IBS CONFERENCES 2024

IBS Conference on
Climate and Human Evolution

October 15-19, 2024

Auditorium, 2F, Mechanical Engineering Building(#303)
Pusan National University, Busan, Korea

Institute for Basic Science

IBS Center for Climate Physics

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PROGRAM

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10:40 - 11:00	**Mid-latitude surface temperature since the late Pleistocene through TEX86 paleothermometry** Daniel M. Cleary (IBS Center for Climate Physics)
11:00 - 11:20	**Investigation of biomarkers from Blombos Cave, South Africa and from Rabat-Temara Caves in Morocco: Insights into Middle Stone Age sites' regional palaeoclimate** Margit H. Simon (NORCE: Norwegian Research Centre)
11:20 - 11:40	**Nature and mechanisms of climate variability in southern Africa over the last 100,000 years inferred from regional high-resolution modelling** Ozan Mert Göktürk (NORCE Norwegian Research Centre AS)
11:40 - 13:00	**LUNCH**
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13:00 - 13:40	**U-Th and U-Pb dating to understand Plio-Pleistocene climate variability in the Southern Hemisphere and its impact on human evolution in South Africa** Rieneke Weij (Department of Geological Sciences, Human Evolution Research Institute, University of Cape Town)
13:40 - 14:00	**Aridification and faunal adaptations to East African Miocene uplift** Qiong Zhang (Stockholm University)
14:00 - 14:20	**Climate Models as Tools for Understanding Hominin History in Northern Germany: Insights from the Last Glacial Cycle** Deepak Kumar Chinnaswamy (Technical University of Braunschweig)
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10:30 - 10:50	**Extreme southward expansion of the Australian monsoon during the Last Glacial Period: implications for human settlement of the continent** Calla Gould-Whaley (University of Melbourne)
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DAY 3, October 17th

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14:50 - 15:30	**Dispersals of Homo sapiens across Asia: Northern and Southern Routes** Michael Petraglia (Australian Research Center for Human Evolution)
15:30 - 15:50	**Understanding the impact of climate and tectonic changes during the Neogene** Ramstein Gilles (LSCE / CEA / CNRS / UVSQ)
15:50 - 16:10	**modern Homo sapiens fossils in the Korean peninsula** Kim Hyun Jin (The Museum of Silhak, Gyeonggi Cultural Foundation)
16:10 - 16:30	**Repeated human occupation of the Nwya Devu Paleolithic site on the high-altitude central Tibetan Plateau during the past 45,000 years** Junyi Ge (Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences)
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11:10 - 11:30	**Modern Human Studies in North Korea** Hyeong Woo Lee (Jeonbuk National University, Korea)
11:30 - 12:10	**Assessing potential climatic drivers of human behavioural evolution on the South African coast** Simon Armitage (Centre for Early Sapiens Behaviour (SapienCE), University of Bergen, Norway)
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14:10 - 14:30	**Evidence of A Climate-Driven Human Genetic Bottleneck around 900ka** Shih-Wei Fang (IBS Center for Climate Physics)
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09:40 - 10:00	**Whole-genome analyses unveil a novel subspecies-level lineage of Korean troglophile harvestmen (Opiliones, Paranonychidae, Kaolinonychus coreanus)** Dongyoung Kim (Seoul National University)
10:00 - 10:20	**Whole genome sequencing of Greenland muskox (Ovibos moschatus) individuals using surface-deposited skeletal elements** Mijin Park (Seoul National University)
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11:30 - 11:50	**Drought as a catalyst for the Classic Mayan collapse from a climate modelling perspective** Qiong Zhang (Stockholm University)
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13:30 - 13:50	**Decoding Ritual Landscape, Transition and Continuity: Towards Ethnoarchaeological Study of the Palghar Region of Maharashtra With Special Reference to the Newly Discovered Geoglyphs of Saturli Village in Mokshada Block, District Palghar, Maharashtra** Tishyarakshita Nagarkar (Department of Anthropology)
13:50 - 14:10	**Vector-borne diseases in the Anthropocene** Ramstein Gilles (Research Director at LSCE Paris-Saclay)
14:10 - 14:30	**Multi-centennial oscillation of the Atlantic Meridional Overturning Circulation and the evolution of human civilization** Haijun Yang (Fudan University)
14:30 - 14:50	**Reduced mass loss from the Greenland ice sheet under stratospheric aerosol injection, and some general considerations about pros and cons of geoengineering techniques** Ralf Greve (Hokkaido University, Sapporo, Japan)
14:50 - 15:10	**CLOSING REMARKS** Axel Timmermann (IBS Center for Climate Physics)
15:10 - 18:00	**COLLABORATION CAFE**

SESSION 1
PALEO-CLIMATE CONTEXT

CHAIRS Rieneke Weij, Hubert Vonhof, Daniel Cleary, Margit H. Simon

SPEAKERS

Hubert Vonhof
Max Planck Institute for Chemistry

Daniel M. Cleary
IBS Center for Climate Physics

Margit H. Simon
NORCE: Norwegian Research Centre

Ozan Mert Göktürk
NORCE Norwegian Research Centre AS

Rieneke Weij
Department of Geological Sciences, Human Evolution Research Institute, University of Cape Town

Qiong Zhang
Stockholm University

Deepak Kumar Chinnaswamy
Technical University of Braunschweig

Ayako Abe-Ouchi
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Ricarda Winkelmann
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Alexander Bakhia
University of Helsinki

Calla Gould-Whaley
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Keynote Presentation

Speaker

Hubert Vonhof

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Abstract

Advances in quantitative climate reconstruction using speleothem records

Hubert Vonhof[1], Sam Nicholson[1], Julian Schroeder [1], Monika Markowska[1,2], Alfredo Martinez-Garcia[1], Elan Levy[3], Jasper Wassenburg[4], Nele Meckler[5], Yves Krueger[5]

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Already since the 1970's speleothems (e.g. stalagmites and stalactites) are under study as archives of climate change. Speleothems can be dated precisely, with U-series geochronology, and since they most commonly consist of calcite (CaCO3) there is a wide range of geochemical proxy data, often initially developed for marine carbonates, that can be applied to reconstruct climate change based on well-dated speleothems.

The most commonly used climate proxy data for speleothems are stable carbon and oxygen isotope ratios of the calcite. This can be complemented with trace element ratios of the calcite, and combined, these data yield valuable insights in changing temperature and/or hydrological conditions in the cave system. These techniques have been applied for decades now, and although the understanding of the climate parameters controlling these proxy data has improved significantly, it remains difficult to quantitatively address specific climate parameters, like temperature, or rainfall amount. The main obstacle is that these classical proxy systems are usually sensitive to changes in both temperature and hydrological parameters, and the relative contribution of these parameters is often difficult to disentangle.

In recent years, this situation is changing, because several new proxy systems have been developed for speleothem records, some of which are believed to solely represent temperature, while others are thought to represent hydrological parameters only. The application of these new proxy techniques has brought about significant advances in the quantification of paleoclimate change, as reconstructed from speleothem records. In this presentation I will show a number of case studies that demonstrate the potential of these new techniques, and where applicable, discuss the relevance of such paleoclimate records for our understanding of the relation between climate change and human evolution and dispersal.

Presentation

Speaker

Daniel M. Cleary

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Abstract

Mid-latitude surface temperature since the late Pleistocene through TEX86 paleothermometry

Daniel M. Cleary[1,2]*, Alfredo Martínez-García[3], Jasper A. Wassenburg[1,2], Kyoung-nam Jo[4], Axel Timmermann[1,2], Yves Krüger[5], Jens Fiebig[6], Nitesh Sinha[1,2], R. Lawrence Edwards[7], Mareike Schmitt[3], Hubert B. Vonhof[3]

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Orbital forcing systematically controls insolation and modifies Earth's climate and atmospheric CO2 concentrations during glacial/interglacial cycles. Our understanding of the associated response in surface temperature has been improved through incorporation of climate model simulations, many of which suggest an amplitude of ~6 °C in global surface temperature during glacial terminations.

However, a notable limitation is the necessity in relying on marine SST reconstructions to benchmark climate models as similar records do not exist for continents. This has largely been due to the absence of terrestrial temperature-proxy records that extend to the mid-Pleistocene. To address this issue, we applied TEX86 palaeothermometry to a 450 kyr composite speleothem record from multiple caves located on the Korean peninsula. After correcting for lapse rate between sites, the resulting temperatures agree well between speleothems and cave sites respectively, supporting the use of this method in quantifying mean annual surface warming/cooling. The resulting TEX86 temperatures suggest that models are underestimating the thermal amplitudes during peak glacial/interglacial conditions by ~2.5°C. In addition, anomalous warming events reoccurs during deglaciations. A comparison with a dust record from the north Pacific suggests that this may be explained by the absence of aerosols in climate models. Dust may have a more substantial influence on the surface heat budget as previously thought. This record represents the longest quantitative and radiometrically dated reconstruction of surface temperature and will provide new insights into past and future climate projections.

Presentation

Speaker

Margit H. Simon

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Abstract

Investigation of biomarkers from Blombos Cave, South Africa and from Rabat-Temara Caves in Morocco: Insights into Middle Stone Age sites' regional palaeoclimate

Margit H. Simon[1,2], Ozan Mert Göktürk[1,2], Willem van der Bilt[3], Pål Tore Mørkved[3], Stefan Sobolowski[4], William J. D`Andrea[5], Zhongshi Zhang[6], Simon J. Armitage[2,7], Christopher S. Henshilwood[2,8], Karen L. van Niekerk[2,9], Eystein Jansen[2,3], Zeljko Rezek[8], Jean-Jacques Hublin[8,9], Abdelouahed Ben-Ncer[10]; Abdeljalil Bouzouggar[10,11], Ismail Ziani[12,13]

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Linking human technological and behavioural advances to environmental changes is challenging, as it requires a robust understanding of past climate at local scales. In addition, attempts of high-resolution cross-African study often have been hindered due to the incompatibility of regional sampling protocols and the produced data. Here, we will present results from climate data (90 ±5 ka BP-68 ±5.4ka BP) directly from the archaeological Middle Stone Age sequences of Blombos Cave (BBC) in South Africa and Contrebandiers Cave and the cave of Dar Es-Soltan 2 in Rabat-Temara region of Morocco. The climate data from BCC is compared to regional high-resolution numerical simulations which cover two distinct periods centred at 82 and 70 thousand years (ka) ago (Marine Isotope Stage [MIS] 5 and the onset of MIS 4, respectively). The hydrogen isotopic composition of leaf waxes (δ2Hwax) and n-alkane distributions and abundances are used to reconstruct hydroclimate near BBC. The leaf wax n-alkane record, one of the first produced in an archaeological setting in this region to date, can be interpreted as a drying signal from MIS 5c to 4. This agrees with our modelling results, which indicate a drier and more continental climate over coastal southern Africa at 70 ka, compared to 82 ka. The simulated aridification is most evident from the reduced precipitation amounts in both summer (~20%) and winter (~30%). The annual number of summer days (Tmax ≥ 25 °C) and cold nights (Tmin < 5 °C) in the vicinity of BBC increases more than 5 and 3-fold, respectively, under the more continental climate at 70 ka. Weaker westerly winds in winter, a cooler Agulhas Current, and a land surface expansion associated with the coastline shift due to lower sea levels at 70 ka all contribute to the simulated climate shift.

At the opposite end of the continent, in the last six decades, archaeological excavations in the Rabat-Temara region of Morocco have yielded a substantial number of human fossils from Middle, Later Stone Age and Neolithic layers. This specific coastal area, spanning just 10 km along the Atlantic, stands out as one of the most abundant sources of H. sapiens specimens, encompassing both early and late forms, as well as one of the richest records of human cultural evolution during the MSA. Similar to the South African record the North African one exhibits a marked increase in sites and higher find densities, particularly during MIS 5. These similarities among regions may be the result of behavioural adaptations to comparable environments and commensurable demographic factors.

However, the environmental background behind the accumulation of these deposits remains an open scientific question because we lack comparable climate datasets and approaches that allow evaluating how material culture and climate co-evolved on a site-specific levelIn this presentation, we will show the pilot data derived from these two caves to reconstruct past vegetation, climate conditions, and ecological changes based on long chain n-alkanes & fatty acids δ2Hwax and δ13Cwax.

Presentation

Speaker

Ozan Mert Göktürk

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Abstract

Nature and mechanisms of climate variability in southern Africa over the last 100,000 years inferred from regional high-resolution modelling

Ozan Mert Göktürk[1,2], Stefan Sobolowski[3], Zhongshi Zhang[4,2], Margit H. Simon[1,2], Eystein Jansen[5,2]

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We present results from regional high-resolution paleoclimate simulations performed for the period between 100-50 thousand years (ka) before present, over southern Africa - a hotspot for human evolution. The Weather Research and Forecasting (WRF) model was used to dynamically downscale output from the global Norwegian Earth System Model (NorESM), from ~ 300 km to 12 km. 30-year long simulations were conducted at 93, 82, 70 and 63 ka, using two different coastline positions at each epoch. This enabled us to decipher millennial-scale climate variations in the region arising from large-scale and local forcing factors, such as orbital variations and sea-level controlled land extent. Our results indicate that the epochal changes in climate over southern Africa during the last glacial era had different imprints on inland and coastal areas. For instance, the climate of the Blombos Cave location, where a well-studied archaeological site resides, is most sensitive to changes in coastline position and land extent, in contrast to inland areas where orbital forcing dominates. Our results have significant implications for possible climate change impacts on the settlement patterns and behavioral evolution of early modern humans in southern Africa.

Keynote Presentation

Speaker

Rieneke Weij

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Abstract

U-Th and U-Pb dating to understand Plio-Pleistocene climate variability in the Southern Hemisphere and its impact on human evolution in South Africa

Rieneke Weij[1,2], Georgina Luti[1,2], Tara Edwards[1,2], Nokuthula Ubisi[1,2], Hubert Vonhof[3], Robyn Pickering[1,2]

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Precise and accurate chronology is paramount to understanding past climate change and human evolution. Speleothems form the “golden standard” among palaeoclimatic archives due to their suitability for U-Th and U-Pb dating technique. Here we reflect on developments in U-Th and U-Pb dating over the last decade. We present two examples from important fossil sites in South Africa and Australia, where speleothems are ubiquitous features and represent significantly wetter conditions in the past.

Contrary to expectations, peaks in southern Australian climatic moisture availability were largely confined to glacial periods during the past 350 ka, including the Last Glacial Maximum, whereas warm interglacials were relatively dry. A cool-moist response is consistent across the austral subtropics and, in part, may result from reduced evaporation under cool glacial temperatures. Insofar as cold glacial environments in the Southern Hemisphere subtropics have been portrayed as uniformly arid, these findings suggest that their characterization as evolutionary or physiological obstacles to movement and expansion of animal, plant and, potentially, human populations should be reconsidered.

In South Africa, the Cradle of Humankind hosts some of the oldest hominid fossil remains. Climatic and environmental change played a pivotal role in the adaptation and diversification of our early prehuman relatives. Previous work[1] has provided robust chronology for the Cradle, however, two important Paranthropus robustus fossiliferous sites, Kromdraai and Gondolin, are yet to be dated and the past climatic conditions in the Cradle remain poorly understood. Current research addresses these two gaps to test and expand on Pickering et al. (2019), by U-Th and U-Pb dating flowstone layers from Kromdraai, Gondolin and Motsetse. We are exploring rapid lower resolution in situ laser ablation U-Pb dating to compliment the more precise but laborious solution work. Laser ablation analysis has the potential to date smaller cm-scaled domains within otherwise undatable flowstones, making it an attractive option. Furthermore, we present the first quantitative multi-proxy study of speleothems from the Cradle to reconstruct changes in palaeotemperatures and rainfall in South Africa during the last 3 Ma, through analyses of fluid inclusions stable isotopes (δ2H and δ18O) and biological proxies (TEX86) of U-Th- and U-Pb-dated flowstones, shedding important light on past climate variability and its influence on human evolution in South Africa.

