

for populations previously supported by cereal dry-farming. Irrigation agriculture was not, however, possible for the northern alluvial plains of the Tigris and Euphrates Rivers, where incised riverbeds were several meters below plain level. Exploitable plain-level levees were only accessible in southern-most alluvial plain, at the head of the present-day Persian Gulf. The archaeological data from this region documents the first irrigation agriculture settlement of the plain during the 8.2 kaBP event. Irrigation agriculture provides about twice the yield of dry-farming in Mesopotamia, but at considerable labor costs relative to dry-farming. With irrigation agriculture surplus production was now available for deployment. But why work more? The 8.2 kaBP event provided the natural force for Mesopotamian irrigation agriculture and surplus production that were essential for the earliest class-formation and urban life.

PP22C-02 1615h

Agriculture, Settlement, and Abrupt Climate Change: The 4.2ka BP event in Northern Mesopotamia

Lauren Ristvet (lmr26@cam.ac.uk)

King's College, University of Cambridge, Cambridge CB2 1ST, United Kingdom

An abrupt aridification event at 4200 BP has been recorded in 41 paleoclimate proxies in the Old World, from Kilimanjaro, Tanzania to Rajasthan, India, East Asia and the Pacific. This event is particularly well defined for Western Asia, where it has been associated with the abandonment of settlements across the Fertile Crescent and the collapse of states on the Levantine coast and in the dry-farming plains of Northern Mesopotamia, including the Akkadian Empire. Adaptations to climate change are constrained by both local environmental and social factors. Agriculturalists, especially those living in pre-industrial societies, are particularly susceptible to changes in precipitation. The Tell Leilan Regional Survey, which systematically studied sites in a 1650km² area of Northeastern Syria, records one set of adaptations to this event in an area where dry-farming provided the subsistence base. The survey transect crosses ecotones, from the present 500mm isohyet in the North to the 250mm isohyet in the South, and contains diverse wadi systems, ground water resources, soil profiles, and an ancient marsh/lake—all of which allow this region to be taken as a microcosm of Northern Mesopotamia. In order to contextualize our study of human response to abrupt climate change, it is necessary to consider how the economic and social systems that were previously in place were transformed by this event. This study attempts to quantify climate change and model its effects on agricultural, pastoral, and settlement systems in Northeastern Syria from 2400–1700 BC. From 2400–2300 BC, optimal climate conditions coincided with the consolidation of an indigenous state. The next century witnessed the Akkadian conquest and imperialization of the Habur plains, which resulted in both the intensification and extensification of agro-production. During the next 300 years, (2200–1900 BC), rainfall plummeted to 70% of the climatic optimum, triggering the abandonment of cities along with their attendant villages. The survey records an 80% decline in settled hectares from the previous period. The only agricultural villages that remained occupied during this crisis were either concentrated along perennial wadis or located in areas with ample groundwater. Otherwise, the survey recorded the presence of a few temporary sites, probably camps belonging to semi-nomadic pastoralists, a lifestyle which may have begun in response to this event. The precipitation regime stabilized at approximately 1900 BC, allowing for a massive resettlement of the area. This resettlement did not, however, lead to a resumption of third millennium agricultural practices; instead, these villages embraced a flexible economic regime, which emphasized a reliance on pastoral as well as agricultural products, and as such, was well-adapted to the more marginal conditions of the early second millennium BC. This paper, therefore, attempts to quantify the effects of the 4.2 ka BP abrupt climate change event on ancient agricultural systems, settlement patterns, and societies through archaeological survey in northern Mesopotamia.

PP22C-03 1630h

Archaeological Evidence for Abrupt Climate Change: Results from Satellite Imagery Analysis and Subsequent Ground-Truthing in the El-Manzalah Region, Northeast Egyptian Delta

Sarah H Parcak (sp313@cam.ac.uk)

Cambridge University, Department of Archaeology Downing Street, Cambridge CB2 3DZ, United Kingdom

