrestrial organic carbon

【A0096】 -Poster

Holocene gradual warming and drying in tropical Australia based on branched tetraether lipid evidence

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Understanding Holocene natural variability of the climate system is crucial for accurate evaluation of the temporal course of current anthropogenic warming and forecasting future climate trends. However, the patterns and mechanisms of Holocene climate variability in tropical Australasia remain highly controversial, partly due to proxy uncertainties and methodological limitations. In this study, we analyze distributions of branched glycerol dialkyl glycerol tetraethers (BrGDGTs) in the sediments of Girraween Lagoon from northern Australia to investigate the temperature and hydroclimate changes spanning the past 10.4 ± 0.1 kyr. Our reconstructed Holocene MAAT record displays a long-term warming trend with an amplitude of 2°C . This overall warming pattern is generally consistent with other adjacent brGDGT-based terrestrial temperatures, alkenone-derived sea surface temperatures from the western equatorial Pacific and model simulations, but not with those inferred from planktonic foraminiferal Mg/Ca paleothermometers. The reconstructed pH values suggest a significant acidification process in Girraween Lagoon during the Holocene, which mainly results from an enhancement of acid production regulated by hydroclimate change in northern Australia, but also a reduction in the input of alkaline waters from the underlying carbonate sinkhole. Combined with other proxy records, we suggest that changes in the El Niño-Southern Oscillation and coupling to the East Asian winter monsoon have played an important role in the transition from a cool and wet to a warmer and seasonal drier climate in tropical Australasia over the Holocene. Our study provides a new perspective on the possible forcing mechanisms of Holocene



Indonesian-Australian Summer Monsoon evolution.

Keywords: BrGDGTs, Hydroclimate variations, Temperature reconstruction, Lake sediment, East Asian winter monsoon

【A0038】-Poster

Unravelling asynchronicity of LIA with equa-tropical climate of south west coast of India based on multi-proxy studies

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Through multi-proxy examinations, a thorough study of the Mundrothruthu (MT) core (70 cm) from the Asthamudi wetland in Kollam, Kerala, India, reveals three climate stages during the Little Ice Age (LIA). High levels of agricultural activity are seen between 1507 and 1518 CE, as evidenced by a large amount of terrestrial inflow, freshwater runoff, and a diverse range of diatoms. Increased TOC% and $\delta^{13}\text{C}_{\text{TOC}}$ values indicate a warm, humid climate with high temperatures, most likely due to a high amount of organic matter being transported and ingested from nearby environments on land. There could have been a greater input of organic materials into the estuary, resulting in higher TOC% and more negative $\delta^{13}\text{C}$ data. The second phase (1519–1548 CE) is marked by a surge in marine palynomorphs, or mixed terrestrial and marine organisms, which are indicative of increased marine invasion caused by higher tidal currents. This movement most likely corresponds to variations in tidal dynamics or sea level. The last epoch (1548–1804 CE) is characterized by more marine taxonomic enhancement, decreased TOC%, and $\delta^{13}\text{C}_{\text{TOC}}$ values, which point to decreased atmospheric CO_2 and a roughly one-degree Celsius drop in temperature. The Inter Tropical Convergence Zone (ITCZ) is moving southward during this time, and there is a decrease in solar insolation. In relation to global changes during the LIA, the study reveals both synchronous and asynchronous climatic behaviour on the southwest coast of India. Due to tidal dynamics and broader climatic alterations, the region which was formerly warm and humid with great agricultural productivity gradually changed to conditions that were dominated by the sea. These results highlight the



intricate interactions that occurred during the LIA between regional and global climate parameters.

Keywords: Little Ice Age, Mundrothruthu, Diatom, Agricultural activities, Palynomorphs

【A0017】 -Oral

Impact of volcanic and banana plantation derivatives in a tropical small mountainous river in Costa Rica

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Small mountainous river systems (SMR) underlain by volcanic lithology substantially contribute to silicate weathering yields and the associated CO₂ consumption. Identifying the sources of trace metals and stable isotopes in dissolved and weathered pools, as well as fluvial soils, provides insights into metal cycling processes and controlling mechanisms that affect river chemistry. The identification of natural and anthropogenic sources is essential for understanding modern river flux and constraining oceanic mass balance.

Here we present the first systematic geochemical analysis of source-to-sink processes in Central America. Riverine surface water and fluvial sediments are analyzed and compared to understand the trace metal dynamics in highly dynamic mountainous rivers influenced by active volcanoes, hydroelectrical dams and banana plantations. This investigation introduces the first Cu-C-N data in Central America, as well as the first dissolved Cu isotopic dataset for a volcanic catchment.

Keywords: Volcanic rivers, Geochemistry, Small Mountainous Rivers (SMRs), Costa Rica, Trace metals

【A0143】 -Oral

Evaluation of sedimentary DNA as a Southern Ocean Sea ice proxy



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Sedimentary ancient DNA (sedaDNA), i.e. DNA molecules originating from past organisms and preserved in sediment archives, is an emerging tool in marine paleoecology. It allows reconstructing entire biological communities, including lineages without a traditional fossil record. Thus, it can enable the reconstruction of past ecosystems to unprecedented detail not possible with microfossil proxies alone. In polar regions, sedaDNA has great potential to be used as a sea ice proxy by tracing sea ice associated species across time. Comparing the biodiversity captured by sedaDNA to traditional proxies such as those based on diatoms will provide a more complete picture of paleo-sea ice reconstructions.

A crucial step before we can reconstruct past sea ice conditions based on sedaDNA, is to calibrate this new proxy by documenting the links between modern sea ice conditions and marine biodiversity as preserved in recent sedimentary DNA. Here we present results from a DNA metabarcoding study that focuses on documenting marine biodiversity linked to sea ice coverage across the Weddell Sea and the Drake Passage in the Southern Ocean. Our surface sediment samples are from locations that in modern times are characterized by open ocean conditions, seasonal or permanent sea ice cover. We successfully extracted DNA from the sediment at >40 stations yielding total DNA concentrations of on average 6.6 ng/μL. We then amplified and sequenced the V9 region of the SSU rDNA targeting eukaryotes with promising results. On average, we obtained a sequencing depth of 500000 reads per sample. First results indicate that communities at the coastal area around the Antarctic Peninsula with a high seasonal variance in sea ice coverage are dominated by diatoms. In the central Weddell Sea and the Drake Passage small flagellates and ciliates are more abundant.

Here, we link identified communities to the modern sea ice coverage, sea ice biomarkers,



microfossil assemblages (diatom and dinoflagellate cyst) and sedimentology. In the future, the found associations between sea ice coverage and sedimentary DNA biodiversity will be used to reconstruct past sea ice conditions as documented in a sediment core in the north-western Weddell Sea.

Keywords: SedaDNA, Sea ice proxy, Southern Ocean, DNA



【A0384】 -Poster

High-resolution precipitation records and paleo-flood events during the Middle-Early Holocene in southwest Taiwan revealed by XRF scanning of sedimentary cores

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To closely decipher the climate-flood dynamics during the Middle-Early Holocene of the paleo Zeng-Wen drainage system, we analyzed XRF scanning data of two long cores drilled in the Tainan Science Park, where archeological excavation was done during 2021-2022. We conducted grain-size and sedimentary facies analyses of Core 690 (50 m long) and Core 700 (100 m long). Both cores were also subjected to XRF scanning. After removing outlier data points, the cps of 14 element variables scanned from XRF were log-ratio transformed. The log-ratio value of potassium (K) was used as an index of riverine input and an indicator of paleo-precipitation. High K values coincide with clay and fine silt deposits. Sedimentary facies analyses suggest that those strata were deposited in tidal flat, marsh, and lagoon environments. The log-ratio K record at the Tainan Science Park is highly compatible with the K₂O% recorded in Core MD18-3569 retrieved from offshore southwest Taiwan. Wavelet analysis and multi-taper spectra suggest that the paleo-precipitation record of 5.5 – 11.5 ka in SW Taiwan shows strong periodicities of ~280, ~340, ~443, and ~590 years. Mega-flood events, as defined by extreme log-ratio K values larger than the 95th percentile, occurred frequently during the earliest Holocene (11.5 – 9.5 Ka) and culminated to the peak at about 9.0 Ka., and then decreased gradually towards the mid-Holocene (5.5 Ka).

Keywords: Paleoflood, XRF

【A0124】 -Oral

A marine barite perspective of the Late Miocene Biogenic Bloom in the equatorial Indian Ocean and equatorial Western Atlantic Ocean

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The late Miocene (11.6-5.33 Ma), with an atmospheric CO₂ concentration similar to the pre-industrial level, represents an ideal time window for understanding the relationship between anthropogenic climate, ocean circulation, and global carbon cycling. During this time interval, biogenic components in marine sediments has increased significantly, which is known as the Late Miocene Biogenic Bloom (LMBB). However, understanding the timing, distribution, and cause of the LMBB remains limited. We use marine barite, a refractory mineral precipitating from the water column associated with carbon export, and other traditional productivity proxies to reconstruct productivity in the equatorial Indian Ocean and equatorial western Atlantic between 12 and 5 Ma. Multi-proxy records reveal the onset of the LMBB in the equatorial Indian Ocean at ~9 Ma, primarily driven by more vigorous upwelling during global cooling. We suggest that the steepened meridional temperature gradient and the Antarctic ice sheet expansion have strengthened ocean overturning, facilitating nutrient supply and biogenic bloom in upwelling regions.

Keywords: Late Miocene, Biogenic bloom, Productivity proxies, Marine barite, Upwelling

【A0647】 -Poster

Shallow benthic foraminifera as indicator of environmental changes in Singapore

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Stable isotopic composition of planktonic foraminifera is widely used as a robust tool for paleoclimate reconstructions. However, in marginal marine environment, shallow benthic species dominate and the lack of planktonic foraminifera makes it difficult to reconstruct paleoclimate using this method. To this end, we investigate the distribution and stable isotopic composition of shallow marine benthic foraminifera from Singapore to determine its suitability as proxies for environmental and rainfall



changes in the local region. Generally, Singapore experience the highest amount of rainfall during the Northeast monsoon period (December to March). Surface sediment samples are collected from several sites around Singapore monthly from August 2023 to October 2024, and analysed for their grain size distribution, carbon content and $\delta^{13}\text{C}_{\text{sediment}}$. Water parameters such as salinity, temperature, $\delta^{18}\text{O}$ and $\delta^{13}\text{C}_{\text{DIC}}$ are also measured. Foraminiferal assemblage of each sampling site is determined and dominant species are identified. *Asterorotalia pulchella* was found to dominate in areas with sandy substrate and *Ammonia* species are prevalent in muddy sediments with relatively high carbon content. Stable isotopic measurements were conducted on these dominant species and results were compared to the rainfall amount and other environmental variables to determine if they are sensitive to rainfall and/or environmental changes, and hence evaluate their suitability as proxies for paleoenvironment and paleoclimate reconstruction.

Keywords: Foraminifera, Singapore, Environmental change, Sediments

【A0134】 -Oral

Unraveling the causes of Pliocene warmth: Carbonate clumped-isotope palaeotemperature and $p\text{CO}_2$ reconstructions in Chinese loess

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The Pliocene witnessed the progressive fall of global sea level in response to the growth of ice sheets at high northern latitudes. However, the Northern Hemisphere did not enter a major ice age until ~ 2.7 Ma, for which several causes have been postulated, including tropical seaway closures, permanent El Niño-like conditions, and Earth's orbital changes. Recent studies have attributed the onset of the Pleistocene ice ages in the Northern Hemisphere to the decrease in $p\text{CO}_2$. However, the link between $p\text{CO}_2$ and Pliocene glaciations, or their delay, is not well understood, mainly because the magnitude of $p\text{CO}_2$ remains uncertain beyond the maximum age of ice cores (~ 0.8 Ma). Here, we develop a carbonate clumped isotope (Δ_{47})–temperature calibration equation specifically for pedogenic carbonate in Chinese loess, to quantify the temperature of carbonate nodule formation and the soil-respired CO_2 concentration ($S(z)$). Then, we apply the new Δ_{47} –temperature calibration to loess-red clay sequences on the Chinese Loess Plateau to reconstruct global $p\text{CO}_2$ history since the Late Miocene.



The palaeotemperature results show an oscillatory cooling trend over time in northern China, with four prominent warm intervals (7.24–7.1 Ma, 5.8–5.2 Ma, 4.6–4.0 Ma, 3.5–2.7 Ma) occurring during the Late Miocene and Pliocene. These characteristics are consistent with those of tropical sea surface temperature records. $p\text{CO}_2$ reconstructed using the pedogenic carbonate palaeobarometer was consistently low (150–325 ppmv) during the intervals of 7.2–4.3 Ma and 2.6–0.8 Ma. In contrast, there is a three-step rise in $p\text{CO}_2$ up to 535 ppmv from 4.3 to 2.6 Ma, coincident with the oscillatory decrease in global sea level and in benthic $\delta^{13}\text{C}$ record. We suggest that the Pliocene CO_2 rise is causally related to the sea-level fall and associated organic carbon oxidation on exposed continental shelves, thereby delaying the onset of the ice age. Our results suggest a negative feedback mechanism due to the long-term cooling since the Late Miocene: i.e., once global cooling reached a critical threshold for ice sheet growth at high northern latitudes, the resulting fall in sea level and exposure of continental shelves in turn led to CO_2 release and caused distinct transient warming. This CO_2 -induced warming during the Pliocene delayed the beginning of the Northern Hemisphere ice age but did not prevent it.

Keywords: Atmospheric CO_2 , Pedogenic carbonate, Loess, Clumped isotope, Palaeotemperature

【A0829】 -Oral

Multiple isotopes trace the environmental signal propagation in the East Asian continental margins

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East Asian continental margin is featured by tremendous terrigenous sediment inputs from two major types of river systems: the mega-rivers in Eurasian continent, e.g. the Changjiang (Yangtze) River, and the small mountainous rivers in Taiwan (tectonically active) and SE mainland China (tectonically stable). Classic weathering indices such as the river water chemistry, CIA, WIP and clay minerals suggest these East Asian rivers are characterized by much different weathering regimes, and sediment transfer rates and recycling processes significantly influence the silicate weathering intensities registered in the river sediments. The small dynamic mountains rivers in Taiwan exhibit



large sedimentary geochemical and provenance heterogeneity despite their fast sediment transfer from land to sea. In addition, we present new data from multiple isotopes (Sr, Li, Si and Mg) to investigate the weathering signal propagation in the continental margins. We observe conservative behaviour of dissolved Li isotopes during estuarine mixing processes but different fractionations of dissolved Sr isotopes and particulate Li isotopes. Despite the hydrodynamic sorting and early diagenetic (reverse weathering) effects, the clay Li and Mg isotopes well preserve the catchment weathering signals and thus can be used to investigate the paleo- weathering history and climate feedback in geological past.

Keywords: Continental margin, Environmental changes, Sedimentary records, Isotopes, Weathering

【A0167】 -Poster

Abyssal and hadal sediment dynamics caused by the mixture of gravity flows and contour currents in the Diamantina Fracture Zone (SE Indian Ocean)

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Diamantina Fracture Zone in the SE Indian Ocean is one of the less unexplored hadal zones (>6000 m) of our planet, which develops the second deepest point (Dordrecht Deep, ca. 7019 m depth) in the Indian Ocean. Humans did not visit its ocean floor until the Chinese submersible *Fendouzhe* conducted 27 scientific dives in January 2023. This expedition collected push cores of shallow sediments, high-resolution submarine videos, and multibeam bathymetry data at a wide range of water depth and geomorphology. This study incorporates these materials to fully assess the sediment dynamics of the Diamantina Fracture Zone and their major causative factors.

The western section with water depth <6,000 m and the Broken Ridge to the north develops foraminifera and calcareous nannofossil oozes and brownish pelagic sediments, whereas the eastern hadal section consists of brownish pelagic sediments with sponge spicule and Fe-Mn nodules. Grain size analyses show the sediments contain two background peaks at 2 and 9-11 μm . In the western to middle section of the fracture zone, angular volcanic-rich sediments with an additional peak at 200-300



µm cover the underlying fine pelagic sediments and calcareous oozes. The upper layer of coarse grains is considered to be deposited by downslope gravity-driven processes. The mass wasting event was likely triggered by the enhanced contour current, rather than earthquakes. The current intensity increases due to the topographical constraints, which also explains the large-scale sediment ripples in the western section. Based on the radiocarbon dating results, the mass wasting event was during the late Last Glacial Period. Hence, the enhanced water masses from Antarctic, mostly Lower Circumpolar Deep Water and Antarctic Bottom Water, triggered the alongslope processes.

This research provides the first knowledge of the mixture of gravity flows and contour currents in the Diamantina Fracture Zone, which further aids in reconstructing the paleoenvironmental changes and the potential responses of climatic events to the deep ocean processes.

Keywords: Deep-sea sediments, Grain size, Event deposition, Triggering factors, LGM

【A0979】 -Poster

Glacial-interglacial cycles recorded in clay minerals from the eastern Tibetan Plateau over the last 800 ka and their indications

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Clay mineral proxies have been widely used to reconstruct changes in provenance and the paleoclimate. However, high-altitude clay mineral indications and long-term and orbital variations have not been fully explored. Herein, we present an 800-ka clay-mineral record from a lacustrine sediment core (ZB13-C2) from the Zoige Basin on the eastern Tibetan Plateau (TP). X-ray diffraction and scanning electron microscopy were used to identify the clay mineral assemblages and their micromorphological characteristics of core ZB13-C2. The results revealed that the clay minerals in core ZB13-C2 are mainly illite, with small amounts of chlorite, kaolinite, and smectite (including irregular mixed-layers of illite-smectite (I/S) and chlorite-smectite (C/S)). The clay mineral assemblages and proxies exhibit three stages of change, which are



mainly controlled by the Zoige watershed range under different climate conditions. The watershed was limited to the southeastern region with altitudes ranging from ~3500 to ~4200 meters above sea level (m a.s.l.), and glacial-interglacial hydraulic erosion controlled the input of bedrock debris during 800-621 ka BP. It expanded to higher altitudes (~4200 to ~4700 m a.s.l.) due to stronger seasonal freeze-thaw weathering without significant glacial-interglacial variations under a cooling and drying climate during 621-100 ka BP. Finally, it expanded to its highest altitudes of ~4700 to ~5200 m a.s.l. northwest of the watershed after 100 ka BP, and hydraulic erosion increased obviously under a warm climate of the interstadial MIS 3 on the TP. The watershed underwent two major expansions under different climatic conditions at ~621 ka and 100 ka BP, with the wet/dry alternation became strong at ~621 ka BP. These results reveal that long-term temperature changes and the wet/dry alternation at high altitudes controlled the watershed range and degree of the physical erosion, and that the indications of clay minerals should be carefully clarified before they are used as climate indicators, especially on the TP.

Keywords: Quaternary, Zoige Basin, Lacustrine sediments, Paleoenvironment, Weathering

【A0080】 -Poster

Global reconstruction of ocean export productivity from the late Eocene to the early Oligocene

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The Earth's climate shifted swiftly from a "greenhouse" state to an "icehouse" state ~34 million years ago (Ma). This climatic transition is characterized by abrupt global cooling, atmospheric CO₂ drawdown, and the initiation of Antarctic glaciation, leading to perturbations of the marine carbon cycle and biosphere. While previous studies have suggested decoupled productivity changes in different ocean regions, the global carbon budget in setting atmospheric CO₂ is still an enigma. Marine barite (BaSO₄) is a reliable proxy of export productivity owing to its biologically induced formation and refractory nature. Here we present the global record of marine barite accumulation rates from more than 9 DSDP/ODP/IODP sites from the late Eocene to the early



Oligocene. We reconstruct changes in ocean export productivity between 41 and 28 Ma and investigate their spatial distribution and contribution to the carbon budget before and after the Antarctic glaciation. Our results suggest changes in productivity are likely associated with the stepwise reorganization of ocean circulation caused by tectonic activities and global cooling. These findings offer implications for understanding carbon-climate-tectonic feedbacks at the onset of the early-Cenozoic icehouse world.

Keywords: Eocene-Oligocene Transition, Productivity, Marine barite, Ocean circulation

【A0083】 -Poster

BrGDGTs-based temperature reconstruction on the Tibetan Plateau: Insights from cumulative positive degree days

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Branched glycerol dialkyl glycerol tetraethers (BrGDGTs) serve as critical paleothermometers. However, BrGDGT-based temperature reconstructions for the Holocene reveal significant regional discrepancies. Exploring the systematic variations in BrGDGTs-based temperature is therefore crucial for understanding past temperature changes and provides a theoretical basis for addressing the "Holocene temperature conundrum". The Tibetan Plateau, known for its high sensitivity to global temperature changes, exemplifies these inconsistencies in BrGDGTs-based temperature trends. In this study, we analyzed a Holocene-spanning sediment core from Nanglalu Lake, located in the southern Tibetan Plateau, to reconstruct Holocene temperatures using BrGDGTs. Our results were compared with 13 published BrGDGT records from other lakes across the plateau, alongside Holocene temperature simulations from the TraCE-21ka climate model, to explore regional patterns in temperature variability. Our findings indicate that BrGDGTs in Nanglalu Lake primarily originate from in-situ lacustrine source, and the reconstructed temperatures reflect lake water temperatures. The Nanglalu record shows a continuous warming trend throughout the Holocene. Comparatively, BrGDGTs-based temperatures across lower-latitude regions of the Tibetan Plateau exhibit a similar warming trend. Conversely, higher-latitude lakes demonstrate 'V' shape pattern, with an initial cooling phase



followed by warming. Notably, BrGDGT-based temperatures across most lake records closely align with cumulative positive degree days (CPDD) derived from the TraCE-21 ka model. This alignment suggests that BrGDGTs-based temperatures are likely proxies for CPDD, reflect the cumulative thermal energy above freezing thresholds. We further propose that the duration of months with above-freezing temperature is the dominant factor driving regional heterogeneity in BrGDGTs-based temperature reconstructions on the Tibetan Plateau.

Keywords: BrGDGTs, Cumulative positive degree days, Tibetan Plateau, Paleotemperature



Session 17. Eolian processes and landscape dynamics in drylands

Conveners: Peng Liang, Andrew Gunn, Abi Stone, Yue Li, Xiaokang Liu

【A0501】 -Poster

Wind-Sand burial and oasis secline: A multidisciplinary perspective on sesert shrub dune evolution in the lower Heihe River Basin, China

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The evolution of deserts and oases has long been a focal point in the study of environmental change in arid regions worldwide. However, the challenge of obtaining high-resolution aeolian sediment profiles, combined with the limited availability of reliable dating methods and materials, has impeded the progress of this research. In this study, we investigate a newly identified *Tamarix* shrubland sediment profile (Hei Shui, abbreviated as HS) located on the northwestern edge of the Badain Jaran Desert, a key region in the lower Heihe River Basin, China. Using AMS ¹⁴C dating of plant macrofossils, along with analyses of grain size, organic matter, and chemical elements as environmental proxies, we reconstruct a comprehensive sedimentary sequence covering the past five centuries. Our findings indicate that increasing aridity has intensified aeolian activity during ~1494–1747 AD, resulting in the burial of large numbers of tamarisk shrub dunes by wind and sand. From ~1747–1946 AD, the climate gradually turned wetter and tamarisk scrub dunes redeveloped. Importantly, this study introduces a novel hypothesis, suggesting that the decline of the adjacent Xixia Heishui City ruins may be attributed to the rapid burial of its oasis environment by aeolian sand, rather than the traditionally proposed causes of war or social turmoil. This research offers new insights into desertification and aeolian processes, advancing our understanding of the region's ecological history and the collapse of ancient civilizations.

Keywords: Tamarix shrub dunes, Aeolian activity, Heishui city, Civilizational decline



【A0298】 -Oral

Formation and evolution of the Yellow River: Controversies and solutions

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Over the past decades, geoscientists have paid close attentions to the issues regarding the evolution of the Yellow River. The main focus of debate is on the timing of the formation of the Yellow River. There are four major proposals regarding the forming time: (1) late Pleistocene, (2) middle Pleistocene, (3) early Pleistocene formation, and (4) prior Pliocene formation. We are here to examine the issue from the perspectives of paleoclimatology. Here is a recognized premise: due to the existence of the vast Chinese Loess Plateau (CLP) with a considerable loess thickness, the Yellow River has sufficient materials eroded from the CLP, and the eroded material is the basis for the formation of the North China Plains. There are two major questions here. First, where did the eroded loess go before the Yellow River went through the Sanmen Gorge? Second, where did the runoff of the upstream rivers go before the Yellow River went through the Sanmenxia Gorge? The precipitation reconstructed based on ¹⁰Be (Xifeng site on the CLP) shows that in the past 900,000 years, the precipitation was close to or higher than modern levels (700-900 mm) during the warm times, and it was at a range from 500 to 300 mm during the cold times. According to the similarity between the Xifeng ¹⁰Be curve and the Luochuan magnetic susceptibility curve, we believe that the precipitation throughout the Quaternary followed the same patterns as those in the past 900,000 years. If the time when the Yellow River went through the Sanmenxia Gorge was 0.15 Ma, then the questions arise: where did the "eroded loess" go between 2.6 and 0.15 Ma? How arid would the climate be if the runoff in such a large watershed were to form a long-lasting 'inland lake'? If the Yellow River went through the Sanmenxia Gorge around 1.25 Ma, we have to answer the same kind of questions. Here, we advocate three proposals to solve the dispute. First, because of the high erodibility of loess and the huge amount of sediment carried by the Yellow River, the best solution to "resolve disputes" is to find "unique signals of loess inherited from the CLP" in the North China Plains and in the seas immediately to the east. Second, since the formation of the Jinshan Gorge was so important for determining the timing of the



integration, we should make deliberated efforts to determine the facies and ages of the sediments in "Yinchuan-Hetao Ancient Lake". Third, the Wei River Basin should have also been a sink of the material eroded from the CLP before the Yellow River went through the Sanmenxia Gorge. Therefore, attentions should be directed to analyzing the facies and ages of the sediments in the Weihe Basin.

Keywords: Yellow River formation, Quaternary climate, Loess-River linkage

【A0956】 -Oral

Orbital forcing on the hydroclimatic evolution in the Arabian Peninsula since the middle Pleistocene and implications for the Hominin migration

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The Arabian Peninsula is a critical geographic landmass situated between Africa and the rest of Eurasia. Climatic shifts across the Pleistocene periodically produced wet-dry conditions in Arabia, dramatically altering the spatial distribution of hominins both within and between continents. We present 500-kyr multi-proxy records of aeolian dust supply into the western equatorial Indian Ocean, based on environmental magnetic, geochemical and diffuse reflectance spectroscopy measurements of marine sediments from core CJ02-08. Low dust input occurred during humid phases, and intense dust input occurred during arid phases. Our combined proxy-based reconstructions suggest that wet-dry evolution of the Arabian Peninsula responded to a combination of global ice volume, Southern Hemisphere meridional temperature gradient, and regional summer insolation forcing, with cooccurring primary orbital cycles of ~100-kyr, 41-kyr, and ~23-kyr. Precession determines the 'Green Arabia periods' (GAPs), but their amplitude is strongly linked to eccentricity via its control over ice sheet extent. GAPs occurred during insolation maxima, in particular during interglacials, are astronomically paced by precession which controls the intensity of the African monsoon system. The GAPs are consistent with the ages of Arabian archeological and fossil hominin sites, at least seven hominin expansions into the Arabian interior, coinciding with brief 'green' windows of reduced aridity. The well-dated succession of GAPs presented here may have played an important role in migration and evolution of hominins. Asynchronous variation of eolian dust during MIS



12 triggered by Antarctic ice sheet growth, which driven the tropical rainbelt of both hemispheres northward. Tropical rainbelt acts as a barrier to cross-equatorial dust transport and can be used as a reference for assessing mean position of the Intertropical Convergence Zone.

Keywords: Arabian Peninsula, Aeolian dust, Orbit, Monsoon, Ice-sheet, Hominin migrations

【A0001】 -Poster

Human impact on dryland landscape: Insights from paleoenvironmental, remote sensing, and modeling investigations

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Self-organized dune fields, as complex systems, not only aggregate into spectrally homogeneous sand seas in arid regions but also give rise to sandy landscapes with mosaic patterns through interactions with vegetation in semi-arid areas. However, the maintenance of fully active sand seas and the emergence of mosaic landscapes in vegetated dune fields remain inadequately explained within a unified theoretical framework. Here we investigate the ecological collapse process of vegetated parabolic dunes in the Hulunbeier Sandy Land of northern China, specifically examining how a small perturbation can initiate a mosaic landscape in fragile drylands. We find that a once-stable parabolic dune system, which had remained stabilized since ca. 14–10 ka, began to destabilize around 30 years ago due to the coupling between a two-year drought and an unprecedented, yet small, anthropogenic disturbance. The subsequent three-year wetter period failed to mitigate this irreversible degradation. Our findings confirm that even a minor perturbation can alter the trajectory of a complex system when its phase space is characterized by declining resilience. Such interactions can trigger critical transitions in dune states at a local scale, ultimately leading to the formation of current common mosaic landscapes. This study offers a potential universal theoretical framework for understanding and reconciling the formation of diverse desert landscapes, both homogeneous and heterogeneous.

Keywords: Parabolic dunes, Complex system behaviors, Hulunbeier sandy land, Dune



reactivation, OSL dating

【A0672】 -Poster

Asynchronous palaeosol development during the past 20 ka in response to climate change across the dune fields of the Asian Summer Monsoonal boundary, northern China

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Aeolian landscapes dominate the semiarid dune fields across the Asian Summer Monsoonal boundary (ASMB) of northern China, where the widespread palaeosols are usually regarded as indicators of enhanced monsoonal precipitation (moisture) during the Late Quaternary. However, the processes of palaeosol development, and their response to climate change, remain controversial due to the complex land-atmosphere interactions within different bioclimatic zones. Here, we review the patterns of palaeosol development, precipitation/moisture (P/ M) evolution, and lake level fluctuations across different sub-regions of the ASMB. With the aid of typical temperature and vegetation records, we qualitatively and quantitatively distinguish the contributions of different climatic factors to palaeosol development since 20 ka (1 ka = 1000 cal yr BP) and elucidate the underlying mechanisms. Our results indicate an asynchronous pattern of palaeosol development, with optimum development during 10–4, 8–4, and 6–2 ka in northeastern (NE) China, north central (NC) China, and on the NE Qinghai-Tibetan Plateau (QTP), respectively. This implies a transmeridional asynchronous pattern of palaeosol development on the scale of the ASMB. Our qualitative and quantitative analysis of the contributions of climatic variables elucidates the various relationships between palaeosol development and the climatic background across different sub-regions of the ASMB. The results demonstrate that temperature and precipitation are the dominant factors for palaeosol development in NE and NC China, respectively; whereas effective moisture, rather than temperature and precipitation alone, controls palaeosol development on the NE QTP, demonstrating different pedogenic responses against the same overall climatic background. These mechanisms are supported by the results of multiple studies of Holocene vegetation evolution and the associated climatic conditions. We conclude that the asynchronous pattern of palaeosol development across the ASMB was caused by variations in different dominant climatic factors, highlighting the diverse and complex interactions of climate change and Earth surface processes, even within the



relatively uniform climatic environment of semiarid northern China. Our findings emphasize the differing responses of palaeosol development to regional climate change and provide new insights into the interactions of the land-atmosphere system in the critical zone of northern China.

Keywords: Palaeosol development, P/M evolution, Qualitative and quantitative analysis, Complex interaction of the land-atmosphere system, Asian Summer Monsoonal boundary

【A0544】 -Oral

Peat agriculture development and desertification in the Mu Us dune field, China

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The Mu Us dune field, located in the semi-arid region on the fringe of the monsoon belt in northern China, is a desert zone characterized by the transition between desert and loess, where agriculture and livestock coexist, and human activities are frequent. The formation and evolution of this region are closely linked to climatic conditions and human activity. Peat and palaeosol deposits, as products of favorable climate periods in the late Quaternary, are widely distributed throughout the Mu Us dune field. In recent years, driven by the urgent needs of population and industrial development, modern agriculture based on peat or palaeosol as the foundation has rapidly developed within the Mu Us dune field. This development has demonstrated great potential for improving soil quality, enhancing carbon sequestration, and contributing to the construction of desert grain silos. However, the peat and palaeosol, formed during geological periods, are non-renewable resources on short time scales, and their use or conservation has long lacked theoretical support and scientific planning. This study selects various types of modern farmland in the Mu Us dune field as the main research objects. Based on satellite remote sensing data and field observations, the study focuses on the current state of peat (palaeosol) agriculture at a regional scale. It addresses the fundamental scientific question of "utilization or conservation" and evaluates the potential desertification risk. The study concludes that the relationship between peat (palaeosol) agricultural activities and desertification in the Mu Us dune field is closely related. On the one hand, peat or palaeosol can effectively improve soil



fertility, enhance soil water retention, and significantly reduce the risk of wind erosion. As a result, modern agriculture in the Mu Us dune field has developed rapidly over the past decade. On the other hand, given the limited reserves of peat and palaeosol deposits in the study area, excessive exploitation or improper management could have severe negative impacts on the ecosystem, increasing the possibility of secondary desertification or large-scale dune activation. Therefore, it is recommended to conduct comprehensive surveys on the distribution, reserves, and characteristics of peat and palaeosol deposits in the study area. Additionally, the land management practices for existing peat (palaeosol) agriculture should be optimized, and potential desertification risks should be scientifically assessed and prevented. This would contribute to the sustainable use and restoration of desert ecosystems and address the fundamental scientific question of whether peat (palaeosol) in dune field should be utilized or conserved.

Keywords: Mu Us dune field, Peat agriculture, Desertification, Sustainable development

【A0591】 -Oral

The relationship between the climate of the Holocene optimum and human activities in the Mu Us Desert, China

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The Mu Us Desert, located on the northwest edge of the East Asian Summer Monsoon zone, at the transition between desert and loess regions, and within the northern agro-pastoral zone, is highly responsive and sensitive to climate change. It contains extensive Holocene aeolian and lacustrine sediments, which provide an excellent resource for reconstructing millennial-scale paleoenvironmental changes. Since the Neolithic period, human activities in the Mu Us Desert have been frequent, leaving behind numerous archaeological sites with stone tools, bone implements, copper artifacts, and faunal and floral fossils. This makes the region an ideal location for studying long-term environmental change sequences, exploring Neolithic human survival strategies, and constructing a historical narrative of Holocene human-environment interactions. This study focuses on the existing Holocene aeolian and



lacustrine sedimentary sequences in the Mu Us Desert, using data from AMS ^{14}C and OSL dating, combined with sedimentary facies analysis and environmental proxies, such as grain size, chemical elements, pollen, charcoal, and organic matter. These data allow for the reconstruction of the sedimentary environments associated with ancient river, lake, marsh, and desert landscapes during the Holocene climatic optimum. Additionally, the study delves into human activity data to reveal the spatiotemporal distribution patterns of archaeological sites and the changes in subsistence strategies since the Neolithic period. Preliminary results indicate that: (a) 8.5-3.0 ka marks the Holocene thermal maximum in the region, characterized by widespread development of paleosols and lacustrine deposits, with evident soil characteristics and high chemical weathering intensity; the vegetation composition likely consisted of *Artemisia*, *Taraxacum*, and *Stipa* grasses; (b) the period from 6.5-3.0 ka represents the climatic optimum, with the highest development of paleosols, the largest proportion of lakes and marshes, and the most frequent human activities. During this period, subsistence strategies shifted from settled agriculture in the Shao period (7.0-4.8 ka BP) to a mixed subsistence economy in the Longshan period (4.8-3.9 ka BP), combining agriculture, animal husbandry, hunting, and fishing, which may have contributed to cultural prosperity; (c) the natural environment of the Mu Us Desert and the intensity of human activities are closely related, reflecting the climate changes during the Holocene thermal maximum, which were influenced by the intensity of the East Asian monsoon.

Keywords: Mu Us Desert, Climatic optimum, Human activities, Environmental evolution

【A0553】 -Poster

Characteristics of Holocene sandy peat in Mu Us Sandy Land and its implications for climate and environment

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Mu Us Sandy Land is located in the marginal region of East Asian monsoon in China and is sensitive to climate change. There are a number of sandy peat layers in area, which record the climate change since the Holocene. On the basis of ^{14}C (AMS ^{14}C)



dating, Sand AI model was used to analyze the particle size, identify the sand transport environment, and calculate the peat deposition rate. The inversion results showed that the Holocene climate in Mu Us Sandy Land experienced three stages: From the dry and cold climate, the extensive sedimentary sand layer developed to the gradually warming climate, and went through the transition period of dry and cold climate to warm and wet climate, and finally formed a relatively warm and wet climate, and sandy peat layer developed. The Holocene sandy peat in Mu Us Sandy Land is an important geological carrier for the study of Holocene climatic and environmental evolution in this region, which is of key significance for the in-depth understanding of paleoclimate. This study focuses on Holocene sandy peat in Mu Us Sandy Land. Mu Us Sandy Land is located in the marginal region of East Asian monsoon in China and is sensitive to climate change. There are a large number of sandy peat layers in the study area, which record the climate change since the Holocene. On the basis of ^{14}C (AMS ^{14}C) dating, Sand AI model was used to analyze the particle size, identify the sand transport environment, and calculate the peat deposition rate. The inversion results showed that the Holocene climate in Mu Us Sandy Land experienced three stages: From the dry and cold climate, the extensive sedimentary sand layer developed to the gradually warming climate, and went through the transition period of dry and cold climate to warm and wet climate, and finally formed a relatively warm and wet climate, and sandy peat layer developed.

Keywords: Granularity, Climate change, Mu Us Sandland

【A1048】 -Poster

Mechanism of the significant increase in dust aerosols in inland Asia since the late Miocene-a regional climate simulation

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This study separately considered deserts formation and tectonic uplift in the northern Tibetan Plateau (NTP) to study the impact of the two events on dust emission in spring in East Asia and quantify their relative contributions to the dust emissions using a regional climate model. The results showed that the thermal effect of the uplift of the NTP induced a reduction in soil moisture, and its dynamic effect strengthened the westerly winds, thereby causing an increase in dust emission of major low-altitude



deserts in East Asia. The formation of these deserts directly led to a decrease in soil moisture, and the dust aerosols emitted from these deserts suppressed the water vapor at the surface by affecting the regional radiation balance. Meanwhile, it also enhanced dust emissions in the source areas by strengthening the westerly winds. Their contributions to spring dust emissions account for 20% and 80%, respectively. The source of dust on the Loess Plateau may be mainly due to the uplift of NTP, which facilitated the transport of dust aerosols from the Qaidam Basin to the Loess Plateau. This study highlights that the thermal and dynamic effect of the NTP, deserts formation, and feedback of dust aerosols may be the main driving factors leading to the increase of dust aerosols in inner Asia since the late Miocene. These findings provide an important reference for understanding the formation and development of the arid areas in East Asia.

Keywords: Dust aerosols, Soil moisture, Regional climate simulation, Uplift, Northern Tibetan Plateau

【A0453】 -Oral

Complex processes and nonlinear evolution of aeolian landscapes in response to climate change

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Arid regions occupy over 40% of the Earth's land surface and are home to more than two billion people. These environments are highly sensitive to global climate change and can influence regional and global climates through a series of feedback mechanisms, making arid zones a crucial component of the Earth's surface system. As systems characterized by multi-scale and multi-factor interactions, the aeolian environments in arid zones exhibit complex system processes, such as multiple stable state transitions and self-organized criticality. This presentation will first systematically review the evolution of the drylands in northern China on multiple timescales, including the late Cenozoic, late Quaternary, and the Last Glacial Maximum, focus on



the direct responses of environmental changes in this region to global temperature fluctuations and monsoon variations at tectonic and orbital scales. Next, the spatial heterogeneity and nonlinear responses of semi-arid dune systems since the Holocene are examined, with a focus on the dune bistability phenomenon, where active and stabilized dunes coexist under similar conditions. Using remote sensing data, stratigraphic evidence, and numerical modeling, the critical transitions of dune systems in northern China are characterized and their dynamic mechanisms are explored. Finally, using nebkhas and other aeolian landscapes as examples, this presentation discusses their spatiotemporal variations and nonlinear behaviors under future climate change impacts. By incorporating theoretical models, machine learning approaches, field evidence and remote sensing analysis, this presentation demonstrates how interdisciplinary study deepens our understanding of complex and nonlinear processes in the evolution of aeolian landscapes, providing valuable insights for sustainable development in arid regions and for desertification control efforts.

Keywords: Aeolian environmental change, Dune bistability, Nonlinear processes, complex systems, Climate change

【A0900】 -Poster

Luminescence dating of young aeolian dunes in the central Tibetan Plateau

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The extensive aeolian dunes on the central TP provide a direct and valuable archive of aeolian activity; however, the age and sediment deposition processes of these dunes are still poorly understood. Optically stimulated luminescence (OSL) dating, an effective method for dating aeolian sediments, has been used sparingly in the region. In this study, we applied quartz single-aliquot regenerative-dose (SAR) OSL, K-feldspar post-infrared infrared-stimulated luminescence (pIRIR), and single-grain K-feldspar pIRIR methods to determine the ages of two well-preserved sand dunes in the Lunpola (LD) and Tuotuohe (TTH) river basins in the central TP. Our results showed that the quartz OSL signal of the TTH dune was dim, while the LD dune quartz exhibited a higher OSL sensitivity than that of the TTH dune. The high recuperation observed could be



attributed to the low signal-to-noise ratio of the OSL signals. The K-feldspar signal was bright, and the pIR₅₀IR₁₇₀ signal could be used to date young dune samples in the central TP, whereas it could be affected by the residual dose, or incomplete bleaching in the TTH profile, resulting in age overestimation. The single-grain K-feldspar protocol had a good potential for dating the young TP dunes. Multi-method luminescence dating is recommended for the cross-checking of young dune samples with low OSL sensitivity in the TP. Our luminescence dating reveals that aeolian dunes in the central TP formed approximately 385 to 330 a and persisted to the present, possibly in response to climate change since the late stage of the Little Ice Age.

Keywords: OSL dating, Dune, PIRIR dating, Little Ice Age, Tibetan Plateau

【A0053】 -Oral

Large-number detrital zircon U-Pb ages reveal global cooling caused the formation of the Chinese Loess Plateau during Late Miocene

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The transportation of surface materials and the evolution of landforms are important links in the interaction between various layers of the Earth system. The erosion, transmission, and deposition of dust substances are controlled by multiple factors such as structure and climate, and have significant impacts on global temperature, precipitation, carbon cycle, and so on. The Chinese Loess Plateau is the geomorphic unit with the largest and longest accumulation history of dust on land. The study of the transmission process of dust on the Chinese Loess Plateau can provide key evidence for the generation, transmission, and driving mechanisms of dust globally. This study used the large sample method of detrital zircon U-Pb age tracing. Based on a thorough investigation of the material characteristics of detrital zircon U-Pb age spectra in potential source areas, more than 37000 age data from nearly 100 samples were statistically analyzed. Combined with source area classification and Monte Carlo



simulation, a new model for quantitatively tracing different source areas was proposed. Based on this, quantitatively estimate the changes in the contribution of different source areas to dust on the Chinese Loess Plateau over the past 8 million years. Summarize the dust deposition flux data of the Chinese Loess Plateau over the past 8 million years, combined with published geochemical and mineral composition data, to comprehensively analyze the changes in material sources and regional weathering intensity on the Loess Plateau. Research has found that the northeast of the Qinghai-Tibet Plateau is the main source area of the Loess Plateau. The process of dust erosion and transmission in the source area of the Loess Plateau is mainly controlled by climate. Since the late Miocene, the world has gradually cooled down, exacerbating the glacial and periglacial processes in the northeast of the Qinghai Tibet Plateau and regional aridification, which has led to an increase in regional dust emissions.

Keywords: Chinese Loess Plateau, Dust emission, Detrital zircon

【A0514】 -Poster

Spatio-temporal changes and suitability evaluation of photovoltaic power stations in China's Desert Regions

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Desertification is a significant ecological issue that affects human survival and development. China is one of the most desertified countries in the world, with 1.68 million square kilometers of desertified land, accounting for 17.58% of the country's total land area. Photovoltaic (PV) desertification control, as an innovative method for combating desertification, not only generates economic benefits from clean energy but also plays a crucial role in mitigating the expansion of desertified areas. Although substantial research has been conducted on the ecological aspects of desert PV, systematic studies on the evolution of desert PV distribution patterns and the factors influencing these changes remain relatively scarce. This study uses the 2010-2022 photovoltaic station distribution dataset for desert areas in China, employing various spatial analysis techniques such as standard deviation ellipse analysis and kernel



density analysis to explore the spatial distribution patterns and evolution of PV stations in northern China's desert regions. Furthermore, multi-source data and machine learning algorithms are utilized to assess the suitability of these areas for PV development across multiple spatial scales. The results indicate that the spatial pattern of desert PV in China can be roughly divided into three phases: (a) a rapid growth phase from 2010 to 2016; (b) a fluctuation and instability phase from 2016 to 2021; and (c) a transformation phase from 2021 to 2022, with a notable trend of large-scale development in the eastern desert regions. Overall, PV desertification control occupies a limited proportion, with the desertification control area accounting for approximately 2% of the total desertification area. (d) Preliminary findings from machine learning, combined with SHAP analysis, suggest that the key factors influencing the suitability of PV station construction, ranked by importance, include land use type, power grid density, topography, and vegetation. These findings provide valuable scientific evidence and guidance for the future siting of PV stations in desert regions and the evaluation of desertification control effectiveness.

Keywords: Machine learning, Photovoltaic power station, Suitability assessment, Spatiotemporal analysis



Session 18. Exploring rapid cultural change: Tipping points, cascading impacts and human societal evolution

Conveners: Martin Hinz, Albert Hafner

【A0036】 -Poster

Indigenous perspectives and sensitivities to climate change impacts and adaptation capacities: A participatory research among Smallholder farmers

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Extreme weather events have led to multi vulnerabilities in many parts of the world, particularly in some African countries with recent severe drought, flood, and intra-seasonal dry spells which have great impacts on Smallholder farming productivities. Therefore, this study examines Indigenous farmers' sensitivities to climate change and their adaptive strategies at the local level. The study focus on investigating the role of Indigenous knowledge through the participatory research method in the assessment of climate change impacts and adaptation measures among the Indigenous Smallholder farmers in Nigeria. Through the participatory research method, local indicators of climate change impacts were assessed through Indigenous perspectives and adaptation options embraced by the local farmers were evaluated. A practical, hands-on research placement outside of an academic setting was carried out in two major farmers communities. The results show that the majority, nearly 97%, of farmers perceived changes in times for the start and finish of the rains during the growing seasons and noticed that low yield of some crops in recent years compared to the past 30 years. Indigenous farmers awareness of climate change, its impacts and specific adaptation measures among rural farmers were seen as local-driven assessments for appraising local indicators of climate change in the study cites. This study has enhanced the Indigenous perspectives and sensitivities to climate change impacts among local Smallholder farmers. This research improved our understanding of how climate change affects Indigenous Smallholder farmers and their socioeconomic systems through the documentation and analysis of local indicators and perceived effects of climate change.



Keywords: Climate change, Societal implications, Adaptive capacity, Participatory research

【A0034】 -Poster

Evidence-based hydroclimate policy outcomes of climate change induces water shortages in tropical cities

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The study provides evidence-based of climate change impacts on water supply in four urban sprawl communities in tropical cities. This study aims at assessing the spatial and temporal hydroclimate variability and change impacts on water availability and supply and the stress the people face to get water during different seasons and climate extreme events. Using historical satellite climate datasets and social surveys, the study assesses the water supply stress during different seasons in urban sprawl communities. Seasonality and spatial-temporal variability analysis were used to examine changes in both rainfall and temperature. Categorization and classification methods were used to assess the local people's perception of climate change impacts on water availability. The results show that there is a significant downward trend in rainfall intensity and frequency with an increase in temperature in recent years. The mean minimum temperature has increased by $1.0^{\circ} < T_{\min} > 1.3^{\circ}\text{C}$ in urban sprawl communities in recent years. Comparing initial years: 1903-1930 with recent years: 1991-2020, it was obvious that both $T_{\max}$ and $T_{\min}$ are getting increasing in trend, rising by 1.5°C . Thus, approximately 80% of the local people perceived that temperature intensity in their communities has increased and over 60% of the participant noted changes in the number of rainy days. The results further ascertain an increase in water stress resulting from climate change, with much more burdens on women, who are forced to walk a long distance to fetch drinking water for the households, during the extreme dry seasons. The results from the present study imply that women bear more burdens of getting a safe drinking water supply during a severe dry spell and drought. There is a need for better provision and management of safe drinking water as an adaptation policy and strategy for urban sprawl communities in Africa. This is an important first step towards attaining SDG goal 6 which targets improving clean water and sanitation for all by 2030.



Keywords: Climate change, Water shortages, Water stress, African cities

【A0928】 -Oral

Beyond local limits: External resources and socio-ecological resilience on ancient Euboea

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The island of Euboea, located in the Aegean Sea, provides an illuminating context for studying the interplay between human societies and fragile ecosystems in constrained environments. Euboea stands out as a key focal point in the formation of interregional networks, serving both to define and to bridge regional social connections: the mainland, the Aegean islands to the north and the Cycladic islands to the south. However, the implications of this network centrality to the island's population dynamics remains poorly known.

This study aims to identify and estimate the share of Euboea's effective carrying capacity enabled by imported off-island resources and activities, from Prehistory to the Classical and Hellenistic periods (5th–3rd centuries BCE). Carrying capacity (namely *the carrying capacity of an environment to a population*) is a concept formulated in ecology that aggregates all factors, principally those considered environmental, that contribute to a theoretical population maximum (Chapman and Byron 2018). This concept has been widely used with increasing recognition that population limiting factors can and often are dramatically influenced by sociocultural conditions.

Expanding on the concept of carrying capacity, we investigate Euboea's reliance on *ghost acreage* (Borgstrom 1965) or *phantom carrying capacity* (Catton 1980) to supplement its limited natural resources in sustaining its effective population throughout its history, particularly the input received through maritime trade networks (Mastrogiannopoulou and Sampson 2017). This integrative perspective guides the investigation of Euboea's landscape use, abuse, and transformation as a case history reflecting broader patterns of environmental challenges in the



Mediterranean.

Using a simulation approach, we analyze how ancient societies on Euboea managed their agricultural and natural resources and how reliance on external resources, such as trade intensity (imports and exports of food resources) impacted the resilience of their socio-ecological systems (population density and growth rates; technological level; erosion and deforestation), potentially causing the island population to overshoot. We propose a multiparadigm model that integrate the dynamics of environmental variables, including soil fertility, climate variability, and resource distribution, and an Agent-Based Modeling component to simulate socio-economic behavior and interaction of households differentiated by economic role (e.g. producers, landowners and traders). Although preliminary, an extensive exploration of model dynamics is compared to archaeological and historical proxies.

We expect that our findings underscore the significance of soil conservation, and the delicate balance required to maintain community resilience in restricted island environments. While internal resources were recognizably finite, Euboea's reliance on external connections mitigated local resource constraints, illustrating how ancient societies, much like ours today, extended their effective carrying capacity beyond the island's physical conditions or visible landscape. Inevitably, these expansions were enabled by favorable regional exchange and good production conditions elsewhere, both of which were often unpredictably fluctuating.

This research also draws connections to the challenges faced by modern Mediterranean landscapes, where urbanization and agricultural intensification threaten the preservation of historic *agriscapes* and ecological balance. By linking past practices to contemporary sustainability issues, the study offers valuable insights into the importance of managing complex dependencies on both local and external resources to ensure long-term resilience in vulnerable environments.

Keywords: Agent-based model, Archaeology, Carrying capacity, Ghost acreage

【A0933】-Poster

Biogeochemical tools to reveal the interaction between climate, archaeology, and arid forest landscapes in the Atacama Desert over the last 13,000 years (Pampa del Tamarugal)

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Biogeochemistry provides valuable information to complement our understanding of human-environment interactions based on geological and archaeological records. These techniques are especially useful in historically understudied socioecological systems like the arid forests of the Atacama Desert, where information is often fragmented within archaeological palimpsest contexts. The Pampa del Tamarugal—a desertic forest in northern Chile characterized by tamarugo tree (*Strombocarpa tamarugo*), specie adapted to extreme arid conditions—provides an ideal setting to study the mobility of ancient hunter-gatherers and their relationship with the landscape using molecular techniques. Long-chain n-alkyl lipids and sterols measured in soils and ancient forests have significantly complemented archaeological and socioecological studies. These biomarkers reveal human presence in fossilized forest remains that grew when the Central Andean Pluvial Events (CAPEs) sustained high groundwater levels during the Late Pleistocene–Holocene transition. This wet episode allowed the expansion of vegetation in the driest desert on Earth. Additionally, $\delta^{13}\text{C}$ and δD in plant biomarkers is an excellent opportunity to reveal evaporative processes and water stress experienced by vegetation during these humid episodes. This type of data together with fecal sterols attributed to herbivores and omnivores diets will give crucial information on wet episodes in this arid area. Our findings suggest that the CAPEs facilitated forest expansion supporting diverse animal life, crucial for the subsistence of past human communities. This integrated biogeochemical approach not only enhances traditional archaeological evidence but also provides deeper insights into climate, environmental changes, and human activity over the last 13 kyrs in the Atacama Desert.

Keywords: Arid Forest Landscapes, Human-environment interactions, Pleistocene-Holocene transition, Central Andean Pluvial Events



【A0079】 -Oral

Climatic and environmental promotion of the earliest rice cultivation in the Hemudu Culture, China

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Initial rice cultivation started in the lower Yangtze during neolithic period, and domestication greatly progressed in the Hemudu Culture (7000-5300 BP) which flourished in the Yaojiang plain. Recent archaeological findings and paleoenvironmental studies suggest that the origin of rice cultivation in the area trace back to before cultural period. However, rice pollen and phytolith concentrations are low due to high sedimentation rates of marine deposits underlying cultural layers. Moreover, during cultural period, site numbers in Yaojiang increase although cultivation records are interrupted at each sediment cores. We can guess that environmental changes affected rice cultivation.

We got climatic and environmental records during and before Hemudu Culture from two sediment cores bored in Yaojiang plain by dating ¹⁴C ages, analyzing biomarkers [$\delta^{13}\text{C}$ and δD of long-chain fatty acids, polycyclic aromatic hydrocarbons (PAHs), pentacyclic triterpene methyl ethers (PTMEs) of grass origin, and branched Glycerol dialkyl glycerol tetraethers (GDGTs)] and microfossils (pollen, phytolith and diatoms).

In the marine layer underlying paddy layers, rice derived PTMEs were dominant in all detected PTMEs although lack of rice pollen and phytolith. Hence, we found that rice was already major plant before the Hemudu Culture appeared. In paddy layers, PTMEs



and fatty acids δD records indicated that rice cultivation was active when precipitation amount was high. Further, maritime diatoms were included in paddy layers. We interpreted these results as follows. Coastal plain was suited for tidal irrigated paddy fields without high engineering skills and high precipitation desalinized paddy fields and promoted cultivation.

Keywords: Rice cultivation, Neolithic culture, Biomarkers, Microfossils

【A1008】 -Poster

Exploring rapid cultural change in early farming societies: The role of past climate and environment

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Waterlogged prehistoric archaeological settlement sites in Europe, particularly in the Alpine region and the Balkans, provide exceptionally detailed chronologies spanning the last 8,000 years. This level of precision is achieved through dendrochronological analyses of construction wood, which, in some cases, allow settlement biographies to be reconstructed with annual resolution. By integrating archaeological data from these sites with both onsite and offsite paleoecological data derived from sediment cores, researchers can identify episodes of rapid cultural change. Environmental factors can have both positive and negative societal impacts: they may enable the expansion of agriculture, reshape settlement systems, or lead to the rapid abandonment of settlements. Conversely, not every observable social change is necessarily driven by environmental factors.

This study presents several mid-Holocene case studies, illustrating how climate and environmental conditions influenced early agricultural societies and examining their effects on the adaptation and resilience of these vulnerable prehistoric communities. Additionally, it explores whether these societies experienced disruptions in the form of tipping points or whether they developed opportunistic economies that rendered them more resistant to environmental influences.

Keywords: Neolithic, Rapid cultural change, Early farming societies, Dendrochronology



【A0894】 -Oral

**300 years of rapid cultural and climatic changes at annual resolution:
Bronze Age ‘pile dwellings’ and the Löss Cold Period (1750–1450 BCE)**

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Prehistoric ‘pile dwellings’ have been discovered in numerous bogs and lakes around the European Alps (UNESCO World Heritage 2011) and provide a unique long-term perspective on the resilience and vulnerabilities of waterfront communities to climate change. Their construction histories can be dated to the exact calendar year using dendrochronology. In this paper, we explore a rapid change in Bronze Age societies that coincided with a period of rapid glacier advances and retreats. While lake shores were populated in the northern Alpine Foreland during the Early and the Late Bronze Age, during the Middle Bronze Age (ca. 1480–1190 BCE) there was an apparent absence of ‘pile dwellings’ lasting more than 290 years. The reason for this shift in settlement activity is still debated. One long-standing hypothesis states that a cold climate led to rising lake levels and rendered former lake shore settlement areas uninhabitable. However, the relations between climatic changes, lake levels and lake shore settlements are still poorly understood. For the first time, we apply a socio-archaeological mixed methods approach from archaeology and micromorphology, including time series statistics on annually-resolved archaeological and paleoclimatic proxy data, to tackle these questions in the scope of the SNSF research project “RISE: Climate Change Resilience and Vulnerabilities of Bronze Age Waterfront Communities (2200–800 BCE)”.

Keywords: Bronze age cultural change, Central europe, Circum-Alpine Lakes, Pile dwellings, Löss Oscillation

【A0997】 -Poster

Signals of change: A semi-quantitative approach to social and demographic tipping points



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In archaeology, the interplay between climate data and social developments is frequently analyzed through demographic proxies, such as summed probability distributions (SPDs) of radiocarbon dates. Besides methodological issues, while they still might be useful for reconstructing population trends, these proxies inherently lag behind the events that trigger social tipping points. Generational delays in the demographic signal, compounded by dating uncertainties and the smoothing effects of calibration methodologies, often obscure the precise timing and nature of transformative thresholds.

Addressing this challenge is central to my ERC project ESTER, which focuses on reconstructing population estimates for Europe and Western Asia over the past 12,000 years. In case studies, ESTER also examines the intersection of population dynamics with environmental changes and technological innovations. To identify early warning signals of demographic shifts and better understand their triggers, we must look beyond demographic proxies to include social and cultural indicators. However, these indicators are often dispersed, heterogeneous, and qualitative in nature, requiring new methods for their systematic analysis.

A promising solution lies in the semi-quantification of these indicators, enabling their integration into comprehensive frameworks for assessing societal change. This presentation outlines ESTER's strategy to develop such methods, focusing on identifying cultural transformations, social shifts, and precursors to demographic processes. Semi-quantitative approaches allow for the detection of tipping points and the evaluation of their underlying drivers, bridging the gap between qualitative and quantitative analysis.

To move beyond visual interpretation of trends, I will demonstrate the application of Monte Carlo-based statistical tests, following the methodology of Kintigh and Ingram (2017). These tests assess whether societal transitions align significantly with climate events or other drivers, offering a more robust framework for testing causal relationships. This approach sheds light on whether environmental changes acted as primary triggers for tipping points or whether other factors, such as innovations or



social pressures, played decisive roles. Additionally, I will explore the adaptation of attribution research methodologies, commonly employed in climate science, for archaeological investigations. These methods aim to disentangle complex cause-effect relationships and enhance our understanding of human-environment dynamics.

By presenting ESTER's conceptual framework and initial results, this talk contributes to advancing interdisciplinary dialogues on rapid cultural change. It aligns closely with the session's goal of exploring tipping points and cascading impacts within human societal evolution, offering novel tools and perspectives for identifying and analyzing the triggers of transformative change.

Keywords: Social tipping points, Semi-quantification, Demographic proxies, Cultural indicators, Monte Carlo methods

【A0105】 -Poster

Rapid or gradual cultural change: exploring the Bantu migration and its impacts on the indigenous communities in East and Southern Africa

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The Bantu migration is one of significant event occurred for about 4000/3000 BP in sub-Saharan Africa. The event involved movement of Bantu-agropastoralists group who traces their origin from Nigeria-Cameroon border and spread to other parts of sub-Saharan Africa via Congo rainforest. The reason for such migration has remained debatable however; it has been affiliated to environmental issues and increase of population pressure over the land. The nature of interaction between Bantu and indigenous communities is debated among archaeologists, linguists, historians, biologists, and ethnographers. While some scholars believe that the nature of interaction was associated with dislocation/absorption and replacement of indigenous (Later Stone Age Hunter-gatherers), other scholars believe on gradual cultural changes involving adoption/accluturation and diffusion. The current study presents such debates by bringing the empirical archaeological evidence from Southern Highlands of Tanzania whereby through stratigraphic analysis, material composition, and chronological considerations the study supports the acculturation mode of



interactions for those two cultural groups. Such conclusion is supported by other secondary data derived from genetic, linguistic, and archaeological evidence done broadly Africa and the same region in specific.

Keywords: Bantu, Sub-Saharan Africa, Indigenous, Interaction

【A0130】 -Oral

Bronze Age tells and mega-sites in the Carpathian Basin around 1500 BC – decline, cultural change and rise

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In the middle of the 2nd millennium, drastic changes took place in the rich Bronze Age culture of the Carpathian Basin. These changes can also be seen in the settlement structures, which within 100 years show a comparatively rapid transition from tell settlements along river courses to large fortified settlements (mega-sites) in the open country. This is associated with changes in population size and economic practices.

In the 16th/15th centuries BC, after the end of the tell settlements and the transition from the Middle to the Late Bronze Age with the large mega-sites, the ecological conditions seem to have changed. On the one hand, overexploitation of the ecosystem is blamed for making the 'tell' economic and social model unsustainable; on the other hand, a deterioration of the climate is blamed for the decline in agricultural production, which ultimately led to the collapse of the existing cultural and social system.

From the 15th century BC onwards, huge fortified mega-sites emerged on the eastern edge of the Carpathian Basin, whose origin, significance and function remain largely unexplained. Our investigations show that seasonal to prolonged droughts were now common, which may have been a possible reason for the shift of settlements from the river courses to the plateaus. In the subsistence economy, the variety of cultivated plants increases, with millet in particular being new compared to the Middle Bronze Age and gaining central importance. In terms of domestic animals, the high proportion of horses in the tell settlements declined sharply. The proportion of sheep and goats decreased and cattle became increasingly dominant. The reasons for these far-reaching changes have led to an intensive discussion of the socio-economic bases and



forms of social organisation. Questions about the development and size of the population and the role of elites in these large settlements remain largely unanswered.

Keywords: Bronze Age, Cultural change, Tell sites versus mega sites, Carpathian basin, around 1500 BC

【A0985】 -Oral

Relationship of ancient Liangzhu City development and environmental changes

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The Liangzhu culture is considered to be the testification of the five thousand years history of Chinese civilization, and has thus attracted a great deal of attention from the archaeological community. However, the rise and fall of the Liangzhu culture, especially the cause of its vanishing, is still a topic of intense debate. Here we utilize geochronology, sedimentology, and microfossil analysis of three boreholes and one profile in the research area to investigate the impact of Holocene geomorphological evolution on the development of Liangzhu Ancient City and explore how human activities respond to climate and environmental changes.

The results indicate that: From the last deglaciation to the early Holocene (before ca. 9400 cal yr BP), the Liangzhu area was widely exposed, and the cores contain coarse sand, gravel, and hard clay layers. During the early to middle Holocene (ca. 9400 – 7600 cal yr BP), the area was rapidly submerged by a westward marine transgression, and the subsequent marine regression moved eastward from the Liangzhu area at approximately 7900–7600 cal yr BP when the rate of sediment supply exceeded the rate of relative sea level (RSL) rise. During the middle to late Holocene (after ca. 7600



cal yr BP), the deposits mainly originated from overbank flooding or from storm surge events rather than from direct RSL rise from ca. 7600–6600 cal yr BP. The Liangzhu Ancient City area remained a swamp and an area of salinization until ca. 5100 cal yr BP. Our findings indicate that between 8.0 and 5.3 ka BP, the Liangzhu area was characterized by fluvial sediment and predominantly comprised of evergreen/deciduous broad-leaved forest vegetation with a warm and humid climate. A shallow wetland environment emerged during 5.3–3.2 ka BP, with a shift to drier conditions and increased occurrences of extreme precipitation events. From 3.2 to 2.0 ka BP, an underwater reduction environment prevailed, although the climate became increasingly arid. Since 2.0 ka BP, the sedimentary facies transitioned from static water deposition to weakly oxidized deposition exposed to the ground. During the Liangzhu Culture period (5.3–4.3 ka BP), humans adapted to local conditions by transforming intermountain wetlands into reservoirs to address flood control requirements, drought relief, and waterway transportation. Pollen data from this period show an expansion of wetland vegetation but a decrease in the proportion of woody plants. Combined with the broad-leaved wood remains excavated in Liangzhu Ancient City, this may indicate that nearby broad-leaved trees were cut and transported to Liangzhu Ancient City for construction. During the late Liangzhu period (4.5–4.3 ka BP), the unstable sedimentary environment and the cooling and drying climates likely contributed to the cultural decline of Liangzhu. Consequently, the reservoir was abandoned, and mountain vegetation reverted primarily to evergreen broad-leaved trees. Against the backdrop of increasingly arid and deteriorating climate conditions, the Liangzhu people's transformation and utilization of wetlands represent a quintessential case of prehistoric civilization adapting to environmental changes, thereby playing an important role in facilitating human society's adjustment to adverse climatic environments.

Keywords: Liangzhu culture, Holocene, Neolithic, Environmental changes

【A0135】 -Oral

Possible roles of culture and climate in Denisovan extinction

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Denisovans, an archaic human group whose genomic introgression has helped Homo



sapiens adapt to environmental extremes, lived in eastern Eurasia at least during the two last glacial cycles. When, where, and why Denisovans ultimately went extinct is unknown. We explore the potential scenarios of Denisovan extinction and quantify the roles of climate and culture using a new version of Hominin Dispersal Model (HDM version 3). Our stochastic partial differential equation model simulates simultaneously the population density, as well as culture, of different human groups (i.e. Denisovans, Neanderthals, and Anatomically Modern Humans-AMHs) in a spatiotemporally changing climate of last 220,000 years and accounts for dispersals, climate-dependent habitats and food resources, population growth, cultural innovations and losses, competition, and interbreeding. Culture is introduced in our model as a boosting factor to total carrying capacity and determines the relative competitiveness between interacting groups based on their respective cultural sophistication levels. By mimicking the Neanderthal extinction event as documented by fossil data, our model also simulates spatiotemporal Denisovan distributions, last refugia, and their interactions with the Neanderthals and the AMHs who dispersed from Africa before and after 60,000 years ago, respectively. A series of parameter sensitivity simulations reveal the essential role of asymmetric cultural cumulations, which are accompanied by competitive advantage for the late AMHs relative to others, in driving Denisovan extinction, and the important climatic effect on regional extirpation patterns.

Keywords: Human evolution, Paleolithic cultures, Climate change, Hominin dispersal model, Model-data integration

【A0208】 -Poster

Assessing the impacts of climate change on endemic species in central Morocco: The case of *Argania spinosa*

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The current research focuses on understanding the impact of climate change on key climatic parameters, particularly temperature and precipitation. These factors are closely linked to vegetation, agriculture, and livelihoods, highlighting the critical



importance of this study. The research employs modern pollen analysis as an environmental indicator to explore the intricate relationships between pollen distribution, contemporary vegetation, and climate change in central Morocco. The case study offers valuable insights into the profound effects of climate change on endemic species, with a particular emphasis on the argan tree (*Argania spinosa*). The findings reveal a complex interplay of climatic factors influencing surface pollen distribution. Severe drought, desertification, and soil degradation have led to shifts in vegetation composition, with a notable transition towards steppe vegetation dominated by Cichorioideae, Poaceae, and Cyperaceae. Distinct pollen assemblage clusters reflect diverse plant communities shaped by varying climatic conditions, ranging from semi-arid to desert environments. Moreover, the study highlights the degradation of the argan tree, a keystone endemic species, driven by climate change and human activities such as overgrazing and deforestation. This tree, which holds significant ecological, botanical, economic, and social value, is increasingly threatened by prolonged drought, rising population pressures, and the expansion of pastoral activities.

Keywords: Pollen, *Argania spinosa*, Climate change, Central Morocco

【A0693】 -Oral

Trace of prehistoric human migrations from lowland to highland in South Asia: An illustration of population movement from Indus Basin to Himalaya as adaptation to climate change

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Human have evolved through a complex system of climate and environmental interactions. Indian Summer Monsoon (ISM) played critical role in shaping human societies and their culture both in highlands and lowlands of South Asia since pre-historic times. Harrapan Civilization flourished in major fluvial systems of Indus Valley under normal monsoon conditions, which boosted agriculture and complex urban landscape during mid-Holocene Period. However, in later Holocene period strong aridity and protracted droughts had a cascading impact on water availability and agriculture leading to collapse of Indus Civilization. To adapt to increasing aridity, large population from Indus Basin migrated to the Himalayan mountains as these regions still received optimal rains from Summer Monsoon as well as from westerlies during



winter seasons which was conducive to agriculture and ecodiversity. Understanding past climate change-induced migration may provide valuable insight to advance knowledge of cascading impacts of climatic-extremes on human and to improve scientific understanding of human colonization and adaptation in the Himalayan mountains.

The main objective of the study is to advance scientific knowledge on the climate change-induced human migration from Indus Basin to Himalaya and help evolving effective coping and adaptation framework to ongoing climate change. The methodology included: (i) comprehensive review of geological, archaeological, palaeobotanical, palaeoclimatological historical, linguistics, genetics and ethnographic records; (ii) reconstruction of knowledge based on the interpretation of critical marine and terrestrial palaeobotanical, limnological and climate data for the past 10 kyr Bp; (iii) direct consultation and interaction with a range of experts specifically climatologists, archaeologists, geologists, anthropologists, historians and paleobotanists.

Findings of the study: (i) rejected the hypothesis of Himalaya being a barrier for human movements as multi-disciplinary datasets traced considerable population movement from Indus Basin to Himalayan mountains from an early date; (ii) early artifact bearing sites in Himalaya hold significance in understanding the extent of human colonization in Himalaya in relation to climate; (iii) foothill region extending parallel to Himalayan mountains in the south acted as a pivotal passageway for constant migration at varying periods; (iv) these facts are reflected by the presence of human skeletons, burials with intricately made grave goods including ornaments and lithics, stone artifacts, stone and bone tools, and numerous cultural similarities between the current mountain and Indus Valley societies; and (v) Neolithic evidences also suggest the presence of semi-nomadic populations practicing early forms of agriculture and domestication of both fauna and flora in Himalaya (7000-5500 BC or ~8950 to 7550 yr BP). The study suggests that interactions of Indian Summer Monsoon (ISM) and westerlies in Northwest Himalaya produced a complex climate dynamic conducive for human settlement during the late Holocene. The routes connected the mountains with lowlands not only created a vertical model that facilitated constant human dispersal, assembled many cultures and enabled fluid socio-cultural interactions, but also equipped human to evolve innovative practices to adapt to climate change and climatic-extremes. Thus, past climate change-induced migration may provide valuable insight to improve scientific understanding of the evolution and adaptation of human societies in Himalaya.



Keywords: Climatic-extremes, Human skeletons, Human adaptation in Himalaya, Domestication of fauna and flora, Vertical model of human dispersal

【A1038】 -Oral

Palaeolandscape evolution during the period of Middle Stone Age occupation of Blombos Cave, South Africa.

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Archaeological sites in caves along the southern coast of South Africa are important for understanding the early emergence of complex human behaviour. Research within the multi-disciplinary Centre of Excellence in Early Sapiens Behaviour (SapienCE) has focused on interrogating whether the capabilities of Middle Stone Age *Homo sapiens* to innovate and develop symbolic behaviour at sites such as Blombos Cave were influenced by environmental and climate changes. Detailed (geo-) archaeological studies have revealed shifts in the frequency and nature of site use (Haaland et al., 2021), subsistence strategies (Reynard and Henshilwood, 2019), and emergence of symbolic culture (Henshilwood et al., 2018). Changing climate conditions and distance between the cave and coastline have been drawn on to explain findings in the archaeological sequence, where environmental variability and periods of social stress can drive complexity in social interactions. Emerging datasets from marine cores, speleothems, and climate models suggest that within a backdrop of regional shifts in climate, conditions likely varied at the local scale (Göktürk et al., 2023). Here, we reconstruct palaeoenvironmental conditions directly surrounding Blombos Cave by studying sedimentary features across the coastline. We targeted aeolianite and palaeosol sequences for geochronological and palaeoenvironmental analyses. These deposits reflect varying periods of environmental stability and instability between 100 ka and 70 ka (Jacobs et al., 2020). We extend this chronology with new optically stimulated luminescence (OSL) ages and we use sedimentological, mineralogical, and geochemical approaches to reconstruct the nature of palaeolandscape evolution over time. This work complements detailed micromorphological analyses of cave sediments to link the archaeological sequence with evidence of a changing surrounding



landscape.

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Keywords: Palaeolandscape, Middle Stone Age (MSA), Sedimentology, Luminescence dating

【A0236】 -Oral

Modeling spatiotemporal neanderthal population dynamics in response to cultural evolution

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Culture for prehistoric populations represents their ability to innovate and utilize tools



and strategies to effectively acquire resources, thereby enhancing survival and reproductive success. Initially, we introduce a method to quantify Homo sapien and Neanderthals culture by utilizing Production Unit (PU) counts, which represent the sequential steps involved in manufacturing stone tools and capture the intricacies and nonlinear progression of technological complexity. These PU counts form the foundation of our data-driven stochastic cultural reference state. To model the cultural evolution, we employ a relaxation ordinary differential equation (ODE) framework, where the cultural reference state acts as an equilibrium, driving the system towards it over time. Subsequently, we quantify the influence of this data-driven culture on dispersal, competition, competitive exclusion and extinction scenarios for the case of Homo sapien versus Neanderthals over the global grid. In view of the stochastic nature of our cultural evolution model and to account for the uncertainties, we employ controlled stochastic elements that align with empirical uncertainty bounds, ensuring that fluctuations remain consistent with observed data. This method provides a robust, data-driven representation of cultural evolution and the corresponding population responses to it, enabling a realistic depiction of Homo sapien and Neanderthals population dynamics.

Keywords: Cultural evolution, Neanderthal extinction

【A0145】 -Oral

The impact of human activities on vegetation during the late Holocene in the West Liao River region

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The influence of human activities on vegetation has always been one of the hot issues in ecological research, but more and more evidence shows that since the Holocene, human activities may have been one of the important factors driving vegetation changes in the historical period. Situated in a transitional zone between forests and grasslands, the West Liao River region stands out as an area where early millet cultivation and pastoral civilization flourished. The West Liao River region has a rich history of human activities during the Holocene period. The Xiajiadian Lower Culture, characterized by agriculture, as well as the Xiajiadian Upper Culture and Liao-Jin



Culture, characterized by pastoralism, have been all discovered in this region. In this study, based on the sediment pollen samples extracted from an oxbow Lake in the southern part of the West Liao River region, we used the Modern Analogue Technique (MAT) to reconstruct the paleoenvironment influenced by human activities in the late Holocene, and combined with the vegetation dynamics model LPJ-GUESS to simulate the potential natural vegetation under the climate conditions. By comparing the pollen-based vegetation with the climate-controlled potential natural vegetation, we quantitatively assess the human effects on vegetation by different production modes during the late Holocene in the West Liao River region.

Keywords: Pollen, Holocene, Human activities, Paleovegetation reconstruction, West Liao River region

【A0020】 -Oral

Holocene variability of East Asian winter monsoon dominated human activity in Central and Eastern China

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Contemporary climate research increasingly spotlights on understanding the intricate and crucial relationship between climate changes and human societies. Palaeoclimate reconstructions can offer valuable insights into the ways in which culture evolution were influenced by their surrounding environments. In particular, climate in the Holocene is of great concern, which can give a measure or baseline of the climatic optimum for agriculture-based societies. As such, evidence for reconstructing and understanding climate changes is more abundant for the Holocene.

For much of East Asia, interest in East Asian Monsoon (EAM) variability is high because of tropical ocean/atmosphere interactions involving the EAM and the EAM's role in transporting large quantities of heat and water vapor to the most-populated regions of the world. The EAM consists of the East Asian Summer Monsoon (EASM) and East Asian winter monsoon (EAWM), which constitutes a pivotal element of the Earth's climate system and exerts a considerable impact on the socioeconomic and cultural development of East Asia. However, the few efforts have focused on the EAWM



reconstruction on the Holocene due to a lack of a reliable signature. And absence of precise climate reconstructions for China has impeded accurate assessment of environmental factors that may have momentarily driven evolution of cultural civilizations. To address these questions, we established a decadal-resolution Holocene SST reconstruction of core SD01 derived from the SMW by studying the downcore an archeal membrane lipid-based paleothermometer, i.e. Tex₈₆. In addition, the other independent proxy is a dataset of integrated archaeological radiocarbon dates from the middle-low reaches of the Yellow River (MLYR) as conjunction with the biomarker of fecal stanol, which are comprehensive proxies of human activity and prehistoric cultures. The results provide robust evidence for synchronous variability of EAWM, recorded human activity and population, prehistoric cultural development of the MLYR during the Holocene. These cultural prosperous phases of Neolithic and Bronze cultures coincide approximately with warm period due to a weakened EAWM. while reduced SST match a decreased population and livestock, civil unrest as well as cultural collapses, and a strengthened EAWM. This suggests that under natural forcing and pressures of climatic variability early human endeavor to seek the strategies for adapting to the fragile natural environment, leading to the rise and fall of early complex societies in the region.

Keywords: East Asian winter monsoon, Neolithic culther, Abrupt climate events, Millennial to centennial-scale climate oscillations



Session 19. Historical climate reconstruction and societal impacts from written records

Conveners: Sam White, Qing Pei, William Hutchison, Heli Huhtamaa

【A0718】 -Poster

Rainfall, runoff and soil erosion in the Wuding River Basin over the past 300 years

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The climate change of the Loess Plateau in the historical period has an important impact on soil erosion. Taking the Wuding River Basin as an example, this paper reconstructed the rainfall and runoff process in the past 300 years based on historical documents and tree-ring data. The influence of the runoff process on soil erosion was analyzed using rainfall combined with literature data and field investigation. The results show that: (1) 1655-1672, 1688-1716, 1723-1732, 1743-1752, 1761-1772, 1785-1794, 1804-1812, 1819-1830, 1844-1852, 1866-1874, 1883-1897 and 1933-1975, these periods were the periods of high annual rainfall, as similar as runoff. (2) Due to continuous human reclamation, the vegetation coverage rate of the Loess Plateau decreased to less than 10% in the 20th century, runoff was intense, and the resulting soil erosion changed the regional landform, settlement layout and agricultural production. (3) Since the middle of the 20th century, the promotion of soil conservation policies and regional governance have led to the slight impact of climate change on the runoff of Wudinghe River in the 21st century, and the soil erosion control has achieved remarkable results.

Keywords: Climate change, The Wuding River, Soil erosion, Historical runoff

【A0564】 -Poster

Wine, vagrants and volcanoes: Impacts of 17th century multi-eruption events on municipal hospitals in early modern Switzerland

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Recent research identifies three major tropical volcanic eruptions of the 17th century as double or multiple eruption events: *Huaynaputina/Paektu (1600)*, *Koma-ga-take/Mt. Parker (1640/1641)*, and the *quadruple Unknown Event (UE) of the 1690s*. While eruptions with significant climatic and societal impacts have been extensively analysed, particularly in vulnerable regions, less attention has been given to the potential teleconnections of multi-eruption events in regions with less pronounced climatic effects.

This paper adopts a transdisciplinary approach to examine the climatic and societal impacts of these three multi-eruption events on early modern hospitals in eastern and western Switzerland. As principal welfare institutions in many European cities, hospitals depended on harvest income to feed their residents, making them especially vulnerable to climate anomalies.

Using the newly developed web data processing tool ClimeApp, the climatic impact is assessed with the most modern climate reconstruction data from the Mode-RA project. Novel archival material from three municipal hospitals – *Hôpital des bourgeois de Fribourg*, *Heilig-Geist-Spital in St. Gallen*, and *Burgerspital in Bern* – provides annually recorded harvest yields, particularly for viticulture and caseiculture, allowing for an analysis of potential interrelations. Key sources, such as the *Ratsmanuale* (protocols) and *Mandatenbücher* (regulations), shed light on whether the municipalities of Fribourg, Bern, and St. Gallen implemented measures or coping mechanisms in response to these eruptions and how these strategies evolved over a century.

This study contributes to a deeper understanding of the agricultural and societal impacts of multi-eruption events over nearly a hundred years in the same region.