[1] *Pickering, R., Herries, A. I., Woodhead, J. D., Hellstrom, J. C., Green, H. E., Paul, B., Ritzman, T., Strait, D. S., Schoville, B. J. & Hancox, P. J. (2019). U–Pb-dated flowstones restrict South African early hominin record to dry climate phases. Nature, 565(7738), 226-229*

Presentation

Speaker

Qiong Zhang

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Abstract

Aridification and faunal adaptations to East African Miocene uplift

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Hominid evolution in Late Miocene is linked to a transition from forested ecosystems to grasslands in Central and East Africa. This ecological shift has been attributed to a major reorganisation of the African hydroclimate during the Miocene. A pivotal factor in this transition is the uplift of the East African Dome, particularly the Ethiopian Highlands, which played a crucial role in altering the regional climate. This would have been a catalyzing factor in the shift towards a grassland-dominated landscape and the aridification of East Africa. While several studies have acknowledged this connection, the detailed temporal evolution of the climate in response to the uplift remains largely unclear. To address this knowledge gap, we use the Earth System Model EC-Earth3 to simulate the Miocene at key time slices (5, 15 and 25 Ma). To capture and explain the climatic effects of the East African uplift, we modify the topographic boundary conditions for the region according to data derived from geophysical modelling. The changed topography leads to a redistribution of precipitation, especially in the 15 and 25 Ma time slices. Our findings indicate that lower elevations in East Africa significantly reduce orographic precipitation, leading to a drier interior of the African continent. Moreover, by elevating pCO2 to Early Miocene levels, our model successfully simulated a forest-covered African landscape as suggested by proxy records. Interestingly, our simulations consistently depict a green East Africa until the Late Miocene, indicating that the uplift of East Africa was a major driver of the region's aridification. We found that a lower topography in East African not only alters regional atmospheric dynamics but also impacts the Arabian Sea, including a weakening of the Hadley Cell over Africa. We further find that topography is a key factor impacting precipitation distribution across Africa, with CO2 changes amplifying this effect. However, the emergence of grasslands cannot be attributed to topographic changes alone, it also requires increased levels of pCO2. Studies of faunal adaptations and change in the Miocene of Africa have largely been site-specfic, i.e., focusing on local environmental conditions. Therefore, broader conclusions linking faunal change to uplift-induced environmental changes are challenging to establish. However, recent studies highlight a shift in faunal composition, particularly among Carnivora (more open habitat forms) and Bovidae (more grazers), between the Kenyan sites of Maboko (ca. 14.8 Ma) and Fort Ternan (13.7 Ma), which coincides with the mid-Miocene Climatic Transition and the onset of climate change just at the time when uplift-mediated climate change had begun to take effect.

Presentation

Speaker

Deepak Kumar Chinnaswamy

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Abstract

Climate Models as Tools for Understanding Hominin History in Northern Germany: Insights from the Last Glacial Cycle

Deepak Kumar Chinnaswamy[1], Antje Schwalb[1], Thomas Terberger[2], Sebastian Wagner[3]

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Climate models are fundamental in shaping the narratives of the future impacts of humans on climate but their potential to illuminate the impact of past climate on humans is a question that still needs to be further investigated. This study explores the possibilities and limitations of using climate models in a paleoclimatic context to understand the environmental background conditions of Hominins, particularly Neanderthals, in Northern Germany.

Temperature and precipitation are pivotal variables in shaping the climate niche of Neanderthals. In more detailed approaches the specifications of these variables go more specific, for example temperature of the warmest month. These climatic constraints consider both archaeological and environmental limitations. Mostly, empirical paleoclimate reconstructions are used for this purpose, and sometimes they are complemented by climate models.

Generally, Intermediate Complexity Models, or lower hierarchy models, are used for comparison with archaeological studies. These models offer faster simulations and integrate components such as the biosphere, but they lack the horizontal resolution and more comprehensive climate processes included within Earth System Models (ESMs). Although ESMs provide more realistic output, they are computationally expensive for long-term simulations. Further, high-resolution simulations of Regional Climate Models have been used for identifying potential niche space of humans in the past. However, most studies rely on a single climate model, which can introduce significant biases, especially in the context of comparing models with empirical reconstructions.

In this study, we utilize six CMIP6 models to examine climatic patterns over Europe during critical periods of the Last Glacial Cycle: the Last Interglacial (LIG), a favorable period for Neanderthals, and the Last Glacial Maximum (LGM), a period representing the harshest conditions humans endured. The models show good agreement in terms of mean climate but show higher spread during seasons characterized by high atmospheric variability, i.e. northern hemispheric winters during the LGM. Discrepancies are specifically pronounced for sea surface temperatures in the North Atlantic. The LIG climate shows a larger thermal range in monthly climatology, with precipitation levels over Europe comparable to the pre-industrial period. At the same time during the LGM, the temperature range was high, still, the monthly mean temperatures were subzero for half of the year with a similar amount of precipitation over Europe. While catabatic winds, along with decreased incoming shortwave radiation because of changes in orbital forcing, kept inland Europe colder during the LGM, it was warmer as a result of land heating during the LIG summers. However, Iberia and parts of western

Europe show less pronounced climatic changes, most likely influenced by the North Atlantic Ocean. Further, the CMIP6 models considered also agree well with the modes of winter atmospheric variability related to North Atlantic Oscillation (NAO) dynamics, while during summer the models show a considerable spread in this respect. LGM has comparatively stronger NAO with pressure centers migrated to the north. However, the influence of NAO on surface temperature is stronger during the warm periods.

Roughly, all models show warming (cooling) in northern and northwestern (southern) Europe during positive NAO but the spatial patterns are different. Concerning the comparison with empirical evidence, the results indicate that although the mean climate is well presented on a larger scale, specific regional details and the representation of atmosphere and ocean-atmosphere teleconnections still shows a considerable spread among models investigated. Therefore, getting into specific aspects and considering a single model might not take into account the full bandwidth of potential climatic background conditions simulated by climate models. Future work will include simulations of Heinrich events to expand analysis and concentrating on abrupt climatic events.

This study highlights the paleoclimate needs of archaeological and environmental research and explores the methodologies used as well as potential future applications of climate models in understanding human evolution.

Presentation

Speaker

Ayako Abe-Ouchi

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Abstract

Modelling abrupt climate changes during ice age cycle

Ayako Abe-Ouchi, Wing-Le Chan, Yuta Kuniyoshi, Takashi Obase, Sam Sherriff-Tadano and Ryouta O'ishi

University of Tokyo, JAMSTEC, and Ryukyu University

Glacial periods were punctuated by abrupt millennial scale climate changes, which could have influenced the human activity. Although glacial abrupt climate changes were shown to have a strong link to the Atlantic Meridional overturning circulation (AMOC) changes and the glacial background climate, simulating the millennial change of AMOC and climate with fully coupled ocean-atmosphere GCM have been challenging. Here we present several 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 Heinrich stadial experiments by adding anomalous freshwater flux in the North Atlantic at the end of each stadial to investigate the Heinrich events in the model. 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. In regions far from North Atlantic, such as Asia, tropics and Southern Hemisphere, clearer climatic contrast of stadials and interstadials are shown when the interval between the abrupt events becomes longer or when freshwater perturbation are given. We like to have furthur discussion on the relation between human and climate related to Dansgaard Oeschger events and Heinrich stadials in the meeting.

Keynote Presentation

Speaker

Ricarda Winkelmann

Max Planck Institute of Geoanthropology

Abstract

The long-term legacy of short-term climate (in)action

Ricarda Winkelmann

Max Planck Institute of Geoanthropology

We are living through a time of profound transitions, in which the accelerating dynamics of global ecological disruption are becoming ever more perceptible, providing evidence that the powers of industrialized humanity have persistent and, at times, irreversible effects of planetary significance. Changes in the Earth system due to anthropogenic influences are observed in every region and across the whole planet – and many of the changes observed in the climate are unprecedented in thousands, if not hundreds of thousands of years (IPCC-AR6). While most climate policy debate focuses on projections until the end of this century, inertia and potential tipping dynamics mean that, in the coming decades, changes in certain Earth system components – such as the ice sheets on Greenland and Antarctica – may be triggered, which then unfold on much longer timescales. This talk takes a closer look at these committed impacts of climate change and the underlying dynamics, in particular in the polar regions.

Presentation

Speaker

Zhongshi Zhang

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Abstract

Atmospheric and oceanic circulation altered by global mean sea-level rise

Zhongshi Zhang, Eystein Jansen, Stefan Pieter Sobolowski, Odd Helge Otterå, Gilles Ramstein, Chuncheng Guo, Aleksi Nummelin, Mats Bentsen, Caoyi Dong, Xijin Wang, Huijun Wang and Zhengtang Guo

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

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

Over recent decades, the rate of global mean sea-level rise has increased, although the magnitude—tens of centimetres—remains small from a geological perspective. Such a modest rise in sea level presents a challenge when attempting to assess its global climate impacts, as the signal is weak.

However, in previous warmer geological periods, sea levels reached up to tens of metres higher than the present levels. These palaeoclimate periods offer a unique opportunity to investigate the climate effects of higher sea levels. Here, using climate simulations of the Last Interglacial period and a set of present-day sea-level sensitivity experiments, we highlight the importance of global mean sea-level rise in modulating global climate. The lowering of terrestrial elevation and deepening of oceanic bathymetry due to a spatially uniform rise in sea level reorganizes atmospheric and oceanic circulations. Our simulations of the Last Interglacial show that considering this aspect of global mean sea-level rise in isolation from changes associated with land–sea masks or freshwater input reduces the long-lasting model–data mismatch in the Southern Hemisphere. Furthermore, the present-day sensitivity experiments demonstrate that a slight increase in global mean sea level causes substantial adjustments in the global climate, particularly at mid–high latitudes.

Presentation

Speaker

Ning Tan

Institute of Geology and Geophysics, Chinese Academy of Sciences
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Abstract

Closure of tropical seaways favors the climate and vegetation in tropical Africa and South America approaching their present conditions

Ning Tan, Huan Li, Zhongshi Zhang et al.

Key Laboratory of Cenozoic Geology and Environment, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China; School of Geographic Science, Nantong University, Tongjingdadao 999, Nantong 226007, China; Department of Atmospheric Science, School of Environmental Studies, China University of Geosciences, Wuhan 430074, China

The closure/narrowing of the Central American Seaway (CAS) and the Indonesian Seaway (Indo) are considered to be important factors that influenced climate during the Pliocene and have been intensively studied. Tropical climate and vegetation also changed significantly during this period, especially in the East African region. The closure/ narrowing of the CAS and Indo can undoubtedly affect climate in trop-ical regions, but there are still too few studies based on AOGCMs that discuss the potential impact of changes to tropical seaways on environmental changes in tropical Africa and South America. In this work, we systematically investigate the effects of tropical seaways' closure/ narrowing on climate and vegetation over these two regions. Our results show that closure of the CAS leads mainly to aridification and savanna expansion in northeastern Brazil. Narrowing of the Indo leads mainly to increased aridification and shrinkage of tropical forests over tropical East Africa.

These results show good agreement with both reconstructed SST values over the Indian Ocean and pollen records in the East African region. Our study highlights the importance of the changes of the tropical seaways in altering the tropical environment and shaping it to be closer to modern conditions.

Keynote Presentation

Speaker

Phil Glauberman

The Catalan Institute of Human Paleoecology and Social Evolution (IPHES), Spain
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Abstract

Early Human Crossroads: Late Pleistocene hominin interaction zones and current research in the Armenian Highlands

Phil Glauberman

Universitat Rovira i Virgili, the Catalan Institute of Human Paleoecology and Social Evolution (IPHES), Tarragona, Spain; Institute of Archaeology and Ethnography, National Academy of Sciences, Republic of Armenia, Yerevan, Armenia; Department of Early Prehistory and Quaternary Ecology, Tübingen, Germany

The Late Pleistocene (MIS 5 – 2 or ~129 – 11 ka) is a crucial period in human evolution that witnessed the disappearance of Neanderthals and Denisovans from the Eurasian fossil record, and the emergence of H. sapiens as the only hominin species on the planet. These hominin groups interacted at different times in different places, such that humans today retain archaic hominin DNA. However, the timing, locations, and environmental conditions that supported these interactions are largely unknown, aside from archaeological, genetic, and paleoenvironmental evidence from a few regions of Eurasia. Brief review of known Late Pleistocene hominin interaction zones in the Levant and Siberian Altai provides a basis from which to examine emergent evidence and ongoing research in the Armenian Highlands, another potential interaction zone. This biodiversity hotspot is situated at the nexus of the Near East and the rest of Eurasia. It is a key region for the study of Pleistocene hominin population dynamics not least due to its geographic location, the mountainous area also encompasses toolstone-rich volcanic and sedimentary areas, several micro-biomes, and was likely a paraglacial refugium. Middle Paleolithic (MP) sites date mainly to MIS 4 – 3 or ~ 60 – 30 ka. The Upper Paleolithic, commonly associated with H. sapiens, first appears in the Armenian Highlands at ~ 39 ka, suggesting chronological overlap of the two technological industries. Hominin fossils are rare and have uncertain stratigraphic contexts. It therefore remains unknown which members of the Late Pleistocene hominin metapopulation authored the MP in the Armenian Highlands. In collaboration with the ICCP, ongoing paleoenvironmental research is collecting new speleothem data from three karstic caves. Preliminary results suggest excellent preservation of Middle and Late Pleistocene speleothem deposits. This pioneering research aims to provide well-dated, highly detailed terrestrial environmental records for the Middle–Late Pleistocene in the region. Current archaeological research in the Armenian Highlands seeks to document the duration and authorship of the MP, test whether the region was a paraglacial refugium for hominins, and document whether Neanderthals and H. sapiens may have co-occupied the region.

Presentation

Speaker

Alexander Bakhia

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Abstract

Rethinking Out-of-Africa I: Ecometric Insights From Dmanisi Herbivores Challenge Prevailing Grassland Hypotheses

Bakhia, Alexander; Tallavaara, Miikka; Saarinen, Juha; Parker, Abigail K.; Bukhsianidze, Maia; Margvelashvili, Ani; Lordkipanidze, David

Department of Geosciences and Geography, University of Helsinki (AB, MT, JS); Department of Computer Science, University of Helsinki (AP); Georgian National Museum, Tbilisi, Georgia (MB, AM, DL)

One of the key discussions regarding the dispersal of hominins out of Africa during the Early Pleistocene has centered on the environmental conditions which the species dispersed into. Some researchers synchronize this dispersal with the expansion of grasslands, placing hominins within the narrow savanna-grassland niche. Conversely, others emphasize the adaptability of hominins to varied, diverse environments as the main reason behind Out-of-Africa I-event. To test these conflicting hypotheses, reconstructing the paleoenvironments at early Eurasia hominin sites such as Dmanisi is required.

Here we explore the ecometrics, paleodiets and average body mass of the Early Pleistocene (c. 1.8 Ma) herbivore community in Dmanisi. These are crucial for understanding the prevalent biome coinciding with hominin presence at the site. Firstly, we present estimates of precipitation, and primary productivity in Dmanisi based on dental ecometrics. Secondly, we use dental mesowear analysis to identify the dietary categories among the fossil taxa, which reflect the vegetation herbivores primarily interacted with. Additionally, regression equations based on dimensions of post-cranial bones were used to estimate the body mass of fossil specimens. A mean body mass value of all ungulates in Dmanisi was then compared with mean body mass values from other Pleistocene localities and correlated with locality-specific net primary productivity values, to see how the mean body mass value in Dmanisi compares to the prediction based on primary productivity.

Ecometric analyses reveal that Dmanisi's early Pleistocene environment was substantially drier and demanding than today, with a mean annual precipitation (MAP) of approximately 536 mm/year— significantly lower than the modern average of 700 mm/year— and a net primary productivity (NPP) of 730. The local herbivore community predominantly consisted of mixed feeders and browsers, as indicated by dental mesowear results, with little evidence supporting a grass-dominated diet.

Additionally, smaller body sizes among the ungulates point to scarce resource availability, likely due to low net primary productivity and heightened intraspecific competition. These results not only challenge the notion that grassland expansion was the primary catalyst for hominin dispersal, but also provide evidence for the adaptability of hominin species to diverse habitats.

Presentation

Speaker

Calla Gould-Whaley

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Abstract

Extreme southward expansion of the Australian monsoon during the Last Glacial Period: implications for human settlement of the continent

Calla Gould-Whaley[1], Prof. Russell Drysdale[1], Dr Pauline Treble[2,3], Dr Jan-Hendrik May[1], Dr John Hellstrom[1]

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[2] *Australian Nuclear Science and Technology Organisation*
[3] *University of New South Wales*

Central Australia is currently characterised by extreme aridity. The assumption that the region was also dry (or even drier) during the Last Glacial Period underpins the premise that humans, upon arrival to Australia ~ 65 kyr, most likely reached the southern part of the continent via coastal routes.