The abrupt global climate changes recorded at 8.2, 5.2 and 4.2 ka BP caused a wide range of transformations within ancient societies, including the focus of

this study: ancient Egypt. In the case of the climatic changes that occurred at 4.2 ka BP, scholars have debated hotly the events surrounding the "collapse" of the Old Kingdom. Despite such studies into the Old Kingdom's "collapse", there have been insufficient regional settlement pattern studies in Egypt to augment hypotheses concerning the mechanisms behind the cultural transformations that occurred at the end of the Old Kingdom. Utilizing a combination of satellite imagery analysis and subsequent ground-truthing techniques over a broad region in the East Delta, this study aims to reconstruct pharaonic settlement distributions in relation to the changing northeast delta topography, river courses, marshlands, and coastline. Although geo-political and religious factors played varying roles in settlement patterns, this study overlies the economic and environmental components behind the settlement of individual sites and areas. For instance, prior to the formation of the Manzala lagoon, beginning in the 4th century AD, the Mendesian branch of the Nile flowed past Mendes and its satellite, maritime port at Tell Tebilla: As early as the Old Kingdom, Tell Tebilla provided an ideal location for the formation of a town, being well-located to exploit both riverine and maritime transportation routes through trade, and regional floral and faunal resources from hunting, fishing, cultivation and animal husbandry. Key factors such as long-term fluctuations in precipitation, flood levels, and river courses, can affect dramatically the fortunes of individual settlements, areas, and regions, resulting in the decline and abandonment of some sites and the foundation and flourishing of other sites, especially within marginal regions. The Egyptian delta represents an ideal region for studying the impacts of climatic changes through time since it is particularly sensitive to river changes, coastal expansion, and changes within the floral and faunal resource base available to settlements through time. In order to locate ancient settlements in the northeast delta, this study introduced a variety of innovative techniques involving satellite image analysis through Corona, Spot, Landsat and ASTER images, in conjunction with existing archaeological survey data and maps. All known sites were plotted against the satellite imagery data, in order to ascertain whether the newly designed site identification methods worked. The technique had a 95 percent success rate in locating over 100 previously known sites. This technique was next applied to locate new sites and sites believed to be destroyed. In order to verify the accuracy of this new site locational technique, this writer conducted ground-truthing during the summer of 2003, assessing and photographing over 60 new and little known sites in the East Delta. The surface pottery from each site was examined and photographed, and revealed settlements dating to the Old Kingdom, Late Period and Roman Periods. Each known and newly-discovered settlement will be plotted on maps of the eastern Delta, in order to show site disbursement during the time periods represented, especially in relation to geziras, rivers, canals, marshes and the ancient coastline. The paper demonstrates the affects that abrupt climatic changes had on ancient settlement patterns, and reveals how satellite imagery interpretation is applicable to similar studies in other regions.

URL: <http://www.deltasina.com>

PP22D MCC: 3001-3003 Tuesday 1700h

Emiliani Lecture (joint with A, OS, GC)

Presiding: B L Otto-Bliesner,
National Center for Atmospheric
Research

PP22D-01 1700h INVITED

The Anthropogenic Era Began Thousands of Years Ago

William F Ruddiman (540-348-1963;
wfr5c@virginia.edu)

University of Virginia, Clark Hall McCormick Road, Charlottesville, VA 22904, United States

The anthropogenic era is generally thought to have begun about 150 years ago when the industrial revolution began producing CO₂ and CH₄ at rates sufficient to alter atmospheric compositions. The hypothesis proposed here is that anthropogenic emissions first altered atmospheric gas concentrations (and climate) thousands of years ago. This hypothesis rests on three arguments: (1) Cyclic variations in CO₂ and CH₄ driven by Earth-orbital changes during the last 400,000 years predict decreases of both gases throughout the Holocene, but CO₂ began an anomalous increase near 8000 years ago and CH₄ about 5000 years ago. (2) Published explanations attributing these Holocene gas increases to natural forcing can be rejected based on available paleoclimatic evidence. (3) Archeological, cultural, historical, and geologic sources provide viable explanations tied to anthropogenic changes that emerged from early agriculture in Eurasia, including

forest clearance after 8000 years ago and lowland irrigation for rice farming by 5000 years ago. Prior to the industrial era, these emissions caused a mean-annual warming effect of 0.8°C globally and 1.5–2°C at high latitudes. The early-anthropogenic warming counteracted most of a natural cooling that would otherwise have occurred, and it may have prevented a glaciation in northeastern Canada predicted by two kinds of climatic models. CO₂ decreases as large as 10 ppm during the last 1000 years cannot be explained by solar-volcanic forcing without violating constraints imposed by reconstructions of northern hemisphere temperature. The CO₂ decreases can be explained by bubonic plague pandemics that the caused widespread abandonment of western Eurasian farms documented in historical records. Rapid regrowth of forests on millions of abandoned farms could have sequestered enough carbon to explain the observed CO₂ decreases. Plague-driven CO₂ decreases were a significant causal factor in the cooler temperatures of the Little Ice Age from 1300 to 1900 A.D.