Keywords: Volcanic eruptions, Viticulture, Caseiculture, Hospitals

【A0478】 -Poster

An investigation of historical low-temperature events in the warm season in China and the related atmospheric circulation

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Low-temperature events, as an important and disastrous weather process, can cause severe damage to agriculture, transportation, and economic systems. However, low-temperature events occurring during the warm season have received less attention from climatologists compared to the harsh winters, with the exception of the well-known cold summer of the post-Tambora period during 1815-1817, which resulted in terrible famines in southwest China. Historical documents have been widely used to study past climate. Aside from abnormal phenomena like snow, frost, and ice, past low-temperature events occurring in late summer and early autumn, which are key periods of rice growth, also attracted people's attention and have been documented. Through the excavation of the original literature, the presented study reconstructed a chronology of low-temperature events in the warm season over the past hundreds of years and analyzed their temporal-spatial characteristics. We also detected low-temperature events in the past decades in southwest China and discussed the corresponding circulation pattern and potential forcing using the instrumental, reanalysis (ERA5), and paleo-simulation (ModE-Sim) datasets. Volcanic eruptions are one of the most important forcings, and Superposed Epoch Analysis (SEA) results show lower temperatures in the years following eruptions in the North Hemisphere and tropical regions. The large-scale circulation anomaly composition presents as the East-Atlantic (EA) pattern. The impact of Pacific Sea surface temperature (SST) is also present in both reanalysis and simulations, which could force an EA pattern by inducing a Rossby wave train (Wulff et al., 2017). In further work, we will make a comparison between low-temperature events in China and Europe, which are both influenced by the EA pattern and volcanic eruptions.

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Keywords: Documentary data, China, Low-temperature events

【A0450】 -Poster

Anemological and atmospheric pressure conditions in south-eastern



Greenland in the second half of the 18th century

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The materials used in this work come from European archives: Moravian Archives in Herrnhut (Germany) and Det Kgl. Bibliotek in Copenhagen (Denmark). Anemological and atmospheric pressure conditions were analysed based on two series of meteorological observations (1 September 1767 – 22 July 1768 and September 1784 – June 1792) from Nuuk (in the past known as Neu-Herrnhut and Godthåb). This is the capital of Greenland, located on the southwestern coast. Meteorological measurements were made by Moravian missionaries conducting religious missions in this area.

The first series is the oldest available long-term series of instrumental measurements for this region. Meteorological observations (air temperature, atmospheric pressure, wind speed and direction) were made twice daily at 8 a.m. and 2 p.m. local time. Measurements in the period 1784–92 were carried out using instructions and instruments provided by members of the Palatinate Meteorological Society. They were made three times daily at 7 a.m., 2 p.m. and 9 p.m. local time.

Observations made in the 18th century were compared with the modern period (1991–2020). To make this possible, historical units were converted to those used today. In the past, wind speed was visually assessed using a scale. For the first series, a 7-degree scale (1–6) and 8 directions were used, while for the second series, wind strength and directions were estimated on a scale of 0–4 and 16 directions, respectively. Based on the instructions for meteorological observations that were passed on to the missionaries and using the Beaufort scale, it was possible to convert both historical scales of wind to presently used units (ms^{-1}). Atmospheric pressure measurements were taken using a mercury barometer with a scale in French inches and Paris lines, which was converted to hPa. The air temperature was converted to degrees Celsius from the Fahrenheit/Réaumur scales used in the past for the first/second series, respectively.



Based on the wind speed, monthly and seasonal average values were determined, and Knoch's classification (after Jankowiak and Parczewski, eds. 1978) was used to determine intervals of wind force. In addition, analyses were made of the frequency of wind from individual directions during the year and for seasons (autumn, winter, spring and summer). The analyses carried out indicate an exceptionally low frequency of wind from the SE direction (3 to 12%), while the highest from the NE (19 to 37%). Wind roses for air temperature were also made for each series. This indicates that the wind from the southwest (especially in winter) brought air masses with the highest temperature.

In the case of atmospheric pressure, values of monthly, seasonal, and annual averages and their changes in the historical period were analysed and compared with the contemporary period. An analysis was made of the frequency of occurrence of atmospheric pressure values for different intervals, as well as the magnitudes of day-to-day changes that affect the human body.

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Keywords: Anemological conditions, Atmospheric pressure, Greenland, Historical climate, Instrumental measurements

【A0869】 -Oral

Historical documents reveal the early warning signals of extreme rainstorm-flood events in the Haihe River Basin

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The instrumental meteorological data available spans less than a century, which is insufficient to robustly investigate extreme events. Using historical documents, we extracted the extreme rainstorm-flood events in the Haihe River Basin (HRB) from 1736 to 1911 and their occurrence period, affected areas, rainfall intensity and process, which are comparable with that of 2023, when the most severe flood event occurred in the Northern China since 1963. By analyzing the characteristics and climatic background of 12 similar extreme events, we identified early warning signals and possible climate conditions for extreme rainstorm-flood events. The findings indicate that, due to the terrain uplift, the majority of severe floods in HRB predominantly occurred in the piedmont plain of the Taihang Mountains. Particularly, the landfall of long-distance typhoons along China's southern coast, together with the northward intensification of the Western Pacific Subtropical High were the preconditions of these flood events. Accompanied by a significant increase in easterly and southeast winds, the water vapor from the western Pacific Ocean and the South China Sea entered the North China Plain from the southeast and southwest double jet streams. In addition, these flood years were dominated by a strong La Niña episode. Typhoon landfall and the strengthening of the northward movement of the western Pacific subtropical high, as well as the ENSO climate state, can be used as early warning signals, which have important significance in preventing and reducing disasters in the HRB.

Keywords: Flood, Haihe River Valley, Past 300 years

【A0585】 -Oral

Reconstruction and analysis of summer heatwave events in modern Shanghai (1873-1949) — based on republican-era newspapers and Xujiahui Station temperature data

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The increase in the intensity and frequency of extreme warm events is a key indicator of global climate change. This study reconstructed the summer high temperature event sequence in Shanghai from 1873 to 1949 based on historical documents of weather forecasts, high temperature events reported in Republican-era newspapers, and related meteorological archives. Based on modern meteorological standards, heat events were identified and classified according to their intensity. The study further



analyzes the spatiotemporal characteristics, occurrence patterns, and societal impacts of these heatwave events through comparison with Xujiahui Station temperature data. The findings are as follows: (1) Between 1873 and 1949, Shanghai experienced over a hundred heatwave events, with the frequency and intensity of high-temperature events in July generally higher than in August. (2) The frequency and intensity of summer heat events in Shanghai significantly increased during two periods: from the early to late 1890s and from the late 1920s to the early 1950s. The most intense heatwave event occurred in 1934. (3) Years with exceptionally strong summer heat events in Shanghai were closely related to anomalies in the Northern Hemisphere subtropical high-pressure system and the West Pacific subtropical high-pressure system. (4) These heatwave events posed significant threats to public health, agricultural production, and urban infrastructure in modern Shanghai, exposing the city's vulnerability to extreme climate events. Moreover, the urban center of Shanghai, undergoing modernization and industrialization, exhibited significant urban heat island effects, further highlighting the complex interactions and responses between urbanization and climate change.

Keywords: Heatwave events, Shanghai, Historical documents, Urban heat island effect, Modernization

【A0318】 -Poster

Climatic anomalies and their impact on the market economy: The relationship between reconstructed solar radiation and crop prices during the 1830s famine in Japan

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How do societies respond to varying climates? This question not only arouses academic curiosity but also offers insights into how our society can adapt to ongoing climate change. To explore this, we focused on early modern Japan (1603–1867), particularly the Tenpō Famine of the 1830s. By reconstructing solar radiation from 18 historical diaries, we adopted a novel approach for analysing the impacts of climatic



anomalies on both agricultural production and the market economy.

The results showed that lower solar radiation, indicative of poor weather conditions, was associated with higher rice prices, particularly during the summer of 1836. The application of principal component analysis to the reconstructed solar radiation data revealed spatio-temporal patterns that elucidated the link between climatic anomalies and their impacts on agricultural production and market prices during the Tenpō Famine. This demonstrates the sensitivity of market prices and economic stability to climate fluctuations. We also examined the effects on other crops, such as wheat and soybeans, to highlight broader economic impacts tied to climate variations.

By utilising high-resolution data, this study reveals more detailed connections between climate, agriculture, and economic fluctuations than previously available. Our findings not only provide valuable historical perspectives but also have significant implications for contemporary climate adaptation strategies and policy-making. Additionally, this study suggests further directions for research and encourages continued exploration into the relationship between climate change, agriculture, and economic fluctuations, inspiring future studies in this field.

Keywords: Climate impact, Economic fluctuation, Solar radiation, Famines, Crop prices

【A0758】 -Poster

A cartographic representation study of Atlas of Extreme Droughts and Floods in China during the Past Millennium (1000-2020)

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The compilation of historical atlases is the core tradition and key mission of historical geography, and in the era of information technology, this field needs to be more inclusive and integrate multidisciplinary wisdom to promote the innovation of theory and methodology. As the first thematic atlas focusing on historical extreme droughts and floods in China, the Atlas of Extreme Droughts and Floods in China during the Past Millennium(1000-2020)has pioneered the integration of historical geography, climate science and the art of map making in multiple dimensions, and opened up a distinctive



cartographic path, covering “thematic data generation-historical mapping-atlas compilation and publication”, and “thematic data generation-historical map compilation and publication”. The complete process of “thematic data generation-historical mapping - atlas compilation and publication”: (1) Thematic data generation: identify the years of extreme droughts and floods from historical documents, in which this study innovatively optimizes the stage-by-stage hierarchical assessment system to provide a homogenized data processing example in response to the characteristics of the spatial and temporal resolution of the historical document records. (2) Thematic mapping: The method of overlaying the graded coloring of site units and the contour lines of droughts and floods breaks through the traditional limitations of using administrative divisions as boundaries or documented locations as disaster sites, which not only conforms to the natural distribution law of climate, but also respects the distribution characteristics of historical documents; and the method of replacing site cities with the center of gravity of the site surfaces is also more in line with the characteristics of the historical documentations. (3) Atlas Compilation and Publication: The atlas is designed to promote the convenience of interdisciplinary application and to meet the needs of readers from different disciplinary backgrounds, with the use of professional software such as ArcGIS and Adobe Illustrator to draw and beautify the contour lines, which ensures that the contents of the atlas are expressed in a scientific and beautiful manner; in addition, the detailed compilation instructions, site data, site history tables and other appendix information provide a good basis for interdisciplinary application. In addition, the detailed compilation instructions, site data, site history table and other appendices provide references for interdisciplinary exchanges and researches, and promote the cross-fertilization of knowledge. The development of this atlas not only greatly enriches the scope of research on historical physical geography and historical map compilation and mapping, and provides a reference path for the expression of historical map cartography in the era of informationization, but also provides unique and important insights and contributions from China to the field of global change.

Keywords: Historical maps, Disaster maps, Map representation, Extreme droughts and floods, Historical geography

【A0594】 -Oral

Floods, politics, and society: Rainstorm and food in 1668 and the Kangxi Emperor's response

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Drawing from historical documents, the events of heavy rain and flooding in the Beijing-Tianjin-Hebei region in August 1668 were meticulously reconstructed. A comparative analysis was conducted, examining major flood occurrences in the Haihe River basin during different historical periods, including 1939, 1963, and 2023. By studying the spatial and temporal distribution as well as the climatic conditions of these four flood events, the aim was to uncover the underlying mechanisms behind large floods in the Haihe River basin, with a particular focus on the impact of typhoons on heavy rainfall and flooding. Subsequently, the study delved into the urban flooding situation in Beijing, reconstructing the extent of flooding within the city and tracing the path of the flood. Furthermore, various historical records from local chronicles such as "QingShilu," "YueshiBian," "SanGangShilue," "KeSheOuWen" and "Ferdinand Verbiest's <European Astronomy>" and other square logs, factual records, and collections of literature, were consulted to gain insights into the process and response to heavy rain and flooding event. The response of the Kangxi Emperor and the Qing government, during the disaster, as well as the societal reaction to the flood, were reexamined to enhance our understanding of disaster management and social response during the early Qing dynasty.

Keywords: Climate change, Social response, Stormwater flooding, Qing dynasty

【A0958】 -Poster

Hydroclimatic representativeness and reassessment of the predictive skill to reconstruct precipitation by the Dryness/Wetness Index from Chinese historical documents

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The Dryness/Wetness Index (DWI) data from China has been widely used in



palaeoclimate research and represents a milestone in the study of past global changes. The initial part of this data, covering the years 1470-1979 (original DWI), is primarily generated from records of droughts and floods in historical documents. However, the extended data from 1980-2000 (precipitation-based DWI) is derived entirely from instrumental precipitation measurements. To date, there is no research on the regional differences in hydroclimatic representativeness of the original DWI. Moreover, when reconstructing precipitation using the combined 1470-2000 DWI data as a proxy and calibrating it with instrumental precipitation data in the late 20th century, the overestimated reconstruction skill has not been quantitatively evaluated. Therefore, utilizing statistical data on crop yield reductions due to drought and flood disasters from 1978-2008, we establish the disaster-based DWI for 30 provinces in China following the same method as the original DWI and explore its representativeness. We find that its sensitivity to precipitation is better in East Central China, with the seasonal window primarily lasting for five months and distributed between April and September. In contrast, it reflects soil water in the Northeastern, Southeast coastal, and Western regions in China. Additionally, by comparing the average predicted R-Squared of summer precipitation reconstruction using precipitation-based DWI and disaster-based DWI (58.6% and 45.0%, respectively), we identify an average overestimation of 13.6%. Even after excluding this inflated R-Squared, the disaster-based DWI remains a highly reliable proxy for reconstructing precipitation.

Keywords: Dryness/Wetness index, Hydroclimatic representativeness, Precipitation reconstruction, Historical documents

【A0776】 -Poster

The HISTRHÔNE database: Current role in writing a climate history of Mediterranean France and future directions

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Abstract: The HISTRHÔNE database provides results from important historical research over seven centuries of all the hydrological events of the lower Rhône River valley (including the Durance River), the Provence area and the Southern French Alps: rising waters and floods of all type and severity, low water and drought, ice, frosts, hailstorms, storminess and other interesting natural events as well as their



consequences such as famine. There are several thousand events stored inside the base, collected over a period of fifty years in French archival repositories. The interface of the database is in French. It is possible to find numerous events for a specific place since the year 1226. The first event in the base is a flood of both the Rhône and the Durance rivers in the city of Avignon on September 17 1226. It is described in the *Chronica Magistri Guillelmi de Podio Laurentii* (1145-1275) written by Guillaume de Puylaurens. The original source of the information is also given, with the place where the archive is located, or the bibliographic reference. There also are four large syntheses for the South-East of France: two historical chronologies about drought and ice freeze events, the reconstructed Rhône River water levels as well as general chronology of extreme climatic events since the early thirteenth century. HISTRHÔNE is a public and open access database, which is online since 2014. It is hosted by the European Center for Research and Teaching in Environmental Geoscience (<https://histrhone.cerege.fr/>).

The benefits of this database for understanding complex phenomena such as historical climate-society interactions in South-eastern France and the Southern Alps are highlighted as well as issues relating to the long-term maintenance of the HISTRHÔNE dataset (for example the addition of new data such as rogations/processions for rain and links to other similar bases).

Keywords: Historical climate, Databases, France, Future research scenarios, Mediterranean

【A0604】 -Oral

Learning from past and present to build resilience to climate change: the ICARUS Belize project

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With climate change, the likelihood of extreme weather events, including droughts, is



increasing. Understanding the occurrence, impacts and responses to such events over the long term is crucial to inform the development of strategies to improve resilience in the face of future change. The ICARUS project takes an interdisciplinary approach to achieving this in Belize. Lying on the Caribbean coast of Central America, Belize (formerly British Honduras) is particularly vulnerable to extreme events given its fragile ecosystems and economic dependency on climate sensitive sectors such as agriculture, forestry and tourism. In the current century, hurricanes Keith (2000) and Dean (2007) and a severe drought in 2019 have had significant environmental and socio-economic impacts. In the Terminal Classic (900 – 1000 CE), it was part of the region where drought contributed to disruption of the Maya civilization

Understanding climate variability often relies on meteorological observations. In Belize such observations began in 1863, but records are discontinuous and inconsistent. A National Meteorological Service was only formally established in 1972. In the absence of reliable long term instrumental records, historical sources, including diaries, colonial reports and newspapers provide vital information on climate variability, the occurrence and severity of extreme events and their impacts. Using such sources, precipitation records have been extended into the late 19th century for sites including Corozal (north), San Ignacio (centre) and Punta Gorda (south). Based on both historic and modern meteorological records we have treated the drier northern districts (Corozal, Orange Walk, Belize and Cayo) separately from the wetter south (Stann Creek and Toledo).

A drought chronology has been developed for Belize for the period 1771-1981. Each drought was assigned into one of three severity categories and given a confidence rating. Droughts were more common and more severe in the drier north. Exceptional drought events occurred in the north in the late 19th century, the early 20th century, during the 1940s, 1955 and 1975. The whole country was affected by drought in the early 1920s, 1940s-1950s and 1975. Comparison with instrumental data largely confirms the documentary drought record, although there are inconsistencies. Drought magnitude since 1771 was similar to that estimated for the Terminal Classic, but probably of shorter duration.

The impacts of historic droughts on water supplies and agricultural production are clearly documented. Drought in the 1880s led to failure of staple maize crops and major losses of sugar cane. Severe droughts between 1943-1955 caused bush fires, loss of cattle and crops (e.g. sugar cane) and economic crisis and unemployment (especially in the north). Such impacts were also seen after the 2019 drought.



Although there are similarities between historical and modern impacts and adaptations, changes in the broader socio-economic context must be considered. Mahogany, a key export from the late 18th century is no longer important, while impacts on domestic water supply are now less acute. Historical records, however, help to inform debates about current and future climate change in Belize.

Keywords: Drought, Historical sources, Impacts, Instrumental records

【A0309】 -Oral

New series of meteorological measurements for Wrocław (SW Poland), 1773-1781 – description and analysis

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The article presents a description of the newly discovered series of meteorological measurements made in Wrocław (SW Poland) in 1773–81 and their importance for climate analysis. The series is the third oldest available for Wrocław. Earlier series exist for 04.1710–1721 (David von Grebner) and 1717–30 (Johann Kanold/A. E. Büchner) (see Przybylak, 2010). The 1773–81 observations were made by Johann Ephraim Scheibel probably in the area of the Gymnasium belonging to the Church of St Elizabeth (central Wrocław). Scheibel (1773) provides information that wind direction was estimated based on the movement of the flag on the St Elizabeth's Church tower, meaning the tower was observable from the meteorological measurement location. Other details about the exposition and place of installation of instruments are not available. Meteorological observations were made three times a day (in the morning, midday and evening) or two times (morning and evening). The following variables were measured: atmospheric precipitation (in French inches with the delimitation of its category: rain or snow), wind (direction [8 directions] and force in a 7-degree scale), air temperature (in °F) and humidity (using hygrometer produced by prof. Johann Heinrich Lambert), atmospheric pressure (in French inches). Atmospheric phenomena and weather were described. The meteorological registers were published in the newspaper *Oekonomische Nachrichten der Patriotischen Gesellschaft in Schlesien*



issued in Wrocław in the years 1773–81. In the years 1773–76, meteorological data were published in each weekly edition of the newspaper (usually seven days of observations ending on Thursday; the newspaper was issued on Saturday). From 1777 onwards, data were published for the entire month and in 3-month blocks in the last two years. Besides measurements, J. E. Scheibel also published in the same source 1–3 pages of weather description of each month or block of 2–3 months.

The air temperature in Wrocław in the period 1773–81 ranged from -22.8 °C (morning date, January 27, 1776) to 33.9°C (midday date, July 4, 1781). The average air temperature in particular measurement times (morning, midday, and evening) was 7.7 °C, 12.3 °C, and 8.8 °C, respectively. For all mentioned times of the day, similarly to today, the highest values were recorded in July and the lowest in January. The preliminary analysis of the values revealed that data from midday can be treated as the maximum observed value during the day. On the other hand, the morning observation seems to indicate the minimum value of the temperature for the day. Therefore, in further analyses, it is necessary to take into account the connection of morning hours with the sunrise times in Wrocław (i.e. from 4:36 in summer to 7:55 in winter).

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Keywords: Historical climatology, Air temperature, Poland

【A0343】 -Poster

Wind and atmospheric pressure changes on Labrador's coast in the late 18th century

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This work investigates the wind and atmospheric conditions along the coast of Labrador in the late 18th century (1771–87), using instrumental meteorological observations made by Moravian missionaries. We will utilise records preserved in three major archival collections: the Moravian Archives in Herrnhut (Germany), the Moravian Archives at Muswell Hill, and the Archives of the Royal Society, the latter two located in London.

Sub-daily observations (twice, thrice, or even four times daily) of winds are available for two sites lying on the coast of Labrador: Nain (Oct 1771–Jul 1786) and Okak (Sep 1776–Jul 1786). Data from Nain for the period Oct 1771–Aug 1776 were disregarded due to low quality. On the other hand, atmospheric pressure data are available only for Nain for the period Oct 1771–Jul 1786, excluding the period Nov 1774–Aug 1775. The wind force assessed on the 7-degree scale (0–6) used by the Moravian Missionaries was converted to a range of Beaufort scale values; then, the mean value of wind of that range was utilised. Atmospheric pressure was measured using a barometer in Paris inches (27.07 mm), which were converted to hPa. The original values were only corrected for gravity and then reduced to sea level. Correction of pressure for temperature was not done, due to the lack of barometer temperature data. Thus, partially corrected values were used for analysis. The basic statistics of both atmospheric pressure and wind speed were calculated, e.g. daily, monthly, seasonal and annual means, and then, based on them, various characteristics were investigated (e.g., annual cycles, day-to-day changes, extremes). Additionally, the results of historical wind and air pressure data were compared with modern data (1991–2020).

Atmospheric pressure and wind speed in Nain, Labrador are influenced by a complex interplay of climatic factors and, in the case of wind, also local topography. According to seasonal (DJF, MAM, etc.) means, the atmospheric pressure was highest in spring (1013.0 hPa) and lowest in winter (1007.5 hPa). On 22nd September 1782, there was probably a change in the barometer, which may have introduced data inhomogeneity in the series. From this time until the end of observations (Jul 1786), the atmospheric pressure was lower on average by ca. 5hPa in comparison to the period Oct 1771–Aug 1782. For this reason, it is difficult to compare them with present values. On the other



hand, comparison of some other characteristics is possible. In the period 1776–86, the mean annual wind speed in Nain and Okak was 4.8 ms^{-1} and $3.0 \text{ m}\cdot\text{s}^{-1}$, respectively. Throughout the year, monthly averages ranged from $3.1 \text{ m}\cdot\text{s}^{-1}$ in July at Nain and $1.6 \text{ m}\cdot\text{s}^{-1}$ in May at Okak to $6.8 \text{ m}\cdot\text{s}^{-1}$ and $4.1 \text{ m}\cdot\text{s}^{-1}$ in January at Nain and Okak, respectively. In the years 1991–2020, the annual average wind speed at Nain was $5.3 \text{ m}\cdot\text{s}^{-1}$, with monthly averages ranging from 3.6 ms^{-1} in Jul–Aug to 6.8 ms^{-1} in December.

The work was supported by the National Science Centre, Poland project No. 2020/39/B/ST10/00653

Keywords: Wind dynamics, Atmospheric pressure, Labrador coast, Historical climatology

【A0382】 -Oral

Agrometeorological relationships and food security in Early Modern Sweden

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Early Modern agriculture in the Swedish realm encountered diverse weather- and climate-related hazards that varied regionally in their impacts. Recent research has shown how in northern Sweden, agricultural production was highly sensitive to cold, short growing seasons, whereas the southernmost regions relied on adequate summer precipitation, rendering them less affected by climatic fluctuations. This study explores these agrometeorological relationships, focusing on regional vulnerabilities and their broader societal consequences. For example, the study explores to what extent trade and the different regional agrometeorological dependencies in Sweden reduced social and economic impacts following climatic shocks, thereby increasing food security.

Drawing on an extensive array of historical records, e.g. farmers' diaries, tithes, official agricultural and demographic statistics, as well as phenological observations—documenting sowing and harvest dates, crop yields, livestock production, food prices, and demographic trends—alongside dendroclimatological reconstructions, and early meteorological observations, this research provides a detailed spatio-temporal analysis of climatic influences on agriculture and society in Early Modern Sweden.



Keywords: Agrometeorology, Early Modern agriculture, Food security

【A0341】 -Poster

A 40-year pre-industrial reanalysis dataset since 1802 produced by assimilating non-instrumental meteorological records of Japan

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Daily atmospheric conditions before the 20th century have rarely been investigated in Japan due to the limited availability of instrumental meteorological records. Recent studies (Wang et al., 2022; 2023) proved the feasibility of reconstructing historical weather by assimilating descriptive weather information. In Japan, the Historical Weather Database on The Web (Yoshimura, 2013) provides diary weather records from over 18 stations since the 1660s. These records enable high-temporal-resolution weather reconstructions through integration with atmospheric models. We first categorize the descriptive records into several weather categories and then assimilate them into the Global Spectral Model through a local ensemble transform Kalman filter scheme. This study performs atmospheric analysis starting from 1802 and creates a 40-year pre-industrial reanalysis dataset with a 6-hour time resolution. The dataset contains multiple two- and three-dimensional variables such as temperature, precipitation, solar radiation, pressure, and wind speed. The first version of the database is expected to cover the first half of the 19th century (over a 50-year time span). After completing the first version, this database will continue to be extended and updated.

We verify the online data assimilation (DA) results by existing documentary evidence. At non-assimilated stations, the time series of rainy-day probability corresponds well with the diary-based rainy category. We additionally calculate the Spearman Rank Order Correlation between reconstructed precipitation and weather records reclassified by the magnitude of precipitation. The correlation coefficients of our DA results are significantly superior to those of the Twentieth Century Reanalysis dataset owing to its weak constraint over Japan. We additionally compare the results with



those of domestic and overseas research. Correlation coefficients over 0.8 have been confirmed at both assimilated and non-assimilated sites between the downward solar radiation flux anomaly in our DA results and monthly standardized solar radiation, which was directly converted from diary weather records. Temperature anomalies also show high consistency between DA results and the ModE-RA Global Climate Reanalysis data from ClimeApp. Regarding precipitation, evidence from the literature suggests that DA results are more reliable than ModE-RA data.

This study creates a long-term pre-industrial reanalysis dataset by assimilating non-instrumental meteorological records for the first time. The reconstructed daily temperature and precipitation data before the 20th century is expected to provide valuable insights into the climatic impact on historical population migration, agriculture, and economic activity in Japan. This reanalysis dataset fills the gap in instrumental meteorological observations and contributes to a better understanding of climate change over a longer timescale.

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Keywords: Dairy records, Pre-industrial weather reconstruction, Online data assimilation, Reanalysis dataset

【A0346】-Poster

Expanding archaeological understanding through multi-index tree-ring dating of medieval wooden artifacts from the Atsuta B site in Nagoya, Japan

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In dendroarchaeology, tree-ring width based dating is regarded as one of the most precise and reliable methods for determining the calendar year in which the tree-rings were formed, by matching the variation patterns in annual tree-ring widths across individual samples. This method can estimate the felling dates of trees with rings near the bark, allowing for the reconstruction of historical human activity based on the age distribution of wooden artifacts. Despite its reliability, tree-ring width-based dating alone may encounter limitations due to the inherent variability in the growth patterns. Recent studies on the annual ring analysis based on oxygen isotope ratios in cellulose have demonstrated the potential of the oxygen isotope ratios ($^{18}\text{O}/^{16}\text{O}$) based dating method as an independent and highly accurate dating tool, especially with smaller number of tree-rings. Oxygen isotope ratios can correlate strongly with its regional master chronology (Nakatsuka et al., 2020), which makes them the robust marker for cross dating. However, this method is time consuming and labour intensive, highlighting the need to integrate it with tree-ring width dating analysis to enable reliable dating of large-scale wooden artifacts. In this study, we focused on 221 wooden artifacts of cypress excavated from the Atsuta B site of Atsuta ward, Nagoya city, Aichi prefecture, Japan. The area is located between Atsuta shrine and Miyanowatashi, which was the key port for people to travel on the Japanese main road, Tokai-Do, during the medieval period. This site is a medieval remain dated to 10th-16th century CE, given by archaeological evidence. Among these, 41 samples retain the outer tree rings near to the bark, identified based on their shape, making them ideal for oxygen isotope analysis to refine their felling dates. This research firstly focuses on refinement of the tentative master chronology of tree ring width created by (Sano et al., 2023) for the dating of medieval cypress wooden artifacts in the Aichi region of Central Japan with enhanced accuracy and secondly incorporates oxygen isotope dating on those 41 specimens with the presence of outer annual layers and finally reconstruct the historical rise and fall of human activity in the Atsuta region during the medieval period. Cross-referencing of tree-ring width dating and oxygen isotope ratio dating will be able to establish a more accurate standard tree-ring curve and methodology to statistically clarify the age distribution of many medieval wooden products. This approach bridges the strengths of two complementary dating techniques, addressing challenges in dating variability and sample size.



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Keywords: Tree-ring width dating, Oxygen isotope ratios dating, Reconstruction of historical human activity, Age distribution of Medieval wood products, Master chronology refinement of Central Japan

【A0048】 -Poster

From fire to famines? The climate and human impacts of the 1831 and 1835 volcanic eruptions in India, China and Japan

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1831 and 1835. Multiple massive eruptions send vast plumes of sulphur into the atmosphere, forming a layer of aerosols that reaches around the globe. In the years that follow, terrible famine strikes countries across Asia: In China, the Imperial bureaucracy records drought and starvation in many eastern provinces; in Japan, hundreds of thousands die in the disastrous Tenpō famine; while in British India, famines in Madras and Agra lead to the reported deaths of over a million people. Just a coincidence? By combining historical accounts with the latest climate reanalysis data, we can begin to identify the contribution of volcanic activity to these famines. Taking India as our main case study, we will see how teleconnections between volcanic eruptions and Indian temperatures may have triggered significant monsoon failures in 1832/33 and 1836/37. But we will also see how the social impacts were intensified by many other climate and historical factors, ranging from the El Niño Southern Oscillation, to over-taxation and environmental decline, to the ideals of free market economics and the consequences of a joint-stock company with power over an entire subcontinent. In the case of Japan, work is still ongoing, but the initial results assessing the link between eruptions and the Tenpō famine will be presented. Meanwhile, in China we will see how droughts and famine often seem to follow major volcanic eruptions, but with impacts moderated by the El Niño/La Niña cycle. The talk will conclude by considering modern famines and climate change, and what lessons we



can draw from such historical studies.

Keywords: Eruptions, Famine, Asia, Historical, 1830s

【A0127】 -Poster

A cross-continental comparison of drought impacts and social responses in Germany and Jing-Jin-Ji Region (China) since the 19th century

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Droughts, as one of the costliest weather-related disasters, have been and will continue to be part of the common human experience. However, endeavours to investigate the general mechanisms of drought-society interactions from cross-regional and long-term perspectives have been insufficient. In light of the above, this study compared three pairs of extreme drought events in Germany and the Jing-Ji-Ji Region (China) that occurred in agrarian societies, during industrialization, and in recent years, with a focus on commonalities. Multi-source data were adopted in this comparison, including (semi-) quantitative reconstructions of dry/wet conditions, descriptions from various types of written documents (i.e., database and information platform, chronicle and compilation, newspaper, official yearbook, and report), and secondary research by historians (i.e., peer-reviewed papers and monographic studies). Additionally, an impact-response structural framework was developed to help integrate textual information in different forms and languages, thus ensuring comparability. The comparison illustrated seven universal and six area-specific key impacts of drought behind diverse manifestations, which existed throughout the transformation from agrarian to modern societies, affecting vegetation, hydrological systems, agricultural performance, food and water security, health, economy, and social stability. Meanwhile, despite dissimilarities in socio-environmental contexts, a similar preference for different societies coping with drought was observed, namely balancing the supply and demand of scarce goods with government participation to tackle socioeconomic issues within drought-stricken areas. As societies developed, governance/management actions and long-term strategies were increasingly adopted in both study areas, and almost all key impacts received some degree of response in recent years. The results not only provide empirical evidence of climate-society links



that go beyond period-specific experiences, which have the potential to bridge the past and the future, but also demonstrate the feasibility of conducting cross-regional comparative studies based on written records, in spite of linguistic differences.

Keywords: Drought impacts, Social responses, Cross-regional comparison, Documentary data



Session 20. Paleoclimate for sustainable water strategies

Conveners: Charlie Marshall, Kelsey Murphy, Jiayue Yin

【A1019】 -Poster

The temperature changes during past 2000 years reconstructed from the Dunde ice core on the Tibetan Plateau

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As the “Third Pole” of the earth, the Tibetan Plateau (TP) sensitively responds to global warming and regional anthropogenic activity because of the high topography and dense population on the high elevation region. Reconstructing past climate and environmental records based on the ice core is important for determining glacier sensitivity and the process that controls regional warming. Here, we focused on the $\delta^{18}\text{O}$ measurements of 132m long Dunde ice core from the Qilian Mountains on the TP (hereafter Dunde-2016). The reproducibility of the $\delta^{18}\text{O}$ records in the Dunde-2016 core was firstly investigated by comparison with the Dunde-1987 ice core record. Then, the $\delta^{18}\text{O}$ of the Dunde-2016 core were investigated for the reconstruction of the post-2000 year climate. Meanwhile, the $\delta^{18}\text{O}$ record in the Dunde-2016 ice core were compared to other TP ice cores and other regional reconstruction records to present the general trend and regional distinction of the climate. The result shows that the excellent consistency of $\delta^{18}\text{O}$ between the cores drilled in early 1987 and in the later 2016, suggested the high degree of reproducibility of the Dunde ice core. The initial chronology of the revisited Dunde-2016 ice core was developed by combining multi-parameter annual layer counting, and the reference horizons of the nuclear test, as well as the glacier flow model. Results showed that the top 111.06m ice core covered the period of 1-2016AD. The positive correlation between ice core $\delta^{18}\text{O}$ and temperature records at nearby meteorological stations showed the representation of Dunde-2016 ice core to the temperature variations in the Northeast TP. On this basis, the post-2000 temperature variability was reconstructed. The record shared alternate warm and cold variations before 910s, suggesting weak expression of the Roman Warm Period and the Dark Age Cold Period. Then, an inconspicuous Medieval Warm Period (920-1230s) was appeared with featuring cold climate in the first half of 1050s



and a warm climate in the later part. After that, the evolutionary three cold intervals in the 16th, 17th, and 19th centuries, and subsequent accelerating warming from 150AD were occurred. This represented significant Little Ice Age and 20th century warming periods in the Dunde-2016 core, respectively. Among the periods, the latest warming period was most obvious, which surpasses any previous periods. Also, the Dunde-2016 $\delta^{18}\text{O}$ record was compared with the other ice core $\delta^{18}\text{O}$ records from three climate domains of the TP on the different time scales, and other reconstructed temperature records. The comparison showed the consistency of the large-scale climate pattern among these records. This highlighted the similarity of temperature changes from ice core $\delta^{18}\text{O}$ over the TP. And the regional scale different magnitude of these records demonstrated the regional dependence of microclimate pattern.

Keywords: Tibetan Plateau, Ice core, Reproducibility, Warm and cold period

【A0996】 -Poster

Sustainability of semi-arid ecosystems under hydrological extremes and anthropogenic impacts: The case of Iriki Lake in southern Morocco

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Located in the arid region of southeastern Morocco, Iriki Lake is one of Africa's largest endorheic lakes, once renowned for its rich biodiversity and cultural heritage. It served as a critical habitat for diverse wildlife species and a meeting point for various tribes, shaping the lives and histories of nomadic communities. Between 1994 and 2016, initiatives by the Moroccan government, which designated the area as a national park, and UNESCO's 'Man and Biosphere Programme (MAB)' sought to preserve archeological sites, animal species, rehabilitate wetlands, and support the revival of nomadic pastoral traditions. However, under the constraints of limited water resources, this balance remains fragile and requires adaptation to hydro-climatic variability and the diverse driving forces impacting the region. The combination of dam construction and prolonged drought has led to the complete desiccation of Iriki Lake, resulting in the extinction of local fauna, the degradation of flora, and the collapse of indigenous livelihoods. Recent evaluations of this ecosystem have highlighted its ability to adapt



to global changes by promoting new sustainable strategies aligned with the region's climate particularity. Iriki Lake has fortunately demonstrated a remarkable ability to temporarily restore its vitality in response to flood events after a prolonged period of drying. The exceptional rainfall event of September 2024 sparked a rare, continuous flow of the Drâa River, rejuvenating the lowlands of Iriki Lake and rekindling hope for a life that had been lost for years. The frequency and intensity of such extreme events are projected to rise, as Morocco's arid regions lie within a recognized climate change hotspot. In response to these challenges, current water policies focus on leveraging exceptional wet periods as critical drought breaks to enhance the resilience of this ecosystem during stress periods. This study presents the findings of an interdisciplinary approaches (hydro-sociology, climatology, and water management) aimed at assessing the holistic status of Iriki Lake while promoting its development as a national and global heritage site. Although still in its infancy, this study provides a guide to initiating collaboration between local communities (nomads, oasis inhabitants and cooperative associations), researchers (hydrologist, paleo-climatologist and archeologist), and stakeholders to advance sustainable and integrated water resource management in this arid region.

Keywords: Iriki Lake, Arid region, Water resource management, Climate change

【A0537】 -Poster

Greater Azau Glacier history during the Late Holocene (Northern Caucasus, Russia)

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Greater Azau is the most frequently visited glacier in Northern Caucasus located at the Elbrus active volcano. In this study we analyze the historical descriptions and maps of the moraines covered by mature pine forest and located between 2290 and 2340 m asl. The main goal of this study is to reconstruct the timing and magnitude of glacier advances of the second half of the Holocene based on minimum tree-ring dates of



moraines (more than 150 samples) covering the 16-20th centuries CE, ten ¹⁴C dates of paleosols buried between four till horizons, and cosmic ray exposure ages of samples collected on moraines (eleven dates of ³⁶Cl and sixteen dates of ¹⁰Be). According to this extensive data set most prominent advances of Greater Azau Glacier occurred in the 19th, 15th–17th, 7th–9th centuries CE, and 0.9-1.2 ka, 2.5-2.9 ka, 3.0-3.2 ka, 3.45 ka, 3.8-5.0 ka. In the Little Ice Age (LIA) maximum occurred in the middle of 19th century CE the glacier front was located between 2330 and 2340 m asl and the glacier was 3.6 km longer than it was in 2024. Between 3.8 and 5.0 ka the position of the glacier front is reconstructed at the elevation 2260 m asl when the glacier was 13.3 km long, i.e. 4.8 km longer than in the 2024. The glacier length ca 3.8-5.0 ka corresponds to the maximum glacier extent in the Late Holocene and possibly in the whole Holocene period. In-between this maximum extent and the LIA at least six glacier advances are recorded. The timing of most prominent advances of the Greater Azau Glacier in the past 5000 years is in general agreement with the Late Holocene glacial chronologies in the European Alps, Scandinavia and other regions of the Northern Hemisphere. The comparison of summer temperature reconstructed from the local tree-ring pine chronology (blue intensity), the snow accumulation from the Elbrus ice-core and the glacier sizes in the past 250 years reveals somewhat contradictory picture: the low accumulation is reconstructed for the period of 1800s-1860s, when the glacier was close to its LIA maximum, while the increased accumulation in 1860s-1920s coincides with the general retreat of the glacier with minor readvances. At the same time the tree-ring based reconstruction reveals cold temperatures in 1830s-1860s and their strong decadal variability, but no clear trends in the subsequent period of glacier retreat in 1860s-1920s. Thus, it is suggested that the LIA maximum advance in the Elbrus area was triggered by the low ablation rather than increased accumulation and, vice versa, the increased accumulation later on must be overcompensated by the warming that resulted in observed glacier retreat. Modeling experiments are necessary to reconcile this complex glacier - climate relationship in order to understand the forcings of the glacier advances in the LIA and in the previous Late Holocene periods of glacier activity. O.N.Solomina studies were supported by grant of the Ministry of Science and Higher Education of Russian Federation (agreement № 075-15-2024-554 of 24.04.2024).

Keywords: Holocene glaciers

【A0223】 -Poster

Prehistoric climatic extremes and collapses of indus valley civilization: A valuable insight for transboundary river basin governance to climate change adaptation in South Asia in twenty first century



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Indian Summer Monsoon (ISM) is a synoptic scale weather system that strongly impacted hydroclimatic regime and played critical role in shaping economy and culture of South Asia since pre-historic time. Harapan Civilization flourished in alluvium and water-rich Indus Valley under normal monsoon conditions, which boosted agriculture and urban settlements during mid-Holocene Period. However, a swift in Indian Summer Monsoon in later Holocene period increased frequency and intensity of floods and droughts which had a cascading impact on water availability, agricultural productivity and economy leading to collapse of Indus Civilization. Understanding of past adaptations to persistent climate change may provide valuable insight for transboundary river basin management as a prerequisite adaptation strategy to climate change in South Asia.

Main objective of the study is to advance scientific knowledge to analyse impacts of hydro-climatic extremes on the rise and collapse of Indus Valley Civilization with a view evolving effective coping and adaptation framework to ongoing climate change. The methodology included: (i) detailed review of ancient archaeological and palaeoclimatological records; (ii) reconstruction of critical marine and terrestrial palaeobotanical, limnological and climate data for the past 10 kyr Bp; (iii) direct consultation and interaction with a range of experts specifically climatologists, archaeologists, geologists, anthropologists, historians and paleo-botanists.

Findings of the study revealed that: (i) During Holocene Period (10 kyr BP) Indian Summer Monsoon remained normal in north-west India; (ii) it helped Indus Civilization to grow by providing steady supply of water and agricultural surpluses that supported development of efficient water and production system, highly urbanized landscape, trade and culture during mid to late Holocene Period (5.5 kyr BP and 3.9 kyr BP); (iii) However, monsoon pattern changed and hydro-climatic conditions were dominated by strong aridity, prolonged droughts and devastating floods, resulting into abrupt decrease in river-discharge and decline in water availability (4.2 kyr Bp); (iv) this ruined farming systems abandoning urban landscape and collapsing Indus Valley Civilization (3.8 kyr Bp); and (v) population moved eastward and northward to adapt to swift changes in climatic conditions.



South Asia which is constituted by some of the largest transboundary river basins including Indus, and home of more than 45% global population depending primarily on subsistence farming with access to less than 5% global water resources is currently emerging a 'hot spot' of climate change. Increasing frequency and intensity of hydroclimatic extremes, particularly floods and droughts have stressed hydrological regimes of South Asia causing substantial decrease in water-availability. This is increasing proportion of water, food and livelihood insecure population in the densely populated river-basins and compelling the poor and weaker sections to migrate. Given this, the findings of the study would help; (i) in improving the scientific understanding of the climatic extremes and their likely impact on the ecological, economic and social sustainability in entire South Asia, and (ii) provide valuable insights to climate policy planners to evolve an integrated transboundary river basin governance framework as an effective adaptation strategy to climate change for South Asia based on the knowledge and experience of prehistoric hydro-climatic extremes.

Keywords: Archaeological and palaeoclimatological records, Prolonged droughts, Climate change hotspot, Past adaptations, Climate policy planners



Session 21. Millennial-scale changes in tropical precipitation: Lessons from the past for a changing future

Conveners: Cristiano M. Chiessi, Martina Hollstein, Haiwei Zhang, Ilham Bouimetarhan, Francisco W. Cruz, Hai Cheng

【A0018】 -Oral

Responses of Amazonian vegetation to a slowdown of the Atlantic meridional overturning circulation: Past perspectives and future insights

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The Atlantic meridional overturning circulation (AMOC) and the Amazon forest are viewed as connected tipping elements in a warming climate system. If global warming exceeds a critical threshold, the AMOC may slow down substantially, changing atmospheric circulation and leading to Amazonia becoming drier in the north and wetter in the south. Yet, the impact of an AMOC slowdown on Amazon vegetation is



still not well-constrained. Here, we investigate Amazonian vegetation and fire responses from 25,000 to 12,500 years ago, encompassing a past major AMOC slowdown (Heinrich stadial 1, from 18,000 to 14,800 years ago), based on pollen and microcharcoal analyses of a marine sediment core and species distribution models forced by distinct climate scenarios. Additionally, we model vegetation responses to an AMOC slowdown considering pre-industrial conditions. During the Last Glacial Maximum (23,000 to 19,000 years ago), despite lower atmospheric CO₂ and relatively drier conditions, the Amazonian landscape remained predominantly forested with a notable expansion of cold- and moisture-affinity tree species driven by significantly colder temperatures. Subsequently, during Heinrich stadial 1 AMOC slowdown, pollen data reveal a decline in cold- and moist- affinity elements, coupled with a rise in seasonal tropical vegetation. This pattern is consistent with the decline in suitability of northern Amazon moist forests in a model with an imposed 50% AMOC weakening under glacial boundary conditions. Our modelling show that a comparable AMOC slowdown under pre-industrial conditions would also trigger a decrease in precipitation over northern Amazonia, increasing the vulnerability of forest formations there. Combined with ongoing disturbances across the basin, including deforestation and shifts in rainfall regimes, this northern increase in forest vulnerability linked to the AMOC slowdown could have a systemic impact on the Amazon ecosystem if anthropogenic forcings remain unabated.

Keywords: Amazon, Atlantic meridional overturning circulation, Palynology, Heinrich stadial 1, Microcharcoal

【A0804】 -Poster

ITCZ movement during Termination IV in South America reconstructed by speleothem records

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The Intertropical Convergence Zone (ITCZ) is a key component of the global climate system, and its position and intensity play a crucial role in shaping rainfall patterns and climate variability in the tropics. These changes have significant implications for the livelihoods and food security of billions of people. In this study, we present a multi-



proxy record from speleothems in Caracos Cave, Colombia, to reconstruct the dynamics of the ITCZ during the Termination IV (T IV) period in South America. Our approach combines $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$, trace elements, triple oxygen isotopes, fluid inclusions, and climate modeling to explore the interactions between the position of ITCZ and regional climate processes. The $\delta^{18}\text{O}$ records from Caracos Cave stalagmites reveal a marked positive shift around 340 ka, with values reaching -2‰ and a change of nearly 8‰. This pattern closely resembles the isotopic signature observed in the speleothem of same cave during Heinrich Event 1 (H1). Previous studies have shown that during H1, the ITCZ shifted southward to approximately 4°S, leading to severe droughts in northern South America. By integrating diverse climate proxies and simulations, this study strengthens our understanding of ITCZ variability during the T IV period and provides a historical framework for interpreting contemporary climate change and future projections.

Keywords: ITCZ, Termination IV, South America, Paleohydrology, Speleothem

【A0091】 -Poster

Retreating ice sheet caused a transition from cold-dry to cold-humid conditions in arid Central Asia

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Water is critical for ecological systems in arid regions, making it imperative to understand how moisture in arid Central Asia (CA) responds to anthropogenic warming. The oscillation of warming and cooling events since the Last Glacial Maximum (LGM, 24–19.5 ka) provides a window for exploring the relationship between moisture and temperature. Employing 109 luminescence ages derived from eight sand dune sediment cores in the Bayanbulak Basin in the CA, this study endeavors to reconstruct



the evolution of sand accumulation, and by extension, moisture dynamics. We found that pre-Holocene sand accumulation was predominant during the LGM and Heinrich Stadial 1 (HS1, 18–14.6 ka), indicative of a cold-dry climate prevailing during these two cold stages. During the Holocene, sand accumulation during Early Holocene is significantly stronger than that during Middle-late Holocene, supporting a long term wetting trend. Additionally, this study reveals that the colder Little Ice Age (LIA, 0.55–0.2 ka) exhibited a wetter condition compared to the warmer Medieval Warming Period (MWP, 1–0.55 ka), indicating a cold-humid climate during the LIA. Corroborated by TraCE-21 ka (Transient Climate of the Last 21,000 Years) simulation, we propose that diminished evaporation over North Atlantic during the LGM and HS1 potentially led to a reduction in water vapor transported by westerlies to the CA. During the Middle and Late Holocene, increased evaporation over North Atlantic, attributed to decreased ice sheet, westerlies intensity became the primary limiting factor. Notably, stronger westerlies during the LIA could have contributed to elevated moisture levels compared to the MWP. These findings not only resolve the debate surrounding the transition from cold-dry to cold-humid conditions but also enhance our comprehension of future moisture variations.

Keywords: Luminescence dating, Arid central Asia, Climatic transition, Northern hemisphere ice sheet, Transverse dunes

【A0599】 -Poster

The monsoon influence on Sea Surface Temperatures in the subtropical South Atlantic during Last Glacial Period

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The long-term rainfall amount variation over southern Brazil is thought to be mainly



driven by the insolation forcing on the South America Monsoon System (SAMS). However, the bimodal rainfall regime over the region limits the interpretations from pioneering studies using $\delta^{18}\text{O}$ in stalagmites and cannot be used to determine annual rainfall accumulation. Here we display a high-resolution trace element data from the Botuverá Cave (27°S) as a proxy for paleo-precipitation amount covering the Last Glacial Period. Our record highlights an in-phase variations between Mg/Ca, Sr/Ca and $\delta^{18}\text{O}$ for the first two insolation cycles suggesting increase in precipitation due to enhanced monsoon activity during periods of high austral summer insolation. Furthermore, this comparison of speleothem records allows us to discuss what is the relationship between the monsoon circulation and variations in sea surface temperature in the South Atlantic. In this regard we compare the speleothem to marine SST records to identify feedback mechanisms between the atmosphere circulation and the South Atlantic. Two modes of precipitation variability are proposed: 1) from 115 to 55 kyrs an in-phase precipitation variability between the areas affected by the South Atlantic Convergence Zone (SACZ) and the Andean Low-Level Jet (ALLJ) moisture trajectories, which are associated with high insolation phases and cooler SST's; and 2) from 55 to 13 kyrs, a precipitation dipole is identified between SACZ and ALLJ monsoon domains with cooler SSTs in the wetter side of ocean in response to the Atlantic Meridional Overturning Circulation (AMOC) weakening. For the millennial timescale, our Sr/Ca and Mg/Ca data indicate a relationship between precipitation and SSTs in some Heinrich Stadial (HS) and Glacial Interstadials events. We argue that the monsoon circulation and its related cloudiness band play an important role in SST changes over South Atlantic at distinct time-scales.

Keywords: Speleothem, Monsoon, South Atlantic, Trace-elements, Stable isotopes

【A0773】 -Oral

The tropical response to weakening of the Atlantic Meridional Overturning Circulation

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Global warming could induce a reduction, or even a collapse of the Atlantic Meridional Overturning Circulation (AMOC – the system of ocean currents that plays a crucial role in global heat transport and deep ocean circulation. Such a reduction in AMOC strength is expected to have global impacts, particularly over the tropics, where models and theory predict large shifts in rainfall patterns. The spatial signature and physical mechanisms underlying this tropical response are poorly understood mainly because model projections cannot be validated using instrumental observations. We addressed these issues evaluating models against hydroclimate changes during Heinrich Stadial 1 (HS1) – the most recent, best-documented geological interval with robust evidence of a weakened or collapsed AMOC. Combining palaeoclimate records and a large ensemble of simulations we identify a unique global response initiated by cooling over the tropical North Atlantic. This pattern of cooling drives atmospheric changes across tropical landmasses communicating the response to the Indian and Pacific oceans. Air-sea interactions across these oceans transmit the response to the Maritime Continent and Northern Australia. This global response drives changes in rainfall patterns across the tropics explaining palaeoclimatic evidence. A similar response is active in future climate projections; however, not all models produce the AMOC-induced cooling over the tropical North Atlantic explaining their divergent hydroclimate projections over large parts of the world. Models with a response consistent with past changes predict stronger and more consistent reductions in tropical rainfall than the consensus of models used by the IPCC, revealing a higher risk of severe drought associated with future reductions in AMOC strength.

Keywords: AMOC, Hydroclimate, Tropics

【A0269】-Poster

Interstadial diversity of East Asian Summer Monsoon linked to changes of the Northern Westerlies

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During the last glacial cycle, the iconic Greenland ice-core records provide evidence of interstadial warmings with various durations ranging from centuries to millennia. However, it's uncertain if this variability translates into diverse tropical climates due to limited high-resolution data. Here we present four speleothem $\delta^{18}\text{O}$ records from the South American and East Asian monsoon regions, spanning both short and long interstadials of the last glacial period. Our data reveals that the East Asian Summer Monsoon (EASM) region exhibits distinctly different $\delta^{18}\text{O}$ depletions between short and long interstadials, whereas the records from the Greenland, Indian and South American monsoon domains show similar isotopic changes for different interstadials. Using an isotope-enabled climate model, we attribute these differences to the shifting latitudinal position of the boreal Westerlies, influenced by high-latitude warming during interstadials. In short interstadials, warmer high latitudes push the Westerlies northward, extending the West Pacific Subtropical High, which transports more ^{18}O -enriched near-source water vapor from west Pacific to eastern China. Consequently, this reduces isotopic depletion, highlighting EASM's unique hydroclimate patterns shaped by both low- and mid-latitude processes, distinct from other tropical monsoons.

Keywords: Atlantic circulation, Speleothem, Duration, Abrupt warming events

【A0336】 -Oral

The impacts of an AMOC slowdown on Australasian hydroclimate during Heinrich 5 and the 8.2 ka event

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Dansgaard–Oeschger and Heinrich stadials during the Last Glacial Period were



associated with a weakening of the Atlantic Meridional Overturning Circulation (AMOC). A similar event happened 8,200 years ago (8.2 ka) during the early Holocene, and was the last centennial-scale abrupt cooling event in the Northern Hemisphere due to an AMOC slowdown. The impacts of an AMOC slowdown on Atlantic temperature are relatively well understood from proxy reconstructions and model simulations, but the precipitation changes in the Indo-Pacific region are less certain. In this study, we use the Australian Earth System Model ACCESS-ESM1.5 (CMIP6/PMIP4 model) to investigate the Australasian hydroclimate response to an AMOC slowdown and shutdown during abrupt climate events under both past warm (interglacial) and cold (glacial) climate conditions. North Atlantic freshwater hosing experiments are performed under 8.2 ka and 49 ka (during Heinrich Stadial 5) boundary conditions. Changes in the Southern Hemisphere monsoon systems, including the Indo-Australian monsoon, are evaluated, as well as shifts in the Inter-tropical Convergence Zone. The simulations provide important information about the hydroclimate response to AMOC weakening under different background states. This may be helpful for predicting possible future impacts. The simulations are also compared with proxy reconstructions, which can further allow us to evaluate model sensitivity to AMOC variability.

Keywords: Heinrich Stadials, 8.2 ka event, Australasian hydroclimate, ACCESS-ESM1.5 model, AMOC slowdown

【A0363】 -Poster

Tracing climate transitions and millennial-scale monsoon variability from the Andaman Sea sediments

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The Indian Summer Monsoon (ISM) shapes tropical precipitation patterns, directly influencing regional climate, oceanographic conditions, and biogeochemical cycles. Understanding millennial-scale ISM variability offers valuable insights into its response to natural climatic drivers and provides context for anticipating future changes. This study investigates ISM-driven changes in the Andaman Sea over the last 1.2 million



years using sedimentary records from deep-sea core NGHP-17 from a water depth of 1344 meters. By integrating planktonic foraminifera and pteropod abundances with carbonate preservation proxies such as the *Limacina* Dissolution Index (LDX) and calcium carbonate percentages ($\text{CaCO}_3\%$), the study explores the interaction between monsoon variability and ocean chemistry during glacial interglacial cycles. The results reveal significant millennial-scale variability in monsoon intensity, reflected in oceanographic shifts during glacial and interglacial periods. Glacial periods, including Marine Isotope Stages (MIS) 2, 4, 13, 17, and 19, exhibited weak water column stratification, vigorous upwelling, and enhanced nutrient availability. These conditions fostered increased biological productivity and improved preservation of aragonite in pteropods. In contrast, interglacial periods, such as MIS 1, 5, 7, and 10, were characterized by intense stratification, nutrient-depleted surface waters, and higher carbonate dissolution, resulting in reduced preservation of pteropods. Moreover, the foraminiferal assemblage indicates that the last 0.4 million years were characterized by significant stratification in the Andaman Sea, driven by intense freshwater dilution. The fluctuations in nutrient availability and carbonate preservation highlight the sensitivity of monsoon dynamics to global climatic drivers, including orbital forcing and Northern Hemisphere insolation. A key finding of this study is the identification of a 100,000-year cyclicity in pteropod preservation, closely aligned with glacial-interglacial cycles. This cyclicity is linked to fluctuations in the aragonite compensation depth (ACD), driven by global climate oscillations and monsoon-induced changes in ocean chemistry. The variability in aragonite preservation underscores the pivotal role of the ISM in regulating carbonate dissolution in the Andaman Sea, offering a window into past ocean-atmosphere interactions in the tropics. The Mid-Pleistocene Transition (MPT), occurring approximately 1 million years ago, appears as a critical period of climatic and monsoonal reorganization. This epoch shifts from a 41,000-year obliquity-dominated glacial cycle to the 100,000-year eccentricity-driven cycles that dominate the late Quaternary. The MPT significantly changed ISM intensity, hydrography, and stratification patterns in the Andaman Sea, improving aragonite preservation in post-MPT sediments. Enhanced stratification during interglacials and stronger nutrient upwelling during glacials post-MPT reflect the complex interaction between global climatic transitions and regional monsoon dynamics. This study highlights the millennial-scale monsoon variability and paleoceanography of the Andaman Sea. The findings highlight how shifts in ISM strength influenced biological productivity and carbonate preservation. By linking monsoon variability to global climatic drivers such as orbital forcing and the MPT, this research offers valuable lessons for understanding future changes in tropical precipitation regimes. As modern climate change accelerates, the insights gained from these long-term records can help contextualize



the potential impacts of anthropogenic warming on monsoon-dominated regions.

Keywords: Foraminifera, Pteropods, Andaman Sea, Indian Summer Monsoon, Stratification

【A0075】 -Poster

Amazon Basin precipitation under different Atlantic Meridional Overturning Circulation and sea surface temperature scenarios during the Heinrich Stadial 1 and Younger Dryas

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Changes in the intensity of the Atlantic Meridional Overturning Circulation (AMOC) have been associated with changes in the mid-latitude of the Intertropical Convergence Zone and the intensity of the South American Monsoon System. These changes affect precipitation patterns in the Amazon Basin, which are essential for maintaining the most biodiverse ecosystem on the planet. Thus, the projected weakening of the AMOC (associated with anthropogenic climate change) represents a significant threat to the stability of the Amazon rainforest. Millennial-scale events within glacial and deglacial periods, such as Heinrich Stadials (HS), offer valuable opportunities to understand the impact that a weak AMOC and other large-scale changes in oceanic and atmospheric climate (e.g., sea ice extent, surface winds, ice sheet height and extent, sea level) exert on Amazonian precipitation. Here we



reconstruct precipitation changes in the Amazon Basin from 27.4 to 3.6 thousand calibrated years before present (cal ka BP), focusing on Heinrich Stadial 1 (HS1, 18.6–14.6 cal ka BP) and the Younger Dryas (YD, 12.9–11.7 cal ka BP, also called Heinrich Stadial 0). To do so, we analyze two marine sediment cores collected from the western equatorial margin of the Atlantic. The cores were radiocarbon dated and studied for major elemental composition. We complement the analyses with: (i) data on the elemental composition of suspended sediments in the main rivers of the Amazon Basin; (ii) a regional compilation of paleoclimate records from tropical South America; and (iii) outputs from a transient fully-coupled climate model run covering the last 21 kyr (TraCE-21ka). The results reveal distinct precipitation patterns during HS1 and the YD, associated with heterogeneous sea surface temperature (SST) anomalies in the western equatorial Atlantic and eastern equatorial Pacific, partially linked to different AMOC scenarios. During HS1, we identified two phases: HS1a (18.6–16.6 cal ka BP) and HS1b (16.6–14.6 cal ka BP). These phases presented changes in the relative concentration of elements such as Al, K, Ca, Ti and Fe, indicating a regional change in precipitation, which migrated from the central Andes (HS1a) to the southeastern Amazon (HS1b). This change appears to have been influenced by the significant weakening of the AMOC and by a positive SST anomaly in the eastern equatorial Pacific relative to the western equatorial Atlantic in HS1b. Precipitation anomalies during the YD were less evident, concentrated in the eastern Amazon and the central Andes. However, we do not rule out that the signal from major elemental composition may have been impacted by a significant sea level rise, which expanded the accommodation space for terrigenous sediments on the continental shelf. The heterogeneous response of precipitation to different AMOC scenarios reinforces the importance of high temporal resolution paleoclimate studies in the Amazon Basin and highlights the need to consider the spatial compartmentalization of precipitation responses, given its continental scale.

Keywords: Amazon Basin, Heinrich Stadial, AMOC, Past precipitation

【A0596】 -Poster

The last 21,000 years of climate evolution in the South American Altiplano based on the CHELSA-TraCE21k transient simulation

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Global transient simulations have improved their skill in reconstructing some of the major climatic and environmental transformations since the last glacial stage. However, they are often run at low spatial resolution, so their ability to simulate regional climate histories is still limited. Recently, Karger et al. (2023) presented the CHELSA-TraCE21k dataset, a statistical downscaling of the TraCE21k global transient simulation to a resolution of ~ 1 km. This new numerical dataset offers great potential for paleoclimate and paleoecological applications. However, its validation against proxy-based information is critical to assess potential biases and misrepresentations that may improve regional climate histories and numerical models. Here we present an analysis of the CHELSA-TraCE21k simulation over the South American Altiplano (14 – 22°S). Using both present-day and proxy datasets, we validate the model's skills in reconstruction of surface temperatures, precipitation and paleo-glacial extent in this high-andean region. We then discussed the simulated paleoclimate evolution in the Altiplano over the last 21,000 years in the light of available paleoclimate reconstructions. The high spatial detail of the simulation offered an opportunity to re-examine some longstanding regional paleoclimate debates, including the climate conditions of the sub-tropical Andes during the LGM (21,000–19,000 yr BP), the spatial extent of pluvial events over the Last Termination (18,000–11,000 yr BP), and the drivers of multi-millennial trends during the Holocene.

The CHELSA-TraCE21k dataset is able to improve the representation of modern surface temperature and precipitation in the Altiplano relative to the original simulation and simulates various features suggested by proxy reconstructions, although fails in replicating the timing and extension of well documented glacier reconstructions. The simulation suggests an average temperature decrease of 3.5°C , a slight precipitation increase (50 mm) relative to the 20th century during the Last Glacial Maximum (LGM), and reveals two moderately wet pulses (50–90 mm) coinciding with Heinrich Stadial 1 and the Younger Dryas intervals. Postglacial conditions were relatively warm and dry, with a multi-millennial warming and precipitation increase throughout the Holocene. While these changes are generally consistent with available proxy evidence, their simulated magnitudes tend to be underestimated when averaged for the entire Altiplano. The spatial analysis of hydroclimate anomalies suggests that the formation of large paleolakes during the Last Termination was not associated with local precipitation rises, but likely from the overflow of the Titicaca basins over the northern Altiplano. The CHELSA-TraCE21k simulation suggests that regional climate histories in the Altiplano were linked to a complex interplay between high-latitude forcing and tropical austral summer insolation. This new high-resolution simulation is a valuable



framework for understanding past climate change in the region. The analysis presented in this study exemplifies the importance of developing climate simulations in regions with complex orography that generally lack detailed proxy reconstructions. Future work, combining proxy data and refined model simulations, will be crucial to confirm these findings and further disentangle the drivers and mechanisms of paleoclimate changes in tropical South America.

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Keywords: Altiplano, South America, CHELSA-TraCE21K, Andes, LGM

【A0232】 -Poster

ENSO modulated rainfall variations in the Western Pacific Warm Pool during the Holocene

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The Western Pacific Warm Pool (WPWP) is Earth's largest reservoir of warm surface waters (permanent sea surface temperature above 28°C). It is considered the steam engine responsible for the atmospheric circulation globally. Hence, small variations in the sea surface temperature can influence the location and strength of convection in the rising limb of the Hadley and Walker circulations, perturbing planetary scale atmospheric circulation, atmospheric heating globally, and tropical hydrology. Uncovering the determinant of rainfall variability is essential, as these changes directly impact human societies by affecting food security, water resources, and economic stability across Asia and the Pacific. However, rainfall is one of the most challenging



atmospheric parameters to reconstruct to this day, thus the general rainfall proxy data gap in the Western Pacific Warm Pool. To solve this, we conducted a high-resolution rainfall reconstruction for the WPWP using plant-wax isotopes (δD and $\delta^{13}C$) together with run off based variations in marine sediment elemental ratios (Ti/Ca and Fe/Ca) obtained by X-Ray Fluorescence (XRF) core scanning from gravity core GeoB17429-2, recovered off the northern coast of Papua New Guinea (PNG) in conjunction with the Community Earth System Model (iCESM) rainfall simulations for the past 15ka. Our biomarker and XRF data reveal a pronounced decrease in rainfall during the Middle Holocene (7-4 kyr BP). We suggest that the drier conditions over PNG during the Middle Holocene are linked to the equatorial September insolation maximum, which caused a thermocline warming in the WPWP, which intensified the Walker Circulation, suppressed ENSO activity, and thus causing persistently drier conditions over PNG.

Keywords: Hydroclimate, Plant-wax, ENSO, WPWP

【A0151】 -Oral

Intensified North Atlantic subtropical high forcing of millennial Atlantic Warm Pool droughts

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The areas surrounding the Atlantic warm pool (AWP) are highly vulnerable to droughts, and yet the climate mechanisms that trigger and sustain droughts at different time scales in the region remain poorly understood. Here, we present a 129.3 ka oxygen isotope record from precisely dated speleothems from western Cuba that documents



a previously unrecognized sensitive link between the North Atlantic Subtropical High (NASH) and atmospheric-oceanic processes on millennial to orbital time scales. Against the backdrop of a warm tropical North Atlantic, the precessional-scale precipitation variability in the region is inversely related to high summer insolation, suggesting a close coupling with an intensified and westward expanded NASH. Between 66 and 129 ka, our data show twelve millennial droughts that occurred under cool stadial as well as warm interstadial conditions, suggesting that both weak and strong atmospheric-oceanic circulation can drive AWP droughts. Additionally, we provide new insight into how orbital forcing may have induced two extreme droughts at 105 ka and 126 ka by exciting the extreme westward extension of the NASH in a manner analogous to the mid-summer dry spell on a seasonal scale.

Keywords: Atlantic warm pool, Droughts, North Atlantic Subtropical High, Speleothems

【A0353】 -Poster

Distinct responses of Asian Summer Monsoon circulation and precipitation to orbital forcing during six Heinrich events

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Climatic fingerprint of Heinrich (H) events was characterized by widespread megadroughts over the Asian Summer Monsoon (ASM) region accompanied by systemic weakening of the ASM. However, recent studies of hydroclimate proxies suggest huge spatial discrepancies in precipitation over the ASM region during some H events, characterized by increased precipitation in the Yangtze River Valley contrasting with the prevalent megadroughts across the whole ASM region. The



mechanism responsible for the spatial discrepancies in precipitation and the relationship between local precipitation and the ASM intensity remain elusive. In this study, we investigate the response of the ASM circulation and precipitation to orbital forcing during six H events based on simulations with a coupled atmosphere-ocean general circulation model. The results show that changes in insolation alone can induce spatial discrepancies in precipitation over the ASM region during the H events. During the H1, 3, 4, 5, 6 events, the amplification of the land-sea pressure contrast in response to a positive hemispheric insolation gradient (30°N-30°S) during boreal summer intensifies moisture transport from the adjacent oceans to the ASM region. The ensuing moisture divergence, combined with anomalous downdrafts, results in decreased precipitation in the South Asian Summer Monsoon (SASM) region, but converse scenario for the East Asian Summer Monsoon (EASM) region. During the H2 event, the increased precipitation across the Yangtze River Valley sharply contrasts the widespread drought over the ASM region, attributing to an anticyclone anomaly over the subtropical Western North Pacific and a cyclone anomaly over Japan and Korea. Moisture budget analysis shows that the dynamic effect, especially the vertical term, rather than the thermodynamic effect, is the dominant control of precipitation changes over the ASM region. Our results also suggest that despite the synchronous variation in the strength of the EASM and SASM in response to orbital forcing, the EASM should not be regarded as an eastward and northward extension of the SASM. Furthermore, our model simulates a weak correlation between the monsoon intensity and precipitation in the SASM region in response to orbital forcing, calling for caution in employing precipitation to reconstruct SASM intensity on orbital time scale.

Keywords: Heinrich events, Asian Summer Monsoon, Paleoclimate simulation, Dynamic analysis, Causal analysis

【A0093】 -Poster

The fate of Amazon sediments since the Last Glacial Maximum

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Past changes in the intensity of the Atlantic Meridional Overturning Circulation (AMOC) usually caused alterations in precipitation patterns over tropical South America. As the largest basin in the world, the Amazon River drainage basin shows intricate and only partially known responses to changes in AMOC strength. Tracking the source of sediments deposited off northeastern South America is of extreme importance to understand how Amazon rivers responded to different AMOC strengths, as well as other environmental changes like different relative sea levels. Here we present a multi-proxy approach to determine the provenance of sediments deposited off the Amazon River mouth since the Last Glacial Maximum using radiogenic isotopes (i.e., Nd and Sr), major elemental ratios (i.e., $\ln(\text{Fe}/\text{K})$), and optically stimulated luminescence sensitivity. We analyzed marine sediment core GL-1251 ($1^{\circ}04.1' \text{ N}$, $45^{\circ}48.0' \text{ W}$, 2.596 m water depth) thus slightly to the east of the Amazon River mouth) that is the most proximal core to the Amazon River mouth ever studied, making it an excellent archive to address this topic and to compare to other existing records. Our data show that during the Last Glacial Maximum and the Bølling–Allerød the deposition at our core site was dominated by sediments delivered by the Amazon River. During these periods, Andean sediments dominate the siliciclastic fraction and the delivery to our core site was favored by the relative low sea level. However, we identify two periods in which cratonic sources dominate the siliciclastic fraction. The first and most prominent occurred during Heinrich stadial 1, and the second along the Holocene. We suggest that under a weakened AMOC (i.e., Heinrich stadial 1), despite the increased Amazon freshwater discharge, few sediments from the Amazon River were deposited at the site of GL-1251. The massive intensification in precipitation over eastern Amazon and northeastern Brazil, in turn, substantially increased cratonic sediment input from Brazilian Shield drainages, resulting in high sedimentation rates. During the Holocene, sea-level rise fostered the predominant transport of the Amazon sediment plume towards the NW shelf and slope, allowing constant sediment input from Brazilian Shield drainages (i.e., cratonic deposition dominance) at the site of core GL-1251. Our data suggest changes in precipitation patterns over tropical South America and shows that sediment provenance in the northeastern South American continental margin was highly affected by a slowdown of the AMOC.

Keywords: Amazon River drainage basin, Sediment provenance, Climate changes, Heinrich stadial 1, Intertropical Convergence Zone

【A0381】 -Oral

Two regimes of meridional ITCZ adjustment during millennial-scale



North Atlantic cold events

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Changes in cross-equatorial northward heat transport mediated by the Atlantic Meridional Overturning Circulation (AMOC) during abrupt millennial-scale North Atlantic cold events, namely Greenland stadials (GS) and Heinrich stadials (HS), triggered latitudinal shifts of the Intertropical Convergence Zone (ITCZ) and thus dramatic fluctuations in the hydroclimate of tropical South America. In northeastern (NE) Brazil, the modern rainfall regime is primarily controlled by the ITCZ seasonal migration, with maximum rainfall during March-April when the ITCZ reaches its southernmost position. The elemental composition of bulk sediments from the northernmost margin of NE Brazil has been widely used to trace past changes in ITCZ position.

Here, we present a reconstruction of millennial-scale ITCZ dynamics based on the longest continuous paleoprecipitation record for NE Brazil, spanning the last 160 thousand years (kyr) with an unprecedented temporal resolution (average of 30 years). This hydroclimate record derives from the calcium/iron (Ca/Fe) log-ratio in bulk sediment from marine sediment cores MD23-3670Q and MD23-3671 (1365 m water-depth, 1°34.7 S, 43°1.4 W), retrieved off NE Brazil during the AMARYLLIS-AMAGAS II cruise in 2023. Our record captures all 25 Dansgaard-Oeschger (D-O) cycles identified in Greenland ice cores, offering a new benchmark for tropical millennial-scale climate variability. Notably, $\ln(\text{Ca/Fe})$ reveals two distinct millennial-scale regimes in NE Brazil hydroclimate during the last glacial cycle, one related to GS and the other to HS. The increased terrigenous input during HS compared to GS indicates enhanced continental precipitation and erosion in NE Brazil during HS. This pattern reflects a larger southward migration of the ITCZ during HS, which may have extended the length of the rainy season over the adjacent continent.

We also tested whether millennial-scale southward ITCZ migrations were proportional



to the AMOC-driven reduction in northward cross-equatorial heat transport (as already shown for HS1), by comparing $\ln(\text{Ca}/\text{Fe})$ values during GS and HS with coeval North Atlantic $^{231}\text{Pa}/^{230}\text{Th}$ values, a proxy for the southward advection of the lowest branch of the AMOC. HS are consistently associated with higher $\ln(\text{Ca}/\text{Fe})$ and $^{231}\text{Pa}/^{230}\text{Th}$ values, supporting the hypothesis that larger reductions in AMOC intensity during HS (compared to GS) led to more pronounced ITCZ shifts. Our study provides the first paleoprecipitation record in South America to capture all 25 D-O cycles, systematically demonstrating that GS and HS correspond to two distinct regimes of southward ITCZ adjustment. These findings advance our understanding of tropical climate dynamics during AMOC slowdown events.

Keywords: Dansgaard-Oeschger cycles, Heinrich Stadials, Intertropical Convergence Zone, Atlantic Meridional Overturning Circulation, NE Brazil

【A0431】 -Poster

Millennial-scale variability of the Asian Summer Monsoon over the last 690,000 years: Insights from cave records

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The Asian Summer Monsoon (ASM) is an important component of the global climate system. While the millennial-scale climate variability (MCV) of ASM have been well characterized by cave oxygen-isotope ($\delta^{18}\text{O}$) records over the last 640 ka, particularly for the last 60 ka, little information from cave records is available on ASM variability beyond U-Th dating limit of ~640 ka. On the other hand, whether the millennial-scale ASM variability recorded by various climate archives are consistent remains unclear, particularly in the context of the paradox observed from the different ASM orbital-scale records. Here, we present high-resolution and absolutely U-Pb dated cave $\delta^{18}\text{O}$



records from two Chinese caves, spanning 690–600 ka BP. Our records between 690–640 ka BP substantiate a coupling relation of millennial-scale weak ASM events with North Atlantic cooling and Antarctic warming, mirroring the pattern observed in the last 640 ka, despite of the potential shift of Atlantic meridional overturning circulation (AMOC) inferred by changes in source of ice rafted debris in the North Atlantic. MCV amplitude comparisons among different ASM proxies show remarkable disparities, suggesting that each record reflects merely a certain aspect of ASM. In our records, summer insolation declines always triggered millennial weak ASM events near the midway at the precession band, responding to the AMOC weakening, which do not take place only at the end of interglacials. Additionally, our analysis suggests that both CO₂ level and global ice volume conditions remain critical factors between ~688–635 ka BP, influencing the ASM millennial variability.

Keywords: Speleothem, U-Pb dating, Asian Summer Monsoon, Millennial events

【A0748】 -Poster

Indian hydroclimate and vegetation during glacial MIS 16: Disentangling high- and low-latitude forcings

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The Indian Summer Monsoon (ISM) accounts for ~90% of Central India's annual precipitation yet understanding its natural variability during past glacial periods remains a challenge in paleoclimate research. Despite considerable documentation of ISM dynamics during the Last Glacial Maximum (LGM), debates persist regarding the role of the primary forcings, including boreal summer insolation, North Atlantic



circulation, ice volume, atmospheric CO₂, and Southern Hemisphere heat export. Hence, pre-LGM paleorecords are crucially needed to evaluate impact of the ISM on fragile ecosystems, such as India's forests and savannas. Here, we focus on MIS 16 (676-621 ka), a severe Quaternary glacial period marked by the first instabilities of the Laurentide ice sheet leading to the development of Heinrich layers in the North Atlantic. We present the first MIS 16 vegetation reconstruction from India's Core Monsoon Zone based on pollen analysis from IODP Site U1446 strategically recovered at the exit of the Mahanadi River to capture a robust signal of the ISM rainfall. Our findings indicate the prevalence of grassland and low tropical forest abundance during MIS 16, indicating overall dry conditions and reduced ISM activity. Furthermore, a progressive expansion of semi-arid vegetation suggests long-term glacial aridification associated with ISM weakening. Intra-glacial variability exhibits alternating wetter/drier phases, linked to ISM strength. Vegetation and hydroclimate changes are primarily controlled by the summer inter-tropical insolation gradient (SITIG), peaking during mid-MIS 16. Conversely, late-MIS 16 ISM weakening suggests that SITIG forcing is overshadowed by the impact of maximum ice volume and millennial-scale variability. Three major dryland expansions reflect ISM responses to millennial ice rafting events and AMOC reductions. This study highlights the complex interplay of forcings driving past glacial ISM variability, crucial for understanding its impact on Indian ecosystems.

Keywords: Indian Summer Monsoon, Vegetation dynamics, MIS 16, High- and low-latitude forcings

【A0399】 -Poster

Rapidly increased salinity of Indonesian Throughflow waters into the Indian Ocean linked to weakened AMOC during the Last Two Terminations

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The Indo-Pacific Warm Pool (IPWP), characterized by its low surface salinity due to high precipitation, serves as a massive freshwater reservoir. The Indonesian Throughflow (ITF), as the only low-latitude return branch of the global thermohaline circulation, transports this freshwater from the Pacific through the Indonesian archipelago into the Indian Ocean. This process influences salinity distribution between the Indian and Pacific Oceans, affects salinity transport from the Indian to the Atlantic Ocean, and ultimately impacts the Atlantic Meridional Overturning Circulation (AMOC). Conversely, evidence indicates that AMOC variability influences the strength and position of the Intertropical Convergence Zone (ITCZ), leading to contrasting precipitation patterns on either side of the equator in the IPWP region. These regional precipitation changes likely influence IPWP salinity — and, consequently, salinity input into the Indian Ocean via the ITF — but the importance of this retroaction loop and its impact remain unclear.

This study reconstructs salinity changes in surface seawater transported by the ITF to the Indian Ocean during the last two terminations. By combining planktonic foraminiferal *Globigerinoides ruber* Mg/Ca-based sea surface temperature with stable oxygen isotope records from sediment core MD98-2165, and correcting the resulting data for global ice volume effect, we generated a surface water $\delta^{18}\text{O}$ record, which reflects regional precipitation/evaporation changes. Our record reveals pronounced millennial-scale salinity increases during both terminations, coinciding with periods of weakened AMOC. These salinity increases may have played a critical role in facilitating the subsequent recovery of AMOC. This finding highlights the Earth's internal feedback mechanisms, whereby interactions between atmospheric and oceanic circulation connect high- and low-latitude climate dynamics.

Keywords: Indo-Pacific Warm Pool, Indonesian Throughflow, AMOC, Intertropical Convergence Zone

【A0040】 -Poster

Oscillations in mid- to late Holocene environments of the lower Negro River, central Amazonia, recorded in pollen and diatom from Lake Pacú sediments

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The mid- to late Holocene transition in the lower Negro River reveals significant insights into the ecological succession and climatic history of central Amazonia. Analyzing sedimentary, pollen and diatom data, this study presents an uninterrupted regional view of the ecological and environmental variations from the largest lake in the lower Negro River. Microfossil findings indicated dominance of igapó forests throughout the analyzed timespan. The sedimentary record suggests that at ca. 5020 cal yr BP, there was a transition from a high-energy "open-fluvial" environment characterized by sand deposition to a low-energy setting, allowing the sedimentation of fine-grained sediments. From ca. 5020 to 1600 cal yr BP, the area witnessed multiple alternations between pioneer (periphytic diatoms and herbaceous plants) and climax species (planktonic diatoms and floodplain forests). The synchronized fluctuations in the terrestrial and aquatic ecosystems suggest significant hydrological variations in central Amazonia during the mid- to late Holocene. After 1600 cal yr BP, the record is marked by the dominance of floodplain forests and planktonic diatoms, resembling a modern igapó forest climax state. Our record underscores the interdependence of aquatic and terrestrial ecosystems in this area. Overall, it depicts a dynamic scenario in the lower Negro River, with water level fluctuations exerting a major control on ecological succession

Keywords: Negro River, Ecological succession, Holocene, Pollen, Diatom

【A0605】 -Poster

North Atlantic SST gradients and their influence on hydroclimate shifts and atmospheric circulation dynamics

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Understanding thermal contrasts across the North Atlantic is essential for assessing their role in climate system dynamics, ocean circulation and atmospheric processes. Variations in sea surface temperature (SST) influence critical climate mechanisms such as North Atlantic Ocean (NAO) dynamics, meridional heat transport, and shifts in atmospheric circulation patterns. This study aims to investigate these thermal contrasts by integrating high-resolution SST records from three strategically chosen sites in the North Atlantic: eastern mid-latitudes (IODP U1385), western mid-latitudes (ODP1058), and high latitudes (IODP U1314). By aligning these records through stratigraphic correlation and spectral analysis, we reconstruct spatiotemporal SST gradients during key climatic intervals.