Archaeological data and demographic modelling suggest that people may have taken an inland route, whilst recent evidence reveals that glacials in the Australian subtropics were times of higher water balance compared to interglacials. A cave in the Ikara-Flinders Ranges (South Australia) contains speleothems that shed light on the palaeohydrology of Australia's southern arid margin through the Last Glacial Period. The timing of speleothem growth phases reveals three multi-millennial periods of high regional water balance, each aligning with Southern Hemisphere summer insolation maxima.

This suggests that moisture delivery to the region was governed by the Indo-Australian Summer Monsoon, with the implication that all of central Australia would also have been receiving tropical rainfall, creating a potentially continuous pathway of perennial water reservoirs, and thriving ecosystems. A period of especially high moisture availability occurred at the time of Heinrich Event 5, which also coincides with the earliest evidence of human presence in the Ikara-Flinders Ranges.

Keynote Presentation

Speaker

Chuan-Chou (River) Shen

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Abstract

Utilizing U-Th dating techniques for paleoclimate and anthropological studies

Chuan-Chou SHEN

Department of Geosciences, National Taiwan University

Absolute U-Th dating is a radiometric method and has been widely applied across various fields of Earth and anthropological sciences, including paleoclimate, paleoceanography, human evolution and migration, ancient civilizations, and the dating of ruins and antiques. It can be used to determine geological sample formation age by analyzing the ratios of daughter isotope (230Th) to parent isotopes (238U and 234U) and also 230Th/232Th and 232Th/238U ratios. It is the most complex dating system due to the involvement of four unstable isotopes. The accuracy and precision of this chronology relies on the analytical precision of isotopic ratios and the uncertainty of initial 230Th incorporated into the sample. For most commonly used samples of limestone, rare quantity amounts of 238U presents from 10-8 to 10-6 g/g, trace amounts of 234U ranging from 10-12 to 10-10 g/g, and extremely trace amounts of 230Th ranging from 10-18 to 10-14 g/g. Moreover, throughout the entire experimental process, the containers and chemicals contain these isotopes, leading to unavoidable experimental contamination. Thus, it is difficult to accurately and precisely analyze these isotope ratios and obtain reliable age. U-Th dating approaches can employ a solution-based protocol involving isolation of U and Th from dissolved samples using ion-exchange chromatography and measured using either thermal ionization mass spectrometry (TIMS) or multi collector-inductively coupled plasma mass spectrometry (MC-ICPMS). These techniques can cover a range from several years to six hundred thousand years (Shen et al., 2012, Geochimica et Cosmochimica Acta; Cheng et al., 2013, Earth and Planetary Science Letters). We have developed new MC-ICPMS techniques to achieve a 2-sigma precision of ±0.08-0.10‰ for 234U/238U ratio. This newly-developed method can extend the dateable range up to eight hundred thousand years. Direct U-Th dating approach by laser ablation-inductively coupled plasma mass spectrometric (LA-ICPMS) techniques offers advantages of rapid, in-situ, and high spatial resolution analysis. Subsampling points are as small as tens of micrometers (μm), where tiny ablated particles are directly measured without the need for chemical processing. However, its low sensitivity, poor performance, and large errors greatly limit the chronological applications. Skeletal remains can potentially be directly dated using solution-based MC-ICPMS or LA-ICPMS techniques to determine a modeled age, which is considered the minimum formation age. Different modern U-Th dating techniques will be discussed in this presentation.

Memo

IBS Conference on

Climate and Human Evolution

October 15-19, 2024
Pusan National University
Busan, Korea

Institute for Basic Science

IBS Center for Climate Physics

SESSION 2

MODELLING HUMANS AND OTHER MAMMALS

CHAIRS Thushara Venugopal, Jiaoyang Ruan

SPEAKERS

Pasquale Raia
University of Naples Federico II

Dan Zhu
Peking University

Miikka Tallavaara
University of Helsinki

Thushara Venugopal
IBS Center for Climate Physics

Christoph P. E. Zollikofer
Dept. of Informatics, University of Zurich, Zurich, Switzerland

Aneesh Sundaresan
IBS Center for Climate Physics

Yaping Shao
Institute for Geophysics and Meteorology, University of Cologne

Keynote Presentation

Speaker

Pasquale Raia

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Abstract

The phylogenetic dimension of human evolution

Pasquale Raia, Alessandro Mondanaro, Silvia Castiglione, Marina Melchionna, Giorgia Girardi, Carmela Serio

University of Naples Federico II

Ever since the introduction of independent contrasts, phylogenetic methods have become the main tool to study phenotypic evolution and diversification. Although current anthropology is now commonplace for phylogenetic methods application, the field still lags behind. The paucity of species and hotly debated phylogenetic reconstructions have most probably slowed down the full use of phylogenetic compartive methods in athropology. And yet, the methods can, and in fact do, tell a lot regards to fundamental aspects of human evolution, such as how human species ecological niches evolved, how the cultural niche did, and last but not the least, how climate likely wiped out most of our ancestors by changing rapidly.

Presentation

Speaker

Dan Zhu

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Abstract

Spatiotemporal relationships between human population and climate during the last glacial period in China

Zinan Lin, Dan Zhu, Jiayi Zhou, Eric Galbraith

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Department of Earth and Planetary Sciences, McGill University, Montreal, Quebec, Canada

Climate variations during the last glacial period had major impacts on plant and animal populations including humans. Yet, relationships between human population levels and climate through time and across space remain elusive. Here, we used the archaeological radiocarbon dates spanning 50 to 10 ka BP in China to indicate fluctuations in human population sizes, and investigated their correlations with climate variables from paleoclimate proxies and climate model outputs using a Bayesian radiocarbon-dated event count (REC) statistical model. We find that temperature has a significant positive effect on population in China during 50 – 10 ka, while the sensitivity of population size to temperature exhibits a declining trend over time, suggesting a potential gradual adaptation to cold climates. We further used a global ecosystem model that explicitly simulates human population dynamics, the ORCHIDEE-FOEGE model, to reconstruct human densities during the LGM, and investigated the roles of climate and atmospheric CO2 levels in shaping the distribution of human populations in China.

Keynote Presentation

Speaker

Miikka Tallavaara

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Abstract

Modelling climate-driven human population dynamics in Africa over the past 400 kilo years

Miikka Tallavaara, Jani Anttila, Edward Armstrong, Paul Valdes

University of Helsinki, Natural Resources Institute Finland, University of Helsinki, University of Bristol

Population dynamics are among the main parameters governing the biological and cultural evolution of humans. Therefore, there is a need for demographic models to understand human population diversification, size, and range changes. A useful tool to complement archaeological and genetic approaches for gaining insights into past population dynamics is provided by computer simulations that combine population growth processes and spatial spreading processes using equation-based or agent-based modeling approaches.

Here, we extend existing equation-based modeling approaches by constraining the model's carrying capacity parameter with information on how climate and other environmental variables influence human hunter-gatherer population densities based on ethnographic data. We assume that the effect of environmental factors on hunter-gatherer density has remained relatively stable through time.

Using this assumption, combined with paleoclimate data from the HadCM3BB-v1.0 climate model, we simulate continental human population dynamics in Africa over the past 400,000 years.

We explore the recent hypothesis that Homo sapiens evolved in a geographically structured African-wide metapopulation, where different subpopulations were variably interconnected, with the strength of these connections determined by climate changes affecting the suitability of different regions. The simulation results in a dynamic climate-driven spatial population configuration that resembles a spatially structured metapopulation, thus supporting the African metapopulation model of H. sapiens origins as a potential explanation for the evolution of our species in Africa. We also analyze potential changes in the strength and direction of population flow between different core areas in Africa and perform sensitivity experiments to explore the effects of different assumptions, such as the importance of coastal areas for human populations.

Presentation

Speaker

Thushara Venugopal

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Abstract

A global dynamical model of terrestrial mammals

Thushara Venugopal[1,2], Axel Timmermann[1,2], Pasquale Raia[3], Silvia Castiglione[3] and Giorgia Girardi[3]

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[3] *DiSTAR, University of Napoli Federico II, Monte Sant'Angelo, Naples, Italy*

The last glacial period brought about a massive extinction of terrestrial megafauna, which affected more than 50% of all mammal species worldwide. Whether the rapid decline of megafauna was caused by human overkill or worsening climatic conditions, or both, is still an unresolved question. Here we present a new spatially explicit dynamical model for more than 2000 terrestrial mammal species, which simulates climate-induced changes in habitat suitability and biomass density, incorporating species dispersion, interspecific competition, and predator-prey interactions as a function of time and across the globe. Forced with realistic climate data, the model simulates well the observed global distribution of mammal biomass and species richness. During glacial periods, the model exhibits a marked decrease in the megafaunal population biomass, leading to global shifts in biodiversity patterns and predator-prey relations. The simulated climate-ecological interactions can be linked to the extinction of iconic species, such as mastodons, mammoths, toxodons, smilodons and other megafaunal populations in the past.

Keynote Presentation

Speaker

Christoph P. E. Zollikofer

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Abstract

Predicting the past: potential and limitations of modeling ancient humans

Christoph P. E. Zollikofer, Marcia S. Ponce de León

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Like any other evolutionary process, human evolution cannot be predicted. Nevertheless, there is great interest in understanding what factors have influenced our past evolutionary trajectory.

Hypotheses about these factors range from changes in human biology and behavior to changes in ecosystems and climate. These hypotheses cannot be tested experimentally, but computational modeling allows for "virtual experiments" to explore a wide range of evolutionary scenarios and compare them with real-world data on human evolution. In this talk, we review current modeling approaches and discuss their potential and limitations. Specifically, we ask how short-term, small-scale processes at the individual level interacted with long-term, large-scale environmental processes to influence African and Eurasian hominin population dynamics during the Late Pleistocene.

Presentation

Speaker

Aneesh Sundaresan

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Abstract

Climate effects on human genetic diversity over Africa

Aneesh Sundaresan, Axel Timmermann

Center for Climate Physics, Institute for Basic Science (IBS), Busan, Republic of Korea, 46241 Pusan National University, Busan, Republic of Korea, 46241

Climate played a pivotal role in past human migration and in creating the complex human genetic diversity over the African continent. This study investigates the impact of the past climate shift on human dispersal and genetic diversity by using the realistic climate-forced agent-based model (ABM) in combination with the bioinformatics tool, BEAST (Bayesian Evolutionary Analysis by Sampling Trees). We conducted an ensemble of forward simulations (with Climate change) covering the past 200,000 years with the ABM, by releasing agents to the eastern part of Africa. The ABM simulations show that glacial/interglacial climate swings caused periodic changes in the total African human population and geographic shifts in the main populated areas. Also, all the ensemble members simulated a gradual increase in the genetic distance from the beginning of the simulation. To find the influence of climate change on human genetic diversity, we conducted another set of ABM simulations for 200,000 years, by fixing the NPP and habitat suitability at a particular time (fixed climate). The 'fixed climate' experiments simulated nearly a constant population size after the initial rise in the population, and the peak population size depends on the NPP and habitat suitability. A phylogenetic analysis using the BEAST program is conducted with 200 randomly selected people, every 4000 years, for all the ensemble members. The maximum clade credibility (MCC) tree, number of coalescence events and the effective population size estimated from the BEAST simulations, corresponding to the two sets of ABM simulations show significant differences. This highlights the role of climate shifts in human evolutionary process and in contributing to the complex human genetic diversity in Africa.

Keynote Presentation

Speaker

Yaping Shao

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Abstract

Reconstruction of Middle to Upper Paleolithic Population Transition in Iberia using Our Way Model

Yaping Shao, Christian Wegener, Konstantin Klein, Gerd-Christian Weniger

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The Iberian Peninsula is of particular interest for the Neanderthal (NEA) to anatomically modern human (AMH) population transition. The AMHs arrived in Iberia last from eastern Europe and thus any possible contacts between the two populations occurred here later than elsewhere. The transition process took place in the earlier part of the Marine Isotope Stage 3 (~ 60-27 ka Cal BP) as repeated and profound climate changes challenged the population stability. To investigate how climate change and population interactions influenced the transition, we combine climate data with archaeological-site data to reconstruct the Human Existence Potential, a measure of the probability of human existence, for both the NEA and AMH populations in the Greenland Interstadial 11-10 (GI11 - 10) and Stadial 10-9/Heinrich event 4 (GS10-9/HE4) times. The Our Way Model, a preliminary Human and Earth System Coupled Model being developed at the University of Cologne, is applied to simulate the Middle to Upper Paleolithic Population Transition in Iberia. We show that during GS10-9/HE4, large parts of the peninsula became unsuitable for NEA human existence and the NEA settlement areas contracted to isolated coastal hot spots and the NEA networks became unstable, triggering the final collapse of the population. The AMHs arrived in Iberia in GI10 but were confined to patches in the northern most strip of the peninsula. They were soon facing the much colder climate of GS10 - 9/HE4, which prevented their further expansion or even caused a contraction of their settlement areas. Thus, due to the constellation of climate change and the dispersal of the two populations into different regions of the peninsula, we show that it is unlikely that the NEAs and AMHs coexisted in extensive areas and the AMHs had a significant influence on the demography of the NEAs. The Middle to Upper Paleolithic Population Transition in Iberian is either in sequential or weak-interaction mode.

Memo

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SESSION 3

THE TIME EVOLVING HUMAN NICHE

CHAIRS **Tom Higham, Elke Zeller**

SPEAKERS

Jin Cheul Kim
Korea Institute of Geoscience and Mineral Resources

Elke Zeller
IBS Center for Climate Physics

Liping Liu
University of Helsinki

Michael Petraglia
Australian Research Center for Human Evolution

Ramstein Gilles
LSCE / CEA / CNRS / UVSQ

Kim Hyun Jin
The Museum of Silhak, Gyeonggi Cultural Foundation

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Keynote Presentation

Speaker

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Abstract

The appearance of early humans in Jeongok-ri, Korea

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The Palaeolithic site of Jeongokri is one of the best-known archaeological sites in the Korean Peninsula and is known for first discovering Acheulian-like handaxes in East Asia. The Acheulean-type hand axe, not found in Asia but only in Africa and Europe, was one of the first sites excavated in East Asia where such artefacts were recovered in 1978. The form of the bifacial handaxe assemblages and their relationship to tool typologies from Africa and Europe have been the subject of prolonged debate. This was seen as clear evidence against Movius' theory in which it was proposed that there was no culture of handaxes in the Palaeolithic of East Asia (Movius, 1948).

Despite the archaeological significance of the site and more than 40 years of research, the chronological framework of the archaeological site at Jeongokri is still under debate due to the lack of suitable material for dating and the age limit of conventional dating methods. This study aims to understand the geological distribution and formation of the Hantan-Imjin River basin, identify the time of human emergence, and understand the characteristics of the climate and ecological environment at the time of human emergence to interpret interconnections.

In this study, direct dating of the artefact-bearing layers was attempted by applying OSL techniques, which showed great potential for use in the accurate determination of the timing of deposition. To extend the age range of OSL dating, a thermally transferred optically stimulated luminescence (TT-OSL) signal and single-grain K-feldspars using the post-Infrared Infrared stimulated luminescence (pIR-IRSL) were also investigated. The Jeongok Basalts were directly analysed using the Ar-Ar method. 10Be dating from the unconsolidated gravel and sand layers underlying the Jeongok Basalt were dated for burial age. These results of multiple absolute dating methods allow the development of chronologies of the Jeongokri archaeological sites and constrain the timing of the earliest hominin occupation in South Korea. The movements and settlements of ancient humans on the Korean Peninsula covered in this study have great archaeological value, and we believe that tracing the emergence of humans on the Korean Peninsula can provide important solutions to the global debate on the origins and movements of ancient humans.

Presentation

Speaker

Elke Zeller

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Abstract

The evolving 3-dimensional landscape of human adaptation

Elke Zeller[1,2], Axel Timmermann[1,2]

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Over the last 3 million years, humans have expanded their ecological niche and adapted to more diverse environments. The temporal evolution and underlying drivers behind this niche expansion still remain largely unknown. By combining archaeological findings with landscape topographic data and model simulations of the climate and biomes, we show that human sites clustered in areas with increased terrain roughness, corresponding to higher levels of biodiversity. We find a gradual increase in human habitat preferences towards rough terrains until about 1.1 million years ago (Ma), followed by a 200 thousand-year-long contraction of the ecological niche. This period coincided with the Mid-Pleistocene Transition and previously hypothesised ancestral population bottlenecks. Our statistical analysis further reveals that from 0.8 Ma onwards the human niche expanded again, with human species (e.g., H. heidelbergensis, H. neanderthalensis, and H. sapiens) adapting to rougher terrain, colder and drier conditions, and towards regions of higher ecological diversity.