By focusing on periods characterised by abrupt climate transitions and glacial variability, we assess how regional thermal gradients drive ocean-atmosphere interactions and contribute to the variability of the North Atlantic climate system.

Our results highlight the importance of longitudinal and latitudinal SST gradients in regulating the strength and persistence of the NAO and its role in modulating ocean-atmosphere heat and moisture exchange. The high-latitude site provides insights into polar amplification processes and feedback mechanisms associated with ice sheet dynamics and freshwater inputs. The subtropical mid-latitude sites, in turn, allow us to assess the influence of zonal contrasts on westerly wind strength, storm tracks, and the transfer of heat and energy across the Atlantic basin.

A key observation is the strong link between SST variability and meridional heat transport, particularly during glacial and interglacial transitions driven by precessional forcing. SST gradients between high and mid-latitude sites are shown to have a significant impact on the Atlantic Meridional Overturning Circulation (AMOC), which plays a central role in maintaining climate stability and distributing heat globally. In addition, SST changes in the eastern and western mid-latitudes reveal the influence of basin-wide dynamics, shedding light on the complex interplay between regional and hemispheric climate patterns.

This study also highlights the role of North Atlantic SST variability in shaping atmospheric circulation patterns at different timescales. During periods of abrupt climate change, thermal gradients appear to amplify feedback processes that modify atmospheric pressure systems and storm activity. These findings not only provide a



deeper understanding of past climate behaviour, but also offer valuable insights into the potential impacts of ongoing and future changes in North Atlantic SSTs on global climate systems.

Keywords: Sea surface temperature, Thermal contrast, Climate dynamics, Hydroclimate shifts

【A0912】 -Oral

Suborbital- and millennial-scale monsoon variability during Pleistocene interglacials

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Observational and modeling results show that the frequency and magnitude of extreme climatic events have increased significantly in the context of global warming. However, whether abrupt climate changes intensified during past warm periods remains poorly constrained due to the lack of high-resolution geological records. Here, we report a 512-m predominantly lacustrine sedimentary record from the Weihe Basin (North China), revealing that lake levels fluctuated significantly on suborbital (half- and quarter-precession) and millennial time scales over the last two million years. Grain-size results reveal that magnitudes of rapid lake level fluctuations increased dramatically during Pleistocene interglacials, differing from glacial amplification of abrupt climate events recorded in North Atlantic marine sediments. Model results indicate that summer insolation maxima in low-latitude region of both hemispheres can lead to intensified monsoon precipitation in East Asia.



Our proxy-model comparison highlights the importance of interhemispheric interaction for driving multiscale hydroclimatic variability in a warming world.

Keywords: East Asian monsoon, Suborbital- and millennial-scale variability, Pleistocene interglacials, Weihe Basin, lacustrine sedimentary

【A0207】 -Poster

Paleoprecipitation pattern over the last millennia in drylands of Northeast Brazil

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Northeastern Brazilian region (NEB) is one of the areas in South America most vulnerable to the impacts of climate change. Historical records describe frequent droughts since the 18th century and today put at risk around 57 million people of experiencing water scarcity. Precipitation is exclusively originated from the Intertropical Convergence Zone (ITCZ) in the north boarder of NEB (N-NEB), while the southern portion (S-NEB) is under the South America Monsoon System (SAMS) influence. Despite previous studies have described the SAMS variability in different time scales, as well as the ITCZ, the relationship between them has not been tested for the last millennia due to a few number records described in South America, especially in NEB. The study area (S-NEB) was recently defined as the first modern arid zone in Brazil by National Institute for Space Research (INPE) and it is positioned in both ITCZ and SAMS margins. Our main goal is to comprehend the paleoprecipitation dynamics over NEB and how ITCZ and SAMS interacts with each other. Two stalagmites from S-NEB collected at Gruta do Jerônimo (9.72°S 39.33°W) were dated by U/Th and analyzed for oxygen isotope ratios in order to reconstitute precipitation during the last



4,000 yrs in high resolution. The isotope results (JER Composite) were integrated by using a composite method (Fohlmeister 2012) and have less than 5 years resolution per samples. There are no abrupt climatic events or large dry/wet periods recorded in JER Composite, however a well-defined periodicities of 21 and 32 years (99% of confidence interval) can be identified and correlated with large scale atmospheric phenomena, as Interdecadal Pacific Oscillation (IPO) and Pacific Decadal Oscillation (PDO). During the positive (negative) phases of Pacific modes, changes in Walker circulation branch could significantly reduce (enhance) the vertical mixing within the atmospheric column and the surrounding atmosphere, thereby affecting the strength of various $\delta^{18}\text{O}$ fractionation processes over South America (Orisson et al., 2024). The South Atlantic Convergence Zone (SACZ), a SAMS feature, shifts slightly to the south during the positive Pacific phases that reduces precipitation over S-NEB, while more strongly shifts to the north during the negative Pacific phases moves the SACZ over or more closer to S-NEB (Silva et al., 2020). Our results suggest that S-NEB paleoprecipitation is mostly affected by SAMS fluctuations, which is modulated by the Pacific variability. Only few concomitant events occurring at S and N-NEB records can be associated with changes in Atlantic sea surface temperature that stretched/weakened the ITCZ-related rainfall and consequently stretches SAMS.

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Keywords: Paleoclimatology, Holocene, Stalagmites, Stable isotopes

【A0852】 -Poster

Precession driven low-latitude precipitation paced by shifting perihelion



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Paleoclimate proxies reveal a significant precessional impact on the low-latitude hydrological cycle. Classical theory suggests that precession modulates the inter-hemisphere summer insolation difference, and hence controls the meridional displacement of the Inter-Tropical Convergence Zone. Accordingly, the low-latitude precipitation changes are expected to be in-phase (for the Northern Hemisphere) or anti-phase (for the Southern Hemisphere) with the Northern Hemisphere summer insolation. However, increasing number of absolutely dated proxies reveal that variations in land precipitation at different low-latitudes follow distinct precession rhythms that are very often not paced by the hemispheric summer insolation. The mechanism underlying such spatial complexity remains elusive. In this study, we argued that the precession driven low-latitude land precipitation is paced by shifting perihelion, rather than the hemispheric summer insolation. More specifically, precession of the Earth's rotation axis alters the season and latitude of perihelion. When perihelion occurs, solar radiation reaches its maximum value, thermodynamically moving the tropical convergence zone from ocean to land, contributing to enhancing the precipitation over land. As perihelion occurs towards



different latitudes and seasons at different precessional phases, this leads asynchronous land precipitation maxima at different latitudes. Our hypothesis, supported by both model simulations and geologic records, suggests that the insolation in individual seasons is equally important in shaping the orbital scale climate changes at low-latitude. This provides new insight on the Milankovitch theory which highlights the role of summer isolation in driving the astronomical climate change.

Keywords: ITCZ, Monsoon, Precession, Perihelion, Tropical precipitation

【A0220】 -Poster

New insights of the Heinrich events inferred by speleothems from Northeast Brazil

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Heinrich events (HEs), characterized by massive and rapid ice-rafted debris from Laurentide Ice Sheet into the Labrador Sea as far south as the Iberian Margin, are observed in some stadial periods during the last glacial, however, it is still unclear regarding to the trigger and response mechanism of the HEs. A landmark work by Wang et al. (2004) was one of the first studies to associate tropical rainfall in southern Hemisphere with HEs, showing wet periods in tropical northeastern Brazil, a region that is currently semi-arid but very sensitive to the hydroclimate changes related to the cold events occurred in the northern Hemisphere, are synchronous with HEs in the North Atlantic. After two decades, we have a new chance to study the relationship between hydroclimate in NE Brazil and cold events in the North Atlantic in the light of much more new speleothem records obtained from TBV and TBR caves, NE Brazil. Here we show evidence of stalagmite growth periods and $d^{18}O$ records during the last 90 kyrs from NE Brazil, in addition to the HEs observed by Wang et al. (2004), we have



newly found wet periods during the HE2 and HE3 and GS 5-8 that were not discovered before. It indicates that previous conclusions that the orbital insolation also modulated these events on millennial timescales need to be reinterpreted, and also provides new insights to understand the mechanisms of the HEs and why the HEs only occurred in some Heinrich Stadials. Additionally, we also compare detailed structures of each HE inferred from cave $d^{18}O$ records in NE Brazil with sea surface temperature and other records in the Atlantic realm, which deepens our understanding of the trigger-response mechanisms of the HEs and its effect on the hydroclimate in the NE Brazil.

Keywords: Speleothem, Heinrich events, NE Brazil, South American monsoon, Oxygen isotope

【A0908】 -Poster

Millennial-scale evolution of South Asian Summer Monsoon during the late Pliocene recorded in the Yuanmou Basin, southwestern China

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Understanding the millennial-scale evolution of the South Asian Summer Monsoon (SASM) is essential for revealing the evolution of the monsoon system and its mechanisms. Quaternary millennial-scale (1-15 kyr period) South Asian Summer Monsoon (SASM) variability is well documented, and provides insights into the response of the SASM to the internal variability of the Earth system. Many studies have focused on the millennial-scale evolution of the SASM since the Quaternary, but the mechanisms of the evolution are controversial. The response of the evolution of the Quaternary millennial-scale SASM to the climate of the northern hemisphere high latitudes, as well as to low-latitude insolation and tropical ocean-atmosphere processes, has long been discussed. However, studies on the pre-Quaternary millennial-scale SASM are scarce due to the lack of reconstructed records. This has hindered our insights into the evolution of millennial-scale SASM.

In this study, we present a high-resolution (~600 y sampling resolution) geochemical



and magnetic susceptibility (MS) dataset during the late Pliocene from a fine-grained lacustrine sedimentary sequence in the Yuanmou Basin, Southwest China (South Asian monsoon regions). The sedimentary succession at Yuanmou Basin provides a window into millennial-scale regional climate change during the expansion of the Northern Hemisphere ice sheet during the late Pliocene. Our record, based on Rb/Sr and magnetic susceptibility data, captures the millennial-scale evolution of the SASM during the late Pliocene. We observe strong half- and quarter-precession signals in the Yuanmou record, with amplitude modulation synchronized with orbital eccentricity and obliquity. We have accurately identified these sub-orbital scale cycles and explored the relationship between these signals and orbital periods. Bicoherence analysis shows that observed some millennial-scale cycles (as short as 3 kyr) may be associated with nonlinear interactions with others. In addition, the observed ~3 kyr cycles may be associated with oscillations in Antarctic ice sheet (AIS) size, reflecting the response of the millennial-scale SASM to changes of the AIS. At the same time, based on previous studies, we provide an in-depth analysis of the origin of these cycle signals. Our results suggest that the half- and quarter-precession signals in the SASM may originate from the insolation and seasonal differences in the equatorial region. Together, these data demonstrate the millennial-scale response of the SASM to the low latitude insolation, as well as to the high-latitude ice sheet forcing during the late Pliocene. Our work will gain new insights into the understanding of millennial-scale SASM variability and its mechanisms.

Keywords: South Asian Summer Monsoon, Millennial-scale, Late Pliocene, Low-latitude insolation, Ice sheet forcing

【A0347】 -Poster

Interhemispheric monsoon variability and its possible forcing during Heinrich Stadial 4: Insights from low latitude speleothem records

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Heinrich Stadial 4 (HS4) features a significant iceberg discharge event of the last glacial



period, in which closely linked interactions occurred between high and low latitude climate systems. However, the scarcity of high-resolution records limits our understanding of the Interhemispheric Monsoon dynamics during this period. Here we present high-resolution, annually laminated speleothem records from Southeast China, combined with previously published data, to precisely examine the impact of HS4 on low-latitude monsoon systems. Though the onset and termination of HS4 are synchronous, the East Asian Summer Monsoon (EASM) exhibits two weak monsoon events during this period, including Heinrich event 4 (HE4) (39.70 ± 0.06 ka BP), consistent with the South American Summer Monsoon (SASM), while the Indian Summer Monsoon (ISM) shows gradual weakening after the onset and a substantial reduction ~ 200 years after HE4. As HS4 onset progresses and HE4 occurs, EASM and SASM remarkably respond to northern high-latitude climate changes, while ISM weakening is also moderated by lower Antarctic temperatures and strong equatorial cross-flow, with suppression dissipating only after Antarctic warming.

Keywords: Speleothem, East Asian Summer Monsoon, Heinrich Stadial 4, Heinrich event 4, Indian Summer Monsoon



Session 22. Understanding thresholds, tipping points, and abrupt climate change across different spatial-temporal scales

Conveners: Aixue Hu, Martin Grosjean, Ilham Bouimetarhan, Bette Otto-Bliesner, Frerk Pöppelmeier

【A1050】 -Oral

Bistability of AMOC and Millennial scale climate variability: Dependence on background climate condition in the past, present and future

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Glacial periods were punctuated by abrupt millennial scale climate changes and have a strong link to the Atlantic Meridional overturning circulation (AMOC) changes. Although paleoclimate is important to understand the present and future, how the bistability and tipping points at present and future are related to the glacial millennial scale climate change is not clear. Here we present several hysteresis diagram of AMOC and climate and compare them with the cases of millennial scale climate variability with our Atmospheric Ocean coupled GCM, MIROC4m. A series of long transient experiments (> 10, 000 years) were performed systematically with different *steady* glacial conditions (CO₂ level, obliquity, precession, meltwater, ice sheet size), to study the dependence of the sweet spot of millennial scale variability on the background climate and summarize the results as phase diagrams. We also show the hysteresis diagram of our model by adding anomalous freshwater flux in the North Atlantic in the model little by little. We chose the model version which we simulate LGM AMOC weaker and shallower than the AMOC under Pre-Industrial condition. We show that a reasonable sweet-spot of intrinsic oscillation exists when the Northern Hemisphere ice sheets exist even without freshwater perturbation. In the sweet spot, self-sustained oscillation with bipolar seesaw pattern and shift between interstadial and stadial occur, with interval between abrupt events ranging



from 1000 years to more than 5000 years depending on the background condition, while an abrupt shift from stadial to interstadial mode occurs in about 100 years. We show the cases of CO₂ from 155 ppm up to 840 ppm and discuss the hysteresis diagram and the oscillatory mode depending on CO₂ level as well as the existence of glacial ice sheets.

Keywords: AMOC, Instability, Bistability, Glacial climate

【A0164】 -Oral

Ocean heat content as a framework for understanding global climate coupling during Dansgaard-Oeschger cycles

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Millennial-scale Dansgaard-Oeschger climate cycles of the last Ice Age are attributed to abrupt switches in the strength of the Atlantic Meridional Overturning Circulation (AMOC). They represent prime examples of tipping points in the Earth System. The weak and strong AMOC modes are associated with cold (stadial) and warm (interstadial) conditions in Greenland ice cores, and gradual warming and cooling in Antarctica, respectively. The thermal bipolar seesaw is a widely-used conceptual model that seeks to explain this bipolar coupling as an interhemispheric redistribution of heat. Here we evaluate an emerging alternative framework centered instead on the global ocean heat content (OHC). We compare climate model runs of spontaneous, unforced D-O oscillations simulated in three different coupled ocean-atmosphere GCMs. In these models, the strong AMOC mode drives a gradual reduction in OHC as the ocean loses heat to the northern high-latitude atmosphere, which is then lost via the radiation balance at the top of the atmosphere. The OHC in all ocean basins varies in phase. Antarctic temperature is strongly correlated to OHC via circumpolar upwelling of deep waters and their control on Southern Ocean sea ice extent.



Greenland temperatures, in turn, are strongly correlated with the rate of ocean heat loss via the state of North Atlantic sea ice and AMOC strength. During the D-O cycle the AMOC acts as a “heat release valve” to the global OHC via so-called deep decoupling oscillations. At intermediate climate states the global ocean heat uptake cannot reach a steady state with North Atlantic heat loss because of the latter’s strong bimodality, causing instability. The OHC framework provides an intuitive explanation for the observed dependence of interstadial duration on background climate conditions such as atmospheric CO₂ concentrations. We discuss whether or not past D-O events can be considered an analogue for future AMOC weakening predicted under continued global warming.

Keywords: Dansgaard-oeschger cycle, Bipolar seesaw, Climate modeling, Abrupt climate change

【A1007】 -Poster

Simulation method of frozen soil embankment considering refined 3-D structural model

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Engineering projects in permafrost areas often encounter various disease problems, such as frost heave, irregular settlement, cracking, landslides, etc. These diseases are mainly caused by the freeze-thaw changes of underground frozen soil. Therefore, if you want to control engineering diseases in permafrost areas, you must first study the mechanism of water and heat changes in permafrost areas and the mechanical manifestations of water and heat changes in permafrost areas. At present, a large number of studies on frozen soil roadbeds often assume that the roadbed is a uniform whole when analyzing its mechanism, and ignore its three-dimensional structure to simplify the calculation and analysis. However, in the process of water and heat changes in frozen soil, the roadbed is the channel of water and heat changes and the main body of mechanical action, and its three-dimensional structure has a significant impact on the simulation results. Therefore, in order to more accurately study the mechanism of roadbed diseases in frozen soil areas, we propose a permafrost area roadbed simulation method based on the finite element method and combined with a three-dimensional random aggregate model. Through the refined three-dimensional



structure, the mechanical process in the roadbed disease problem can be more accurately simulated and analyzed. And two examples are used to demonstrate the superiority of the proposed method.

Keywords: Finite element method, Permafrost, Highway roadbed, 3D structural model

【A0289】 -Poster

Peatlands have the potential to emerge as significant contributors to future climate warming

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Peatlands store a substantial amount of carbon in the terrestrial ecosystem. They are both long-term sinks of organic carbon and a major natural source of atmospheric methane. The accumulation of carbon is a result of net primary production surpassing decomposition rates over millennia, whereas methane production is intricately linked to the anaerobic decomposition of carbon mass. Warming-induced alterations in net primary productivity and decomposition rates are impacting net emissions, thereby jeopardizing the carbon sink capacity of these carbon-rich ecosystems and potentially turning them into sources of carbon dioxide and methane. In this study, we modelled the past and future trends of peatland carbon and methane fluxes and their influence on the climate system. We found that peatlands > 25 °N will remain a carbon sink and methane source under a low-warming scenario (RCP2.6) but they would shift from being not only a source of methane but also a source of carbon dioxide under a high-warming scenario (RCP8.5) by the mid-21st century leading to a strong radiative forcing (0.25 W m⁻²) by the end of the 23rd century. This underlines the potential warming feedback in which peatland radiative forcing on the climate system would shift from negative to positive in the future.

Keywords: Peatlands, Carbon balance, Methane, Modelling, Radiative forcing

【A0620】 -Oral

Millennial-scale changes in water availability and its consequences over tropical South America



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Water availability is arguably one of the main concerns for tropical South American societies in a changing climate. Among the main variables that control water availability is rainfall. A specific tipping element of the climate system, namely the Atlantic meridional overturning circulation (AMOC), is believed to exert a strong control over tropical South American rainfall. This same tipping element may substantially slowdown, or even collapse, until the end of the century, potentially altering rainfall over tropical South America. However, since the AMOC did not show marked changes in strength during the instrumental climate record, our knowledge about its consequences over tropical South American rainfall and beyond strongly relies on paleoclimate information. Indeed, the AMOC showed repeated slowdown events in the recent geological history of the Earth and the paleoclimate record allows the investigation of the consequences of such events. Here we review recent studies and provide new data showing that marked weakening events of the AMOC led to a substantial rainfall decrease over northernmost South America, while the southern South American tropics experienced copious rainfall. These oscillations in AMOC strength dramatically changed tropical water availability over tropical South America within some decades. Reduced rainfall over northernmost South America during AMOC slowdown events fostered a decline of tropical rainforest and an expansion of seasonal tropical vegetation in the northern Amazon. Conversely, the increase in rainfall over the southern South American tropics favored the expansion of more forested vegetation types across southern Amazon and northeastern Brazil. Importantly, a future slowdown of the AMOC may trigger the former effect again but may not be able to produce the latter, given the current widespread land use changes over the southern and eastern Amazon, as well as over northeastern Brazil.

Keywords: Tipping elements, Rainfall, Vegetation, Late Quaternary, South America



【A1052】 -Oral

First signs of millennial climate variability during the late Pliocene intensification of Northern Hemisphere Glaciation

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Millennial climate variability (MCV) is an intrinsic feature of Quaternary glacial periods. The occurrence of MCV during times of enlarged ice sheets suggests a possible link between its emergence and the intensification of Northern Hemisphere Glaciation (iNHG) during the Plio-Pleistocene transition. In this study, we present findings from marine sediment cores retrieved from IODP Site U1385 on the Iberian Margin to explore the onset of MCV associated with the iNHG.

XRF-derived elemental ratios (Ca/Ti and Zr/Sr) reveal four distinct stadial events during Marine Isotope Stages (MIS) G6, G4, G2, and 104. These ‘precursor events’ precede the onset of persistent MCV, marked by multiple stadial events beginning with MIS 100 (2.54 Ma) (Hodell et al. in prep). The planktic $\delta^{18}\text{O}$ record of *G. bulloides* exhibits millennial-scale sea surface cooling during each stadial event. These stadials consistently occur when the mixed benthic $\delta^{18}\text{O}$ values (*C. wuellerstorfi* and *U. peregrina*) exceed 3.8‰, the threshold for MCV identified for the last 1.45 Ma at Site U1385 (Hodell et al. 2023).

Using a precession-tuned age model, all stadial events appear to correlate 1:1 with peaks in ice-rafted debris (IRD) in the high-latitude North Atlantic, within the error of the respective age models. This correlation suggests a connection to iceberg calving and freshwater forcing, highlighting the role of ice-sheet dynamics in driving millennial-scale variability.

Reference:



Hodell, D.A., Crowhurst, S.J., Lourens, L., Margari, V., Nicolson, John., Rolfe, J.E. Skinner, L.C., Thomas, N.C., Tzedakis, P.C., Mlenek-Vautravers, M., Wolff, E.W., 2023. A 1.5-million-year record of orbital and millennial climate variability in the North Atlantic. *Climate of the Past* 19: 607 – 636. <https://doi.org/10.5194/cp-19-607-2023>

Keywords: Millennial climate variability, Marine sediment cores, Plio-Pleistocene Transition, Iberian Margin

【A0482】 -Poster

Combined control of polar stratification and iron fertilization on the Late Pliocene atmospheric $p\text{CO}_2$ drawdown

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The late Pliocene witnessed profound global climate transition to the Pleistocene glacial cycles, attributed partially a clear drawdown of the atmospheric CO_2 levels to around 280 ppm, the proposed threshold for Northern Hemisphere Glaciation. Yet, underlying processes that may drive this atmospheric carbon removal has yet to be found. With aid of biogeochemical modeling, we here propose that combination of diminished Pacific Meridional overturning circulation (PMOC) and enhanced global iron deposition substantially contribute to the late Pliocene $p\text{CO}_2^{\text{atm}}$ reduction. The reduction of PMOC leads to substantial isolation of the deep Pacific, facilitating carbon sequestration in the abyssal cell. More dust deposition improves oceanic surface productivity, thereby lowering $p\text{CO}_2^{\text{atm}}$. By comparing with existing proxies, we further show that the weakened PMOC may result in the latitudinal heterogeneity of surface productivity, whereas the inter-basin difference of production may be attributed to the varied iron deposition pattern. Essentially, the intermediate-deep yet sufficiently strong PMOC simulated in this study can to some extent reconcile the conundrum that the late Pliocene North Pacific was associated with both sustained high production and no deep (>3000 m) water formation.

Keywords: CO_2 , PMOC, Pliocene, Iron fertilization



【A0400】 -Oral

Open ocean convection drives enhanced eastern pathway of the glacial Atlantic Meridional Overturning Circulation

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Abundant proxy records suggest a profound reorganization of the Atlantic Meridional Overturning Circulation (AMOC) during the Last Glacial Maximum (LGM, ~21,000 years ago), with the North Atlantic Deep Water (NADW) shoaling significantly relative to the present-day (PD) and forming Glacial North Atlantic Intermediate Water (GNAIW). However, almost all previous observational and modeling studies have focused on the zonal mean two-dimensional AMOC feature, while recent progress in the understanding of modern AMOC reveals a more complicated three-dimensional structure, with NADW penetrating from the subpolar North Atlantic to lower latitude through different pathways. Here, combining $^{231}\text{Pa}/^{230}\text{Th}$ reconstructions and model simulations, we uncover a significant change in the three-dimensional structure of the glacial AMOC. Specifically, the mid-latitude eastern pathway (EP), located east of the Mid-Atlantic Ridge and transporting about half of the PD NADW from the subpolar gyre to the subtropical gyre, experienced substantial intensification during the LGM. A greater portion of the GNAIW was transported in the eastern basin during the LGM compared to NADW at the PD, resulting in opposite $^{231}\text{Pa}/^{230}\text{Th}$ changes between eastern and western basin during the LGM. Furthermore, in contrast to the wind-steering mechanism of EP at PD, the intensified LGM EP was caused primarily by the rim current forced by the basin-scale open-ocean convection over the subpolar North Atlantic. Our results underscore the importance of accounting for three-dimensional oceanographic changes to achieve more accurate reconstructions of past AMOC.

Keywords: AMOC, Last Glacial Maximum, $^{231}\text{Pa}/^{230}\text{Th}$

【A0856】 -Poster

Atmospheric blocking as a stabiliser during abrupt climate change in eastern Europe during the Last Deglaciation

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Abrupt climate change has occurred frequently in Earth history, most notably during the termination of major glaciations in the Quaternary. Changes occurred over decadal timescales and destabilised or transformed landscapes and ecosystems. We use the Younger Dryas as a natural experiment to better understand the regional propagation of abrupt change. We applied hydrogen isotope analyses (δD) of plant wax lipid biomarkers as indicators of hydrological change and moisture origin from five lake records across Central Europe, namely lakes Meerfelder Maar, Steisslingen, Hämelsee, and Rehwiess palaeolake in Germany, and Lake Czechowskie (Trzechowskie palaeolake) in Poland. Using recurrence analysis, a method to detect and classify time-series and characterise dynamical regime shifts (tipping points), we identify the transition from warm to cold states, or from the relatively warm Allerød to the cold Younger Dryas, and return to the Holocene warm state. Further, isotopic gradients from the Allerød, Younger Dryas and early Holocene are compared with modern gradients, revealing



spatial differences in the timing of the onset of the Younger Dryas event, in the magnitude and variability of change as well as the structure of the Younger Dryas event. We show that the pattern of δD responses during the YD were not consistent geographically, and that variation at different locations suggests greater climatic stability and smaller degree of change in the east. These spatiotemporal patterns are compared with modelling results and infer that atmospheric blocking over the Fennoscandian Ice Sheet (FIS) was likely the main driver of spatiotemporal patterns, creating a sustained high-pressure system over Fennoscandia deflecting the flow of westerly winds. This blocking effect only happens during summer as there are strong westerlies from September to April or May. Despite the abrupt climate change at the end of the Deglaciation, this resulted in a more stable climate during the YD event in eastern Europe, while western Europe was affected by major climate fluctuations during the second half of the YD because of weaker summer atmospheric blocking at the end of the YD meant more Atlantic inflow reaching MFM in the west but not in the east.

Keywords: Abrupt climate change, Plant wax, Hydrogen isotopes, Younger Dryas, Atmospheric blocking

【A0335】 -Oral

Role of Atmospheric and ocean circulations in controlling the ITCZ movement in a warming world

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The Intertropical Convergence Zone (ITCZ) is a region where trade winds converge, leading to enhanced cloudiness and precipitation. Its meridional position shifts can significantly impact regional and global climates. By analyzing CMIP6 simulation and a set of specially designed experiments with the Community Earth System Model version 2 (CESM2), we found that the mean location of the ITCZ is proportional to the inter-hemispheric temperature contrast. However, its meridional shift in response to greenhouse gas-induced warming is influenced by changes in both atmospheric and oceanic circulations. The primary oceanic driver is the Atlantic Meridional Overturning



Circulation (AMOC), while the atmospheric influence stems mainly from variations in the Hadley Cells.

Among the CMIP6 models analyzed, approximately one-third predict a southward ITCZ shift, another third a northward shift, and the remainder show little change. ERA5 reanalysis data suggests a southward movement of the ITCZ. Comparisons of AMOC changes indicate that models with a southward ITCZ shift exhibit the greatest AMOC weakening, while those with a northward shift show the least. Concurrently, an intensifying contrast between the northern and southern Hadley Cells suggests a northward ITCZ movement. These findings imply that a southward ITCZ shift arises primarily from AMOC changes.

Further CESM2 experiments reveal that AMOC collapse alone drives a southward ITCZ shift, whereas combining AMOC collapse with greenhouse gas-induced warming moderates the southward movement. Additionally, our results suggest that the observed southward ITCZ shift in reanalysis data may serve as an indicator of AMOC weakening in the real world.

Keywords: ITCZ, AMOC, Hadley Cell

【A0121】 -Poster

Astronomically forced hydrological changes during the Paleocene-Eocene Thermal Maximum

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Since the Industrial Revolution, anthropogenic carbon emissions have caused a sustained increase in atmospheric CO₂ concentrations, leading to ongoing global warming. Understanding changes in the hydrological cycle and their impacts on sedimentary systems has become increasingly urgent under this warming trajectory. The Paleocene-Eocene Thermal Maximum (PETM), characterized by carbon emissions comparable in magnitude to modern anthropogenic activities, is widely regarded as a critical analogue for future high-emission scenarios. As such, the PETM provides a



unique opportunity to study the hydrological dynamics and responses of sedimentary systems under global warming.

This study aims to synthesize global hydrological data from the PETM to assess the role of orbital forcing in modulating the hydrological cycle during the PETM. Specifically, it seeks to uncover the spatio-temporal patterns of hydrological changes driven by astronomical orbital parameters and the possible mechanisms. By studying these processes, this research provides valuable insights into the interplay between orbital dynamics, the hydrological cycle, and the evolution of sedimentary systems in a high-CO₂ world.

Keywords: PETM, Astronomical cycle, Hydrological cycle, Sedimentary system

【A0310】 -Poster

Orbitally paced local overprint of a global climate change: The Eocene-Oligocene Transition in the Transylvanian Basin (Central Paratethys)

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The Eocene-Oligocene transition marks a crucial period in Earth's history, characterized by global cooling and the onset of permanent ice in Antarctica. This event had profound effects on the global oceans and marine biota, but its regional impact remains poorly understood in certain areas, such as the Transylvanian Basin (Romania). To address this knowledge gap, we examined a 35 m thick uppermost



Eocene-lowermost Oligocene section of the Brebi Formation. We employed a multi-proxy methodology focused on the benthic foraminiferal assemblages and derived calcareous/agglutinated ratios and epifaunal/infaunal ratios, complemented with time series analysis for cyclostratigraphy, and stable isotope analysis ($\delta^{18}\text{O}$ and $\delta^{13}\text{C}$) on bulk sediment from the re-collected type section of the formation. Revising the stratigraphic framework established by Rusu et al. (1993), we incorporated planktonic foraminifera and nannoplankton data to refine the placement of the Eocene-Oligocene boundary. Our results reveal a distinctive difference between the Eocene and Oligocene assemblages, as evidenced by multivariate analyses, despite the lack of a major faunal turnover. Notably, the transition period (EOT) is detectable through multiple independent proxies, such as faunal shifts and changes in the cyclicity patterns and the sedimentation rate. From ~22 m upwards, the obliquity signal becomes stronger than the long eccentricity cycle, and between 12–23 m, we identified a disturbance zone marked by spectral noise, disrupted cycles, and significant changes in benthic foraminiferal assemblages. Within this disturbance zone, two minima in the abundance of *Heterolepa eoceana* coincide with peaks in *Gyroidinoides soldanii* and *Neoeponides schreibersii*, suggesting environmental fluctuations likely tied to pulsed food supply and reduced oxygen levels. These trends are corroborated by shifts in the calcareous/agglutinated ratio towards agglutinated forms and a corresponding increase in infaunal taxa, alongside pronounced drops in the dissolved oxygen level. Despite the decline in diversity during this interval, high evenness and low dominance indicate that this reduction is not due to a few dominant species, but rather caused by environmental stressors. Overall, while the Eocene-Oligocene transition in this restricted basin shows more subtle faunal changes compared to global records, multivariate analyses reveal nuanced ecological trends that mirror broader global cooling patterns. These findings suggest that the Transylvanian Basin experienced regionally distinct yet interconnected environmental shifts, reinforcing the complexity of the EOT at both local and global scales. Future work will aim to enhance the resolution of this dataset through further section correlation and analysis.

Keywords: Eocene-Oligocene transition, Central Paratethys, Benthic foraminifera, Cyclostratigraphy

【A0959】 -Poster

Global-scale response of temperature and precipitation to the Dansgaard-Oeschger cycles and Heinrich events



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Glacial climate is characterized by millennial-scale variability, known as Dansgaard-Oeschger (D-O) cycle, which is attributed to the changes in the Atlantic Meridional Overturning Circulation (AMOC). Some of the D-O stadials (cold periods in the Northern Hemisphere) overlap the periods of massive iceberg discharge from the Laurentide Ice Sheet and prolong cold states, referred to as Heinrich stadials. Proxy-based reconstructions and modelling simulations have suggested that, compared with non-Heinrich stadials, Heinrich stadials are associated with larger-amplitude climatic anomalies in the North Atlantic and far-field regions due to greater weakening of the AMOC. However, it is still not clear how the climatic response in far-field regions differs between Heinrich and non-Heinrich stadials, and when and how the climatic anomalies in each region arise. Here we investigate the spatio-temporal characteristics of temperature and precipitation changes in both Heinrich and non-Heinrich stadials in model simulations with the coupled atmosphere-ocean general circulation model MIROC4m and compare with multi proxy-based reconstructions. We show two simulations with and without freshwater hosing over the northern North Atlantic under glacial boundary conditions (hosing and non-hosing experiment), corresponding to the Heinrich and non-Heinrich stadials, respectively. In both simulations, global-scale climate and the AMOC fluctuate with a millennial time scale. A common feature of the two simulations is that when the AMOC is weak, conditions at northern high latitudes become colder and drier, the Intertropical Convergence Zone (ITCZ) moves southward, and the Southern Hemisphere became gradually warmer and wetter, and vice versa. In the non-hosing experiment, however, millennial-scale changes in precipitation in some low and mid-latitude regions are too small to detect or show the opposite signal to some proxy-based reconstructions. Compared with non-hosing experiment, the hosing experiment shows that the amplitude of cooling around the northern North Atlantic is larger and that low SST anomalies propagate to lower latitudes of the North Atlantic during the stadial. At the same time, the hosing experiment shows that the amplitude of warming over the Southern Ocean is larger, and that high SST anomalies propagate as far as north of the equator over the Pacific. Related to the difference in magnitude and propagation extent of SST anomalies, the precipitation response during the stadial in hosing experiment has a more significant signal even in low- and mid-latitude regions. For example, there is precipitation in the



northeast Pacific, and decreased precipitation in the Cariaco Basin, which is in agreement with proxy-based reconstructions. Thus, our study implies that the Heinrich stadial may not simply increase the amplitude of the North Atlantic climate variability but may also induce markedly different responses of low and mid-latitude climate associated with a different distribution of SST anomalies.

Keywords: Dansgaard-Oeschger cycle, Heinrich event, AMOC, Hydrological change

【A1045】 -Oral

Role of thermal component for driving the millennial-scale oscillations of the Atlantic Meridional Overturning Circulation

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During the mid-glacial periods, abrupt warming/cooling events (Dansgaard-Oeschger (D-O) events) occurred with a millennial time scale, and were closely related to abrupt changes in the Atlantic meridional overturning circulation (AMOC) and its heat transport. Several studies using coupled atmosphere-ocean models including our MIROC4m AOGCM have recently shown millennial-scale self-sustained oscillations with no change in external forcings (Kuniyoshi et al. 2022GRL). These studies propose several internal feedbacks, i.e, hydrological changes in salt oscillator, deep decoupling and thermal oscillator, which involves sea ice change and subsurface temperature change in the North Atlantic, and stochastic changes in surface wind. These feedbacks, however, are proposed only from analysis of the self-sustained oscillations in their AOGCMs, and further investigation on the role of each feedback has not been carried out yet. Here we developed a method to evaluate each feedback involving hydrology, heat, and wind. Specifically, we modified the coupler in the MIROC4m AOGCM so that each of the freshwater flux, heat flux, and momentum flux passed from the atmosphere to the sea ice-ocean component every three hours is replaced with a specified climatology. In this study, using this modified coupler, we conduct three kinds of partially coupled experiments by fixing freshwater, heat, and winds separately. These experiments are branched from the simulation of self-sustained oscillation with the fully coupled MIROC4m (Kuniyoshi et al. 2022GRL). The climatology of each flux used in the partially coupled experiments is taken from the range of amplitude of the



self-sustained oscillation in the fully coupled MIROC4m. This means the time-averaged values of the weak AMOC period and of the strong AMOC period, and the intermediate values between the two states are used as the climatology. As a result, no millennial-scale climate oscillation occurs when we fix heat flux, while oscillations are still observed even when we fix freshwater flux and wind stress. This suggests that the AMOC oscillations could be driven even without changes in hydrology and surface wind stress and that changes in sea surface heat flux could be the main driving factor of the oscillations. The influence of surface heat flux on the self-sustained oscillations of the AMOC will be further investigated and the role of the sea ice - heat flux feedback will be discussed.

Keywords: Dansgaard-Oeschger cycle, AMOC, Self-sustained oscillation, Millennial-scale

【A0550】 -Poster

Significant amount of particulate organic carbon transported by event-triggered canyon hyperpycnal flows

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Sinking and burial of marine plankton and terrestrial particulate organic carbon (POC) in the ocean comprise the key components of global carbon cycle. The deep-sea fan systems connected with the submarine canyon has been increasingly realized to be the other hotspot for the burial of POC, besides the deltas and continental shelves. However, the mechanisms by which the POC is transferred from land and the coastal ocean to the deep ocean via a submarine canyon are poorly understood. Here, we investigated the spatiotemporal variabilities in sinking POC fluxes and their controlling mechanisms by measuring the contents, the stable carbon ($\delta^{13}\text{C}$) and radiocarbon ($\Delta^{14}\text{C}$) isotopic compositions of POC at ~500 m and ~2055 m collected using time-series sediment traps, complemented by monitoring the suspended sediment concentration changes at ~2056 m, from May 2017 to May 2018 in deep Gaoping Canyon of the South China Sea. Results show that the POC fluxes at ~500 m range from 1.1 to 3.2 mg m⁻² d⁻¹, which are significantly lower than those at ~2055 m varying between 12.5 and



247.4 mg m⁻² d⁻¹. The POC at ~500 m mostly have high $\delta^{13}\text{C}$ and $\Delta^{14}\text{C}$ values of -22.5 to -22.1‰ and $+23$ to -20‰ , respectively, which are similar to those modern surface and slightly aged plankton-produced POC. In contrast, the POC at 2055 m and in October, December, and January at 500 m show $\delta^{13}\text{C}$ and $\Delta^{14}\text{C}$ values ranging from -24.7 to -22.8‰ and -55 to -754‰ , respectively, falling in between those marine POC and highly aged terrestrial POC discharged by Taiwan rivers. The POC fluxes generally increase with decreasing $\delta^{13}\text{C}$ and $\Delta^{14}\text{C}$ values. High sinking POC fluxes at 2055 m coincide with the high suspended sediment concentrations greater than 0.5 mg L⁻¹. This suggests that hyperpycnal flows initiated by flood and earthquake events are responsible for the export of terrestrial dominated POC to the deep sea. Therefore, hyperpycnal flows triggered by extreme events play a major role in transporting the POC from the coast to the deep sea.

Keywords: Particulate organic carbon, Stable carbon isotope, Radiocarbon, Submarine canyon, Global carbon cycle

【A0374】 -Oral

Quantifying the impact of AMOC variations on atmospheric CO₂ and ocean deoxygenation in the past climate

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The Atlantic Meridional Overturning Circulation (AMOC) redistributes heat, salt, nutrients, and carbon as part of the global thermohaline circulation. AMOC is regarded as one of the core tipping elements in the Earth system, with tipping points that could be triggered by anthropogenic activities. An abrupt change in the AMOC state would drastically impact the global climate and carbon and oxygen dynamics, leading to potential threats to marine ecosystems. Paleo records have shown that the AMOC experienced substantial changes in the Pleistocene, such as during the Dansgaard-Oeschger cycles and Younger Dryas. However, how AMOC variations affected atmospheric CO₂ and ocean biogeochemistry in the past climate remains ambiguous. Recent advancements in coupled carbon cycle-climate models, particularly comprehensive Earth System Models, provide new opportunities to address this question.



We use the state-of-the-art Max Planck Institute Earth System Model (MPI-ESM) to conduct transient simulations for the last deglaciation. We prognostically compute atmospheric CO₂ for the global carbon cycle and prescribe it for radiation computation. We force the model with reconstructions of atmospheric greenhouse gas concentrations, orbital parameters, ice sheets, and dust deposition. In line with the physical ocean component, we account for the automatic adjustment of marine biogeochemical tracers in response to changing bathymetry and coastlines related to deglacial meltwater discharge and isostatic adjustment. Our preliminary results show that atmospheric CO₂ rises in response to an AMOC decline forced by meltwater pulses from ice sheet reconstructions and is dominated by terrestrial carbon release. The volume of oxygen minimum zones (OMZ) generally increases with an AMOC decline. Under the consecutive AMOC declines forced by meltwater pulses, the response of OMZ significantly lags the changes in AMOC due to the interplay between changes in ventilation, primary production and organic matter remineralisation.

To examine the impact of the background climate states, we further simulate abrupt AMOC changes under glacial and interglacial climates via freshwater hosing. Both atmospheric CO₂ and the volume of OMZ vary in larger magnitudes under the glacial climate than in the interglacial climate. Unlike in the transient simulation, the volume of OMZ first decreases in response to an AMOC decline, then increases with the recovery of AMOC and eventually reaches a higher level than in the reference states. We will further conduct a multi-model comparison to study the robustness of the above findings based on MPI-ESM.

Keywords: AMOC, Modelling, The Last deglaciation, Carbon cycle, Ocean biogeochemistry

【A0922】-Oral

Tipping of Atlantic Meridional Overturning Circulation (AMOC) under different types of forcings

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The tipping of AMOC has significant impact on climate and may be able to induce further tipping of other elements of the Earth system. In the near future, tipping of



AMOC may occur mainly due to the increase of atmospheric CO₂. While in the past, variations of orbital configuration, vegetation, and continental ice sheets could all cause abrupt changes of AMOC. Whether the characteristics and mechanisms of tipping under these different types of forcings are similar is unclear. Here we use an atmosphere-ocean general circulation model CESM1.2 to simulate the climate change under increase of CO₂ (global warming), removal of vegetation, and variation of precession. The variation of precession is such that the Northern Hemispheric summer insolation decreases with time. Quick collapse (i.e., tipping) of AMOC is obtained in all three types of forcings. Under global warming, AMOC weakens immediately with the increase of CO₂ due to the freshening of the deepwater formation region, which itself is due mainly to the increased net precipitation over the North Atlantic. Under the removal of vegetation and variation of precession, however, the AMOC responds slowly at the beginning; it takes multiple millennia before the abrupt weakening occurs. The tipping in these latter two cases is due mainly to the increase of meltwater from Arctic sea ice and the positive feedback between the weakening of AMOC and increase of Arctic sea ice. Because it takes a long time for the tipping of AMOC to be triggered in these cases, the tipping may be missed if the applied forcing is removed soon or the simulations are not continued for long enough.

Keywords: AMOC, Tipping, Collapse, Orbital forcing, Precession

【A0855】 -Poster

Influences of ocean states on the development of the Eurasian ice sheets following MIS 3

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The Eurasian Ice Sheet complex (EIS) was the third largest ice sheet complex during the Last Glacial Maximum (LGM, 21 ka). While the precise temporal and spatial evolution of the EIS during the last glacial cycle remains uncertain, substantial evidence suggests that nearly ice-free conditions prevailed during Marine Isotope Stage 3 (MIS 3). Between MIS 3 and the LGM, the EIS likely underwent significant expansions, driven by decreasing boreal summer insolation, a slight reduction in greenhouse gases, and abrupt millennial-scale shifts between stadial and interstadial



conditions. To investigate this, we conducted transient simulations using the advanced Earth system model AWI-ESM, which includes asynchronously coupled dynamic ice sheets, covering the period from 38 ka to 20 ka. Our results show that the formation of the EIS follows a bifurcation transition, where a thin ice and snow cover forms initially in response to cooling over Eurasia. A weakened Atlantic Meridional Overturning Circulation (AMOC) appears to be crucial for initiating this buildup. Additionally, sensitivity experiments reveal significant non-linearity in surface mass balance changes in response to variations in temperature and precipitation, highlighting the high sensitivity of EIS formation. Our findings emphasize the complex and highly non-linear nature of the Earth system, driven by internal climate feedbacks, particularly the interactions between ice sheets and climate.

Keywords: Eurasian Ice Sheets, AMOC, MIS 3, Climate-ice sheet interactions

【A0238】 -Poster

Large increases in Antarctic snowfall during Heinrich Stadials of the last ice age

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During the last glacial period, the North Atlantic region experienced cold intervals characterized by significant iceberg discharge events. These intervals, known as Heinrich stadials, coincided with abrupt climate shifts observed globally. In Antarctica, the accelerated warming was identified from ice-core isotopic records, but changes in precipitation have remained unknown. Here, we present accumulation-rate reconstructions for the last glacial period at centennial resolutions for four ice-core sites in East Antarctica. Surprisingly, large and rapid accumulation increases on a millennial timescale occurred during the Heinrich stadials beyond what is expected from the site warming amplitudes. The sensitivity of accumulation rate to surface temperature for these events could be up to 27% K⁻¹, which is more than double the Antarctic modern sensitivity. The increased snowfall may be attributed to enhanced



atmospheric moisture content or meridional transport, which in turn may be driven by a cascade of southward shift of the Intertropical Convergence Zone (ITCZ), southward shift and strengthening of Southern Hemisphere westerly winds, and enhanced wind-driven upwelling of Southern Ocean deep water.

Keywords: Antarctica, Heinrich event, Ice core, Snowfall, Last glacial

【A0239】 -Poster

Characteristics of self-sustained oscillations of the Atlantic Meridional Overturning Circulation

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The Atlantic Meridional Overturning Circulation (AMOC) is a major tipping element in the Earth system, and its collapse may have global impacts due to its critical role in interhemispheric heat transport. Paleoclimate evidence suggests that the AMOC exhibited quasi-oscillatory behavior during the last glacial period, characterized by repeated rapid strengthening followed by a two-stage weakening. These variations, known as Dansgaard-Oeschger (DO) Events, have been the subject of extensive research, but their physical drivers remain poorly understood. Here, we employ the Bern3D Earth system model of intermediate complexity to investigate the physical mechanisms underlying DO-events. The model reproduces self-sustained AMOC variability, but only under a narrow range of climatic boundary conditions representative of the intermediate glacial climate of Marine Isotope Stage 3. These simulated oscillations closely resemble the structure and time scales of DO-events reconstructed from Greenland ice cores, featuring rapid AMOC increases of up to 20 Sv followed by a gradual decline to the previous weak circulation state. We investigate the physical drivers for this behavior and explore the dependencies of these oscillations on vertical mixing, wind stress, and atmospheric CO₂ concentrations. These parameters determine the magnitude of the initial AMOC increase, how quickly the circulation returns to its prior state, and the frequency of the oscillations. As such, the model can reproduce a wide range of DO-like variability resembling many characteristics found in the proxy records.



Keywords: AMOC, Tipping points, Abrupt climate change

【A0281】 -Poster

Understanding the Late Bronze Age civilisation collapse using Holocene transient simulations

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The Late Bronze Age (LBA) collapse (1300–1100 BCE) marked a profound societal upheaval across the ancient Mediterranean, with the decline of civilizations such as the Mycenaeans, Hittites, and Minoans. While traditionally attributed to invasions by the "Sea Peoples," emerging paleoclimate evidence suggests that severe and prolonged droughts played a significant role in this collapse. A key methodology for exploring unknown past climate conditions is the use of Holocene transient simulations. These allow us to understand how climate evolved over millennia and identify environmental stressors like drought, temperature changes, or extreme weather events that may have contributed to societal disruptions. This study evaluates the extent to which three Holocene transient climate simulations (MPI-ESM, TraCE-21ka, and EC-Earth3 8K) capture the prolonged arid conditions observed in regional proxies during the LBA collapse. The transient simulations reveal a prolonged drying trend for the Balkan area from 4000 until 1000 BCE. For the Peloponnese region, the three models display an unstable climate from 1350 until 1050 BCE. Within this there are notable clusters of multi-decadal droughts which align partially with proxy evidence but differ in timing and persistence. We demonstrate that transient simulations do replicate regional drought patterns but rarely agree on precise temporal dynamics. We then delve into the dynamics causing this unstable climatic period, using the EC-Earth 8K simulation. Our results support the hypothesis that environmental stressors, particularly drought, contributed to the LBA collapse. Understanding the climatic drivers behind the LBA collapse holds profound implications for both historical and contemporary analyses of societal resilience. If prolonged droughts played a pivotal role in the collapse of several ancient civilizations, this supports the argument that environmental factors can lead to large-scale migrations, resource scarcity and societal unrest. This has implications for the vulnerability of modern societies to climate change. By drawing parallels between the LBA collapse and contemporary climate challenges, the study underscores the



importance of understanding how current and future climate variability could lead to similar societal disruptions, urging policymakers to incorporate historical insights into modern climate mitigation strategies.

Keywords: Civilisation collapse, Abrupt climate change, Transient simulations

【A0811】 -Oral

Threshold on sea level rise and ice sheet melting on tropical hydrology and health

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A major contribution of PALSEA (Carlson et al., 2019) and last deglaciation MIP is to document and simulate the last sea level rise and the temporal and spatial melting of the Laurentide and Fennoscandian ice sheets. More important, for our purpose, is the teleconnection between fresh water fluxes during Heinrich events and their impact on African monsoon (Multiza et al., 2008). Both features depict clearly the nonlinear relationships between ice sheet and climate that occurred in the past. Therefore, it is important to test accelerated ice sheet melting scenarios for future climate changes.

We first show that a rapid accelerated freshwater flux, coming from the Greenland ice sheet (GRIS) produces, similarly as glacial periods, large reorganizations of tropical hydrology with a huge monsoon's decrease over the Sahel (Defrance et al., 2017; Chemison et al., 2022). This major climatic feature has drastic consequences both on the loss of agricultural areas and associated migration (Defrance et al., 2017). The most striking result was, therefore, that an accelerated GRIS melting produces not only a coastal migration, but also an important migration in African monsoonal areas.

Moreover, large hydrological and climatic changes over Africa do not only concern human migration, but also vector-borne diseases' dispersal. For instance, the dispersal of malaria in Africa during the 21st century has been computed using RCP scenarios,



downscaled GCM results and biological models (Caminade et al., 2014). The major result of this study was that vectors of malaria moved from central Africa towards the eastern African plateau, due to the temperature and dryness. A new study, superimposing to RCP scenarios an accelerated GRIS melting, depicts an extension of malaria towards South Africa (Chemison et al., 2017). These studies illustrate the need for threshold studies, accounting for cryosphere and climate interactions.

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Keywords: Accelerated melting of Greenland Ice Sheet, Tropical hydrology, Agricultural loss, Human migration, Dispersal of vector-borne diseases



【A1055】 -Oral

Ambitious but delayed mitigation might not avoid crossing climate tipping thresholds

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At global scales, concrete actions to limit greenhouse gas emissions have not bent the CO₂ emissions curve to date, even though some national efforts are promising. Using an emissions-driven Earth system model, we explore the conditions where even the most aggressive levels of climate mitigation, immediately halting CO₂ emissions, would be ineffective if action is delayed and the climate system is too close to a tipping point, such as the collapse of the Atlantic Meridional Overturning Circulation (AMOC). We identify the global warming level, emissions threshold and mechanism associated with the increased probability of a long-term (>100 years) collapsed circulation. These thresholds may occur at lower global warming levels due to internal variability of the climate system than is expected based on previous studies. We show that significant cooling occurs after CO₂ emissions cease only if AMOC is strongly reduced or collapsed resulting in considerable consequences for regional climates. Our results are also relevant for community efforts exploring the possibility of approaching tipping points (like TIPMIP) and the need to address internal climate variability.

Keywords: Tipping point, AMOC collapse, AMOC bifurcation

【A0523】 -Oral

Precise timing, duration and impact of 4.2 ka event on monsoon seasonality and productivity in the southwestern Bay of Bengal

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The Indian subcontinent has a long history predominantly shaped by the monsoon system, a critical climatic phenomenon that governs regional agricultural practices and



ecosystems. The Indian monsoon is marked by a prominent shift termed as 4.2 ka event. A weakening of the Summer Monsoon resulted in aridification and the subsequent collapse of many civilizations during the 4.2 ka event. However, little information is available about the onset, and duration of 4.2 ka event and its impact on monsoon seasonality, productivity and carbon burial in the western Bay of Bengal. Here, we present a decadal resolution marine sediment-based record of the precise onset, duration, carbon burial, monsoon seasonality and productivity changes in the western Bay of Bengal during the 4.2 ka event, by using the planktic foraminiferal and sediment characteristics. We report an abrupt decrease in carbon burial beginning at 4.65 ka and continuing till 4.1 ka. The Summer Monsoon was weaker and winter monsoon was relatively stronger during this interval. The synchronous decrease in coarse fraction ($>63\ \mu\text{m}$), CaCO_3 , C_{org} and nitrogen (N) suggests a collapse in productivity. The increase in C_{org}/N at the onset of the event suggests an increase in terrestrial input due to a stronger winter monsoon. Therefore, it is clear that the changes during the 4.2 ka event lasted for ~ 550 years and resulted in a significant decrease in carbon burial in response to weaker Summer Monsoon and relatively stronger winter monsoon in the southwestern Bay of Bengal. The Indian subcontinent has a long history predominantly shaped by the monsoon system, a critical climatic phenomenon that governs regional agricultural practices and ecosystems. The Indian monsoon is marked by a prominent shift termed as 4.2 ka event. A weakening of the Summer Monsoon resulted in aridification and the subsequent collapse of many civilizations during the 4.2 ka event. However, little information is available about the onset, and duration of 4.2 ka event and its impact on monsoon seasonality, productivity and carbon burial in the western Bay of Bengal. Here, we present a decadal resolution marine sediment-based record of the precise onset, duration, carbon burial, monsoon seasonality and productivity changes in the western Bay of Bengal during the 4.2 ka event, by using the planktic foraminiferal and sediment characteristics. We report an abrupt decrease in carbon burial beginning at 4.65 ka and continuing till 4.1 ka. The Summer Monsoon was weaker and winter monsoon was relatively stronger during this interval. The synchronous decrease in coarse fraction ($>63\ \mu\text{m}$), CaCO_3 , C_{org} and nitrogen (N) suggests a collapse in productivity. The increase in C_{org}/N at the onset of the event suggests an increase in terrestrial input due to a stronger winter monsoon. Therefore, it is clear that the changes during the 4.2 ka event lasted for ~ 550 years and resulted in a significant decrease in carbon burial in response to weaker Summer Monsoon and relatively stronger winter monsoon in the southwestern Bay of Bengal.

Keywords: 4.2 ka event, Monsoon, Civilizations, Planktic foraminifera, Bay of Bengal



【A0166】 -Poster

Synergic variations of the South Pacific deep circulation and carbon reservoir during the late Pliocene intensification of the Northern Hemisphere Glaciation

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The intensification of Northern Hemisphere Glaciation at ~2.7 Ma ago, known as the significant iNHG event during the late Pliocene, has marked a prominent transition of Earth's climate from uni-polar to bi-polar ice sheets. Here, we present proxy records from the deep sea sediments of Ocean Drilling Program Site 1123 in the South Pacific (41°47'S · 171°30'W · water depth 3290 m), covering a time span of approximately 3.5 to 1.7 million years, aiming to reveal the South Pacific deep circulation and ocean carbon reservoir changes during this period. After careful rinsing of the sediment samples, we selected benthic foraminifer *C. Wuellerstorfi* and *G. Mundulus* for B/Ca ratio and fish tooth ϵ_{Nd} isotope analysis, with a temporal resolution of approximately 3 to 10 thousand years, totaling 112 sediment samples.

Our results show that the ϵ_{Nd} of ODP Site 1123 rapidly shifted towards negative values by approximately 2 units during the iNHG period. Meanwhile, the deep-water $\Delta[\text{CO}_3^{2-}]$ reconstructed using the B/Ca ratio of benthic foraminifera exhibited a positive shift at around 2.9 Ma and then a negative shift at around 2.7 Ma. We interpret that the positive shift in $\Delta[\text{CO}_3^{2-}]$ at ODP Site 1123 at ~2.9 Ma might be caused by the weakening of the Antarctic Circumpolar Current (ACC), which reduced the upwelling in the Southern Ocean and thereby caused a shift of the major source of the water mass bathing this site from the north with more negative carbonate ion concentrations to that in the south with more positive carbonate ion concentrations. The enhanced northward expansion of southern sourced water in the deep Pacific Ocean could result in a decrease in the Pacific carbon reservoir. We further hypothesize that the enhanced input of sub-Antarctic dust during the iNHG period had great potential for increasing the iron fertilization effect, thereby strengthening the biological pump in the sub-Antarctic region. This process had resulted in an increase in the carbon storage and a more negative carbonate ion concentration in the southern sourced water flowing into the Pacific Ocean, ultimately causing the negative shift in $\Delta[\text{CO}_3^{2-}]$ at ODP Site



1123 and enhancing carbon storage in the Pacific Ocean. Our results demonstrate that the Pacific Ocean had played a great role in the decline of the atmospheric $p\text{CO}_2$ and finally contributed to the final formation of the iNHG event.

Keywords: Late Pliocene, Intensification of northern hemisphere glaciation, Deep circulation, Carbon reservoir

【A0727】 -Poster

In search of tipping points on a way to construct a late Pleistocene–Holocene stacked benthic $\delta^{18}\text{O}$ record of the Caspian Sea

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The Caspian Sea is the largest isolated water body in the world. It serves as a reflection of both regional and global climate events. The modern understanding of the evolution and sea-level changes of the Caspian Sea is primarily based on geomorphological analysis of marine terraces and the dating of their sediments, as well as on coastal data. Some studies focus on detailed investigations of specific areas of the Caspian Sea. However, for reliable reconstructions of past events, it is not sufficient to rely on such studies alone. It is necessary to have a continuous sedimentary record of both transgressive and regressive phases, which is only accessible in the deep-sea areas of the Caspian Sea. In this paper, we use this record to construct the $\delta^{18}\text{O}$ stack for the last 23 ka. Stable oxygen isotopes represent a valuable analytical tool for elucidating paleogeographic patterns. In the case of lakes and inland seas, stable oxygen isotopes provide a distinctive and comprehensive account of basin history, which would otherwise be challenging to obtain. However, the employment of additional proxies is essential for the identification and development of a strategy for locating tipping points and for the assembly of oxygen isotope records from disparate locations throughout the Caspian Sea and time periods. Ostracods were chosen as the material for measuring $\delta^{18}\text{O}$ since the calcite $\delta^{18}\text{O}$ values of their shells provide a "snapshot" record of the water conditions at the discrete time of calcification. The results of the measurements were analysed in conjunction with the supporting materials in order to obtain a unified and consistent paleogeographic picture. A key challenge in the construction of a composite stack is the establishment of a common timescale for the individual core records prior to stacking. However, the synthesis and unification of the



radiocarbon data have made this possible. The microfaunal studies and literature review enabled the identification of the principal tipping points. By assigning radioisotopic ages, a timescale was established for each core, which was then compared with climatic events that have had a decisive influence on Caspian Sea level fluctuations. A more reliable age model was created, which served as the basis for a composite stack together with previously published material on deep-sea drilling in the Caspian Sea. The observed microfaunal changes were found to be associated with the changing basins. The oxygen isotope curve correlates with documented changes in climate. The identified stages correspond to the Last Glacial Maximum, the Late Glacial, and the Holocene. The course of the $\delta^{18}\text{O}$ stack confirms the sensitivity of the Caspian Sea to spatio-temporal climate signals, allowing for correlations within the region. The change in the water balance components is the primary factor controlling the stable oxygen isotope composition.

The research was funded by the RSF project No. 24-77-00011.

Keywords: Paleogeography, Paleoclimatology, Ostracods, Stable oxygen isotopes, Marine sediment records

【A0777】 -Poster

From Past to Present: Diversity trends of benthic foraminifera in the margin of NW South America

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Northwestern South America's Caribbean and Pacific margins are recognized as marine biodiversity hotspots. However, research has predominantly focused on coastal ecosystems, leaving deeper environments, such as the continental slope zone, understudied, particularly regarding microfaunal composition and diversity. Recent studies provide valuable insights into the distribution of benthic foraminifera along the current shelf and slope of the Caribbean and Pacific basins adjacent to Colombia. Based on this, we utilize quantitative data from Fiorini (2015) to calculate Shannon diversity indices (H') and incorporate the H' index reported by Patarroyo and Martínez (2021). We compare these with our new data on benthic foraminiferal diversity



spanning the Cenozoic. Our analysis includes over 700 samples from 11 onshore wells in the Caribbean margin, covering a temporal range from the Paleocene to the Pleistocene, mostly when the Pacific and Caribbean were connected through the Central American Seaway (CAS).

On average, richness and H' values are 24.7 and 2.5 in the present Caribbean slope, respectively, while in Pacific environments, the values are higher at 40.3 and 2.9. Our Cenozoic dataset shows richness peaks during the early Miocene (25.5) and late Miocene (25.4) but declines to 4.3 in the Pliocene and 2.5 in the Paleocene. The H' index shows its highest values in the late Oligocene (3.15) and late Miocene (3.05), with its lowest in the Paleocene and Pliocene (0.66).

Peaks in benthic foraminiferal richness align with periods when major river systems flowing into the southern Caribbean Sea were active, delivering high loads of organic matter and nutrients that enhanced primary productivity. Conversely, the lowest richness values correspond to tectonically intense periods, such as the collision of the Caribbean oceanic plate with South America in the early Paleocene and the complete closure of the CAS in the Pliocene, which caused significant ecosystem stress. The highest diversities in the late Oligocene reflect periods of regional tectonic stability, mesotrophic conditions, and climatic cooling, which created environments conducive to maintaining high diversity.

Our results reveal that the current Pacific slope exhibits significantly higher richness than the Caribbean. However, present-day richness in the Caribbean is comparable to the highest levels observed during the Cenozoic. In terms of diversity, H' values for both the Pacific and Caribbean approach 3 are similar to the highest diversity levels recorded in the Cenozoic. These findings underscore the resilience of these ecosystems despite past tectonic and environmental upheavals.

This comparison identifies critical thresholds and shifts in diversity over geological time, providing insights into the ecological resilience of benthic communities under past climatic and environmental changes. These findings deepen our understanding of how biodiversity responds to long-term natural drivers, offering valuable lessons from the past for interpreting present-day ecosystems and laying the groundwork for future research to address current anthropogenic pressures.

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Keywords: Benthic foraminifera, Cenozoic diversity, Caribbean and Pacific margins, Ecological resilience

【A0434】 -Poster

Preliminary study of abrupt events around MIS M2 using U-Pb dated speleothems

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The Piacenzian stage (3.6–2.6 Ma) of the Pliocene epoch marks the most recent period with sustained global warmth, comparable to future climate predictions. Marine Isotope Stage (MIS) M2, also known as the ~3.3 Ma event, is recognized globally as a cooling interval that interrupted the relatively warm background climate state. Elucidating the abrupt climate events during M2 is vital for grasping the evolution of such events in the context of anticipated future warming. Despite significant paleoclimate findings from speleothems in the Asian monsoon region, studies have been hindered by the upper limit of the U-Th dating method, precluding examination of periods exceeding 640 ka.

Utilizing the latest U-Pb carbonate dating method developed at the isotope lab of Xi'an Jiaotong University, here we have identified the MIS M2 period speleothems from Sanbao cave, thus obtaining the oldest speleothem record of Asian Summer Monsoon with unprecedented high resolution during the M2 period. Our findings indicate that the Asian Summer Monsoon experienced multiple millennial-scale abrupt events during M2, potentially reflecting abrupt shifts in the Atlantic Meridional Overturning Circulation (AMOC) against the backdrop of Pliocene warmth. Further research is of paramount importance for our understanding of AMOC variations in the current context.



Keywords: MIS M2, Carbonate U-Pb dating, Speleothem, Abrupt events, AMOC

【A0373】 -Oral

Two-stage climate and vegetation change at the East Asian monsoonal margin across the Miocene Climatic Optimum

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The change in vegetation at the margins of the East Asian Summer Monsoon (EASM) during the Miocene Climatic Optimum (MCO) remains poorly understood. Here, we present a high-resolution terrestrial sequence, paleomagnetically dated to 18.2-13.5 Ma, from the Tongxin Basin of midwestern China. Our multi-indicator analysis, encompassing pollen, $\delta^{13}\text{C}_{\text{TOC}}$, $\delta^{18}\text{O}_{\text{carb}}$ - $\delta^{13}\text{C}_{\text{carb}}$, and magnetic susceptibility, reveals that the regional vegetation and climate had two distinct stages during the MCO, manifesting as stable arid steppe from 17.0-16.0 Ma, and woodland steppe with six forested environments from 16.0-14.0 Ma. Together with other adjacent records, this supports the EASM as the main control on terrestrial vegetation. Further comparisons of marine-terrestrial data and time series analysis suggest that in the late MCO, the oceanic carbon reservoir (OCR) experienced early strong perturbations (mainly C_{max} events) accompanied by multiple oscillations. The instability signals likely impacted and were amplified as rapid shifts in forest-steppe environments at the monsoon margins via EASM. Our study highlights the regulation of inland ecologically vulnerable areas by low-latitude forcing in a greenhouse world.

Keywords: Miocene climatic optimum, East Asian Summer Monsoon, Vegetation, Tongxin fauna, Oceanic carbon reservoir

【A0308】 -Poster

Bottom water temperature in the middle Miocene: Deep heat with limited ice volume



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While the warmer than present mid-Miocene climate is considered as a potential analog for the near future, it presents an apparent climate paradox as some reconstructions, based on deep ocean isotopic and temperature reconstructions, suggest that the extent of continental ice at that time was as large or greater than at present. The estimate of ice volume is hindered by the sparsity of bottom water temperature (BWT) records, especially in the Pacific Ocean. Here, we present Mg/Ca records of benthic foraminifera *Cibicoides wuellerstorfi* and *Cibicoides mundulus* from seven Pacific sites for the middle Miocene (17-11 Ma), calibrate paleothermometer Mg/Ca in these two species with a new equation, and reconstruct BWT and seawater $\delta^{18}\text{O}_{\text{sw}}$ at various locations of the global Ocean during the middle Miocene. The results show that the BWT was 3-4°C higher during the mid-Miocene, while the hydrographic structure resembled that of the modern ocean, with temperatures generally decreasing from shallow to deep water and from low to high latitudes. The reconstructed $\delta^{18}\text{O}_{\text{sw}}$ records from different sites are heterogenous, implying local hydrographic imprints on the global ice volume effect. We propose that the $\delta^{18}\text{O}_{\text{sw}}$ records at 4000-4500 m of the eastern equatorial Pacific (EEP) may represent the global average $\delta^{18}\text{O}_{\text{sw}}$. MCO $\delta^{18}\text{O}_{\text{sw}}$ records from ODP site 1171 and IODP U1338 are about 1‰ more negative than modern seawater showing > +1‰ shift at the MMCT, apparently suggesting that the ice volume during middle Miocene was substantially smaller than present level, with the corollary that the $\delta^{18}\text{O}_{\text{sw}}$ paradox may have been an artifact.

Keywords: Middle Miocene, BWT, Ice volume

【A0827】-Poster

The Eigen-Microstate approach and its applications to critical behaviors in earth systems

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Phase transitions and critical phenomena are prevalent in physics, often linked to tipping processes in Earth systems. Recently, we proposed the eigen-microstate approach (EMA) as a framework to extend phase transition theory from equilibrium statistical physics to non-equilibrium systems. Building on Gibbs ensemble theory, EMA conceptualizes an eigen-ensemble as a collection of eigen-microstates. It posits that the macroscopic properties and dynamics of a system are governed by eigen-microstates, each associated with a probability that determines its contribution to macroscopic behavior. Traditional thermodynamic quantities can be redefined within this theoretical framework. For instance, the Boltzmann entropy corresponds to the entropy of eigen-microstates in the eigen-ensemble.

We will present recent advancements in applying EMA to study critical behaviors in Earth systems across diverse spatiotemporal scales, including interannual phenomena and weather-scale events. Additionally, we will discuss progress in investigating potential critical behaviors on the Tibetan Plateau.

Keywords: Critical behaviors, Phase transitions, Tipping point, Statistical physics

【A0724】 -Oral

Trace hydrologic cycle on the Iberian Margin during abrupt climate changes

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The ice melting events and freshening of North Atlantic surface water have been proposed to be the main trigger of slowing down of Atlantic meridional overturning circulation (AMOC) and abrupt climate changes during the glacial periods. However, direct reconstructions of seawater salinity are still lacking in the North Atlantic. To fill this gap, we performed proxies comparisons based on three different proxies on the Iberian Margin, including the percentage of tetra-saturated alkenone ($C_{37:4}\%$); seawater oxygen isotope estimated from foraminifera and hydrogen isotope ratio of alkenones. Moreover, we calibrate the alkenone hydrogen isotope by using lab culture.



Here are the main findings:

First, the $C_{37:4}$ represents cold temperature, instead of salinity, on the Iberian Margin. Second, the freshening of surface water reconstructed by foraminifera lag behind the cooling on the Iberian Margin. Third, the variations of alkenone hydrogen isotope ratios is significantly different from the pattern of seawater oxygen isotope by foraminifera. Some non-salinity effects, such as CO_2 and temperature, on the fractionation of alkenone to water are detected in our culture works. After removing these non-salinity effects, the alkenone hydrogen isotope matches better with the foraminifera oxygen isotope ratios.

In conclusion, based on our records on the Iberian Margin, the surface freshening did not always trigger the weakening of AMOC and significant freshening occurred during the middle of a cooling events. Thus, ice melting events may play a potential role as an amplifier in these abrupt climate events.

Keywords: Abrupt climate change, Sea surface salinity, Alkenone, Hydrogen isotope

【A0396】-Poster

Pliocene-Pleistocene climatic transition in East Asia: New insights from the continental sedimentary archive of the Huaihe River Basin, East China

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The Pliocene-Pleistocene Transition (PPT) represents a pivotal global shift from greenhouse climates to glacial-interglacial cycles. There are numerous paleoenvironmental records spanning the PPT from marine sediments and from the East Asian monsoon margin, but there are few terrestrial records from the core area of the monsoon (humid and semi-humid areas), particularly from fluvial-lacustrine sequences. Here we present a high-resolution terrestrial record from the Huaihe River



Basin, East China, spanning the past ~8 Ma. Records of grain size, carbonate carbon and oxygen isotopes ($\delta^{13}\text{C}_{\text{carb}}$, $\delta^{18}\text{O}_{\text{carb}}$), and color space values (L, a*, b*) reveal gradual environmental changes during the PPT (3.6–2.7 Ma). These changes included a pronounced drying trend in the monsoon core area, indicating that the PPT influenced not only arid and semi-arid regions but that it also led to significant drying in humid and semi-humid zones. Comparison with other records suggests that the Tibetan Plateau uplift at ~3.6 Ma may have initiated the PPT, via enhanced chemical weathering, reduced atmospheric $p\text{CO}_2$, and the resulting expansion of Northern Hemisphere glaciation. These major environmental changes during the PPT caused global cooling and other shifts in Earth's climate, including in the core area of the East Asian monsoon.

Keywords: Pliocene-Pleistocene transition, East Asia, Huaihe River Basin, Aridification, Carbonate carbon and oxygen isotopes



Session 23. Advancing climate prediction with paleoclimate data and models

Conveners: Pedro DiNezio, Timothy Shanahan, Jiang Zhu, Bette Otto-Bliesner

【A0256】 -Poster

Mesoscale convective systems from the Cenozoic into the future: Insights from high-resolution community earth system model simulations

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High-resolution climate models are essential for resolving finer-scale weather systems, which are critical for predicting the impacts of climate change. Mesoscale convective systems (MCSs), defined as organized clusters of thunderstorms, are prominent features of global precipitation, contributing more than half of total precipitation in the tropics and some midlatitude regions. However, studying MCSs across Earth's history, especially in paleoclimate contexts, has been limited by computational constraints. This project aims to track MCSs during key Cenozoic intervals, including the Last Glacial Maximum (~21 ka; 190 ppm CO₂), mid-Pliocene Warm Period (~3.2 Ma; 400 ppm CO₂), and Early Eocene Climatic Optimum (~50 Ma; 840 and 1680 ppm CO₂), as well as a preindustrial control (284.7 ppm CO₂). These paleoclimate intervals were selected to capture a range of different climate states, from icehouse to hothouse climates. This study uses a new set of isotope-enabled Community Earth System Model 1.3 simulations, with ~0.25° atmospheric and land resolution and ~0.1° ocean and sea ice resolution. These simulations allow for the development and evolution of organized MCSs and meso-scale ocean eddies, which have never been explored in the



context of coupled paleoclimate systems. In addition, we employ a deep learning model utilizing the U-Net architecture for image segmentation, trained on ERA5 reanalysis data, in combination with Tempest Extremes, an adaptable feature-tracking algorithm, to detect and track MCSs within these simulations.

This study investigates whether changes in MCS characteristics scale with global mean temperature, similar to patterns observed in extreme precipitation events. Preliminary results indicate a poleward expansion in MCS activity with increasing atmospheric CO₂, accompanied by a general increase in MCS precipitation and a higher contribution of MCSs to annual total precipitation. Furthermore, we find that higher surface temperatures correspond to elevated levels of outgoing longwave radiation and brightness temperature, indicating the presence of warmer high cloud tops associated with these storm systems. This change in cloud-top temperature, a commonly used metric for tracking MCSs, suggests a shift in the characteristics that define these storm systems compared to present-day conditions. By examining MCSs across these diverse climate states, we aim to further uncover patterns and relationships between storm characteristics and global temperature. This research will provide valuable insights into past hydroclimate changes and contribute to more accurate predictions of future MCS behavior in a warming world. Ongoing work will compare these results with a high-emission RCP8.5 global warming scenario to better understand how MCS behavior will respond to future warming.

Keywords: Hydroclimate, High-resolution modeling, Extreme events

【A0388】 -Poster

Precipitation responses to atmospheric circulation in central Chile: A paleoclimatic simulation approach

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Precipitation patterns and drought frequencies in central Chile are strongly influenced



by broad-scale atmospheric dynamics, notably the interplay between the Southern Hemisphere Westerly Winds and the Southeast Pacific Subtropical Anticyclone. Understanding the dependence of precipitation to atmospheric circulation changes is crucial for reconstructing past climates and projecting future hydrological scenarios. This study employs an ensemble of CMIP6 paleoclimate simulations spanning the Last Glacial Maximum and mid-Holocene, relative to a pre-industrial baseline. We evaluate the influence of large-scale atmospheric circulation patterns, particularly the Southern Hemisphere Westerly Winds, on regional precipitation in central Chile. Our results indicate that variations in these large-scale circulation features played a decisive role in modulating regional moisture delivery. During intervals when the Westerlies extended equatorward or the Anticyclone weakened, precipitation generally increased, while poleward shifts and anticyclonic intensification led to drier conditions. These findings highlight the sensitivity of central Chile's hydroclimate to hemispheric atmospheric circulation changes and underscore the importance of understanding past circulation alterations for anticipating future hydrological scenarios.

Keywords: CMIP6, Mid-Holocene, Last Glacial Maximum, Chile, Atmospheric circulation

【A0425】 -Oral

Planning for the next Palaeoclimate Modelling Intercomparison Project (PMIP7)

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With the IPCC being commissioned to produce a seventh assessment report, it became clear that there would be a need for a new set of climate model experiments. The Coupled Model Intercomparison Project 7 (CMIP7) has been launched, with PMIP7 as an affiliated community effort. CMIP7 will contain a selection of simulations, called the Fast Track, that need to be run first. One of these is a sensitivity experiment looking at the role of changes in the Earth's orbital parameters. The "abrupt-127k" experiment consists of instantaneously jumping to the orbital configuration of 127,000 years ago, whilst also altering the greenhouse gas to those observed in ice cores at the time. The



experiment will allow analysis of how models become seasonally sea ice free in the Arctic, and can be extended to become a last interglacial simulation (lig127k). The other experiments that are expected to form part of PMIP7 will be briefly discussed along with other requirements, requests and opportunities.

Keywords: Model, PMIP

【A0602】 -Oral

Mid-Holocene regional simulation of the Peruvian coastal upwelling system improve model-data paleoceanographic comparisons

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The Humboldt Current System (HCS), the most extent Eastern Boundary upwelling system, is also one of the most productive and oxygen-depleted oceanic regions in the world. The Holocene period, characterized by orbitally-driven insolation changes, provides natural experimental conditions to understand the HCS sensitivity to radiative forcing, and its physical and biogeochemical response to variations in the global climate mean state. Paleoceanographic reconstructions indicate cooler mean conditions off Peru during the mid-Holocene, interpreted as evidence for intensified coastal upwelling. On the other hand, proxy records also suggest more oxygenated waters, which seems in contradiction with an intensified upwelling. Insights from Earth system models are limited because of the strong systematic bias in the South-East Pacific, where the coastal upwelling is not correctly represented, simulated temperatures are too high and the oxygen minimum zone too weak. Here we solve this problem with the first dynamical downscaling of a global paleoclimatic simulation in the HCS. We simulate the regional dynamics of the HCS during the mid-Holocene (MH, from 6k to 5.9k years BP), the pre-industrial (PI, from 1750 to 1850), and modern (PD, 1900-1950) periods, using the regional physical-biogeochemical coupled model



CROCO-PISCES at a horizontal resolution of $1/6^\circ$ over the whole HCS area. The model was run in climatological mode for both periods. The transient simulation TR5AS-Vlr01 of the IPSL model, which spans from 6k years BP to 1950 AD, was used for the atmospheric forcing and open boundary conditions (OBC). The atmospheric forcing and biogeochemical OBC were bias-corrected using instrumental observations.

Changes in the amplitude of the SST seasonality are found in the simulation, with a cooler (warmer) summer (winter) during in the mid-Holocene as a result of the reduced insolation seasonal contrast at that time in the southern Hemisphere. In average the HCS was colder in the MH regional simulation compared to the PI period, in agreement with proxy observations. An intensification of the upwelling contributed to this cooling, especially in summer and in the northern HCS. Subsurface oxygenation shows also a seasonal change with more (less) oxygen in austral winter (summer). In average, mean oxygenation appears higher along the coast in the mid-Holocene simulation, especially in the central and southern coast, in agreement with proxy observation. Increased oxygenation appears related to reduced primary productivity possibly due to reduced Si availability and/or to a reduced light availability associated to a deeper mixed layer. The study demonstrates the potential of combining regional modelling with paleoclimate data to improve our understanding of the processes of natural variability in regions affected by strong model biases such as eastern boundary upwellings.

Keywords: Upwelling, Downscaling, Mid-Holocene

【A0796】 -Poster

Examining the role of the Pacific Ocean in the unusual warming of the Western Indian Ocean over past century

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The Western Indian Ocean (WIO) has undergone rapid warming over the past century, surpassing that in other tropical Indo-Pacific Ocean basins. Warming in the Indian Ocean is often associated with El Niño conditions. El Niño events transfer warm



anomalies from the Pacific to the Indian Ocean through a series of ocean-atmosphere interactions, accumulating heat in the WIO. In this study, we use coral datasets in the WIO to reconstruct regional sea surface temperature (SST) from 1846 to 2006, and employ different ensembles from the Community Earth System Model to test the Pacific's role in driving WIO warming. Our coral-based reconstructions show a significant warming of approximately 1°C in the WIO after the 1920s, coinciding with more frequent and stronger El Niño events. In the large ensemble (1920-2014) and Last Millennium Ensemble (1920-2005), the WIO is not the fastest-warming region in the tropical Indo-Pacific Ocean. Although these models reflect the intensification of El Niño events by showing an increase in the eastern Pacific SST standard deviation, they fail to replicate the enhanced eastern Pacific SST skewness observed in the instrumental SST data (ERSST and HadISST). A Pacific pacemaker ensemble (1920-2014, using observed SST in the tropical Pacific) displays the skewness that is inherent in the experimental design, but WIO warming is still weaker than observed. Additionally, the Indo-Pacific interaction in the coral reconstructions exhibits decadal variability, with different decades characterized by distinct combinations of physical mechanisms. Although the models generally capture the dynamical mechanisms observed in recent decades, they lack the decadal modulations in Indo-Pacific interaction. The models' biases in representing the long-term changes in ENSO and decadal variations in Indo-Pacific interaction likely contribute to their underestimation of WIO warming.