Presentation

Speaker

Liping Liu

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Abstract

The evolution of human niche size in East Asia over the Pleistocene

Liping Liu, Tegan Foister, Abigail Parker, Edward Armstrong, Anu Kaakinen, Paul Valdes, Indre Žliobaitė, Miikka Tallavaara

University of Helsinki, The Swedish Museum of Natural History, University of Bristol

The initial dispersal of humans out of Africa at the beginning of the Pleistocene is well known as "Out of Africa I." How this happened is a matter of intense debate. Scientists argue whether early Homo species migrated out of Africa through homogeneous habitats, such as savanna-like grasslands or woodlands/forests, or through heterogeneous set of habitats. This debate is also related to the question about the evolution of plasticity and niche size among humans.

Here, we characterize the environmental conditions of human occupations in East Asia across the Pleistocene in order to understand the evolution of human niche. Our dataset consists of 187 mammal fossil localities from continental China. Some of these sites (N = 112) show evidence of human presence (human fossils and/or archaeology), which allows us to track variability in human habitats and, consequently, changes in niche size over time. To achieve this goal, we combine data from fossil herbivore mammal teeth traits - the so-called dental ecometrics (e.g. hypsodonty and bunodonty) - and from climate model. Hypsodonty describes the height of a tooth in relation to its length or width. Among the dental ecometric variables, the mean hypsodonty of a mammal community is related to precipitation and high hypsodonty values are common in grasslands or other open habitats but rare in woody habitats, whereas bunodonty refers to a tooth morphology with separate cusps that are not fused into elongated, loph structures. Faunal communities with a high proportion of bunodont species are typically found in relatively warm and humid forested environments that lack seasonality. Annual mean temperature and annual precipitation values for each locality were extracted from HadCM3BB-v1.0 climate model simulations.

Both fossil herbivore mammal dental ecometrics and climate model data show that human niche size remained relatively small until the Late Middle Pleistocene, when significant expansion in niche size occurred. Our results indicate that Early Pleistocene and early Middle Pleistocene Homo in East Asia mainly occupied open forests and tended to be absent in two extreme habitats: the closed canopy forest and the cold/dry habitats. The results suggest that temperate grasslands that characterize for example the famous Nihewan Basin localities, were only marginal habitats for Early Pleistocene humans who were generally a subtropical woodland/open forest dweller in East Asia. During the significant expansion of human niche in the Late Middle Pleistocene humans began to occupy both closed canopy sub-tropical and tropical forests and cold/dry habitats. Interestingly, this niche size expansion co-occurs with what appears to be increased human diversity in East Asia.

Keynote Presentation

Speaker

Michael Petraglia

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Abstract

Dispersals of Homo sapiens across Asia: Northern and Southern Routes

Michael Petraglia

Australian Research Centre for Human Evolution, Griffith University, Australia

The dispersal of our species from Africa to Asia and beyond is one of the most important topics in human evolutionary studies. Climatic and environmental variability would had a profound effects on the timing of terrestrial movements across continents and the degree to which human populations could persist in fluctuating ecosystems. Here we will examine routes of movement across northern and southern routes of Asia through time, examining mounting evidence for multiple dispersals of Homo sapiens populations. We will also present and synthesise the results of primary interdisciplinary archaeological field investigations in Arabia, southern Asia and eastern Asia, examining the influence of environmental variability and population responses over the last 200,000 years.

Presentation

Speaker

Ramstein Gilles

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Abstract

Understanding the impact of climate and tectonic changes during the Neogene

Gilles RAMSTEIN[1], Corentin GIBERT[2], Frédéric FLUTEAU[3], Anaïs VIGNOLES[4], Camille CONTOUX[1], William E. Banks[4,5], Doris BARBONI[6], Jean-Renaud BOISSERIE[7,8], Olivier CHAVASSEAU[7], Franck Guy[7], Camille NOUS[9], Olga OTERO[7], Pierre SEPULCHRE[1], Antoine SOURON[4]

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From the origins of human ancestors (Apes) in tropical Africa, from their dispersal outside Africa during the early Neogene to the spatial patterns of Australopithecines during the Pliocene, it is possible to compute the imprint of tectonics and astronomical forcings on climate change to make inferences pertaining to these populations' dispersal history. In this talk, we will explain the deep-time trends associated with Apes spatial distribution, from their initial location over the tropical forests of Africa to Southeastern India, where they still exist today. We will demonstrate how this long "journey" is strongly correlated with climate changes. We may follow their pathways thanks to climate and vegetation modelling.

At the other extreme, we will also investigate how the more rapid precession cycles (20 Ky), influenced Australopithecine dispersal and their climatic niches during the mid-Pliocene.

In each case, our work benefits from the fact that there are strong climatic constraints on hominid and hominin dispersal, but we can also show and quantify characteristics that are not related to climate change, but rather are linked to other factors at play in niche evolution.

To achieve this goal, we use a sophisticated IPSL / GCM climate model and provide global simulations of the different periods, as well as sensitivity studies in order to disentangle the different forcing factors. Moreover, we downscale the atmospheric model to high resolution (50km) in order to provide to the necessary climate imputs needed to estimate hominin niches and their potential distributions.

Presentation

Speaker

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Abstract

Modern Homo sapiens fossils in the Korean peninsula

Kim Hyun Jin

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Modern Homo sapiens fossils have been discovered in limestone caves on the Korean Peninsula, primarily concentrated in North Korea. Although not widely known outside the country, these fossils are of significant scientific value, as they illustrate the spread of modern Homo sapiens across East Asia. In North Korea, the specimens identified as modern Homo sapiens include: <Soongnisan Man>, <Jungri Man>, <Geumcheon Man>, <Mandanlli Man>, <Geumpyeong Man>, <Ryonggok Man>, <Daeheung Man>, <Naengjeong Man>, <Hwangju Man>, <Punggok Man>, <Ryongnam Man> and <Gangdong Man>. North Korean researchers have categorized these specimens into two chronological periods: the "early period" and the "late period".

Recent research achievements have significantly advanced our understanding of early human habitation in the Korean Peninsula. The Cheongphadae Cave, where five specimens of <Hwangju Man> have been studied, has been the focus of extensive research employing various dating methods and physical anthropological analyses. Additionally, Limgyeong Cave, the site of the most recent Homo sapiens identification known as <Gangdong Man>, has been designated as a North Korean conservation site due to its considerable scientific value. In South Korea, the discovery of <Sangsi Man> in the Sangsi Rockshelter in Danyang during the 1980s marked a significant milestone. This was followed by the notable discovery of fossils in Gunang Cave in 2011, further contributing to the understanding of early human presence in the region.

This presentation will explore the current cases and research trends concerning modern Homo sapiens found on the Korean Peninsula, which have remained relatively unknown to both domestic and international scholars. Research on North Korean material has been constrained by access difficulties and limited availability of images. However, recent developments in North Korean academia, such as the increased publication of research findings in international journals, offer promising prospects for future research. The present study of specimens from the Korean Peninsula aims to stimulate new debates on various hypotheses regarding the dispersal of modern Homo sapiens. Additionally, it will provide critical insights into the origins and migrations of these populations in Northeast Asia.

Presentation

Speaker

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Abstract

Repeated human occupation of the Nwya Devu Paleolithic site on the high-altitude central Tibetan Plateau during the past 45,000 years

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The timing and mechanisms of the human occupation of the demanding high-altitude Tibetan Plateau environment are of great interest. Here, we report on our reinvestigations and dating of the Nwya Devu site, located nearly 4600 meters above sea level on the central Tibetan Plateau. A new microblade techno-complex was identified on a lower lake shore at this site, distinct from the previously reported blade tool assemblage. These two lithic assemblages were dated to 45.6±2.6 ka and 10.3±0.5 ka using optically stimulated luminescence and accelerator mass spectrometry 14C methods. They represent, respectively, the earliest known Paleolithic and microlithic sites on the interior Tibetan Plateau, indicating multiple occupation episodes of hunter-gatherers during the past 45 ka. Our studies reveal that relatively stable depositional conditions and a paleoenvironment characterized by a comparatively warm climate facilitated these multiple occupations at Nwya Devu. The contemporaneous occurrence of the Upper Paleolithic blade technology on the Tibetan Plateau and most of Eurasia between 50-40 ka indicates rapid, large-scale dispersals of humans that profoundly affected human demography on a large scale. Combining new archaeological evidence and previously reported genetic data, we conclude that the Tibetan Plateau provided a relatively stable habitat for Upper Paleolithic hunter-gatherers, which may have contributed to the complex and multiple-origin gene pool of present-day Tibetans.

Keynote Presentation

Speaker

Tom Higham

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Abstract

Improved chronometric and biomolecular approaches to understanding dispersals of early Homo sapiens across Eurasia

Tom Higham

University of Vienna

The Late Middle and Early Upper Palaeolithic, roughly between 30-60,000 years ago, is a key period in human evolution. It witnesses the transition between a Neanderthal (and Denisovan) dominated Eurasia, to one which was exclusively occupied by Homo sapiens. Recent discoveries in archaeology, genomics, isotope geochemistry, residue analysis, dating science and more, have revolutionised our understanding of the period. We now have some answers to what once seemed intractable questions. Did Neanderthals and Homo sapiens (and Denisovans) meet? How long was their overlap, and where did they encounter one another? When did Neanderthals disappear from the fossil record? There are still many important questions that need to be addressed, however, not least in the vast regions of Eurasia that have seen limited to no fieldwork or the application of the latest scientific methods.

In this talk I will present some new data regarding the spread of early Homo sapiens across Eurasia. My team has worked on a range of important sites documenting the Initial Early Upper Palaeolithic or IUP, from France to east of Lake Baikal. Several researchers suggest this stone tool technocomplex may represent a wide dispersal of Homo sapiens groups. Using several archaeological science approaches, including improved dating methods (radiocarbon and OSL dating), the targetted application of ancient archaeogenomics, as well as and novel biomolecular applications such as palaeoproteomics, I will outline the broad picture of some of these new results.

Presentation

Speaker

Tishyarakshita Nagarkar

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Abstract

Unveiling the enduring legacy and the behavioural niche: Analysing the cognitive and ritualistic facets of bow and arrow usage among the Indigenous Tribes of the Konkan Region of Maharashtra, India

Tishyarakshita Nagarkar

Department of Anthropology, Savitribai Phule University

The arrow-making craft practiced by the indigenous tribes of the Konkan region in Maharashtra is a fascinating blend of practical expertise, meticulous craftsmanship, and profound cultural significance. This practice exemplifies the ingenuity and flexibility of the tribal communities, maintaining a connection to their traditional customs while embracing modern influences.

Although this subject showcases the remarkable skills of ancient humans and their adaptive strategies for survival and hunting, it has not been extensively explored or thoroughly studied in this region.

This paper seeks to offer a comprehensive analysis of the traditional craft of arrow-making among the tribes of Konkan. The study will also emphasise the materials, tools, processes, and rituals associated with this long standing tradition, as well as the cognitive and the cultural significance it holds.

Using a comprehensive research methodology that includes ethnographic and archaeological fieldwork, interviews with tribal artisans, analysis of historical records, and extensive study of tribal practices, the researcher has strived to reveal the underlying concepts and cognitive principles behind the making and the utilisation of the bow and arrow. This has been achieved through a thorough analysis of the materials selected and the ceremonial importance of the bow and arrow, particularly in terms of their practical and probable use.

Presentation

Speaker

Muhammad Abdul Wasay

IBS Center for Climate Physics

Abstract

Simulating spatiotemporal cultural evolution using a cultural complexity metric

Muhammad Abdul Wasay; Jiaoyang Ruan; Axel Timmermann

IBS Center for Climate Physics

We present a method of quantifying culture by leveraging Procedural Unit (PU) counts, which reflect the complexity of tool manufacturing processes through discrete, sequential steps, see (P., Jonathan & P., Charles (2024)). PU counts serve as the foundation for our Empirical Cultural Reference (ECR) state, capturing both the cultural evolution as well as the innovation dynamics. The ECR state is derived through a statistical model and it encapsulates the central tendency as well as the variability. The model employs a relaxation ordinary differential equation (ODE) to describe the dynamics of cultural evolution. In this framework, the ECR state serves as the target equilibrium, driving the system towards it.

To account for uncertainties and fluctuations, the model incorporates controlled stochasticity that respects the empirical uncertainty bounds, ensuring that deviations remain within realistic/empirical limits. This framework allows for a more realistic empirical-data driven representation of cultural evolution through different phases of human history.

Citation

P., Jonathan & P., Charles (2024). 3.3 million years of stone tool complexity suggests that cumulative culture began during the Middle Pleistocene. Proc. Natl. Acad. Sci. U.S.A. Vol. 121, No. 26, e2319175121

Presentation

Speaker

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Abstract

From Paleolithic to Present: Tracing Human Migration Patterns in Jammu and Kashmir in Response to Climate Fluctuations

Mehak Jonjua

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Nestled amidst the majestic peaks and verdant valleys of Jammu and Kashmir lies a region steeped in a rich history of human existence. From the earliest Paleolithic inhabitants to the vibrant cultures of today, the story of this land is deeply connected with the ebb and flow of climate fluctuations and the migrations they have prompted. By integrating archaeological, paleoclimatological, and anthropological data, the study investigates how environmental changes have influenced the movements and settlement patterns of human populations over millennia. Drawing upon evidence from archaeological excavations, paleoclimate reconstructions, and genetic studies, we trace the trajectories of human dispersals in response to climatic shifts. From the early hunter-gatherer societies to the establishment of agricultural communities, we elucidate how changing climatic conditions have shaped the adaptive strategies and mobility patterns of prehistoric inhabitants.

Furthermore, we analyze historical records and contemporary migration trends to provide insights into the enduring impact of climate variability on human mobility in Jammu and Kashmir. Through this interdisciplinary approach, the research study contributes to a comprehensive understanding of the long-term interactions between humans and their environment in the Jammu and Kashmir region.

Presentation

Speaker

Hyeong Woo Lee

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Abstract

Modern Human Studies in North Korea

Hyeong Woo Lee

Jeonbuk National University, Korea

Archaeological studies in North Korea have been positioned as a central academic discipline since the state's establishment. Even before North Korea's regime formation, legal frameworks were established for the effective preservation and management of cultural heritage, along with relevant institutions. Following the 1950s war, significant new research achievements emerged from the early 1960s, including the introduction of Paleolithic archaeology and paleoanthropology (Y. H. Do 1962b; Institute of Archaeology and Ethnology 1962; Y. H. Do 1962a). Additionally, the first Paleolithic excavation by North Korean were conducted (Institute of Archaeology and Ethnology 1963; Y. H. Do 1964).

From the 1960s, North Korea was engulfed in a rigid political atmosphere, leading to the replacement of many researchers and the emergence of new ideologies that began to influence academic researches. Despite this, the 1970-80s saw an increase in archaeological data, notably marked by publications such as "Paleolithic Period of Korea" and “Anthropology (2nd Edition),” which set new standards in North Korean Paleolithic archaeology and paleoanthropology (Institute of Archaeology 1977; W. J. Jang 1988).

The emergence of the new disciplines of Paleolithic archaeology and paleoanthropology in North Korea also signifies the introduction of long-established scientific paradigms.

Kroeber's writings clearly articulate the paradigm in question: “What White means by evolution is a fixed, necessary, inherent, and predetermined process” (A. L. Kroeber 1946: 9). Two major scientific paradigms dominate in scientific community globally: typological thinking or essentialism, where substances are seen as fixed and clearly classifiable; and Darwinism or materialism, which views substances as variable and classification as an arbitrary, evolving process (M. O'Brien and L. Lyman 2000).

In the 1970s and 1980s, North Korean Paleolithic archaeology predominantly adopted typological thinking (H. W. Lee 2022). In terms of hominin evolution, North Koreans advocate a stepwise unilinear evolution, viewing each species as a distinct substance. Human evolution in North Korea is addressed in five stages: Australopith (Nambang-wonsung-i), Homo habilis (Neung-in), Homo erectus (Won-in), archaic Homo sapiens (Go-in), and Homo sapiens (Shin-in) (H. Lee 2020a).

Despite the relatively stable number of Paleolithic sites discovered since the 1960s, North Korea boasts a quantitative advantage in fossil data over South Korea, particularly in finds of archaic Homo sapiens and Homo sapiens from the Middle and Upper Paleolithic periods. This abundance has bolstered North Korean pride in having a significant collection of modern human fossils, with discoveries reported from sites like Jungri, Punggok, Geumcheon, Daehung, Geumpyeong, Raengjeong, and Yonggok since the 1970s (Kim C. J. et al. 2009; Jang W. J. et al. 2009).

North Koreans' interest in modern humans remains influenced by typological thinking, emphasizing the evolution of modern humans as a continuous, uninterrupted process, referred to as the multiregional origin of modern humans, which distinctly opposes the Out of Africa model and rejects the hybridization model, namely the Assimilation Model (H. W. Lee 2020a)

Identifying new archaeological evidence continues to be a primary research focus for understanding Paleolithic hominins in North Korea. Additionally, understanding the political context that North Korean researchers contend with is crucial, as state power directly influences academia.

Nevertheless, understanding scientific paradigms provides more fundamental insights.

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Keynote Presentation

Speaker

Simon Armitage

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Abstract

Assessing potential climatic drivers of human behavioural evolution on the South African coast

Simon Armitage, Christopher Henshilwood, Karen van Niekerk and the SapienCE research team

SFF Centre for Early Sapiens Behaviour (SapienCE), University of Bergen, Post Box 7805, 5020, Bergen, Norway

Coastal and near-coastal archaeological sites in South Africa have yielded an extensive and varied record of human behavioural development. Between ~120-50 ka, a number of innovations in symbolic behaviour, subsistence practices and technology are evidenced at these sites. Although individually and collectively spectacular, these innovations are only part of a behavioural evolution that occurred during the Middle Stone Age (MSA) of southern Africa. Since 2017, the Centre for Early Sapiens Behaviour (SapienCE) at the University of Bergen, Norway, has investigated evidence for this behavioural evolution, documenting the process and attempting to test the plausibility of potential drivers. In particular, SapienCE has focussed on contextualising behavioural changes during the MSA by using a multidisciplinary approach to better understand contemporaneous climatic and environmental changes. Key challenges addressed in this in this presentation include: 1) minimising the constraints imposed by chronological uncertainties when palaeoclimate records with each other and with the archaeological record, and 2) understanding the relationship between long-term, regional climatic records and the environments/landscapes experienced by individual hunter-gatherers on a day-to-day basis.

IBS Conference on

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Institute for Basic Science

IBS Center for Climate Physics

SESSION 4

HUMAN RESPONSES TO ABRUPT CLIMATE CHANGE

CHAIR Ricarda Winkelmann

SPEAKERS

Chronis Tzedakis
Environmental Change Research Centre, Department of Geography, University College London

Shih-Wei Fang
IBS Center for Climate Physics

Kelvin Richards
IPRC, University of Hawaii

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Keynote Presentation

Speaker

Chronis Tzedakis

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Abstract

When hominins first came to Europe: colonization, depopulation and climate

Chromis Tzedakis[1], Vasiliki Margari[1], David A. Hodell[2], Simon A. Parfitt[3,4], Nick M. Ashton[5], Joan O. Grimalt[6], Hyuna Kim[7,8], Kyung-Sook Yun[7,8], Philip L. Gibbard[9], Chris B. Stringer[4], Axel Timmermann[7,8]

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Early hominins were present in SW Asia ~1.8 million years ago [Ma], but the earliest evidence of hominin occupation in Europe from sites in Italy and Spain indicates a delay of at least ~200 thousand years [kyr]. Margari et al. (2023) suggested that this dispersal lag may be attributed to a period of cooler interglacials ~1.8-1.6 Ma, which in turn may be related to the long amplitude modulation of the obliquity 41-kyr cycle.

Between ~1.6 and 1.2 Ma, glacial-interglacial cycles were marked by exceptionally pure 41-kyr cycles, with maximum ice volumes ranging between one half and one third of the Last Glacial Maximum value. Climate reconstructions from terrestrial sites in Iberia show wet, warm and stable interglacial conditions, and short and relatively warm glacials that would have allowed early hominin populations to persist and expand. A progressive lengthening and intensification of glacial-interglacial cycles took place over the so-called Middle Pleistocene Transition (~1.2-0.7 Ma), with the first major glaciation thought to have occurred around 0.9 Ma during Marine Isotope Stage [MIS] 22.

However, analysing marine and terrestrial proxies from a deep-sea core off Portugal, Margari et al. (2023), discovered the presence of pronounced millennial climate variability during the MIS 34 glacial period (~1.15-1.12 Ma) that terminated with one of the most extreme cooling events ever recorded in that area, when sea surface temperatures dropped below 6°C and semi-desert vegetation dominated the adjacent land. Climate envelope model results showed a drastic decrease in early hominin habitat suitability that would have led to the depopulation of Europe. With the archeological record hinting at a possible long hiatus in European and SW Asian occupation, Margari et al. proposed that reoccupation of Europe may have been delayed potentially until after the marked glaciation of MIS 22. Then, a more resilient species with evolutionary or behavioral changes that allowed survival in the increasing intensity of glacial conditions of the Middle Pleistocene may have begun a new phase of colonization.

Margari, V., Hodell, D.A., Parfitt, S.A., Ashton, N.M., Grimalt, J.O., Kim, H., Yun, K.-S., Gibbard, P.L., Stringer, C.B., Timmermann, A. & Tzedakis, P.C. (2023) Extreme glacial cooling likely led to hominin depopulation of Europe in the Early Pleistocene. Science 381, 693-699, science.org/doi/10.1126/science.adf4445

Presentation

Speaker

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Abstract

Evidence of A Climate-Driven Human Genetic Bottleneck around 900ka

Shih-Wei Fang*[1,2], Aneesh Sundaresanand[1,2], Jiaoyang Ruan[1,2], Pasquale Raia[3], Ali R. Vahdati[4], and Axel Timmermann[1,2]

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Ancient human population changes are often estimated by genomic information from fossils. Recent studies suggest the existence of a human genetic bottleneck around 900 ka, even though the cause remains uncertain. Using an agent-based model to mimic ancient human activities with mitochondrial DNA information inherited, we find that an extreme human genetic reduction (~80% genetic diversity loss) existed around 900 ka, driven by climate changes. This enormous genetic loss was caused by a relatively small population loss (~30%) mainly related to the extinct populations in southern Africa.

We attribute the regional population changes individually to distinct climate states, including precipitation, temperature, and net primary production changes. Our results reveal the importance of regional extinctions and survival in controlling ancient human DNA, as well as the lineage of us, H. Sapiens. One possible consequence is the merging into 23 pairs of Chromosomes, which may be a dominant species within the survival populations in East Africa.

Presentation

Speaker

Kelvin Richards

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Abstract

The response of humans to climate change: the impact of dispersal, competition and interbreeding

Kelvin J Richards and Axel Timmermann

IPRC, ICCP

It has been suggested that the presence of a novelty seeking polymorphism in Homo sapiens made certain individuals in the population more adventurous, affecting the out-of-Africa migrations. First, we show that in a population responding to climate change by migrating there is an increase in the frequency of the novelty seeking polymorphism. In contrast, in a static landscape the advantage is lost and the frequency decreases. Migration, however, is not done in isolation and can involve competition with other species. Here we have in mind interactions between Homo sapiens and Homo neanderthalensis. Making use of coupled reaction/fractional diffusion equations, we explore how the form of migration, competition, interbreeding between populations, and environmental conditions all affect the outcome and species survival. We show that all factors need to be considered when assessing why one species comes to dominate at the expense of the other.

Presentation

Speaker

Lan Dai

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Abstract

Climatic and ecological responses to medium-sized asteroid collisions

Lan Dai, Axel Timmermann

IBS Center for Climate Physics

The collision of medium-sized asteroids with Earth can inject massive amounts of dust into the atmosphere, with unknown consequences for terrestrial and marine ecosystems. Here, we use the coupled high-top Community Earth System Model Version 2 with interactive chemistry to investigate how medium-sized asteroid strikes would impact climate, vegetation, and marine productivity. Our simulations, which inject up to 400 million tons of dust into the stratosphere, show dramatic disruptions in climate, atmospheric chemistry and global photosynthesis. Global mean temperatures are projected to drop by 4 $^{\circ}$C, and global precipitation is expected to decrease by 15%. The largest reductions in global terrestrial and marine net primary productivity reach about 36% and 25%, respectively. Depending on the iron amount of the asteroid, and the subsequent marine dust deposition, large diatom blooms can occur in iron-limited regions such as the Southern Ocean and the eastern equatorial Pacific. The abrupt cooling and ecosystem collapses caused by asteroid collisions would severely reduce the habitat suitability for humans and wildlife. Our simulated climatic and ecological responses to dust injections from medium-sized asteroid collisions provide the basis to quantify the possible effects of abrupt events on planetary life.

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Institute for Basic Science

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SESSION 5

GENOMICS AND ANCESTRY

CHAIRS Axel Timmermann, Chiara Barbieri

SPEAKERS

Chiara Barbieri
University of Cagliari

Leonardo Vallini
University of Mainz

Juhyeon Lee
Seoul National University

Donghee Kim
School of Biological Sciences, Seoul National University

Dongju Zhang
College of Earth and Environment Sciences, Lanzhou University

Jiaoyang Ruan
IBS Center for Climate Physics

Dongyoung Kim
Seoul National University

Mijin Park
Seoul National University

Keynote Presentation

Speaker

Chiara Barbieri

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Abstract

Contrasting genetic and linguistic histories and population dynamics

Chiara Barbieri

University of Cagliari

Human history is written in both our genes and our languages. The extent to which our biological and linguistic histories are congruent has been the subject of considerable debate. Transmission with modification can shape genes and languages similarly, while horizontal contact can uniquely affect languages. Which forces are in play to build the structure of large and small language families? Do different languages pose barriers to gene flow between populations? Are population and individual dynamics correlated to language diversity? To disentangle patterns of demographic and cultural transmission we need a global systematic assessment of matches and mismatches, and a framework to describe mismatches and language shifts.

In this talk, I will present gene-language studies at a local scale and at a cross-continental scale and contextualize them with their potential and limitations. Local studies from South America are anchored with historical knowledge available. Global-scale systematic surveys are performed with the genomic database GeLaTo (Genes and Languages Together), which has been assembled to provide a compatible resource for multidisciplinary studies on genetic, linguistic and cultural diversity. Potential gene-language matching profiles are screened through ecological models of geographic proximity and time frame compatibility. Comparisons between demographic histories and language family sizes suggest that isolation and population expansions are influencing the linguistic landscape. While substantial genetic cohesiveness for speakers of related languages emerges, exceptions are informative of population dynamics acting in different continents.

Presentation

Speaker

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Abstract

The Persian plateau served as hub for Homo sapiens after the main out of Africa dispersal

Leonardo Vallini[1,2], Carlo Zampieri[1], Mohammad Javad Shoaee[3], Eugenio Bortolini[4], Giulia Marciani[4,5], Serena Aneli[6], Telmo Pievani[1], Stefano Benazzi[4], Alberto Barausse[1], Massimo Mezzavilla[1], Michael D. Petraglia[7,8,9], Luca Pagani[1,10]

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Genetic, palaeoanthropological and palaeoclimatological evidence point to 70-60 thousand years ago (kya) as the most likely time window for the latest colonisation of Eurasia by Homo sapiens. The same evidence, however, also suggests that for several millennia human populations outside of Africa did not expand much geographically until their broader spread across the continent ~45 kya.

Despite the length of this timeframe, constituting approximately one third of the time our species spent outside of Africa, the geographic whereabouts of these early settlers is poorly characterised. Here we combine genetic evidence and palaeoecological models to infer the geographic region that acted as a hub for our species during the early phases of colonisation of Eurasia. With a novel genetic approach we show that, among available ancient and contemporary populations, individuals from the Persian Plateau and Mesopotamia carry an ancestry component that most closely matches the genetic characteristics of the Hub population. Palaeoecological modelling predicts large parts of the Persian Plateau as suitable for human occupation, and that it could sustain a larger population compared to other Western Asian regions. In conclusion, our multidisciplinary effort shed light on the millennia that separated the OoA and the differentiation of Eurasians into Europeans, East Asians and Oceanians and pointed to the area of the Prehistoric Persian Plateau as the best candidate Hub location,and as a tempting treasure trove for future archaeological investigations.

Presentation

Speaker

Juhyeon Lee

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Abstract

Bronze and Iron Age genomes from Central Mongolia illuminate a population turnover between culturally and genetically distinct prehistoric pastoralists

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The population movement and mixture are influenced by factors such as climate, disease, and culture. Understanding these dynamics is fundamental to comprehending their underlying causes. This study focused on the population history of Bronze and Iron Age central Mongolia, a region ideal for studying population movement and mixture. Specifically, central Mongolia served as the contact zone between two distinct Late Bronze Age cultures: Deer Stone-Khirgisuur Complex (DSKC) in the west and the figure-shaped burials in the east. To understand their interaction, especially during the rapid expansion of the Early Iron Age (EIA) Slab Grave culture, we analyzed genome-wide data from 30 ancient individuals from central Mongolia. Despite their geographical proximity, two distinct genetic clusters persisted, with DSKC burials associated with one cluster and figure-shaped/slab burials with the other, indicating limited population mixing and the maintenance of cultural differences. However, shared ancestry and long Identical by Descent blocks were identified between individuals from these cultural groups across Mongolia, supporting the hypothesis of DSKC population displacement by descendants of figure-shaped burials during the EIA Slab Grave expansion. This study provides a detailed genetic perspective on major prehistoric transitions in Mongolia, highlighting the complex interplay between cultural and population dynamics.

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Presentation

Speaker

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Abstract

Detecting basal aurochs-derived tracts in the genome of African taurine cattle

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The African taurine cattle, the earliest domestic cattle in Africa, have captivated researchers for their diverging genetic profile from the Eurasian taurine as well as their phenotypes potentially adaptive to the environments of sub-Saharan Africa. Especially, it's been hypothesized that now extinct local aurochs populations may have contributed to the distinct genetic profile and adaptations of the African taurine. Consistent with this hypothesis, previous studies detected a significant amount of contribution (up to ~20% of ancestry) from a basal taurine lineage, possibly representing the now extinct African aurochs. However, due to scarcity of ancient African aurochs genomes, the identity of this basal taurine ancestry in the African taurine still remains elusive. In this study, we identify genomic segments likely introgressed from a deeply divergent source population in the genome of African taurine using a method, Skov's Hidden Markov Model (HMM), not requiring an explicit model of the demographic history nor genome sequences representing the source. These identified segments cover ca. 15% of the callable genome of African taurine per individual genome, largely coinciding with our previous estimate of the amount of the basal taurine contribution. Also, we show that the identified genomic segments are from a source that are more deeply branching than the available Eurasian auroch genomes, while not closely matching to the available Moroccan aurochs genomes. Our study corroborates our previous report on the basal taurine lineage introgression in the African taurine and suggests the yet-to-be-identified genetic diversity among the extinct African/Middle Eastern aurochs populations.

Presentation

Speaker

Dongju Zhang

College of Earth and Environment Sciences, Lanzhou University

Abstract

Middle and Late Pleistocene Denisovan subsistence at Baishiya Karst Cave

Huan Xia[1,2,3#], Dongju Zhang[1,2*], Jian Wang[1,4#], Zandra Fagernäs[5#], Ting Li[1], Yuanxin Li[1], Juanting Yao[1], Dongpeng Lin[1], Gaudry Troché[5], Geoff M. Smith[6], Xiaoshan Chen[1], Ting Cheng[1], Xuke Shen[1], Yuanyuan Han[1,2], Jesper V. Olsen[7], Zhongwei Shen[1], Zhiqi Pei[1,8], Jean-Jacques Hublin[9,10], Fahu Chen[1,2*], Frido Welker[5*]

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Genetic and fragmented palaeoanthropological data suggest that Denisovans were once widely distributed across eastern Eurasia. Despite limited archaeological evidence, this indicates that Denisovans were capable of adapting to a highly diverse range of environments. Here we integrate zooarchaeological and proteomic analyses of the late Middle to Late Pleistocene faunal assemblage from Baishiya Karst Cave on the Tibetan Plateau, where a Denisovan mandible and Denisovan sedimentary mitochondrial DNA were found. Using zooarchaeology by mass spectrometry, we identify a new hominin rib specimen that dates to approximately 48–32 thousand years ago (layer 3). Shotgun proteomic analysis taxonomically assigns this specimen to the Denisovan lineage, extending their presence at Baishiya Karst Cave well into the Late Pleistocene. Throughout the stratigraphic sequence, the faunal assemblage is dominated by Caprinae, together with megaherbivores, carnivores, small mammals and birds. The high proportion of anthropogenic modifications on the bone surfaces suggests that Denisovans were the primary agent of faunal accumulation. The chaîne opératoire of carcass processing indicates that animal taxa were exploited for their meat, marrow and hides, while bone was also used as raw material for the production of tools. Our results shed light on the behaviour of Denisovans and their adaptations to the diverse and fluctuating environments of the late Middle and Late Pleistocene of eastern Eurasia.