Keywords: Western Indian Ocean, Warming, Indo-Pacific interaction, Community Earth System Model, Coral-based reconstruction

【A0534】 -Poster

Reconciling East Asia's mid-Holocene temperature discrepancy through vegetation-climate feedback

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The term “Holocene temperature conundrum” refers to the inconsistencies between



proxy-based reconstructions and transient model simulations, and it challenges our understanding of global temperature evolution during the Holocene. Climate reconstructions indicate a cooling trend following the Holocene Thermal Maximum, while model simulations indicate a consistent warming trend due to ice-sheet retreat and rising greenhouse gas concentrations. Various factors, such as seasonal biases and overlooked feedback processes, have been proposed as potential causes for this discrepancy. In this study, we examined the impact of vegetation-climate feedback on the temperature anomaly patterns in East Asia during the mid-Holocene (6 ka). By utilizing the fully coupled Earth system model EC-Earth and performing simulations with and without coupled dynamic vegetation, our objective was to isolate the influence of vegetation changes on regional temperature patterns. Our findings reveal that vegetation-climate feedback contributed to warming across most of East Asia, resulting in spatially diverse temperature changes during the mid-Holocene and significantly improved model-data agreement. These results highlight the crucial role of vegetation-climate feedback in addressing the Holocene temperature conundrum and emphasize its importance for simulating accurate climate scenarios.

Keywords: Holocene temperature conundrum, Vegetation-climate feedback, East Asia

【A0754】 -Poster

Reducing uncertainty in rainfall projections using paleodata

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Validating climate projections is challenging, particularly at regional scales required for business and communities to adapt to climate change. This issue is particularly critical in the case of hydroclimatic variability, for which global climate models continue to produce divergent projections across vast areas of the planet, particularly the global. To address this limitation, we validated the mechanisms and response patterns in the models by comparing them with reconstructions of past climate changes recorded in geological archives. Our findings reveal coupled interactions in tropical oceans capable of intensifying extreme hydroclimatic events on a global scale. This approach not only reduces uncertainty in climate projections but also identifies key features of the coupled ocean-atmosphere system that could amplify future changes, highlighting the urgent need to mitigate anthropogenic greenhouse gas emissions.



Keywords: Climate projections, Climate models, Hydroclimate

【A0760】 -Poster

The effect of global mean sea-level rise to maritime continent and East Asia summer precipitation

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Global mean sea level (GMSL) rose at an accelerated rate in recent decades, posing significant challenges to vulnerable regions such as the Maritime Continent (MC). With its numerous sea passages and low-lying island nations, the MC requires particular attention to the impacts of GMSL rise. Here, our modeling study demonstrates that even modest sea-level datum rise (tens of centimeters) can alter the oceanic circulation, leading to significant warming of sea surface temperatures (SST) near Guinea and Java. This warming enhances convection and increases summer precipitation over southern parts of the MC. Meanwhile, the upward flow driven by warm SST anomaly move northward in the upper troposphere, where it converges and subsides over the northern MC. This subsidence suppresses local precipitation, as well as excites the Pacific–Japan (PJ) pattern on decadal time scales, which decreases/increases summer precipitation in Southeast China/North China.

Keywords: Sea level rise

【A0397】 -Poster

Role of sea level and seaway in modulating the Hadley circulation change during the last glacial period

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Paleoclimate records revealed that the Hadley circulation, the most prominent meridional circulation in Earth's system, contracted during the Last Glacial (LG) period. However, whether climate models can replicate this Hadley circulation change and the relevant mechanisms remain unclear. Here, using climate simulations based the Norwegian Earth System Model (NorESM1-F), we show that sea level fall and closure/constriction of seaways play important roles in modulating the Hadley circulation changes during the initial stage of the LG period (~70 ka). The sea level fall leads to an inter-hemispheric energy imbalance, which in turn causes a southward shift of Hadley circulation. The closure/constriction of seaways weakens (strengthens) the Hadley circulation in the Northern (Southern) Hemisphere and shifts its edges equatorward in both hemispheres through influencing the meridional temperature gradient. Our results demonstrate the importance of taking changes in global mean sea level and seaways into account when simulating the glacial climate.

Keywords: Hadley circulation, Last glacial period, Sea level fall, Seaways closure/constriction

【A0722】 -Oral

New classes of climate model emulators to improve paleoclimate reconstructions

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It is well known that the predictability of the climate varies over time and will depend on the initial conditions, especially when considering non-linear systems such as El Niño Southern Oscillation (ENSO). While recent decades have seen a few extreme ENSO events, proxy data reveal a large amplitude in tropical Pacific sea surface temperature's low frequency modulations over past millennia. To better interpret what is observed in proxies, a useful approach is to combine the climate information derived from natural archives with the physics of GCMs using paleoclimate data assimilation (PDA). Recently, efficient online ensemble-based data assimilation techniques have been developed relying on climate model emulators and the predictable components of the climate system. The skill of these ensemble forecasts



is a key factor for the success of PDA especially when considering Particle Filters. Such predictability may however change according to the host-GCM, the emulator skills in capturing the host-GCM non-linear behaviours and the dimension of the problem. In this study, we explore these issues in a perfect model framework across PMIP3 and PMIP4 climate model simulations for the past millennium, relying on various types of architectures and climate model emulators. Our results indicate that relying on a hierarchy of multi-model approaches provides a promising way to better quantify uncertainties and decipher the relative contribution from internal dynamics and external forcings embedded in proxy records, particularly regarding ENSO.

Keywords: Climate model emulators, Nonlinear dynamics, Climate variability, ENSO, Proxy data assimilation

【A0719】 -Poster

Impacts of Mid-Pliocene ice sheets and vegetation on Afro-Asian Summer Monsoon rainfall revealed by EC-Earth simulations

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The impact of mid-Pliocene boundary conditions on Afro-Asian Summer Monsoon (AfroASM) rainfall is examined using the fully coupled Earth System Model EC-Earth3-LR. Our focus lies on the effects of varying CO₂ concentration, diminished ice sheets and vegetation dynamics. We find that the enhanced Afro-ASM rainfall is predominantly caused by the “warmer-gets-wetter” mechanism due to elevated CO₂ levels. Additionally, the ice sheet, similar in size to that of the mid-Pliocene era, creates several indirect effects. These include sea ice-albedo feedback and inter-hemispheric atmosphere energy transport. Such influences result in the southward shift of Hadley circulation and formation of Pacific-Japan pattern, leading to reduced rainfall in North African and South Asian monsoon regions but increased rainfall in East Asian monsoon region. Interestingly, while dynamic vegetation feedback has a minimal direct effect on Afro-ASM rainfall, it significantly influences rainfall in the mid-high latitudes of the North Hemisphere by enhancing water vapor feedback.

Keywords: Afro-Asian Summer Monsoon rainfall, Mid-Pliocene, Boundary conditions



【A0913】 -Poster

The study of climate sensitivity during the Pliocene warm period based on a two-dimensional EBM model

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During the Pliocene, atmospheric CO₂ concentrations were similar to modern levels (410 ppmv), but the global mean temperature was 2–4°C higher than today. This discrepancy could be attributed to changes in atmospheric water vapor content, variations in polar ice albedo, and other factors. Accurately assessing the contributions of these internal feedback mechanisms would provide a crucial basis for predicting future climate change trends. This study modifies and expands upon the simple two-dimensional energy balance model (2D-EBM) developed by Zhuang and North (2017) by incorporating dynamic ice albedo feedback and atmospheric water vapor content feedback. Using the standard boundary condition data from PlioMIP2 (CO₂ levels, land-sea distribution) as input, and setting the solar constant to 1357 W/m², we designed a series of equilibrium state simulation experiments for the Pliocene. The study analyzed the sensitivity of the model's global mean temperature to the initial values of atmospheric water vapor content, ice sheet area, dynamic water vapor feedback, and dynamic ice albedo feedback. The results showed that dynamic water vapor feedback had the greatest impact on global mean temperature, followed by dynamic ice albedo feedback, while the initial value of ice sheet area had the weakest impact.

Keywords: Pliocene, Climate sensitivity, EBM model

【A0880】 -Poster

Modeling global silicate weathering flux during the Last Glacial Maximum in the framework of GEOCLIM

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There were contrasting differences between the present and the last glacial maximum (LGM) in terms of changes in climate, $p\text{CO}_2$, and sea level. Silicate weathering is one of the most important processes of the long-term carbon cycle. How global silicate weathering rates and fluxes would respond to these changes remains puzzling. Here, we used paleoclimate outputs from more than ten models for the LGM and present gridded datasets to model global silicate weathering fluxes in the framework of GEOCLIM. We will show how silicate weathering fluxes are globally distributed and discuss the factors such as temperature, runoff, slope, and erosion that might contribute to silicate weathering with an XGBoost regression analysis.

Keywords: Last Glacial Maximum, Silicate weathering, GEOCLIM

【A0466】 -Poster

On the combination of different forcing factors and their impact on deglacial AMOC evolution in CESM simulations

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Transition from the cold Last Glacial Maximum (LGM) to the warm interglacial state of the Holocene was triggered by changes in insolation and geochemical processes. Significant sea level rise, together with melting ice sheets, represent the most distinctive features of the last deglaciation. By meltwater release, ice sheets modulate the Atlantic Meridional Overturning Circulation (AMOC), which causes significant oceanic and atmospheric changes, and contributes to a sequence of abrupt climate events that characterize this deglacial period. Understanding the stability of the AMOC under deglacial boundary conditions is of vital importance for better understanding of the climate trajectory from the LGM to the Holocene, and for an improvement of our knowledge of climate change mechanisms and the enhancement of climate model accuracy. To this end, we explore the impact of different glacial/deglacial boundary conditions (orbital parameters, greenhouse gas concentrations (GHG), ice-sheet topography) on the stability of the AMOC in freshwater hosing experiments using the



Earth system model CESM1.2. This study is part of coordinated activities within the German climate modeling initiative-PalMod. For this purpose, four different model configurations with various combinations of boundary conditions are used: (i) Full 15.2 ka boundary conditions, (ii) 15.2 ka boundary conditions except for LGM GHG, (iii) LGM boundary conditions with 15.2 ka ice-sheet topography, and (iv) full LGM boundary conditions. After initial, spin-up model integrations (3000-4000 years) for each of these parameter combinations, freshwater hosing (0.1 Sv and 0.2 Sv; 400-700 years) is applied in the ice-rafted debris belt in the Northern Atlantic Ocean (40°N–55°N, 45°W–20°W) for each experiment, which leads to pronounced perturbations of the AMOC. We find that the AMOC is most stable with respect to hosing under full 15.2 ka boundary conditions. Under reduced (LGM) GHG forcing, the AMOC becomes more unstable and collapses in response to only 0.1 Sv of freshwater hosing. Under certain conditions (15.2 ka boundary conditions with 0.1 Sv hosing), the AMOC exhibits bistability. Abrupt recovery along with an overshoot of the AMOC after removal of the hosing resembles Bølling/Allerød (B/A) warming by its intensity and duration. Finally, spontaneous (unhosed) millennial-scale AMOC oscillations (“Dansgaard-Oeschger-like”) are found under LGM boundary conditions with (intermediate) 15.2 ka ice-sheet topography, as well as multicentennial AMOC oscillations under full LGM boundary conditions. In sum, our set of experiments indicates that the deglacial AMOC evolution was the result of a non-linear complex interplay between different forcing factors rather than a simple (linear) response to meltwater forcing. It also shows the capability of the model to successfully simulate some of the typical features of the last deglaciation, which might enable us to more reliably assess future climate changes in upcoming climate projection experiments.

Keywords: AMOC, Deglacial, Hosing, CESM

【A0348】 -Oral

A synthesis of regional paleoclimate variations in China over the past ~21 ka

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In this study, we utilize multiple proxies, including pollen, diatoms, geochemistry, and physical properties of sediments from various archives such as lake sediments, peats, and paleosols distributed across different regions of China, to quantitatively and semi-quantitatively reconstruct paleoclimate variations in monsoonal and arid areas over the past ~21,000 years. Our results reveal significant variability in both monsoonal and arid climates, with notable regional differences. Compared to observational data from 1961 to 1990, mean annual temperature (MAT) and seasonal temperature (ST) during the Last Glacial Maximum (LGM) were ~5°C (ranging from 3°C to 8°C) lower, and ~2°C (ranging from 1°C to 3°C) higher during the Holocene Optimum (HO). Mean annual precipitation (MAP) and seasonal precipitation (SP) exhibited variations of 30-150%, with greater seasonality during the middle Holocene (~8-5 ka). A distinct pattern of paleoclimate variability was observed in the transitional zone between monsoonal humid and arid regions. These quantitative and semi-quantitative reconstructions from diverse regions of China highlight a heterogeneous and notable diversity in regional temperature and precipitation patterns.

We conducted dynamic downscaling of paleoclimate modeling using the fully-forced transient experiment (TraCE 21 ka) results as lateral boundary conditions, nested within the regional climate model (RegCM4), to examine regional climate differences in China over the past ~21,000 years and to analyze the forcing mechanisms behind paleoclimate variations. By comparing proxy-based paleoclimate reconstructions with the output of the TraCE 21 ka transient climate simulations, we assessed the consistency and discrepancies in regional paleoclimate variations. Our findings reveal a distinct regional diversity in paleoclimate changes over the past ~21,000 years, with notable differences in amplitude, frequency, and the underlying forcing mechanisms.

Keywords: Regional Paleoclimate, Proxy-based paleoclimate reconstruction, Asian monsoon, Arid climate, The past ~21 ka

【A0648】-Poster

Decadal climate prediction informed by paleoclimate records using the AI climate model ClimaX

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The concept of “Present is the key to the past” is widely applied in paleoclimate studies. By cross-referencing different proxy records, paleoclimatologists can piece together a picture of Earth's climate history, creating robust climate reconstructions spanning hundreds, thousands, or even millions of years, which are crucial for understanding long-term climate variability and trends. However, the potential of proxy records for interpreting present and predicting future climate states remains underutilized. As artificial intelligence (AI) continues to rapidly evolve, data-driven models based on deep learning (DL) have been gradually applied to the domain of atmospheric science, and have made major breakthroughs in weather forecasting and climate prediction, achieving results comparable to traditional numerical weather prediction (NWP) models or even better. ClimaX, a novel AI model built on Transformer architecture, is one of them. ClimaX is the first fundamental model for weather and climate, by pre-training heterogeneous datasets spanning different variables, spatio-temporal coverage, and physical groundings, it can be fine-tuned for various downstream tasks such as climate projection. Therefore, here, we explore whether machine learning (ML) can serve as a powerful tool to connect the "past-present-future" in climate science. We investigate the application of the ClimaX model to paleoclimate research, using climate fields reconstructed from proxy records by paleoclimate data assimilation (PDA) to pre-train the model and fine-tune it for future climate projections. As a case study, we focus on the tropical Pacific, conducting experiments on decadal climate variability projections. This approach demonstrates the potential of AI to integrate paleoclimate data for both the interpretation of present conditions and the prediction of future climate trends.

Keywords: Climate projection, Proxy records, Paleoclimate data assimilation, AI

【A0832】 -Poster

Coupled seasonal data assimilation of sea ice, ocean, and atmospheric dynamics over the last millennium

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"Online" data assimilation (DA) integrates forecasts from an ocean-atmosphere-sea-ice coupled linear inverse model with climate proxy records to generate a new seasonal-resolution reanalysis dataset over the last millennium. This approach utilizes a novel season-to-season updating strategy. Instrumental verification reveals that this method achieves the highest accuracy with the fewest proxies in surface temperature reconstructions compared to other paleo-DA products, particularly during boreal winter when proxy data are scarce. It also demonstrates high accuracy in other oceanic and sea ice variables. Additionally, the method effectively captures the seasonal evolution of El Niño events. Direct proxy verification underscores the robustness of this reconstruction throughout the last millennium. The reconstruction distinctly illustrates a pronounced Medieval Climate Anomaly (MCA) and Little Ice Age (LIA) because of the seasonal pronounced polar amplification and new updating strategies.

Keywords: Coupled data assimilation, Last millennium, Linear inverse model, Sea ice

【A1016】 -Poster

Simulation of the last millennium climate with the different versions of the climate model INM-CM

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The simulation of the climate of the last millennium using two versions of the climate model developed in INM RAS is considered. The model INM-CM48 (participated in CMIP6) and the new version INM-CM6 simulated the last millennium climate in accordance with the CMIP6 experimental design for the *past1000* and *historical* experiments. The new model version differs from a previous version by the change in cloudiness and condensation scheme, that leads to higher sensitivity to CO₂ increase. The changes are included also in calculation of aerosol evolution, land snow, atmospheric boundary layer parameterizations and other blocks. The model is capable to reproduce near surface air temperature, precipitation, sea level pressure, cloud radiation forcing and other parameters better than previous version. The largest improvement can be seen in simulation of temperature in tropical troposphere, polar tropopause, and surface temperature in the Southern Ocean. Comparison of the model and proxy data shows that the new version of the model reproduces the



temperature response to major volcanic eruptions much more realistically than previous version, especially the response to Northern Hemisphere high latitude volcanic eruptions. The *past1000* forcings are insufficient to reproduce the warming of the Middle Ages and the cooling of the Little Ice Age by both models. However, both versions successfully (close to the observational data) reproduce the temperature change in the 20th century in accordance with the *historical* experiment forcings.

The studies were supported by grant of the Ministry of Science and Higher Education of Russian Federation (agreement No. 075-15-2024-554 of 24.04.2024)

Keywords: Past1000, INMCM, Model-data comparison

【A0960】 -Poster

Investigating the roles of CO₂ and paleogeography in shaping the Pliocene climate using an atmosphere-ocean-vegetation coupled model

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The Pliocene is thought to have been warmer than present-day and has been the focus of many studies as a possible analogue of near-future warming. It is known that in the Pliocene, there were less tundra and more forests in the Arctic and the Sahara Desert was smaller than in present-day, and there were more grassland and forests elsewhere. Recent studies have indicated that, in addition to CO₂ forcing, non-CO₂ forcings, such as orography, land configuration, vegetation, and ice sheets, also play an important role in shaping the differences between present day and Pliocene climates. In many modelling studies, vegetation is fixed and treated as one of the non-CO₂ forcings. However, vegetation can change in response to the other forcings such as CO₂ and paleogeography. In this study, in order to investigate the role of CO₂ and non-CO₂ forcings including the effect of vegetation feedback, we conducted experiments using an atmosphere-ocean-vegetation coupled model, MIROC4m-LPJ, and set CO₂ concentration and paleogeography to those of pre-industrial and of the Late Pliocene. What is more, in order to investigate the role of separate parts of the paleogeography, we conducted experiments in which northern and southern high latitudes are set to Pliocene separately. While Pliocene CO₂ concentration contributes to a globally warmer climate than pre-industrial, paleogeography has a large effect,



both seasonally and locally. With Pliocene paleogeography alone, the continents at northern high latitudes tend to be warmer in boreal summer and colder in boreal winter. The summer warming in these regions leads to a reduction in surface area covered by tundra and an increase in forests, further enhancing the warming. The effect of this paleogeography on the summer warming is as large as that due to CO₂ forcing. The Pliocene paleogeography also enhances the precipitation in North Africa compared to pre-industrial. The Pliocene paleogeography of the northern Hemisphere high latitudes has an influence on North Africa precipitation via the Summer Monsoon.

Keywords: Pliocene, Paleogeography

【A0767】 -Poster

Bezenghi and IGAN glacier cores as an archive of environmental information

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A comprehensive study of glacier cores using various analytical methods has both theoretical and practical value. Glacier cores represent one of the main sources of palaeoclimatic data today. The application of isotopic, chemical, radioisotopic and other methods of core research allows us to recover information on palaeotemperatures, the magnitude of glacier accumulation, atmospheric composition and other climatic characteristics. The combination of different approaches makes it possible to reconstruct palaeoclimate conditions, identify natural fluctuations of climatic systems, determine the date and duration of climatic events, and conduct a deeper analysis of climate changes over the last decades (Mikhlenko, 2008). In addition, glacial core data not only allow reconstructing changes in the past, but are also used to improve projections of various climate models (Thompson, 2015).

The aim of this work was to apply data from analyses of glacial cores to assess and compare the state of ecosystems in the high-mountain Caucasus and mid-mountain Urals, as well as to compare the influence of the nature of the glacier and climatic



conditions of its existence on the quality of palaeoclimatic information. The paper presents new results on complex geochemical analyses of glacial cores from Bezenghi and IGAN to try to reconstruct climatic conditions in the past. The preservation of the isotope record in ice from different glaciers is compared and the reasons for the disruption of the original climatic signal are discussed. In addition, the mineralogical composition of insoluble inclusions in cores is compared, and the changing dynamics and nature of possible sources of these particles are analysed. The laboratory analyses performed show that the IGAN core, although representing a valuable palaeoarchive of data, exhibits significant problems with the preservation of palaeoclimatic data. In contrast, the Bezenghi core is characterised by its excellent data preservation. However, by considering the results from Bezenghi and other high-resolution Caucasian cores, and taking into account various input parameters such as geographic location and data sources, we can analyse and interpret the information obtained from IGAN in more depth.

The study was supported by grant of the Ministry of Science and Higher Education of Russian Federation (agreement No. 075-15-2024-554 of 24/04/2024).

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Keywords: Climate change, Ice core, Glaciers, Chemical composition

【A0670】 -Poster

Reconstructions of climate during last two millennium based on hybrid gain analog offline EnKF using multiple types of proxy records

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We use the Hybrid Gain Analog Offline EnKF (HGAOEnKF) with multiple types of proxy records, to reconstruct the temperature, precipitation, and large-scale climate variability during the last two millennia. First, a new reanalysis product (NNU-2ka Reanalysis) is generated through the HGAOEnKF with the expanded proxy database. A comparison with observed SST variability shows that our assimilated tropical SST variability performs reasonably well for the seasonal cycle and monthly ENSO characteristics, notably the phase-locking and onset timing, and more realistic spatial fields relative to the model simulations. Sensitivity experiments show that the proxy records from the ocean contribute more to the temperature reconstruction skill with both assimilation methods. We then further reconstruct the Pacific decadal variability (PDV) and Atlantic meridional overturning circulation (AMOC) using the oxygen isotope records.

Keywords: Paleoclimate data assimilation, Last two millennia, Enkf, Large-scale climate variability

【A0283】 -Poster

AWI's contribution to PlioMIP3 with two generations of earth system models

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The Pliocene Model Intercomparison Project (PlioMIP) has been ongoing since 2012, with the Alfred Wegener Institute (AWI) as an active contributor. During PlioMIP2 in 2020, AWI provided a substantial simulation ensemble using the Earth System Model COSMOS with dynamic vegetation. Since then, our institute has developed two new multi-resolution models: AWI-ESM2 and AWI-CM3. For the current third iteration of PlioMIP, we are employing both models to simulate the Late Pliocene and Early Pliocene climates according to the new simulation design proposed for PlioMIP3. Although AWI-ESM2 and AWI-CM3 use different atmospheric models, they share the same ocean model. This setup not only allows us to contribute our own “mini-MIP” with AWI-affiliated models—exploring how the Earth System responds to varying boundary conditions and model parameters—but also offers a unique opportunity to



understand better the impact of differences in atmospheric model characteristics on simulated Pliocene climate. Specifically, AWI-CM3 uses the OpenIFS atmospheric model (cycle 43r3v2), shared with the EC-Earth community, while AWI-ESM2 employs ECHAM6, versions of which have been part of the Max Planck Institute for Meteorology model family, including ECHAM5 in COSMOS and ECHAM6 in MPI-ESM. Both models incorporate the ocean model FESOM2. For PlioMIP3-compliant simulations, we maintain an atmospheric resolution of approximately 200 km in ECHAM6 and 100 km in OpenIFS. To simulate ocean dynamics, we use CORE2-grade resolution ocean meshes (nominal 1° resolution) with high spatial refinement to better resolve high-latitude and coastal dynamics. Both climate models include modifications in their paleogeography and initial conditions to accurately represent the Pliocene environment. Our models have already been used for PMIP4/CMIP6-compliant simulations, including *piControl*, *abrupt-4xCO2*, *historical*, *midHolocene*, and *lig127k* across various resolutions. The results are generally consistent with the CMIP6 ensemble in most climate performance metrics. To support PlioMIP3's model intercomparison effort, we plan to contribute core simulations LP and PI, as well as optional and legacy simulations: EP, LP280, LP560, PI400, PI560, LP_pi-orog, LP_lp-orog, LP_pi-ice, PI_lp-ice, and LP_pi-EAIS. These will be completed over 2025 and potentially into 2026. Here, we present an initial overview of the findings derived from AWI's contribution to PlioMIP3 using AWI-ESM2 and AWI-CM3.

Keywords: Pliocene Epoch, Past warm climates, Earth System Modelling, PlioMIP3, PMIP4/CMIP6

【A0793】 -Poster

Fast oceanic inter-hemispheric teleconnections due to an AMOC weakening

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The Atlantic Meridional Overturning Circulation (AMOC) is a critically important system of ocean currents that redistributes heat in the Atlantic Ocean. Paleoclimate records and modeling studies indicate that the AMOC weakened significantly on a multi-centennial timescale during the Quaternary, and particularly during Heinrich stadials (HS), substantially modifying global climate patterns. Given the accelerated



melting of the Greenland ice sheet and Arctic glaciers, identifying the current state of the AMOC is of great importance to mitigation and adaption to future changes. Previous proxy-data and modelling studies suggested that the AMOC weakening signal propagates to the Southern Hemisphere on, at least, a centennial timescale resulting in a pattern known as the Bipolar seesaw. However, here using state-of-the-art Earth system and eddy-permitting coupled ocean-sea-ice models, we show that a weakening of the AMOC increases the temperature and salinity of the South Atlantic ocean on a decadal timescale through the propagation of Kelvin and Rossby waves. By evaluating these processes in observational data of the past century, we find that the AMOC weakening signal emerged in 1975.

Keywords: AMOC, Bipolar seesaw, Meltwater, Ocean waves, High resolution modelling

【A0943】 -Oral

Main drivers of low-frequency surface temperature variability in earth system models cannot explain the observed latitudinal gradient of variability

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Knowledge on regional climate variability is crucial for making future climate projections. Yet, as previous studies demonstrated, long-term temperature variability is underestimated in climate model simulations when compared to palaeodata. Here we utilise the wealth of available paleotemperature reconstructions to estimate the latitudinal gradient of millennial-scale surface temperature variability for the Holocene. We compare the results to the estimations based on earth system model simulations and find that the models underestimate low-frequency temperature variability especially in the tropics and the Southern Hemisphere. Assuming the enhanced variability reconstructed from proxy data holds for both, the past and the future, we examine the potential implications for future threshold crossings and extreme event attribution. Furthermore, we investigate the drivers of the low-frequency variability in the model simulations and find that neither internal oscillations of the Atlantic Meridional Overturning Circulation nor forced variability from volcanism can explain the latitudinal pattern of surface temperature variability the Holocene palaeodata indicates.



Keywords: Climate variability, Model-data comparison

【A0176】 -Oral

A novel approach to disentangle the circulation signal from Pa/Th reconstructions

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The Atlantic Meridional Overturning Circulation (AMOC) is a critical climate driver on centennial to multi-millennial timescale, but its role in past climate change remains under-constrained. One of the most direct tracers of past changes in water mass advection and thus AMOC is the protactinium to thorium ratio ($^{231}\text{Pa}/^{230}\text{Th}$) reconstructed from marine sediments. yet their interpretation is complicated by the influence of both large-scale circulation patterns and local particle effects. These entangled influences can obscure the direct relationship between $^{231}\text{Pa}/^{230}\text{Th}$ ratios and AMOC dynamics and lead to spatially heterogeneous $^{231}\text{Pa}/^{230}\text{Th}$ responses. Therefore, we present a modelling framework to quantify the spatial sensitivity of $^{231}\text{Pa}/^{230}\text{Th}$ as a proxy for AMOC strength in the Atlantic Ocean. Using the Bern3D Earth System Model of Intermediate Complexity, we explicitly simulate the $^{231}\text{Pa}/^{230}\text{Th}$ response to forced step-changes in AMOC in a suite of sensitivity simulations across different climatic backgrounds: the pre-industrial era, the Last Glacial Maximum, and Marine Isotope Stage 3. By decomposing the ^{231}Pa and ^{230}Th responses into transport-driven and particle-induced components, we aim to distinguish the primary influences on $^{231}\text{Pa}/^{230}\text{Th}$ values in each scenario. Additionally, we evaluate the sensitivity of $^{231}\text{Pa}/^{230}\text{Th}$ ratios to changes in AMOC strength and investigate the spatial variability of this sensitivity across different climate states. This analysis will help to identify sensitivities and dominating processes in sediment core reconstructions, inform future drilling sites, and ultimately will provide a coherent interpretative framework.

Keywords: AMOC, Pa/Th, Proxy, Sensitivity

【A0963】 -Oral

Antarctic circumpolar current evolution and its relation to southern



hemisphere westerly winds during the Holocene

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The Antarctic Circumpolar Current (ACC), the Earth's largest ocean current system, significantly influences global ocean circulation, climate, and the stability of the Antarctic ice sheet. Despite its importance, the driving forces behind the ACC remain largely elusive. This study, utilizing simulation data combined with reconstructions, explores the ACC's evolution and its relationship with the Southern Hemisphere Westerly Winds (SWW) during the Holocene. Both simulation and reconstruction results indicate that the ACC has become stronger and shifted towards the poles during the Holocene. Concurrently, the SWW has also grown stronger and shifted poleward. The ACC's increasing trend is driven by two ways. One way operates in the ocean, where rising in SH (Southern Hemisphere) mid-latitude seawater temperature, lead to sea ice melt. Consequently, seawater salinity and density decrease. Simultaneously, the south-to-north gradient of salinity and density increases, thereby strengthening the ACC during the Holocene. The other way operates in the atmosphere, where the SH mid-latitude surface temperature increases. Simultaneously, sea level pressure decreases. However the south-to-north gradient of both surface temperature and sea level pressure intensifies. These enhanced gradients lead to increased wind stress, which intensifies the SWW and poleward shift. The intensified SWW further amplifies the ACC and poleward shift during the Holocene. In summary, the ACC's strengthening during the Holocene is a result of temperature increases, which alters seawater properties and intensifies the SWW.

Keywords: Antarctic circumpolar current, Southern hemisphere westerly winds, Simulation, Holocene

【A0055】-Poster

Differential vegetation feedback on global land monsoon during the mid-Holocene and last interglacial

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This study investigates the impact of vegetation-climate feedback on the global land monsoon system during the Last Interglacial (LIG, 127,000 years BP) and the mid-Holocene (MH, 6,000 years BP) using the earth system model EC-Earth3. Our findings indicate that vegetation changes significantly influenced the global monsoon area and precipitation patterns, especially in North African and Indian monsoon region. North African monsoon region experienced the most substantial increase in vegetation during both the LIG and MH, resulting in significant increases in monsoonal precipitation by 9.8% and 6.0%, respectively. The vegetation feedback also intensified the Saharan Heat Low, strengthened monsoonal flows, and enhanced precipitation over the North African monsoon region. In contrast, the Indian monsoon region exhibited divergent responses to vegetation changes. During the LIG, precipitation in the Indian monsoon region decreased by 2.2% while it increased by 1.6% during the MH. These differences highlight the complex and region-specific impacts of vegetation feedback on monsoon systems. Overall, this study demonstrates that vegetation feedback exerts distinct influences on global monsoon during the MH and LIG. These findings highlight the importance of considering vegetation-climate feedback in understanding past monsoon variability and in predicting future climate change impacts on monsoon systems.

Keywords: Last interglacial, Mid-Holocene, Global land monsoon, Vegetation feedback

【A0581】 -Oral

Effect of the changes in atmospheric ozone on mid-Holocene and last-interglacial climates

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The climates of mid-Holocene (MH; 6 ka) and Last Interglacial (LIG; 127 ka) were warmer than the preindustrial (PI) condition, which would be attributed to the different astronomical forcing. This modified the seasonal and latitudinal distribution



of the incoming solar radiation, whose effect is further amplified by the feedback mechanisms in the climate system. One of the potential feedback that may help warming the MH and LIG climates is the variation of the stratospheric ozone. It has been discussed that the effect of the changes in the stratospheric ozone distributions during the MH when the obliquity was higher than in the PI would extend down to the troposphere and change the surface wind speed in the southern extratropics, potentially affecting the sea-ice distribution and climate via modulating the Ekman transport in the surface ocean (Noda et al., 2017). However, the impact of this feedback under the LIG condition in which the precession forcing was stronger than in the MH condition owing to the high eccentricity remains ambiguous. Here we employ the MRI-ESM 2.0, which is an Earth system model that couples an interactive ozone model. Using this model, we simulate the MH and LIG climates and discuss the impact of the consideration of the dynamical change in ozone on the simulated climate. In the MH condition, the model simulates that the vertical and seasonal changes of the stratospheric ozone near the southern pole relative to PI were similar to the results presented by Noda et al. (2017). However, our results exhibit a strengthening southern westerly jet during the austral winter and spring, which is the opposite of the results by Noda et al. (2017). In the LIG condition, these signals were even stronger than in the MH condition. This indicates that the variation of the precession forcing also affects the ozone distribution. We further show that the impact of the change in the ozone distribution on the sea-ice distribution and the surface air temperature over Antarctica and the Southern Ocean is asymmetric zonally, while its impact on the zonally-averaged surface temperature in the southern hemisphere was not strong compared with the results simulated in Noda et al. (2017). These results infer that the impact of stratospheric ozone may be crucial in estimating the climate at least locally in the past interglacial periods. For a better quantitative constraint on the impact of the changes in the atmospheric ozone, investigation using multiple earth system models with interactive ozone would be desirable.

Reference:

Noda, S., K. Kodera, Y. Adachi, M. Deushi, A. Kitoh, R. Mizuta, S. Murakami, K. Yoshida, and S. Yoden, 2017. Impact of interactive chemistry of stratospheric ozone on Southern Hemisphere paleoclimate simulation. *Journal of Geophysical Research: Atmospheres*, 122(2), 878-895.

Keywords: Ozone, Interglacial

【A0257】 -Oral



Marine carbon isotope proxy-model comparison using measurements from annually banded calcifiers and output from ocean circulation inverse models

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Anthropogenic activities release carbon dioxide (CO₂) into the atmosphere, driving global temperature increases through the greenhouse effect. The ocean acts as a significant carbon sink, sequestering a portion of this CO₂ and mitigating the rise in atmospheric concentrations. Accurately quantifying the oceanic carbon cycle is essential for understanding carbon flux from the atmosphere to the ocean. Ocean climate models are key tools for investigating the processes governing carbon dynamics once it enters marine systems.

The Ocean Circulation and Biogeochemistry Inverse Model (OCIM-BGC) integrates physical climatological mean ocean circulation with a biogeochemical component, enabling the simulation of the carbon cycle, including isotopes $\Delta^{14}\text{C}$ and $\delta^{13}\text{C}$. The model is constrained by GLODAPv2 instrumental data, including dissolved oxygen, phosphate, inorganic carbon, and alkalinity, and measurements of dissolved organic matter. However, GLODAPv2 measurements date back only to the 1970s, limiting its utility for evaluating model performance in earlier periods.

Annually banded marine calcifiers, such as corals, algae, bivalves, and sclerosponges, provide a valuable source of historical carbon isotope data spanning several centuries of widespread coverage of ocean regions. However, biological processes inherent to calcifiers, such as seasonal growth biases and isotopic fractionation during skeletal formation, may introduce offsets from oceanic carbon isotopic values.

This study compares $\Delta^{14}\text{C}$ and $\delta^{13}\text{C}$ measurements from marine carbonates with corresponding isotopic outputs from the OCIM-BGC. Preliminary findings indicate



systematic offsets between these datasets, potentially attributable to air-sea gas exchange processes and biological fractionation. Analysis of these discrepancies between the records will serve to better constrain the carbon cycling processes critical to understanding the removal of anthropogenic carbon dioxide from the atmosphere and into the oceans.

Keywords: Carbon, Ocean, Isotope, Model, Marine calcifier

【A1014】 -Oral

Seasonal precipitation evolution in the northern hemisphere since the Holocene and its future implications

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Seasonal temperature and precipitation trends under future global warming are a key focus of climate change research. Due to the Earth system's complexity, there is still uncertainty. Studying past warming events, like those during the Holocene, can provide valuable insights for future projections. In this study, we use pollen records from the Northern Hemisphere to reconstruct seasonal temperature and precipitation changes since the Holocene and compares these results with TraCE-21ka simulation data. The results show that Northern Hemisphere temperatures warmed in the early to mid-Holocene, followed by cooling. Temperature gradients between high and low latitudes have increased over time. Precipitation trends show contrasting patterns: in middle latitudes, westerly wind zone precipitation increased steadily, while in low latitudes, monsoon precipitation rose in the early to mid-Holocene but later declined. These patterns reveal significant regional differences in temperature and precipitation changes. The simulations effectively reproduce these precipitation trends. Analysis shows that increasing westerly zone precipitation was driven by changes in solar radiation and ocean circulation, while decreasing monsoon precipitation was caused by reduced summer solar radiation. Compared to future global warming from rising



CO₂ levels, precipitation changes will primarily depend on thermodynamic processes. While past trends offer some guidance, different driving forces may lead to significant variations in the spatial patterns and magnitudes of precipitation changes under future warming conditions.

Keywords: Seasonal temperature and precipitation reconstruction, Pollen data, TraCE-21ka simulation, Northern hemisphere, Holocene

【A1047】 -Poster

Orbital-scale variations in northern east Asian monsoon precipitation: Contributions of terrestrial and oceanic moisture sources

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Water vapor is the material basis of precipitation and an important component of global hydrological cycle. Quantifying the contributions of oceanic and terrestrial moisture sources is crucial for comprehending regional precipitation and hydroclimate changes. Previous studies have extensively investigated the East Asian Summer Monsoon and its precipitation changes using geological climate records, but it remains unclear how water vapor from different sources affects orbital-scale precipitation changes in East Asia. In this study, long-term transient simulations using a climate model with a water-tagging scheme were conducted over the past 300,000 years to explore the contributions of oceanic and terrestrial moisture sources to precipitation changes in the northern East Asian monsoon region (NEA, 35-45°N, 105-120°E). The results showed that, in the climatological annual NEA precipitation over the past 300 kyr, terrestrial source was the primary moisture source, accounting for approximately 57.6%, followed by Pacific sources contributing 20.9%, while other sources had a minor contribution. The orbital-scale changes of NEA annual precipitation, dominated by the rainy season (May to September), was mainly characterized by a significant 23-kyr cycle and a weak 100-kyr cycle. Moisture source analysis found that the significant 23-kyr cycle in NEA precipitation was caused by the superposition of the synchronous 23-kyr cycles of precipitation from the terrestrial and Pacific sources, while the asynchronous 100-kyr cycle changes of precipitation from terrestrial and Pacific sources were the reason for the weak 100-kyr cycle in NEA precipitation. Further analysis of water vapor flux showed that the orbital-scale NEA precipitation changes



were mainly controlled by the Northern Hemisphere summer insolation changes caused by precession, while changes in ice volume also had a certain modulation effect on NEA precipitation by regulating the contribution rates of terrestrial and Pacific moisture sources. This study highlights the importance of oceanic and terrestrial moisture sources changes associated with external forcing in understanding the orbital-scale East Asian monsoon precipitation changes.

Keywords: Moisture sources, Precipitation, Transient simulation, Asian monsoon, Orbital scale

【A0652】 -Poster

The latitudinal migration of intertropical convergence zone in response to precession across the Holocene

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The intertropical convergence zone (ITCZ) is where the most intense rainfall occurs over the globe, locating near the tropics, it dominates the hydroclimate of the tropics and regulates the global water cycle through its latitudinal position. The north-south shift of the ITCZ is primarily controlled by the cross-equatorial energy transport, where it migrates into the warmer hemisphere in order to transport energy into the cooler hemisphere, compensating for the surplus of energy that's been transported into the warmer hemisphere. During the Holocene (current interglacial, 11.7 kyr BP to present), the orbital precession is one of the main external drivers that regulate the migration of the ITCZ. The Northern Hemisphere summers have gradually cooled since the Holocene thermal maximum (~ 8 kyr BP) in response to orbital precession, while the Southern Hemisphere summers gradually warmed. However, it's still unclear how the interhemispheric energy contrast changed across the Holocene, and therefore how the annual ITCZ migrated due to the Holocene precession, together with its driving mechanisms and the timing of its shift, either global or regional. Here we investigate how the ITCZ migrates in response to orbital precession during the Holocene utilizing water isotope-enabled climate model iCESM1.2, combined with available rainfall signal proxy records. Applying three metrics measuring the ITCZ location, we show that the annual mean position of ITCZ has migrated southward from the early Holocene (~ 8kyr BP), with boreal summer and autumn contributing most to its migration. This is



largely following the declining trend of the boreal summer insolation, as the Northern Hemisphere cooled, more energy is transported from the Southern Hemisphere, thus migrating the ITCZ southward.

Keywords: ITCZ migration, The Holocene, Precession, Model simulation

【A0138】 -Poster

Tropical circulation shifts and regional climate impacts: Comparing mid-Piacenzian warmth and future warming (SSP245)

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Future changes in tropical atmospheric circulation, including the Hadley and Walker circulations, along with their regional impacts are critical scientific concerns. However, previous studies have mainly focused on future projections, with few systematic comparisons to circulation changes during past geological warm periods and limited examination of the regional climate responses to these shifts. This study compares changes in tropical atmospheric circulation between the late Pliocene (mid-Piacenzian warm period, MPWP) and the mid-21st century under a moderate emission scenario (SSP245), using three Earth system models of PlioMIP2 and ScenarioMIP, compared to the pre-industrial period. Results show similar responses in both periods: a poleward shift of the Hadley circulation in annual and boreal winter, a weakened Hadley circulation in the Northern Hemisphere throughout the year, and a weakened Walker circulation with its ascending branch shifting eastward, particularly evident in annual and boreal summer. However, the subtropical dry zones respond differently in the two periods. The subtropical dry zone of the Northern Hemisphere shrinks in the late Pliocene, while it expands in the mid-21st century, especially in North Africa. In both periods, changes in the Walker circulation leading to an eastward shift of the western Pacific precipitation belt, to lower precipitation over Indonesia and to increased precipitation in the central and eastern Pacific. The similar tropical circulation shifts, combined with the contrasting regional climate impacts of past warmth and future warming, provide valuable constraints for future climate projections.

Keywords: Hadley circulation, Walker circulation, Late Pliocene, AI index, Future projection



【A0266】 -Poster

Atmospheric and oceanic circulation altered by global mean sea-level rise

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In recent decades, the rate of global mean sea-level rise has accelerated, yet its magnitude—measured in tens of centimeters—remains relatively small from a geological perspective. This modest increase poses significant challenges in assessing its global climate impact, as the associated signal is often weak and hard to discern. However, in previous, warmer geological epochs, sea levels were substantially higher, reaching tens of metres above current levels. These paleoclimate periods provide a unique opportunity to explore the climatic effects associated with elevated sea levels.

Here, we use climate simulations of the last interglacial period alongside a series of present-day sea level sensitivity experiments to highlight the critical role of global mean sea level rise in influencing the global climate system. Our findings reveal that a spatially uniform rise in sea level not only lowers terrestrial elevations but also deepens oceanic bathymetry, leading to significant reorganizations in both atmospheric and oceanic circulation patterns. These results highlight the importance of considering sea level rise as a critical factor in understanding future climate scenarios. Furthermore, we demonstrated clear model spread when we repeat these experiments with different climate models, although a spatially uniform sea-level rise remains idealized and simplified.



Keywords: Sea-level rise, Modelling, Climate

【A0506】 -Poster

Contrast change of cyclogenesis in tropical and extratropical during the Eocene

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Modern tropical cyclones (TCs), which form in the tropics, feature deep warm-core symmetric structures. However, the characteristics of TCs in the early Eocene remain unclear. Here, we showed evidence from proxy data, climate modeling, and cyclone phase space that cyclones with deep warm-core symmetric structures appeared at high latitudes during the early Eocene. Under the favorable conditions of warm sea surface temperature and weak baroclinicity, most of these cyclones originated from the transition of extratropical cyclones. Meanwhile, in the tropics, the TCs were less frequent but more intense in the early Eocene than those in the modern era. Notably, only 36.91% of symmetric cyclones had a deep warm core, while 49.86% had a warm core at lower levels. These shallow-depth cyclones tended to induce more extreme rainfall than modern deep warm core TCs. The suppressed vertical development is largely explained by the weakened upper-level ascending motion and the enhanced vertical wind shear. Our findings shed new light on understanding the changes in TCs under high carbon dioxide levels and highlight the growing threat of extreme rainfall and winds associated with TCs at high latitudes.

Keywords: Tropical cyclone, Early Eocene

【A0904】 -Poster

Clearing clouds of uncertainty with the help of paleoclimate

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Cloud feedback has long been identified as the leading source of uncertainty in the



climate forcing-feedback framework, dominating the inter-model spread in how the global-average temperature responds to CO₂ doubling, the equilibrium climate sensitivity (ECS). The increase of cloud feedback in the most recent generation of models is also responsible for the higher ECS than the previous generation of models. In this study, I use the Community Earth System Model as an example to show how we can constrain the cloud parameterizations and feedbacks through simulation of past climate changes. Specifically, the paleoclimate simulations suggest that models with too strong or too weak cloud feedback may fail to simulate realistic ice age and/or hothouse climates in Earth's past. Further, I show that paleoclimate constraints can be used to identify the physical, numerical, and parametrical inconsistencies in the cloud and convection parameterizations. This study stresses the importance of paleoclimate constraints in the assessment of climate models and the improvement of understanding and modeling of climate dynamics under warming conditions.

Keywords: Climate modeling, Climate sensitivity, Paleoclimate constraints



Session 24. Pacific, Indian and Atlantic: Tropical climate mean-state and variability across time scales

Conveners: Isma Abdelkader Di Carlo, Pascale Braconnot, Josephine Brown, Chris Brierley, Matthieu Carré, Mary Elliot

【A0606】 -Poster

Holocene evolution of the tropical variability at interannual scale and the evolution of the mean climate in the Pacific Ocean

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The Holocene period, which began a little over 10,000 years ago, provides a long timescale perspective on the links between changes in the mean state, related to the climate's response to changes in insolation and greenhouse gases, in a context relatively close to the present. In particular, between the mid-Holocene, about 6,000 years ago, and the present, high latitudes are cooling while the tropics are warming. Paleoclimatic records from corals and bivalve shells indicate that tropical variability on interannual scales was reduced throughout most of the Holocene. There is some consensus among modeling studies that insolation changes dampened El Niño-Southern Oscillation (ENSO) in the early and mid-Holocene compared to today. Classic indicators of ENSO variability tell us that the variability trend is not linear on decadal to centennial time scales over the entire Holocene. Several mechanisms have been invoked in the literature to explain these changes; in particular analyses of climate simulations indicate that reduced ENSO variability during the mid-Holocene can be explained by a weakened thermocline feedback. In this study, we use transient simulations from Earth System Models to explore how changes may have occurred. We focus our work on Indo-Pacific teleconnections as well as comparison to proxy data.

Keywords: ENSO, Holocene, Earth System Models, Proxy data, Teleconnections



【A0785】 -Poster

The paleoceanography of the southwest subtropical Pacific during the past 1.2 myr

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This study presents new data on the variability of the vertical water gradient in the southwest Pacific Ocean region, in the southern Coral Sea, a region impacted by the southward flow of Tropical waters. In order to reconstruct changes in the water column structure during past Glacial-Interglacial terminations, we analysed multiple species of planktonic foraminifera with known ecological differences such as depth habitats and season of life. Our study uses sediment core MD06-3018 collected from 2470 m depth in the eastern side of New Caledonia Trough (NCT), during a Marion Dufresne cruise in 2006. Our strategy has been to analyse both Mg/Ca and $\delta^{18}\text{O}$ on multi-species of planktonic foraminiferal to reconstruct the vertical thermal-hydrological variabilities over specific intervals of the past million years. The age model of this sediment core is well constrained by tuning the $\delta^{18}\text{O}$ record of benthic foraminifera *Cibicides wuellerstorfi* to reference stratigraphic record. We analysed four different species of foraminifera: surface dwellers (*Globigerinoides ruber* s.s., with a depth habitat 0-50 meters water depth), mid-depth dwellers (*Pulleniatina obliquiloculata* at ~50-100 meters water depth and *Neogloboquadrina dutertrei* at ~75-125 meters water depth) and deeper thermocline dwellers (*Globorotalia truncatulinoides* at >300 m). We focus on specific Glacial-Interglacial transitions: Marine Isotope Stage (MIS) 2/1, MIS 6/5, and MIS 12/11. Our preliminary results reveal striking differences between the changes in subsurface water hydrology associated with each termination.

Keywords: Planktonic foraminifera, Vertical water gradient, The Southwest Pacific Ocean

【A0329】 -Oral

Reconstruction of the hydroclimate variability in the southern Andaman Sea over the last 110 ka



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The southern Andaman Sea, located near the equator within the Indo-Pacific Warm Pool (IPWP), offers an ideal location for studying past changes in convection over the IPWP and the influence of the Walker circulation. Currently, the Andaman Sea receives freshwater from both precipitation and runoff during the Indian Summer Monsoon (ISM) season, leading to significant seasonal variations in sea surface salinity (SSS) and oxygen isotope ratio ($\delta^{18}\text{O}_{\text{sw}}$). To reconstruct changes in sea-surface temperature (SST) and $\delta^{18}\text{O}_{\text{sw}}$ over the last climatic cycle (110 ka), we analyzed Mg/Ca ratios and $\delta^{18}\text{O}$ from the planktonic foraminifera *Globigerinoides ruber* ss in core BAR94-25.

Our data show that changes in $\delta^{18}\text{O}_{\text{sw}}$ (which we use as a proxy for SSS) are primarily driven by the precession cycle (23 ka), with an in-phase relationship with boreal autumn insolation. SSS is out of phase (lag ~ 4.5 ka) with the Chinese stalagmite $\delta^{18}\text{O}$ record, which is sensitive to the East Asian Summer Monsoon (EASM). To further explore the connection to the El Niño-Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD), we compared our $\delta^{18}\text{O}_{\text{sw}}$ record with a published ENSO index, and an IOD index that we reconstructed. Our findings reveal that decreases in $\delta^{18}\text{O}_{\text{sw}}$ —indicative of fresher sea surface waters—occur during periods dominated by La Niña-like and/or positive IOD-like conditions, coinciding with intervals of increased fall insolation and enhanced Walker convection. Conversely, significant increases in $\delta^{18}\text{O}_{\text{sw}}$ —corresponding to higher SSS—are observed during periods dominated by El Niño-like and negative IOD-like conditions.

Within the precession band, the in-phase relationship between our $\delta^{18}\text{O}_{\text{sw}}$ record, the ENSO index, and the IOD-like index suggests an interaction between the equatorial western Pacific and the eastern Indian Ocean mediated by the Walker circulation system. Atmospheric convection and ENSO-IOD dynamics appear to have played a crucial role in regulating rainfall in the Andaman Sea region. Other long records of the IOD are needed to better understand the interactions of the IOD with ENSO and the Asian monsoon system at the precessional orbital timescale.



Keywords: Paleoceanography, ENSO, IOD, Foraminifera, Salinity

【A0946】 -Oral

Reconstructing the eastern Indian Ocean hydrology from 1890 to 2011 using monthly resolution coral record from Timor Sea: Implicating Indonesian throughflow variability over the past century

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Earth's hydrological cycle is changing in response to the global warming, leading to a freshening of surface ocean waters in wet regions (tropics) and an increase in salinity in dry regions (subtropics). This salinity shift is most prominently observed in the eastern Indian Ocean, which is largely controlled by the strength of the Indonesian Throughflow (ITF). The re-analysis of instrumental data, along with coupled ocean-atmosphere model scenarios, provide an understanding of the ITF variability and its linkages with the inter-annual modes of climate variability such as the El Niño Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD). However, the lack of longer climatic records of ITF variability makes it challenging to isolate the anthropogenic signal from natural variability. Therefore, longer record of ITF variability are crucial for enhancing our understanding of ITF dynamics and for making confident prediction on its future behaviour in response to the human induced warming.

In this study, we present absolutely dated, seasonally resolved proxy records of sea surface salinity from the Timor Sea, using cores taken from long-lived corals (~240 years) on Ashmore-Hibernia reef. Herein we report the oxygen isotopic composition of seawater ($\delta^{18}\text{O}_{\text{sw}}$) reconstructed for the last 120 yrs (1890 -2011). The resulting monthly coral record exhibits a strong correlation with the sea surface salinity from ~1940 to 2011. The surface hydrology at the core site is majorly influenced by the regional precipitation and the advection. The observed lag between $\delta^{18}\text{O}_{\text{sw}}$ and the Australian monsoon, indicates a significant effect of ITF on the sea surface salinity. Furthermore, the $\delta^{18}\text{O}_{\text{sw}}$ signifying the surface hydrology co-occurs with the Nino



index, shows low rainfall and high salinity condition during El-Niño events and increased freshening during La Niña. The present study provides a long-term record of climatic variability at Timor Sea that aids in understanding the linkage between ENSO, IOD and ITF strength.

Keywords: Indonesian throughflow, Timor Sea, Coral $\delta^{18}\text{O}_{\text{sw}}$ record, Australian monsoon, ENSO & IOD

【A0575】 -Poster

Variable correlation between sea surface temperature in global ocean basins and the West African Monsoon during the last millennium

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SST variability in different global ocean basins, such as the Atlantic, the Pacific and the Indian Ocean, has been shown to strongly modulate the monsoon rainfall in West Africa on several different time scales, from interannual to multidecadal. However, while the relationship between the West African Monsoon and these SST variability patterns, such as the Atlantic Multidecadal Variability, the Atlantic Niño and the El Niño Southern Oscillation does not appear to be stationary and has been shown to change over the most recent decades, the low availability of long observational datasets and proxy coverage in the West African region limits our understanding of how these relationships vary on a longer, e.g., multidecadal or centennial, scale. In this study we use model output from a ‘last millennium’ simulation (850-1850 CE) produced with the fully coupled ocean-atmosphere-land model EC-Earth 3, which allows us to analyse spatial and temporal changes in the relationships. The results show a clear centennial variability in the correlations between the monsoon rainfall in West Africa and SSTs in the Atlantic and Pacific basins through the last millennium, ranging from strong correlations around $R=0.8$ to in some centuries to non-existent correlations at other times. While there could be several causes behind the varying relationships, preliminary analysis shows that at least some of the varying correlation is linked to changes in the spatial pattern of the SST indices, e.g., shifting from a hemispheric SST contrast in the Atlantic Ocean in periods of high correlations to a uniform signal across the Atlantic in periods of low correlation, which modifies how they impact the West African Monsoon and its regional rainfall.



Keywords: Monsoon, Last millennium, SST variability, West Africa

【A0244】 -Oral

Reconstructing rapid climate variability in the Indo-Pacific warm pool: Insights from *Tridacna* shell during the Holocene

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Current global warming introduces significant uncertainties in future predictions interannual climate variability such as the El Niño-Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD). These interannual phenomena strongly influence global climate patterns, regional weather systems, and ecosystems. Past and present interannual climate variability shows distinct patterns depending on the region and time period. Model and data provide evidences for changes in ENSO variability across the Holocene, with differences observed between the eastern and western Pacific Ocean (Carré et al., 2021). This study explores Holocene interannual climate variability using fossil archives from two study sites in the Indo-Pacific warm pool. Giant clams (*Tridacna* spp.) are aragonitic bivalves that inhabit shallow, warm waters of tropical regions. Previous studies have shown that *Tridacna* spp. provide unique records of interannual climate variability (Driscoll et al., 2014). Our study integrates geochemical and sclerochronological analyses in giant clams, achieving a new level of



precision that sets a novel standard for reconstructing past climate variability. We demonstrate that daily growth patterns in shells of *Tridacna* spp. reflect changes in both biological and environmental factors, providing high-resolution records of past climate variability. Trace elements (Mg/Ca, Sr/Ca and Ba/Ca) and stable isotopes ($\delta^{18}\text{O}$ and $\delta^{13}\text{C}$) in bivalve shells also provide insights into variations in sea surface temperature, salinity, precipitation and currents. The combination of both methods on the *Tridacna* shell provides a high-resolution multi-proxy approach at intra-seasonal to millennial time scales. Modern and fossil samples studied come from Belitung Island in the Kalimantan Strait, and the Huon Peninsula in northern Papua New Guinea. According to the instrumental data the two study sites exhibit a particular climatology, characterized by a clear seasonal signal and a semi-seasonal signal. These two signals can be attributed to the seasonal migration of the monsoon, which drives changes in surface conditions (SST, SSS, and productivity) by reversing and/or intensifying surface currents. A comparison of these two sites thus provides an overview of the semi-annual, seasonal and interannual variations in the warm pool. Calibrations for geochemical and sclerochronological analyses on modern shells correlate well with the instrumental data, validating the methods employed. The results show environmental modifications through changes in current strength and direction, SST and SSS due to ENSO and monsoon effects. Frequency analysis has revealed variations in the semi-seasonal signal recorded in the modern shell, directly linked to the El Niño phenomenon. This finding provides a deeper understanding of interannual variability and offers a robust tool for interpreting past climate dynamics with greater precision. Preliminary mid-Holocene results suggest temporal and spatial fluctuations, pointing to slightly different seasonal patterns. The study aims to reconstruct climate variability across several temporal scales using high-resolution data from *Tridacna* shells and compare these findings with model simulations. This approach enhances understanding of Holocene climate dynamics, shedding light on interactions between interannual and seasonal variability.

Keywords: ENSO, *Tridacna* Shell, Holocene, Geochemistry, Sclerochronology

【A0098】 -Poster

Glacial-deglacial bloom of giant diatoms in the tropical western Pacific through utilization of subsurface nutrients

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During the Pleistocene epoch, diatom mat blooming occurred in the global ocean for several times, particularly during several glacial periods (MIS 14, 12, 6, 4, 2). One intriguing phenomenon related to these blooming is the deposition of *Ethmodiscus rex* diatom mats in tropical-subtropical oligotrophic marine zones. However, the causal mechanism of this occurrence, known as the " *Ethmodiscus rex* problem " remains under debate and it is crucial to understand this mechanism. This study investigates the diatom mat core GT01, which was enriched in *E. rex* and retrieved from the Mariana Trench's Challenger Deep in the Western equatorial Pacific Ocean. We aim to determine the geological age of the diatom blooming event through AMS ¹⁴C dating and to explore the nitrogen source of the diatom bloom using $\delta^{13}\text{C}$, $\delta^{15}\text{N}_{\text{org}}$, and other proxies, and conduct a semi quantitative assessment of the sea surface productivity status during that period.

By comparing the nitrogen isotope signals and considering the isotopic fractionation effects of diatom biology and remineralization, it is suggested that the main source of nitrogen nutrients for *E. rex* diatom bursts is subsurface nitrate rather than the "new nitrogen". This viewpoint aligns with the findings of previous biological studies on *Ethmodiscus* species. Based on the nitrogen nutrient source, there is a further hypothesis that *E. rex* diatoms may also uptake nutrients such as phosphate concurrently with subsurface nitrate. The carbon isotope signal indicates a significant increase in marine primary productivity during the flourishing of *E. rex* diatoms. The extensive remineralization of organic matter during deposition, along with the substantial production of respired carbon, may have contributed to the reduction of atmospheric CO₂ concentration during glacial periods.

As primary producer in the ocean, diatoms are crucial in coupling nitrogen and carbon cycles in marine ecosystems. Investigating the nutrient sources and productivity of diatom mats is vital for gaining insights into the oceanic carbon and nitrogen cycles. These findings enhance our understanding of global biogeochemical cycles and their broader implications for past marine productivity and climate regulation.

Keywords: Subsurface nutrients, Western Pacific, Nitrogen isotope, Diatom blooming

【A0225】 -Oral

Indo-Pacific climate variability modulates subsurface temperature



variability recorded in Andaman Sea corals during the last centuries

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The Indo-Pacific region is surrounded by highly populated areas that are susceptible to climate extremes, like floods, droughts, and heatwaves. Timing and severity of these extremes are influenced by the Asian monsoon, Indian Ocean Dipole (IOD), El Niño-Southern Oscillation (ENSO), and Indo-Pacific inter-basin interactions. Sea surface temperature (SST) is one of the main drivers of basin-wide climate extremes and therefore an essential metric to understand. Historical SST products suffer from sparse coverage and high uncertainty before the 1960s. Improvements on these products from satellite measurements are available since the 1980s but are limited to the upper few mm of the water column. Consequently, assessments of subsurface temperature variability on interannual to multidecadal timescales under past and present climate change remain difficult. The carbonate skeletons of massive shallow-water corals provide continuous records of subsurface temperature that complement SST observations and provide insights into ocean-atmosphere dynamics of the shallow ocean.

Here we present monthly-resolved records of the Sr/Ca-temperature proxy from *Porites* corals of the southern Andaman Sea (Ko Racha Yai, Thailand, ~7.6°N), northeastern Indian Ocean. Coral Sr/Ca tracks the variability and annual cycle of high-resolution (~5 km x 5 km) satellite SST fairly well during the calibration period, including a double-peak in spring and fall SST resulting from regular monsoonal forcing. In some years, coral Sr/Ca indicates prominent events of exaggerated cooling in late fall and winter that are not apparent in the satellite SST. These events coincide with years of combined positive IOD (pIOD) and El Niño events (1994-95, 1997-98, 2006-07), as well as one La Niña event (1999-00). These Sr/Ca-based cooling events are evident in cores of single and of different *Porites* corals, highlighting intra- and inter-colony reproducibility. These anomalous events across multiple temperature proxy records, capture a distinct IOD signal in an area which based on historical and satellite SST products is normally considered too far north of the eastern node of the IOD to be impacted.



The prominent cooling events in coral Sr/Ca, relative to satellite SST, can be best explained by subsurface exposure to large-amplitude internal waves (LAIW). In the Andaman Sea, LAIW transports colder subthermocline water up to the depth where corals grow (5-10 m), but rarely to the sea surface where satellite SST is monitored. We show that the reef cooling by LAIW varies on interannual to decadal timescales, likely due to thermocline variations caused by the IOD, ENSO, and Asian monsoon. Combined pIOD and El Niño events along with a weaker Asian Summer Monsoon may cause stronger upwelling Kelvin waves from the equatorial eastern Indian Ocean, resulting in a shallower thermocline and thus stronger LAIW-cooling of the Andaman Sea coral reefs. We will present a monthly coral Sr/Ca reconstruction of northeastern Indian Ocean shallow subsurface temperature back into the pre-instrumental era, to investigate these mechanisms on decadal to multidecadal timescales. Our results will provide unique insights into ocean-atmosphere interactions of northeastern Indian Ocean subsurface temperature and Indo-Pacific climate variability over the last centuries.

Keywords: Indo-Pacific climate, Andaman Sea, Subsurface temperature variability, Coral Sr/Ca

【A0290】 -Poster

Strong ENSO-mean state relationship in the Eastern Pacific during MIS5e not sustained in glacial times

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The amplitude and frequency of El Niño-Southern Oscillation (ENSO) are expected to



change in the future along with tropical Pacific Ocean circulation. However, the relationship between ENSO and the Pacific mean state is still unclear due to the shortness of instrumental observations. Here we present a paleoclimate record from Peru, the most El Niño-impacted country in the world, that quantifies ENSO variability changes over a broad range of mean temperature changes from glacial condition to the last interglacial warmth. Using ultra-high-resolution X-Ray fluorescence (XRF) analyses, we resolve the seasonal cycle of fluvial sediment discharge and estimate ENSO-related interannual climate variability in 13 finely laminated marine sedimentary segments totalizing 2880 years, and providing a record of unprecedented robustness. During the last interglacial, changes in ENSO amplitude and frequency are found strongly and positively correlated with mean sea surface temperature changes in the Peruvian upwelling, linked to the mean Walker circulation strength. In glacial conditions, however, despite a significant ENSO activity, variations seem disconnected from mean climate rapid shifts. These observations, while supporting the ENSO-mean state relationship predicted by climate models, highlight its non-stationarity and thus its potential evolution with increasing greenhouse gas forcing.

Keywords: ENSO, Peru, Laminated sediments, Interglacial

【A0403】 -Poster

The change in ENSO response outside the pacific cold tongue during the 4.2ka event: Insights from coral records

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The nature of how the El Niño-Southern Oscillation (ENSO) impact global climate is critical knowledge to predict future climates under the expected scenario of extreme climate variability. An abrupt cooling event that occurred between 4500 to 3900a BP, known as the 4.2ka event, has long been believed to be linked to intensified ENSO variability. However, records from the Asian monsoon and the Pacific Cold Tongue suggest opposing ENSO behaviors during this period, with enhanced variability in the monsoon region and weakened variability in the Pacific Cold Tongue. Massive reef-building corals from tropical oceans provide a unique opportunity to quantitatively



characterize ENSO variability and its impact, as they allow for monthly to sub-monthly SST reconstructions over decades to centuries. The Pacific cold tongue, where ENSO events primarily occur, allows coral to directly record ENSO activity, providing reliable evidence. Outside this region, coral records of ENSO rely on atmospheric teleconnections, making them indirect. This study hypothesizes that coral responses to ENSO outside the cold tongue can serve as a test to determine whether ENSO teleconnections influence global climate. We present new monthly-resolved coral records from the South China Sea (SCS) spanning 104 years (4400-4300 years BP) and 41 years (4050-4010 years BP) during the 4.2 ka event. Comparing our SCS coral records with previously published records from both inside and outside the Pacific Cold Tongue, we find no consistent ENSO response across regions. This suggests that the impact of ENSO during the 4.2 ka event was limited, and that the weakened Asian monsoon may not have been driven by intensified ENSO activity. Our results challenge the traditional view that ENSO was the primary mechanism behind the 4.2 ka climatic event.

Keywords: ENSO, Coral, 4.2ka event

【A0227】 -Poster

30-years of palaeoenvironmental variation at the end of the Little Ice Age reconstructed from a giant clam shell from the northern Great Barrier Reef

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The end of the Little Ice Age (LIA) is regarded as the last significant cold period before



the onset of the global warming trend since the Industrial Revolution. We use the shell of a 30-year lifespan giant clam (*Tridacna gigas*) that lived around 1800 CE to reconstruct environmental conditions on the northern Great Barrier Reef, southwest Pacific, prior to global warming. Stable isotope ($\delta^{18}\text{O}$, $\delta^{13}\text{C}$) and trace element proxies (Sr/Ca, Mg/Ca) from both the inner and outer shell layers are used to estimate sea-surface temperature (SST), rainfall variability, and ENSO events.

We compared isotope ($\delta^{18}\text{O}$, $\delta^{13}\text{C}$) and trace element proxies (Sr/Ca, Mg/Ca) from both the inner and outer shell layers to show that the $\delta^{18}\text{O}$ values of the inner shell layer have a consistent negative offset of 0.21 ‰ from the outer shell layer. The removal of this offset enables us to better utilise both layers of the shell to reconstruct longer and more reliable records. We used the combined $\delta^{18}\text{O}_{\text{Shell}}$ data to reconstruct palaeo-SSTs around the early 19th century, showing SST variation between 22.9 to 29.0°C (mean = 25.5°C). The mean SST in summer (December to February) was 26.8 °C, whilst the mean SST in winter (June to August) was 23.4°C. We found a good correlation between outer shell $\delta^{13}\text{C}_{\text{Shell}}$ and local precipitation and used this to reconstruct the ENSO variability. Trace element proxies are too ambiguous to independently provide precise quantitative palaeoenvironmental reconstructions. Both Sr/Ca and Mg/Ca from the inner shell show an increasing trend with shell age. The Mg/Ca of the outer shell shows great potential as a palaeothermometry proxy, however, more calibration is needed for future studies.

The reconstructed environment indicates that cooling at the end of LIA also extended to the Southern Hemisphere, at least in the Southwest Pacific. The average SST at the end of the LIA was approximately 1.2°C lower than the present-day and this cooling was more significant in summer than in winter. Additionally, the northern GBR had a more distinct wet/dry seasonality during this period. Monthly shell-reconstructed SST and precipitation also opened a window into past ENSO variability.

After comparing the other palaeoenvironmental reconstruction records from both the western and eastern Pacific coasts, and higher latitudes in the Southern Hemisphere, we suggest that in the early 19th century, La Niña events prevailed. This trend led to decreased SSTs and wetter environmental conditions in the Southern Hemisphere. The records provide a better understanding of ENSO or climatic variation at the end of LIA and before modern global warming. However, comparisons with regional reconstructed environmental records shows spatial heterogeneity and also archive heterogeneity, therefore, we recommend more detailed local sub-annual palaeoenvironmental reconstructions from various regions and archives in the near



future.

Keywords: *Tridacna*, Sclerochronology, Geochemistry, ENSO

【A0787】 -Poster

Calibration study of giant clam *Tridacna squamosa* Island of Belitung, Indonesia

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Fossil shells of marine bivalves such as giant *Tridacna* provide unique information on past environments with seasonal to daily resolutions. Changes in mean seasonal cycles and inter-annual variability can be reconstructed by sequentially analyzing the composition of the annual layers of calcium carbonate. In this study, we have conducted a new calibration study of modern *Tridacna squamosa* which have been collected in Belitung Island, Indonesia, during different year (2016, 2017 and 2019). At this locality, the seasonal cycle is characterized by a double seasonal peak in sea surface temperature due to the inversion of surface currents associated with the SE and NW monsoons. We analyzed both the stable isotope ($\delta^{18}\text{O}$) and trace element profiles (Mg/Ca, Ba/Ca). The aim of this study was to demonstrate the reproducibility of the trace elements between samples collected on different dates in the same site. The lifespan of the specimen collected were 2 to 5 years long and geochemical profiles showed significant overlap between modern dead collected specimen. The results show that Ba/Ca records are highly reproducible between samples exhibiting a single seasonal peak during the period May-June. Mg/Ca show a good reproducibility between samples exhibiting a double seasonal peak. We compared our records to local hydrology: sea surface temperature, rainfall and productivity. Mg/Ca shows a clear



relationship with SST. Ba/Ca has previously been shown to reflect both productivity and/or riverine sources of Barium. At Belitung site there are 2 seasonal increases in productivity, and the shell Ba/Ca only increases during the may-june period highlighting a more complex relationship than previously observed.

Keywords: Seasonal climate variability, Interannual climate variability, Calibration, *Tridacna*

【A0559】 -Poster

Late Miocene biogenic bloom in the western Pacific

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Biogenic components of sediment accumulated at high rates beneath the Indian, Pacific, and Atlantic oceans during the late Miocene and early Pliocene, but the origin of these changes remains controversial. Since the eastern Pacific is the more well-studied area for biogenic bloom, we focused on filling the relevant records in the western Pacific to elucidate the sedimentary process within the Pacific and figure out the underlying mechanism for late Miocene biogenic bloom. We reconstruct the opal/TiO₂, opal/BaSO₄, BaSO₄/TiO₂, Al₂O₃/TiO₂, CaCO₃/TiO₂, and biogenic mass accumulation rates (MAR) at ODP Site 807 in the western Pacific to indicate late Miocene biogenic bloom. Our results suggest that the timing of biogenic bloom in the western Pacific is about 1.5 Ma earlier than in the eastern Pacific. Steeper thermocline tilt in the Pacific from 5 Ma to 4 Ma may lead to increased discrepancy in CaCO₃ MAR in the eastern and western Pacific. The decline of CaCO₃ MAR at Site 807 around 6 Ma presumably be caused by the dissolution of carbonate driven by the weakened formation of the North Atlantic Deep Water.

Keywords: Biogenic bloom, Late Miocene, Western Pacific

【A0661】 -Poster

Hydroclimate variability and Indonesian throughflow intensity in the Makassar Strait during the last deglaciation

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The evolution of the complex tropical hydroclimate and its link to Indonesian Throughflow (ITF) intensity during the last glacial/interglacial termination remains a subject of ongoing debate. Using core TR1926B (117°47.4360'E, and 616 m water depth), we investigated last deglaciation changes of tropical precipitation and ITF strength in the Makassar strait, the main pathway of ITF. Our study is based on X-ray Fluorescence (XRF) core scanning data, Mg/Ca-based temperatures from surface dweller *Globigerinoides ruber*, and assemblages of mixed layer /thermocline dweller species. The proxies of current strength (grain size and log (Zr/Rb)) derived from XRF core scanning record both ITF intensity from the Makassar Strait and river runoff from Borneo/Kalimantan. Our results show that the last deglaciation is characterized by a > 3°C raise in sea surface temperature (SST), and a decrease in terrigenous supply suggesting dryer conditions in the Borneo region. During Heinrich Stadial 1 (HS1), the increased ratio of thermocline foraminifera to mixed-layer foraminifera dwellers suggests a reduced flow of warm, fresh thermocline water from the North Pacific into the Makassar Strait. We propose that the weakening of the ITF resulted from a shift in the transport of North Pacific tropical water, which was redirected eastward into the Pacific North Equatorial Countercurrent (NECC) due to an intensification of the Mindanao Current. Additionally, a southward displacement of the Inter-Tropical Convergence Zone (ITCZ) likely led to reduced precipitation in the ITF region during HS1.

Keywords: El Niño-like, Dry climate, Weakened ITF, Shoaling thermocline, Heinrich Stadial 1

【A0169】 -Oral

Glacial hydroclimate over the tropical West Pacific: Inferences from vegetation landscape and modelling studies

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The dynamics of the West Pacific Warm Pool and the associated atmospheric



circulation characterize the low-latitude hydrological cycle over a range of time scales. Among a number of key questions regarding the evolution of this ocean-atmosphere interaction system, the intensity and position of the ascending branch of the Walker circulation during glacial periods has long been debated. We address this issue by comparing a couple of vegetation reconstructions with climate simulations from the Community Earth System Model 2 (CESM2). A compilation of vegetation reconstructions from Southeast Asia, including our new *n*-alkane $\delta^{13}\text{C}$ and pollen records from the South China Sea, shows a glacial contraction of lowland rainforests in longitudinal extent compared to the Holocene, especially in the southern region of Sundaland. Furthermore, the previously proposed “savannah corridor” most likely existed in the interior of Sundaland during the Last Glacial Maximum (LGM), extending from the Malay Peninsula to the Lesser Sunda Islands.

Modelling studies suggest that changes in the seasonality of precipitation, rather than mean annual rainfall, can largely account for glacial-interglacial changes in vegetation composition. During the boreal winter, the glacial emergence of Sundaland shifted the ascending branch of the Walker Circulation eastward and reduced the general atmospheric convective activity over Southeast Asia relative to the Holocene. The terrestrial cooling of glacial Sundaland also drove divergent winds from land to sea and caused the subsidence of air masses, leading to a reversal of the atmospheric circulation and a dissolution of the Intertropical Convergence Zone (ITCZ) over Sundaland. Accordingly, the prevalence of descending air motion gave rise to generally drier conditions, especially along the western region of Sundaland.

During the glacial austral winter, an eastward shift of deep atmospheric convection and an overall reduction of convective activity over Sundaland was also observed compared to the Holocene. In particular, the reduced convective intensity caused a northward contraction of the ITCZ over southern Sundaland, resulting in a severe reduction in precipitation. Taken together, the dry season of both hemispheres became drier during the LGM. The enhanced water stress was favorable for the spread of grasses and thus for the establishment of open environments.

Keywords: Walker Circulation, Warm Pool convection, Precipitation seasonality, Grassland expansion

【A0934】-Poster

Gradually warming western Pacific warm pool during late mid-Pleistocene Transition and its relationship with the weakening of



Indonesian throughflow

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Explaining the Mid-Pleistocene Transition (MPT) is still challenging. The 900 ka is an important time and a turning point during the MPT. However, from this point to the complete of the late MPT (~0.9-0.6 Ma), the role of tropical Pacific was less discussed. We provide a ~1.4-Ma Mg/Ca and $\delta^{18}\text{O}$ measurements in planktonic foraminifera *Trilobatus sacculifer* records from Site U1490 to reconstruct the new SST and $\delta^{18}\text{O}_{\text{sw}}$ record near the center of the west Pacific warm pool (WPWP). There is a gradually warming and slightly freshening surface water in western tropical Pacific between ~0.9 Ma and 0.6 Ma. By comparing with published records from the eastern Indian Ocean, we suggested that this gradually warming and slightly freshening conditions (~0.9-0.6 Ma) in the WPWP might be due to the synchronously weakened Indonesian Throughflow and related pile-up of ocean heat in the WPWP, which might be caused by significantly lowering sea level, global icesheet expansion and/or enhanced Australian monsoon. Then the gradually warming signal might be propagated eastward as the enhanced North Equatorial Countercurrent.

Keywords: West Pacific Warm Pool, Sea surface temperature, Mid-Pleistocene Transition, Indonesian Through flow, North Equatorial Countercurrent

【A0250】-Poster

Simulated tropical Atlantic-Pacific climate variability changes under Holocene and last interglacial boundary conditions

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It is still uncertain how the tropics will evolve under anthropogenic climate change. In order to better understand tropical Atlantic and Pacific dynamics, their teleconnections to the Caribbean basin and the link of seasonality and interannual variability under different background climate conditions, we combine an isotope-enabled climate model with proxy records of temperature and hydrology from tropical fossil corals. Motivated by the past warm climate time-windows covered by the coral records, we conducted time-slice simulations for the Pre-Industrial (PI) period, the Mid-Holocene (6 ka) and the Last Interglacial (124 ka) using the water and carbon isotope-enabled Community Earth System Model (iCESM) at a nominal horizontal resolution of 1° in the atmosphere, land, ocean and sea-ice components. Coral records from Bonaire Island in the southern Caribbean representing time-windows during the Mid-Holocene and the Last Interglacial are used for model-data comparison.

In response to the changes in orbital and greenhouse gas boundary conditions, both 6 ka and 124 ka simulations show distinct climate anomalies such as increased sea surface temperature (SST) seasonality in the Southern Caribbean, which is consistent with the coral records. Furthermore, in boreal summer over the tropical Atlantic, both simulations indicate a northward shift of the Intertropical Convergence Zone. The tropical eastern Pacific exhibits La Niña-like conditions in SST with a cooling by 0.4°C and 0.5°C during boreal winter for 6 ka and 124 ka, respectively, which is also evident from an increased zonal sea level pressure gradient as compared to PI. Additionally, both of our simulations reveal a statistically significant reduction in the interannual variability of SST in the Central Pacific and a significant increase in the Eastern Pacific, with 124 ka showing larger amplitudes of the anomalies by up to 20% relative to PI. In terms of the interaction between seasonality and interannual variability, previous work pointed to a link between Pacific SST interannual variability and Southern Caribbean SST seasonality under modern climate conditions. Whether this link also holds for past warm climate states will be discussed based on our simulations and available coral records from the Atlantic and Pacific. This will provide deeper insights into Atlantic-Pacific teleconnections under future climate warming.

Keywords: Climate variability, Tropical Atlantic-Pacific teleconnections, Model-data comparison, Holocene, Last interglacial

【A0391】 -Poster

Extreme positive IOD events trigger widespread warming of the Indian Ocean in the following year during the last millennium



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The warming of the Indian Ocean is typically associated with El Niño events, and isolated Indian Ocean Dipole (IOD) events alone are generally insufficient to cause significant warming. However, the warming observed in the Indian Ocean sea surface temperatures (SST) in 2020 may have been driven by an extreme positive IOD (pIOD) event that occurred in 2019. Due to the limitations of observational data length, whether such events are rare or coincidental remains a matter of debate. In this study, we utilized two different assimilation datasets (Last Millennium Reanalysis and Paleo Hydrodynamics Data Assimilation) along with Last Millennium Ensemble data to identify isolated extreme IOD events over the past millennium. We then examined the changes in Indian Ocean SST before and after these events using Superposed Epoch Analysis. Sensitivity experiments were conducted to explore the mechanisms by which extreme pIOD events influence Indian Ocean SST variability. The results indicate that, after excluding the effects of El Niño, isolated extreme pIOD events during the past millennium led to significant warming of the Indian Ocean SST in the following year. The underlying mechanism is likely due to the increase in temperature of the Indian Ocean thermocline, which then propagates to a widespread SST increase across the entire Indian Ocean. In the context of ongoing global warming, the potential increase in extreme pIOD events could lead to further SST warming in the Indian Ocean, which may trigger more pronounced climate changes, warranting careful attention.

Keywords: Indian Ocean Dipole, Last millennium, Warming of the Indian Ocean

【A0644】 -Poster

Reconstructing the Pacific decadal oscillation over the last 2000 years by fusing global terrestrial and marine records

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The Pacific Decadal Oscillation (PDO) has a significant impact on global climate.