Presentation

Speaker

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Abstract

Simulating the potential scenarios of Denisovans 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 Denisovans 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 reproducing the Neanderthals extinction event as documented by fossil data, our model also simulates past Denisovans distributions, last refugia, and their spatiotemporal interactions with Neanderthals and the two waves of 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 causing the extinction of Denisovans, and the important climatic effects on their regional extirpation patterns.

Presentation

Speaker

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Abstract

Whole-genome analyses unveil a novel subspecies-level lineage of Korean troglophile harvestmen (Opiliones, Paranonychidae, Kaolinonychus coreanus)

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Harvestmen have been an extraordinary model of historical biogeography and adaptive evolution due to their low vagility, deep evolutionary history, and narrow environmental niches. Kaolinonychus coreanus, a cave-dwelling harvestman species complex distributed throughout the inland region of the Korean peninsula, is an attractive system for studying the demographic history and cave adaptation of terrestrial invertebrates. Here, we produced the first draft genome assembly of this species and low-coverage whole genome sequences for 177 individuals collected from 52 sites across Korea. As a result, we found that individuals from the Gariwang-san mountain region show a genetic profile that is extremely divergent from those of the two previously described subspecies, K. c. coreanus and K. c. longipes, suggesting a novel subspecies-level lineage without marked morphological differentiation. Our whole-genome analyses also revealed K. c. longipes subspecies was formed by a mixture of the Gariwang-san lineage and K. c. coreanus. We aim to elucidate further the evolutionary signatures of genetic adaptation within the K. coreanus species complex by comparing cave- and non-cave-dwelling populations within each lineage.

Presentation

Speaker

Mijin Park

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Abstract

Whole genome sequencing of Greenland muskox (Ovibos moschatus) individuals using surface-deposited skeletal elements

Mijin Park[1], Juhyeon Lee[1], Donghee Kim[1], Raffaela Bianco[2], Johannes Krause[2], Tae-Yoon S. Park[3], Won Young Lee[3]*, Choongwon Jeong[1,4]*

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The muskox (Ovibos moschatus) is a large-bodied ungulate species adapted to the tundra climate in Canada and Greenland. The current natural population in Greenland is assumed to have expanded from the Canadian Arctic Archipelago to north and northeast Greenland approximately 2,000 years ago through a serial founder event. However, their initial expansion process to Greenland as well as subsequent gene flow has not been thoroughly studied due to limited accessibility to muskox samples suitable for genome sequencing. In this study, we collected surface-deposited muskox skeletal elements from Ella Island in northeast Greenland and assessed their suitability for the non-disruptive source of genome information. Firstly, by comparing 13 libraries from 10 individuals, our analysis revealed that muskox horn shafts exhibit superb level of DNA preservation, making them easily accessible and high-quality targets for sampling in the field. Secondly, genomes of the newly sequenced Ella island individuals (n=9; 0.1-43.8x coverage) showed that they form a clade with previously published individuals from nearby sites, supporting that the surface-deposited horn samples can yield high-quality genomic data. Finally, using the newly produced high-coverage genomes, we quantified the extreme reduction in genetic diversity over time in the Greenland populations through the Multiple Sequentially Markovian coalescent (MSMC) analysis. In summary, our study presents an accessible non-disruptive sampling strategy for muskox conservation genomics, along with high-quality whole genome sequences from eastern Greenland.

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SESSION 6

THE ANTHROPOCENE

CHAIR Shih-Wei Fang

SPEAKERS

Buhm Soon Park
Korea Advanced Institute of Science and Technology (KAIST)

Qiong Zhang
Stockholm University

Tishyarakshita Nagarkar
Department of Anthropology

Ramstein Gilles
Research Director at LSCE Paris-Saclay

Haijun Yang
Fudan University

Ralf Greve
Hokkaido University, Sapporo, Japan

Keynote Presentation

Speaker

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Abstract

The Climate Crisis and Cultural Heritage in the Anthropocene

Buhm Soon Park

Korea Advanced Institute of Science and Technology (KAIST)

The climate crisis in the Anthropocene is not merely a physical manifestation of the destabilized Earth system. With growing evidence that human activities are the primary cause, it is also, as writer Amitav Ghosh noted in his book The Great Derangement (2018), "a crisis of culture, and thus of the imagination." To confront the Anthropocene, it is imperative that we strive to change the cultural values that have built and subsisted modern civilizations – namely, capital-driven, power-expansive, and nature-extractive sociopolitical systems. More importantly, we need to appreciate cultural imaginations that have historically privileged the practice of care – i.e., care for communities, landscapes, and living and nonliving creatures. It is true that the current climate crisis, including sea level rise, increasingly frequent severe storms, more extreme wildfires and bushfires, poses a real threat to world heritage sites and records. This paper explores the other side of this challenging issue: how climate activism can benefit from cultural heritage in both tangible forms (e.g., archeological sites, historical records) and intangible ones (e.g., storytelling, rituals).

Presentation

Speaker

Qiong Zhang

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Abstract

Drought as a catalyst for the Classic Mayan collapse from a climate modelling perspective

Qiong Zhang[1,2], Josefine Axelsson[1,2], Fredrik Charpentier Ljungqvist[2,3]

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A period of severe droughts spanning the ninth to eleventh century CE was unprecedented in Maya prehistory and significantly contributed to the regional collapse of the Maya civilisation. Although various hypotheses, ranging from solar variability to deforestation, have been proposed to explain these prolonged droughts, no comprehensive validation or interlinking of these hypotheses. In this study, we address this gap by analysing data from the EC-Earth3 last millennium simulation. Our findings confirm a 300-year persistent drought in the Maya lowlands from the ninth to twelfth century CE. Several climatic contributors to this persistent drought were identified, including a weakened Atlantic Meridional Overturning Circulation (AMOC) that led to reduced climate variability in the North Atlantic, increased frequency of El Niño events, decreased hurricane genesis in the eastern Pacific, and an intensified interoceanic SST gradient between the eastern Pacific and tropical Atlantic. These results underline that although the Maya lowlands being a geographically small-scale region, its climate was influenced by remote forcings, demonstrating the teleconnections inherent in global climate systems. Our study therefore not only clarifies the complex climatic factors behind the Mayan collapse but also emphasizes the interconnection of the climate – a crucial insight in an era of rapidly changing climate world.

Presentation

Speaker

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Abstract

Decoding Ritual Landscape, Transition and Continuity: Towards Ethnoarchaeological Study of the Palghar Region of Maharashtra With Special Reference to the Newly Discovered Geoglyphs of Saturli Village in Mokshada Block, District Palghar, Maharashtra

Tishyarakshita Nagarkar

Department of Anthropology

This paper presents an ethnoarchaeological cereberation of the ritual landscape and cultural continuity of the religious practices and the rites of passage practiced by the indigenous communities living in the region in the Palghar region of Maharashtra, with special reference to the newly discovered geoglyphs in the village of Saturli in the Mokhada block of Palghar district. Besides locating the sites, the study has utilized first-hand archaeological data, along with the application of landscape and sacred geography theory infused with ethnographic data and experimental archaeology. This research employs a multidisciplinary approach, using both qualitative and quantitative methodologies. The author considers the characteristics of the site, its potential creators, and its possible successors by using the careful techniques of ethnoarchaeology and landscape surveys such as route of migration, nature and extent of settlement pattern, site selection and the ancestry through genealogy and man-nature-man-land relationship pattern.

As the study also seeks to understand the possible authors of geoglyphs and the role of the climate surrounding the cultural genesis, pollen and sedimentological records are in the process of the lab analysis, to get a deeper understanding of the influence of climate on these activities. Additionally, it explores the traditions of the indigenous people to assess the presence of cultural continuity in the region, role of the changing climate of the culture and the formation of the site. Furthermore, its purpose is to provide light on the history and culture of the area in novel ways that have not been previously explored.

Keywords

Reconstructing the past, Ethnoarchaeological Research, Contextualizing the symbols through culture continuity, Decoding the geoglyphs of the tribal landscape, Tribal Culture in the archaeological context

Presentation

Speaker

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Abstract

Vector-borne diseases in the Anthropocene

RAMSTEIN Gilles[1], CAMINADE Cyril[2], CHEMISON Alizée[1], TOMPKINS Adrian M.[2], DEFRANCE Dimitri[3], JONES Anne[4], MORSE Andy[5]

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Most of the paleo climate modeling groups are involved in the CMIP scenario exercise. In addition, paleo climate modelers are used to investigate glacial / deglacial cycles at long time scales.

Therefore, they know that many important climatic thresholds occurred at pluri-secular time scales. In particular, the cryosphere has not a linear response to climate changes. Based on sea-level data reconstructions of the last deglaciation cycle (21-6k), it has been demonstrated that there are melting acceleration and stagnation phases.

To account for such non-linear instability of the ice sheet, we designed an original ice-melting scenario superimposed to RCP8.5 in order to explore an accelerated melting of the Greenland ice sheet (GRIS). We used an analogy with ice sheet destabilization periods and associated icebergs surges over the North Atlantic during glacial episodes. Through large-scale teleconnections, these rapid ice-melting events (although occurring at high latitudes) have been shown to deeply modify the African monsoon intensity and its location (Mulitza, Paleoceanography and Paleoclimatology, 2008). To explore whether a large melting of the Greenland ice sheet could affect the African monsoon, we added freshwater inputs corresponding to an accelerating melting of GRIS (equivalent to a sea level rise ranging from 0.5 to 3 meters) to standard RCP8.5 scenario (DeFrance et al., PNAS, 2017).

In a second step, we used these scenarios to drive different mathematical malaria models to investigate the impact of such an accelerated melting of GRIS on malaria transmission risk in Africa. A first study based on standard RCP scenarios demonstrated that malaria risk might spread from the lowland areas to the East African plateau in future (Caminade et al., PNAS 2014). We show that an accelerated GRIS melting might additionally lead to a southward shift of malaria over Southern Africa in future (Chemison et al., Nature Communications, 2021).

We will describe the impact of such rapid-ice melting scenarios for malaria and Rift Valley fever (Chemison et al., Nature Scientific Reports, 2024) and discuss new avenues for the development of novel vector borne disease models.

Presentation

Speaker

Haijun Yang

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Abstract

Multi-centennial oscillation of the Atlantic Meridional Overturning Circulation and the evolution of human civilization

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The Atlantic Meridional Overturning Circulation (AMOC) is a large-scale ocean circulation system that plays a key role in the global climate system. Long-term proxy data indicate that the Earth's climate system has a climate variability on a time scale of several centuries. The cause and mechanism of this variability has long been a major scientific issue that has puzzled climatologists and archaeologists. Changes in the Atlantic Meridional Overturning Circulation (AMOC) are believed to have influenced the historical development of human civilization. For instance, a weakening of the AMOC is believed to possibly be associated with the Little Ice Age in Europe, a period from the 14th to the 19th centuries when the climate in Europe was unusually cold. Moreover, changes in the AMOC could also affect storm activity and precipitation patterns, impacting human societal aspects like agriculture, water supply, ecosystems, and economic activities. We have established a theory of the multi-centennial self-sustaining oscillation of the AMOC, which can well explain the multi-centennial variability found in observations and numerical models. This helps to deeply understand the origin of the multi-centennial variability of the climate system and will contribute to the understanding of the evolution of human civilization over the past five thousand years.

Presentation

Speaker

Ralf Greve

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Abstract

Reduced mass loss from the Greenland ice sheet under stratospheric aerosol injection, and some general considerations about pros and cons of geoengineering techniques

Ralf Greve

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Geoengineering (aka "climate intervention") is a highly contentious topic. Stratospheric aerosol injection (SAI), which falls into the category of solar geoengineering, has been proposed as one potential method. In a recently published study (Moore, Greve and 4 others, 2023, doi: 10.1029/2023JF007112), we use the SICOPOLIS (www.sicopolis.net) and Elmer/Ice (elmerice.elmerfem.org) dynamic models driven by changes in surface mass balance, surface temperature and ocean temperature (similar to ISMIP6-Greenland; Goelzer et al., 2020, doi: 10.5194/tc-14-3071-2020) to estimate the sea-level-rise contribution from the Greenland ice sheet under the IPCC RCP4.5, RCP8.5 and GeoMIP G4 (Kravitz et al., 2013, doi: 10.1002/2013JD020569) scenarios. The G4 scenario adds 5 Tg/yr sulfate aerosols to the equatorial lower stratosphere to the IPCC RCP4.5 scenario.

We simulate the mass loss of the Greenland ice sheet for the period 2015-2090 under the three scenarios with four earth system models, using SICOPOLIS with hybrid shallow-ice--shelfy-stream dynamics and Elmer/Ice in the Elmer/Ice-sheet set-up with shelfy stream dynamics. Relative to the constant-climate control simulations, the losses from 2015 to 2090 are 89.1 [79.9, 99.8] mm SLE (millimetres of sea-level equivalent) for RCP8.5, 62.8 [56.9, 70.9] mm SLE for RCP4.5 and 41.3 [22.5, 56.8] mm SLE for G4 (mean and full range). Thus, the mass loss under RCP4.5 is 36%-48% smaller than under RCP8.5, and under G4 (RCP4.5 + SAI) it is 31%-38% smaller than under RCP4.5. The partitioning of the mass loss between surface mass balance (SMB) and calving differs between the two ice-sheet models: while for both models the SMB contribution is dominant, SICOPOLIS predicts a relatively larger contribution due to calving.

Our results indicate that SAI can be beneficial for limiting the decay of the Greenland ice sheet. However, the study is not meant to be a plea for SAI testing or implementation. Rather, we will put it into a wider context and discuss pros and cons of geoengineering approaches to mitigate some of the adverse effects of anthropogenic climate change.

IBS Conference on

Climate and Human Evolution

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Pusan National University
Busan, Korea

Institute for Basic Science

IBS Center for Climate Physics

POSTER SESSION

POSTER PRESENTATION

SPEAKERS

Guohao Liang
Institute of Geophysics and Meteorology, University of Cologne, Germany, Program for HESCOR

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Department of Geology & Geophysics, University of Utah

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Carlos Pérez-Mejías
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Sayak Basu
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Anupam Samanta
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Poster Presentation

Speaker

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Abstract

Dispersal of Homo sapiens to East Asia

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The dispersal of Homo sapiens from Africa to East Asia is a fundamental aspect of human evolutionary history, yet many questions remain regarding the mechanisms, routes, and timings of this migration. Climate may play a crucial role in early human migration, this research proposal aims to investigate the impact of climate change on the dispersal of Homo sapiens to East Asia based on the Climate-driven Human Dispersal Model (HDM).

Poster Presentation

Speaker

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Abstract

Joint climate and fire histories from stalagmites – a Bayesian proxy system modelling approach

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Exploring the connections between humans, climate, and fire from the past to the present relies on access to high-resolution information about terrestrial climatic conditions and ecosystem changes. Stalagmites are one of the most valuable terrestrial palaeoenvironmental records as they often preserve long climatic sequences with high temporal resolution, can be absolutely dated with high precision, and record detailed information on a range of climatic and environmental variables. For this reason, speleothems are widely used as palaeoenvironmental archives, predominantly to reconstruct past hydroclimate variability. More recently, speleothems have been found to preserve information on past fires via organic molecular biomarkers such as anhydrosugars and polycyclic aromatic hydrocarbons (PAHs) and have become an archive of particular interest for reconstructing joint climate and fire histories beyond the instrumental record.

Despite this promise, palaeoclimate and palaeofire proxy data in stalagmites can be challenging to interpret due to the complex nature of karst systems and speleothem formation that influences climate signal incorporation. A powerful way to improve reconstructions from proxy data are numerical forward models – or "proxy system models" (PSMs) – of the karst and stalagmite system that account for the conditions and processes that govern how external forcings are transmitted through the surface and karst, and ultimately recorded in the stalagmite archive. Here we present a newly developed stalagmite PSM targeting both established palaeoclimate proxies and novel biomarker proxies of fire activity. We will employ the model within a Bayesian joint inversion framework to allow for a robust representation of uncertainties and quantitative integration of multiple proxies.

As part of the StalFire consortium project, the model draws upon extensive monitoring and stalagmite record development in California caves exposed to significant fires. We present forward modelling results of cave hydrology, stable isotope and fire biomarkers using the examples of C67 cave in the southern Sierra Nevada and White Moon Cave in the Santa Cruz Mountains, focusing on disentangling moisture source and precipitation amount effects. Going forward, model inversion will support the exploration of hydroclimate and fire activity in California over the past 70,000 years.

Poster Presentation

Speaker

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Abstract

The role of sea level and seaways in modulating large-scale atmospheric circulations during the Last Glacial Period

Yeyi Fu, Mingna Wu, Zhongshi Zhang

China University of Geosciences

Paleo-climate records revealed that the Hadley circulation (HC) contracted, while the Walker circulation (WC) weakened and shifted eastward during the Last Glacial (LG) period. However, whether climate modelling can replicate changes in these tropical large-scale atmospheric circulations and the relevant mechanisms remain unclear. Here, using climate simulations based the Norwegian Earth System Model (NorESM1-F), we show that sea level decline and closure of seaways play important roles in modulating the tropical large-scale atmospheric circulations during the initial stage of the Last Glacial (LG) period (~70ka). The sea level fall can lead to an inter-hemispheric energy imbalance, which in turn causes a southward shift of HC. The closure of seaways can weaken the HC in the Northern Hemisphere while strengthening its southern counterpart and resulting in equatorward shits of its boundaries in both hemispheres. Furthermore, the eastward shift of the WC can be attributed to both the fall in sea level and the closure of seaways, while the weakening of the WC is primarily attributed to the latter factor. Our results demonstrate the importance of taking changes in global mean sea level and seaways into account when simulating the climate during glacial periods.

Poster Presentation

Speaker

Christian Wirths

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Abstract

Unravelling Antarctica's contribution to Quaternary Sea Level variability

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Sea-level change is one of the many climatic drivers of human evolution. Especially, the impact of the large northern hemispheric Ice Sheets on Quaternary Sea Level variability has been extensively studied in the past. In contrast, the role of Antarctica as a driver for global sea level change during this period, especially during major climate transitions, is mostly unknown.

Here, we use the Parallel Ice Sheet Model (PISM) to simulate the transient evolution of the Antarctic Ice Sheet through the Quaternary. Computation of the evolution of ice sheets in PISM is enabled by means of a climate index approach that is based on snapshots of climatic conditions at key periods. The climate index approach interpolates between individual climate snapshots based on various paleo-proxy records. 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.

In our study, we aim to quantify Antarctica's influence on sea level variability and its uncertainty during the Quaternary, especially during potential dynamic transitions of the climate-cryosphere system. The findings from this study will contribute to an improved understanding of the climatic boundary conditions, in particular coastal accessibility which is an important element driving human evolution.

Poster Presentation

Speaker

Nitesh Sinha

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Abstract

Understanding orbital-scale variations of the Eastern Asian Summer Monsoon

Nitesh Sinha[1,2], Axel Timmermann[1,2], Sun-Seon Lee[1,2], Kyoung-Nam Jo[3], Jasper A. Wassenburg[1,2], Daniel M. Cleary[1,2], Kyung-Sook Yun[1,2]

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To interpret speleothem oxygen isotope (δ18O) records it is necessary to quantify the individual contributions from local rainfall and temperature changes, the integrated upstream history of Rayleigh distillation, and other possible source effects. Focusing on the East Asian summer monsoon (EASM) region, we determine the drivers of orbital-scale precipitation-δ18O variations using a 130,000-year accelerated astronomically-forced transient simulation conducted with the isotope-enabled Community Earth System Model 1.2. The model simulates a zonally-elongated band of precessional-scale variability in EASM precipitation stretching from central China to southern Japan. EASM variations in this band are anti-correlated with local summer insolation. The corresponding changes in precipitation-δ18O exhibit a zonal dipole pattern with strong precessional signals in the western part of the EASM region and rather weak signals over far eastern China, the Korean Peninsula, and Japan. A comparison of precipitation and moisture transport patterns between low and high precession conditions shows that the North Pacific Subtropical High (NPSH) primarily controls the EASM precipitation variability. For northern summer perihelion conditions, the anomalous western NPSH (WNPSH) generates anomalous southerlies, thereby limiting Indian summer monsoon (ISM) moisture transport to the east. This process is further reflected in a shorter Rayleigh distillation pathway and hence more positive δ18O over the eastern EASM region.

In contrast, for northern summer aphelion conditions, the southward migration of the WNPSH leads to an increased moisture transport from the remote ISM to Eastern Asia and hence more depleted precipitation-δ18O values. Deuterium excess (d-excess) in the transient simulation further captures the corresponding changes in moisture source locations and source surface conditions for extreme orbital states. According to our analysis, the precessional-scale interplay between Pacific and ISM moisture sources strongly controls variations in speleothem-δ18O in central and northeastern China, whereas the much weaker signal over Korea and Japan can be explained by compensating effects of oceanic and continental moistures.

Poster Presentation

Speaker

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Abstract

Impact of Solar Activity and ENSO on the Early Summer Asian Monsoon During the Last Millennium

Shih-Yu Lee, Po-Ju Chen

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The Asian Monsoonal rainfall accounts for the majority of annual regional precipitation in East and South Asia and could be remotely regulated by El Niño-Southern Oscillation (ENSO). Besides, several paleoclimate records and simulations have indicated solar signals in the Asian Monsoon, implying the impact of solar activity on the regional monsoon precipitation. By conducting multi-linear regression analysis to the solar irradiance forced single-forcing experiment in the last millennium, this study presents the comparison of solar and ENSO effects on monsoonal precipitation in South and East Asia during early summer (May–June). Increased total solar irradiance during high solar activity years tends to trigger a favorable environment for developing monsoon onset, leading to more precipitation against ENSO-related patterns over Southeast and South Asia before peak-summer (July–August). The result supports reconstructed terrestrial records and underlines considerable influences of the solar cycle on the variation of the Asian Summer Monsoon.

Poster Presentation

Speaker

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Abstract

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.

Poster Presentation

Speaker

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Abstract

Seasonal scheduling of shellfish collection and paleoenvironmental reconstruction based on archaeological shells from Blombos Cave, South Africa

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The Blombos Cave on the southern coast of South Africa is well known for its archaeological remains, which are important for understanding modern human behaviour's development during the Middle Stone Age. This study explores the seasonal scheduling of shellfish collection and the seasonality of the marine climate off Blombos Cave through stable oxygen isotope analysis of the marine gastropod Turbo sarmaticus. By analyzing δ18O values in sequential growth increments of T. sarmaticus shells from archaeological deposits, we reconstruct past sea surface temperatures (SSTs) and seasonal patterns of occupation over the interval 100-70 ka. The δ18O values reveal distinct seasonal fluctuations in SSTs with an amplitude corresponding to approximately 4 °C. This agrees well with the sea surface temperature seasonality off Blombos Cave today, which is influenced by the interaction between the Agulhas Current, which brings warmer water from the Indian Ocean, and the Benguela Current, which brings cooler water from the Atlantic Ocean.

Moreover, the isotopic data provide evidence for the seasonality of human occupation at Blombos Cave. Our preliminary analysis indicates that early Homo sapiens inhabited the site predominantly during the warmer season, exploiting the marine resources during these times. Further studies will include clumped isotope analysis to obtain an independent temperature proxy. This will give us better estimates of the oxygen isotopic composition of coastal waters, allowing better reconstructions of SST and the seasonality of occupation.

Poster Presentation

Speaker

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Abstract

Fluid inclusion isotopes in Moroccan speleothems: a potential tool to reconstruct droughts and provide climate context for early human occupation in northwest Africa

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Morocco is rich in archeological sites documenting the presence of Homo sapiens during the Middle Stone Ages starting as early as 315 ± 34 ka at Jebel Irhoud. Nowadays Morocco (and northern Africa in general) is isolated by the Mediterranean Sea in the north and the (West) Sahara desert in the south. Climatic context to answer critical questions is lacking. What pathway did our early human ancestors take to reach Morocco? Was Morocco a refugia with a continuously suitable habitat for human occupation, or were suitable and unsuitable habitats alternated driven by orbitally induced changes in climate? To address these questions we consider speleothem growth phases and proxies to reconstruct climate as well as Homo sapiens habitat suitability modeling.

We demonstrate that growth phases of Moroccan speleothems show high consistency with modeled Homo sapiens habitat suitability over the last 400,000 years. Interestingly, glacials are associated with higher suitability, which is corroborated by speleothem growth during MIS2, 3, and 10.

Speleothem growth during the glacials may be explained by winter rainfall. Increased moisture transport was likely facilitated by a southward shift of the westerlies.

Winter rainfall in Morocco can be reconstructed from speleothem proxy data. Winter rainfall amount may affect drip rates and precipitation minus evaporation (P-E), which can affect evaporation conditions inside the cave environment. Here we explore the use of speleothem fluid inclusion isotopes (□^{18}O and □^{2}H) to assess their fidelity to reflect in-cave evaporation conditions. We develop a new measurement protocol to quantify evaporative water loss during analytical procedures. This allows to distinguish between evaporation naturally occurring inside the cave and analytically induced evaporation. Fluid inclusion isotope data from an approximately 400,000 years old Touhami Cave flowstone plots close to the local meteoric water line and is consistent with the modern drip water isotope compositions. It is also clear that in-cave evaporative conditions may have changed during the time of flowstone deposition.

Poster Presentation

Speaker

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Abstract

Reconstructing MIS3 climate during Neanderthal extinction in Iberia using speleothems from Spain

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The Iberian Peninsula is one of the last places where Neanderthals survived and possibly interbred with Homo sapiens. Current understanding of the timing of Neanderthal disappearance indicates a difference between the north and south, with Mousterian industries, considered Neanderthal, ending around 44 - 45 ka BP in northern Spain and around 36 - 37 ka BP in the south. Although various hypotheses have been proposed, including major changes in climate and ecosystems or competition with Homo sapiens as possible causes of their extinction, it remains a major topic of discussion.

We present two stalagmite records from eastern Spain, spanning from 59 to 31 ka BP, well covering MIS3, the time interval during which Neanderthals are estimated to have disappeared from both northern and southern Iberia. The stalagmites come from semi-dry areas in two different climate regimes: a continental Mediterranean with annual precipitation around 431 mm in the Iberian Range, and a slightly more humid maritime Mediterranean area in the Balearic Islands. The new proxy data has been resolved at high resolution with very precise chronology, exhibiting temporal uncertainties of around 170 years during the transition from MIS4 to MIS3, and age errors lower than 100 years in the recent part of MIS3, between 35 to 31 ka BP.

Among the results obtained, the d13C profile resembles sea surface temperatures in the proximal Atlantic Ocean, showing a clear response of vegetation and soil respiration to the Dansgaard-Oeschger (DO) oscillations characterized in Greenland ice records. It is noteworthy to evaluate the amplitudes in the isotope profiles for each DO event, which are not constant, unlike what is observed in Greenland records. Thus, the sensitivity and intensity of the d13C response differ among each DO event, a pattern also observed in the responses to the stadials associated with Heinrich events (HS5a, 5, 4, and 3).

This paleoclimate record aims to provide valuable insights into the vegetation and soil conditions in two different biogeographical regions: the Mesomediterranean-Supramediterranean boundary in the Iberian Range, and the Thermomediterranean in the Balearic Islands. These insights are crucial for characterizing the mosaic of vegetation and biodiversity reservoirs found in Iberia at that time, which are regarded as glacial refugia for hominins during cold phases of the last glacial cycle.

Poster Presentation

Speaker

Sayak Basu

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Abstract

Leveraging the combination of observational data and climate model simulations for better understanding of speleothem d18O in the Armenian highlands

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The Armenian Highlands, located at the crossroads of Europe and central Asia, was a potential conduit for hominin interbreeding and expansion between the two regions during the Late Pleistocene. This period witnessed significant abrupt climate change events (D-O cycles / Heinrich events) and glacial-interglacial transitions. Therefore, it is important to assess the hominin response to these global climatic shifts. However, our knowledge of climate-human interactions in the Caucasus region is limited due to dearth of high-resolution climatic records. Speleothems provide precise chronologies and a range of climate proxies, including stable isotopes (d18O and d13C) and trace elements at high resolution. Here, we attempt to reconstruct paleo-hydrological conditions in the Armenian Highlands using a stalagmite (ARJ-6) collected from Arjeri cave. We focused on the top part of ARJ-6 that spans from 27 to 10 ka. However, the climatic interpretation of speleothem d18O is not straight forward. It is thus important to understand the source of the moisture as well as the isotopic fractionation along the moisture pathway. Towards this, we use an isotope-enabled climate model (IsoGSM2) with moisture-tagging capability. This approach enables us to investigate the role of relative contributions of moisture from various sources (Black Sea, Mediterranean etc...) to the interannual d18O variability in Armenian rainfall. We, then, explore the atmospheric circulation patterns that are responsible for the changes in source-wise moisture contributions. Whether the mechanisms that govern interannaul d18O variability are similar on longer timescales has been evaluated using a present-day run of i-CESM d18O. The combined results of IsoGSM2 and i-CESM simulated d18O values will be used to interpret the ARJ-6 speleothem d18O data.

Poster Presentation

Speaker

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Abstract

Mixed calcite-aragonite speleothems from Botswana reveal past inter-annual climate fluctuations

Anupam Samanta[1,2#]; Nitesh Sinha[1,2#]; Jasper A. Wassenburg[1,2]; Andrea Borsato[3]; Silvia Frisia[3]; Fulvio Franchi[4]; Hai Cheng[5]; Yun Seok Yang[1,2]; Axel Timmermann[1,2]

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Speleothems (secondary cave carbonates) are excellent archives of past climate. We present speleothem data from Gcwihaba Cave in north Botswana, a key location to study climate effects on early human evolution. We employed oxygen (□^{18}O), carbon (□^{13}C) isotope, and trace element (such as Mg/Ca, Sr/Ca, and Ba/Ca) analyses to reconstruct past climate shifts in Southern Africa.

Gcwihaba speleothems consist of calcite - aragonite mixed mineralogies as shown by X-ray Diffraction and Raman spectroscopy, confirming earlier work in this cave (Railsback et al., 1994). This can potentially influence/alter the isotopic proxy response to climate parameters. Mineralogical and petrographic studies of these speleothems are thus crucial to determine the climate signals within them.

Preliminary petrographic investigations of selected samples show micro to millimeter scale alternate visible laminations. U-Th ages and layer counting indicate they are likely of an annual nature that is dictated by the strong seasonal contrast of rainfall in the area. Modern-day calcite farming experiments during late winter to early summer also show the co-existence of aragonite-calcite precipitation in the cave. The seasonal layers may give further insight into the generation and modulation of interannual climate variability in this area, which is partly linked to the Indian Ocean Dipole and El Niño-Southern Oscillation phenomena.

Initial chronological information based on U-series dating confirms that the growth period of these samples covers approximately the last 300,000 years. Two speleothems are of Holocene age; one speleothem is approximately 50,000 years old. A flowstone is dated between 130 and 300 thousand years before the present; however, the record consists of several growth interruptions, which may be related to drier climate conditions.

Poster Presentation

Speaker

Jyoti Jadhav

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Abstract

Elucidating the mechanisms of 400-kyr tropical hydroclimate variability during the Plio-Pleistocene

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The control of the eccentricity on annual mean insolation is minimal. Yet, a strong variability on eccentricity timescales, especially the 400-kyr cycle, has been observed in tropical hydroclimate records. As suggested previously this variability may have played an important role in shaping early human evolution in eastern Africa.