However, previous reconstructions of the PDO have lacked consensus due to differences in regions and types of paleoclimate proxies used. In this study, we combined advantages of different proxies using the nested principal component regression method, synthesizing global well-dated high-resolution terrestrial tree ring $\delta^{18}\text{O}$, speleothem $\delta^{18}\text{O}$, and marine coral $\delta^{18}\text{O}$ records to reconstruct the PDO from 383 to 2000 CE. The reconstructed PDO shows persistent decadal changes and the PDO variability has increased since the Industrial Revolution, possibly related to more frequent shifts in PDO phases. Over the past millennium, PDO can modulate the El Niño-Southern Oscillation (ENSO), with more frequent El Niño (La Niña) events during positive (negative) PDO phases. Additionally, superposed epoch analysis did not find clear evidence of volcanic eruption events affecting PDO phases. Our new reconstruction of the PDO provides an extension of instrumental records and benefit the research on the mechanisms of decadal climate variability.

Keywords: Pacific Decadal Oscillation, Reconstructing, The last 2000 years

【A0209】 -Oral

Tracing the stepwise warming trend in the tropical Indian Ocean through a 40-year record of oxygen isotope composition in Maldives corals

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Sea surface temperature (SST) across the tropical Indian Ocean is warming at a significantly higher rate than other tropical oceans over the past two decades. However, the cause of the abnormal warming remains unclear due to the short duration of instrumental observations as well as sparse long-term paleoclimate proxy records (e.g., from corals) within this region. Before coral-based records can be compiled to infer long-term environmental change in the region, an assessment of the suitability and robustness of the various coral archive types for evaluating warming must be made. Here, we present a 40-year coral stable oxygen isotopic ratio ($\delta^{18}\text{O}$)



record derived from both dome-shaped (i.e., massive) and microatoll corals (*Porites* sp.) from the southern Maldives, located in the equatorial Indian Ocean. We found a consistent $\delta^{18}\text{O}$ reproducibility in both dome-shaped and microatoll corals, demonstrating the viability of utilising a range of coral morphotypes for reconstructing longterm ocean conditions and climate change. Statistical analysis indicates that our coral $\delta^{18}\text{O}$ values are primarily influenced by SST rather than sea surface salinity (SSS). Notably, the $\delta^{18}\text{O}$ record exhibits a stepwise shift, with average $\delta^{18}\text{O}$ values of -4.93‰ and -5.01‰ for the periods 1978–1999 and 2000–2019, respectively. This shift in $\delta^{18}\text{O}$ corresponds with the increase in regional SST, despite its relatively small magnitude of approximately 0.3°C . Furthermore, the negative shift in $\delta^{18}\text{O}$ values after 2000 coincides with the transition to La Niña-like conditions and the negative Interdecadal Pacific Oscillation (IPO) phase in the tropical Pacific Ocean. Under these conditions, the geostrophic transport of the Indonesian Throughflow (ITF) was enhanced, which likely contributed to warming in the tropical Indian Ocean by bringing in more warm water from the Pacific. Therefore, the consistent shifts between our Maldives coral $\delta^{18}\text{O}$ anomalies and instrumental SST anomalies support the argument that an intensified ITF may have contributed to the abnormal warming in the tropical Indian Ocean over the past two decades. Our findings suggest that microatoll corals in well-flushed open ocean environments can provide robust climatic proxy data comparable to dome-shaped corals. By compiling these records, we show the primary impact of SST on coral $\delta^{18}\text{O}$ values in the tropical Indian Ocean, evidenced by a notable shift closely aligned with regional SST fluctuations around 2000.

Keywords: Tropical Indian Ocean warming, Coral $\delta^{18}\text{O}$ records, Sea surface temperature (SST), Indonesian Throughflow (ITF), Paleoclimate proxies

【A0375】 -Oral

Enhanced frequency of multi-year El Niño-Southern Oscillation across the Holocene

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The El Niño-Southern Oscillation (ENSO) events that persist and develop for a second year or beyond (multi-year) are relatively rare. Compared to single-year events they create cumulative impacts and are linked to extended periods of extreme weather events worldwide. Here we combine central Pacific fossil coral oxygen isotope reconstructions with a multi-model ensemble of transient Holocene global climate simulations to investigate the evolution of multi-year ENSO during the Holocene (beginning ~11,700 years ago), when the global climate was relatively stable and mainly driven by seasonal insolation. We find that the ratio of multi-year to single-year ENSO events increased by a factor of 5, associated with a longer ENSO period (from 3.5 to 4.1 years) over the past ~7,000 years in proxies. This change is verified qualitatively by a subset of model simulations with a more realistic representation of ENSO periodicity. More frequent multi-year ENSO and prolonged ENSO period are caused by a shallower thermocline and stronger upper ocean stratification in the tropical eastern Pacific towards the present day. The sensitivity of ENSO duration to orbital forcing provides a warning signal highlighting the urgency of minimising anthropogenic influence which could accelerate the long-term trend towards more persistent ENSO damages.

Keywords: El Nino Southern Oscillation, Transient simulation, The Holocene, Proxy reconstruction

【A0614】 -Oral

Nonlinear sensitivity of ENSO across climate states

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Understanding the sensitivity of El Niño Southern Oscillation (ENSO) across climate states is of societal and ecosystem importance given the unabated global warming. Paleoclimate archives and climate models suggest that ENSO activity depends on mean state conditions. However, due to climate model biases, short observational record and proxy-data uncertainties, evaluating ENSO sensitivity remains challenging. Here we combine 174 state-of-the-art model simulations of past climates and future warming to evaluate ENSO activity throughout a wide range of climate states. We find that the sensitivity of ENSO to the background climate is nonlinear and tied to the climatological position of the tropical Pacific convection centers, namely the Intertropical and South Pacific Convergence Zones. Simulations with atmospheric CO₂ lower than today display a poleward shift of the convection centers and weakened ENSO. Moderate equatorward shifts of the convection centers occur under CO₂-induced warming increasing ENSO activity, while strong equatorward shifts reduce ENSO variability in extreme CO₂ warming scenarios, resulting in a permanent El Niño-like mean state. Furthermore, we find that Eastern Pacific El Niños are more sensitive to the background state than Central El Niño events. Our results provide a comprehensive mechanism of how tropical Pacific mean state modulates ENSO activity.

Keywords: El Niño Southern Oscillation, PMIP4, CMIP6, Intertropical Convergence Zone

【A0436】 -Poster

Transitional evolution of the orbital-cycles in upper-water thermal structure of the western equatorial Pacific since the Pliocene

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Since the Pliocene Warmth, the global climate has progressively cooled, the ice sheets in the Northern Hemisphere have expanded, and the driving effect of orbital cycles on Earth's climate change has been strengthened stage by stage. The intensified transport of heat and water vapor from low-latitude ocean to high-latitude serves as a key



mechanism of climate evolution since the Pliocene, yet the relevant research remains insufficiently explored. Here we analyze the orbital-scale characteristics of the regional upper hydrothermal structure variation since ~4 Ma by the millennial-resolved $\delta^{18}\text{O}$ records of surface-dwelling and subsurface dwelling planktonic foraminifera from IODP Site U1489 drilled in the center of WPWP. The results show that: ~4.0-3.1 Ma, $\delta^{18}\text{O}$ amplitudes exhibit minimal variation, ~3.1-1.5 Ma transitioning to dominance by 41 ka periodicity, and then increasing ~1.5 Ma. Notably, *Globigerinoides ruber* $\delta^{18}\text{O}$ display a predominant cycle of approximately 100 ka since ~0.9 Ma, while those in *Pulleniatina obliquiloculata* indicate a stronger 23 ka signal that gradually intensifies between ~3.1-1.5 Ma and remains significant thereafter since ~1.5 Ma. These results suggest that following the Pliocene warmth, seasonal variations in low-latitude insolation—governed by precession—and meridional radiation gradients controlled by obliquity significantly influence upper-water hydrothermal structures within the Western Pacific Warm Pool. Furthermore, characteristic transformation of orbital cycles identified around ~3.1 Ma and ~1.5 Ma precede both NHG and MPT respectively indicating a close relationship between alterations in upper warm pool hydrothermal structure and shifts occurring at high latitudes alongside global climatic changes.

Keywords: West Pacific Warm Pool, Upper-water, Orbital cycles, Plio-Pleistocene

【A0601】 -Poster

Impact of summer-persistent ENSO events on the global climate and the occurrence of extreme weather events

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The El Niño Southern Oscillation (ENSO), a leading driver of climate variability in the tropical Pacific Ocean, exerts considerable influence on global weather systems and ecosystems, affecting communities across the world. This study examines the underexplored phenomenon of summer-persistent ENSO events, exploring their worldwide climatic effects and their contribution to the occurrence of extreme weather events.



ENSO events are typically associated with a distinct cycle, with El Niño phases following this pattern more closely. In contrast, some La Niña events may fall below the ENSO threshold during the summer and then regain strength in the following winter, leading to multi-year La Niña events. However, there have been cases where ENSO events exhibit prolonged decay, with sea surface temperature (SST) anomalies remaining above the ENSO threshold well into the northern hemisphere summer. A notable example is the 2018/19 El Niño, which persisted until July and was associated with major events such as the 2020 Australian bushfires and the record-breaking North Pacific heatwave in 2019. This El Niño was succeeded by a triple-dip La Niña linked to severe weather impacts across Africa, Australia, and the United States. These examples underscore the critical need to study summer-persistent ENSO events and their global impacts.

This study is structured around three primary objectives: identifying past summer-persistent ENSO events, analysing their effects on global temperature and precipitation patterns, and investigating their association with extreme weather events. Using the Oceanic Niño Index derived from the Extended Reconstructed Sea Surface Temperature dataset (ERSSTv.5), we classified ENSO events into conventional and summer-persistent ENSO events. The latter was defined by cases where the Oceanic Niño Index remained above the ENSO threshold through June of the decaying year. A total of 18 summer-persistent ENSO events were identified since 1895, divided into six summer-persistent El Niño and twelve summer-persistent La Niñas. To evaluate the climatic impacts, we utilised NOAA-CIRES-DOE 20th Century Reanalysis (NCEP 20CR) composites of 2-meter temperature and precipitation, comparing these ENSO types across both winter and summer seasons. The robustness of the composite analysis was assessed using AMIP ensemble simulations with dynamic atmospheric and vegetation components of EC-Earth Earth system model. This study enhances our understanding of summer-persistent ENSO events and their global climate effects, providing critical insights for mitigating their impacts on climate variability and extreme weather events.

Keywords: El Niño Southern Oscillation (ENSO), Climate variability, ENSO variability, Extreme weather

【A0821】 -Poster

Impact of relationship between El Niño Southern Oscillation and sea surface temperature interannual variability modes in the subtropical Atlantic Ocean and Indian Ocean on monsoon precipitation in Southern



Africa

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The rainy season in most southern Africa (SAF; African landmass south of 10°S) is monsoon-like regime occurring between October and March months with a peak during December-February (DJF), in which more than 50 % of total annual rainfall tend to occur. This rainfall is associated with monsoon characteristic circulation (Angola Low at low-level and Botswana High at upper-level). Since the climatological conditions can be affected by occurrence of climate variability modes (e.g., ENSO), this study sought to examine how selected SST interannual modes (South Atlantic Subtropical dipole - SASD and Subtropical Indian Ocean dipole - SIOD) affect ENSO related impacts during DJF when both ENSO and rainfall in SAF are in their mature phases. Analysis of the impacts of individual occurrence of the modes confirms the well-known ENSO related rainfall pattern, with positive (negative) anomalies during El Niño (La Niña). While La Niña (LN) related circulation anomalies appear to be remotely forced, those related with El Niño (EN) seem to be linked with existing teleconnections between South America (SA) and SAF. SASD is associated with tripole-like precipitation pattern, with positive (negative) in the center of the pattern during its positive (negative) phases. However, the strongest and significant anomalies are observed over South Africa. The anomalies are associated with tropic-tropics and subtropical interactions between SA and SAF. The SIOD impact on rainfall in SAF is very weak and non-significant, with exception of parts of Mozambique and Madagascar where relatively strong and significant anomalies are noticeable, associated mainly with tropic-tropics teleconnections between SA and SAF although weak subtropical interactions are also noticeable. When the ENSO and SASD are out of phase, the SASD tends to complement the ENSO-related impacts over SAF by weakening the regional equivalent barotropic Rossby wave, anomalous mid-tropospheric vertical motions and anomalous precipitation, likely favored by Atlantic Multidecadal Oscillation (AMO) background. The opposite is true. Different to previous studies, we found that when the SIOD and ENSO are out of phase, the SIOD tends to disrupt the ENSO-related atmospheric response over SAF by weakening the regional equivalent barotropic Rossby wave, anomalous vertical motions and anomalous precipitation. The opposite is true. Understanding such teleconnection holds promise for improving subseasonal to



seasonal predictions of monsoon precipitation in SAF, a region highly vulnerable to weather and climate related extreme events.

Keywords: Southern Africa, Monsoon precipitation, ENSO, SASD, SIOD, Interaction of climate modes, Teleconnections,

【A0407】 -Poster

Decadal sea surface temperature changes in the tropical Indian Ocean

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Over the past five decades, sea surface temperature (SST) has increased significantly faster in the tropical Indian Ocean than in the tropical Pacific and Atlantic Oceans. However, it remains uncertain to what extent this anomalous warming results from human-induced global warming or natural internal variability in the climate system. Because instrumental data are mostly too short in the region, highly-resolved and longer proxy records are required to delineate the contributions of anthropogenic climate change from natural variability. We obtained coral cores from massive *Porites* sp. and slabs from microatoll corals from the southern Maldives, to study 20th century SST changes in the central tropical Indian Ocean. We apply both band counting and high-precision U-Th dating methods to determine the age model of the record, and use the chemical composition (e.g., $\delta^{18}\text{O}$) in the corals to reconstruct the SST history. Our record significantly extends existing climate data for the central Indian Ocean and shows an overall warming trend during the past 110 years, with significant decadal variations in SST.

Keywords: Sea surface temperature, Tropical Indian Ocean, Coral, Decadal variation

【A0892】 -Poster

Can ocean heat content regulate Indian Summer Monsoon rainfall?

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Modern studies suggest that the upper ocean heat content (OHC) in the tropical Indian Ocean (TIO) is a better qualitative predictor of the Indian Summer Monsoon rainfall (ISMR). But it's still unknown how the OHC is mechanically linked to ISMR and whether it can be applied to long-term climate changes. By analyzing reanalysis datasets across the 20th century, we illustrate that in contrast to those anomalies associated with stronger ISM westerlies, higher ISMR is accompanied with summer surface high pressure and east wind anomalies from the South China Sea to the Bay of Bengal (BOB), and is loosely related to increased western TIO OHC during decayed phases of positive Indian Ocean dipole (IOD) and of El Niño. Except for 1944-1968 AD, this interannually lagged ISMR response to winter OHC is insignificant, probably suppressed by those simultaneous effects of positive IOD and El Niño on ISMR. In our paleoclimatic simulations, this modern observed lagged response is interrupted by seasonally reversed insolation anomalies at the 23,000-year precessional band. Our sensitivity experiments further prove that, the ISMR can be simultaneously reduced by positive IOD-like summer OHC anomalies both for modern and precessional situations. This damping effect is mainly contributed by the warmer western TIO that triggers anomalous surface high pressure, easterly winds, and drastically reduced rainfall from BOB to Arabian Peninsula, but with slightly increased rainfall in the northern ISM region. And the cooler southeastern TIO will only moderately increase rainfall in the southern ISM region.

Keywords: Upper Ocean Heat Content, Indian Ocean Dipole, Indian Summer Monsoon rainfall, Modern observation, Paleoclimate simulation, Proxy reconstruction

【A0444】 -Oral

Intensification of the Indonesian throughflow in a coupled GCM during the last interglacial: A model-data comparison

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The Indonesian Throughflow (ITF) plays a pivotal role in large-scale ocean-atmosphere interactions in the tropics, regulating the heat and freshwater budget between the Pacific and Indian Oceans. Despite its importance in the climate system, how would the ITF change in the context of projected global warming remains poorly resolved in the literature, though simulations from CMIP6 (the Coupled Model Intercomparison Project Phase 6) suggest a weakening trend. Alternatively, geological past provides valuable time windows to explore the climate dynamics surrounding the ITF in a warmer-than-today world. For instance, the Last Interglacial (LIG, Marine Isotope Stage 5e or Eemian), with global surface temperature reached about 2 °C above present, serves as an outstanding analog to explore the climate response to the external forcing and the mechanisms behind it. In this regard, past proxy studies have suggested an intensification of ITF during the LIG. However, the mechanisms underlying this intensification, together with its environmental implications, are yet to be explored.

Here, we present model outputs from a set of Last Interglacial snapshot simulations carried out by CAS-FGOALS (the Chinese Academy of Sciences Flexible Global Ocean–Atmosphere–Land System model) under the protocol of PMIP for four time periods at 130, 128, 125, and 115 ka. Compared to the piControl simulations (the annual mean ITF flux is 18.46 Sv), an annual mean ITF flux increase of about 30.6% - 35.9% was found in the LIG snapshot simulations (24.11-25.08 Sv). We found this enhancement of the ITF was closely correlated with a La Niña-like state during the LIG. During the LIG, there was an increased SST gradient between the tropical western Pacific and tropical central-eastern Pacific, accompanied by intensified easterlies over the tropical western Pacific. This increased SST gradient and intensified easterlies acted as positive feedback, reinforcing each other and resulting in a La Niña-like state with elevated sea levels in the western Pacific. This led to an asymmetric increase in sea level height between the tropical western Pacific and the tropical eastern Indian Ocean, which increased the pressure contrast between the two basins and subsequently strengthened ITF volume transport. Comparisons between models and proxies further support our conclusions. An examination of the changes in the thermocline water temperature record from the eastern Indian Ocean found an enhancement of ITF during MIS 5. Besides, the Maritime Continent was supposed to be more humid by pollen records from west Java and sediment composition from Halmahera Sea.



Further analysis suggests that the simulated ITF strengthened during the LIG is inconsistent with the projected ITF weakening in the 21st century. The projected slow-down in Walker circulation and the reduced SST gradient between the tropical western and eastern Pacific in the future differ from the conditions during the LIG, which we think may explain this discrepancy. While the future global warming is primarily driven by increased CO₂ levels, the climate changes during the LIG were principally caused by changes in orbital parameters.

Keywords: LIG, ITF, ENSO-like state

【A0609】 -Oral

Forcing mechanisms of the half-precession cycle in the western equatorial Pacific temperature

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The western equatorial Pacific (WEP) plays an important role on global and regional climate. Its temperature reconstructions during the Quaternary display orbital-scale variations, containing major cycles of ~100, 40 and 20 kyr. However, the half-precession (~10-kyr) cycle, despite its uniqueness in the equatorial insolation, is paid less attention. Here we perform a systematic study on the half-precession cycle in the WEP temperature and related mechanisms based on transient climate simulations combined with high-resolution temperature reconstructions. Our results show that the half-precession cycle is a robust feature in the long-term evolution of the WEP temperature, although it is insignificant in some proxy records. Our model results further show that the forcing mechanisms of the half-precession cycle in the WEP temperature at different depths are different, which is related to the distinct local ocean circulation patterns. Our simulated half-precession cycles in the WEP temperature provide a possible explanation for the half-precession signal recorded in proxy records.

Keywords: Western Equatorial Pacific, Astronomical forcing, Half-Precession cycle,



Ocean circulation

【A0456】 -Poster

Sedimentary archives from the eastern Indian Ocean showing a major change in both of the Indonesian throughflow and Australian monsoon at ~1.6 Ma

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The Indonesian Throughflow (ITF) as an only component of the global thermohaline circulation at low latitudes modulates heat and freshwater budgets between the Pacific and Indian Ocean which has a global significance. Previous studies indicate the ITF has been varying with constriction of the Indonesian Gateway, with its restrictions causing significant paleo-oceanographic and -climatic changes. The sedimentary archives from IODP Site U1482 located in the eastern Indian Ocean reveal a major shift at ~1.6 Ma in thermohaline profiles of the ITF waters for the upper ocean column including surface thru the intermediate layers and in various proxies of terrestrial inputs from northwest Australia. This shift points to significant changes in the ITF showing cooling and freshening of the waters and as well weakening of Australian Summer Monsoon and aridification of northwest Australia. The significant change of the ITF at 1.6 Ma by the first order likely being caused by constriction of the Indonesian Gateway nearly synchronized with the intensified west Pacific warm pool and strengthened walker circulation and may disclose the early onset of the Mid-Pleistocene Transition.

Keywords: Seawater properties, Terrestrial input, Indonesian throughflow, Australian monsoon

【A0794】 -Poster

Tropical surface and intermediate water changes in the northern Indian Ocean over the last two glacial terminations

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The Maldives, in the central equatorial Indian Ocean, is a shallow carbonate platform and presents the ideal repository between atmospheric and oceanographic interactions with tropical climate events. We present high-resolution $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ records of five planktonic foraminiferal species (*Globigerinoides ruber*, *Trilobatus sacculifer* (w/o sac), *Neogloboquadrina dutertrei*, *Pullentina obliquiloculata*, and *Globorotalia menardii*) and one benthic species (*Cibicidoides* sp.) from International Ocean Discovery Program (IODP) Site U1467 to monitor tropical oceanographic changes. These records span Marine Isotope Stage (MIS) 6 to the present and reveal $\delta^{13}\text{C}$ minima in all six species at Termination II and the most recent deglaciation (Termination I). The amplitude of these $\delta^{13}\text{C}$ minima within planktonic and benthic foraminiferal species varies by around $\sim 0.5\text{‰}$ to 0.2‰ . This implies temperature dependent equilibrium from the atmospheric $\delta^{13}\text{C}$ across the vertical profile of the Maldivian Inner Seaway. We detangle nutrients from air-sea gas exchange with paleo-nutrient proxy Cd/Ca and reveal nutrient depleted, oligotrophic conditions throughout the two terminations. Evidence for air-sea gas exchange between the atmosphere and the ocean is further supported with $\delta^{13}\text{C}$ predictions derived from Mg/Ca paleotemperature matching measured $\delta^{13}\text{C}$ values in magnitude across both terminations. Our study supports recent studies confirming the global imprint of thermodynamic air-sea gas exchange on the global oceans despite different sources of mixed layer and thermocline waters. Furthermore, results from this study further support the strength of using multiple planktonic species of various depths in water column thermal reconstructions across glacial-interglacial timescales.

Keywords: Glacial terminations, Stable isotopes, $\delta^{13}\text{C}$ minima, Multi-species planktonic foraminifera

【A0583】-Poster

Emergence of modern silk road pattern no later than mid-Pliocene

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The Silk Road Pattern (SRP), manifested as a zonally extended Rossby wave train, propagates along the subtropical westerly jet over Eurasia during boreal summer. SRP is one of the most important mode of interannual variability in the Northern Hemisphere (NH) because it exerts extensive climatic impact from Europe to East Asia. Nevertheless, it is still unclear when the modern SRP established and what the underlying mechanism is. Here, by using a set of simulations covering early Eocene, Mid-Miocene, Mid-Pliocene and current climate conducted by CESM1.2, we show evidence that the SRP of modern structure emerged no later than Pliocene. This result is validated by the analysis on stationary Rossby wave number (Ks) and the energy conversion process. The evolution of SRP is closely linked with the variation of summer subtropical westerly jet, which is further shaped by the uplift of Tibetan Plateau and changes of land-sea distribution. Our findings highlight the interaction between the variability of waveguide teleconnection, SRP, and the evolution of paleogeography over the geological periods.

Keywords: Silk road pattern, Interannual variability, Paleoclimate simulation, Westerley Jet, Paleogeography

【A0292】 -Oral

Precession control of temperature seasonality changes in the West Pacific Warm Pool since the Last Glacial Maximum

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The Holocene temperature history and its forcing mechanisms remain elusive due to the conflict between proxy reconstructions and model simulations. Recently, this model-data inconsistency has been partly attributed to the seasonal bias in the proxy indicators. This study attempts to assess changes in the seasonal variability of sea surface temperature in the low-latitude western Pacific since the Last Glacial Maximum (LGM), based on the standard deviation of oxygen isotope ($\delta^{18}\text{O}$) measured from individual planktonic foraminifera at four sites. The reconstructed temperature seasonality shows interhemispheric trends since the LGM, increasing in the Northern Hemisphere and decreasing in the Southern Hemisphere from the LGM to the early



Holocene, then reversing towards the late Holocene. And we find that the meridional gradient in the amplitudes of temperature seasonality was similar to today, which is consistent with the orbital insolation forcing. Combining with the model outputs from transient simulations (Trace-21ka), we suggest that temperature seasonality of the west Pacific warm pool appears to be controlled solely by precession, and shows no evident response to changes in global ice volume and atmospheric CO₂ levels. According to our reconstruction, if proxies from tropical-subtropical oceans tended to record warm season temperature changes as proposed by previous studies, they would cause the 'Thermal Maximum' phenomenon during the early-mid Holocene.

Keywords: Individual planktonic foraminifera, Oxygen isotopes, West Pacific Warm Pool, Temperature seasonality, Holocene temperature conundrum



Session 25. Interdisciplinary perspectives on tephra and volcanic hazards in the context of climate change

Conveners: Shuang Zhang, Chunqing Sun, Victoria Smith, Feng Shi, Simon Blockley

【A0355】 -Poster

Major Late-Pleistocene explosive eruptions of Changbaishan and Japanese volcanoes revealed by a 100 kyr tephra record from the Japan Sea

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Large amounts of volcanic ashes can be ejected into atmosphere through explosive eruptions, and then deposit across widespread regions, which provide valuable isochronous marker horizons for Quaternary studies. Many subaerial volcanoes around northeast Asia have experienced frequent large-magnitude eruptions. However, many of them are not fully characterized geochronologically and geochemically, such as Changbaishan sitting on the border between China and North Korea. We identified ten tephra layers in marine sediment cores from the Japan Sea, confirming the occurrence of seven major eruptions around northeast Asia over the past 100 kyr. Three of the tephra layers are major marker horizons around northeast Asia: AT (~30 kyr), Aso-4 (~86 kyr), and Toya (108 kyr), which were used to constrain age models of the sediment cores. A pre-AT tephra, possibly correlative with the A-Kn eruption of the Aira caldera, was recognized in the central Japan Sea, and it is linked to the high-resolution sedimentary record of Lake Suigetsu. The fourth Aso-4 component was recognized in this study, while component 3 was not recognized in the



sediment cores from the Japan Sea, suggesting that the eruption and tephra dispersal processes of the ~86 kyr Aso-4 eruption were complex. Additionally, one tephra ash layer with the age of ~88.7 kyr was identified in the eastern Japan Sea, and its composition is similar to that of the BT-30 tephra recorded in the Lake Biwa, and this layer may serve as a new marker horizon from the Japan Sea to central Japan. For the first time, the Changbaishan Tianwenfeng eruption was correlated with the B-J tephra from the Japan Sea, and was dated to ~48–53 kyr based on the age models of the marine sediment cores. The B-Ym tephra with an age of ~84.8 kyr recorded in the eastern Japan Sea was correlated to the Changbaishan tephra, but the source eruption was not determined. These two tephra layers could be used as visible marker horizons across the Japan Sea, as the thickness of the tephra layers in the sediment cores implicate the potential of detecting them in other sites.

Keywords: Changbaishan, B-J, B-Ym, Tianwenfeng, Aso-4, Aira

【A0317】 -Oral

A ~120 ka cryptotephra framework of Japan Sea for revealing volcanic eruptive histories and tephra dispersals of Japanese volcanoes

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Volcanic eruptions can affect regional to global climate through ejecting various kinds of gases and fine particles forming aerosols unbalancing the radiation of the atmosphere. Japan hosts large number of subaerial volcanoes of the world, and the highly active volcanic eruptions from this region produce many volcanic ash deposits to the Pacific Ocean, north America or even Greenland ice sheet. However, only very limited number of these tephras were identified in Japan Sea western to Japan, which impedes the establishment of complete volcanic eruptive histories and understanding tephra dispersals of Japanese volcanoes. Here, we constructed the first



complete ~120 ka cryptotephra sequence of Japan Sea by isolating and analyzing cryptotephra records from marine cores of IODP 346 U1424 and U1425. A total of 25 volcanic eruptions from Japan islands and 2 eruptions from the Ulleung island were recognized. We reconstructed Bayesian age-depth models by using well known eruptions with precise dating results, such as the AT and Aso-4. Japanese volcanic eruptive histories were refined by identifying 10 unknown sourced tephra layers and assignments of eruptive ages to 8 less timing constrained eruptions. We show that significant number of volcanic eruptions can eject volcanic ashes to the west of Japan island, previously underestimated by visible tephra records. Finally, several tephra layers can be correlated with high resolution terrestrial records from Japan islands, northeast China, and even Greenland ice cores, providing regional to hemispherical marker horizons for linking palaeoenvironmental records of north-hemisphere.

Keywords: Cryptotephra, Sea of Japan, Chronology, Eruptive histories, Tephra dispersals

【A0234】 -Poster

Dwindling effective radiative forcing of large volcanic eruption: The compensation role of ocean latent heat flux

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Climatic impacts of historical volcanism are principally tied to the eruption size, while observation vs. model discrepancies have been commonly attributed to the uncertainties in paleo-reconstruction or malpresentation of volcanic aerosols in the models. Here we present convergent evidence for significant compensation effect of ocean latent heat (LH) in balancing the tropical volcanic-induced heat loss, by introducing an effective perturbation ratio which is found to decrease with increasing eruption magnitude. Four LH compensation hot spots overlapping with the trade wind regions are identified, together with three western boundary currents regions with intensified LH loss. Comparison between the 1258 Samalas and 1452 Unidentified eruptions suggests considerable modulation of the concurring ENSO on LH anomaly, which is further verified by CESM large ensemble sensitivity experiments. This study depicts how the interplay between the ocean and the atmosphere could contribute to



the overall resilience of the climate system in the face of volcanic disturbances.

Keywords: Volcanic eruption, Effective radiative forcing, Compensation, Latent heat

【A0364】 -Oral

First discovery of the Laacher See Tephra in the Eastern Alps: Necessity for reassessing fallout patterns

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We report the pioneering identification of the Laacher See Tephra (LST) in the Eastern Alps, specifically in Lake Plansee, Tyrol, Austria. Using a comprehensive core-scanning workflow (magnetic susceptibility, computed tomography, XRF, μ XRF, and electron probe microanalysis), we identified the LST despite the near-total dissolution of volcanic glass in alkaline lake sediments, by focusing on both the volcanic minerals associated with the eruption and the remaining geochemical signatures. This approach highlights the critical need to extend detection strategies beyond glass shards, particularly in cases of significant alteration and minute amounts of tephra glass shards.

The discovery of LST within the internal region of the Eastern Alps challenges existing assumptions about the LST's distribution patterns, suggesting a broader fallout area than previously recognized. It underscores the need for comprehensive tephrochronological investigations, particularly in regions beyond traditionally accepted fallout zones. This finding not only advances chronological frameworks and paleoenvironmental reconstructions but also the assessment of eruption impacts on past ecosystems, including human communities, and potential implications for future volcanic events.



Our methodology's sensitivity in detecting trace amounts of cryptotephra and associated minerals opens new avenues for understanding tephra fallout dynamics and distribution. The identification of the LST in Lake Plansee highlights the potential for similar discoveries in other previously overlooked regions, including environments like alkaline lakes.

Keywords: Laacher See Tephra, Tephra fallout, Distribution maps, Cryptotephra, Tephra identification

【A0819】 -Oral

What's in a shard? Potential insights from sparse cryptotephra deposits

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Cryptotephra deposits have long been used as an age equivalent geochronological method on the basis that their glass geochemistry enables linkages to the eruptions that produced them. Their analysis in palaeoenvironmental research has further contributed to volcanic histories, and to investigating the environmental and societal impacts of past eruptions. Cryptotephra in highly resolved polar ice cores has been particularly useful for determining the relationship between volcanic eruptions and past climate responses, while at the same time affording precise ages for prehistoric eruptions. Recent efforts to expand the usefulness of cryptotephra analysis include inverse ash dispersion modelling to infer eruption source parameters as a means of refining volcano-climate modelling (Plunkett et al. 2022). Cryptotephra shard concentrations exhibit high spatial variability, however, and can be limited by the distance between the source and the deposition site, especially if latitudinal distances are great, as well as meteorological conditions that govern their transport and deposition. Low shard concentrations, sometimes comprising individual grains associated with a given volcanic event, present challenges for interpretation, not least by limiting the potential for robust geochemical datasets.

This paper considers to what extent data obtainable from sparse cryptotephra can be used to understand past eruptions. Research on macro-tephra deposits has shown that shard size and shape reflect eruption style and impact ash dispersal, but suggest that



large sample sizes and complex image analysis are needed to make statistically robust inferences (Saxby et al. 2020; Benet et al. 2024). Here we collate data from cryptotephra deposits from historic eruptions, including their geochemical characterisation, grain size, shape and texture, and consider their relationship to known eruption characteristics. We compare the information obtained from the first sighted shard in a sample to progressively larger datasets from the same sample to evaluate the extent to which reliable inferences might be drawn from a restricted number of shards. We conclude with recommendations for data recording that can be effectively implemented during routine shard counting on a standard light microscope.

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Keywords: Cryptotephra, Ash shard morphology, Eruption style, Light microscopy

【A0887】 -Poster

West African Summer Monsoon variability over the past half millennium

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The West African Summer Monsoon (WASM) is a critical driver of regional ecosystems



and livelihoods, profoundly influencing agricultural productivity, water resources, and societal stability. The recent intensification of extreme climate events in West Africa has been closely linked to changes in WASM dynamics. However, understanding its natural variability and underlying mechanisms remains limited due to the dominance of anthropogenic forcing in modern observations and the short temporal span of instrumental data. To address these gaps, this study reconstructs the WASM index over the past half-millennium (1480–2000 CE) using 22 high-resolution proxy records, including 14 tree-ring chronologies, 1 sediment record, and 7 speleothem records. Our analysis reveals that WASM fluctuations in recent decades remain within the envelope of natural variability observed over the past 500 years. Interannual variability is strongly influenced by the El Niño–Southern Oscillation (ENSO) and volcanic eruptions, while multidecadal variability is predominantly modulated by the Atlantic Multidecadal Oscillation (AMO). These findings provide critical insights into the interplay between natural climate variability and external forcings, offering a long-term perspective on WASM dynamics. By improving our understanding of these processes, this study contributes to enhanced predictions of future monsoonal natural behavior under anthropogenic climate change.

Keywords: West African Summer Monsoon, El Niño–Southern Oscillation, Volcanic eruption, Atlantic Multidecadal Oscillation

【A0931】 -Poster

~60 ka tephra-framework of northwest Pacific Ocean: Depicting regional eruptive history and radiocarbon reservoir effect

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Tephra are valuable marker horizons for synchronizing environmental studies, and can be used to reconstruct explosive eruptive histories. Explosive eruptions from Japan arc produced many widespread tephra layers around northeast Asia and northern hemisphere, while the full eruptive history of this region is not reconstructed. We found 6 visible tephra layers in the NP02 core (~5 m) northwest Pacific Ocean downwind direction to the Japan arc. The thickness of these tephra layers is 2 to 6 cm, and the color is pale white to yellow. We correlated four of these tephra layers to To-Of, Spfa-1, Kt-3, Kc-Sr respectively, and the age framework of this core can be



constructed using these well dated layers. Additionally, one tephra exhibits similar glass compositions to the Kc-Sr, and suggesting an unknown explosive eruption from Kutcharo volcano. The tephra layer at around 50 cm was correlated to the To-H suggesting a significant radiocarbon reservoir in this region when considering the radiocarbon date of 28.413 cal ka BP at 49-52 cm of the same core.

Keywords: Kc-Sr, Kutcharo, Age reservoir, To-Of, Spfa-1

【A0359】 -Oral

Linking tephra layers to climate shifts: A multi-proximal approach from Björn drift contourite deposits (IODP Expedition 395)

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The study of Late Pleistocene contourite drift sediments in the Björn Drift region, South of Iceland, offers a unique opportunity to investigate the interplay between volcanic activity, ocean circulation, and climatic transitions. This research focuses on the analysis of tephra layers interspersed within the sedimentary sequence between 20 and 70 meters below the seafloor. These layers act as precise time markers for volcanic events, allowing us to correlate these events with broader climatic cycles and oceanographic shifts. Visual interpretation reveals the thickness of these ash layers varies between 10s of a centimeter of very fine-grained size fractions. These are found to be mixed between bulk sediments comprised of silty clay with moderate bioturbation. Tephra layers in the sediments provide a chronological framework for understanding the timing of volcanic eruptions during the Late Pleistocene. Coupled with stable carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotopic data from bulk sediments, this



study sheds light on the influence of volcanic activity on marine productivity, nutrient cycling, and the carbon cycle across glacial and interglacial periods. Foraminiferal assemblages, sensitive to sea surface temperature, salinity, and changes in ocean circulation, offer insights into the responses of marine ecosystems to volcanic and climatic events. Variations in foraminiferal species at Site U1554 particularly *Globigerina bulloides*, *Neogloboquadrina pachyderma*, *N. incompta*, and *Turborotalita quinqueloba* enable the reconstruction of past oceanographic conditions, particularly concerning a transition from colder to warmer surface waters. As ice sheets began to retreat from glacial to interglacial conditions, the reduction in pressure could have led to enhanced volcanic eruptions. This could increase tephra deposition in the marine core, contributing to the sedimentary record during a glacial period. By combining tephrochronology with stable isotope data, and foraminiferal analysis, this study provides a comprehensive view of the mechanisms driving climate variability during the Late Pleistocene. Our findings highlight the interconnectedness of volcanic forcing, ocean circulation, and marine ecosystem responses during glacial-interglacial transitions, offering valuable insights into the sensitivity of the North Atlantic to climatic and volcanic perturbations.

Keywords: Tephra layers, Volcanic ash, Bjorn drift, IODP 395, Climatic shifts

【A0392】 -Poster

A new tephrochronological record of a raised bog in eastern lowland Scotland

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Cryptotephra have been widely used as a chronological tool for studying past environmental change, but many temporal and spatial gaps remain in our knowledge of the distribution of cryptotephra records. Here, last millennium cryptotephra were identified and analysed for the first time in eastern lowland Scotland. Six tephra layers were identified in six replicate short peat cores at Bankhead Moss, a raised bog in Fife, eastern lowland Scotland. Geochemical and stratigraphic correlations indicate that the tephra originate from Icelandic and Alaskan sources. We make firm correlations to Askja 1875 and WRAe, a broad correlation to Mount Churchill with the possibility of Lena tephra being inferred from its estimated timing, and uncertain correlations of



three tephra layers of Icelandic origin, considering the mixed nature of these three tephra layers under the potential influence from post-depositional reworking and multiple volcanic sources, e.g. Hekla, Öræfajökull and Katla. This is the first secure record of the Askja 1875 tephra in the British Isles, which significantly extends its known spatial distribution and suggests a more complex dispersal pattern of this tephra than previously thought. Persistent presence of shards throughout parts of the peat sequences may reflect post-depositional movement of tephra shards within the peat, reworking from surrounding landscape, and/or sparse fallout from other eruptions. Our records indicate that any single peat core from this site gives a good approximation of the overall tephrostratigraphy, but there is considerable spatial variation in tephra concentrations between cores. Age-depth models for the six cores based on cryptotephra, spheroidal carbonaceous particle (SCP) counts, and radiocarbon dates likewise vary between cores, showing a pattern consistent with peat accumulation in a domed raised bog. These spatial differences in tephrostratigraphy highlight the value of a multiple-core approach in palaeoenvironmental peatland research.

Keywords: Cryptotephra, Askja 1875, Hekla tephra, Wrae tephra

【A0541】 -Poster

Determining the seasonality of volcanic eruptions from tephra layers recorded in ice cores

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Past volcanic eruptions can provide chronostratigraphic links between various proxy records, and thus are a powerful dating tool in paleoclimatology. Knowing the precise timing of volcanic eruptions is important for establishing global and regional chronological frameworks and for assessing any leads and lags in the climate system. Beyond constraining the absolute timing of past volcanic eruptions, it is also important to identify the season of volcanic eruptions, as this can have a major impact on their climatic forcing, especially for extratropical eruptions (e.g. Thoohey et al., 2019). Tephra layers and sulphate concentrations in ice cores provide one of the most well-resolved chronologies for studying the timing of past volcanic events with



uncertainties in absolute age on the order of a couple of years or less over the past two thousand years. This dating accuracy was achieved by counting annual layers on seasonally varying ions with one-year cyclicity along the ice-core stratigraphy. Previous studies have used the seasonality of these ions (e.g. sea salts) to determine the timing of eruption signals in ice cores for individual volcanic events (e.g. Oppenheimer et al., 2018).

Here we build upon this approach by developing a method that can be applied quantitatively (including assessment of uncertainty) across all eruptions recorded in an ice core. We use a Fast Fourier Transform to determine the phase of the annual cycle (i.e. seasonal timing) of a range of aerosols in snow samples from Greenland (Chellman, 2009). This information is then applied to past tephra layers and sulphate peaks in ice cores to develop the first seasonally constrained volcanic chronology throughout the Common Era. By constraining the season of past volcanic events in ice cores, the outcomes of this study will improve on currently used volcanic forcings (e.g. in PMIP past 1000 simulations) which assume a start date on the first of January for unidentified eruptions (which make up 90% of the eruptions in the record).

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Keywords: Ice cores, Chronology, Volcanic eruptions, Tephra, Climate forcing

【A0513】-Poster

Climate impacts of volcanic eruptions across multi-timescales

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Volcanic eruptions are significant drivers of climate variability, affecting global climate



across timescales from interannual to geological periods by injecting sulfur compounds, greenhouse gases, and volcanic ash into the atmosphere. Despite their critical role, comprehensive analyses spanning different timescales are lacking. In this study, we investigate the climatic impacts of volcanic eruptions at both interannual and long-term scales using the latest coupled Community Earth System Model version 2 (CESM2). At the interannual scale, we examine the climatic impacts of the Changbaishan Millennium Eruption. Based on geo-petrochemical estimates, we conducted volcanic sensitivity simulations using the CESM2 with the Whole Atmosphere Community Climate Model version 6 (WACCM6). We assess the climatic impacts of the Millennium eruption and compare the influence of different model components and forcing approaches on simulation outcomes. At longer timescales, we focus on the Pana super-volcano eruption, which coincided with the termination of the Early Eocene Climatic Optimum. Studying such events presents significant challenges due to insufficient geological records for accurately quantifying eruption frequency and duration, as well as difficulties in simulating their long-term cooling effects. To address these limitations, we employ a snapshot simulation to ideally reproduce the climatic impacts following the eruption. Our findings underscore the importance of integrate petrography, volcanic geochemistry, and advanced climate modeling simulations to achieve a more comprehensive understanding of the climatic impacts of volcanism across different timescales.

Keywords: Volcanic eruptions, Community Earth System Model

【A0705】 -Oral

Developing late Quaternary Eastern Mediterranean marine tepthrostratigraphy: Implications for regional volcanic histories

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The Eastern Mediterranean is an important region for palaeoenvironmental research because it is sensitive to a complex pattern of climatic and environmental change, influenced by orbital forcing and multiple feedback mechanisms, during the late Quaternary. The Middle to Upper Palaeolithic transition in the Levant is characterized



by key archaeological shifts. During this period there is also potential for abrupt climatic transitions to influence the distribution of humans across the region. One issue is the precision and resolution to which we can date Levantine archaeological sites and the wider environmental record. Examination of the cause and impact of climatic changes in this region requires the development of long, continuous, well-dated sedimentary sequences.

This study establishes the first marine crypto-tephrostratigraphy on a well-dated marine core MD81-LC31 from the Levantine Sea, covering the last ~200,000 years and consists of three visible tephra and eight cryptotephra, the majority (two visible and seven cryptotephra) of which derive from Santorini. The detection of multiple sub-Plinian volcanic products in marine sediments distal to Santorini indicates that these eruptions were more explosive than previously thought. In addition, a previously unknown MIS 5e eruption from the Kos volcano is identified. The detection of an unknown Kos eruption adds to our knowledge of the active and hazardous nature of Kos/Nisyros/Yali volcanic complex.

Keywords: Tephrochronology, Eastern Mediterranean, Marine tephra, Volcanic history, MIS 5e

【A0019】 -Poster

Developing a tephrochronological framework for synchronisation of archaeological and environmental records in the southern caucuses for MIS 3

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This presentation will outline the recent history of studies that use volcanic ash (tephra) as a tool to synchronise and date archaeological records in the Southern Caucasus and extend the potential for these records to be correlated to sites in the wider Eastern



Mediterranean region. The presentation will review work on published sites from in Georgia and Armenia in MIS3 (e.g. Ortvale Klde, Kalavan, Ararat Cave, (Cullen et al., 2021; Malinsky-Buller et al., 2021; Sherrif et al., 2024) and report on tephra from several unpublished sites in Armenia. The presentation will then review available and forthcoming geochemical data from the local and regional source volcanoes. These data will be used to discuss the potential and challenges for reliable correlation between archaeological records across the region. Because many of the volcanic centres in Armenia and Turkey produce widespread explosive volcanism there is also potential for records from the southern caucuses to be compared to sites further afield, including both archaeological and environmental records. This potential will be discussed with particular reference to the Anatolian volcanoes. The presentation will then examine what further work needs to be undertaken to secure correlations between records in the region and beyond.

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Keywords: Tephrochronology, Palaeolithic, Archaeology, Armenia, MIS 3

【A0871】 -Poster

Historical variability in the summer Temperature-Humidity-Wind index across the Qinghai-Tibet Plateau over the past 500 years

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The Qinghai-Tibet Plateau has experienced unprecedented warming over the past six decades, contributing to more frequent extreme weather events with significant implications for human health. However, the links between regional climate variability and human health risks remain underexplored. This study reconstructs the summer (June–August) Temperature-Humidity-Wind (THW) index, an indicator of apparent temperature and associated health risks, for the southern and southeastern Qinghai-Tibet Plateau over the past 500 years using 20 tree-ring width chronologies. Our results reveal that the post-1971 CE upward trend in summer THW index across the southern, southeastern, and northeastern Qinghai-Tibet Plateau is the most rapid observed in the past 500 years. However, the current levels remain below thresholds for heat-related health risks. Furthermore, the THW index demonstrates a significant correlation with total solar irradiance on multi-decadal scales, underscoring the influence of solar variability on regional climate. Notably, the two coldest periods (1630–1660 and 1670–1700 CE) of the past 500 years are coincided with reduced solar activity during the Little Ice Age. These intervals were characterized by pronounced decreases in THW index, which likely contributed to lower oxygen availability and elevated risks of chronic mountain sickness, subsequently reducing life expectancy in the region. This study highlights the role of paleoclimate variability in shaping human health outcomes and underscores the importance of continued monitoring and modeling of THW index trends to anticipate and mitigate future health risks in a rapidly warming world.

Keywords: Temperature-Humidity-Wind index, Human health, Tree ring width, Solar activity

【A0210】 -Oral

Volcanic impacts on global monsoon precipitation: Latitude dependence and the role of SST pattern

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Changes in global monsoon rainfall have a great influence on social and economic development. As an important factor of natural external forcing, it is of great scientific and social significance to understand the impact of volcanic eruptions on the hydroclimate over global monsoon regions. Here we show divergent monsoon responses to volcanic eruptions at different latitudes based on reconstructions, observations, and climate model simulations. Monsoon precipitation decreased after tropical volcanic eruptions, which is caused by decreased moisture and weakened monsoon circulation. There is a distinct remote impact of volcanic forcing such that large volcanoes erupted in one hemisphere can enhance monsoon precipitation in the other hemisphere, resulting from enhanced cross-equator flow. As an El Niño-like SST anomaly usually occurs after volcanic eruptions, it can further modulate the monsoon precipitation through atmospheric teleconnection. Based on model simulations, we found that under ENSO neutral and warm phases initial conditions, the Pacific favors an El Niño-like anomaly after volcanic eruptions, while La Niña-like SST anomalies tend to occur following eruptions under ENSO cold phase initial condition. Such SST response further regulates the monsoon precipitation changes. The direct radiative forcing dominates Northern hemispheric monsoon rainfall, while the Indirect SST response dominates Southern hemispheric monsoon rainfall. These results imply that attention should be paid to the background oceanic state when predicting the global monsoon precipitation responses to volcanic eruptions. Since major volcanic eruptions are generally not included in current projection scenarios because they are inherently unpredictable events. By using 60 plausible future volcanic eruption scenarios, we revealed the volcanic impacts on the future changes of summer precipitation over global monsoon regions. Episodic volcanic forcing not only leads to a 10% overall reduction of the centennial global monsoon precipitation but also causes a larger ensemble spread (~20%) compared to no-volcanic and constant background-volcanic scenarios. Our results demonstrate the importance of statistical representation of potential volcanism for the projections of future monsoon variability.

Keywords: Volcanic eruption, Global monsoon, ENSO



Session 26. Contribution of past fire time-series and models to fire science across the earth system

Conveners: Boris Vannière, Douglas I. Kelley, Chantelle Burton, Douglas S. Hamilton

【A0433】 -Poster

Reconstructing 13,000 years of fire history and ecosystem responses from lacustrine sediments in a low-flammability central European landscape

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Wildfires have devastating effects on landscapes and human communities and drive notable environmental transformations. These shifts include altering nutrient fluxes, which are critical for primary production, shaping plant traits, and regulating atmospheric oxygen levels. Fire-induced vegetation loss and related erosional processes often profoundly impact biogeochemical cycles.

Recent studies highlight the substantial impact of wildfires on aquatic ecosystems, underscoring the need for further research into fire-related lacustrine environments. Potential post-fire effects on lake ecosystems include altered water mixing regimes caused by deforestation, filling of depositional basins due to increased soil erosion and sediment delivery, and mass movement triggering in the basin. Because ecosystem responses to fire are highly complex and variable, understanding how fire-related processes affect lacustrine ecosystems is crucial. Additionally, gaining long-term perspectives is essential for assessing how lake resilience may change under future fire regimes increasingly influenced by climate change. This knowledge enhances our understanding of current trends in lacustrine ecosystem development and resilience.

The impact of wildfires on Earth's ecosystems is increasing, even in regions previously considered less prone to ignition and fire spread. Located in Central Europe, Poland is an example of such a region, where the long-term variability of fire regimes remains poorly understood due to a lack of studies covering periods beyond several millennia.



The sediment record of Lake Gorzyńskie (western Poland) addresses this knowledge gap. Therefore, we present a new reconstruction of fire activity in the low-flammability landscape of Central Europe, based on sedimentary macrocharcoal (>100 µm) analysis. These results are complemented by non-destructive methods such as XRF and HSI to decipher changes in terrigenous delivery and primary production shifts in the lake ecosystem. Along with these, pollen data are analyzed to investigate vegetation changes over time.

Our findings reveal over fifty substantial fire episodes in the region over the past ca. 13,000 years. Preliminary results suggest that natural fires occurred during the late Allerød and early Holocene, particularly in warmer climates. However, during these times, the maximum number of fires per 500 years did not exceed five episodes. This pattern changed dramatically following the emergence of the Polish State at the end of the 10th century CE. Increased demand for agricultural fields and timber drove large-scale deforestation. We hypothesize that these deforestations were likely achieved through the use of fire, an effective method for woodland clearance to create farmland and reduce forest density. This transformation is evident in pollen data, which document the shift from natural late glacial vegetation, through mid-Holocene minor human impact, to a human-dominated landscape.

We also demonstrate the effects of fire episodes on the lacustrine ecosystem. Sedimentological and geochemical (XRF) observations allowed for tracking erosional processes, while hyperspectral scanning imaging (HSI) of sediment revealed long-term changes in past primary productivity and oxygenation of bottom waters. Future research will focus on identifying burnt biomass and further exploring fire's impacts on lake ecosystems.

This study is a contribution to the scientific projects financed by the National Science Centre, Poland as No. 2021/43/D/ST10/00212 and 2020/37/B/ST10/01903.

Keywords: Lake sediments, Pollen, Paleofires, HSI, XRF

【A0439】 -Poster

The history of vegetation fires recorded in annually laminated lake sediments of Lake Lehmilampi (Finland)

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Extreme events such as droughts and heat waves are becoming more frequent, making large areas affected by fire. At the same time, little information is available to assess the vulnerability of forests to changing conditions and the increasing likelihood of fires. Especially, the boreal forest zone is still an understudied area in this context. Therefore, more reconstructions are needed to assess the role of climate and likely human activity in fire occurrence.

Lake sediments are one of the best natural archives for paleoenvironmental reconstructions. They are closely linked to the conditions of the catchment area, climate, vegetation and soil substrate. The best among them are annually laminated (varved) sediments as they provide a high-resolution time scales to track past changes.

To investigate the history of vegetation fires in the boreal zone, a sediment core from Lake Lehmilampi was analyzed. Lehmilampi is a small lake located in the central part of Finland, in the Finnish Lake District. The bedrock in the catchment consists of plutonic rocks, while the surface geology is dominated by Quaternary glacial till and clay. Most of the catchment area is forested, with pine, birch, and spruce being the dominant tree species in the area. The north-western part of the catchment is agricultural land.

A 257-cm-long sediment core was taken in 2016, using a Livingstone gravity corer. The core was opened and photographed. Then, thin sections were prepared and scanned. Three independent varve counts along with radiometric measurements allowed for developing a reliable age-depth model. The entire core was sampled with 1 cm intervals for macrocharcoal analysis. During sample preparation a hydrochloric acid solution (HCl) and a sodium hydroxide (NaOH) were added. Then samples were wet-sieved using a mesh size of 100 μm . The macrocharcoal were counted under the microscope and their morphotypes and sizes were determined.

The preliminary results show, that the age at the bottom of the profile is $3,315^{+66}_{-77}$. The macrocharcoal analysis results indicate that vegetation fires have occurred in the area over the last 3,000 years. At least one macrocharcoal piece was observed in 154



samples out of total number of 257 samples, what is 60% of all samples. The highest abundance of macrocharcoal is in the 100-300 μm size range. The predominant macrocharcoal morphotype found in the sediments is grass, with admixtures of leaves, herbaceous and wood fragments. In general, there is a high frequency of fires in the top 150 cm of the sediment core, which suggests that the recent fires might have been related to the human activity but since only the topmost ~ 30 cm of sediment contains the anthropochore indicators (e.g., *Secale cereale*) it is likely that the wildfires reconstructed from Lake Lehmilampi were natural fires. Moreover, analysis indicate the high fire activity is observed also at approximately 70 cm (1100 CE), 110 cm (550 CE), and 210 cm (715 BCE) of the core depths, where no human impact was observed.

This study is a contribution to the scientific projects financed by the National Science Centre, Poland No. 2021/43/D/ST10/00212.

Keywords: Boreal zone, Finland, Varves, Lake sediments, Wildfires

【A0757】 -Poster

The SNSF advanced grant project burnice: Reconstructing past biomass burning emissions from atmospheric ethane concentrations

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Recent changes in the number, frequency, and size of fires have been associated with anthropogenic climate change, but are also connected to other human activities, such as active fire suppression and land-use change. In view of the ongoing anthropogenic climate warming, understanding the link between climate and biomass burning is crucial. To isolate the climatic effect from the other anthropogenic influences, we aim to reconstruct how biomass burning emissions responded to past climate transitions (i.e., stadial–interstadial, glacial–interglacial).

Ethane is an ideal tracer to achieve this goal, as it predominantly originates from



biomass burning. In the atmosphere, ethane is destroyed through reactions with OH radicals and, to a lesser extent, Cl atoms, resulting in a tropospheric lifetime of about two–three months. This lifetime is long enough for ethane to be preserved in polar ice cores, but short enough such that analysing ice cores in both hemispheres yields complementary information, allowing to better constrain ethane source locations. Indeed, ethane has been successfully used to help constrain biomass burning emissions over the last 2,000 years (Nicewonger et al., 2020).

However, measuring ethane is challenging, not only due to its low atmospheric abundance. Recent findings suggest that ethane, as well as other alkanes, are produced during melt extraction of dust-rich ice-core samples. Hence, the wet extraction used by Nicewonger et al. is not suitable for reconstructing ethane concentrations during dusty glacial periods. To circumvent the liquid phase and hence in-extractu production of alkanes we use laser-induced sublimation extraction. The extracted gases are analysed on a custom-built GC-IRMS system, which allows for parallel measurement of ethane, acetylene, propane, methane, and the carbon-isotopic composition of methane, all of which contain complementary information on past biomass burning emissions.

In a second step, the measured ethane concentrations are translated into tropical and extratropical biomass burning emission estimates. The standard tool to find viable emission scenarios in agreement with measured ice-core trace gas records are atmospheric multi-box models. These box models require calibration for atmospheric exchange parameters and ethane lifetime. However, atmospheric chemistry, i.e., the ethane OH and Cl sink, and atmospheric dynamics were significantly different during glacial conditions. To better capture these changes in atmospheric chemistry and dynamics, we rely on the Community Atmosphere Model with Chemistry (CAM-Chem), which is embedded in the Community Earth System Model (CESM). Using this modelling framework, we will derive sensitivity factors to quantify how biomass burning emissions in the various source areas contributed to the measured ethane concentrations at the ice-core sites.

Reference

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Keywords: Ethane, Biomass burning, Ice core, Glacial-interglacial, Stadial-interstadial

【A0344】 -Poster

The history of forest fires in the central part of the East European Plain in the Holocene

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The central part of the East European Plain is a densely populated area of great economic importance. Modern forest fires regularly cause significant damage in this region. A very valuable natural archive of palaeoenvironmental changes, including forest fires, are peat and lake deposits.

Studies of macrocharcoal in combination with other methods, most notably pollen analysis, allow the reconstruction of the Holocene forest fire history. The modelling forest fires time-series in the Holocene makes it possible to better determine the main factors of fire occurrence and identify the features of their impact on the ecosystems in the study region.

Our reconstruction is based on the analysis of 16 sections within 6 key areas in different parts of the East European Plain confined to the middle and southern taiga, broad-leaved forests and forest-steppe zones. Pollen analysis was performed for each of the key areas based on the reference section. The fire history was reconstructed using the *tapas* R package (Finsinger, Bonnici, 2022), which allows estimation of the long-term fire trend and detection of peaks to identify the occurrence of local fire episodes and fire return intervals. In addition, all the time series of the macrocharcoal accumulation rate have been analysed and synthesised in *Paleofire: An R package* (Blarquez et al., 2014) to perform a general integral reconstruction of biomass burning.

The results obtained have shown that the history of Holocene forest fires in the East European Plain can be divided into three main phases. Within a period of ~9000-6000 cal. yr BP, a relatively large number of forest fires were recorded, probably caused by climatic changes. However, the trend in this interval is characterized by a progressive decrease in pyrogenic activity. Frequent fires in some areas lead to the development of post-pyrogenic forest communities dominated by pine and birch.



From ~6000 cal. yr BP (the second part of the Holocene Thermal Maximum), biomass burning decreased significantly and fire activity was extremely low, leading to an expansion of broadleaved species in forest ecosystems. The beginning of active human influence on the central part of the East European Plain (around 2500 cal. yr BP) is marked by an increase in fire frequency and biomass burning. Since then, significant changes in vegetation cover have been recorded. This trend continues to the present day.

The study was supported by grant of the Ministry of Science and Higher Education of Russian Federation (agreement No. 075-15-2024-554 of 24.04.2024).

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Keywords: Macrocharcoal analysis, East European Plain, Forest fire history, Pollen analysis

【A0216】-Poster

Increasing spring dryness accelerates the transition toward pyrogenic vegetation in eastern boreal North America

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Climate change is increasing vegetation flammability, thus intensifying fire activity and reshaping the dynamics of boreal forests in eastern North America. This new context raises important questions about long-term effects on biodiversity, forest structure and composition, as well as ecosystem resilience. Here, we offer critical insights into possible future changes by investigating shifts that have occurred over the past 8000 years, relying on joint inferences from high-resolution paleoecological datasets (charcoal, pollen, chironomids, testate amoebae) with model simulations of vapor pressure deficit (VPD) and plant-available soil water (ASW). We provide compelling evidence that increasingly dry spring conditions over the past 3000 years have triggered a regime shift towards fewer but larger and more severe fire episodes, fostering the widespread expansion of fire-prone conifer species and altering the region's landscape and ecological balance of boreal forests. Our findings suggest that the ongoing increase in VPD and decrease in ASW caused by climate change will accelerate the transition to more pyrogenic vegetation, as long as key thresholds necessary for successful regeneration are not exceeded. These changes will redefine the structure and function of boreal ecosystems in the coming decades.

Keywords: Paleoecology, Wildfire, Climate change, Boreal Forest, Pinus Banksiana

【A0973】-Poster

Twentieth century change in the fire regimes of the Blue Mountains of NSW as recorded in the accumulation and character of charcoal in temperate highland peat swamps

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A significant concern surrounding the 2019-2020 Australian 'Black Summer' bushfires, as well as other similar recent events globally, is the question as to whether these represent a new and more extreme fire regime with an increase in frequency, intensity



or area burnt. While Australia's terrestrial ecosystems have been actively shaped by fire for millennia, increasing severe fire weather or climatic variability due to anthropogenic climate change may be resulting in more extreme fire. This study utilizes high-resolution ^{14}C dating, charcoal accumulation (CHAR) and Raman spectroscopy to examine fire over the past century across the upper Blue Mountains of NSW in eastern Australia. We particularly focus on changes to fire intensity and severity using parameters derived from the position and shape of features in the sub-bands of Raman spectra which have previously been shown to be sensitive to the structure of charcoal and 'thermal maturity'. These, together with CHAR, show that trends across the Twentieth Century in the Blue Mountains landscape are inconsistent with the hypothesis that fire is becoming more severe. Ultimately our goal is to use this calibration exercise to quantify links between charcoal and fire, such that this can be used to better characterize fire regimes over the many thousands of years (represented by the sediments in the mires of the Blue Mountains).

Keywords: Fire, Paleowildfire, Charcoal, Climate, ^{14}C dating, CHAR, Raman thermometry, Intensity

【A0802】 -Poster

Reconstructing volcanic histories: Spectral footprints of the Doña Juana Eruptions

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Low-latitude volcanoes face significant challenges for reconstructing their geological histories due to heavy precipitation, dense vegetation, and scarce outcrops, limiting traditional volcanic reconstruction techniques. Developing alternative tools to address these challenges is critical for risk assessment and volcanic hazard in these regions. Organic materials, such as buried woods and ancient charcoal, frequently preserved in these environments, emerge as viable archives for understanding volcanic histories, including as flow and flow avulsion temperatures, topography changes, and ages. This study explores the application of Fourier Transform Infrared Spectroscopy (FTIR-IR) to reconstruct volcanic topographies from ancient pyrogenic charcoal (n=40) collected



from the Doña Juana Volcanic Complex (Nariño, Colombia). Samples span diverse ages, altitude gradients, and locations, with a modern charcoal database aiding the identification of temperature-topography associations. Key chemical spectral patterns were analyzed using Linear Discriminant Analysis (LDA) and Principal Component Analysis (PCA), revealing a model with ~60% predictive accuracy and robust confidence intervals. This accessible, low-cost approach demonstrates significant potential for regions with underdeveloped methodologies, offering a practical solution for refining sampling strategies and improving volcanic hazard assessments, with predictive power expected to increase as more data become available.

Keywords: Volcano, FTIR, Spectra, Volcanic complex Doña Juana

【A0420】 -Poster

History of wildfires in the western and central part of the central Siberian plateau: Long-term fire activity based on peat archives

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This study aimed to analyze fire regimes in less and more continental climates of the Central Siberian Plateau. Two key sites along the Lower Tunguska River, a tributary of the Yenisei, were investigated. The Turukhansk site (65.815755°N, 87.977055°E) represents a less continental climate, while the Tura site (64.272295°N, 100.206872°E) is in a more continental region. Both sites are dominated by larch and secondary birch forests within the permafrost zone. At each site, two peat archives located at least 5 km apart were studied. Samples of 1 cm³ were collected at 1 cm intervals, treated with 5% H₂O₂ for 24 hours, photographed, and analyzed for macrocharcoal particles using Otsu's image binarization method. The results were processed with the CharAnalysis program.

At the Turukhansk site, the first bog began forming 8,800 cal. BP, but no macrocharcoal particles were detected. The second bog started accumulating peat at 6,200 cal. BP. Between 6,200 and 4,500 cal. BP, three fire events were recorded, followed by a 300-year gap (around 4,200 cal. BP) with one fire event. Macrocharcoal particles were absent afterward. At the Tura site, macrocharcoal particles were found in both peat archives, which began developing at 7,800 and 7,500 cal. BP. From 7,800 to 6,000 cal.



BP, fire events occurred every 400–600 years. Between 6,000 and 5,500 cal. BP, charcoal accumulation rates decreased. In the subsequent millennium (5,500–4,500 cal. BP), fire frequency increased to one event every 400–600 years. From 4,500 to 3,700 cal. BP, fire events were absent, and charcoal accumulation rates were near zero. High charcoal accumulation rates occurred between 3,700 and 2,700 cal. BP, with fire intervals of 100–200 years. No fire activity was recorded until 400 cal. BP, after which fires became frequent again.

In the mid-Holocene (6,200–4,500 cal. BP at Turukhansk and 7,800–4,500 cal. BP at Tura), fire activity was recorded at both sites and declined around the same time. These fires were likely climate-driven, occurring during the warmest Holocene interval. Fires were less widespread at Turukhansk, being recorded in only one peat archive. Subsequently, fires were observed only at the Tura site. The 3,700–2,700 cal. BP interval aligns with a temperature increase around 3,400 cal. BP. After 2,700 cal. BP, no fires occurred until 400 cal. BP. From 400 cal. BP to the present, fires at Tura occur approximately every 100–200 years. This research suggests that wildfires during the Holocene were more frequent in the central part of the Central Siberian Plateau than in the western part.

The studies were supported by a grant of the Ministry of Science and Higher Education of Russian Federation (agreement No. 075-15-2024-554 of 24.04.2024)

Keywords: Fires, Charcoal, Holocene, Peatland

【A0897】 -Poster

Spatiotemporal evolution of wildfire activity during the Paleocene-Eocene thermal maximum in China

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The Paleocene-Eocene Thermal Maximum (PETM) was the most prominent warming event in the Cenozoic and serves as a geological analog for the current global warming driven by anthropogenic CO₂ emissions from burning fossil fuels. As a primary disruptor of Earth's ecosystems, wildfire activity affects the balance of ecosystems, the



global carbon cycle, and climate change. Therefore, studying the evolution and driving mechanisms of wildfires during the PETM is essential for predicting wildfire activity under global warming scenarios and for understanding the carbon cycle in the context of wildfire disturbances. Current research on wildfires during the PETM has mainly focused on the Northern Hemisphere, particularly Europe and North America, whereas studies on mainland China remain limited. In this study, we analyzed black carbon concentration and carbon isotope in the Beigou section of the Nanyang Basin and the Xilutian section of the Fushun Basin to reconstruct the spatiotemporal evolution of wildfires in arid/semi-arid and humid zones. We integrated these findings with those of previous studies on the paleoclimate of the research area to elucidate the driving mechanisms behind wildfire occurrences. Our results indicate that wildfire activity weakened at the onset of the PETM, with the negative carbon isotope period characterized by low wildfire activity, except for a brief resurgence in the Nanyang Basin. During the recovery phase of the PETM, wildfire activity gradually increased, returning to the pre-PETM levels. The prolonged low wildfire state was likely caused by extremely high temperatures and precipitation as well as the resulting vegetation succession. During the PETM recovery phase, increased wildfire activity transformed “short-term carbon sinks” of the biological-atmospheric carbon cycle into “long-term carbon sinks” through the burial of black carbon. This process of carbon sink conversion may have acted as a negative feedback mechanism, contributing to carbon sequestration and the eventual recovery from the PETM.

Keywords: PETM, Wildfire, Carbon cycle, Nanyang Basin, Fushun Basin



Session 27. Reconstructing intermediate circulation and water mass properties through time

Conveners: Norbert Frank, Isabelle Gil, Graeme MacGilchrist, Lélia Matos, Nazik Ogretme

【A0168】 -Oral

Stepwise evolution of Mediterranean outflow water during the past 250 kyr

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Mediterranean Outflow Water (MOW) is an important intermediate water mass of salt and heat contributing to form the North Atlantic Deep Water (NADW), thereby playing a role in modulating global climate change. Previous studies were mostly concentrated on the Gulf of Cadiz, where the MOW immediately exits from the Mediterranean, and suggested a coupling of MOW intensity to African monsoon forcing. However, regarding how the MOW changed along the northward path and interacted with the underlying NADW, it is still being highly debated. Here, by adopting the terrigenous non-cohesive “sortable silt” (10–63 μm , denote as *SS-mean*) as a reliable proxy of MOW dynamics, we present a 250-ka long record of the lower branch of the MOW strength on Site U1588 (1339 m water depth), which was retrieved from the Iberian Margin during the IODP Expedition 397. After removing organic matters and marine carbonates, the terrigenous detrital sediments were analyzed on a Malvern Mastersizer 3000 instrument. The grain-size results show a bimodal distribution of



grain size with the main mode between 5–8 μm , and can best be explained by a three endmember model. Two endmembers are characteristic of riverine and dust inputs respectively, and the other shows a tight temporal correspondence with *SS-mean*. Besides that, the significant correlation ($R^2=0.43$, $P<0.01$) between the percentage and mean value of the sortable silt fraction justifies the use of *SS-mean* as an indicator of the MOW strength. The age model is constructed by tuning benthic foraminifera oxygen isotopes tuning to the LR04 global stack, with shipboard tie-points constrained. By comparing our *SS-mean* record at Site U1588 to nearby Site 1389 and Site 1391 along the MOW's pathway but with different water depths, we suggest two phases of the MOW variability in terms of both flow intensity and prevalent depth over the past 250 kyr. It appears that the astronomical cyclicity of precession dominates flow intensity of the MOW, while its depth migration is regulated by sea level related interglacial-glacial cycles.

Keywords: Mediterranean Outflow Water (MOW), Grain size, Sortable silt, Iberian Margin, IODP Expedition 397

【A0237】 -Oral

Intermediate water circulation shifts and their role in driving paleoproductivity changes in the North Pacific

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The reconstruction of past marine biological productivity and its interactions with ocean circulation and global climate change are a key challenge to understand Earth's climate system. Episodes of high productivity drive elemental and mineralogical changes in Fe-Mn crusts, making them valuable archives for investigating past changes in ocean circulation and biogeochemical cycles. However, the relationship between export productivity in the North Pacific, phosphorus (P) cycling, and intermediate circulation modes remains limited. To explore the coupling of these processes, we present time-series bioactive element compositions and Ba/Mn ratios across periods of high-productivity from a Fe-Mn crust sample (CXD31) recovered from water depth of ~1357 m in the central North Pacific. An age model established using high-resolution magnetic scanning, authigenic beryllium (Be) isotopes analyzed on a superconducting



quantum interference device (SQUID) and an accelerator mass spectrometry (AMS), revealing a stable growth rate of 3.3 ± 1.8 mm/Myr over the past ~23 Myr. Elemental concentrations were measured using an electron probe microanalyzer (EPMA) and a laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS). Temporal variations in Ba/Mn ratios align with paleoproductivity trends from the equatorial upwelling zone (EUZ) to the central Pacific, highlighting the influence of local nutrient inputs. Correlations between Ba, Cu, Ni, and Zn concentrations and low-latitude benthic foraminiferal $\delta^{13}\text{C}$ records further connect intermediate water properties to nutrient cycling and carbon dynamics. Key circulation changes occurred during intervals of high productivity (~2.7 Ma and ~23.0–15.9 Ma), as indicated by peaks in Ba/Mn ratios and P concentrations. These findings indicate that enhanced productivity and P accumulation were driven, on one hand, by the cessation of North Pacific Deep Water (NPDW) formation, occurring prior to the intensification of oxygen-rich Antarctic Bottom Water (AABW). On the other hand, strengthened Antarctic Intermediate Water (AAIW) and increased aeolian dust input further boosted productivity during high-productivity periods. This study demonstrates a strong coupling between marine paleoproductivity, P biogeochemical cycles, and intermediate-water circulation, shedding light on the evolution of intermediate water mass properties through geological time.

Keywords: Paleoproductivity, Intermediate-water circulation, Barium, Ferromanganese crust, North Pacific

【A0518】 -Poster

Millennial-scale variations of the Holocene North Atlantic hydrology inferred from Nd isotope composition on seawater and authigenic fractions: Impact on cold-water coral reef growth at the SW Rockall Trough margin

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Variations in North Atlantic Ocean mid-depth circulation during the Holocene are poorly understood, although it is believed that they had a significant influence on the properties of water entering the Nordic Sea by redistribution of heat and freshwater. We provide new constraints for North Atlantic mid-depth circulation using neodymium isotopes (ϵ_{Nd}) analyses carried out on precisely U-Th dated coral fragments of Cold Water Coral (CWC, *L. pertusa* and *M. oculata*) and foraminifera samples from several sediment cores taken at intermediate- and deep-water depth on the SW Rockall Trough. CWC ϵ_{Nd} values varied between -12.2 ± 0.3 and -16.7 ± 0.4 . An increase in ϵ_{Nd} reflects a westward contraction of the unradiogenic mid-SPG water (~ -15), associated with a higher proportion of more radiogenic Eastern North Atlantic Water (~ -11) transported northward to the Rockall Trough by boundary currents along the European margin. The early Holocene is marked by a greater eastward extension of the mid-SPG followed by a shift from 7 to 5 ka BP toward more radiogenic ϵ_{Nd} values revealing a progressive westward contraction of the mid-SPG. During the late Holocene, ϵ_{Nd} values display millennial scale variability with eastward extensions of the mid-SPG. The strong eastward extension of the mid-SPG between 8.8 and 6.6 ka BP is associated to a climatic Holocene optimum, an increase of the Atlantic Meridional Overturning circulation (AMOC) associated to a maximum strength of the Iceland-Scotland Overflow Water (ISOW). The first step in this transition occurred around 7 ka BP and is associated with the onset of Labrador Sea Water formation and a decrease of the ISOW strength associated to a contraction of the mid-SPG, subsequently leading to a greater intrusion of saline subtropical water in the subpolar Atlantic. We have highlighted millennial variations in the eastward extension of the mid-SPG during the late Holocene corresponding to warm periods in northern Europe (e.g. the Medieval Warm Period and the Roman Warm Period). In addition, we have also demonstrated that CWC abundance is marked by a pronounced increase in the mid-Holocene (~ 6 ka) and is modulated by millennial-scale variability throughout the late Holocene. The mid-Holocene proliferation of CWC coincides with a major re-organization of the circulation at thermocline depth in the Rockall Trough. This event must have established a modern-like winter mixed layer and thermocline structure, generating suitable conditions for enhanced surface productivity, downslope transport of food particles, bottom current acceleration at mound depth and thus CWC growth. Several short time intervals of decreased CWC occurrences closely match prominent increases in North Atlantic drift ice and storminess in Northern Europe. We, therefore, propose that high



detrital supply and/or changes in the vertical density gradient associated with millennial-scale ice rafted detritus (IRD) events are the likely controlling factors for CWC growth and subsequent mound formation on the SW Rockall Trough margin.

Keywords: Cold water corals, Rockall Trough, Holocene, Nd isotopic composition, North Atlantic hydrology

【A0992】 -Oral

The temperature evolution of the Atlantic thermocline since the last glacial maximum revealed through framework forming cold-water corals

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The subtropical and tropical thermocline reflects a pseudo steady state between the equatorial upwelling of polar deep waters and the downward displacement of warm surface waters via turbulent heat diffusion and Ekman pumping. Presently the thermocline is deepening due to global warming. For the last global warming event, i.e. the end of the last glacial period, little is known about the mid-depth Atlantic response to global warming, but models predict fast and dramatic thermocline deepening and thus warming, in particular when North Atlantic deep convection is reduced. Since the LGM a 2.6°C mean global ocean warming occurred when using noble gas ratios trapped in ice cores. Climate models and tropical Karst waters imply far stronger Earth surface warming of up to 6°C. Such a discrepancy can be resolved if oceanic temperatures have large spatial variance, and if rare gases are not in steady state. In this work, the Heidelberg research team has studied the temperature history of the upper thermocline from the Azores Front in the North Atlantic to the margins off Brazil and Angola in the South Atlantic. Our findings are based on the Li/Mg thermometer in cold-water corals. Hundreds of precisely dated cold-water coral have been studied in cooperation with numerous partners world-wide. The coral samples were collected from 300-1200 m water depths. The mean temperature increase since the LGM corresponds to 5-6°C and the thermocline deepened by hundreds of meters. The southern hemisphere reveals a particular fast warming 17.0 ka ago, while the northern Atlantic followed with fluctuating warming and thermocline deepening starting some 15 ka ago and ending some 11.5 ka ago. The observations support the oceanic climate seesaw proposed by Stocker and Johnson in 2003. While the picture



of the thermocline temperature evolution still remains fragmented, post glacial warming is less important surrounding the Azores Front thus in the region dominated by wind driven Ekman pumping.

Keywords: Thermocline warming

【A1017】 -Poster

Mapping the thermocline ocean Nd-isotope composition over the past 60 ka

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Neodymium isotopes, here the $^{143}\text{Nd}/^{144}\text{Nd}$ ratio expressed as ϵ_{Nd} , have been used to fingerprint water masses through the Atlantic and to study climate driven changes of water mass provenance. In 2006 it was first demonstrated by van de Flierdt and coworkers that cold-water corals can trace the Nd isotope composition of the mid-depth seawater in which they bath. Subsequently, the Nd-isotope toolbox has been further refined and explored to study the temporal and spatial changes of water masses in the Atlantic and Mediterranean Sea. The number of studies and the time resolution, however, is still limited. In this synthesis, we explore the mid-depth waters latitudinal mean isotope composition and its total variance. Samples originate mostly in the eastern Atlantic and span about 300 to 1200 m water depth and cover 60 ka. The Nd isotope composition of cold-water corals spans a vast range of ϵ_{Nd} from as high as -3 to as low as -20. The eastern Atlantic reveals two centers of unradiogenic Nd contributions, one off Angola and Brazil (0-20°S) and the other related to the Labrador Sea (50-70°N). Centers of radiogenic Nd contributions are the South Atlantic (south of 40°S), the water masses influenced by either active seafloor volcanism (Azores) and the spreading Mediterranean Sea Water (20-30°N). Lastly the waters entering the Arctic Ocean (>60°N) off Iceland reveal radiogenic contributions to the otherwise unradiogenic North Atlantic. The regional zonal and/or time variance can be as high as 5 epsilon units. In cases this variance is associated to climate driven changes of the circulation, in others it is more likely related to changing local Nd fluxes and isotope



exchange from volcanism and hydrothermal activity, river runoff, and dust fluxes. Consequently, cold-water corals permit tracing the upper ocean Nd isotope composition, its vast variance in space and time and its redistribution. The present observations highlight multiple unradiogenic and radiogenic Nd sources to the mid-depth ocean. Thus, the spatio-temporal variance is elevated if compared to the underlying deep ocean isotope composition, which however nevertheless mimics the upper layer mean Nd isotope composition as expected from reversible scavenging. Finally, the Nd isotope patterns clearly highlight that the subsurface circulation does not allow to effectively homogenize the different ocean basins via the large-scale recirculation pathways.

Keywords: Thermocline ocean, Neodymium isotopes, Sources and sinks

【A0499】 -Poster

Mg/Ca-based Southern Ocean temperature reconstructions during mid-Miocene

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The Miocene Climate Optimum (MCO, ~17–15 Ma) represents the warmest interval of the Neogene period. During the MCO, atmospheric CO₂ levels are estimated to have varied between ~400 ppmv and ~1000 ppmv. However, reconstructions of sea surface temperatures (SSTs) and deep ocean temperatures (BWTs) during the MCO are limited. This study reconstructs SSTs and BWTs in the Southern Ocean during the MCO and compares them with existing temperatures from global oceans in the same period. SSTs were produced from Mg/Ca ratios in planktonic foraminifera (*Globigerina bulloides*), while BWTs were inferred from Mg/Ca ratios in benthic foraminifera (*Melonis sp.*). The planktonic and benthic foraminifera were collected from ODP Site 1170 on the flank of the South Tasman Rise (~55°S paleolatitude at 15 Ma). Our results suggest that during the MCO, SSTs were ~17°C and BWTs were ~9°C. Compared with the modern SSTs and BWTs at the same position, both reconstructed temperatures are higher. Furthermore, the surface-to-deep ocean temperature gradient in the Southern Ocean decreased from ~10°C to ~5°C in the MCO.