Here, we present results both from Pliocene/Pleistocene paleoclimate proxies and an unprecedented transient climate simulation conducted with NCAR's realistic Community Earth System Model version 1.2; the latter covers the climate history of the past 3 million years. The analyses of existing carbon isotope records (i.e., planktic and benthic δ13C) from marine sediment cores of the Pacific and Atlantic oceans and other paleoclimatic (terrigenous dust flux) archives from the Pliocene and early Pleistocene (>1.5 Myr) reveal clear 400-kyr climate signals, suggesting eccentricity-paced changes in the long-term carbon cycle. Our model simulates 400-kyr variability in tropical hydroclimate. However, the climatic control on the robust feature of the carbon cycle (i.e., the 400-kyr oscillation) and dynamics during the Plio-Pleistocene is poorly understood. Our study focuses on different hypotheses following the antiphase relation of marine δ13C with the eccentricity cycle. First, we will provide a combined perspective on the role of atmospheric circulation and, thus, dust in the dynamic of the carbon cycle and productivity, and second, assess the ecosystem response (vegetation) to changes in precipitation in connection with changes in atmospheric CO2.

Poster Presentation

Speaker

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Abstract

Reconciling East Asia's mid-Holocene temperature discrepancy through vegetation-climate feedback

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The Holocene temperature conundrum, marked by inconsistencies between proxy-based reconstructions and transient model simulations, challenges our understanding of Holocene temperature evolution. Reconstructions suggest a cooling trend after 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 found the impact of vegetation-climate feedback on 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, we aim 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 enhanced the 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.

Poster Presentation

Speaker

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Abstract

Integrating Climate Variables in Population Projections for Enhanced Climate Change Risk Assessment

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Estimates of future population distribution are extremely important for accurately assessing the future impacts of climate change, as population distribution directly affects vulnerability and exposure to climate-related risks. However, climate change impacts have rarely been integrated into projections of future population distributions, leading to potential underestimations of risk in certain areas. Therefore, we have recalculated future population projections by enhancing the method developed by Reimann et al. (2023), incorporating key climate change-related variables such as temperature, precipitation, agricultural productivity, and water resource availability. This integration aims to produce a more comprehensive and realistic projection of how populations may redistribute in response to climate change.

The enhanced method utilizes a gravity model approach, similar to that described in the study by Reimann et al. (2023), but with significant improvements. The gravity model traditionally estimates migration flows based on factors like distance and population size, reflecting the "attractiveness" of destinations and the "resistance" to migration posed by distance. Our improved approach includes dynamic climate variables such as temperature anomalies, shifts in precipitation patterns, and changes in agricultural productivity, which are crucial for understanding how environmental changes drive migration. Furthermore, we consider the availability of water resources, recognizing that water scarcity or abundance is a critical determinant of human settlement patterns.

The results demonstrate that population migration hotspots shift significantly, leading to notable changes in the spatial distribution of future extreme weather risks, as estimated by studies like Sano and Oki (2022) and others. These shifts highlight areas that may become increasingly vulnerable due to climate change, emphasizing the need for targeted adaptation and mitigation strategies. For example, regions projected to experience severe droughts might see population declines, while areas with improved agricultural conditions might attract more people, thus redistributing the risk landscape.

The findings of this study offer a novel and improved projection of future population distribution, facilitating a more plausible and nuanced analysis of future climate change risks. This research provides numerous implications and directions for future climate change policymaking, underscoring the necessity of integrating dynamic population changes into climate impact assessments to enhance the accuracy and effectiveness of climate policies.

Policymakers can utilize these projections to identify regions that are likely to experience significant demographic changes due to climate stressors, enabling them to allocate resources more efficiently and design interventions that are responsive to the evolving landscape of risk. Furthermore, this research significantly contributes to risk communication by providing clearer and more detailed information about potential future scenarios. By highlighting areas at greatest risk, this study encourages a collaborative approach to risk management, involving local communities, governments, and international bodies.

In summary, this study not only enhances the scientific understanding of future population distributions in the context of climate change but also serves as a critical tool for policymakers and risk communicators. By fostering informed decision-making and effective risk communication, the research helps to build more resilient societies capable of adapting to the challenges posed by a changing climate.

Reimann, L., Jones, B., Bieker, N., Wolff, C., Aerts, J. C., & Vafeidis, A. T. (2023). Exploring spatial feedbacks between adaptation policies and internal migration patterns due to sea-level rise. nature communications, 14(1), 2630.

Sano, T., & Oki, T. (2022). Future population transgress climatic risk boundaries of extreme temperature and precipitation. Environmental Research Communications, 4(8), 081001.

Poster Presentation

Speaker

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Abstract

Abrupt Climate Changes Before and After the Founding of the Xia Dynasty-Simulations and Mechanisms

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The climate was very stable during the Holocene, and it is a period of brilliant development of human civilization. The period of 5.0–3.0 ka BP (before present, present=1950 A.D.) marks a critical transition from the mid-to late-Holocene, characterized by significant climate regime changes. The most notable event during this period was the abrupt climate change known as the "4.2 ka BP event," which occurred from 4.2 to 3.9 ka BP and demarcated the boundary between the warmer mid-Holocene and the cooler late-Holocene. This abrupt climate shift is thought to have led to the collapse of several ancient civilizations, but the Xia dynasty in Ancient China was founded. It was the first dynasty in Chinese history, which started the glorious historical period of China. We have discovered the role of the abrupt climate change from wet to dry in the establishment of the Xia Dynasty by climate model, and identified the mechanism of its influence.

Poster Presentation

Speaker

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Abstract

Contextualising southern South African paleo-environments during the Middle Stone Age (100-50 ka), based on sediment provenance reconstructions

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The southern Cape of South Africa has been a key locus for recovering archaeological evidence from sites occupied by early humans after 165 ka. The period from 100-50 ka is an especially significant time in the development of the cultural, cognitive, and subsistence innovations in that area among early Homo sapiens (H.sapiens). However, detailed environmental reconstructions from this area are lacking, hindering our ability to determine the climate to which early humans were exposed at the time. Here, we present a South African river sediments study, coupled to marine sediment core signals from site MD20-3591 (36°43.707 S; 22°9.151 E, water depth 2464m) during the 100-50 ka time interval, to infer rainfall seasonality changes.

Radiogenic isotope (87Sr/86Sr ratios and eNd), grain size and X-ray fluorescence records from marine sediment core MD20-3591, located approximately 1600 km downstream from the Limpopo River, within the main flow of the Agulhas Current, will be shown to provide insights on the sediment source changes during 100-50 ka. The eNd record is used to reconstruct sediment sources while regional chemical weathering records can be obtained from the 87Sr/86Sr ratio. On orbital time scales, the eNd record is reflecting changes in distal river discharge transported southwards in the Agulhas Current, likely resulting from a combination of local insolation and latitudinal ITCZ shifts.

We find an increased sediment contribution from the Limpopo River catchment during local summer insolation maxima which likely drove southward shifts in the subtropical rain belts and increased runoff from this basin. During local summer insolation minima, we observe more locally sourced sediments based on the MD20-3591 eNd record. This is indicative of more local humid conditions over the river catchments of southern South Africa, arising from a northward shift in the westerlies influencing the winter rainfall zone.

Finally, XRF, grain size and radiogenic isotope data reveal a consistent pattern of more local South African sediment input at marine sediment core site MD20-3591 during MIS 4 glacial, with coarser sediment input from rivers due to a reduced distance from the palaeoshoreline at the sea-level low-stand.

Poster Presentation

Speaker

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Abstract

A Simple Model Study of the Multicentennial Oscillation of AMOC

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In this work, we extend our previous theoretical and coupled model research on the multi-centennial oscillation (MCO) of the Atlantic Meridional Overturning Circulation (AMOC) using a simple ocean model. Initially, we simulate a climatological state of AMOC that closely resembles real-world state by the simplified two-dimensional ocean model. Based on this state, we demonstrate that stochastic freshwater forcing can excite MCOs in the AMOC and these oscillations are driven by the tropical-subpolar salinity advection feedback. In addition, we also analyse the factors that affect the MCO oscillation period of AMOC. Our analysis reveals that the oscillation period of the AMOC is influenced by the depth and intensity of its equilibrium state. Specifically, for a given AMOC strength, a greater depth corresponds to a longer oscillation period, while for a constant depth, a stronger AMOC results in a shorter oscillation period. Furthermore, under stochastic forcing in the form of red noise, we find millennial oscillations, which require further investigation in the future. We also examine the role of wind-driven circulation and find it has minimal impact on the MCO oscillation period. The findings from the simple model align with those from box and coupled models, providing a new perspective on the multi-centennial variability of the climate system.We suggest that AMOC-induced variability may have historically influenced significant climatic events, potentially impacting the succession of Chinese dynasties and the rise and fall of civilizations. Our study offers valuable insights into the mechanisms driving long-term climate variability, emphasizing the importance of the AMOC in shaping historical climate patterns.

Poster Presentation

Speaker

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Abstract

Study of Multicentennial Variability in the Atlantic Ocean Based on a Three-Dimensional Ocean Circulation Model

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Many paleoclimate proxy data indicate that there have been multicentennial climate changes in the historical climate system, predominantly distributed around the North Atlantic. Due to its long timescale memory and the significant oceanic heat meridional transport, changes in the Atlantic Meridional Overturning Circulation (AMOC) are often used to explain low-frequency signals in various regions.

This study uses the three-dimensional ocean model MITgcm to simulate the circulation state of the Atlantic to explore the multicentennial natural variability of AMOC. Centurial scale variability is associated with changes in the strength of the thermohaline circulation. Under free forcing (with a small amplitude random perturbation added to the freshwater flux), there are centurial oscillations (with periods between 200-300 years) in a single-basin two-dimensional model, driven by large-scale SSS anomaly advection. When the AMOC strengthens, more subtropical seawater flows into the subpolar region, causing the subpolar region to warm and become saltier. Warming reduces the density of subpolar seawater, inhibiting deepwater formation and thereby weakening the AMOC, a process known as temperature advection negative feedback. Increasing salinity increases the density of subpolar seawater, promoting deepwater formation and thereby strengthening the AMOC, a process known as salinity advection positive feedback.

This process helps us understand the multicentennial variability of the AMOC. When the timescale of subpolar sea surface temperature anomaly decay is much shorter than that of salinity anomaly, the influx of lighter subtropical seawater into the subpolar region might instead increase the density of subpolar seawater, with salinity advection positive feedback dominating.

Natural variability has had a significant impact on actual climate changes since the 20th century. Similarly, multicentennial scale natural variability can affect climate changes on multicentennial timescales. However, compared to climate variability on shorter or longer timescales, multicentennial climate variability has received relatively less attention. Therefore, this study is of great significance for predicting future climate changes and for cultural exploration.

Poster Presentation

Speaker

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Abstract

Climate or competition? The case of third molar elongation in Plio-Pleistocene African suids

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Plio-Pleistocene African suids showed convergent increases in third molars (M3s) crown height and length. These changes have been interpreted as adaptations to herbivory in progressively open landscapes due to climatic change. To evaluate this interpretation, we provide a synthesis of dental morphometric and paleoecological data (microwear and stable isotopes) of three suid lineages: Nyanzachoerus-Notochoerus, Kolpochoerus, and Metridiochoerus.

In addition to the strong anagenetic changes in some lineages, cladogenesis in all three lineages falls within two intervals of climatic variability: 3.0-2.5 Ma, 2.0-1.5 Ma. Early specimens display short, low-crowned M3s that are supposedly ill-adapted to grass-eating. The Nyanzachoerus-Notochoerus lineage started as mixed feeders and progressively became reliant on grasses. Both Kolpochoerus and Metridiochoerus quickly became grass-eaters, long before the M3 elongations in certain lineages. The narrowing of the suid dietary niche during the Pliocene coincides with the gradual decline in the relative abundance of suids, in contrast to the thriving of the bovids. During the early Pleistocene, the diet of the three suid lineages converged on C4 plants (likely grasses). Compared to Notochoerus and Metridiochoerus, the lower crowns and thicker enamel of Kolpochoerus suggest a more mesic ecological niche.

The discordance between diet and M3 elongations does not support a progressive adaptation to open landscapes. The elongations can be better explained by the progressive narrowing of their ecological niche and dietary specialization in eating short grasses due to competition with other herbivorous mammals. As such, biotic interactions are likely driving forces of morphological evolution in other taxa, including humans.

Poster Presentation

Speaker

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Abstract

Self-sustained Multicentennial Oscillation of the Atlantic Meridional Overturning Circulation in Two-hemisphere Box Models

Xiangying Zhou, Kunpeng Yang, Haijun Yang

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Our previous studies have given a new insight in the theory for a self-sustained multicentennial oscillation (MCO) of the Atlantic meridional overturning circulation (AMOC) in a one-hemisphere box model. In this paper, we extend the one-hemisphere model to a more realistic two-hemisphere model, and study the roles of both the thermohaline and wind-driven circulations in the MCO. A similar self-sustained AMOC MCO in the two-hemisphere box model is identified. Several new findings are summarized as follows. First, the salinity advection feedback in the North Atlantic still plays the most important role in controlling AMOC MCO, while that in the South Atlantic is unimportant. Second, in comparison to the self-sustained AMOC MCO in the one-hemisphere box model, the counterpart in the two-hemisphere box model exhibits higher probability of occurrence and less sensitivity to changes in basin geometry. Third, the wind-driven circulation can weaken MCO amplitude because the negative feedback between the wind-driven and thermohaline circulations restrains the salinity advection feedback, while its effect on MCO period is negligible. Fourth, without the thermohaline circulation, there will be no MCO, suggesting the thermohaline circulation is a necessary condition for the AMOC MCO. Similar to previous studies, stochastic freshwater forcing can excite sustained AMOC MCO, and the MCO is an intrinsic mode of the thermohaline circulation. We also find a damped millennial oscillatory mode in the two-hemispheric box model, which needs to be investigated further in the future.

Poster Presentation

Speaker

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Abstract

The Multi-Centennial Variability of Climate Determined the Rise and Fall of Tubo Dynasty

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The Tubo Dynasty (~618-842 AD) located in Tibetan Plateau experienced significant fluctuations in power largely influenced by climate variability. This study employs EC-Earth 3 numerical model, alongside historical documents, proxy data such as ice core and lake sediment data to investigate the reason why the Tubo Dynasty collapsed. In our study, the EC-Earth 3 past-8000-year transient simulation shows a warm and humid climate during the early Tubo Dynasty, promoting its agricultural productivity and societal prosperity, which is corroborated by evidence proposed in previous study.

However, by the late 8th century, the climate of Tubo Dynasty gradually shifted to cooler and drier conditions, resulting in agricultural decline and socio-economic crises. This climatic deterioration exacerbated internal civil conflicts and external threats, leading to the dynasty's downfall.

This research highlights the critical role of climate variability in the rise and fall of the Tubo Dynasty, and highly promotes the research of climate change influence on the evolution of human civilization.

Poster Presentation

Speaker

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Abstract

Asynchronous Holocene human population changes in north and south China as related to animal resource utilization

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During the Holocene, rich Neolithic and Bronze cultures developed in the middle and lower reaches of Yellow River valley (north China) and Yangtze River valley (south China), making them the core areas of past human activities. Thus, it is important to reveal the process and driving mechanism of regional population change. Agriculture development has always been taken as the key driver of population changes, and current studies mainly focus on the role that cultivation played, however, it is still unclear if animal resource utilization also contributed to regional population changes. Here, the spatiotemporal changes of population and domestic animal utilization levels in north and south China from 10 to 2 ka BP have been reconstructed based on 27935 archaeological sites and faunal remains data from 94 sites, respectively, and the change in potential wild animal resources has been simulated by the Minimum Terrestrial Resource Model (MTRM). The results show asynchronous changes of population occurred in north and south China during 10-2 ka BP, which were correlated with regional domestic and potential wild animal resource utilization. In north China, more significant population growth corresponded to a greater increase of domestic animal ratios and a sharp decline of potential wild animal resources after 8 ka BP. In south China, less significant population growth was accompanied by a slower increase of domestic animal ratios and stable variations of potential wild animal resources. This research suggests that different changes of potential wild animal resources in north and south China contributed to spatial variations in survival pressure, utilization level of domestic animals, and population growth, which was further determined by asynchronous changes of precipitation in the two regions. This study explains the impact of climate changes on population from a new perspective.

Keywords

population, domestic animals, wild animal resources, climate change

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