Keywords: Paleoceanography, Miocene Climate Optimum, Southern Ocean



【A0144】 -Poster

Radiocarbon evidence of a North Atlantic intermediate water reconfiguration between the 1960s and 1980s

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The Atlantic Meridional Overturning Circulation (AMOC) is a critical modulating component of the Earth's climate system, therefore, documenting the timing and amplitude of AMOC variability since the Industrial Era is essential for understanding future climate. However, there are very few continuous high-resolution records from this time period in the subsurface ocean which restricts us from exploring the nature of changes in the ocean interior. Here, we present new seawater radiocarbon (^{14}C) records of intermediate depth water (between 1400 m and 2000 m) for the Industrial Era since 1830 CE obtained from the calcitic skeleton of four cold-water bamboo corals from the tropical Atlantic. These samples were collected in 2013 with lifespans ranging from 64 to 161 years. No bomb ^{14}C was detected in the calcitic skeleton, indicating that the tropical intermediate North Atlantic had not yet been invaded by bomb ^{14}C at the time of collection. The data show a relatively constant $\Delta^{14}\text{C}$ before 1960 CE with a synchronous basin-wide increase in ^{14}C content reached by 1980 CE. The stepwise shift in $\Delta^{14}\text{C}$ may be explained by the North Atlantic Deep Water (NADW) becoming shallower in the tropical North Atlantic and/or a southward retreat of Antarctic Intermediate Water (AAIW), in either case potentially linked to a weakening of AMOC. Our study indicates synchronous large-scale oceanic reconfiguration occurred throughout the tropical and North Atlantic starting in the 1960s and that there has been no subsequent return to the state of the pre-mid-20th century oceanic interior.

Keywords: Atlantic Meridional Overturning Circulation (AMOC), Cold-water corals, North Atlantic Deep Water, Antarctic Intermediate Water

【A0050】 -Poster

Atlantic intermediate circulation and heat transfer during the last glacial



period: A cold-water coral record

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The Atlantic Meridional Overturning Circulation (AMOC) redistributes heat and salt, but also oxygen and carbon, throughout the Atlantic. The system is known to change in strength and (water-mass) configuration alongside the major orbital and millennial-scale climatic changes. During the last glacial period, significant changes in the AMOC had a profound impact on the (inter)hemispheric heat transfer. Tropical West Atlantic studies indicate decreased surface temperatures, accompanied by increased subsurface temperatures, most significantly during millennial-scale glacial stadials. On the other hand, deep-water temperatures decreased by around 2°C. These glacial AMOC changes led to increased export of polar waters towards the Equator and enhanced subsurface ocean stratification, thereby affecting the global heat transfer dynamics. Nevertheless, to better understand glacial circulation changes we should also consider intermediate-depth waters.

The intermediate (300-1500 m) ocean depths host several ecosystem-engineering cold-water coral species, which have inhabited numerous Atlantic areas for the last hundred thousand years. Their calcium carbonate skeletons are nicely preserved in the geologic record and several coral proxies enable the reconstruction of the intermediate-depth histories. Here, we reconstruct intermediate water temperature and water provenance at 700m water-depth in the subtropical northwest Atlantic (Florida Strait) since the last glacial period. Furthermore, coral trace element ratios (Li/Mg) and neodymium isotopes (ϵ_{Nd}) records are combined with other available Atlantic data to help clarify how orbital and millennial-scale climatic changes affected these ocean depths.

Our record shows decreased intermediate-depth glacial temperatures, in line with previous findings for the glacial thermocline waters in the Atlantic, reinforcing the



previously proposed scenario of increased glacial export of polar waters towards the Equator and enhanced subsurface ocean stratification. Consequently, Atlantic intermediate waters were insignificant for the (inter)hemispheric heat transfer during this period. Our ϵ_{Nd} record further supports this glacial increased export of southern sourced waters to the (tropical and) subtropical West Atlantic, except during the glacial stadials: Younger Dryas, Heinrich Event (HE)1 and – possibly – HE2. On the contrary, southern sourced waters were previously suggested to have increased in the tropical East Atlantic exactly during (at least) one of these glacial stadials (HE2). Thus, an apparent East-West seesaw on the export of southern source waters during the last glacial stadials could be suggested, although more data is necessary to confirm.

In sum, despite the change in Atlantic water mass geometry that occurred during the last glacial, the poleward heat transfer was (apparently) not affected. However, not much is known regarding the effect on carbon and oxygen transfer. Further paleo records and an increased geographical resolution are needed to better constrain the role of the intermediate circulation on the global Ocean change.

Keywords: Neodymium-isotopes, Li/Mg-thermometry, Cold-water corals, Intermediate-Depth Circulation, Glacial-interglacial cycles

【A0477】 -Oral

Antarctic intermediate water transport changes in the SW Atlantic over the last 45,000 years based on sortable silt and metal/ratios

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Off the southeastern Brazilian continental margin, the Antarctic Intermediate Water (AAIW) is transported northwards by the Intermediate Western Boundary Current (IWBC). Here we evaluate IWBC's flow speed changes in the last 45,000 years based on sortable silt (SS) variations of four sediment cores retrieved from the SW Atlantic continental slope (~25°S). Our results confirm the suitability of SS as a reliable past flow speed proxy in the study area, enabling us to recognize the interaction complexity



between the IWBC and regional oceanographic processes. The cores, retrieved from depths between 840 m and 1558 m, reveal distinct sedimentation rates and grain-size distributions reflecting the hydrodynamic conditions associated with the IWBC and Deep Western Boundary Current (DWBC). The shallower core (retrieved at 840 m water depth) presented the highest flow speeds, decreasing from 22 cm s^{-1} at 40,000 cal BP to 18 cm s^{-1} at around 23,000 cal BP. However, the cores retrieved at 1343 and 1558 m maintained lower but stable speeds (3 to 7 cm s^{-1}). Higher sedimentation rates in the 1469 m core were accompanied by more flow speed variability, with increased flow speeds coinciding with Heinrich stadials 1, 3, and 4 and the Younger Dryas. Further corroborated by the correlation between $\text{Ln}(\text{Zr/Rb})$ and $\text{Ln}(\text{Zr/Ti})$ values and SS. Additionally, over the last 45,000 years, estimated paleo-speeds remained within modern velocity ranges of the IWBC and DWBC, suggesting no significant vertical displacements occurred. We hypothesize that the increase in intermediate water flow speeds during these Northern Hemisphere abrupt climatic events was a response of an intermediate regional hydrodynamic feature to an Atlantic Meridional Overturning Circulation slowdown.

Keywords: Intermediate western boundary current, SE Brazil, Continental slope, Paleocurrent

【A0584】 -Poster

Radiocarbon constraints on North Indian deep ocean ventilation and deglacial carbon dioxide release

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Late Quaternary Indian Ocean circulation evolution and its role in carbon cycle dynamics remain poorly constrained. Here, we reconstructed the radiocarbon ventilation history of the North Indian Ocean over the past 30 kyr BP, using core I106



at the Ninetyeast Ridge. The results show higher ^{14}C ventilation ages (Benthic-Atmospheric ^{14}C offsets reaching ~ 3000 yrs in average) during the last glacial period than nowadays, indicating that deep-water ventilation of the glacial North Indian Ocean was reduced and Indian Deep Waters (IDWs) were part of the glacial aged carbon pool. They also present a rapid rise in ventilation of IDWs during late Heinrich Stadial 1 and the Younger Dryas event, consistent with existing stable isotope data and Nd isotope trends that imply an enhanced inflow of well-ventilated, low- CO_2 North Atlantic Deep Water (NADW) into the North Indian Ocean. The increase in ventilation of IDWs and NADW incursion would have caused a shift of the deep-ocean carbon pool with evidence of degassing from the North Indian Ocean. Together with ^{14}C ventilation records in the Indian sector of the Southern Ocean, it can be inferred that portions of deep Indian Ocean carbon pool were likely transferred via the IDW transport southward and subsequently released to the atmosphere from the Southern Ocean. These findings highlight that part of ^{14}C -depleted, CO_2 -rich IDWs contributed to the rapid rise in deglacial atmospheric CO_2 via a Southern Ocean link.

Keywords: Radiocarbon ventilation, Indian Ocean, Carbon sequestration, Foraminifera, Late Quaternary

【A0809】 -Oral

Deglacial and Holocene evolution of the North Pacific Upper and Intermediate Ocean Circulation

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Variations in the northward circulation in the upper ocean and southward transport of intermediate water critically alter the vertical structure of ocean water at the basin scale in the North Pacific. The complex physical and biogeochemical conditions resulting from the combined effects of distinct water masses might lead to controversies regarding paleoenvironmental interpretations. Although many studies of KC dynamics have been carried out, the change in KC intensity during the Holocene is still debatable. Single-cell microzooplankton, such as radiolarians, are highly sensitive to environmental changes and water properties as a proxy to reconstruct the



evolution of water structure at various depths. In this study, we analyze the high sedimentation rate and complete sedimentary history of the OT and reconstruct the vertical structure of the OT water and its evolutionary patterns by using characteristic radiolarian assemblage changes at shallow to deep-water depths, in order to unravel the dynamic changes in North Pacific upper and intermediate ocean circulations (KC and NPIW) since the last deglaciation on the basis of biogenic records from the OT. This study provides robust data and a new perspective for understanding the connection to deglacial and Holocene variability in North Pacific upper and intermediate ocean circulation.

Keywords: Last deglacial-Holocene, Kuroshio current, North Pacific Intermediate Water, Radiolarian proxy

【A0677】 -Oral

Millennial reorganizations of ocean circulation of the North Pacific during the last deglaciation

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Millennial-scale variations in atmospheric CO₂ concentrations during the last deglaciation are partly attributed to the sequestration and release of respired carbon in the deep ocean. The deep North Pacific, which stores a significant amount of respired carbon, is a crucial factor influencing changes in atmospheric CO₂ concentrations. However, our understanding of millennial-scale changes in respired carbon in the deep North Pacific remains insufficient. Here, we present a high-resolution, well-dated record of respired carbon changes in the subtropical North Pacific from 10 to 24 ka. Our data indicate increased storage of respired carbon in the subtropical North Pacific during the Last Glacial Maximum, late Heinrich Stadial 1 (HS1), and Bølling-Allerød (BA), and release during early HS1, the onset of BA, and the Younger Dryas, which is synchronous with the stepwise changes in atmospheric CO₂. The variations in respired carbon in the subtropical North Pacific during the last deglaciation were regulated by the reorganization of ocean interior circulation and surface productivity in the North Pacific. We suggest that the North Pacific, in concert



with the Southern Ocean and the Atlantic, played a role in driving the continuous millennial-scale changes in atmospheric CO₂ concentrations and the Earth's transition out of the glacial period. Millennial-scale variations in atmospheric CO₂ concentrations during the last deglaciation are partly attributed to the sequestration and release of respired carbon in the deep ocean. The deep North Pacific, which stores a significant amount of respired carbon, is a crucial factor influencing changes in atmospheric CO₂ concentrations. However, our understanding of millennial-scale changes in respired carbon in the deep North Pacific remains insufficient. Here, we present a high-resolution, well-dated record of respired carbon changes in the subtropical North Pacific from 10 to 24 ka. Our data indicate increased storage of respired carbon in the subtropical North Pacific during the Last Glacial Maximum, late Heinrich Stadial 1 (HS1), and Bølling-Allerød (BA), and release during early HS1, the onset of BA, and the Younger Dryas, which is synchronous with the stepwise changes in atmospheric CO₂. The variations in respired carbon in the subtropical North Pacific during the last deglaciation were regulated by the reorganization of ocean interior circulation and surface productivity in the North Pacific. We suggest that the North Pacific, in concert with the Southern Ocean and the Atlantic, played a role in driving the continuous millennial-scale changes in atmospheric CO₂ concentrations and the Earth's transition out of the glacial period.

Keywords: North Pacific Intermediate Water, North Pacific Deep Water, Millennial-scale variations



Session 28. Southeast Asian monsoon evolution during the Quaternary: Records, synthesis and model results

Conveners: Harunur Rashid, Shengfa Liu, Rong Xiang, Yang Wang

【A0158】 -Oral

Late Quaternary record of Indian Summer Monsoon from the northeastern Indian Ocean

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We investigated planktonic foraminifera, pteropods abundances and their isotopic, elemental compositions of cores retrieved from the Bay of Bengal and the Andaman Sea to document the Indian Summer Monsoon variability during the late Quaternary. The northern Bay of Bengal and the Andaman Sea receive a massive amount of rain and river discharge during summer, resulting in strong stratification and pervasiveness of oligotrophic conditions, which are reflected in the planktonic foraminifera distribution, providing an opportunity to study the effect of monsoon forcing and stratification history. The cores analyzed span from a few kilo years to 1.2 million years documenting centennial–millennial–orbital scale changes in the evolution of the Indian Summer Monsoon. The monsoon records show periods of intensified monsoon periods have witnessed lower productivity, similar to prevalent oceanographic conditions in the study area. The prominent stratification events were observed during interglacial periods whereas periods of enhanced productivity and well-ventilated water column were observed during glacial periods. During the last glacial cycle, strong stratification and intense ISM were seen during MIS 3 and Bølling/Allerød (B/A). Indian Summer Monsoon was strong during the Eemian interglacial and early to mid-Holocene which slowly muted upwelling and productivity. The intense Summer Monsoon periods have resulted in poor preservation of pteropods. The better preservation and abundance of pteropods are observed during glacial periods marked by weak stratification and well-ventilated water column. Overall, the late Quaternary productivity variations are primarily modulated by salinity-related stratification and have been controlled by variations in the northern hemisphere insolation, internal forcings, Atlantic teleconnection on Heinrich and D/O time scales and shifting



feedback associated with the summer-winter monsoon interaction.

Keywords: Indian Summer Monsoon, Planktic foraminifera, Productivity, Stratification, Andaman Sea

【A0833】 -Poster

The climate-driven mechanisms of sedimentary evolution in the mud area southwest off Cheju Island during the Holocene

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Southwestern Cheju Island Mud (SWCIM), located on the northern part of the East China Sea (ECS) outer shelf, serves as an important sink that has retained high-resolution sedimentary records from the Holocene. However, the sediment sources and formation mechanisms of SWCIM remain unclear. This study utilizes clastic mineral and benthic foraminiferal records from both the interior and periphery of the mud area, in conjunction with sedimentation rate distributions, to investigate the mechanisms of sediment supply, transport, and deposition in response to climate and the associated ocean currents change. The results indicate that the sediments in the SWCIM primarily originate from resuspended sediments of the (Old) Huanghe River. Since the Holocene, these resuspended sediments have been gradually transported by tidal currents transitioning to the Yellow Sea Coastal Current (YSCC). The intensity of the East Asian winter monsoon (EAWM) and its driven coastal currents predominantly control the sediment supply to the SWCIM. Variations in the strength of the Yellow Sea Warm Current (YSWC) and the YSCC driven by Holocene climate change can influence the position and trapping efficiency of vortex systems, thereby facilitating the formation and shift of depocenter during different periods. This study reveals the critical role of climate change and the associated variations in ocean currents in the sedimentary evolution of mud area, providing a scientific basis for understanding and predicting future changes in marine environments.

Keywords: Yellow Sea Warm Current, Yellow Sea Coastal Current, Climate change, East Asian monsoon

【A0268】 -Poster



Orbit-induced rainfall dipole pattern in South Asia over the past 425 ka

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On decadal, centennial, and millennial timescales, South Asian Summer Monsoon (SASM) precipitation often exhibits distinct dipole patterns, characterized by significant east-west or north-south spatial variations. However, the persistence of these spatial differences in monsoon precipitation over longer orbital timescales remains uncertain. To investigate this issue, we conducted a series of equilibrium simulations using the NorESM-L model, spanning the past 425 ka, to assess the sensitivity of precipitation to various potential forcings.

Our findings, consistent with previous research, indicate that the strength of the SASM is predominantly influenced by northern hemisphere summer insolation. A northward shift in the ascending core of the Hadley circulation further modifies the spatial distribution of precipitation across South Asia on orbital timescales. Generally, during periods of strong (weak) SASM associated with high (low) northern hemisphere summer insolation, simulated precipitation in northern South Asia is significantly higher (lower) compared to the southern region. These results partially align with existing geological records and support the presence of a north-south dipole precipitation pattern in South Asia. This temporal and spatial variability in precipitation within the South Asian monsoon domain underscores the complex hydrological dynamics at play, suggesting that higher precipitation does not necessarily correlate with higher temperatures on orbital timescales. These insights challenge the contemporary understanding of synchronized precipitation and temperature patterns in the South Asian monsoon region, revealing a more intricate relationship that warrants further investigation.

Keywords: South Asia, Precipitation, Dipolar pattern, Orbital scale

【A0389】 -Poster

Indian monsoon activity in the Northeast Indian Ocean since the Middle Pleistocene and its influence on the dissolution of foraminifera shells



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Indian monsoon is a large-scale, highly active ocean-atmosphere-land interaction system, which affects the livelihood and agricultural production of more than one billion people. Thus, understanding the evolution of monsoon climate change throughout geological history is of significant practical importance.

The IODP 353 Expedition recovered deep-sea sediments from sites in the Northeast Indian Ocean, to reconstruct changes in Indian monsoon circulation and rainfall patterns. In this study, two IODP 353 sites drilled in the Bay of Bengal (BOB) and Andaman Sea, the core rainfall area of Indian monsoon, were selected. We analyzed foraminifera assemblages, total organic carbon (TOC), TOC/nitrogen ratio and biosilicon content in sediment samples, and combined with previous results of the stable oxygen isotope ratios, Mg/Ca ratio of foraminifera shells, and biomarker TEX₈₆.

At Site U1446 in the Northwest BOB, we observed a clear and variable dissolution of carbonate above the lysocline following the Middle Pleistocene Transition (MPT). Our findings suggest that variations in Summer Monsoon intensity are a key controlling factor of supra-lysocline carbonate dissolution in this region. We also compared paleo-surface sea temperature (SST) derived from Mg/Ca ratio of planktonic foraminifera *Globigerinoides ruber* with the SST estimates from the biomarker TEX₈₆, alongside carbonate dissolution indices such as the planktonic foraminifera fragment index and SEM imaging of foraminifera shell structure. Our results show the impact of carbonate dissolution on the SST reconstructions based on the Mg/Ca ratio of foraminiferal shells. We reconstructed sea surface paleosalinity and paleoproductivity in the study area since 1.45 Ma, and examined the evolution processes of the Indian monsoon on different timescales. Our results indicate that the variations in the Indian Summer Monsoon in this region cannot be simply characterized as periods of strengthening or weakening. Rather, they exhibit more complex features, influenced by both regional dynamics and periodic change in global climate.



Keywords: Bengal/Andaman Sea, Foraminifera, Late Quaternary, Carbonate dissolution, Indian monsoon

【A0570】 -Poster

The vital role of vegetation cover in shaping East Asian Summer Monsoon changes during the late Pliocene warm period

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The late Pliocene warm period is the most recent geological warm period with atmospheric CO₂ concentrations similar to today's (~405 ppm) but higher than the modern reference pre-industrial period (280 ppm), and with different vegetation and ice cover. Both CO₂ concentrations and vegetation cover could impact the global and regional climate, but their relative roles in the East Asian Summer Monsoon aren't well understood. In this study, we assess the influences of vegetation change and CO₂ enhancement on the East Asian Summer Monsoon during the late Pliocene through sensitivity experiments. Compared to the modern reference pre-industrial period, the Summer Monsoon intensified with a meridional dipole pattern of the summer precipitation change over East China during the late Pliocene. Changes in vegetation and ice sheet play a major role in the East Asian summer climate change, while the elevated CO₂ plays a minor role. Compared to the modern reference pre-industrial period, the late Pliocene vegetation would cause a dipole pattern of the surface albedo change, which increases at 50–65°N and decreases at 30–50°N. Correspondingly, the thermal structure over East Asia changed, with the tropospheric warming being greater over mid-latitudes than other latitudes, driven primarily by the albedo feedback and secondarily by other climate feedbacks. The vegetation-induced adjustment of the thermal structure over East Asia could enhance the Summer Monsoon and northward water vapour transport via diabatic heating. Furthermore, this could potentially lead to a change in dipole pattern of summer precipitation over East China due to the secondary circulation induced by the poleward shift of the westerlies. The vegetation cover plays a crucial role on the variation of the East Asian



Summer Monsoon during the late Pliocene based on our sensitivity experiments. We should pay attention to the vegetation feedback in the future warming world.

Keywords: Pliocene, Vegetation, East Asian Summer Monsoon

【A0940】 -Poster

The origin of the modern-like East Asian monsoon: Insights from new data synthesis and climate modelling work

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It is debated as to whether the modern-like East Asian monsoon formed during the late Oligocene–early Miocene or the Eocene. Here, we investigate Cenozoic climate patterns over East Asia by compiling geological records and conducting climate modelling based on improved paleogeographies. Our results show that a zonal (semi-)arid climate pattern was dominant in East Asia over tectonic timescales during most of the Paleogene, with humid conditions restricted to the southernmost and northeastern China, and that a modern-like monsoon-dominated climate pattern formed since the late Oligocene–early Miocene (~28–22 Ma). Our simulations further indicate a strong sensitivity of East Asian rainfall to orbital forcing, which can explain the seemingly unstable character (wet–dry fluctuations) of the dry belt across East Asia during the Eocene. Furthermore, our results suggest that paleogeographic changes, rather than atmospheric CO₂ levels, played a crucial role in the establishment of the modern-like East Asian monsoon.

Keywords: East Asian monsoon, Geological records, Paleoclimate modelling, Cenozoic

【A0674】 -Poster

Study on influences of calcification intensity of planktonic foraminifera in modern South China Sea

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Anthropogenic carbon dioxide has been accumulated in ocean, leading to growing acidification of sea water and prominent change in marine carbonate systems. These changes could affect the calcification of marine calcareous organisms, causing unexpected changes in marine calcite production and marine “carbonate pump”, which is vital to the global carbon cycle. The specific influencing factors of their calcification intensity is in dispute now. Three species of planktonic foraminifera, *Neoglobobulimina dutertrei*, *Globigerinoides ruber* and *Globigerinoides sacculifer*, are choosed to measure their size normalized weight (SNW) as a proxy of their calcification intensity. A total of 58 samples captured by a time series sediment trap TJ-A-1 at 500m water depth in South China Sea from 2015 to 2018 are used to study the possible response of planktonic foraminifera calcification to climate change. By correlative and regressive analysis between environmental factors and SNW, this study analyze the specific factors affecting the calcification process of planktic foraminifera of different species in detail. Seasonal variation and mutation around the end of big El Nino event are found in foraminiferal calcification. This research underscores the complex interplay between environmental factors and calcification, highlighting the need for region-specific analysis when studying the impact of climate events like El Niño on marine organisms.

Keywords: Planktonic foraminifera, Size-normalized weight, Calcification, Carbonate production

【A0133】 -Poster

Warming-induced changes of dry-wet boundary in northern China

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The response of vegetation to past global warming, as revealed by geological records,



can provide insights into future changes. We used a detailed compilation of published pollen records to produce dry-wet boundary changes across northern China for the Last Glacial Maximum (LGM), mid-Holocene, Last Interglacial (LIG), and mid-Pliocene, representing major changes in global temperature. The results showed that in the region east of 110°E, the trend of the dry-wet boundary rotated anticlockwise by around 30°, 5° and 10°, during the warm periods of the mid-Holocene, LIG, and mid-Pliocene, relative to the LGM, mid-Holocene, and LIG, respectively. The climate simulation results also showed the successive anticlockwise rotation of the trend of the boundary in response to global warming, which is roughly consistent with geological records from this region. Contrary to the warming-induced northwestward shift observed in the boundary in the region east of 110°E, the boundary in the region west of 110°E showed a complex pattern of temporal changes: the boundary remained stationary during the mid-Holocene compared with the LGM, while it shifted northward during the LIG relative to the mid-Holocene, and it shifted southward during the mid-Pliocene relative to the LIG.

Our results demonstrate an enhanced east-west climatic contrast in northern China with increase global temperature. The climate simulation results also indicated that the western Pacific subtropical high shifted northward and extended westward with global warming, thereby inducing a northwestward shift in the East Asian subtropical monsoon. Overall, our results suggest that the eastern region of northern China will become wetter under a warmer climate, which will promote the shrinkage of sandy deserts in the region.

Keywords: Dry-wet boundary, East Asian Summer Monsoon, Past global warming, Northern China, Spatial climate pattern

【A0349】 -Poster

Vegetation and climate changes in western Yunnan, China since the Last Glacial Maximum

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Western Yunnan, located to east of the Tibetan Plateau, is characterized by a diverse



terrain that includes plateau surfaces, alpine and lake basins. In contrast to plains, mountainous areas experience significant variations in temperature, humidity, and vegetation, thus mountain ecosystems are particularly sensitive to climate change. In this study, a 14.56-m-long core and a 10.6-m-long core were recovered from Lake Tianchi (core YL; 25°52.4'N, 99°16.8'E, 2550 m above sea level (a.s.l.)) and Lake Ximenlongtan (core XMLT-1; 22°38.4'N, 99°35.8'E, 1140 m a.s.l.), respectively. Additionally, we collected 45 surface soil samples along an altitudinal transect from 780 to 3000 m a.s.l. in the Gaoligong Mountains to establish relationship between vegetation and pollen assemblage. A total of 42 AMS ¹⁴C dates were used to build age models, and pollen analyses were carried out on samples from lake sediments and soils.

The results show that core YL spans the last 23 ka, while core XMLT-1 covers the last 9.4 ka. Around Lake Tianchi, the *Tsuga dumosa* forest zone migrated at least 650 m upward from 23 to ~7 ka, indicating a gradual increase in mean annual temperature exceeding 3.9 °C. In response to this warming, there was a successive colonization of different tree communities: grass and deciduous broadleaved trees dominated from 23 to 15 ka; warm deciduous broadleaved trees prevailed from 15 to 8 ka; and finally, warm coniferous trees (primarily *Tsuga dumosa*) and subtropical evergreen broadleaved trees dominated from 10 to 5 ka. After 5 ka, there was an increase in deciduous trees and grass, while evergreen trees decreased. Around the Lake Ximenlongtan area, tropical evergreen broadleaved trees dominated from 9.4 to 5 ka. However, after 5 ka, subtropical evergreen trees and grass increased at the expense of tropical evergreen trees.

At both sites, a significant shift in vegetation took place ~5 ka. The concurrent decline of subtropical evergreen trees around Lake Tianchi and tropical evergreen trees around Lake XMLT suggest a notable cooling event in western Yunnan, highlighting a trend toward decreasing monsoon intensity.

Keywords: Yunnan, Pollen records, Vegetation, Climate change

【A0566】 -Poster

Decadal causes of the Wanli megadrought in northern China during the Ming Dynasty: Perspectives from tropical and polar regions

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Climate change has profound implications for the social stability and societal crisis. The prominent Wanli megadrought (1585–1590 CE) had a profound impact on northern China and may have contributed to the collapse of the Ming Dynasty. Despite its historical significance, the underlying mechanisms of the Wanli megadrought remain unclear. This study combines reconstruction and CESM Last Millennium Ensemble (CESM-LME) simulation to investigate the decadal-scale evolution of the Wanli megadrought. The reconstructed summer precipitation over much of northern China reveals a decadal Wanli megadrought period during 1581 and 1592 CE. The simulation reasonably reproduces the Wanli megadrought and associated climate fluctuations preceding and succeeding it on a decadal timescale. During the Wanli megadrought, simulated summer precipitation decreased from the Yangtze River to northern China, accompanied by anomalous air subsidence and a weakened eastward-shifted western North Pacific subtropical high (WPSH). These circulation anomalies during the Wanli megadrought were driven by warming over the Maritime Continent and cooling over the Arctic Seas on a decadal timescale, as evidenced by proxy data and simulation. Warming over the Maritime Continent caused the weakening and eastward retreat of the WPSH through its influence on the decadal Pacific–Japan-like Rossby wave trains. Cooling over the Arctic Seas and loss of sea ice in Barents Sea contributed to anomalous air subsidence over the northern China via a Rossby wave train that propagated southeastward. Perspectives from tropical and polar regions would benefit our understanding of the Wanli megadrought in northern China during the Ming Dynasty on a decadal timescale.

Keywords: Wanli megadrought, Northern China, Maritime continent, Barents Sea sea-ice, Ming dynasty collapse

【A1027】 -Poster

50 kyr of water column stratification related to the Kuroshio Current and the East Asian monsoon (Core MD103264)

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The South China Sea is one of the major marginal seas in the world and is located in the tropical region, making it an important area for tropical climate and monsoon systems. The sedimentary environment and sediment supply in the South China Sea are stable, making it an ideal area for studying paleoclimate change. The core MD103264 (119.33°E, 21.54°N, water depth 2890 m) is approximately 23 meters long and was taken from the northern slope of the South China Sea near Taiwan Island. The reconstructed age model shows that the core covers a time span of approximately 50,000 years. This core mainly receives sediments from Taiwan, and because the Kuroshio Branch, influenced by the hydrological conditions of the equatorial Pacific, intermittently invades the South China Sea and flows through the core area, the sediment records from this region can appropriately reflect long-term changes in the Kuroshio Branch. This study analyzes the surface dwelled planktonic foraminifera species *Globigerinoides ruber* and the subsurface dwelled species *Pulleniatina obliquiloculata* fossil shells in the core. By measuring their stable carbon and oxygen isotopes and Mg/Ca ratios, we can obtain sea surface and subsurface temperature records for the past 50,000 years, as well as long-term variations in water oxygen isotopes that reflect seawater salinity changes. The results, compared with other reconstructed core records from the surrounding South China Sea, help us understand the climatic changes in the South China Sea and its surrounding areas during the alternation of glacial and interglacial periods, thereby inferring the global climate change patterns. Furthermore, it can reveal changes in monsoon intensity and persistence, and how these changes have influenced the climate patterns of the Asian continent, helping us understand the climate fluctuations over the past several thousand or tens of thousands of years.

Keywords: South China Sea, Kuroshio current, East Asian monsoon

【A0174】 -Oral

Monsoon activity and paleoceanographic responses in the southwestern Andaman Sea since 1.45 Ma

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The Indian Summer Monsoon (ISM) is a crucial component of interhemispheric heat and moisture transport, importantly influences socio-economic activities in South Asia through complex ocean-atmosphere land interactions. Although highly significant, the long-term variability of the ISM and associated paleoenvironmental responses remain poorly understood. The different feedbacks of various monsoon indices to orbital forcing changes underscore the necessity for further research. Modern oceanographic observations reveal a positive correlation between the salinity difference in the Andaman Sea and the Bay of Bengal (BoB) and southwest monsoon intensity. The productivity in the Andaman Sea is influenced not only by the regional water structure shaped by southwest monsoon activity but also by the nutrient-rich Southwest Monsoon Current from the Arabian Sea. Using planktonic foraminifera assemblage records from sediment samples at Site U1448 of the International Ocean Discovery Program (IODP) Expedition 353, we reconstructed paleosalinity and paleoproductivity changes in the Andaman Sea since 1.45 million years. Comparative analysis with Site U1446 in the northwestern BoB, allowed us to evaluate ISM evolution and its impact on regional paleoceanography. Before the mid-Pleistocene transition (MPT), paleoproductivity at Site U1448 was lower, whereas the paleosalinity difference between Site U1448 and Site U1446 was higher. This elevated salinity difference likely reflects a northward shift of the Intertropical Convergence Zone (ITCZ) rainfall belt, caused by a reduced interhemispheric thermal gradient resulting from lower obliquity, rather than strong monsoon activity. In the post-MPT period, paleosalinity difference between these sites increased, and productivity at Site U1448 rose, coinciding with the restoration of obliquity, global ice volume expanded, increasing the cross-equatorial pressure gradient between the hemispheres and re-strengthening ISM. Our spectral analysis indicate that ISM was primarily regulated by the obliquity and related heterodynes during the pre-MPT period, while the salinity gradient and productivity proxies show eccentricity and related extension cycle and precession cycles during the post-MPT period. This shift highlights a transition in the ISM's external forcing mechanisms from obliquity to precession cycles, and underscores the strong modulation of the ISM and the associated paleoceanographic environment by internal forcing of the Earth's system.



Keywords: Indian monsoon, Andaman Sea, Mid-Pleistocene Transition, Planktic foraminifera, Quaternary

【A0717】 -Poster

Evolution of Indian monsoon precipitation and vegetation dynamics in the Bay of Bengal region since the last glacial period

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The Indian Summer Monsoon (ISM) is among the most sensitive weather systems in the world and influences one-quarter of the world's population. However, the long-term variability of ISM precipitation from the last glacial to the present remains a subject of major debate. In this study, we reconstruct high-resolution palynological records from two sediment cores in the Bay of Bengal (BoB) to shed light on changes in regional vegetation and ISM precipitation since ~48 ka BP. Using principal component analysis (PCA), we highlight how climatic conditions and transportation pathways influence sporopollen variations. Our findings reveal that pollen and fern spore concentrations, indicative of terrestrial vegetation, decrease with increasing distance from the coast, primarily reflecting inputs from the Ganges-Brahmaputra (G-B) river basins. Significant shifts in pollen records around 40.5 ka and 12 ka ago suggest notable changes in hydrodynamic forces and heavy precipitation, signaling strong ISM activity. Data from the E87-32B core during the early to middle Holocene of MIS 1 show that ISM precipitation was greater than during MIS 3, likely influenced by summer solar insolation (SSI). From the Last Glacier Maximum (LGM) to the middle Holocene in MIS 1, marking the transition from the last glacial to the interglacial, the region experienced a transformation from extensive herbaceous vegetation to tropical and subtropical broadleaved forests, followed by different fluctuations in ISM precipitation in two cores. According to the YDY10 broad-leaved forest data, three low values correspond to H1, YD, and 8.2 ka cold and dry events, respectively, consisting of Atlantic meridional overturning circulation (AMOC) variation. While of core E87-32B, the pollen value of broad-leaved forests increases from the LGM to the early and middle Holocene, with stronger ISM precipitation. This indicates that the ISM is driven by AMOC and other factors, such as river input. Overall, this study offers a comprehensive perspective on historical climate and vegetation dynamics in the BoB



region.

Keywords: Indian Summer Monsoon, Paleo-precipitation, Paleo-vegetation, Last Glacial, Bay of Bengal

【A0511】 -Poster

Monsoon-driven terrigenous fluxes regulate marine organic matter burial on the Sunda Shelf since the middle Holocene

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As one of the most essential processes in balancing atmospheric carbon dioxide content ($p\text{CO}_2$), organic matter (OM) burial on continental shelves is crucial to the global carbon cycle and climate evolution. Despite the extensive work carried out to assess the amounts and processes of OM burial on the shelves, the mechanisms controlling efficient OM burial in the geological past, especially through profound climate transitions, are still understudied. To fill this gap, a middle-late Holocene sequence drilled from the Sunda Shelf, the world's largest low-latitude shelf, was comprehensively studied with chronological, sedimentary, mineralogical, and organic geochemical methods. Our results indicate that the effectively buried OM on the Sunda Shelf is mainly from marine sources with fluxes ranging from 0.20 to 0.35 $\text{g}/\text{cm}^2/\text{kyr}$. The OM flux showed high and low values with relatively steady states during the Holocene Climatic Optimum and the Neoglaciatio, respectively, and declined rapidly during the significant transition between the two stages. Similar features are also manifest in fluxes of biogenic silica, total terrigenous components, and specific minerals, like quartz and clay minerals. All those terrigenous and paleoproductivity fluxes are strongly correlated with each other and show close relationships with Asian Monsoon intensity. During the Holocene Climatic Optimum with the more vigorous Asian Monsoon, larger amounts of terrigenous components, including nutrients, were delivered to the shelf. Higher OM fluxes would occur in response to higher primary productivity and greater burial efficiency. At the Neoglaciatio stage, when the Asian Monsoon was relatively weak, the situation was just the opposite. Moreover, both OM flux and content show negative correlations



with quartz/clay ratios, indicating that clay fluxes predominantly regulated the middle-late Holocene OM burial on the Sunda shelf.

Keywords: Asian Monsoon, Organic carbon burial, Clay mineral, Sedimentary flux, Sunda Shelf

【A0241】 -Oral

Asian monsoon orbital variability directly paced by CO₂ and precession, not eccentricity

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The Asian monsoon system supports over 3 billion people in East and South Asia today. It is therefore imperative to understand the factors that control the monsoon. In particular, geological data have widely recorded changes in monsoon intensity at orbital time-scale (~20,000, ~41,000, and ~100,000 year cycles), suggesting that insolation variations, coupled with greenhouse gas variations and ice sheet changes strongly control the monsoon system. However, it is unclear whether the monsoon intensity changes are directly controlled by insolation and what are the impacts of greenhouse gases and ice sheets.

Here we use a recently updated version of HadCM3B paleoclimate model with realistic boundary conditions to explore the orbital timescale drivers of Asian monsoon variations through the last 800,000 years. Three sets of 219 snapshot simulations were performed to simulate the last 800,000 years at 4000 year frequency (1000 year from 21kyr to present). The three sets differ by their orbital timescale forcings: one with changing insolation only, one with changing insolation and greenhouse gas variations only and the last one combining variations of insolation, greenhouse gas and ice sheet.

Our results show the strong influence of precession at ~21000 year period. However, at eccentricity timescales (~100 kyr) the direct solar insolation impact is relatively small. Instead, we find that changes in greenhouse gases lead to a strong 100kyr response. Ice sheets do not impact directly the Asian monsoon's pace but its amplitude. This motivates further investigations considering separately what is impacting the pace or the amplitude of Asian monsoon variations at orbital timescale to untangle its



tangled drivers and has important implications for older time periods, and the future.

Keywords: Asian monsoon, Orbital-scale variations, Snapshot simulations, HadCM3B, Sensitivity study

【A0696】 -Oral

Hydroclimate variability records from IODP Site U1448 in the Andaman Sea over the last 1.4 million years

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The Indian Summer Monsoon affects the livelihood of the large population residing on the Indian subcontinent. Hence, a lot of interest has been focused into studying this large monsoon system to understand its long-term evolution and more importantly, to improve forecasts. In this study, we present the records of alkenone hydrogen ($\delta D_{\text{alkenone}}$), leaf wax hydrogen (δD_{wax}), and leaf wax carbon ($\delta^{13}C_{\text{wax}}$) isotopic compositions, pentacyclic triterpene methyl ethers (PTMEs), and polycyclic aromatic hydrocarbons (PAHs) from the International Ocean Discovery Program (IODP) Site U1448 in the Andaman Sea. Our past sea surface salinity record during Late Pleistocene reconstructed using $\delta D_{\text{alkenone}}$ reveals some similarities with the seawater oxygen isotope compositions ($\delta^{18}O_{\text{sw}}$) from the nearby Site NGHP 17 (Gebregiorgis et al. 2018) and IODP Site U1446 (Clemens et al. 2021). As observed in the $\delta^{18}O_{\text{sw}}$ records from Site NGHP 17 (located nearby Site U1448, eastern side of Bay of Bengal) and Site U1446 (located at the western side of the Bay of Bengal), Site U1448 $\delta D_{\text{alkenone}}$ also recorded the two low precipitation events which are noted during the weakening of the Atlantic Meridional Overturning Circulation (AMOC) during Heinrich Stadial 11 and the Younger Dryas. Additionally, multiple high precipitation events shown by the other records are also shown by Site U1448 $\delta D_{\text{alkenone}}$. This observation gives merit to the reliability of $\delta D_{\text{alkenone}}$ as a paleosalinity proxy. Interestingly, δD_{wax} indicate spatial difference, as shown by the records from Site U1448 and Site U1446 (McGrath et al. 2021). $\delta^{13}C_{\text{wax}}$ and PTMEs data revealed obvious vegetational shifts that occurred during Late Pleistocene. C_3 vegetation dominance over C_4 vegetation is observed during Marine Isotope Stage (MIS) 1 and MIS 5, accompanied by low PTMEs signal which implies a change in environment from savanna to forest. Meanwhile, the increased abundance of C_4 vegetation over C_3 vegetation detected during MIS 2 and



MIS 4 occurred synchronously with the increase in PTMEs which indicates the exchange from forest to savanna environment. Furthermore, PAHs data indicate that the occurrence of paleofire is higher during increased C₄ plant abundance during the Late Pleistocene. The results point towards a link between increased fire activity and the exchange to savanna environment. We will also present our key findings on the hydroclimate variability records across the Mid-Pleistocene Transition.

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Keywords: Indian Summer Monsoon, Alkenone δD , Paleosalinity reconstruction, IODP site U1448

【A0716】 -Poster

Complex interplay of forcings drives Indian vegetation and Summer Monsoon variability during MIS 11

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Marine Isotope Stage (MIS) 11 has long been considered a unique Quaternary interglacial due to its orbital similarities with the Holocene, persistence of high atmospheric CO₂ concentrations and extended duration triggering unusual polar ice-sheet loss. Despite its importance, Indian Summer Monsoon (ISM) variability within the core monsoon zone (CMZ), as well as its impacts on vulnerable tropical forests, remain unexplored. Here, we document, for the first time, MIS 11 ISM-driven vegetation changes and their underlying forcings by combining pollen analysis from IODP Site U1446, strategically retrieved from the Bay of Bengal to represent the CMZ, with model simulations. Our results reveal the distinct roles of insolation, CO₂, ice volume, and millennial-scale variability in driving coupled ISM-vegetation changes, depending on the changing boundary conditions through MIS 11. Orbital- and millennial-scale tropical forest changes mirror southern European vegetation and atmospheric methane variability, ultimately reflecting shifts in the Intertropical Convergence Zone (ITCZ) that impact the tropical regions, a primary source of CH₄ emissions.

Our proxy and model reconstructions show that ISM-vegetation changes during MIS 11c closely followed boreal summer insolation, revealing its dominant role under warm background conditions with high CO₂ and reduced ice volume. Conversely, during MIS 11b-a, ISM-vegetation decreased while insolation remained high, indicating that its influence was overshadowed by expanding ice sheets, lower CO₂, and the interaction of orbital and millennial-scale variations. Millennial-scale climate variability during the younger MIS 11b-a substages is expressed by prominent forest contractions tied to southward ITCZ shifts, Atlantic meridional overturning circulation (AMOC) reductions and high-latitude ice sheet dynamics, which were rapidly followed by abrupt forest expansions associated with northward ITCZ shifts, AMOC strengthening and CH₄ overshoots. Conspicuously, the first and most severe forest setback interrupted MIS 11 full interglacial conditions, suggesting that extreme ISM weakening could also occur under similarly warm future conditions. Our findings provide new insights into ISM behavior during MIS 11, highlighting its high sensitivity to climate changes in the context of projected ISM intensification and its effect on the



extent and composition of the tropical forest, which is key component of both global carbon and methane cycles.

Keywords: Interglacial climate, Marine Isotope Stage (MIS) 11, Indian Summer Monsoon, Vegetation, Climate forcings

【A0423】 -Oral

Indian monsoon driven N₂O emission in the Arabian Sea during the last two interglacial cycles

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Under a 2°C future warming scenario, calculating the total Carbon budget becomes imperative. In this context, estimating other greenhouse gases, such as nitrous oxide (N₂O), is crucial. This study aims to delineate the long-term variability of atmospheric N₂O. Modern estimates suggest that oceans contribute nearly 40% of natural N₂O emissions to the atmosphere, primarily through denitrification in oxygen-deficient waters. The Arabian Sea, with its intense Oxygen Minimum Zone (OMZ), accounts for almost one-third of these emissions. The strength of the OMZ is controlled by enhanced primary productivity during the strong monsoon seasons, leading to higher denitrification and increased N₂O production. To understand the role of the Arabian Sea denitrification in N₂O dynamics, we analysed the relative abundance of planktic foraminifera *G. bulloides*, total nitrogen, and $\delta^{15}\text{N}$ of the bulk sediments from the marine sedimentary core SSD004 GC11 (6.0000°N, 78.9312°E; 2901 m), spanning last 175 kyr BP. Our $\delta^{15}\text{N}$ record shows strong covariance with *G. bulloides* values, closely resembling atmospheric N₂O observed in ice core records. Higher $\delta^{15}\text{N}$ and *G. bulloides* during interglacials indicate higher denitrification linked to increased productivity and higher atmospheric N₂O levels, while lower values during glacials suggest the opposite.

We compiled published $\delta^{15}\text{N}$ records from across the Arabian Sea, revealing synchronous denitrification fluctuations regionally. However, the magnitude of these variations differed, influenced by the spatial distribution of the OMZ core and changes in subsurface ventilation on glacial-interglacial timescales. This study highlights the Indian Monsoon's role in driving Arabian Sea denitrification and its contribution to atmospheric N₂O levels.



Keywords: Denitrification, Arabian Sea, Indian Summer Monsoon, Nitrous oxide

【A0974】 -Poster

An overview of the existing foraminiferal census count and sediment geochemistry data from the northern Indian Ocean and their utility in reconstructing the past strength of the Indian Summer Monsoon

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Indian Summer Monsoon (ISM) is the product of the pressure difference between the Tibetan Plateau and the tropical Indian Ocean (~30°S), resulting in the transport of moisture and subsequent enormous rainfall in the Indian subcontinent. Consequently, a sharp contrast in salinity develops between the Arabian Sea and the Bay of Bengal, in which evaporation dominates the former, whereas precipitation dominates the latter basin. However, the variation in sea-surface temperature is small. Further, the northern Indian Ocean surface oceanography is dominated by a seasonally changing monsoon gyre. The high-nutrient but low-oxygen waters of this unique, seasonally reversing gyre are separated from the low-nutrient but high-oxygen waters of the subtropical gyre to the south by a distinct hydro-chemical front from near 10°S. In addition, the cyclonic summer-monsoon wind patterns generate upwelling on the Somali margin, bringing cold, nutrient-rich waters that stimulate productivity than the eastern Arabian Sea. Here, we provide an overview of the impact of these dynamic changes in productivity, sea-surface temperature (SST), and salinity by integrating more than 600 foraminiferal census counts and bulk sediment geochemical data from sediment core tops and plankton nets between 25°N and 10°S and 40°E and 110°E of the past six decades. *Globigerinoides ruber* (white) is the most abundant, with >30% concentration in the southern region of the equator but >20 % in the eastern Bay of Bengal and Andaman Sea, and Java coast. The abundance of *Globigerina bulloides* is >30% in the upwelling region of the western Arabian Sea but is also common (<10%) in the southern tip of India. *G. sacculifer* is relatively ubiquitous in the northern Indian Ocean but is absent in the western Arabian Sea. The abundance of *Pulleniatina obliquiloculata* is ~5% with >10% random patched, but its concentration increases in the southwestern Indian Ocean. Due to the dissolution-resistant chemistry of the test, it is found in the tropical Indian Ocean. Our improved compilation



provides a better linkage between the circulation and foraminiferal abundances.

Keywords: Indian Summer Monsoon, Foraminiferal assemblages, Dissolution, Thermocline

【A0917】 -Oral

Indian Summer Monsoon variability and its impact on the thermal structure in the Bay of Bengal during the past 24 ka based on lipid biomarkers

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Changes in the upper water thermal structure of the northern tropical Indian Ocean are considered a good proxy to assess the past strength of the Indian Summer Monsoon (ISM). Recent studies suggest that the lipid biomarker Glycerol Dialkyl Glycerol Tetraethers (GDGTs) and their derivatives, such as hydroxylated isoprenoid GDGTs (OH-isoGDGTs), hold the potential to reconstruct past thermal structure but rarely applied to the tropical Indian Ocean. Here, we use a central Bay of Bengal sediment core IND-23-02 (12.8266°N; 86.989°E) retrieved at 3163 m water depth too distant from the continental slope to be influenced by the mass-transport deposits. This study has applied the isoprenoid GDGTs (isoGDGTs) and OH-isoGDGTs proxies to reconstruct the thermal gradient between the mixed layer and thermocline. The isoGDGTs indices (i.e., Methane Index, %iGDGT2, and Crenarchaeol/Crenarchaeol-iso) suggest that the principal archaeal origin of GDGTs is *Thaumarchaeota* group I.1a, thereby, supporting the reliability of TEX₈₆ and RI-OH as temperature proxy. Water depth indicators of GDGTs (i.e., isoGDGT2/isoGDGT3 and OH0/OH2) suggest that the TEX₈₆ and RI-OH reflect temperatures at different water depths. Compared with modern climatological data, the TEX₈₆^H and RI-OH proxies most likely record temperatures at ~0-15 m and ~50-60 m water depths (i.e., mixed layer and thermocline), respectively. Our data show a relatively small difference (ΔT) between TEX₈₆^H-T and RI-OH-T during three dry, i.e., the Last Glacial Maximum (LGM), late-Heinrich Stadial 1 (HS1), and Younger Dryas (YD) - 10.5 ka periods and a larger ΔT during three relatively wet, i.e., early-HS1, Bolling/Allerod (B/A), and early Holocene (7-9 ka) intervals. These temperature differences suggest that the thermal gradient between the mixed layer and thermocline increases during the stronger ISM while it



decreases during weaker ISM periods. The variation of thermal gradient matches the Ganga-Brahmaputra-Meghna (GBM) runoff changes inferred by the branched GDGTs indices (i.e., $\Sigma IIIa/\Sigma IIa$ and BIT) and precipitation by the speleothem $\delta^{18}O$ records of the NE Indian. The freshwater barrier layer, formed by GBM runoff and direct precipitation, causes salinity stratification in the upper water column, leading to a weakening of convection/mixing in the upper layers, thus reducing the vertical heat transfer and increasing the thermal gradient. Our study is the first attempt to apply TEX₈₆ and RI-OH proxies together to reconstruct the thermal gradient in the northern tropical Indian Ocean, highlighting the potential to use lipid biomarkers to reconstruct the past strength of the ISM.

Keywords: Upper water thermal structure, GDGTs, LGM, Heinrich Stadial, Bay of Bengal

【A0671】 -Oral

Provenance of late Quaternary sediments off Mekong River in the southern South China Sea: Insights from clay mineral and Sr-Nd isotopic compositions

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The Mekong River is the largest river system surrounding the South China Sea and supplies the highest amounts of terrigenous sediments to this region, particularly the southern South China Sea. However, the historical changes in sediment contributions from different reaches of this basin to the southern South China Sea remain a subject of debate. To address the scientific question, this study investigated clay mineralogy and Sr-Nd isotopic compositions from two sediment cores (MD05-2896, and SO18383-3) in the southern South China Sea, along with river sediments from the Mekong River Basin. This study aims to discriminate sediment provenance and reconstruct the history of sediment contributions from different reaches of the Mekong River Basin during the Late Quaternary. The results reveal that the sediment cores exhibit similar clay mineral assemblages and Sr-Nd isotopic compositions throughout the Late



Quaternary. The clay mineral assemblage is dominated by smectite (43%) and illite (26%), with moderate amounts of kaolinite (15%) and chlorite (15%). The $^{87}\text{Sr}/^{86}\text{Sr}$ ratio and ϵ_{Nd} value range from 0.7232 to 0.7276 and from -11.8 to -9.6 , respectively. Based on clay mineralogy and Sr-Nd isotopic data, the middle reach of the Mekong River is identified as the primary source of terrigenous sediments to the southern South China Sea, with minor contributions from the upper and lower reaches.

Keywords: Clay minerals, Sr-Nd isotopes, Sediment provenance, Mekong River, South China Sea

【A0812】 -Oral

Simulating precipitation and isotope variability in the East Asian Summer Monsoon region over a precession cycle based on AWIESM-wiso

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Isotope records are commonly utilized to reconstruct past precipitation variability and Summer Monsoon intensity. However, the oxygen isotopic composition in precipitation is influenced by a range of factors, including precipitation amount, temperature, and moisture sources and pathways, making it challenging to ascertain the extent to which isotope records reflect precipitation changes and the spatiotemporal variability of this relationship. In this study, we have developed a novel isotope-enabled climate model capable of simultaneously simulating both climate conditions and isotope ratios in all parts of the hydrological cycle. Using this model, we simulate the climatic and isotopic variations in a set of 24 equilibrium experiments, together covering a precession cycle, with a focus on the East Asian Summer Monsoon region. We employ multiple regression analysis to quantify the degree to which isotopes are influenced by various environmental factors at different phases of the precession cycle. Additionally, the model incorporates the ability to track



moisture source regions and their characteristics, enabling us to examine how the moisture sources of East Asian Summer Monsoon precipitation evolve over the course of the precession cycle and how this shift affects the isotope-precipitation relationship.

Keywords: Precession, Isotope modeling, Moisture source, Southeast Asian monsoon

【A0756】 -Poster

Eastern Indian Ocean coccolith change and its implications for South Asian monsoon variation since the last glaciation

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Coccolithophores, fundamental primary producers in the ocean, have a vital function in the carbon cycle through photosynthesis and synthesizing calcium carbonate plates (coccoliths). Since the last glacial period, the coccolith assemblages in the eastern Indian Ocean have experienced significant changes, which coincide with climatic and oceanographic variations. Our study is based on quantitative analysis of coccolith assemblages in a sediment core recovered from the eastern Indian Ocean. By analyzing coccoliths in the sediment, we can detect distinct cyclic patterns in coccolith primary productivity, which are associated with variations in monsoonal strength and ocean circulation influenced by these astronomical cycles. The results of our study reveal that average percentage of *Florisphaera profunda* is approximately 56.71% while 10.72% *Emiliania huxleyi* and 25.04% *Gephyrocapsa oceanica* of the total countable number. The productivity gradually increased during the period between 8 and 16 kyr. The high abundance of *F. profunda* suggests that variations in nutrient availability, caused by changes in water column stratification and monsoonal intensity, were strongly linked to periods of precession and semi-precession. *E. huxleyi* and *G. oceanica* show distinct variations in their abundance and response to changes in nutrient availability, influencing regional primary productivity. Our findings indicate that the South Asian Monsoon variations are crucial in regulating the availability of nutrients and the stratification of the water column.

Keywords: Coccolith, Eastern Indian Ocean, South Asian monsoon, Primary productivity



【A0971】 -Oral

Late Quaternary evolution of the sea surface water oxygen isotope stacked from the South China Sea

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Abstract

The "monsoon-type" oxygen isotope ($\delta^{18}\text{O}$) curve of planktonic foraminifera from the South China Sea (SCS) serves as a typical representation of low-latitude hydrological cycle evolution on orbital scales. However, this record is hard to interpret due to the inclusion of multiple climatic signals. Here we present 169 kyrs' high resolution records of *G. ruber* $\delta^{18}\text{O}$ and Mg/Ca from core MD05-2896/97 in the southern SCS (latitude: 08°49.05'N /08°49.53'N, longitude: 111°26.47'E /111°26.51'E; water depth: 1657m /1658m), which include previously published *G. ruber* $\delta^{18}\text{O}$ and Mg/Ca records from 0ka to 23ka, our newly analyzed 442 $\delta^{18}\text{O}$ samples and 202 Mg/Ca samples in the core depth of 2.03~11.03m (spanning 23~123ka) for MD05-2896, and 157 $\delta^{18}\text{O}$ and Mg/Ca samples in the core depth of 9.4~12.5m (spanning 120~169 ka) for MD05-2897. Then we try to update the "monsoon-type" $\delta^{18}\text{O}$ curve since 170 ka by compiling *Globigerinoides ruber* $\delta^{18}\text{O}$ and Mg/Ca records of eight cores from the SCS (MD05-2896/97, GIK17961-2, TX05, 251PC, MD05-2899, MD05-2901, ODP1145 and MD05-2904), and obtain the SCS stacked residual sea surface water $\delta^{18}\text{O}$ ($\delta^{18}\text{O}_{\text{sw-ivc}}$) curve by correcting the temperature and global ice volume signals included in the original $\delta^{18}\text{O}$ curve. In this way, we try to reveal the orbital-scale hydroclimatic linkage between SCS and surrounding Asian-Indo-Pacific regions. We find that while those northern SCS $\delta^{18}\text{O}_{\text{sw-ivc}}$ records are dominated by 100,000-year and 40,000-year cycles, the southern SCS $\delta^{18}\text{O}_{\text{sw-ivc}}$ also exhibit significant 23,000-year' precessional cycles that are similar to the Indo-Pacific Warm Pool (IPWP) stacked $\delta^{18}\text{O}_{\text{sw-ivc}}$ curve. At precession band, the phase of SCS stacked $\delta^{18}\text{O}_{\text{sw-ivc}}$ lags IPWP $\delta^{18}\text{O}_{\text{sw-ivc}}$ by about 36°, and both are out-of-phase with the Asian stalagmite $\delta^{18}\text{O}$, suggesting that the SCS may be also a crucial moisture source (as IPWP) of the Asian Summer Monsoon. We also find that precessional cycles in the original SCS stacked "monsoon-type" $\delta^{18}\text{O}$ can be largely attributable to temperature signal, and after correcting this temperature effect and global ice volume effect, the residual SCS $\delta^{18}\text{O}_{\text{sw-ivc}}$ are dominated by 100,000-year cycle, broadly similar to the long-term trend of IPWP $\delta^{18}\text{O}_{\text{sw-ivc}}$. But the fluctuation amplitudes of SCS $\delta^{18}\text{O}_{\text{sw-ivc}}$ were significantly larger than those of IPWP $\delta^{18}\text{O}_{\text{sw-ivc}}$.



$\delta^{18}\text{O}_{\text{SW-IVC}}$ during periods of 130 ~ 120 ka and 20 ~ 10 ka with rapid sea-level rise. These two positive shifts of SCS $\delta^{18}\text{O}_{\text{SW-IVC}}$ may be preconditioned by more fresh water input from surrounding continental region (resulting negative $\delta^{18}\text{O}_{\text{SW-IVC}}$) under glacial conditions, and triggered by the incursion of IPWP water mass with much more positive $\delta^{18}\text{O}_{\text{SW-IVC}}$ during deglacial periods. Thus, relative to the IPWP open ocean, the SCS $\delta^{18}\text{O}_{\text{SW-IVC}}$ is more sensitive to sea level changes than to precessional dominated monsoonal hydroclimate fluctuations.

Keywords: Late Quaternary, South China Sea, Monsoonal hydroclimate, Indo-Pacific warm pool

【A0137】 -Poster

Multi-proxy paleoenvironmental reconstruction from Noboru Umeda peat swamp, eastern Thailand

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Thailand locates in the heart of mainland southeast Asia, where multiple sub-monsoonal systems converge. Monsoon-derived rainfall shapes environmental changes across the regions by influencing hydrological dynamics and sediment deposition. Peat swamps from this area are highly sensitive to climate variability, providing a valuable opportunity to study past changes in the monsoon systems. Peat swamps are vital for ecological, environmental and climate regulation functions, particularly as carbon sinks. Understanding past environmental changes in peat swamp is essential for reconstructing regional climatic shifts over time.

This study utilizes a multi-proxy approach, including lipid biomarker analysis, total organic carbon (TOC) content, bulk $\delta^{13}\text{C}$, carbon to nitrogen ratio, XRF-core scanning, and radiocarbon dating, to analyze sediment sequences from the Noboru Umeda peat swamp in Trat province, eastern Thailand. Radiocarbon dating estimates that the sediment sequence extends back to approximately 7700 cal yr BP. An increase in TOC and bromine concentrations within the top 70 cm of the sediment core, dated to around 2020 cal yr BP, suggests favorable conditions for peat accumulation, characterized by lower depositional energy and enhanced organic matter deposition.



Correspondingly, decreases in titanium (Ti) and potassium (K) concentrations suggest reduced minerogenic input from the surrounding region, consistent with low-energy environments. These conditions may reflect decreased terrestrial runoff due to lower precipitation intensity or reduced catchment erosion, indicating a period of weaker Summer Monsoon system. The lipid biomarker distribution along the sediment core gives insights into vegetation composition shifts in the region. In conclusion, multi proxies from Noboru Umede in eastern Thailand can provide a more detailed picture of the peat ecosystem's response to past environmental and climatic changes.

Keywords: Peat swamp, Biomarkers, Eastern Thailand, Paleoenvironment

【A0233】 -Oral

Indian winter monsoon controls sea subsurface temperature in the north Arabian Sea during the Holocene

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Surface seawater stratification shows a sensitive response to solar insolation and large-scale ocean current, further playing an important role in the air-sea interactions at different time scales. However, the variation of surface seawater structure and its driving mechanism in the Indian Ocean is poorly understood. A sediment core from Makran margin was utilized to analyze UK'37-derived SST (sea surface temperature) and the TEX₈₆-derived SSST (sea subsurface temperature), unveiling the forces of surface seawater thermal structure through the past 8000 years. The SSST records show significant warming, while SST records show opposite trend in the north AS during the Holocene. The vertical temperature difference between sea surface and subsurface shows a decreasing trend toward the late Holocene, suggesting a decrease in surface water stratification induced by the strengthening of Asian winter monsoon (AWM) during the period. The temporal variability of SSST is responsive to vertical temperature difference and thus mainly controlled by the AWM variation. The Holocene SSST variation followed the boreal summer insolation, associated with tropical climate changes induced by the movement of the Inter-tropical Convergence Zone (ITCZ). During the middle Holocene, the northward return of Inter-tropical Convergence Zone (ITCZ) and weakening of AWM led to a stronger surface water



stratification and a cooling trend of SSST. Furthermore, the millennial SSST changes during the Holocene revealed a close link with North Atlantic climate changes, mainly through atmospheric circulations in winter.

Keywords: Holocene, Sea subsurface temperature, Indian monsoon, Inter-tropical convergence zone, North Arabian Sea

【A0643】 -Oral

Holocene East Asian winter monsoon changes inferred from Mg/Ca ratio of *globigerina bulloides*: A winter proxy in the northern South China Sea

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The flux and seasonality of planktonic foraminiferal were studied through a three-year time-series sediment trap deployed in the Xisha Trough, South China Sea (SCS). We found strong seasonality occurred in *Globigerina bulloides*, with over 93% of its species-specific fluxes occurring from late September/October to February, suggesting it may have the potential to be developed as a winter proxy-species. Further stable isotope results show that *G. bulloides* has similar values with that of *G. ruber* during the winter, indicating *G. bulloides* may calcify at the upper mix layer and can be used as a winter sea surface proxy in the northern SCS. To reconstruct Holocene East Asian winter monsoon changes, $\delta^{18}\text{O}$ and Mg/Ca ratio were measured on *G. bulloides* from core GHE 27L in the northern SCS. The reconstructed core-top SST based on Mg/Ca of *G. bulloides* is about 23°C, in accord with the modern winter SST. Therefore the Mg/Ca based SST of *G. bulloides* was used to indicate past East Asian Winter Monsoon (EAWM) changes. Our result indicate that the Holocene EAWM is strong during the middle Holocene, and then weakened during the late Holocene. Our result provide strong evidence that the East Asian Summer Monsoon and EAWM show in-phase changes during the mid to late Holocene.

Keywords: East Asian winter monsoon, Foraminifera, Mg/Ca ratio, Holocene, Northern South China Sea

【A0916】 -Poster

Indian Summer Monsoon history during the last glacial cycle revealed by



a loess sequence from the Tibetan Plateau

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The Indian Summer Monsoon (ISM) has a profound influence on the environment and people of East Asia. However, despite its importance, the variability and dynamic mechanisms of the ISM remain inadequately understood. This study investigates the evolution of the ISM since the Last Interglacial by analyzing the well-preserved Cuoweng (CW) loess–paleosol sequence in the southeastern Tibetan Plateau. A robust chronological framework is established using quartz optically stimulated luminescence (OSL) dating and K-feldspar post-infrared infrared stimulated luminescence (pIRIR) dating. The history of the ISM over the past ~135 ka is reconstructed based on multiple environmental proxies. The results indicate that the ISM experienced significant glacial–interglacial fluctuations during the last glacial cycle, exhibiting a strengthened monsoon during warm periods and a weakened one during cold periods. Additionally, suborbital-scale cyclic variations in the ISM during the marine isotope stage (MIS) 5 are revealed, with enhanced monsoon conditions during MIS 5a, 5c, and 5e and weakened conditions during MIS 5b and 5d. These findings suggest that the ISM variations are primarily influenced by a combination of high- and low-latitude forcing. This study provides new insights into the complex responses of the ISM to climate change, enhancing our understanding of its potential future changes.

Keywords: Loess, Indian Summer Monsoon, Last Interglacial, Magnetic susceptibility, Climate change

【A0896】 -Poster

Indian Summer Monsoon variations since late MIS3: A perspective from multiproxy evidence from Lake Xingyun in southwestern China

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The variability of the Indian Summer Monsoon (ISM) is a central research topic tightly linked to precipitation changes in the highly populated South Asian monsoon region. Understanding the variability and related dynamic mechanisms of the ISM on orbital-millennial time scale provides insight into the metastable nature of the Earth's system, which offers favorable conditions for disaster prevention and mitigation. Here, we present a multiproxy record spanning the late Marine Isotope Stage 3 (40.2–0.0 cal ka BP), including median grain size, *n*-alkane distribution pattern, hydrogen isotope of C₃₁ *n*-alkane (δD_{C31}), and stable oxygen isotope of endogenic carbonates ($\delta^{18}O_{carb}$) from Lake Xingyun in southwestern China. The results showed that the ISM relatively strong during 40.2–30.0 cal ka BP, weakened during 30.0–16.0 cal ka BP and then it was progressively enhanced during 16.0–11.7 cal ka BP. The strongest ISM occurred during 10.7–6.5 cal ka BP and became weakened during 6.5–0.0 cal ka BP. The ISM precipitation increased overall with rising temperatures on the orbital scale despite of some millennial exceptions. The ISM variations were strongly controlled by changes in Northern Hemisphere summer insolation, and influenced by Earth's boundary conditions (i.e., CO₂ concentration and ice sheets) during the glacial-interglacial period. Moreover, the Heinrich Events (i.e., H3, H2, and H1) and Younger Dryas (YD) occurred in different climatic states of the Earth system, and thus the ISM responded differently in magnitude to these millennial-scale cold events. As such, the ISM during Heinrich Events (i.e., H3, H2, and H1) was more significantly weakened than that during the YD. These findings highlight the complexity of ISM changes with different warming scenarios, and provide a perspective for understanding the different hydrological responses to abrupt cold events in terms of magnitude.

Keywords: Indian Summer Monsoon, Hydrogen isotope, Grain size, N-alkanes, MIS3

【A0629】 -Poster

Sea level and East Asian monsoon influenced chemical weathering records in the southern South China Sea over the past 21 ka

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High-resolution major element geochemistry of Core MD05-2892 from the lower



Sunda Slope was analyzed to investigate the variation of chemical weathering records and its controlling factors in the southern South China Sea since the last glaciation. Chemical index of alteration (CIA) and $\text{SiO}_2/\text{Na}_2\text{O}$ ratio were selected as chemical weathering proxies. The values of the proxies are higher during the last glaciation than during the Holocene. We attribute this to the provenance shift caused by sea level change. Provenance analysis indicates that the Malay Peninsula and Sumatra were the major sediment sources for the study region during the last glaciation, while the Indochina Peninsula has been the major source since the early Holocene. Accordingly, the weathering evolution analysis reveals increased physical erosion in the Malay Peninsula and Sumatra during enhanced East Asian Summer Monsoon rainfall, while increased chemical weathering in the Indochina Peninsula during the intensified monsoon rainfall. Therefore, the chemical weathering records of the deep-sea sediments in the southern South China Sea were regulated by monsoon rainfall-driven physical erosion in the Malay Peninsula and Sumatra during the last glaciation, while the records have been influenced by monsoon rainfall-induced chemical weathering in the Indochina Peninsula since the early Holocene. This study emphasizes that higher weathering values of the deep-sea sediments during the last glaciation could be related to the provenance variation driven by sea level change, rather than to enhanced chemical weathering in the same provenance.

Keywords: Major elements, Sea level, East Asian monsoon, Chemical weathering, Southern South China Sea

【A0147】 -Oral

Orbital variability and climatic drivers modulating the East and South Asian monsoons during the last 70 krys: New insights from the Korean vegetation

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In East Asia, climatic models simulate a striking paradox for the end of the century showing a higher increase in rainfalls during winter compared to summer. Such



seasonal distribution of the precipitation conflicts with the fundamental feature of a monsoonal system, and evidences a strong decoupling with the South Asian monsoon, where moister summer and drier winter are simulated. Uncertainties are accentuated by the northern distribution of the East Asian Summer Monsoon (EASM), which is the unique monsoon system extending to the temperate region. This feature reinforces its sensitivity to subarctic climate variability and, considerably increases the challenge of identifying low versus high latitudes controls.

To address these issues, we present a new vegetation record based on the analysis of pollen grains and spores from the deep-sea core ES14-GC01 collected in the East Sea, a relevant way to estimate the seasonal hydroclimatic pattern in the Korean Peninsula. 80% of the rainfall are supplied by the EASM and vegetation tightly depends on the amount and seasonal distribution of precipitation. Our record, covering the last 70 kyrs, is compared with recently published South Asian Summer Monsoon (SASM)-derived vegetation records from the Bay of Bengal (IODP U1446) to evaluate the relationship between the two main Asian monsoon systems during the Holocene and the last glacial period.

Glacial vegetation in Korea is marked by a large development of steppic taxa, including *Artemisia* and *Poaceae*, which extend well south beyond the present-day Summer Monsoon front, revealing drier and colder conditions. From 62 to 46 ka, reinforced EASM is recorded by high percentages of the temperate broadleaved forest, composed of *Quercus* *Lepidobalanus*-type, *Alnus*, *Betula* and *Ulmus-Zelkova*, when obliquity reached its maximum. From 46 to 14 ka, the progressive replacement of boreal trees, *Picea* and *Abies*, by the steppic taxa, reflecting a decrease in rainfall, is reported through the MIS 3, with a maximum expansion of the steppe during the MIS 2. For the first time, our vegetation record supports a strong influence of obliquity on the EASM, as previously suggested by models but never demonstrated by data. The highest percentages of temperate broadleaved forest are recorded, between 8 and 11 kyrs, reflecting the EASM maximum during the early Holocene, characterized by the highest insolation. A progressive expansion of conifers into the temperate forest ecosystem indicates a long-term winter cooling and reduced rainfalls through the second phase of the Holocene, mirroring the insolation pattern. At orbital scale, vegetation changes point out a common variability of Asian monsoons during the Holocene, when the East and the South Asia respond directly to the North Hemisphere insolation, as the result of reinforced land-ocean temperature contrast. Obliquity strongly affected the EASM and SASM during the last glacial but its influence triggered distinct processes. In East Asia, obliquity modulates the seasonal temperature contrast and therefore, the



summer rainfall intensity and the northward distribution of the monsoon front. In contrast, its effect on the South Asian region is caused by the modulation of interhemispheric temperature gradient, which affects the position of the ITCZ.

Keywords: East Asian monsoon, Pollen-derived vegetation, Orbital scale, Holocene, Last glacial period



Session 29. The missing piece: Holocene records from remote areas

Conveners: Nannan Li, Giorgia Camperio, Tobias Schneider, Ronald Lloren, Nathalie Dubois

【A0468】 -Poster

Paleoenvironmental reconstruction of Laguna Ñe Luan, Patagonia, Argentina: Rock magnetic and geochemical analyses

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Laguna Ñe Luan, also known as "Laguna Ojo de Guanaco", is located approximately 30 km south of Maquinchao in the central-southern region of Río Negro, Patagonia, Argentina. This study addresses the paleoenvironmental dynamics of the region by analyzing three sediment cores retrieved from the deepest part of the lake with a gravity corer. The composite sediment record is 2 m long and provides a unique opportunity to study regional climatic variability and depositional environments in an underexplored area of Patagonia. This region is particularly important due to its latitudinal position, which makes it a valuable site for paleoclimate reconstruction, as the Southern Hemisphere is currently underrepresented in climate studies.

The sediment cores were split into halves. Spot magnetic susceptibility (k) measurements were taken on one of the half, and elemental composition was analyzed at a spatial resolution of 1 mm on the ITRAX XRF-CS using a Chromium (Cr) X-ray tube. Subsequently, the cores were sub-sampled. One half of the core was sub-sampled using cubic plastic boxes (8 cm³) for rock magnetic analysis, while the other half was sampled every centimeter for geochemical analysis including total carbon (TC), total nitrogen (TN), and total sulfur (TS). Moreover, total organic carbon (TOC) and total inorganic carbon (TIC) was determined. The elemental composition and geochemical analyses were performed at the GEOPOLAR Institute, University of Bremen. Preliminary geochemical results indicate interesting variations, including an increase



in C, N, S, and TOC, and a decrease in magnetic susceptibility (k), especially towards the 30 cm top of the core. These trends are crucial for understanding how recent climate change is defined and contrasted with past climatic changes.

A comprehensive set of laboratory experiments will be conducted on each sample to characterize the magnetic properties of the sediments. The intensity and directions of natural remanent magnetization (NRM) will be measured, including declination (D) and inclination (I). Magnetic analyses will also include the acquisition of anhysteretic remanent magnetization (ARM) and isothermal remanent magnetization (IRM) up to saturation and hysteresis loops to study the magnetic mineralogy and grain size. All magnetic measurements will be conducted at the Institute de Physique du Globe de Paris (IPGP-Université Paris Cité), France.

An age-depth model will be constructed using ^{210}Pb and ^{137}Cs dating, complemented by radiocarbon dating. Paleomagnetic data will refine the chronology and reveal geomagnetic secular variation as additional markers. Notably, two tephra layers identified within the sedimentary sequence will serve as chronological constraints and provide insights into regional volcanic activity.

This multidisciplinary study offers a comprehensive understanding of the environmental history of Laguna Ñe Luan, contributing paleoclimate data for Patagonia. By integrating rock magnetic and geochemical analyses, we will uncover new insights into climatic and depositional processes that have shaped this region over the past millennia.

Keywords: Paleoenvironmental reconstruction, Geochemical analyses, Rock magnetism, Lake sediments, Patagonia

【A0286】 -Poster

Palynological analysis of modern and archeological ungulate feces: Investigating taxonomic diversity and agropastoral practices in a little explored Andean area from south America

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The pollen content of paleofeces is a valuable reservoir of paleobiological and cultural information. In South America, palynological studies have been conducted on ungulate paleofeces in Patagonia, but few studies have been performed in the South-Central Andes, a region with a long history of human-camelid interactions. Here, we present an exploratory study in El Bolsón (Catamarca, Argentina), an Andean high-altitude valley, aimed at assessing whether pollen spectra of Holocene ungulate paleofeces varies across taxa and/or agropastoral management. Feces and paleofeces were collected, and pollen was extracted from the inner part of both samples. Pollen identification and counts were carried out using an optical microscope and reference collections.

We first conducted an actualistic study, analyzing modern feces and interviewing local populations about agro-pastoral practices to model pollen spectra in a known environmental and cultural context. We studied 12 feces of domestic llamas (*Lama glama*, n=3), goats (*Capra aegagrus hircus*, n=6), and sheep (*Ovis orientalis aries*, n=3) from different agro-pastoralist contexts in wet season. Most presented high total pollen concentration (>6000 grains/gr). Goat feces were dominated by dicotyledons, including Asteraceae subf. Asteroideae (68-80%) and Fabaceae (10-24%), while monocotyledons, particularly Poaceae (91-98%), were predominant in llama and sheep feces. Interviews revealed that goats are kept overnight and released in daytime, whereas the llamas and sheep are kept enclosed in the same corral, where monocotyledons prevail.

For the archaeological application, we studied ungulate paleofeces from Los Viscos rockshelter (2464 masl), containing occupations spanning the last 1200 years. The zooarchaeological record suggests the historical importance of camelids, including vicuñas (*Vicugna vicugna*) and domestic llamas, unlike the modern dominance of European livestock. We selected 3 paleofeces from a stratigraphic unit radiocarbon-dated to 590±50 ¹⁴C BP -one of which is an aggregate of at least three pellets crushed together. All samples were morphologically compatible with Artiodactyla. Unlike modern samples, paleofeces had low pollen concentration (<1000 grains/gr), except for the aggregated one (14453 grains/gr), which may relate to ecological, cultural, or taphonomic differences. Identified pollen types included *Poaceae*, *Asteraceae* subf. *Asteroideae*, *Chenopodiaceae*/*Amaranthaceae*, and *Lentibulariaceae*, among others.



We also compared these results with paleofeces of the same period from a previous multiproxy study at the site, where one pellet was aDNA-identified as goat (Petrigh *et al.* 2021). Low pollen concentration and similar pollen types were also found. Paleofeces pollen spectra are consistent with that of the modern goat sample, suggesting that these past animals probably were not enclosed in monocotyledon-dominated areas, as in the modern sheep and llama corral, and may have been wild or else handled under other conditions.

This new study contributes to the palynological analysis of late Holocene paleofeces from Andean South America. The results suggest that variability in feces pollen may be more influenced by agro-pastoralist practices than by taxonomic variation. They also highlight the importance of ethnographically-informed modern analogs in interpreting paleofeces. Future research will focus on broadening the modern sample to include seasonal variation and paleofeces from different site areas and stratigraphic units.

Reference:

Petrigh, R. S., N. J. Velázquez, M. H. Fugassa, L. S. Burry, M. Mondini and M. A. Korstanje, 2021. Herbivore coprolites from the South-Central Andes. A multiproxy study at Los Viscos Archaeological Site, Catamarca, Argentina. *Journal of Archaeological Science: Reports* 38: 103063. <https://doi.org/10.1016/j.jasrep.2021.103063>

Keywords: Paleofeces, Feces, Pollen, South-Central Andes, Camelids

【A0041】 -Poster

Holocene on the High Country: A multi-proxy reconstruction of systemic paleoenvironmental sensitivity across high-altitude Australia

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High-altitude environments are extremely sensitive to, and thus regarded 'sentinels' of, global environmental change. This is attributable to their geomorphology and ecology being strongly prescribed by the interaction between elevation and climate, which yields marginal conditions, amplified rates of warming, restricted habitat islands



and steep ecological gradients. These features predispose high-altitude landscapes to rapid and dramatic change in response to even mild deviations in regional climate. Such acute sensitivity has been exacerbated by prolonged and unsustainable land use change that has reduced biophysical resilience to stress.

However, empirical observations of high-altitude change are often defined according to either abiotic (e.g., erosion rates) or especially biotic (e.g., species distributions) criteria. This bias extends to paleoenvironmental research, which is disproportionately represented by paleoecological, namely palynological, reconstructions in these regions. Such reductionist approaches inform projections that are unrepresentative of 'systemic' sensitivity – that is, pertaining to the response behaviour of the landscape as an integrated geoecological system comprising both abiotic and biotic components. A holistic reframing of sensitivity is critical for constraining not only the degree to which earth surface processes contribute to observed ecological change, but also the resilience of high-altitude landscapes, with implications for the conservation of their unique ecosystem services and ecological communities.

Multi-proxy analysis represents an avenue for achieving systemic insights into paleoenvironmental sensitivity through the triangulation of a suite of abiotic and biotic proxies. Such an approach is especially pertinent to the High Country of New South Wales, Australia, which represents the largest continuous extent of high-altitude environment on the continental mainland. The region is by global standards highly restricted on account of it being near its climatic limit and is also heavily degraded by land use change, rendering it hypersensitive to climate change. However, consistent with the global research convention, our understanding of the long-term sensitivity of the High Country is informed by a sparse archive of paleoecological records, rendering the region an ideal location for multi-proxy reconstructions of systemic change.

In view of these knowledge gaps, we present a suite of Holocene multi-proxy records from lakes and mires across a broad altitudinal transect of the major altitudinal (alpine, subalpine, montane and tableland) zones of the High Country of mainland Australia. Through multivariate analysis, we infer how key metrics of sensitivity (i.e., rates, magnitudes and directions of change) have varied between abiotic and biotic processes, across sites and with altitude over the current interglacial period. Being characterised by climatic conditions most comparable to present, the Holocene represents an optimal paleo-analogue for projecting the future trajectories of systemic environmental change. The results of such research will inform policy and strategies on how to conserve and maximise the resilience of high-altitude landscapes in the era



of global environmental change.

Keywords: Paleoenvironmental reconstructions, Systemic sensitivity, Paleoclimate, Paleoecology, High-altitude landscapes

【A0325】 -Poster

Investigating the Southern Ocean's response to abrupt climate change in the Ross Sea over the last 2,000 years

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A review of current paleoclimate literature from Antarctica highlights that our understanding of short-term climate variability over the past 2,000 years is primarily based on ice core records. While these continental archives have provided invaluable insights, the response of the Southern Ocean during this period remains poorly understood due to the limited availability of marine records. The GRETA project aims to fill this gap by investigating the Southern Ocean's response to a cooling event recorded in Victoria Land (Ross Sea) (ca.1.3–1.9 kyr CE). Specifically, we focused on reconstructing sea ice dynamics—both pack ice and fast ice—and key oceanic properties such as sea surface temperature, circulation patterns, and upwelling in the



Ross Sea during this abrupt climatic shift. Our research is based on marine sediment cores from five sites: Granite Harbour, Joides Basin, Wood Bay, Edisto Inlet and Robertson Bay. By integrating these marine records with ice core data and climate model simulations, we seek to enhance our understanding of sub-millennial variability in atmosphere-ocean interactions. Preliminary results from our analysis indicate significant shifts in sea ice extent and water mass properties during this period, offering new insights into the complex interactions between the atmosphere and the Southern Ocean. These findings will contribute to a more comprehensive understanding of regional climate variability and its broader implications for global climate systems.

Keywords: Ross Sea, Antarctica, Paleoclimate, Sea ice, Marine record

【A0864】 -Oral

Holocene environmental change in the northern Ecuadorian Andes: First insights from lake sediment archives

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Tropical high-mountain regions, which are biodiversity hotspots, are highly vulnerable



to the impacts of anthropogenic climate change and biodiversity loss. For example, land degradation, deforestation, and freshwater depletion pose significant challenges for land management, closely linked to ecosystem and societal changes. Despite their importance, these regions remain underrepresented in paleoenvironmental research, highlighting the need for targeted studies. Our pilot study aims to address this knowledge gap by reconstructing Holocene landscape dynamics in the northern Ecuadorian Andes, a region of high ecological and cultural value, using natural lake sediment archives. We employed a multi-proxy approach, combining sub-bottom profiles (SBP) with a detailed analysis of short sediment cores from lakes San Pablo, Cuicocha (SBP only), Muertepungo (SBP only), and the Mojanda Lake Region, all located in the high-altitude region around Ecuador's capital Quito (3000-4000 m a.s.l.). Our analysis includes sedimentological descriptions, non-invasive techniques such as line-scan imaging, high-resolution magnetic susceptibility, and XRF-core scanning, as well as invasive analyses on sub-samples (at 1 cm intervals), including grain size, bulk mineralogy, bulk geochemistry, bioindicators, and macrocharcoal. Radiocarbon and tephra analysis were conducted on additional samples to establish a chronological framework. Preliminary results indicate notable differences among the studied lakes, reflected in distinct sediment layers with unique properties. These variations are being linked to shifts in water levels, temperature, and other factors. By integrating these initial findings with local knowledge from communities, this interdisciplinary project aims to establish a long-term, sustained co-production of knowledge and foster a collaborative approach to address the impacts of climate change and biodiversity loss in the northern Ecuadorian Andes.

Keywords: Palaeoenvironment, Ecuadorian lakes, Sub-bottom profiles, Sediment cores, Multi-proxy analysis

【A0784】 -Poster

Sediments of lake big kisegach: Seismoacoustic characteristics, chronology and magnetic properties

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Bolshoy Kisegach is the largest lake, part of the Kisegach-Miass lake and river system, located on the territory of the Ilmen State Reserve (South Ural Mountains, Russia).

In 2016, from the central part of the lake, five core columns with length from 258 to 540 cm, were selected based on seismoacoustic studies.

Based on preliminary petromagnetic studies, the longest core column No2 was selected as the reference. The age was estimated based on the radiocarbon AMS dating. Measurements of bulk density, LOI_{350} , XRD and magnetic properties (NRM, magnetic susceptibility, hysteresis parameters and thermomagnetic analysis) were taken for core samples. High-resolution scanning electron microscopy was used to visualize the magnetic fraction particles.

The maximum thickness of the sediments (7.5 m) was localized in the central part of the lake by the analysis of seismoacoustic data. Two units differing in their acoustic properties were identified. They are corresponding to Neopleistocene and Holocene sediments respectively. Acoustic boundaries correspond to changes in the bulk density of dry sediment and are indicators of lithogenetic changes.

The radiocarbon AMS dating allows to create an age model reflecting changes in the sedimentation rate over the 14000 cal yr BP. The approximate age of lake formation was estimated to be 23000 cal yr BP.

The study of the core shows that lithological and petromagnetic features of the lake sediments act as informative indicators of the sedimentogenesis conditions in accordance with the climatic stages in the Neopleistocene and Holocene.

Mineralized (Neopleistocene) and mineral-organogenic (Holocene) sapropel sediments are weakly magnetic. The magnetic fraction is represented by ferrous minerals, sulfides and iron oxides. Ferromagnetic grains are heterogeneous. The magnetic fraction of Pleistocene sediments is characterized by a high content of single-domain particles. However, the Holocene sediments is characterized by a higher content of the multi-domain component.

Variations of petromagnetic characteristics and ratios of hysteresis parameters in combination with lithological characteristics act as informative indicators of lithological zonality and climatic events. They reflect changes in reservoir accommodation and supply of detrital material associated with changes in climate



humidity. The importance of the magnetic susceptibility paramagnetic component in paleoclimatic reconstructions is noted.

In the history of the lake system evolution, the stages of regression and reduction of lake accommodation in Alleröd-Interstadial and Young Dryas are determined. YD is noted as the coldest episode in the history of the lake. From ~12150 cal yr BP, the watering phase begins, which continues until the end of Preboreal stage. Boreal stage is compared with the regressive phase. Approximately of 10400 cal yr BP, the climate is changed. No significant climatic events have been recorded during the Atlantic and Subboreal stages. The beginning of the Subatlantic stage is characterized by a humidity increasing. The Subatlantic stage is interpreted as the warmest and most humid. During the 1000-650 cal yr BP, the humidity decreased.

This research was funded by the Ministry of Science and Higher Education of the Russian Federation under grant agreement No. 075-15-2024-554 dated 24.04.2024.

Keywords: Lake sediments, Paleolimnology, Seismoacoustic profiling, Petromagnetic parameters, Sedimentation conditions

【A0370】 -Poster

Moist Younger Dryas in northeastern China invalidated

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The Younger Dryas (YD, 12,900 to 11,700 years before the present), a major cold event during the last deglaciation, provides an invaluable palaeo analogue for potential collapse of the Atlantic Meridional Overturning Circulation (AMOC) under current global warming. Studying YD's climate disruptions offers crucial insights into likely atmospheric, oceanic, and ecological impacts, helping predict the profound



consequences of weakened AMOC in today's warming world. In East Asia, however, the climate condition and impacts on terrestrial ecosystems of YD remain greatly controversial. Reported YD hydroclimate condition is unexpectedly moist and can vary from place to place, diverging from the conventional understanding. Here, we present a hydrogen isotope composition sequence of lipid biomarkers and a decadal pollen-based quantitative climate reconstruction from precisely dated peat, to reconstruct the hydroclimate over northeast China. We observe a decrease in regional precipitation amounts and increase in the hydrogen isotopes values, showing moist YD doesn't not hold up. In contrast, we conclude increased evapotranspiration, as well as a change in atmospheric circulation associated with the YD.

Keywords: YD, Pollen, Biomarker, Hydroclimate

【A0822】 -Poster

From fresh snow petrel stomach oil to deposits: A valuable archive for paleoenvironmental reconstruction

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Snow petrel (*Pagodroma nivea*) stomach oil deposits hold significant potential as an archive for uncovering historical occupation patterns (e.g., Steele and Hiller, 1997) and assessing variations in Antarctic Sea ice conditions (e.g., McClymont et al., 2022). This study uses gas chromatography-mass spectrometry (GC-MS) for biomarker analysis, focusing on fatty acids and alcohols, and isotope ratio mass spectrometry (IRMS) for stable carbon and nitrogen isotope analysis to compare the biochemical profiles of fresh stomach oil and stomach oil deposits. Significant differences in fatty acid compositions and isotopic signatures were identified between the two sample types. Holocene shifts in dietary signals were observed in deposits representing the south-east Weddell Sea, offshore Dronning Maud Land. These shifts are potentially linked to changes in foraging range, which are closely associated with environmental factors such as sea-ice extent and oceanographic conditions. The findings underscore the utility of snow petrel stomach oil as a proxy for long-term ecological monitoring in



polar ecosystems. By providing insights into marine food web dynamics and the impacts of environmental variability, this research contributes to a broader understanding of the ecological responses of Antarctic top predators to changing environmental conditions.

Keywords: Snow petrel stomach oil deposits, Weddell Sea, Biochemistry, Holocene records

【A0161】 -Oral

Millennial-scale impacts of climate and land use on fynbos vegetation in the Cape Floristic Region, South Africa

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Climate change projections continue to raise concerns over ecosystem vulnerability and global biodiversity loss. Mediterranean-type ecosystems (MTEs) are also anticipated to be especially sensitive to change due to altering fire regimes, variations in plant available moisture, and invasive species which can impact ecosystem services. Jonkershoek (JNK), a biodiversity hotspot and an MTE in the Cape Floristic Region of South Africa has a decadal history of ecological monitoring without centennial and millennial-scale records of land use to conceptualize change. This study applied multiple paleoecological proxies including pollen, dung spores, charcoal and geochemistry to investigate 5400 years of different land use and climate regimes, and their impact on the fynbos vegetation.

The results suggest an incredible resilience within the fynbos biome through time. During the mid-Holocene, under cooler conditions and San hunter-gatherer occupation characterised by moderate fire regimes, restioid fynbos dominated the slopes. By the late Holocene, this transitioned to grassier fynbos associated with variable climates and reduced fire activity. Subsequently, under the cooler conditions in the Little Ice Age, the intensified anthropogenic activities from European settlers brought about indiscriminate fires, soil disturbances, and the proliferation of invasive alien plants (IAPs). Despite these pressures, the resurgence of Restionaceae highlights



the fynbos biome's capacity for resilience and recovery.

An understanding of the trajectory of recent changes in MTEs for designing effective restoration strategies requires long-term monitoring and historical knowledge that predates the more recent intensive human impact. For instance, fire regimes in the recent 400 years are atypical when compared with the longer-term history of the site. This can be linked to anthropogenic influence and fuel load increase from invasive taxa. While ecological thresholds may not have been crossed presently at the biome level, proactive management is essential to mitigate fire frequencies and reduce biomass to preserve ecosystem integrity, especially under future climate scenarios. This study emphasises the critical role of palaeoecological in providing information for future management of vegetation and fires, offering a vital complement to decadal-scale monitoring efforts for sustainable ecosystem management.

Keywords: Paleoecology, Fynbos, Fire regimes, Land management, Mediterranean ecosystems

【A0883】 -Poster

A global high-resolution modeling of the mid-Holocene climate

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The Mid-Holocene (MH; 6 ka) is a key period for studying past climate changes, providing insights into the interactions between insolation, monsoon systems, and ecosystems under natural forcings, primarily driven by orbital changes. Thus, the MH experiment has been one of the standard experiments since the first phase of the Paleoclimate Modelling Intercomparison Project (PMIP). However, most simulations were carried out using low resolutions, typically with a horizontal resolution of $\sim 2^\circ$ for the atmosphere, limiting their ability to capture fine-scale processes. Here we conduct a series of high-resolution ($\sim 0.25^\circ$) MH experiments using CAM4, to investigate the influence of orbital changes, Sahara greening, vegetation expansion, and reduced dust emissions on the MH climate. These experiments allow us to explore not only the changes of precipitation and surface temperature in greater detail, but also those of the tropical cyclone (TC).



Results from the high-resolution simulations show a much larger change in the annual mean precipitation over most regions between MH and pre-industrial (PI) compared to the low-resolution results; the responses of Summer Monsoon to insolation change are thus much stronger too. Compared to low-resolution simulations, the high-resolution experiments also show larger increase in surface temperature over mid- to high-latitude lands. Additionally, the results show that the greening of Sahara causes a great reduction in TC activity over North Atlantic. Our study highlights the critical importance of high-resolution modeling in capturing global and regional climate dynamics and extreme weather events.

Keywords: Mid-Holocene, High-resolution modeling, Climate, Tropical cyclone

【A0579】 -Poster

Millennial-scale perspective of the Holocene Indian Monsoon change in the Central Himalaya

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The Holocene climate history of the central Himalaya remains poorly constrained. Here, we present a high-resolution peat record from the Alaknanda valley, Mana (India), to reconstruct Indian Summer Monsoon (ISM) variability and its relationship with the winter westerlies. Age-constrained multi-proxy approach, including $\delta^{13}\text{C}_{\text{org}}$, total organic carbon, grain size, and AMS ^{14}C dating, was used to decipher ISM variations. Our results, particularly the $\delta^{13}\text{C}_{\text{org}}$ record, indicate periods of enhanced ISM and warm/ wetter conditions during $\sim 10,000$ – 7780 and ~ 5260 – 1990 years BP. Conversely, we identified periods of reduced ISM and cool/drier conditions during $\sim 11,200$ – $10,000$, ~ 7780 – 5260 , and ~ 1990 – 1100 years BP. Spectral and wavelet analyses of $\delta^{13}\text{C}_{\text{org}}$ reveal periodicities at ~ 550 -, 450 -, and 400 -year intervals, potentially mirroring solar cycle forcing on the ISM during the Holocene. Subsequently, increasing winter insolation enhanced winter westerlies, influencing moisture delivery. Our findings suggest that the Holocene evolution of moisture conditions in the central Himalaya was primarily governed by the interplay between ISM and winter westerlies, driven by



insolation variations at 30°N. This study provides novel insights into the mechanisms driving climate change in the central Himalaya.

Keywords: Holocene, Indian Monsoon, Central Himalaya, Multi-proxy

【A0733】 -Poster

Late Holocene vegetation and environmental changes in coastal Karnataka, southwest India-a multiproxy record based on a sediment sequence from Lake Ramasamuda

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This study presents a multiproxy record (based on lipid-biomarkers and palynology) of the paleovegetation dynamics in coastal Karnataka using a sedimentary sequence from Lake Ramasamudra, coastal Karnataka, southwest India. Non-arboreal plants dominate the region. *Poaceae*, *Typha*, *Euphorbiaceae*, *Combretaceae*, and *Chenopodiaceae* are the dominant plant species. The biomarker indices indicate dominance of aquatic plants (emergent macrophytes and submerged or floating plants) over terrestrial plants. The sediment core spanning the past 1566 years, from 2005 to 439 cal yr BP, reveals four distinct climatic phases. Phase 1 (2005-1550 cal yr BP) is characterised by a period of weak Indian Summer Monsoon (ISM), diminished vegetation growth, and reduced aquatic productivity. It was followed by three successive stages of strengthening monsoon and increasing vegetation growth. In Phase 2 (1550-1230 cal yr BP), the monsoon strengthened, leading to strong precipitation, intense vegetation growth, and high aquatic productivity. Phase 3 (1230-570 cal yr BP) features an extremely moist climate with a significant proliferation of both arboreal and non-arboreal plant taxa. Phase 4 (570-440 cal yr BP) shows a further increase in vegetation growth and enhanced monsoon strength. A comparative study



with regional records suggests a similar trend in broad climate variability, revealing a global teleconnection. The climatic evolution of coastal Karnataka aligns with the shifts in the Intertropical Convergence Zone (ITCZ), El Niño Southern Oscillation (ENSO), and Total Solar Irradiance (TSI). Additionally, the signatures of global factors like ITCZ, ENSO, and TSI have been overprinted by the signatures of regional factors such as sea surface temperature (SST), especially during periods of active Indian Ocean Dipole (IOD).

Keywords: Lipid biomarkers, Palynology, Indian Ocean Dipole, Indian Summer Monsoon, Lake productivity

【A0284】 -Poster

Quantifying pre- and post-Columbian human-plant interactions and ecosystem resilience in South America

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Humans and landscapes have coevolved, woven into heterogeneous mosaics where ecosystems were shaped by negative and positive impacts. Quantifying these dynamics is crucial to track ecosystem changes and redefine ecological baselines for effective conservation strategies. However, significant knowledge gaps persist, largely due to poor integration of human activity proxies. This research investigates human-plant interactions during the late-Holocene in South America, a region where current understanding is limited by substantial data gaps. We hypothesize that European colonization triggered an ecological state shift, fundamentally altering ecosystem resilience. To test this, we will develop a Past Anthropogenic Activity Index by integrating multiple proxy datasets using multivariate statistical methods. To address data gaps, we will reconstruct vegetation histories from two sediment cores in Northeast Brazil: a seasonally dry tropical forest and mangrove. These cores span the past 1,000 and 7,000 years, respectively, and represent neglected areas with long-term human occupation. Analyses will include pollen and charcoal examination, X-ray fluorescence scanning, loss-on-ignition and statistical approaches to compare resilience and disturbance indicators across pre- and post-Columbian periods. We expect to demonstrate that European colonization significantly reduced vegetation resilience, providing new insights into the long-term impacts of land management practices on South American ecosystems.



Keywords: Holocene, Human impact, Vegetation reconstruction, Palynology, Statistics

【A0295】 -Oral

Holocene temperature record from sub-Antarctic Macquarie Island using sedimentary biomarkers (GDGTs)

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The Southern Ocean region remains a key data gap for palaeo-temperature records. Furthermore, understanding long-term variability in the Southern Hemisphere westerly winds (SHW) and temperature informs how large-scale climate processes, particularly the Southern Ocean carbon sink, may react to future climates. Instrumental records show the SHW have intensified and moved poleward in recent decades in response to warming. However, there is insufficient understanding of long-term SHW responses to temperature change, limiting the assessment of the impacts of future changes in SHW dynamics. To establish this, we are undertaking multi-proxy analyses of lake sediment cores dating to c. 12,000 years BP from three sites on sub-Antarctic Macquarie Island (54°38'S, 158°52'E). Our multi-site, multi-proxy approach enables examination of different climate variables in parallel, providing comprehensive understanding of past climate and environmental changes. Methods involve Lead-210, 20th century atmospheric nuclear weapons testing fallout signatures, and radiocarbon to date the cores, diatom-conductivity inference models, and geochemical indicators to reconstruct the SHW. Sedimentary biomarkers (glycerol dialkyl glycerol tetraethers-GDGTs) are being used to quantify past temperatures. Results show that GDGT-inferred temperatures from lake surface sediments agree well with measured lake temperatures and mean summer air temperatures (MSAT) on Macquarie Island. Downcore temperature estimates across the 21st century align well with the instrumental record (1949–2011) in timing and magnitude, while preliminary results spanning the Holocene show MSAT varied between 7.5–12°C ±2°C. This study represents the first quantitative palaeo-temperature record and application of GDGTs on Macquarie Island. These temperature records will be integrated with Macquarie



Island SHW records and existing mid-to-high-latitude Southern Hemisphere palaeo-records to understand links with large-scale climate modes, and aid projections of future SHW and temperature changes across the sub-Antarctic.

Keywords: Southern Ocean, Macquarie Island, Southern Hemisphere westerlies winds, Temperature, GDGTs

【A0372】 -Poster

Centennial-scale variability in atmospheric circulation in Antarctica: Insights from a coastal East Antarctic ice core record

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A 108 m ice core (32SC), extracted from the coastal region of East Antarctica in February 2016, was analyzed to investigate the relationship between sea salt records and sea ice as well as atmospheric circulation patterns. The first component of Empirical Orthogonal Function (EOF) analysis of major chemical ions in the ice core (32SC REOF1), accounting for 58.31% of the variance in ion concentrations, serves as a record of sea salt aerosols. It is shown that sea ice does not significantly influence 32SC REOF1, as evidenced by the absence of strong correlations with sea ice data. Instead, 32SC REOF1 is closely related to the strength of meridional atmospheric transport from the southern Indian Ocean to Princess Elizabeth Land during the winter months. Overall, the ice core record reveals a significant increasing trend in 32SC REOF1 from 1616-1850 CE to 1851-2016 CE, with the mean value increasing by a factor of 2.4. This centennial-scale trend is likely attributed to changes in the latitudinal position of the Southern Hemisphere Westerly Winds (SHWW) belt. During the earlier period (1616-1850 CE), the $\delta^{18}\text{O}$ (H_2O) of 32SC indicates that the temperature was possibly lower. During this time period, the SHWW in the southern Indian Ocean may have experienced an equatorward shift and a decrease in intensity, potentially resulting in a decrease in cyclone frequency and a subsequent decline in sea salt transport in high latitudes. In contrast, the later period (1851-2016 CE) was warmer than the earlier period. The SHWW in the southern Indian Ocean during this time was positioned closer to the pole. This positioning contributed to an increase in meridional wind speed poleward, which in turn led to a stronger transport of sea salts. Comparisons with sea salt records from other Antarctic ice cores reveal that the shift



in the latitudinal position of the SHWW belt on a centennial timescale is a regional phenomenon, particularly evident in the southern Indian Ocean.

Keywords: Ice core, Sea salts, Antarctica, Atmospheric circulation

【A0369】 -Oral

Environmental records from the tropical sphagnum peatlands of Réunion Island since the last glacial maximum

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Tropical peatlands, particularly those on volcanic islands, hold great potential as environmental archives for recording long-term climate and volcanic activity. In contrast to the widespread distribution of temperate and boreal peatlands, peat is rarely formed on tropical volcanic islands, and therefore paleoecological reconstructions of tropical island peatlands are less frequently mentioned or researched.

Our study investigated the dynamics of *Sphagnum* peatlands from La Réunion Island, a tropical island in the Indian Ocean. We studied three different *Sphagnum* peatlands: the first, dating back nearly 25,000 years before present, is located in the core of the national park; the second, a blanket bog, is situated very close to the active volcano; and the third is located in an urban area, where a thin layer of peat has been deposited



directly on a volcanic slab. This study helps us understand how peat can start accumulating in such tropical environments. Our primary objectives are to use the peat core as environmental archives to reconstruct the dynamics of peat accumulation, *Sphagnum* ecology and the deposition of trace elements in the Indian Ocean. We firstly used the ^{14}C , Gamma emitter radionuclides, XRF core scanner, and Geotek MSCL system (VNIR Hyperspectral Camera) to date the age, reveal the variations of elemental composition, and obtain paleo-proxy data. It shows that the oldest peat core reveals the presence of older than expected sedimentary sequences, which date back nearly 25,000 years, providing a window into the Last Glacial Maximum and the Holocene. The four peaks in the Fe/Mn ratio imply that there have been at least four periods of enhanced oxidation in the peatland. The most recent period of enhanced oxidation state was accompanied by a rapid increase in the content of organic matter, Mg, Al, Si, S, Ca, Ti, Mn, Fe, Ni, Rb and Pb. We have reconstructed the sedimentary history and paleoenvironmental record of this tropical island peatland and attempted to use hyperspectral technique to discover novel proxies to better reconstruct peatland paleoenvironments.

Keywords: Tropical island peatlands, Paleoecological reconstruction, Trace elements

【A1004】 -Poster

Sedimentation rates and accumulation of organic carbon in lakes of southern Spitsbergen (Hornsund)

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Arctic warms several times faster than the rest of the globe and high latitude lakes are responding rapidly to such accelerated climate change. Lakes represent reliable archives of climatic and environmental changes thus impacts of the ongoing warming of the Arctic freshwaters can be achieved through investigations of sediment cores. In that context it is particularly important to understand mechanisms influencing accumulation of organic carbon in northern lakes. In this study, we used two model high Arctic lake systems (lakes Myrktjørna and Revvatnet) that are directly and indirectly influenced by climate-triggered glacier decline to understand past organic carbon sequestration patterns. Both lakes are situated in the southwestern part of



Spitsbergen (Hornsund area) in mountain valleys composed of marble (Revvatnet valley) and amphibolite (Myrktjørna valley). Importantly, while Lake Revvatnet positioned on uplifted marine terrace is disconnected from any glaciers, Lake Myrktjørna is fed from the Brategg Glacier that is rapidly declining over the last decades. Short sediment cores from each lake were collected and subsampled with 1 cm (Revvatnet) or 0.5 cm (Myrktjørna) resolution. The application of dating methods based on the short-lived isotopes (^{137}Cs and ^{210}Pb) enabled the calculation of sedimentation rates in both lakes and the development of reliable age-depth models. Additionally, the cores were analyzed for total organic carbon (TOC) content, which allowed for the determination of accumulation rates for TOC. These data were then used to investigate the impact of climate warming on organic carbon burial rates in these lakes.

Keywords: Spitsbergen, Organic carbon

【A0025】 -Oral

Reconstructing Holocene canal system development and water management system in Ur City (Southern Iraq) through diatom microfossils

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Studies of ancient canal systems and water management are crucial for understanding early urban civilizations' adaptive strategies to environmental challenges. The early southern Mesopotamian city of Ur (Tell al-Muqayyar, Iraq) was inhabited for over 5000 years and relied upon the Euphrates River for agricultural and urban water supplies. During these millennia the region experienced significant environmental change, from a littoral to a riverine and eventually a desert environment. In the fifth to third millennia BCE, as the settlement was founded and grew into a large, walled urban centre, the area was likely not far removed from the coast of the Persian/Arabian Gulf and associated marsh areas. As the Gulf retreated to the southeast and as the city expanded, Ur's hinterland developed into a riverine environment where agriculture was dependent on canal irrigation and where local



transport used canals and harbors. Towards the end of Ur's occupation, the Euphrates River shifted to the north and the Ur area became increasingly arid.

In this paper, we use analysis of diatoms to trace these environmental and hydrological shifts. We use diatom microfossils from sediment samples collected from locations believed to be associated with one of Ur's ancient city canals, its two city harbors, and other water courses in the immediate hinterland to reconstruct the past development of Ur's canal systems and potential water management practices in response to environmental changes. We collected nine sediment cores, each approximately 10 meters deep from the current ground surface. Diatom extraction has been completed, and initial observations reveal high concentrations of diatom remains at specific depths (around 700–800 cm) in cores AU1, AU9, and AU4. These cores are situated within areas identified in previous archaeological studies as the city's 'West Harbor', 'City Canal', and 'North Harbor'. Here, most of diatom species in AU1 and AU9 are high-nutrient preferred, but those in AU4 are low-nutrient preferred which indicates evidence of their systematic water management. In contrast, significantly fewer diatoms were found in other auger samples. This pattern strongly suggests that the archaeological feature identified as a city canal was in fact a canal and that it contained polluted water from the city centre. The ongoing work includes diatom species identification, XRF data analysis, radiocarbon dating, and geochemical analysis with a focus on salinity and nutrient conditions to identify freshwater and brackish water bodies of 9 study sites within or around the canal system.

While archaeologically well researched, the relationship between humans and their environments has been less covered. So, we aim to establish further detailed timelines for canal construction, usage, and abandonment, potentially linked to climate shifts or sociopolitical changes at ancient Ur. We expect that the results will enhance our understanding of how Ur's residents adapted their water infrastructure in response to landscape changes, and how they maintained sustainability of watercourses, contributing to broader discussions of ancient urban resilience and environmental adaptation.

Keywords: Mesopotamia, Water management, Archeology, City canal, Diatom

【A0294】 -Poster

Holocene vegetation dynamics, carbon deposition, sea level changes, and human impact inferred from the blocked river channel core in the Baía de Caxiuana region, northern Brazil



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Tropical peat deposits as a potential carbon (C) stock are important to global climate change. Hence, it is necessary to explore the mechanism of formation and dynamics of tropical peat ecosystems. Up to the present, the paleoecology of peat ecosystems in eastern Amazonia is still little known. In this paper, we investigate the vegetation dynamics by pollen and spores, peat and organic C accumulation, macro-charcoal, mineral identification, and chemical composition based on multi-proxy analysis of a 395-cm-long radiocarbon dated sediment core, named Lagoa da Fazenda (LF), from a blocked river channel of the Caxiuanã Bay in eastern Amazonia, Brazil. This study site can be a representative of the net of former small river valleys with carbon-rich organic matter deposits in the Holocene in eastern Amazonia. The study results indicate that the onset of the peat with organic C deposits forming a local inundated forest was since ca. 7000 cal yr BP, which may be caused by the Atlantic sea level rise. Since ca. 5000 cal yr BP, the Atlantic sea level further rose. Peat and C accumulation rates remained at a high level since the start but became lower and more fluctuated since 2600 cal yr BP, which is influenced by river flooding, which may be caused by regional human activities causing soil erosion inferred from the previous lake-like Rio Curuá record in the study region. The local vegetation changed from the inundated forest to a Cyperaceae swamp since 1800 cal yr BP until the present. A strong local human influence was recorded since ca. 260 cal yr BP.

Keywords: Eastern Amazonia, Holocene, Peat and organic carbon, Atlantic sea level, Vegetation dynamics, Human activities



Session 30. Holocene coastal marine environments in the Arctic: Proxy records and development

Conveners: Beth Caissie, Maija Heikkilä, Anna Pieńkowski, Christof Pierce

【A0635】 -Poster

Holocene diatom-based environmental reconstructions for the Bay of Sept-Îles, Canada

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Diatoms are frequently used for paleoenvironmental studies in freshwater ecosystems, but less so in estuarine and marine environments. The Bay of Sept-Îles, in the Gulf of Saint-Lawrence (Québec, Canada), is the site of North America's busiest mineral port, exposing its system to various anthropogenic pressures. The main objective of this project is to define past reference conditions for various environmental variables and assess current environmental changes in the ecosystem based on marine coastal diatom models. Diatom assemblages from surface sediments were characterized and environmental variables were measured at 35 sites along a 85 km coastal transect following the 20-30 m bathymetric depth. More than 500 diatom taxa were identified and 19 surface water variables were measured (once in July 2021 and once in July 2022). Multivariate numerical methods were employed to determine the species response to the measured parameters. Turbidity and temperature explained a significant proportion of the variation in the diatom data, leading to the development of quantitative transfer functions for these variables. Models were subsequently applied to the sedimentary diatom assemblages from a 30 cm sediment core extracted within the Bay, at a depth of 20 m. The quantitative inferences provide insight into the dynamics of past environmental changes in this high-use coastal environment. The analysis of the sediment core also revealed temporal variations in species assemblages, and through the industrial era. Our results offer useful knowledge on the state of variability of this region, which until recently had been little-studied, and offers a means to guide management towards sustainable development in subarctic coastal ecosystems under diverse pressures.

Keywords: Diatoms, Bioindicators, Coastal environment, Quantitative reconstruction



【A0405】 -Poster

Influence of Arctic surface air temperature and sea ice on terrestrial organic matter export to the Chukchi Sea during the last three centuries

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The Arctic is experiencing rapid carbon re-mobilization and larger supply of terrestrial organic carbon to the Arctic Ocean as a result of sea ice loss, thawing of permafrost and subsequent melting water discharge through rivers that can ultimately influence the overturning circulation. Although these changes are thought to be caused mainly by human activities, natural variability beyond the instrumental period is poorly documented and quantified. In this study, we generated time-series of bulk organic parameters (TOC, TN, $\delta^{13}\text{C}_{\text{org}}$, $\delta^{15}\text{N}$ and C/N) and representative terrestrial biomarkers (campesterol, β -sitosterol and high-molecular-weight homolog n-alkanes) from 19 surface sediments and 5 multi-cores covering the last three centuries, from the Chukchi Sea. TOC and TN downcore profiles both indicate higher values in southern Chukchi Sea than at higher latitudes. They also show a long-term increase since the beginning of the Industrial Era in all cores that coincides with decreasing $\delta^{13}\text{C}_{\text{org}}$, pointing out enhanced supply of terrestrial organic carbon. This trend is consistently more pronounced in the southern coastal core sites. This interpretation is confirmed by the terrestrial biomarker data showing increase since ~1850-1900. The average chain length of n-alkanes (ACL_{27-31}), an indicator of past moisture/temperature conditions, indicates increase aridity over the lands surrounding the Chukchi Sea since ~1850. Other indexes based on n-alkane distributions, i.e. Paq and CPI, show decreasing contribution of wetland vegetation since ~1850 and relatively fresh organic carbon, respectively. Finally, we provide evidence of the strong control of regional air temperature and summer sea ice exerted on the export of land-material to the Chukchi Sea and on the vegetation type on surrounding lands, since the beginning of the 18th century. Our results further emphasize the early and high sensitivity of the Arctic region to global warming and its consequences on the carbon cycle.



Keywords: Biomarkers, Terrigenous input, Permafrost thaw, Arctic region, Industrial era

【A0377】 -Poster

Arctic marine environments and ecosystems during the Holocene thermal maximum

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At ~10,000-6,000 yrs BP (before present), the Holocene Thermal Maximum was a period of warmer-than-present climate expressed in warmer air and ocean temperatures across the globe. At high latitudes in the Northern hemisphere, the HTM has been suggested as an interval of reduced sea ice and increased Atlantic water inflow, similar to a projected future warmer Arctic scenario. However, existing evidence is equivocal and remains limited in scope and approach. Here, we present preliminary findings from APHRODITE (*Arctic Palaeorecords from the Htm: a ROaDmap for Imminent Transitions in marine Ecosystems*; National Science Centre OPUS 2022/47/B/ST10/02633), a project focused on the pan-Arctic signature and timing of the HTM with an emphasis on marine environments and ecosystems. In the marine channels of the Canadian Arctic Archipelago, our micropalaeontological data suggest reduced sea ice but glacioisostatically-driven dwindling Atlantic Water influence during the HTM. In the Barents Sea, preliminary micropalaeontological and biogeochemical data imply minimal sea ice off western Svalbard but seasonal sea ice farther to the northeast. The timing of the HTM is offset between these two regions, with the Barents Sea lagging behind Arctic North America. Ongoing work on these and other regions will further elucidate the timing and nature of the HTM across the Circumpolar North, providing a past parallel to a future warmer Arctic.

Keywords: Polar, HTM, Sea ice, Biological productivity

【A0141】 -Poster

Western Arctic environments and biological communities since the industrial revolution



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The Arctic Ocean and terrestrial environment have recently been reported to be changing drastically. Still, it is unclear whether these changes are similar to natural variations in the past or how sudden and large they are compared to natural variations. Sediment cores from the Beaufort Seas were collected in summer 2022 at four sites on the Canadian continental shelf and Alaskan upper continental slope to provide a comprehensive picture of the ocean environment during the preindustrial period before anthropogenic influences. The obtained cores consist of clayey silts continuously deposited during the last 665 to 2415 years with uniquely high sedimentation rates of 0.17 to 0.74 cm y⁻¹. The dry bulk density and Ca/Ti records show ~20, ~30, 50–60, 100–125, 200, and 300-year cycles, likely attributed to the variation in the Aleutian Low that controls the Bering Strait inflow of Pacific waters influencing our core sites. Sedimentary ancient DNA analysis shows that the biological community shifted around 1950 and 1980 with increasing Pacific species.

Keywords: Arctic, Sediment core, Paleoenvironment, Biological community, Late Holocene



Session 31. Open session on past global changes

Conveners: Marie-France Loutre, Iván Hernández-Almeida, Martin Grosjean, Liping Zhou

【A0763】 -Poster

Different origin of Al-Sahabi Paleo-River, Libya

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The Al-Sahabi paleo-river, an ancient fluvial system that once flowed across the central Sahara from south to north, offers critical insights into the paleo-hydrology and hydroclimatic history of northern Africa. This river, primarily associated with the Sahabi Formation in the northeastern Sirt Basin, is thought to have existed during the Neogene period, shaping much of the region's geomorphology. The pre-existence of the paleo-river is confirmed by evidences from different perspectives such as fossil records, Satellite data, and seismic surveys. Notably, seismic acquisitions followed drilling for oil exploration purposes on the Gulf of Sirt revealed a deep and wide canyon cut into Miocene limestone, suggesting substantial river activity during wetter climatic periods. However, only the origin of the Al-Sahabi paleo-river is on debates, with two primary hypotheses about the water sources. The first proposes the Tibesti Mountains located on the south of the country as the origin, while the other suggests Lake Chad placed on Chad during its expansion phases. This discourse illustrates wider arguments over paleo-river systems in the Sahara, including the Fezzan and Kufrah systems, which were operational during humid periods. Comprehending these systems is essential for reconstructing the region's paleo-climates, especially during the Miocene and Pliocene epochs, when variable precipitation patterns facilitated the development of large river networks. This review paper consolidates the existing information regarding the Al-Sahabi paleo-river, its chronology, and the discussions surrounding its origin, while placing it within the wider framework of paleoclimatic alterations in the Sahara.

Keywords: Plaeoriver, Alsaahabi river, Paleoclimatic alterations, Sahara

【A0393】 -Oral

Concurrent Asian monsoon strengthening and early modern human



dispersal to East Asia during the last interglacial

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The relationship between initial *Homo sapiens* dispersal from Africa to East Asia and the orbitally paced evolution of the Asian Summer Monsoon (ASM)—currently the largest monsoon system—remains underexplored due to lack of coordinated synthesis of both Asian paleoanthropological and paleoclimatic data. Here, we investigate orbital-scale ASM dynamics during the last 280 thousand years (kyr) and their likely influences on early *H. sapiens* dispersal to East Asia, through a unique integration of i) new centennial-resolution ASM records from the Chinese Loess Plateau, ii) model-based East Asian hydroclimatic reconstructions, iii) paleoanthropological data compilations, and iv) global *H. sapiens* habitat suitability simulations. Our combined proxy- and model-based reconstructions suggest that ASM precipitation responded to a combination of Northern Hemisphere ice volume, greenhouse gas, and regional summer insolation forcing, with cooccurring primary orbital cycles of ~100-kyr, 41-kyr, and ~20-kyr. Between ~125 and 70 kyr ago, Summer Monsoon rains and temperatures increased in vast areas across Asia. This episode coincides with the earliest *H. sapiens* fossil occurrence at multiple localities in East Asia. Following the transcontinental increase in simulated habitat suitability, we suggest that ASM strengthening together with Southeast African climate deterioration may have promoted the initial *H. sapiens* dispersal from their African homeland to remote East Asia during the last interglacial.

Keywords: Asian monsoon, Paleoclimate, Loess, Environmental magnetism, Human dispersal

【A0378】 -Oral

Luminescence dating of long lake cores: Experience from Lake Malawi

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Chronologies for long lake sequences can be constructed using a range of techniques including radiocarbon dating, identification of known-age event horizons such as volcanic ash or variations in the Earth's magnetic field and by tuning palaeoclimate signals to those of well-dated archives. However, these techniques are not universally applicable, and can leave sections of a core undated. Worse, application of different techniques to the same sequence can yield core sections with irreconcilable chronologies, as occurred between ~74 ka and ~590 ka in GLAD7-Mal05-1 from Lake Malawi. Luminescence dating techniques can be used to determine the time elapsed since mineral grains were last exposed to sunlight. Where terrestrial material is incorporated into lakes via subaerial transportation, the luminescence age very closely approximates the date of deposition, making direct dating of the sediment possible. Since luminescence techniques can provide accurate ages between ~1 and ~400 ka under ideal circumstances, they have considerable potential for dating long lake cores. However, factors such as signal resetting prior to deposition, signal saturation, variations in mean sediment water content and subaqueous redeposition have the potential to hamper the generation of accurate ages. Using data from Lake Malawi, we present solutions to (some of) these problems.

Keywords: Luminescence dating, Lake Malawi, Lake cores

【A0530】 -Poster

Holocene environmental changes in Morocco: A comprehensive database

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Holocene environmental changes in Morocco have been reconstructed on the basis of published paleoclimate records from different natural archives. Herein, we present a comprehensive database that includes Holocene records from speleothems, lake sediments, tree-rings, and marine sediments. The Holocene in Morocco has been a period of important environmental and climatic change, impacted by natural forces and human activity. During the early Holocene (11.7–8 ka BP), warm and humid conditions associated with the African Humid Period led to abundant vegetation and high lake levels, especially in the Middle Atlas. By the mid-Holocene (8–4.2 ka BP), the



climate began to dry as the monsoonal rains retreated southward and the Azores High increased, bringing an aridification across both northern and southern Morocco. Around 4.2 ka BP, an abrupt aridification event generated widespread environmental shifts, including declining lake levels and changes in vegetation patterns. The late Holocene (4.2 ka BP to the present) had more climate variability, alternating between wetter and drier periods. Periods include the Medieval Climate Anomaly (900–1300 AD), characterized by drier conditions, and the Little Ice Age (1300–1850 AD), marked by cooler and wetter conditions in some areas. During this period, human impacts became more evident. Moreover, the Arabization of Morocco around 600–700 AD introduced new agricultural practices and land-use strategies that transformed landscapes, contributing to deforestation and soil erosion.

Keywords: Holocene, Morocco, Paleoclimate, Human impact

【A0667】 -Poster

Debris flow dynamics and dendrochronological data: A case study of the Alyavumyok stream, Khibiny

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Khibiny is the largest mountain range on the Kola Peninsula, located in the northern part of European Russia. These compact, plateau-like mountains (up to 1201 m above sea level) have steep slopes and are deeply cut by numerous erosion valleys, 100–400 meters deep. The region is prone to hazardous natural events such as snow avalanches, rockfalls, scree, and debris flows. The most frequently observed types of the latter are snowmelt period slush flows and rainfall induced medium magnitude debris flows. Over the years, the Khibiny Mountains have seen increasing use for tourism and mining activities. Therefore, assessing debris flow activity is crucial not only for paleoclimate reconstructions but also for preventing disasters related to natural hazards.

To obtain high-resolution data on debris flow processes (with accuracy from one year to several years), dendrochronological analysis is the most effective method. Debris flows of varying intensity leave scars on trees or destroy entire vegetation generations,



exposing fresh surfaces. Fieldwork was conducted in the eastern part of the Khibiny range, in the valley of the Alyavumyok stream. Tree cores were collected from various locations within and outside the valley. Our team examined 130 trees, 40 of which showed visible damage (scars). From each tree, we collected at least two cores to determine age and an additional two or four cores from scarred areas. The samples were taken from pine, spruce, and birch trees, with the oldest trees dating back to the mid-17th century. Based on the dating of scars, vegetation community ages across the valley, and growth curve analysis, conclusions were made about changes in debris flow intensity over the past 300 years. A detailed map of the valley was also created, showing the age of vegetation generations.

Objective: To assess the dynamics of debris flow activity in the Alyavumyok stream valley over the past 300 years using dendrochronological analysis.

Keywords: Debris flows, Dendrochronology

【A0708】 -Poster

Potential contribution of leading modes of climate variability to the Arctic temperature variations in the 20th century according to observations and CMIP6 models

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Understanding the mechanisms of the early 20th century warming is the key to determine the relative contribution of internal natural variability and external influences to global and regional climate change, which is crucial for the modern period as well. Still, a comprehensive theory explaining the early 20th century warming and its stronger manifestation in high latitudes is a matter of debate so the quantification of each mechanism that could be responsible for the early warming event is an important issue. Therefore, analysis of early 20th century warming event is complicated by insufficient quantity and spatio-temporal quality of observational data.

The consensus among the majority of studies demonstrate that the pronounced



warming anomaly in the first half of the 20th century can be explained by a combination of internal climate variability and external anthropogenic and natural forcings. Numerical experiments with various generations of climate model ensembles demonstrate that a more precise consideration of different external factors affecting the climate result in a better reproduction of surface temperature changes on both global and regional scales over the past century.

However, while the modern warming is qualitatively reproduced over the model-mean ensemble—suggesting that external influences as the predominant factor—the magnitude of early 20th century temperature increase remains significantly underestimated in climate models. Consequently, the discrepancy between the observed and simulated Arctic surface temperature underscores the significant role of internal climate variation on a multi-decadal time scale (Delworth and Knutson, 2000; Latonin et al., 2021). Concurrently, individual model realizations are capable to reproduce internal temperature variations that are similar to the observed.

The key factors of the Arctic surface temperature growth over the past decades could be caused by contribution of leading atmosphere and ocean variability modes such as AMO, NAO and PDO (Cai et al., 2021). The assessment of the internal climate variability impact to the Arctic temperature regime changes based on multiple regression analysis, reveal that the leading modes of atmosphere-ocean variability explain more than 70% of the winter detrended surface temperature fluctuations in the Arctic during the 20th century, with a dominant influence of the North Atlantic region. Simultaneously, the impact of natural variability modes to surface temperature variability during the winter season across four Arctic sectors demonstrate considerable differences in contribution estimates depending on the specific region.

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Keywords: Climate change, Arctic amplification, Models

【A0683】 -Poster

Coccolithophore-environment relationship in the Western Pacific Ocean: Insights from a compiled surface sediment dataset

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Calcareous phytoplankton, coccolithophores, play a fundamental role in the modern ocean's carbon cycle through primary production via photosynthesis and carbon export to the deep ocean. Their distribution and diversity in the photic zone are controlled by a combination of physical, chemical, and biological parameters, such as sea surface temperature (SST), sea surface salinity (SSS) and nutrient availability. This study provides general insight into the response of coccolithophores to environmental variables in the Western Pacific and marginal seas, allowing the development of quantitative studies (e.g., transfer functions) in this region.

We combined published calcareous nannofossil abundance data from recent 671 surface sediment samples with relevant environmental measurements in the entire Western Pacific Ocean to study the biogeographic patterns of coccolithophores in this region. The new database extends from 55°S latitude to 42°N latitude. The database includes samples in both the open Western Pacific (n=244) and all marginal basins (e.g., Japan Sea, n=130; Yellow and East China Seas, n=81; South China Sea, n=152; Coral and Tasman Seas, n=42) and the Southern Ocean (n=20), spanning temperate, subtropical, tropical subpolar and polar climate zones. Some of the sampling areas are strongly influenced by the seasonally reversing East Asian monsoon system, with some areas affected by freshwater and nutrient delivery from the continent. (e.g., the Yellow River, Yangtze River, and Pearl River). The published datasets were taxonomically harmonized, initially resulting in seven extant coccolithophore species. Environmental data obtained from the World Ocean Atlas includes variables relevant for calcareous



phytoplankton (nutrient, SST, SSS, AOU), extracted at different depths in the photic zone. Multivariate statistical analyses (PCA, DCA and CCA) were applied to this dataset to describe the relationship between species composition and the selected environmental variables. Preliminary results indicate that surface ocean nutrient concentration and temperatures are the most important variables driving coccolithophore assemblage composition in this region. The next steps will be deriving new statistical models to apply them in quantitative reconstructions in sites with downcore nannofossil abundance in the Western Pacific region.

Keywords: Western Pacific Ocean, Calcareous nannofossils, Surface sediments, Transfer functions

【A0637】 -Poster

Enhanced zonal trade winds warm the western South Atlantic surface during MIS 4 glacial descent

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Marine Isotope Stage 4 (MIS 4) was punctuated by full glacial conditions between 70-60 ka. The transition into full glacial conditions was characterized by a substantial cooling of the oceans, extensive ice formation expansion, a significant fall in sea level (about 100 m), a drawdown of atmospheric carbon dioxide (CO_{2atm}), and changes in ocean circulation. The authors Barker and Diz (2014) observed a sudden cooling in surface of the southeastern South Atlantic during MIS 4, which coincided with decreases in temperature over both Greenland and Antarctica. These findings lend support to the hypothesis of globally synchronous cold conditions during this period. However, recent paleoclimate records based on planktonic foraminiferal Mg/Ca ratios suggest a warming trend at sea surface temperature (SST) of the western margin of the South Atlantic, challenging this notion of global cooling, as reported in the studies of Santos et al. (2017). To address this apparent anomaly, we evaluate the influence of (i) CO_{2atm} concentration, (ii) Atlantic Meridional Overturning Circulation (AMOC)



strength, and (iii) the southeastern trade wind system over SST in order to elucidate the mechanisms underlying the thermal response of the South Atlantic during MIS 4. To achieve this goal, ten records of Mg/Ca-based temperatures from planktonic foraminifera were compiled from sediment cores retrieved on both margins of the South Atlantic. The compiled data covered MIS 4, as well as a portion of MIS 5 and 3 (total time recovery: ~75-30 ka), providing a robust basis for reconstructing past oceanic and climatic conditions. The thermal evolution during MIS 4 manifests two distinct behaviors. During the early phase of this stage, a pronounced thermal contrast between the eastern and western margins is evident. It is proposed that this SST contrast during the early phase results from changes in the trade wind system. The pronounced intensification of both meridional and zonal wind components is likely to have enhanced upwelling along the eastern margin of the South Atlantic, simultaneously strengthening the South Equatorial Current and increasing the transport of warm waters towards the western South Atlantic. In contrast, the latter phase of MIS 4 is marked by a synchronous temperature increase across both margins, which is attributed to a weakened AMOC state coupled with rising CO_{2atm} concentrations and global temperatures. These findings suggest a more prominent role of the trade wind system in modulating upper ocean circulation and driving the thermal evolution of the South Atlantic during the early phase of MIS 4 than previously reported in the literature.

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Keywords: Paleoceanography, Sea surface temperature, Quaternary

【A0054】 -Poster

Simulating the response of land cover to Holocene climate change in the Northern Hemisphere monsoon region

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During the mid-Holocene, changes in the Earth's orbital period (especially precession) drove an increase in the amount of solar radiation in the Northern Hemisphere during summer, resulting in a warmer and wetter Northern Hemisphere monsoon region, including North Africa and East Asia. This is confirmed by a large geological record. However, considering only the radiative forcing changes caused by the orbital parameter changes, the climate simulations of the current Earth system models have a large deviation, indicating the importance of the internal feedback of the Earth system. Using a land surface model and machine-learning methods combined with multiple geological records, we investigate (1) the spatial patterns of vegetation and wetlands in North Africa and their responses to climate change during the middle Holocene, and (2) the mid-Holocene climate change and its impact on vegetation in China. These works highlight the important impacts of Holocene climate change on land cover dynamics and the potential climate feedback of land cover changes.

Keywords: Holocene, Vegetation, Land surface model, Spatial pattern

【A0265】 -Poster

Orbital-scale competition of biogenic carbonate and opal production at Del Caño Rise in the southwestern Indian sector of the Southern Ocean during the late Pleistocene

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Geochemical properties measured in core MD19-3575CQ, collected from the Del Caño



Rise in the Subantarctic Zone of the southwestern Indian sector of the Southern Ocean, allowed to document changes in phytoplankton productivity over the last 235 ka. CaCO_3 and biogenic opal contents varied oppositely with high CaCO_3 and low biogenic opal contents during the interglacial periods and *vice versa* during the glacial periods. During the glacial periods, the biogenic opal production by diatoms was enhanced as a result of more silica supply when the Subantarctic Front shifted northward across Del Caño Rise. Fe-bearing dust particles or Fe remobilized from the rise's sediments may have further promoted diatom productivity. On the other hand, CaCO_3 production by coccolithophores was reduced because of cold ocean temperature and competition for nutrients with diatoms. More organic carbon was buried at the core site during the glacial periods than during interglacial periods, probably in relation to a greater export efficiency by diatoms compared to coccolithophores as well as a better preservation of the organic matter when the Circumpolar Deep Water was less ventilated.

Keywords: Phytoplankton production, Ocean front, Sea ice, Carbon cycle, Southern Ocean

【A0918】 -Poster

The Younger Dryas event recorded in Maar Lakes from the tropical to cool temperate zone

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The Younger Dryas event was a period of rapid climate cooling occurred at the end of the last glaciation and greater than anything over the past 20,000 years. Here, we present high-resolution BrGDGTs-based quantitative temperature records from maar lake sediments in the tropical, temperate and cool temperate zones across China. The temperature variations show distinct changes from the oldest Dryas (OD), Bølling-Allerød (BA), the Younger Dryas (YD) and pre-Boreal (PB). The winter monsoon (especially cold surges) could play an important role in the rapid transmission of the temperature signal from the Arctic to the land in East Asia. In the tropical Maar Lake Huguangyan, the mean temperature during the YD was about 20°C and colder about 3°C comparing with the Bølling-Allerød (BA). In the temperate zone, maar Lake Sihailongwan show annual water temperatures decreased about 3°C during the YD than the BA. In the cool temperate zone, Lake Kielguo recorded the summer



temperatures was about 12°C during the YD, and colder about 3°C than the modern summer temperatures. At the end of the YD, the increase rate of temperature was about 0.18°C per decade (mean annual temperate), 0.2°C per decade (mean water temperate) and 0.05°C per decade (mean summer temperate), respectively. The temperature increasing rate was similar or greater than the modern temperature rise rate. Knowledge of this abrupt climate changes is of importance for evaluating the impact of future warming.

Keywords: The Younger Dryas, Maar Lake, Temperature

【A0306】 -Poster

Community building for open and FAIR phytolith data: International committee on open phytolith science (ICOPS)

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Scientific knowledge production in the palaeo-sciences is growing at rapid pace. Access and management of datasets is key for tracking scientific progress, ethical practices, and social impact. Findable, accessible, interoperable, and reusable datasets (FAIR) have emerged as gold standards for open access research. However, there are skills gaps hindering the adoption of open and FAIR practices. For example, the phytolith research community uses microscopic silica casts of plants to reconstruct vegetation, climate, and plant use. Still, it lags other sister disciplines because of multiple data standards, poor curatorship, and limited sharing. This restricts the use of big-data approaches and AI for evaluating phytolith science.



Community building is an important step towards addressing data challenges and is pivotal for supporting the adoption of FAIR data management and stewardship, open-source coding, and reproducible workflows. Training courses are often not sufficient to help researchers implement best practices as they need greater peer-support and mentoring to put what they have learnt into practice. The International Committee on Open Phytolith Science (ICOPS) has been created within the International Phytolith Society to work on increasing the knowledge and implementation of open science practices in phytolith research.

This talk will highlight the work of ICOPS including the FAIR Phytoliths project, the phytolith ontology (PHYT-ON), open research training workshops and clinics, and our Open Publishing Guide. We encourage phytolith researchers, and those more broadly in archaeobotany/palaeobotany, to get involved in our training, seminars, discussions and working initiatives to be part of a broader community of open researchers working together to improve data sharing and the overall quality of research.

Keywords: Open science, Phytoliths, FAIR principles, Palaeo-sciences

【A0324】 -Poster

Towards validating quartz electron spin resonance (ESR) – thermochronometry: Preliminary insights from Anadarko Basin borehole sediments (USA)

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Quantifying the thermal histories of rocks is essential to constrain rock exhumation histories, thereby enabling constraints on the rates and timing of landscape evolution over a range of spatio-temporal timescales (Reiners et al. 2005). Deciphering recent time-temperature histories (<100°C) is crucial for understanding Earth surface processes and interactions between tectonics, erosion, and climate over Quaternary



timescales. However, constraining recent thermal histories (~1 My) at temperatures lower than 100°C remains a challenge. To this end, trapped charge techniques like Electron spin resonance (ESR) dating can exploit the low temperature sensitivity (<100°C) of various paramagnetic defect centres (Al, Ti centres) in the quartz crystal lattice to determine thermal histories over Quaternary timescales. This method offers the potential to fill the temporal gap that remains unresolved by other thermochronometric methods.

The potential of quartz ESR-thermochronometry has been previously investigated (Scherer et al. 1991; Grun et al. 1999; King et al. 2020 and references therein). However, this method is still in its developmental stages and lacks a robust calibration/validation study with samples of known thermal histories. In this study, we present preliminary investigations on the kinetics of different ESR centres in quartz extracted from borehole sediments of the Anadarko Basin (USA) that have known temperature histories (~30-80°C, Carter et al. 1998) and discuss the challenges and potential of different ESR centres in reconstructing temperature histories under laboratory and natural conditions.

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Keywords: Electron spin resonance, Quartz, Anadarko Basin, Low temperature



thermochronology

【A0068】 -Poster

Land snails: Seasonal to weather timescale climatic change records in the terrestrial realm

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Land snails are widely distributed in the terrestrial realm and they are sensitive to the climatic changes, especially to precipitation and temperature. Previous studies suggested that snail shell's oxygen isotope ($\delta^{18}\text{O}_s$) mainly record the information of snail body water, which is ultimately originated from $\delta^{18}\text{O}$ of precipitation ($\delta^{18}\text{O}_p$). To validate this inference, we carried out high-resolution (one sample for every two days) investigation on the $\delta^{18}\text{O}$ of snail body water ($\delta^{18}\text{O}_{bw}$) for the whole growing season in 2021, and intra-shell (millimeter scale) $\delta^{18}\text{O}_s$ analysis was conducted for non-adult shells collected during this time interval. The results show that the $\delta^{18}\text{O}_{bw}$ do mimic the variations of the monitored $\delta^{18}\text{O}_p$ changes. This indicates that $\delta^{18}\text{O}_p$ dominates or paces the seasonal scale $\delta^{18}\text{O}_{bw}$ changes. Furthermore, the measured intra-shell $\delta^{18}\text{O}_s$ also show consistent changes on seasonal time scale with the theoretical calculated $\delta^{18}\text{O}_s$, which is derived from the monitored $\delta^{18}\text{O}_p$ and temperature. Moreover, we further conducted ultra-high resolution (micro scale) intra-shell $\delta^{18}\text{O}_s$ measurements using secondary ion mass spectroscopy (SIMS), and similarly, the $\delta^{18}\text{O}_s$ seems to track the fluctuations of $\delta^{18}\text{O}_p$. Notably, the intra-shell $\delta^{18}\text{O}_s$ could even record the "Once-in-a-millennium" super rainstorm events in Zhengzhou in 2021. Altogether, our study demonstrated that $\delta^{18}\text{O}_s$ could be used as seasonal to weather scale climatic change proxy and to reveal the paleo-weather changes in the terrestrial realm under different climatic backgrounds.

Keywords: Terrestrial snail, Seasonal/Weather timescale, Paleo-weather, High-resolution climate change, Intra-shell oxygen isotope

【A0783】 -Poster

A conceptual model for Pleistocene to Holocene dune formation in the Pacific subtropical semiarid coast of Chile: A landscape paleoenvironmental perspective



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To present the Quaternary eolian stratigraphic record along the Pacific coast of subtropical semiarid Chile (35-28°S) has been mostly studied regarding their paleoclimate significance, nonetheless other main environmental factors are known to affect dune evolution at the millennial to multimillennial time scale, including sediment (i.e., mineral sand) supply linked to glacial and fluvial erosion and transport, eustatic sea level, coastal drift, ocean storminess, wind speed. In Chile, Pleistocene to Holocene dated dunes occur on tectonically elevated marine terraces and to the north of heavily loaded sediment high-flow river outlets to the Pacific Ocean. Rhythmic development of clay-rich Bt paleosols punctuate the dune stratigraphy and denote multimillennial conspicuous humidity changes linked to the latitudinal migration of the southern westerly wind belt. In this conference paper we present new post-IR infrared stimulated luminescence 225°C (pIRIR225) ages, provenance Zr, sediment and pedogenetic data from the paleodune stratigraphic site of Chigualoco. Building on previous studies and previously reported landscape evolution data, we propose a data-based conceptual model in order to assess the role of climate change, Andean glacier erosion, fluvial transport, sea level, tectonics and coastal drift in the paleodune formation of coastal semiarid Chile. We use this conceptual model to assess possible future dune-fields evolution in the study area under global and local change scenarios.

Keywords: Coastal paleodunes, Semiarid Chile, Environmental change, Pleistocene, Sediment provenance

【A0202】-Poster

Macrophyte pollen as indicator of lake-ecosystems changes in the past

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During past few years, we were carrying out paleolimnological research on the study of small island lakes located in Lake Ladoga, NW Russia. Three lakes on the Lunkulansaari Island and four lakes on the Valaam Island were studied by now. In the early developmental stages, they were part of Lake Ladoga and were isolated during the last Ladoga regression at the end of the Subboreal. The lakes are located at different absolute altitudes, so they are a source of information about the Ladoga level changes in the Late Holocene. The lakes' sediment sequences were investigated by pollen analysis. After completing the first reconstructions, we have noticed a correlation between macrophyte pollen and the lakes developmental stages, i.e. the disappearance of macrophyte pollen during the isolation stage. Then we decided to focus on macrophyte pollen in our research and try to understand whether they can be used as an indicator of lake-ecosystems changes.

Macrophyte pollen are rarely used in paleolimnological studies due to their lower occurrence compared to terrestrial plant pollen. However, living specifically in the aquatic environment, macrophytes are sensitive to any changes in it, e.g. water-level fluctuations. Moreover, lake sediments create excellent conditions for the paleogeographic proxy's preservation, including macrophyte pollen.

In the course of our research, we got data on changes in the macrophyte diversity and abundance during sedimentation, the time of lake settlement by different macrophytes, and the changes of dominant species. The full reconstruction on the example of two of them is published in our recent article (Gazizova, Sapelko 2024). Below we consider the lakes developmental stages in outline. In the first stage (the Late Atlantic–Early Subboreal), the lakes were part of Lake Ladoga. Aquatic vegetation was sparse. In the second stage (the end of the Sub-Boreal), the Ladoga regression occurred and the lakes isolation began. The temporary disappearance of macrophyte pollen indicates an initial sharp drop in the Ladoga level. As the lakes was progressively losing the connection with the Ladoga, macrophytes started to repopulate them. At first, these were pioneer species that were eventually replaced by others in the third stage. There was the period (Sub-Atlantic) of the lakes' isolated existence and the formation of their own ecosystem with a variety of macrophytes. Now these are shallow overgrown lakes at different stages of succession.

In result, macrophyte pollen data allowed us to refine the isolation process and the



Late Holocene history of the lakes. Our research shows the importance of macrophyte pollen in paleolimnological studies as the indicator of lake-ecosystems changes. Research is ongoing including studying the role of macrophyte pollen in sea-level changes in the past.

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Keywords: Lake sediments, Macrophytes, Pollen analysis, Lake-level changes, Paleoreconstructions

【A0957】 -Poster

Ecorefuges and environmental transitions: Human-plant interactions at ancient Tagua Tagua Lake

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The Pleistocene-Holocene transition in central Chile is characterized by a significant environmental shift, transitioning from glacial conditions to warmer conditions during the Early Holocene, with a Mid Holocene significantly more arid. Núñez et al. (1987) proposed that the ancient Tagua Tagua Lake (ATTL) (34°30' S) acted as an 'ecorefuge', a key concept for understanding its role during this period. The lacustrine ecosystem of ATTL likely provided a variety of more stable resources compared to surrounding areas during these periods of environmental stress, fostering a "relictual" way of life during the Pleistocene-Holocene transition (defined here as ~12,500–10,500 years BP). Tagua Tagua 3 is a well-documented geoarchaeological site, evidencing human occupation from an initial phase around 12,600 cal BP to multiple subsequent phases between 11,700 and 5,000 cal BP. To explore how these hunter-gatherer groups



utilized plant resources, we analyzed carpological remains recovered through flotation from a sediment column encompassing the site's entire stratigraphic sequence. This approach enabled a detailed investigation of plant-use practices during periods of both occupation and abandonment. Additionally, a reference collection was developed using local ethnobotanical knowledge, historical chronicles, and specialized literature, which enriched the interpretation of findings and provided a broader cultural and environmental context.

This new evidence offers an opportunity to contrast and expand upon "classical" perspectives on this period, which have largely relied on pollen records that exhibit low preservation in the study area. Furthermore, the focus on anthropogenic use of the plant landscape opens a discussion on potential human impacts on the environment, a topic that has not been systematically revisited in the ancient Tagua Tagua Lake region for over three decades. This discussion has significant implications for the study of socio-ecological systems on a global scale.

Keywords: Pleistocene-Holocene Transition, Hunter-gatherer, Socio-ecological systems, Central Chile

【A0954】 -Poster

On the potential of glaciochemical analysis of Joinville Island firn core for the sea ice reconstruction around the northern Antarctic Peninsula

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The Antarctic Peninsula is one of the fastest-warming regions on Earth, profoundly affecting its cryosphere and marine ecosystems. This study investigates the potential of glaciochemical records from two firn cores collected on Joinville Island to reconstruct sea ice variability and primary productivity in the northern Antarctic Peninsula from 1993 to 2005. Major ions, including Na⁺, Cl⁻, MSA, SO₄²⁻, and others, were analyzed using ion chromatography, alongside isotopic (δ¹⁸O) measurements.



The study identified significant correlations between ion concentrations and environmental parameters, with Na^+ and Cl^- strongly associated with wind strength and sea ice extent ($r = 0.59\text{--}0.66$), while MSA exhibited the highest correlation with sea ice dynamics ($r = 0.80$). The analysis revealed a net accumulation rate of 0.4 m water equivalent per year, with stratigraphy indicating post-depositional processes such as melting and refreezing that impact ion variability. Hierarchical clustering grouped ions based on their sources, with marine aerosols (e.g., Na^+ , Cl^-) reflecting sea spray influence and biogenic compounds (e.g., MSA) linked to primary productivity. The results underscore the region's sensitivity to climatic fluctuations, with changes in sea ice influencing phytoplankton blooms and marine sulfur cycles. This study refines the understanding of glaciochemical proxies for reconstructing past environmental conditions, emphasizing the complex interplay between atmospheric, oceanic, and cryospheric processes. By linking glaciochemical data to satellite-derived sea ice records, it highlights the utility of firn cores in tracking regional climate changes and their broader implications for polar ecosystems and global climate models.

Keywords: Glaciochemistry, Sea ice dynamics, Methanesulfonic Acid (MSA), Climate proxies, Environmental reconstruction

【A0051】 -Poster

Transient climate simulation of the past 4.5 million years based on the coupled intermediate complexity model, iLOVECLIM

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The Earth experienced dramatic climate changes during the past several million years, including a long-term gradual cooling from the Pliocene (5.3-2.6 million years ago; Ma) to the Pleistocene (2.6-0.011 Ma) and an abrupt transition from 41-kyr to 100-kyr glacial-interglacial cycles at ca. 1.2-0.8 Ma (i.e., the Mid-Pleistocene transition).



Investigating the mechanisms that triggered these climatic responses requires long-term transient climate simulations which can be used to quantify the sensitivity of the Earth's climate to different external and internal forcings. However, few such simulations exist and therefore, key questions regarding the long-term evolution of the earth system remain unanswered. Here, we used iLOVECLIM, a coupled Earth system numerical model of intermediate complexity, to generate a 4.5-million-year transient climate simulation, the longest to date. iLOVECLIM is ideally suited for this task as it requires substantially less computational resources and time to perform transient climate simulations compared to fully coupled general circulation models. We performed the simulations with interactive atmosphere, ocean and vegetation components and used the model set-up of previous long-term transient simulations. Briefly, we applied an acceleration factor of five to the external forcings and split the full simulation into 44 chunks run in parallel to reduce computing time. Each chunk was initialized from an interglacial period, covers at least one glacial-interglacial cycle and has an overlap period of 20,000 years in order to compensate for issues related to spin-up effects and initial conditions. The complete simulation is a composite of all the individual chunks and time-sliding linear interpolation performed on the overlap intervals. While the simulations are still ongoing, preliminary tests demonstrate that our model set-up and experimental design are able to produce reasonable outputs. When it is completed, the final simulation will be evaluated against available paleoclimate data and existing transient climate simulations. Apart from running a simulation with all the forcings (i.e., orbital parameters, greenhouse gases, and ice-sheets) combined, we also plan to run subsequent simulations with each individual forcing alone to evaluate the climate responses associated with each. The outcomes of our simulations will be provided in the form of monthly and annual output data for the last 4.5 Ma. We hope that the results from our long-term climate simulations will provide a better mechanistic understanding of the major climate reorganizations that occurred during Plio-Pleistocene and be useful for future data-model comparisons and data assimilation endeavours.

Keywords: Climate model, Transient simulation, Pliocene, Pleistocene

【A0222】 -Poster

Productivity dynamics during the Late Miocene Biogenic Bloom: Insights from the XRF evidence at ODP Site 1143

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Late Miocene Biological Bloom (LMBB), spanning from the late Miocene to early Pliocene, is characterized by high accumulation rates of opal from diatoms and calcite from calcareous nannofossils and planktonic foraminifera. The trigger mechanisms for the onset and termination of this global event, which is heterogeneous at spatial and temporal scales, remain unclear. Changes in astronomical configuration linked to monsoon activity have recently been proposed as likely triggers for the termination in the low-latitude region. At the southern South China Sea ODP Site 1143, the LMBB event has been suggested to have occurred during the ca. 12-6 Ma interval with high CaCO_3 and opal accumulation rates, as well as elevated diatom and radiolarian abundances. In our study, X-ray fluorescence (XRF) scanning derived Ca/Al, Si/Al and Zr/Ti ratio are used as proxies for sediment CaCO_3 content, opal content and terrestrial input, respectively. Four productivity maximum (PM) events are identified from Ca/Al and Si/Al records during the ca. 9-6 Ma interval, corresponding to enhanced terrestrial inputs indicated by Zr/Ti record. Therein, PM3, centred at ~7 Ma (a time of climate state transition) stands out due to its association with maxima eccentricity and precession configurations. Unlike the others driven by enhanced terrestrial inputs resulting from a strengthened Summer Monsoon during periods of minimum eccentricity and precession, PM3 was likely triggered by enhanced terrestrial inputs accompanied by the C4 grass expansion, decline in atmospheric $p\text{CO}_2$ and enhanced winter monsoon. Furthermore, favorable tectonic conditions during PM1 (centered at ~8 Ma) likely amplified the influence of orbital configurations on terrestrial inputs and productivity through the reorganization of river systems.

Keywords: Late Miocene biological bloom, XRF, Astronomical configuration, Hydroclimate change

【A0848】 -Poster

Local summer insolation modulated Southern Ocean productivity and Antarctic icesheet evolution since MIS 5

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The relationship of marine productivity in the Southern Ocean (SO) to dynamics of the Antarctic icesheet (AIS) since the Late Pleistocene remains uncertain. Here, we investigated Late Pleistocene variation in productivity in the Antarctic Zone of the SO, and the response of the AIS to various potential forcing mechanisms. We analyzed secular variation in multiple biogenic components and ice-rafted debris (IRD) of a sediment core (ANT34/D5-12) from the Atlantic sector of the SO. Productivity, as tracked by the fluxes of excess Ba and opal, was controlled mainly by ventilation and local summer insolation, whereas icesheet dynamics revealed by IRD were modulated by the latter. These records nonetheless show distinct precessional variability (~23 kyr cycle) related to austral summer insolation. During high (low) insolation intervals, productivity was high (low), and the AIS contracted (expanded). Based on these data and published paleoclimate records, we propose that marine productivity and icesheet dynamics during the Late Pleistocene were primarily controlled by local Antarctic summer mean insolation through regulation of water-column stratification depth. These findings support hypotheses for the independent evolution of Antarctic climate (i.e., not paced by Northern Hemisphere summer insolation) and provide new insights into biogeochemical cycling in the SO and AIS dynamics.

Keywords: Weddell Sea, Ice-rafted debris, Ventilation, Late Pleistocene, Precession

【A0632】 -Poster

Productivity in the Antarctic Zone and its dynamic coupling with atmosphere-ocean-ice processes over 800 ka

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The Antarctic Zone (AZ) of the Southern Ocean is the upwelling zone of the Meridional



Overturning Circulation, where the atmosphere-ocean-ice coupling processes regulate the global climate change and the carbon cycle. In this study, we use terrigenous particle size distribution of bulk sample, XRF, sortable silt (SS) and trace elements from Site U1537 and U1538 in the Southern Atlantic, reconstruct the productivity, Southern Hemisphere Westerly Winds (SWW), and Antarctic Circumpolar Current (ACC) changes in the Antarctic Zone over the past 800 ka. Combining the dust flux record of the well-dated EDC ice core to unravel characteristics and potential driving mechanisms of productivity in the Antarctic zone. The results of Site U1537 and U1538 show the characteristic of synchronous changes in ACC and productivity over the past 800ka, with increased during interglacial periods, and decreased during glacial periods. The reconstruction records of SWW exhibit poleward/strengthening during warm periods and northward /weakening during cold periods, controlled by global ice-volume ($\delta^{18}\text{O}_{\text{sw}}$). The poleward/strengthening SWW strengthened the upwelling during the interglacial period, which helped to bringing more nutrients and promoting productivity enhancement. The changes in primary productivity were not completely consistent between U1537 and U1538 during the interglacial period before Mid-Brunhes Event (MBE, ~430ka), may be related to the extent of Antarctica ice sheet /sea ice. The above results indicate that the iron (Fe) fertilization is not the dominated mechanism of productivity changes in the Antarctic Zone, and the enhancement of productivity during the interglacial period is more likely to be related to the synergistic effect of atmosphere-ocean- ice, which needs more study to understand.

Keywords: Antarctic zone, Southern Hemisphere Westerly Winds, Antarctic Circumpolar Current, Mid-Brunhes Event

【A0376】 -Oral

Proxy-based global climate field reconstructions over the Common Era using sequential particle filter: Quantifying uncertainty sources and robust features

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With few instrumental observations longer than a hundred years, the recent developments in the field of paleoclimate data assimilation (PDA) now allow producing skilful spatially resolved global climate reconstructions over the Common Era (CE).



These products offer the opportunity to enhance our understanding of decadal to centennial low-frequency variability and assess climate models ability in reproducing such dynamics. Large uncertainties remain however between different existing assimilation products mainly because of the different methodology applied, the General Circulation Model (GCM) considered and/or the proxies used. Relying on a recently developed PDA approach based on a sequential importance resampling particle filter and the use of Linear Inverse Models to emulate a large set of GCMs, we present here an ensemble of spatial climate reconstructions over the CE exploring different PDA configurations to assess these uncertainties. Comparing our reconstructions with existing assimilation products and independent proxy records, we further explore and attribute possible sources to identified robust phenomena.

Keywords: Paleoclimate data assimilation, Uncertainty quantification, Particle filters, Linear inverse models

【A0086】 -Poster

Paleoceanographic information from the turbidite-containing sediments in the South Shetland Trench of the Antarctic Ocean

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About 11 m-long piston core (PC02) was collected from the South Shetland Trench (61°59.02'S, 62°19.41'W, 4731 m deep) during KH-19-6 expedition using R/V Hakuho-maru in 2019. Based on visual observation of core sediments and examination of core photos and CT images, 29 turbidite layers were distinctly recognized, overlying the liquefied mud and sand/gravels at the lower part of core, which are consistently repeated, despite the different thickness. Each set of turbidite layer consists of the upper turbidite mud and lower muddy sand, both of which were capped by the hemipelagic mud layer, although the boundary between the hemipelagic mud and turbidite mud seems unclear. Grain size analysis confirms the upward fining trend within a set of hemipelagic mud, turbidite mud, and muddy sand. Each muddy sand coincides exactly with the maximum magnetic susceptibility (MS) whereas the minimum MS corresponds to the hemipelagic mud. The AMS ¹⁴C dating of bulk



sediments in the hemipelagic mud layer marks old core-top age (~8.6 ka) and about 15.7 ka for the lowest hemipelagic mud. Geochemical properties (TC, TN, and biogenic opal), representing the surface water productivity, were different between the turbidite muds and hemipelagic muds, and the turbidite muds are higher than hemipelagic muds. Such difference implies that the turbidite muds might be transported from the shallower areas where the open ocean favors high productivity. In addition, the hemipelagic muds, after excluding turbidite mud and muddy sand, show the upward increasing TN contents. Based on the linear sedimentation rate and assumed age model, the climate shift from the middle Holocene climate optimum to the late Holocene Neoglacial condition seems to be recorded even in the South Shetland Trench of the Antarctic Ocean.

Keywords: Paleoceanography, Paleoclimate, Trench

【A0736】 -Oral

Advancing climate model simulations for the Past 2000 Years: The PMIP Past2K working group initiative

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The Past2K Working Group within PMIP is dedicated to enhancing our understanding of climate variability over the past 2000 years through coordinated climate model experiments and improved reconstructions. Building on the achievements of CMIP6, our efforts for CMIP7 focus on refining external forcing datasets (volcanic, solar, land-



use, and greenhouse gas), improving experimental design, and fostering interdisciplinary collaboration.

Current activities include (1) Updating forcing datasets with the latest high-resolution data; and (2) Developing protocols to bridge paleoclimate observations and Earth System Models. We aim to engage the broader scientific community, including PAGES scientists, to collaboratively address key challenges in paleoclimate modeling. By integrating expertise from across disciplines, the Past2K initiative seeks to inform not only our understanding of past natural climate variability but also their implications for future projections. The climate of the Common Era is particularly crucial for constraining and understanding the natural baseline of variability over the last century, providing essential context for interpreting and projecting the impacts of anthropogenic global warming.

We invite researchers interested in the past 2000 years of climate change to join us in shaping this effort. Together, we can advance our collective understanding of the Common Era's climate history and its relevance for future climate challenges.

Keywords: Paleoclimate modeling, Common Era, Paleoclimate observations, Natural climate variability, CMIP7

【A1003】 -Poster

The Holocene sedimentary evolution history and driving mechanism of the alluvial plain in the middle and lower reaches of the Yangtze River

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River processes are among the most significant external forces in shaping terrestrial landforms. High-resolution chronological stratigraphy is crucial for understanding how river sedimentary systems respond to changes in external driving forces on centennial to millennial timescales. Existing studies suggest that the variation in sedimentation rates and the formation of sedimentary sequences in the Holocene alluvial plains of the lower and middle Yangtze River are influenced by multiple factors, including sea-level rise, climate change, and tectonic activity. However, due to limitations in high-



resolution chronological stratigraphy, the sedimentary evolution history of the Yangtze River alluvial plains remains poorly understood, and there is still a significant gap in knowledge regarding the formation processes and driving mechanisms. To further investigate this process, we collected a 36.5-meter-long sediment core (WW02) from Wuwei City in the lower Yangtze River basin. Through sedimentary facies analysis and chronological analysis based on 23 optically stimulated luminescence (OSL) samples and 9 radiocarbon (^{14}C) samples, we reconstructed the Holocene sedimentary evolution history of the region. The preliminary study results show that the WW02 core is mainly composed of mud, silt, and peat, with intercalated sandy layers, indicating a sedimentary environment that alternates between alluvial plains and lacustrine facies formed during periods of Yangtze River flooding. The age-depth curve indicates that between 7 and 12 ka, the alluvial plain experienced rapid sediment accumulation. However, after around 6 ka, the sedimentation rate significantly slowed down, aligning with the trend of sea-level rise proposed by Lambeck et al. (2014). Based on previous studies of borehole stratigraphy and dating results, the sedimentation rate and the changes observed in core WW02 also follow this trend. This study provides critical insights into the sedimentary history and driving mechanisms of the Yangtze River alluvial plains during the Holocene, shedding light on the complex interaction between external forces such as sea-level rise and climate change in shaping regional sedimentation patterns.

Keywords: Lower Yangtze River Alluvial Plain, Holocene sedimentation, Optically stimulated luminescence and ^{14}C dating, Sedimentation rate

【A0743】 -Poster

Towards a global-scale temperature reconstruction for the marine isotope stage 11 “super-interglacial”

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Marine Isotope Stage 11c (MIS11c; ~430–390 thousand years ago) was an unusually long interglacial characterised by significantly diminished Greenland and Antarctic Ice Sheets and sea levels ~6–13 meters higher than today. Despite its significance as a potential analogue for future sea level outcomes, regional and global-scale



temperature estimates for MIS11c remain poorly constrained relative to sea level reconstructions. To address this shortcoming, we are developing a global temperature reconstruction for MIS11c using a new global-scale compilation of nearly 200 geochemical proxy records deriving from ocean sediments and ice cores, each aligned onto a consistent chronology based on regional benthic foraminiferal $\delta^{18}\text{O}$ patterns. Our methodology combines probabilistic forward and inverse proxy system models to estimate past surface temperatures and assess proxy biases, including multi-climatic influences and seasonal aliasing. Combined with recent transient and time-slice climate model simulations, these reconstructions are being used to refine spatial and seasonal temperature patterns and lay the foundation for future MIS11c model-based frameworks. This work aims to improve understanding of MIS11c climate dynamics and inform predictions of ice sheet stability, sea level rise, and AMOC behavior under future warming scenarios.

Keywords: MIS11c, Super-interglacial

【A0350】 -Oral

Multiple sources of atmospheric CO_2 activated by AMOC recovery at the onset of interglacial MIS 9

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Using new high-precision ice core measurements of CO_2 , $\delta^{13}\text{C}\text{-CO}_2$, CH_4 , and N_2O , this study provides the first carbon isotopic constraints on a sizeable, centennial-scale CO_2



jump at the onset of Marine Isotope Stage 9 (MIS 9). The end of the Heinrich stadial (HS) characterizing Termination IV (T-IV, ca. 343 to 333 ka ago) shows a 250-year-long jump in the greenhouse gas concentrations, followed by a 1.3 ka gradual decline back to initial concentration. During this time, CO₂ and CH₄ reach their highest levels over the past 800 ka prior to industrialization. The initial jump in CO₂ is not accompanied by a change in $\delta^{13}\text{C-CO}_2$, suggesting that multiple mechanisms contributed to the exceptionally elevated CO₂ values. Following the jump, a slow 0.2‰ enrichment in $\delta^{13}\text{C-CO}_2$ occurs. We propose that during the jump the sudden resumption of deepwater formation in the North Atlantic (NA) triggered an amplified release of CO₂ from the Southern Ocean (SO) by a northward shift of the Intertropical Convergence Zone (ITCZ) and the SO westerlies, potentially in combination with a rapid terrestrial carbon release. The latter is expected from temporally enhanced wildfire activity related to higher fuel load and regionally changing weather conditions in connection to the ITCZ shift. A combination of marine proxy evidence and box model simulation suggests that the $\delta^{13}\text{C-CO}_2$ decrease expected from these processes is compensated by a net temperature increase in global sea surface temperature (SST) at the time of the AMOC resumption.

Keywords: Ice cores, Carbon cycle, Stable carbon isotopic composition, Termination IV

【A0825】 -Poster

Multi-dimensional analysis of glacier dynamics in the Alaknanda Basin, Western Himalaya: Integration of area change assessment and equilibrium line altitude studies (1994–2023)

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This research presents an integrated analysis of glacier dynamics in the Alaknanda Basin of the Garhwal Himalaya, combining long-term area change assessment with Equilibrium Line Altitude (ELA) investigations. Using multi-temporal remote sensing data spanning 29 years (1994-2023), we analyzed 25 glaciers through two complementary approaches. The area change analysis revealed a total reduction from 148.998 km² to 144.488 km² (loss of 4.505 km² or 3.03%), with an average annual retreat rate of 0.10%. Notably, smaller glacier (<2 km²) exhibited accelerated retreat rates of 0.155 km² /year compared to large glacier (>5 km²) at 0.065 km² /year. The



study employed two distinct methodological approaches for ELA estimation: Area-Altitude Balance Ratio (AABR) and Accumulation Area Ratio (AAR), revealing elevations ranging from 4354 m to 5831 m a.s.l. Significant variations were observed between high-altitude glaciers (e.g., G079313E30844N at 5710 m) and low-elevation glaciers (e.g., Tipra Glacier at 4354 m), demonstrating the complex relationship between topographic settings and glacier dynamics. Key findings include the distinctive behavior of major glaciers such as Bhagirath Kharak (area loss of 0.15 km²) and Satopanth Glacier, which exhibited a relatively low ELA (4485-4525 m) despite its significant area change (0.488 km²). This research marks methodological contributions by addressing systematic errors in global glacier inventories thorough improved boundary delineation and provides a comprehensive framework for understanding glacier health in the region. The findings have crucial implications for natural hazard assessment in the Himalayan region under changing climatic conditions.

Keywords: Glacier dynamics, Equilibrium line altitude, Area change assessment, Glacier mapping, Alaknanda Basin

【A0798】 -Poster

Micromorphological analysis of Maastrichtian-aged paleosols from the Lameta formation: Insights into pre-deccan volcanic environments in Central India

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This study conducts an in-depth micromorphological analysis of Maastrichtian-aged (65 Ma) paleosols from the Lower Limestone and Mottled Nodular Bed (MNB) units of the Infratrappean Lameta Formation in Central India. Situated immediately beneath the Deccan Traps—widely considered a major factor in the K-Pg mass extinction—the Lameta Formation offers essential insights into pre-volcanic environmental conditions preceding this pivotal extinction event.

Field investigations were carried out at exposures in the Cantonment area and along the Narmada River in Madhya Pradesh, India. Detailed thin-section analyses distinguished pedogenic processes from diagenetic alterations in the lithified paleosols, shedding light on the paleoenvironmental characteristics of the formation.



Major diagenetic modifications observed include sparitic calcite, poikilotopic calcite, iron oxide cementation, sutured quartz grains, and distorted coatings. Despite these alterations, the paleosols preserved key pedogenic features, such as clay coatings, calcite hypo- and quasi-coatings, micritic nodules, Fe/Mn hypo- and quasi-coatings, nodules, and remnants of organic matter.

These micromorphological observations revealed a range of paleosol development stages, from weakly to well-developed profiles, influenced by varying hydrological regimes and topographical conditions. Based on these findings, a paleoenvironmental model was constructed for the Lower Limestone (LLM) and Mottled Nodular Bed (MNB) units. The model suggests that the Lower Limestone region represented poorly drained, humid habitats, whereas the MNB unit reflected drier paleoenvironments. This environmental differentiation within the Lameta Formation provides valuable insights into climatic variability and landscape evolution immediately preceding Deccan volcanics.

Keywords: Paleosols, Micromorphology, Deccan volcanics

【A0795】 -Oral

Warming on the East Antarctic Plateau inferred from ice borehole thermometry

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The Antarctic Ice Sheet holds the largest potential for global sea-level rise, yet its response to climate change remains a significant source of uncertainty in future projections. Understanding recent climatic trends in East Antarctica is challenging due to a limited instrumental record. Additionally, paleoclimatic information from ice cores hasn't been able to clearly resolve recent temperature changes on the Antarctic Plateau, mainly because of noise affecting the high-resolution climate signal and uncertainties in the transfer function between climate and ice-core records.



Complementary to the information derived from ice cores, the temperature distribution through the ice sheet also provides a record of past climate changes. This allows the reconstruction of the past surface temperature history based on the vertical temperature profile obtained from boreholes.

In this study, we present precise borehole temperature profiles from five boreholes, each 80–200 meters deep, located near the EPICA Dronning Maud Land drilling site (Kohnen Station) on the East Antarctic Plateau. We analyze inferred surface temperature warming estimates and explore their relationship to ice-core isotopic records, providing insights into recent climatic trends in this critical region.

Keywords: Borehole thermometry, Antarctic climate

【A0999】-Poster

Comparison REVEALS estimates vegetation simulations – a perspective from China

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Global dynamic vegetation models (GDVMs) serve as essential tools for elucidating terrestrial ecosystem responses to rapid climate change and facilitating projections of future ecosystem dynamics. Nevertheless, individual GDVMs exhibit considerable variability in their outputs, attributable to differences in their structural complexity, sensitivity to abiotic drivers, and parameterization schemes for vegetation processes. This study presents a comparative analysis of vegetation cover changes across China, using the vegetation-cover module of the MPI-ESM1.2, high-resolution LPJ-GUESS simulations, and pollen-based quantitative reconstructions derived from the REVEALS



model. To quantify the disparities between model simulations and reconstructions, we employed two metrics: the root-mean-square error (RMSE) of total tree cover and the Bray-Curtis dissimilarity index based on three distinct land cover classifications - evergreen trees, summergreen trees, and herbaceous vegetation.

The concordance between vegetation simulations and REVEALS reconstructions demonstrates both temporal and spatial heterogeneity. Model simulations consistently indicate elevated tree cover throughout the past 8ka, with MPI-ESM1.2 exhibiting better agreement with REVEALS compared to LPJ-GUESS. Both models systematically overestimate tree cover relative to reconstructions, particularly in Eastern and Northern subtropical China. Comparative analyses of simulated and reconstructed climate parameters indicate that model-data discrepancies in vegetation cover during the early Holocene cannot be attributed to climate biases. Conversely, the disparities observed during the mid- and late Holocene likely stem from a combination of climate biases and anthropogenic land-use modifications. Our findings underscore the limitations of current model configurations for paleo-vegetation simulations and highlight the inherent complexities in evaluating vegetation simulations with paleo-reconstructions.

Keywords: Reveals, LPJ-Guess, MPI-ESM1.2, China

【A1023】 -Poster

Multi-proxy reconstructions of paleotemperature in the southern South China Sea since the last deglaciation

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The accuracy of paleothermometers is a prerequisite for understanding the past sea surface temperature (SST) changes in the tropical seas. Here, we analyzed the SST estimates reconstructed by four lipid proxies with common linear and newly advanced models in parallel in a sediment core collected from the southern South China Sea (SCS). After excluding the impact of terrestrial input, all of the four proxies-inferred SSTs displayed a gradually warming pattern since 18.3 ka. Our long-chain alkenones-derived annual SST at seawater depth of 0–30 m (SST 0–30 m) record closely matched the regional synthetic SST record from the entire southern SCS, corresponding to high-



latitude climate events during the deglaciation. The temperatures reconstructed by long chain diols (LCDs) showed an upper limit of 27°C, and we thus proposed that they reflected the optimal survival temperature for organisms producing LCDs when SST was higher than 27°C. Isoprenoid and hydroxy glycerol dialkyl glycerol tetraethers (iGDGTs and OH-GDGTs)-derived temperatures likely reflected the subsurface temperature (subT) at seawater depth of 30–125 m and SST towards the warm season in the tropical sea, respectively.

Keywords: Temperature reconstruction, Lipid biomarkers, South China Sea, Last deglaciation

【A0419】 -Poster

Shelf-basin carbonate partitioning shapes Cenozoic carbon cycle on eccentricity timescales

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Prior to the Cenozoic bipolar ice ages, between 66 and 6 million years ago, benthic foraminiferal oxygen and carbon isotopes—proxies for bottom-water temperatures and the cryosphere, and for the carbon cycle, respectively—exhibited synchronous changes on 405,000- and 100,000-year eccentricity timescales. However, the mechanisms underlying the in-phase behavior of oxygen and carbon isotopes remain elusive. Here, we present a high-resolution reconstruction of benthic foraminiferal boron-to-calcium ratios from the Miocene, revealing that eccentricity-paced fluctuations in deep-sea carbonate ion saturation aligned with variations in oxygen and carbon isotopes, as well as pelagic carbonate deposition. In combination with modelling outputs, we propose that warm conditions during eccentricity maxima intensified monsoon rainfall and chemical weathering, enhancing the transport of dissolved inorganic carbon and alkalinity from land to continental margins submerged by rising sea levels due to ice melting. This process redistributed massive carbonate burial from the deep-ocean basins to continental shelves, lowering seawater carbonate ion concentrations and reducing the carbon isotopic composition of the dissolved inorganic carbon reservoir. Our findings highlight the crucial role of the low-



latitude hydrological cycle in regulating carbon-cycle dynamics in warm climate states.

Keywords: Eccentricity cycle, Low-latitude hydrological cycle, Carbon cycle, Carbonate burial, Ocean Drilling Project

【A0891】 -Poster

The Southern Ocean induced northern high latitude cooling since the late Pliocene

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An intriguing hypothesis for the mysterious expansion of the Northern Hemisphere Ice Sheets (NHIS) is that the Antarctic Ice Sheet (AIS) acted as a forerunner, with its expansion triggering the subsequent growth of the NHIS. These were motivated by the findings that the expansion of the AIS may precede the expansion of the NHIS during the period of significant climate transition including the Mid-Pleistocene Transition and the onset of Northern Hemisphere Glaciation. The mechanism behind this may be that the expansion of the AIS could cause the northward migration of the Antarctic Polar Front (APF) and/or the expansion of sea ice, which in turn weakened the Atlantic Meridional Overturning Circulation (AMOC) and led to the expansion of the NHIS. However, there are still limitations in our understanding of the changes in the APF and ice sheet dynamics since the late Pliocene, which restrict our comprehension of the above theory.

Here, we present new terrigenous and biogenic records for International Ocean Discovery Program Hole U1524A. The terrigenous records were used to explore the dynamics of the West Antarctic Ice Sheet (WAIS) — the relatively active part of the AIS, while the biogenic records were used to infer productivity changes in the Southern Ocean. Our records indicate that accompanied by the growth of WAIS, the APF gradually migrated northward from 3.3 to 1.6 Ma, which was in line with the decline of atmospheric CO₂. Compared to the AMOC records, our data suggest that the northward migration of the APF likely provided basic support for the weakening of the AMOC, offsetting the warming effects driven by other processes, such as negative feedback from the NHIS itself.



Keywords: WAIS NHIS terrigenous productivity

【A0201】 -Oral

Modelling the Northern Hemisphere ice sheet evolution during the last deglaciation and MIS-11 with an ice sheet-ice shelf coupled model

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Ice sheet models are essential tools for studying ice sheet dynamics in response to the climate evolution during the Quaternary glacial-interglacial cycles. Here, we develop a new version of the Northern Hemisphere ice sheet model (NHISM, Zweck and Huybrechts, 2005) by adding a user-friendly ice shelf module and other new characteristics such as the option to easily change the horizontal resolution. This new ice sheet-ice shelf coupled model is named NHISM1.1. The ice shelf module is based on the shallow shelf approximation, allowing simulation of ice stream advance into the ocean and the transformation between floating and grounded ice. NHISM1.1 is first used to conduct equilibrium ice-sheet simulations driven by observed present-day climate. It simulates a reasonable spatial distribution of the Northern Hemisphere ice sheets with a bias of less than 10% in the Greenland Ice Sheet volume compared to observation. We then use NHISM1.1 to perform transient ice sheet simulations for two distinct periods in the past, the Last Deglaciation and the entire MIS-11 period. In both cases, NHISM1.1 is driven by climate outputs of transient simulations performed with the LOVECLIM1.3 model. The performance of NHISM1.1 and the influence of various model configuration is evaluated by comparison with proxy reconstructions and other model simulations as well as sensitivity experiments. Our results show that the results are largely consistent with geological evidence and that the incorporation of an ice shelf module is critical in properly reproducing glacial inception in ice sheet simulations.

Keywords: Northern Hemisphere ice sheets, Paleoclimate simulations, Last deglaciation, MIS-11

【A0188】 -Oral



Sahara's surface transformation forced an abrupt hydroclimate decline and Neolithic culture transition in northern China

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The remote forcing from land surface changes in the Sahara is hypothesized to play a pivotal role in modulating the intensity of the East Asian Summer Monsoon (EASM) through ocean-atmospheric teleconnections. This modulation has far-reaching consequences, particularly in facilitating societal shifts documented in northern China. Here, we present a well-dated lake-level record from the Daihai Lake Basin in northern China, providing quantitative assessments of Holocene monsoonal precipitation and the consequent migrations of the northern boundary of the EASM. Our reconstruction, informed by a water-and-energy balance model, indicates that annual precipitation reached 700 mm during 8-5 ka, followed by a rapid decline to 550 mm between 5 and 4 ka. This shift coherently aligns with a significant 300 km northwestward movement of the EASM northern boundary during the Middle Holocene (MH), in contrast to its current position. Our findings underscore that these changes cannot be entirely attributed to orbital forcing, as corroborated by simulation tests. Climate model simulations deployed in our study suggest that the presence of the Green Sahara during the MH significantly strengthened the EASM and led to a northward shift of the monsoon rainfall belt. Conversely, the Sahara's reversion to a desert landscape in the late Holocene was accompanied by a corresponding southward retraction of monsoon influence. These dramatic hydroclimate changes during 5-4 ka likely triggered or at least contributed to a shift in Neolithic cultures and societal transformation in northern China. With decreasing agricultural productivity, communities transitioned



from millet farming to a mixed rainfed agriculture and animal husbandry system. Thus, our findings elucidate not only the variability of the EASM but also the profound implications of a remote forcing, such as surface transformations of the Sahara, on climatic changes and cultural evolution in northern China.

Keywords: Abrupt change, Hydroclimate decline, Surface feedback, Culture transition, Monsoon precipitation

【A0660】 -Poster

Enhanced oceanic CO₂ buffering capacity due to limited carbonate counter pump in the early Miocene

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The carbonate counter pump (CCP) is essential for buffering atmospheric CO₂ fluctuations by regulating seawater alkalinity, yet its long-term impact remains poorly quantified. This study investigates the CCP dynamics during the late Oligocene to early Miocene—an important low-CO₂ period in the Cenozoic—using marine sediments from the western Pacific. This study performed high-resolution optical measurements of coccolith carbonate mass and accumulation rate to quantify the CCP. Simultaneously, a geochemical proxy, the coccolith Sr/Ca ratio, was utilized to reconstruct primary productivity. The results reveal intensified respiration-driven carbonate dissolution alongside enhanced primary productivity since the earliest Miocene (~23-21 Ma). Model-based estimates indicate ~25% weight loss of the biogenic carbonate due to water-column dissolution. Extrapolating our results to the entire tropical pelagic ocean suggests a release of 4.5 ± 1.9 Tmol yr⁻¹ of alkalinity, which represents about one-sixth of the total riverine alkalinity input (~30 Tmol yr⁻¹). Our results highlight a previously underrepresented coupling of the CCP with the biological carbon pump, which may synergistically amplify the oceanic CO₂ buffering capacity in the early Miocene. Such combined mechanisms may have helped maintain relatively stable CO₂ concentrations during the early Miocene and could be more essential in future climate scenarios.

Keywords: Coccolithophore, Atmospheric CO₂, Biological carbon pump, Oligocene-Miocene transition



【A0267】 -Poster

Dynamics of the Aurora Subglacial Basin (East Antarctic Ice Sheet) during past warm periods

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There is a growing concern of ice mass loss in the Antarctic Ice Sheet (AIS) due to global warming in the future. Even partial loss of the AIS could cause a significant sea-level rise, as its complete loss would contribute approximately 53 m to global sea level (Wilson et al., 2018). Furthermore, it has emerged the possibility that the melting of the ice sheet will be an initiator of tipping cascade, triggering abrupt and irreversible changes in climate tipping elements in different parts of the world (McKay et al., 2022). It is therefore an important challenge to better understand which parts of the Antarctic ice sheet are vulnerable to global warming.

To address this challenge, a comprehensive study of Antarctic and Southern Ocean variability during past warm periods such as the super interglacials (MIS5e, MIS7, MIS9), which are considered as analogous to the near future climate, is useful. Understanding the behavior of the AIS and Southern Ocean during past warm periods is crucial for predicting future responses of Antarctic ice sheet to global climate change. Especially, the response of East Antarctica Ice Sheet (EAIS) to global warming is poorly understood compared to West Antarctica.

Marine based ice sectors, such as Wilkes and Aurora Subglacial Basin (ASB) in East Antarctica have been found to be vulnerable to oceanic forcing such as the intrusion of warm Circumpolar Deep Water to the Antarctic shelf (Wise et al., 2017). Moreover, it has been reported that the ice mass of ASB, which could potentially cause a 3.5 m rise in global sea level, has been rapidly declining over the last decades (Greene et al., 2017).



In this study, we therefore reconstruct ice sheet dynamics in the ASB during MIS5e, MIS7e and MIS 9 super interglacials from marine sediment cores collected from the vicinity of the ASB (relative to the Antarctic Coastal Current, 60–150°E). Mineral composition in surface sediments collected from Antarctic Zone were analyzed to evaluate it as a provenance proxy, allowing to infer ice sheet dynamics in the ASB. The validity of this approach has been demonstrated by previous studies (Wilson et al., 2018; Tooze et al., 2020; Iizuka et al., 2023), showing significant differences in the lithology of the bedrock of each basin, exhibiting potential for application of this methodology in the ASB. In addition, sediment grain size was also measured to investigate the link between sediment transport energy to changes in glacial melt or current strength. In this presentation, we report the application of this approach to sediment cores (PC404, GC1509) collected offshore from the ASB and discuss advance and retreat of ASB ice sheet and changes in coastal currents in MIS 5e, MIS 7e and MIS 9 super interglacials.

Keywords: Antarctic Ice Sheet, Super interglacials, Ice sheet dynamics

【A0847】 -Poster

X-ray micro-CT pipeline optimized for large-scale tree-ring paleoclimate research

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Tree-ring data provides essential insights into historical climate conditions and current ecosystem dynamics. Density measurements complement traditional tree-ring width series by extracting additional climatic information embedded within tree rings, with maximum latewood density serving as the gold standard for summer temperature reconstructions. However, the labor-intensive wood sample preparation required by conventional techniques is one of the main limiting factors for the widespread use of tree-ring densitometry. X-ray micro-computed tomography (X μ CT) offers a novel, non-destructive, 3D densitometry technique that enables simultaneous study of tree-ring width and wood density at high resolution and with minimal sample preparation. Here we present a highly optimized X μ CT pipeline aimed at large-scale tree-ring densitometry studies, capable of processing large amounts of increment cores with a low demand for human labor time (2.4 - 6.4 minutes per 35 cm sample). Key parts include large and efficient sample holders (16 - 48 samples per scan), optimized and standardized scan settings (helical X μ CT at 15, 30, and 60 μ m voxel size), and custom software packages. Overall, this X μ CT toolchain represents a significant leap forward in tree-ring densitometry, enabling large-scale paleoclimatic studies with a wide spatial extent, high replication, and long temporal range.

Keywords: Computed tomography, Tree-ring density, Dendroclimatology

【A0611】 -Oral

Two-millennia-long temperature reconstruction derived from X-ray computed tomography of Bristlecone pine samples from the White Mountains, California, USA

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Long, high-resolution temperature proxies are essential for understanding global climate history and the general functioning of the Earth's climate system. However, there is a significant lack of such proxies, particularly at lower latitudes.

In this study, we present a two-millennia-long warm-season temperature reconstruction based on the maximum latewood density (MXD) of bristlecone pine samples collected from the upper tree line in the White Mountains, California, USA (37.5°N, 118.2°W, 3400–3500 m a.s.l.). Our previous research demonstrated that the MXD of these trees is sensitive to mean temperatures from March to September, enabling the development of a reconstruction extending back to CE 1725 (De Mil et al., 2024). Here, we extend this reconstruction using a recently developed high-throughput, high-resolution X-ray computed tomography (X μ CT) pipeline used for the analysis of samples from remnant wood at the tree line and higher elevations upslope.

This extended reconstruction allows us to estimate low-frequency temperature variations in the Great Basin region of the southwestern United States over the past two millennia, as well as to examine temperature extremes and their connections to known explosive volcanic eruptions. In this presentation, we showcase the reconstruction and the results of our analysis, compare it with other records from the southwestern US, North America, and the Northern Hemisphere, and discuss the broader implications. This study represents the first dendroclimatic reconstruction of this length derived using X μ CT technique.

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Reference:

De Mil, T., Matskovsky, V., Salzer, M., Corluy, L., Verschuren, L., Pearson, C., Hoorebeke L. Van, Trouet V., Bulcke J. Van den, 2024. Bristlecone pine maximum latewood density as a superior proxy for millennium-length temperature reconstructions. *Geophysical Research Letters*, 51, e2024GL109799. <https://doi.org/10.1029/2024GL109799>

Keywords: Pinus Longaeva, X-Ray computed tomography, Maximum latewood density, Densitometry, 2k



【A0155】 -Poster
Impact of climate change and migration rates on mammalian biodiversity in north America

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Climate change has significantly influenced species distributions and biodiversity, posing critical challenges for conservation efforts. This study examines the interplay between climate change and species migration rates in shaping mammalian biodiversity across North America. Using the species distribution modeling framework *megaSDM*, we analyzed 267 mammalian species under various climate scenarios and forecasted timeframes. Key findings reveal that dispersal constraints strongly limit the ability of species to track suitable habitats, with the Hudson Bay Coastal Plain and eastern coastal areas experiencing pronounced impacts. These constraints are exacerbated by geographic features such as mountain ranges and waterways.

Temperature Annual Range emerged as the most influential environmental variable affecting species distribution, highlighting the pivotal role of temperature variability in driving biodiversity patterns. Notably, species diversity is highest in regions at the junction of North and South America, which may serve as critical biodiversity hotspots. However, across all scenarios, a consistent decline in diversity, ranging from 0 to 30 species, was observed when incorporating dispersal limitations. These results underscore the urgent need to integrate migration rates into conservation strategies to avoid overestimating species resilience under future climate conditions.

Our findings provide actionable insights for enhancing habitat connectivity and supporting species migration as essential components of mitigating climate change impacts on biodiversity.

Keywords: Climate change, Species migration rate, Biodiversity

【A0273】 -Poster
Reconstructing global temperature timeseries of 3.6 million years



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The understanding of late Cenozoic climate changes largely stems from geologic records, especially stable oxygen ratios ($\delta^{18}\text{O}$) from benthic foraminifera, Mg/Ca ratio and alkenone records. Their signals are essential indicators but, they are the result of tangled climatic drivers, like orbital-scale parameters (insolation, ice sheet and greenhouse gas variations) which are the main drivers of the typical glacial-interglacial cycles of the Quaternary climate variations. Climate models can be useful tools to help unravel the roles of various forcings with their associated feedback in particular to explore major transitions like the mid-Pleistocene transition or late Pliocene transition.

One of the approaches to study long-time variations of the climate with a model is “discretizing” the time by running in parallel a succession of individual runs representing an equilibrium state of the climate at each time step. This method called “snapshot simulations” have been introduced previously using HadCM3. Here, we present the results obtained with the updated version of the model (HadCM3B), covering the last 3.6 million years at 4kyr frequency (total of more than 900 simulations). We take advantage of the recently published temperature stacks from Mg/Ca ratios and alkenone records of Clark et al., (2024) to evaluate the model performance at global and regional scales. We also compare the individual records used to construct the global temperature stacks with the local timeseries from the model.

This allows us to discuss the impact of the forcings given to the model (especially the prescribed greenhouse gases and ice sheet variations) as well as to identify the potential weaknesses present in geological stacks.

Keywords: Orbital-scale variations, Comparison model-data, Snapshot simulations, HadCM3

【A0274】 -Oral

Ancient environmental DNA in past global change research: From taxon detection to population genetics

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The field of ancient environmental DNA (eDNA) has become a reliable and complementarity proxy for recording past biodiversity. Often more taxa are observed in genetic data than in other, more traditional methods, particularly for aquatic and insect pollinated plants (Clarke et al., 2020). Moreover, in many contexts the recovered DNA is thought to originate from the local environment (Alsos et al., 2018), making it ideal for corroborating regional pollen profiles in studying past ecosystems. In principle, ancient eDNA can also provide a more granular taxonomic identification, if intra-species variation ("population variation") can be accessed. This has thus far only been possible from material high in genetic material from a single taxa, such as bones and teeth. Using fossils for this type of analysis is only possible for species that leave behind material, many species do not. In contrast, environmental archives contain DNA from many taxa occurring during the time of deposition. Not only that, unlike bones, which are recovered sporadically, environmental archives contain continuous time series. At present, methods for recovering and sequencing aDNA are becoming more advanced and cheaper, finally allowing metagenomic approaches to obtain genetic data from environmental samples at amounts that are comparable to more traditional skeletal samples.

Ancient environmental population genomics is in its infancy. Only a handful of studies have been published (Vernot et al., 2021). DNA extracted from environmental archives is challenging to analyse. Samples can contain material from more than one individual, and always have DNA from more than one species. Moreover, typically only trace amounts of DNA from any given species can be recovered. In addition to the data from ancient environmental material, population diversity data has to be available either from modern or ancient individuals. Thus, at present, only a limited amount of taxa can be studied. Furthermore, new analytical methods are required to analyse the fast amount of genetic data that is becoming available. Nevertheless, there is an incredible potential of performing population level analysis on environmental archives, dramatically expanding the available research questions. I will provide a glimpse of the bright future, and hard obstacles of applying ancient environmental genomics to past global change research.

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Keywords: Ancient environmental DNA, Population genetics, Ancient environmental genomics

【A0498】 -Poster

Gridded Holocene temperature data in China upscaled from proxy-based reconstructions and application in simulating potential cropland distribution

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Studies of Holocene climate change focus on global-scale climate model simulations and proxy-based reconstructions at sites. Climate simulations have a desirable coverage but could not reproduce the Holocene climate change indicated by geological records of China. Based on the published temperature reconstructions from pollen data, our study quantitatively reconstructed the climate grid data for each millennium since 12 ka in China using various machine learning methods. We randomly select 75% of the data as a training set and the rest 25% as an independent validation set. The performance of each model is evaluated with five-fold cross-validation and the



independent validation. The average RMSE of the five-fold cross-validation for different models is 1.01°C, and the average RMSE for the validation set is 1.32°C. The reconstructed data can well capture the Holocene temperature changes at 74 pollen sites, with averaged correlation coefficient of 0.85. The results suggest that the temperature in China increased from 12 to 8 ka and decreased after reaching a maximum in the middle Holocene. We further reconstruct the Holocene precipitation grid data and explore the effect of climate on the potential distribution of crops based on the reconstructed climate data.

Keywords: Holocene, Climate, Gridded data, China, Cropland distribution

【A0502】 -Poster

Valencia Spain October-29-2024: An extreme hydroclimate event explained with ENSO lagged influences

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During the past October 29th, flash flooding ravaged parts of Eastern Spain (known in Spain as riadas), killing at least 220 people, as the equivalent of months of rainfall fell within a matter of hours. The extreme downpour is being blamed on a seasonal “gota fría” or “cold drop”, when cold air meets warmer air from the Mediterranean and leads to storms. These kind of extreme autumn meteorological events is frequent in Spain, France and Italy. Although global warming has been considered climatically, “the culprit” of the Hydroclimate event that has happened in Valencia in 2024, in this work, lagged climate variability is considered as the main cause. The multiple and delayed influences of ENSO on extreme rainfalls both in Valencia and Spain are analysed. The applied multiple delays are from zero to four decades, which indicates different propagation speeds of the ENSO influence from the tropical Pacific to the Iberian Peninsula and the Mediterranean realm. Climate delays have been detected and applied in different climatic processes, but rarely exceed two years. However, in this study, two series of rainfall events are analysed, one, qualitatively, in Valencia lasting several centuries, and another in Spain, quantitatively, lasting more than a hundred years (CEDA/CRU,2024); and both extreme rainfall events are explained with the delayed, integrated ENSO-N3 reconstructed and observed records, since 1300 AD (Li et al., 2013). An important example of ENSO delayed influences is a multicentennial



lag of ENSO estimated thanks to the Laguna Pallcacocha record, that over the last 12 Kyr shows intensity and frequency of events that match the delayed solar activity. In this work, the multiple lagged ENSO influences are not different during the last decades. The evaluated error of this multi-delayed ENSO, shows the WW-II and the post nuclear-prohibition (1963-1980) with great values. This kind of modelling clearly suggest that the climate variability appears to be dominated by the multiple lagged influences of ENSO.

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Keywords: ENSO, Hydroclimate impacts, Climate variability



【A0505】 -Poster

Climate of the Arctic: Non conventional northern Hemisphere temperature and the Arctic Sea-Ice (ASI) cover scenarios for the 21st century

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The Arctic is currently undergoing one of the most dramatic climatic changes on Earth. However, during the last decades novel observational and proxy records have provided information about the natural climate variability of the Arctic. This work provides evidence of the links between, lagged and recurrent solar and oceanic influences, and Arctic climate. The proposed links, based on simple models, implicitly include multi-centennial climate recurrences associated to solar influences, and a well-known oceanic heat transport mechanism: the Ocean Conveyor Belt (which Atlantic surface branch is known as the Gulf Stream [GS]). The Northern Hemisphere Temperature (NHT) proxy record (over the last two millennia), after a to be calibrated with instrumental records [HadCRUT5 (Osborn et al., 2021)], were analyzed and extrapolated for the next centuries. The extrapolation for the NHT, was based on self-similar models, with evaluated solar/climate recurrences of around 930 yr. After to be justified with spectral analysis of solar and hemispheric climate records over the Holocene, the resultant extrapolated records show a non-warming scenario of NHT for the next decades and centuries. This non-warming forecast is verified with an independent negative Arctic sea-ice (ASI) proxy reconstructed records [Kinnard et al 2011]. These lagged influence (400 yr later) of marine records is justified by the GS influence, that carried the climate signal from the tropics to middle latitudes. Additionally, another two independent climate information of ASI from observations and simulations, are considered. One is coming from ASI observations and extrapolations (with the negative of the mentioned NHT), that is verified with an analogue detected in ASI-K11. Another, is coming when the additional GHG influences (from CMIP5) are linearly extrapolated to zero rcp0.0, based on NHT recurrences and lags (see Part II) detected, constituting a consequent third verification forecast based on the extrapolation of the ASI scenarios, rcp4.5 and rcp2.6, to the rcp0.0, that represent non-extra, or zero-additional, GHG scenario. The results, indicate: a) the non-warming (non-decreasing) NHT (ASI) for the rest of the 21st century; b) the lagged



and recurrent ocean influences on NH climate; and c) the need to consider ocean influences on the Arctic climate modelling. Additional verifications of NHT are provided from Gulf of Mexico (Thirumalai et al., 2021), Chasepeake Bay and Arctic deep water [Cronin et al., 2003; Cronin et al., 2012], that present a lead respect the NHT of several centuries.

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Keywords: NHT, Arctic, Climate variability, Scenarios

【A0217】 -Oral

How rabbits caused chaos: Mercury increase on the remote sub-Antarctic Macquarie Island

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Mercury (Hg) is a volatile toxic metal with a high capacity for atmospheric emission and transport. The biogeochemical cycle of Hg is sensitive to landscape changes, yet our understanding of how local disturbances impacts the Hg cycle remains limited. A primary challenge in Hg research is distinguishing changes in Hg levels driven by



human activities from those caused by natural events. This research examines how industrialisation, colonisation, and natural events have impacted toxic metal pollution in the Australia-Pacific region, and how Hg can be used as a proxy for understanding past environmental change. Studies have detected Hg increases in remote areas of Australia, the Southern Ocean, and Antarctica, with increased deposition occurring post-Industrial Revolution and during the Anthropocene. Research on the impacts of the Anthropocene on the Hg cycle in remote southern hemisphere regions is limited. While increases in Hg in the sub-Antarctic have been linked to long-range pollution transport, local landscape disturbances are often not considered. Due to Hg's strong binding affinity for organic matter, changes in landscape ecology can significantly impact the associated Hg profile.

Here, we present preliminary data from lake sediment records from Macquarie Island, a remote sub-Antarctic island with a history of extensive landscape disturbance following the introduction of rabbits in the 1900s. This coincides with increased atmospheric pollution in the southern hemisphere. Because of Hg's high affinity for organic matter, landscape disturbance and large-scale erosion can lead to increased organic matter and therefore Hg in the sediment profile. Preliminary results indicate a widespread increase in Hg across the islands lake catchments since the early 1900s, coinciding with the arrival of rabbits by sealers, rising pollution in the southern hemisphere, and a rapidly changing climate. We use a multi-proxy framework—including total Hg, carbon and nitrogen isotopes, Hg isotopes, X-ray fluorescence data, and ^{14}C and ^{210}Pb dating—to identify the causes of this Hg increase on Macquarie Island. Identifying Hg sources and deposition mechanisms in remote ecosystems is crucial to developing accurate global models of Hg cycling. A multi-proxy framework allows for precise quantification and interpretation of mercury deposition sources and accumulation rates in the context of climate change. This research introduces a new assessment approach that must be considered when studying changes in Hg deposition, aiming to avoid potential overstatements of interhemispheric variations in Hg deposition, particularly in regions with a history of later colonisation. This is provide crucial information for Australia to meet its international obligations under the Minamata Convention on Mercury. This research is in collaboration with the Australian Nuclear Science and Technology Organisation, the British Antarctic Survey, and the University of Tianjin, China.

Keywords: Mercury

【A0179】 -Poster



Identification of the Cretaceous-Paleogene boundary at northern Ninetyeast Ridge: Evidence from planktonic foraminiferal biostratigraphy and portable X-Ray fluorescence analysis

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During the latest Maastrichtian, an asteroid impact led to a massive influx of carbon dioxide into the atmosphere over a short period, causing global warming. The magnitude of the temperature increase during this event was comparable to the current trends in global warming. Studying climate change during this period provides valuable insights into today's climate research. To conduct such studies, it is crucial to establish an accurate chronostratigraphic framework first. In this regard, planktonic foraminifera are excellent tools for biostratigraphic research. However, due to the challenges in obtaining such age-old sediment samples from ocean drilling, research on the Cretaceous-Paleogene boundary in marine sediments is less developed than in terrestrial ones. Here we select samples from site U1443 of International Ocean Discovery Program (IODP) Expedition 353 at northern Ninetyeast Ridge for planktonic foraminiferal biostratigraphy research from late Cretaceous to early Paleogene. Incorporating portable X-ray fluorescence (XRF) data, the stratigraphic position of the Cretaceous-Paleogene boundary has been determined.

The biostratigraphic results show that the last occurrence of *Abathomphalus mayaroensis* was identified in sample U1443A-39X-4 W, 111-115 cm (287.56 m), determining the age at a core depth of 287.44 m to be 66.35 Ma. In sample U1443A-39X-4 W, 39-43 cm (286.84 m), the last occurrence of *Globotruncana* spp. (belonging to P0 fossil zone) was identified, indicating that the age at a core depth of 286.72 m is 66.04 Ma, which corresponds to the Cretaceous-Paleogene boundary. In sample U1443A-39X-3 W, 115.0-117.0 cm (286.27 m), the first occurrence of *Parvularugoglobigerina eugubina* (belonging to P α fossil zone) was identified, indicating the age at a core depth of 286.44 m to be 66.00 Ma. Portable XRF results show that slightly below the Cretaceous-Paleogene boundary (about 287.00 m) determined by planktonic foraminifera biostratigraphy, concentrations of calcium, barium, potassium, sulfur, and strontium exhibited a marked decrease, while iron



concentrations increased. This study provides a crucial foundation for future global stratigraphic correlations and paleoclimate research.

Keywords: Ninetyeast Ridge, Cretaceous-Paleogene boundary, Planktonic foraminifera biostratigraphy, Portable XRF

【A0948】 -Oral

Sea surface temperature variability in the Western Indian Ocean over the common era

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The Indian Ocean remains by far the least documented and least understood oceanic basin despite its fast warming and subsequent consequences on regional climate change and livelihood of human populations. This lack was also emphasized by the global compilation of sea surface temperature (SST) proxy records of the Common Era climate (CE, last 2000 years) undertaken by the Ocean2k-LR group of PAGES (McGregor et al., 2015). The first SST reconstruction presented here, obtained from the marine core MOZO-CSF18 and resolving the decadal variability of the last 2000 years in the western Indian Ocean, constitutes an important step in filling our knowledge gap. Proxy values over the instrumental period are in the range of observations and show centennial-scale oscillations of 0.5°C amplitude that are also reproduced by the well-dated 194 year-long $\delta^{18}\text{O}$ coral record from Malindi, Kenya. Both archives reveal clear cooling triggered by volcanic eruptions of the Tambora, Krakatau and Agung. Wavelet analysis of the last 2000-year SST signal evidences of dominant low frequency variability of ENSO shared by continental proxy records.

Keywords: Indian Ocean, SSTs, Common Era, ENSO

【A0778】 -Oral

Embracing joint species distribution models to better analyse palaeoecological time series



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Palaeoecological data are notoriously complex and hence present difficulties for researchers when they attempt to model them. One of the primary ways researchers have analysed palaeoecological data over the past five decades and more is through multivariate ordinations, which decompose the multivariate species data into uncorrelated components of variation (axes). Statistical inference, if possible at all, relies on permutation testing that typically assumes the data are regularly-spaced in time, because these methods lack a formal statistical model to underpin them.

Recent developments within statistical ecology have led to the development of model-based ordination methods and the broader class of Joint Species Distribution Models (JSDMs). These methods are all underpinned by a formal statistical model, often extending univariate generalized linear models to the multivariate setting while allowing for correlations between the species responses. Yet, until recently it was difficult to apply these methods to the species-rich data sets typical of much palaeoecological research, in part due to the data being an irregular times series.

Here, I discuss a recently developed model, the multivariate generalized additive model (MVGAM; Clark & Wells, 2023) and demonstrate how it can be used to model palaeoecological timeseries. MVGAMs include low rank, latent variables that are the counterpart of ordination axes, and which can be used to model different trends shared among groups of taxa, and thus account for and model correlations among species (i.e. associations among species). These shared trends can be modelled using penalised splines, and thus borrow the many good properties of generalized additive models (GAMs) for palaeoecological data (Simpson, 2018).

In this talk, I will introduce the general ideas behind JSDMs and why palaeoecologists should be interested in them, before moving on to discuss the MVGAM. I will show how to fit these models to palaeoecological data, using classic data sets to illustrate the properties of MVGAMs and show how they compare to more traditional approaches. I will conclude the talk by discussing the broader potential of JSDMs to drive new research ideas and support more rigorous analysis of palaeoecological data.

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Keywords: Joint species distribution models, Palaeoecological time series, Species associations, Common trends

【A1033】 -Oral

Proxy-informed enhancement of ocean memory in an Earth system model to simulate long-term climate variability

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For making informed projections about future climate change, knowledge on natural climate variability is essential. However, as highlighted by previous studies using palaeoclimate data, climate models often underestimate long-term temperature variability on multidecadal to millennial timescales, both in the ocean and on land (Laepple et al. 2023). In this study, we explore the impact of enhanced long-term memory in the ocean on atmospheric variability. By nudging sea surface temperatures (SSTs) in a long control run of the Alfred Wegener Institute Earth System Model (AWI-ESM), we increase the long-term ocean memory in the model to ensure that it better reflects observational evidence from palaeoclimate data (Laepple & Huybers 2014). In our model setup, SSTs are restored to match modified values, while other dynamics and thermodynamics evolve freely, meaning the atmosphere and sea ice adjust to the altered SST variability. We test various spatial patterns and scaling behaviours of ocean variability during the Holocene to assess the resulting variability on land. These results are then compared with independent data on the spatial patterns of terrestrial climate variability, allowing us to investigate how ocean variability drives land variability on long timescales (e.g., Hébert et al. 2022).



Keywords: Climate variability, Model nudging, Model-data comparison

【A0497】 -Poster

Using luminescence dating to constrain the age model for 1.1 Ma Lake Bosumtwi drill core, Ghana, western Africa

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A ~1.1 Ma (300 m) drill core collected from Lake Bosumtwi in 2004 represents one of only a few long continuous sediment records from continental western African. Lake Bosumtwi fills the majority of a ~10 km diameter crater formed by a bolide impact; despite the lake's small size and modest drainage basin, Lake Bosumtwi's sediments contain a proven archive of late-Quaternary climate variability. Unfortunately, the utility of this record has been limited by large chronologic uncertainty. Though several attempts have been made to constrain the chronology of this record, there are few direct dates older than ~150 ka (75 m). To reduce the chronologic uncertainty, we produced 26 luminescence ages, collected at a ~4 m resolution from 50-150 m below lake floor. There have been significant improvements to luminescence methodologies in recent years, that allow us to markedly extend the range of direct ages from this record. With an improved chronology we will be able to reanalyze legacy proxy records from the Lake Bosumtwi drill core including textural, physical properties, and bulk organic geochemical data sets. With these datasets and the updated chronology, we will be able to study changes to the West African monsoon system and hydroclimatic relationships across the continent.

Keywords: Luminescence dating, Western Africa, Lake, Quaternary, Sediment core

【A0487】 -Oral

Monsoon dynamics: Integrating records and simulations of key late cenozoic intervals

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Understanding past climate is crucial for refining future projections. Proxy data and climate models are essential tools for acquiring past climate information, yet discrepancies between these methods often persist. Here, we propose an innovative framework that integrates proxy data with model simulations by systematically decomposing the physical processes governing monsoon variability. Using the East Asian Summer Monsoon (EASM) as a case study across key periods from the Paleoclimate Modelling Intercomparison Project (PMIP), we find: 1) dynamic processes overwhelmingly dominate over thermodynamic influences on the increase in EASM precipitation in both records and simulations during the mid-Holocene; 2) thermodynamic and dynamic processes play contrasting roles during the Last Glacial Maximum, which can reconcile spatially non-uniform variations between records and simulations; and 3) In both records and simulations, enhanced precipitation in the tropical and subtropical EASM regions during the mid-Piacenzian Warm Period is primarily driven by thermodynamic and dynamic processes, respectively, reflecting distinct water vapor sources.

Our study highlights the value of decomposing monsoon dynamics in bridging the gap between proxy records and model simulations. The dynamic analysis reveals that simulations consistently yield a decomposed process that spatially aligns with the records. However, discrepancies primarily stem from biases in the simulations, particularly in the relative contributions of different physical processes to precipitation changes. These findings underscore the need for refining climate models to better represent the physical processes driving monsoon variability.

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Keywords: Proxy records, Model simulations, Monsoon dynamics decomposition, Integration of records and simulations

【A0524】 -Poster

Reconstruction of atmospheric CH₄ concentration history since the Industrial Revolution from the SE-Dome II ice core, southeastern Greenland

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Methane (CH₄) is emitted from both natural and anthropogenic sources. Direct observations of atmospheric CH₄ started only in the 1980s; thus, we need to reconstruct the past concentrations from ice cores to gain the knowledge on the histories of anthropogenic source strengths and natural source changes associated with climatic changes since the Industrial Revolution. In fact, high-resolution and precision CH₄ data for the industrial period is available from the Law Dome ice core from Antarctica, which was drilled at a high-accumulation site (about 1 m w.e. year⁻¹). However, there have been no high-quality data from Greenland, because of in-situ production of CH₄ in high-impurity layers in the ice sheet and the lack of ice cores from Greenland with very high accumulation rate like the Law Dome core. In this study, we have overcome these problems and reconstructed the CH₄ concentration since the 1840s by analyzing the SE-Dome II ice core (67°19'17" N, 36°47'03" W, 3,161 m a.s.l, accumulation rate: 1.04 ± 0.20 m w.e. year⁻¹), southeastern Greenland (Kawakami et al., 2023).



We analyzed 170 samples (ice age: 1800-1969, depth: 250-78m), and the air in the samples was extracted with an established wet-extraction technique. The length of each sample was determined to contain approximately 1 year (~1 m) of accumulation to minimize the possible age reversal or age discontinuity of trapped gases due to inhomogeneous gas trapping in the bubble close-off region at the bottom of firn.

The air bubbles are closed off at the bottom of firn, so the age of ice and gas are different at the same depth, i.e., we cannot reconstruct the CH₄ history by using the ice age. The ice age was determined by counting the seasonal variation of the H₂O₂ concentration (Kawakami et al., 2023). In this study, we compared the CH₄ data of the SE-Dome II core to that of BRW and calculated the difference between the ice age and gas age (known as Δ age). As a result, Δ age for the SE-Dome II core was estimated to be 40 years.

The CH₄ concentration increased from ~830 ppb to ~1800 ppb between the 1840s and 2000s, especially increased rapidly since the 1950s. The data from NEEM core shows artifactual spikes of up to ~150 ppb above a 10-year moving average due to in-situ CH₄ production, but we do not find anomalous values in the SE-Dome II data. We speculate that there are no spikes like the NEEM core data because impurities in the SE-Dome II core are low concentration due to extremely high accumulation rate. The growth rate was ~10 ppb/yr since the 1840s and increased to ~40 ppb/yr between the late 1970s and early 1980s, which is twice as large as the growth rate at Point Barrow (Alaska) in the late 1980s. The growth rate from the SE-Dome II data is in agreement with that of the direct arctic observation for the overlapping period (since the late 1980s).

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Keywords: CH₄, Ice core, Greenland, Methane



【A0886】 -Poster

Comparison of ocean dynamics using two different earth system models for the mid-Miocene climate optimum

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The Middle Miocene Climate Optimum (MMCO, ~16.9–14.75 Ma) represents a significant global warming event, with global mean temperatures estimated to be 4–6°C higher than today. This warming was particularly pronounced in the high-latitude regions of both hemispheres, highlighting the importance of studying the large-scale climate features of this period. Insights from the MMCO are not only critical for understanding paleoclimate dynamics but also for informing projections of future climate change under high-emission scenarios. To address uncertainties related to models, we utilized two state-of-the-art coupled atmosphere-ocean general circulation models (AOGCMs): IPSL-CM5A2 and NorESM1-F. Both models, using updated paleogeographic reconstructions and prescribed atmospheric pCO₂ of 2.5xPAL and 1.5xPAL, simulate global mean annual surface air temperature anomalies generally consistent with proxy records (4–7°C warming). However, notable discrepancies arise in the Northern Hemisphere high latitudes. The NorESM1-F model produces stronger warming in these regions, driven by near-complete sea-ice loss and sustained modern-like Atlantic Meridional Overturning Circulation (AMOC) strength. In contrast, IPSL-CM5A2 simulates more moderate warming, characterized by seasonal sea ice and a weakened AMOC. Our findings underscore the critical role of ocean component dynamics in shaping high-latitude climate responses, emphasizing the need to address model uncertainties when investigating both past and future climate change scenarios.

Keywords: Mid-Miocene Climate Optimum, High latitude warming, Model discrepancy, AMOC strength



【A0535】 -Oral

Free soda – a fair record collection to unravel Southern Ocean dynamics over the last glacial cycle

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On glacial-interglacial timescales, various processes in the Southern Ocean are thought to play a crucial role in the drawdown of carbon dioxide and its release back to the atmosphere. These processes include changes in sea ice cover, sea surface temperatures, export production, deep water formation and ocean circulation, often entangled and (co-)dependent. Yet, from a circumpolar point of view, the dynamics of single processes as well as their interactions are not fully understood, limiting our insight into Southern Ocean-governed atmospheric CO₂ modulation.

A main obstacle to a more comprehensive understanding of these Southern Ocean processes and their interplay is the data availability and reusability from previous studies that allow to fully explore, investigate and compare new findings and ideas. While data sharing has become more and more common in paleosciences, the adoption of common standards and formats remains slow. Likewise, older data sets not being converted into updated data formats hinders their incorporation in recent studies.

Hence, to facilitate analyses of the complex processes and their relationships in the Southern Ocean, we present here our compilation of previously published proxy data for the Southern Ocean over the Last Glacial Cycle converted into the Linked open Paleo Data (LiPD) format (McKay and Emile-Geay, 2016). With the FAIR principles in mind, the LiPD format offers extensive (meta-)data standards, increasing the interoperability and reusability of published data and allowing for easier and more



comprehensive analyses.

To stimulate the (re-)use of this data compilation and analytical tools, we create a website that includes our data compilation as well as search and plot functions, additional code for analyses, and allows entry of new data, serving as a platform to expedite the integration of new data and as reference of a comprehensive overview for comparison and analyses.

Recent efforts have already demonstrated the additional value of data compilation efforts: The PAGES C-SIDE working group published a comprehensive overview of Southern Ocean sea ice proxy data (Chadwick et al., 2022) and a first achievement from our current data compilation explored sea surface temperature (SST) proxy data (Thöle et al., in prep.).

The expansion of our data compilation to other proxies will enable us to analyze different processes separately as well as investigate their interplay while at the same time facilitate the (re-)use of our data compilation and analyses.

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Keywords: Data compilation, FAIR data, Southern Ocean, Glacial-interglacials

【A0577】 -Poster

Pleistocene subtropical front dynamics in the southwest Pacific Ocean

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The Antarctic Circumpolar Current (ACC) plays a crucial role in redistributing nutrients, governing the upwelling of CO₂-rich sub-surface waters, and delivering heat to the Antarctic ice sheet, thereby modulating CO₂ release to the atmosphere as well as ice melt and, consequently, sea level rise. However, projections of its future behavior remain uncertain due to the complex migration of ACC-associated frontal systems.

This study revisits Pleistocene sediments recovered during Ocean Drilling Program (ODP) Leg 189 near Tasmania, a key region where ACC frontal systems reach their southernmost extent, making it particularly sensitive to ocean-driven Antarctic ice sheet melt. Building on Nürnberg et al. (2004), we employ organic geochemical and quantitative dinocyst assemblage-based proxies from Sites 1171 and 1172, located in the Subantarctic Zone and north of the Subtropical Front, respectively, to reconstruct Pleistocene sea surface conditions and infer glacial-interglacial ACC dynamics. New stable and radiogenic isotope data further refine the age models of these records.

Our quantitative proxies provide insights into past oceanographic conditions, with limited prior documentation of their response to Southern Ocean frontal migrations. Covering the past 500,000 years and encompassing MIS 11 and 5 as potential analogues for future climate scenarios under anthropogenic forcing, this study enables detailed comparisons across multiple glacial-interglacial cycles to examine the varying dynamics at play.

Preliminary results reveal strong oceanographic shifts between glacial and interglacial periods, indicating pronounced frontal system migration in this region despite geographic constraints imposed by the Australian landmass. These findings have implications for understanding future ocean-induced melting of the Wilkes Land ice sheet.

Keywords: Antarctic Circumpolar Current, Subtropical front, Southern Ocean

【A0291】 -Poster

Enhanced seasonality of surface air temperature over China during the mid-Holocene

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Using all available simulations performed by climate models participating in PMIP4 (Paleoclimate Modelling Intercomparison Project phase 4), we quantify the seasonality change of surface air temperature over China during the mid-Holocene (6000 years ago) and the associated physical mechanisms. Relative to the preindustrial period, all 16 models consistently show an enhanced temperature seasonality (i.e., summer minus winter temperature) across China during that interglacial period, with a nationally averaged enhancement of 2.44°C or 9% for the multimodel mean. The temperature seasonality change is closely related with the seasonal contrast variation of surface energy fluxes mainly due to the mid-Holocene orbital forcing. Specifically, the summer–winter increase in surface net shortwave radiation dominates the intensified temperature seasonality at the large scale of China during the mid-Holocene; the surface net longwave radiation has a minor positive contribution in most of the Tibetan Plateau and eastern China; and both the surface latent and sensible heat fluxes show partial offset effects in most of the country. There are uncertainties in the reconstructed temperature seasonality over China during the mid-Holocene based on the proxy data that can reflect seasonal signals.

Keywords: Mid-Holocene, Temperature seasonality, China, PMIP4 simulations

【A1006】 -Poster

Varved sediments of Lake Gorzyńskie, western Poland: A new archive of climatic and environmental changes during the late glacial and the Holocene in central Europe

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Lacustrine varved sediments are of crucial importance for reconstructing past environmental changes. In this study, we present a new varved sediment record of Lake Gorzyńskie located in western Poland, a region where well-documented varved sediment sites are scarce. The complete sediment profile from this lake is 10.45 meters long and covers the last ≈13,250 years. Using varve counting, isotope dating (¹⁴C, ²¹⁰Pb,



^{137}Cs), and variable varve thickness, a robust combined age-depth model was developed. Sediment lithology, varve microfacies, and statistical analysis of the chemical composition, including hierarchical clustering and principal component analysis, allowed for the identification of six main depositional phases: the late Allerød ($\approx 13,250 - 12,675$ cal BP), the Younger Dryas ($12,675 - 11,600$ cal BP), the Early Holocene ($11,600 - 9,100$ cal BP), the main part of the Holocene ($9,100 - 2,250$ cal BP), and two phases of the Late Holocene ($2,250 - 750$ cal BP, 750 cal BP – present). After the Younger Dryas/Holocene transition, stable sedimentation conditions are evident in the Early Holocene, followed by increased variability during the main part of the Holocene. Short-term fluctuations coinciding with known paleoclimatic events such as the Preboreal Oscillation and the 10.3 ka climate event, are also evident. Dramatic changes in the Late Holocene are most likely associated with increasing human impact. The Lake Gorzyńskie sediment record offers not only valuable insights into the long-term trends in environmental history of western Poland but also into short-term paleoclimate variability during the Late Glacial and Holocene.

Keywords: Varves, Late glacial, Holocene, Micro-XRF

【A0926】 -Oral

The last glacial cycle in the Canary Islands: New paleoclimate reconstructions from lake records

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New lake records from the Canary Islands have improved the reconstructions of climate variability during the last glacial cycle. Preliminary age models indicate that the sequences of La Vega Lagunera (north of Tenerife) reached 400 ka in the proximal zones (40 m depth) and include the whole Holocene in the more distal zones (8 m depth). The sequences of El Malpaís de La Rasca (southern Tenerife, 1.6 m long),



Garajonay (La Gomera, 6 m long) and Playa de Taburiente (La Palma, 1.2 m long) all span the Holocene.

Preliminary analyses including magnetic susceptibility, XRF geochemistry, elemental composition (TOC, TN, TS), mineralogy and lipid biomarkers have allowed us to characterize depositional changes and their relationship with watershed erosion, water balance and climatic variability. In La Vega Lagunera a clastic lake has been identified during the Pleistocene with higher sediment delivery rates during cold periods (MIS 2, MIS 4) and lower during warmer periods (Holocene, MIS 3, MIS 5), and millennial-scale cycles during MIS 3 and MIS 4. Climate during the last glacial maximum (MIS 2) seemed to have been less humid, with greater similarity to mid-latitude records. The onset of the Holocene is the best defined environmental and climate transition of the entire sequence.

Holocene records in all islands show depositional variability related to local conditions, but suggest increased fluvial/alluvial activity in the basins during the Groenlandian (11.7 Ka-8.2 Ka), a progressive decline during the Norgripian (8.2 Ka-4.2 Ka) and a decrease in clastic inputs during the Megalayian (last ~4.2 Ka). These trends point to an increase in aridity throughout the Holocene. Improved age models are in progress (OSL, ^{14}C) to characterize the observed cyclicity patterns and associate them to the glacial/interglacial paleoclimatic evolution of these oceanic islands and the relative role of subtropical and mid-latitude atmospheric and oceanic patterns.

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Keywords: Canary Islands, Paleoclimate, Lake records, Volcanic islands, Last glacial cycle

【A1039】 -Poster

Paleodiet and paleoenvironment through dung analyzes of a ground sloth from Cacao 1a site, southern Argentinian Puna

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Multiproxy analysis of coprolites provide valuable insights about the diet of extinct organisms and paleoenvironments. The aim of this study was to investigate the zoological origin and paleodiet of a ground sloth and paleovegetation through coprolite analysis found at Cueva Cacao 1A archaeological site (Catamarca, Argentina). Radiocarbon dating places the coprolite at $43,000 \pm 2,000$ yr ^{14}C BP, making it one of the earliest and most well-preserved megafauna dung of South America. Various proxies, including pollen, cuticles and macro-remains of plants, phytoliths and aDNA, were extracted from the coprolite following a multiproxy analysis protocol for fecal samples. The study presents detailed descriptions of the findings and the zoological origin assignment based on morphological characters, internal content and aDNA analyses of coprolite. Ancient DNA was detected by amplification of a short mitochondrial rRNA 12S fragments confirming the coprolite identification as *Megatheriidae/Mylodontidae*. Pollen, macro remains, plant cuticles and phytoliths exhibited remarkable preservation, allowing for taxonomic identifications down to genus and species level. Palynological results revealed the presence of pollen types from the families *Poaceae*, *Apiaceae*, *Asteraceae* subf. *Asteroideae*, and the genus *Adesmia* (Fam. *Fabaceae*), among others. Cuticle analysis also confirmed the presence of *Poaceae* represented by *Festuca*, *Pappostipa*, *Cinnagrostis* and *Puccinellia*. Additionally, *Asteraceae* species of *Baccharis* and *Parastrephia* were identified, as well as species of *Adesmia* and *Fabiana* (Fam. *Solanaceae*). Macro-remain analysis indicated the presence of aff. *Cinnagrostis* sp., along with two shrub species of



Baccharis and another one aff. *Ephedra* sp. (Fam. *Ephedraceae*). Phytoliths analysis showed the predominance of morphotypes associated with the *Cyperaceae* and *Poaceae* (Subf. *Pooideae*, *Panicoideae*, *Danthonoideae*, and *Chloridoideae*), and a lower proportion of shrubs and herbaceous dicotyledonous compared to modern vegetation. The results suggest the *Megatheriidae/Myodontidae* zoological origin and a grazing-browsing dietary pattern, with a clear selectivity for grasses. These findings provide valuable insights into the ground sloth paleodiet and the paleovegetation which allows us to make inferences about the environment between 50,341 and 40,886 yr cal. BP in the Argentinean southern Puna. This research underscores the importance of multiproxy approaches, which are increasingly relevant for obtaining comprehensive and complementary information regarding the paleoenvironment in the hyper-arid regions of Argentina during the Pleistocene.

Keywords: Pleistocene, Coprolite, Multiproxy analysis, Paleoenvironment, Extinct megafauna

【A0925】 -Poster

Antarctic Circumpolar Current dynamics and marine productivity in the pacific Antarctic Zone over the last 280 kyr

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Deciphering the mechanisms driving past marine productivity (paleoproductivity) within the Antarctic Zone (AZ) is critical for understanding cryosphere-climate interactions. Here, we analyze multi-proxy records from gravity core ANT36/A3-08, recovered from the seasonal sea ice zone (SIZ) of the Amundsen Sea, to explore paleoproductivity changes over the past ~280 kyr. Our results show that regional paleoproductivity and bottom flow velocities are tightly linked to Antarctic Circumpolar Current (ACC) dynamics, modulated by 100 kyr eccentricity-paced glacial-interglacial cycles. During glacial periods, a northward-shifted Southern Westerly Wind Belt (SWW), weakened ACC, extensive sea ice coverage, and reduced Southern Ocean ventilation jointly suppressed bottom flow velocities and limited nutrient availability, leading to lower paleoproductivity in the Amundsen SIZ. Conversely, interglacial



periods were marked by a poleward-shifted SWW and intensified ACC dynamics, which enhanced bottom flow velocities through topographic form stress and strengthened northward Ekman transport. This transport induced the upwelling of warm, nutrient-rich deep waters, promoting sea ice retreat, increasing surface nutrient availability, and elevating paleoproductivity. Orbital forcing further modulated these dynamics. High eccentricity phases amplified seasonal contrasts, steepened vertical density gradients, and fostered baroclinic instability, strengthening ACC transport and enhancing nutrient redistribution. In contrast, the low eccentricity phases diminished seasonal contrast. Such conditions saw obliquity-driven insolation facilitating early summer sea ice retreat and regional upwelling, sustaining productivity. These results highlight the interplay between ACC dynamics, SWW shifts, and orbital forcing in shaping paleoproductivity in the Amundsen Sea SZ, providing insights into potential responses of the Pacific AZ under future climate change scenarios.

Keywords: Amundsen Sea, Multi-proxy records, Glacial/interglacial cycles, Orbital forcing, Lower Overturning Circulation

【A0484】 -Oral

Vegetation stability declines under climate and human pressures since the last deglaciation

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Both human activities and climate change have played crucial roles in shaping vegetation dynamics. Previous studies have demonstrated that rapid climate changes and intensive human activities in the modern era have significantly impacted vegetation turnover rates and plant diversity. In this study, we compiled global pollen records from the past 15,000 years to perform global-scale research on vegetation regime stability since the last deglaciation—when climate shifted rapidly, and human cultures began to develop and flourish.

The results reveal a marked decrease in vegetation regime stability during the deglaciation, driven by rapid climatic changes. In contrast, the Holocene witnessed a



gradual increase in vegetation regime stability, peaking during the mid-Holocene. This stability likely provided an ideal environment for the development and flourishing of ancient human cultures and societies. However, traditional forms of human land use—such as fishing/gathering/hunting, extensive agriculture, pastoralism, intensive agriculture, and urbanization—were found to significantly reduce vegetation regime stability. As human activities expanded, particularly after around 3000 BP, vegetation regime stability began to decline.

Our findings underscore the dominant role of climate change in influencing vegetation stability dynamics over the past 15,000 years. However, as human activities expanded, land use emerged as a critical determinant of vegetation dynamics and stability, surpassing climatic factors in importance.

Keywords: Pollen, Stability, Last deglaciation, Holocene, Vegetation

【A0379】 -Poster

Mediterranean circulation variability as forced by high- and low-latitude freshwater inputs over the last two glacial cycles: Inferred from Nd isotopes in fish and foraminifera

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The Mediterranean thermohaline circulation is thought to play a key role in the rhythmic deposition of organic-rich sedimentary layers, known as sapropels, which signify anoxic deep-water phases in the geologic past. However, the intricate interactions between climatic and oceanographic processes leading to sapropel



formation are still highly debated, especially regarding circulation dynamics and surface hydrology. Here, we present a deep-water record of Nd isotope composition (ϵ_{Nd}) over the last ~250,000 years (250 kyr), covering the sapropels S1 to S9; this is the longest ϵ_{Nd} record for the Mediterranean Sea to our knowledge. Core CP10/11 is collected from the open Ionian Sea at 1,501 m water depth, and the ϵ_{Nd} data are based on the reliable archives of fish teeth/debris and foraminifera shells. More radiogenic ϵ_{Nd} values are consistently found during the periods when sapropels deposited. This reflects enhanced Nile contribution relative to the Atlantic-derived contribution to the EMS, indicative of deep-water stagnating conditions. There is a stepwise evolution of deep-water properties in the EMS, showing a more radiogenic background of ϵ_{Nd} for the last glacial cycle (i.e. ~140–0 kyr, including sapropels S1 to S5), and a less radiogenic level of ϵ_{Nd} otherwise (i.e. ~250–140 kyr, including sapropels S9 to S6). These findings support a scenario whereby the last glacial cycle, the EMS was influenced strongly by the remote effects of an intensified African monsoon via the Nile and potential North-African paleo-river inputs. By contrast, more local precipitation and glacier melting waters from the northern borderlands should have significantly contributed to the sea surface composition, leading to the deposition of sapropels during unfavorable conditions, such as S6 in glacial period and S8 in cold stadial.

Keywords: Nd isotopes (ϵ_{Nd}), Mediterranean circulation, Sapropels, African monsoon, Westerly

【A0182】 -Poster

Holocene paleoflood records in alluvial plains: A case from abandoned channel areas of the lower Yellow River, China

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The lower Yellow River witnessed enormous floods, levee breaches, and channel avulsions in historical periods, which have generated extensive paleoflood sediments on the North China Plain. However, the sedimentary features of paleoflood deposits



in alluvial plains have not been fully investigated. Here, a series of paleoflood stratigraphy were investigated along the abandoned channel areas, which have been used to reconstruct and generate a process-based facies model for floods in the lower Yellow River. By combining sedimentary evidence and radiometric dating the main characteristics and typical sequences of paleoflood sediments on the alluvial plain are summarized. Our results indicate that four sedimentary units are similar in the LYR, especially Unit III and Unit IV are widely distributed, representing the cycles of flood and non-flood cycles since ~4.0 ka. Lacustrine deposits (FA1) and buried soil (FA2) that developed during relatively stable periods without flood aggradation can help revise the stratigraphic correlation. A model of paleoflood deposition along the abandoned channel areas is proposed, showing multiple phases of the flooding process. Slackwater deposits with distinctive sedimentary characteristics can still be an important indicator of past flood events in the Yellow River floodplain and similar physiographic settings. Recognition of paleoflood sedimentary records in the lower Yellow River will help to understand the frequency, process and impacts of flooding for more populated and higher-risk areas on the floodplain and similar sedimentary environments.

Keywords: Paleoflood, Sedimentary characteristics, Abandoned channels, Floodplain, Lower Yellow River

【A0077】 -Oral

How can Norwegian mountain peatbogs represent useful archives to understand the effect of precipitation on peatlands carbon budget?

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There is extensive literature on temporal carbon accumulation changes in arctic and boreal peatlands in northern peatlands, but little has been achieved in comparing mountain peatlands carbon sinks capacities in wet regions such as Norway. Projections in Norway show a rise in temperature and annual rainfall with more intense seasonal events in western, eastern, and northern parts. In this context, this study hypothesizes that temporal variability of temperature and precipitation during the Holocene led to weaker and stronger evapotranspiration and moisture signals affecting local and regional vegetation in peatland ecosystems, water-table changes, and carbon



accumulation capacity. This study aims in disentangling the responses of the carbon budget at different hydrological gradients during the Holocene and compare temporal carbon sink capacity of peatlands in two of the most important plateaus not only in Norway, but in Europe. Methods involve a multiproxy approach to reconstruct carbon accumulation rate, local vegetation changes, %C and %N to investigate the relationship between the proxies and Holocene carbon changes. Results for carbon accumulation rates, show very specific trends in early, mid and late Holocene and correlation with temperature and precipitation reconstructed values at different stages of the Holocene.

Keywords: Peatlands, Carbon, Macrofossils, Mountain, Holocene

【A0491】 -Poster

Millennial-scale surface hydrological variations in the eastern tropical Indian Ocean linked to northern hemisphere high-latitude

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Hydrological variations in surface waters of the eastern tropical Indian Ocean significantly impact low-latitude climate processes, such as the Indonesian-Australian monsoon and the Indian Ocean Dipole. Deciphering the evolution history and driving mechanism behind is thus important for insight into the low-latitude and global climate change. Previous studies revealed that Northern Hemisphere high-latitude affects surface hydrological variations of the tropical eastern Indian Ocean by regulating the state of the Atlantic Meridional Overturning Circulation (AMOC)/Global Ocean Conveyor Belt. However, this mechanism on millennial timescale since the last glacial remains unclear due to the scarcity of high-resolution records from the eastern tropical Indian Ocean. Here, we present millennial-scale thermohaline records of surface waters over the past ~32 kyr based on Mg/Ca ratio and $\delta^{18}\text{O}$ of the surface-dwelling planktonic foraminifera species *Globigerinoides ruber* from Core SO257-18567 drilled off northwest Australia in the tropical eastern Indian Ocean. Comparison of the new records with published paleo-oceanographic and -climatological records reveals that sea surface temperature increased and salinity decreased the eastern



tropical Indian Ocean during Heinrich stadial 1 and Younger Dryas events, which is likely attributed to collapse of the AMOC and southward shift of the Intertropical Convergence Zone due to melting of Northern Hemisphere high-latitude ice sheet. In addition, our results disclosed that onset of the deglacial sea surface warming in the eastern tropical Indian Ocean could be ascribed to increased Northern Hemisphere high-latitude summer insolation rather than global atmospheric CO₂ rise, leading to a weakened Hadley circulation and collapsed AMOC.

Keywords: Planktonic foraminifera, Sea surface temperature and salinity, Millennial timescale, Eastern Tropical Indian Ocean, Northern hemisphere high-latitude

【A0905】 -Poster

Sea-level and climatic evolution in the postglacial Qiantang River incised-valley system: Insights from grain-size end-member modelling and geochemical characteristics

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Climatic and sea-level fluctuations exert far-reaching impacts on coastal systems by regulating hydrological processes and sediment-transport patterns on various temporal and spatial scales. The postglacial Qiantang River incised-valley fill is a natural laboratory to decipher these influences due to continuous sedimentation since the Last Glacial Maximum and complex coupling relationships with the nearby Changjiang and East China Sea continental shelf. Based on a 60 m-long sedimentary succession (core SE3), the sediment sources, dispersal patterns and associated responses to sea-level and climatic change are studied in detail via geochemical analysis and grain-size end-member (EM) modelling. Results indicate that relative sea-level and climatic changes determine the spatio-temporal distribution of the modelled 5 grain-size EMs and sediment-dispersal pathways in the Qiantang River system. The contents of the finest EM1 and total amounts of the coarsest EMs (i.e., EM5+EM4) are sensitive to relative sea-level variation, with the highest EM1 content but lowest EM5+EM4 amount indicating the maximum marine transgression. Accompanying with seawater intrusion, the Changjiang-derived sediments began to import into the Qiantang River system since the formation of paleo-estuary, represented by the total amount of EM1 and EM2, that bears a positive relationship with the Changjiang sediment contribution



obtained by quantitative calculation with geochemical data. Furthermore, the Changjiang-derived EM1 and EM2 became the dominant components during the formation of shallow marine and more seaward part of modern estuary. The vertical variation pattern of their total amount and associated geochemical characteristics in shallow marine and modern estuary environments mainly reflects the combination of Zhe-Min coastal currents and intermittently strengthening East Asian Winter Monsoon, that have significantly changed the characters of suspended sediment derived from the Changjiang during the transportation into the Qiantang River system. Additionally, three intervals clustered with paleo-floods are documented in the fluvial environment and more proximal part of paleo-estuary, that are characterized by positive excursions of the relative contents of EM5 within the coarsest EMs (i.e., EM5+EM4) and TOC/TN values. These paleo-floods can be attributed to the abnormally climatic variation during the Younger Dryas (YD, 13–11 ka BP), 10.6–10.3 ka and 9.3 ka cooling events. In summary, high-resolution grain-size EMs complied with geochemical characteristics enables the appraisal of the responses of coastal incised-valley fill to climatic and sea-level variations, even in a system characterized by complex sediment-dispersal pathways and physical processes. This study should shed a new light in a similar coastal setting worldwide to reconstruct and predict climatic and sea-level evolution.

Keywords: Postglacial, Qiantang River incised valley, Grain-size end-member modelling, Sediment-dispersal system, Environmental change

【A0462】 -Poster

Unraveling the secrets of coral reef prosperity during warm Miocene

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Coral reefs represent the most biodiverse ecosystems on Earth, hosting approximately 25% of all marine species despite occupying less than 1% of the ocean floor. Understanding the evolutionary dynamics of coral reefs is critical for predicting their future roles under ongoing ocean warming, acidification, and sea-level rise - conditions similar to those of past oceans with elevated atmospheric pCO₂. The Miocene epoch is particularly important, as it featured flora, fauna, and paleogeography comparable to the present, along with atmospheric pCO₂ levels resembling future projections. During this period, extensive reef systems flourished off northeastern and



northwestern Australia, providing valuable archives for studying coral reef characteristics under warmer climates.

This study investigates Miocene coral and coralline algae fossils collected from Ocean Drilling Program (ODP) Sites 811/825 on the northeastern margin (Queensland Plateau) and International Ocean Discovery Program (IODP) Site U1464 on the northwestern margin (Northwest Shelf) of Australia. Corals and coralline algae, the primary contributors to reef frameworks, have exhibited microstructural and mineralogical adaptations that enhance their resilience to environmental stressors. For instance, corals may sustain aragonite skeleton formation through the non-classical crystallization of amorphous carbonate particles, mitigating the impacts of ocean acidification. Similarly, reef-building crustose coralline algae could rapidly adapt to ocean warming and acidification by increasing dolomite accumulation. To analyze these adaptations, a suite of advanced techniques-including light microscopy, field emission scanning electron microscopy, in-situ Raman spectroscopy, in-situ X-ray diffraction, and transmission electron microscopy-was applied to the fossil samples. These methods revealed key microstructural and mineralogical features, providing insights into crystallization pathways and early diagenesis processes.

This pilot study also explores the feasibility of stable isotope and trace metal geochemistry for analyzing the fossils. Further, organic biomarker analysis (e.g., glycerol dialkyl glycerol tetraethers (GDGTs) and alkenones) in coeval sediments will be used for sea surface temperature (SST) reconstructions to explore the temperature forcing of coral reefs development. By integrating microstructural, mineralogical, geochemical, and biomarker approaches across multiple sites, this research aims to elucidate why coral reefs thrived during the warm, high-pCO₂ conditions of the Miocene epoch.

Keywords: Coral reefs, Miocene, Coral, Coralline algae

【A0120】 -Poster

An interplay of land-sea development off southern South Africa since the last deglaciation

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Oceanic systems along the southern coast of South Africa have been proposed to be affected by various factors, while few studies about the paleoceanic conditions since the last deglaciation have been carried out in this region. In order to better understand paleoceanographic and paleoenvironmental changes and its driving mechanisms on the southern coast of South Africa, marine sediment core GeoB20628-1 offshore the southern Cape coast was investigated for organic-walled dinoflagellate cysts (dinocysts) in combination with multiproxy data from the same series of samples, including pollen and spores, microcharcoal, foraminiferal organic linings and appendage of crustaceans. The results emphasize significantly distinct depositional environmental changes driven by the interplay of marine transgression, fluvial input, upwelling intensity and its interactions with vegetation and climate changes in southernmost Africa since the last deglaciation (14 ka). Three dinocyst groups dominating in three different zones were distinguished based on statistical analysis. High representation of dinocysts produced by autotrophic taxa (Group 1) like *Operculodinium centrocarpum*, *Tuberculodinium vancampoe* and *Spiniferites* spp. indicates lagoonal environment during the last deglaciation with low sea level stand. During the transition from the last deglaciation to the Holocene, the maximum values of heterotrophic taxa (Group 2) like *Brigantedinium* spp., *Echinidinium* spp., *Protoperidinium monospinum* indicate fluvial nutrient input due to strong river discharge. Since the Holocene, the Group 2 was replaced by other heterotrophic taxa (Group 3) such as *Selenopemphix quanta*, *Echinidinium aculeatum* and *Echinidinium transparentum* indicating cool and nutrient-rich waters with active upwelling probably caused by strengthened tropical easterlies.

Keywords: Organic-walled dinoflagellate cysts, Paleoceanography, Land-Sea interactions, Last deglaciation, South Africa

【A0110】 -Poster

A transient simulation of vegetation dynamics from the last glacial maximum to present

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Understanding the mechanisms driving vegetation dynamics under past climate changes provides crucial insights for assessing ecosystem resilience to ongoing climate change. Here, we present results from a transient simulation of the ORCHIDEE terrestrial biosphere model, forced by bias-corrected TraCE-21K-II climate outputs, spanning the period from the Last Glacial Maximum (21 ka) to the present day. Our simulation reveals substantial deglacial forest expansion in the Northern Hemisphere, reaching its maximum extent around 8 ka, approximately 1 ka earlier than indicated by pollen-based reconstructions. The simulated tree cover closely tracks the changes in summer temperature, while less sensitive to winter temperature changes. We conducted factorial experiments to isolate the effects of different forcings (temperature, precipitation and CO₂ concentration) on the trajectories of vegetation dynamics, showing an important role of rising CO₂ in driving forest expansion and shifts in plant functional type (PFT) composition. Further, we employed the climate-change velocity methodology to compare forest cover velocities with climate velocities at decadal, centennial, and millennial scales, with a focus on periods with abrupt climate changes such as the Bølling–Allerød Interstadial and the Younger Dryas. The resulted patterns of forest cover velocities across space and through time provide implications for conservation in a world experiencing accelerated climate-change velocities.

Keywords: Vegetation dynamics, Process-based model, Climate change velocity, Deglacial forest expansion, Abrupt changes

【A0333】 -Oral

An over 500,000 years lacustrine core in the high-altitude lake Nam Co of the Tibet Plateau

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Located in the heart of the Tibetan Plateau, Nam Co is a closed lake spanning over 2,000 square kilometers and situated at an elevation exceeding 4,700 meters. The sediment thickness within the lake exceeds 700 meters, providing comprehensive insights into the climate and environmental conditions covering several glacial and interglacial cycles. With the support of the International Continental Scientific Drilling Program (ICDP) and China's Second Tibet Integrated Expedition Project (STEP), the NamCore drilling project aims to achieve: (1) Reconstructing the long-term climate change history across multiple glacial-interglacial stages and elucidating its relationship with global atmospheric circulation patterns; (2) Investigating the evolution and resilience of high-altitude terrestrial and lacustrine ecosystems under glacial and interglacial climate conditions; (3) Understanding the metabolic factors influencing lake sediment microbial communities in various glacial-interglacial environments; (4) Providing fundamental observation data on paleomagnetic changes to simulate the paleomagnetic field prior to the Holocene epoch. Depending on a stable and wind-resistant drilling barge manufactured in China, and a skilled drilling team as well as the long-term used drilling equipment provided by ICDP, the field campaign was successfully conducted from June 6 to July 17 of 2024, resulting in the retrieval of a total length of 950 meters of lake core. The deepest depth reached by the drill exceeded 510 meters. Based on seismic survey data, it is anticipated that the age of the lake core surpasses MIS 13 stage (approximately 550,000 yrs BP). Furthermore, the average resolution achieved is as high as 10 yrs cm⁻¹. A combination of multiple dating methods will be employed in order to establish a robust deposition time series. ¹⁴C will be utilized for sediments less than 50,000 yrs BP while OSL and post-IR IRSL method will be employed to date back approximately 200,000 yrs BP. For more older deposits, amino acid racemization (AAR), uranium/thorium ratio (U/Th), cosmic ray Beryllium isotope (¹⁰Be/⁹Be), as well as geomagnetic polarity analysis, thermochronology assessment and cyclic stratigraphy will be integrated to obtain reliable chronological sequences of cores. Proxies will be utilized to indicate climate and environmental changes, such as geochemical indicators, pollen, biomarkers, sedaDNA, environmental magnetic indicators, etc. for reconstructing paleo-temperature, precipitation, water level, vegetation, aquatic biodiversity and other changes in the lake basin. The relationship between these changes and atmospheric circulation changes and glacial activities in the lake basins will be also discussed.

Keywords: Lake core sediments, Tibetan Plateau, ICDP, Indian monsoon, Cycles



【A0136】 -Oral
Pronounced hydroclimatic variations at Rodderberg (Germany) during MIS 11

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A principal challenge for the future is to enhance our preparedness for extreme events such as droughts and floods, as well as the related socio-economic challenges posed by global warming. This will require a thorough understanding of past hydroclimatic feedbacks of terrestrial environmental systems on global ocean–atmospheric interactions. In this regard, palaeoclimatic reconstructions have long been employed to enhance comprehension of past climate variability and to develop more resilient climate predictions. However, there is still a requirement for high-resolution hydroclimatic data from continents and from periods without human interference in order to gain a profound comprehension of the complexities of past terrestrial environments. To address this scientific gap, we present a new hydroclimatic dataset with decadal temporal resolution from the silted-up volcanic crater basin of Rodderberg in the immediate vicinity of the city of Bonn, western Germany. The examined sediment sequence encompasses multiple glacial-interglacial cycles in superposition, which distinguish this record as a rare and promising environmental archive. This natural sink consistently retained sediments associated with lacustrine productivity and erosion in the catchment area.

The sediment succession from Rodderberg reveals lacustrine sediments during interglacial periods and loess derivatives during glacial periods, in addition to a Holocene luvisol at the top of the record. The challenging aspect of this project was establishing a robust chronology. We employed a combination of luminescence dating, well-known and dated volcanic ash layers, pollen biostratigraphy for interglacials and correlative age-depth modelling, with the objective to establish a reliable timescale for these sediments.

Based on multiproxy studies of lacustrine sediments, our investigation focuses on the oldest interglacial, which has been tentatively dated to 417-363 ka. This correlates to



marine isotope stage 11 (MIS 11), an interglacial, which is supposed to be comparable to the Holocene. Elemental data was obtained in 2 mm spatial resolution by XRF core scanning, supported by bulk geochemistry, magnetic susceptibility and grain size analyses and is interpreted as a response to hydroclimatic fluctuations. During periods of increased precipitation, runoff from the catchment increased, resulting in a higher transfer of allochthonous organic and minerogenic matter and nutrients to the lake. This caused an increase in lacustrine production, in phases even anoxic or meromictic conditions. In addition, and due to higher runoff, the lake level rose causing a dilution of carbonates in the water column. Consequently, there was a reduction in biochemical precipitation of calcite. In contrast, periods with less rainfall document less runoff, a lower trophic level with less lacustrine productivity and a lower lake level. In consequence, increased precipitation of calcite occurred.

The Rodderberg record provides evidence of three ca. 10,000 year-long periods with dominance of increased humidity. The first of which likely corresponds with the current interglacial period, the Holocene. In addition to this long-term periodicity of hydroclimatic variability, sub-millennial and sub-centennial variations are documented. Collectively, this database offers valuable insights into the environmental reactions and their biogeochemical responses triggered by hydroclimatic variability for Middle Pleistocene interglacial conditions.

Keywords: Hydroclimate, Interglacial, Sediments, Crater Lake, Geochemistry



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