PP31A MCC: 3004 Wednesday 0800h

Climate of the Last Glacial-Interglacial Cycle: New Insights From Models and Data (joint with A, OS, C, GC)

Presiding: N S Diffenbaugh,
University of California, Santa Cruz; C
Eakin, NOAA Paleoclimatology,
National Climatic Data Center

PP31A-01 0800h

Polar MM5 Simulations of the Winter Climate of the Laurentide Ice Sheet During the Last Glacial Maximum

E. Richard Toracinta¹ (614-292-1094;
toracinta.1@osu.edu); David H. Bromwich¹
(614-292-1094;
bromwich@polarimet1.mps.ohio-state.edu); Robert
J. Oglesby² (bob.oglesby@nsstc.nasa.gov); Helin
Wei³ (Helin.Wei@noaa.gov); James L. Fastook⁴
(fastook@maine.edu); Terence Hughes⁴
(terry.hughes@maine.edu)

¹Polar Meteorology Group Byrd Polar Research Center The Ohio State University, 1090 Carmack Road 108 Scott Hall, Columbus, OH 43210-1002, United States

²NASA Marshall Space Flight Center National Space Science and Technology Center, 320 Sparkman Drive, Huntsville, AL 35805, United States

³National Centers for Environmental Prediction, WNP2, NOAA WWB207 5200 Auth Road, Camp Springs, MD 20746-4304, United States

⁴Institute for Quaternary and Climate Studies University of Maine, 303 Edward T. Bryand Global Sciences Center, Orono, ME 04469-5790, United States

Polar MM5 simulations are conducted using a 60-km domain centered over North America during Last Glacial Maximum (LGM), roughly 21,000 calendar years ago, when much of continent was covered by the Laurentide Ice Sheet (LIS). The objective is to describe the winter atmospheric circulation over North America using a fine-resolution regional climate model that is well suited for high latitude applications. The Polar MM5 LGM boundary conditions include continental ice sheets, appropriate orbital forcing, reduced CO₂ concentration, paleovegetation, modified sea surface temperatures, and lowered sea level. Output from a CCM3 (NCAR Community Climate Model version 3) simulation of the LGM is used to provide the initial and lateral boundary conditions for Polar MM5. The model atmosphere responds strongly to the LGM boundary conditions. Cooling over the LIS drives a pronounced wintertime low-level katabatic flow. From November through March the upper level flow is split around a blocking anticyclone over the LIS, with a northern branch over the Canadian Arctic and a southern branch impacting southern North America. This split flow pattern, which is most pronounced in January, has a first order influence on the distribution of precipitation in the model domain and is not present in recent GCM simulations of the LGM. Possible reasons for the presence of the split flow, including ice sheet configuration, model resolution, and model physics, are investigated through a series of sensitivity studies. Each contributes to the winter split jet stream in Polar MM5. Comparisons of model output with available proxy data over North America are also discussed.

PP

PP31A-02 0815h

A Multi-Proxy Speleothem Based Record of Asian Monsoon Variability During the Last Glacial Period

Kathleen R. Johnson¹ (kathleen@eps.berkeley.edu)B. Lynn Ingram¹ (ingram@eps.berkeley.edu)Warren Sharp² (wsharp@bgc.org)Pingzhong Zhang³ (pzhang@lzu.edu.cn)¹University of California, Berkeley, Department of Earth and Planetary Science 307 McCone Hall, Berkeley, CA 94720-4767, United States²Berkeley Geochronology Center, 2455 Ridge Rd., Berkeley, CA 94709, United States³Lanzhou University, College of Earth and Environmental Science, Lanzhou 730000, China

Speleothems are well suited for paleoclimatic reconstruction as they preserve paleoclimate proxy data in highly resolvable growth bands and can be precisely dated using U-series dating. Variations in stable isotope composition, trace element composition, and growth band thickness along speleothem growth axes reflect past variations in precipitation and temperature. Oxygen isotopes in speleothems collected from higher latitudes have been widely utilized as paleothermometers due to the strong correlation between $\delta^{18}\text{O}$ of precipitation and surface temperature in these regions. Oxygen isotopes in speleothems from lower latitudes or monsoon regions, however, may be more useful as paleoprecipitation proxies, due to the dominance of the amount effect in these regions. Speleothems collected from Wanxiang Cave, China (33.31° N, 105.00° E.) provide high-resolution records of the Southeast Asian Monsoon variability during the Late Pleistocene. The speleothems are well dated by U-series TIMS methods. The favorable ($^{230}\text{Th}/^{232}\text{Th}$) activity ratios (350-3000) result in the need for only very minor detritus corrections. Wanxiang Cave is located near the northern limit of the summer monsoon, where oxygen isotopes in modern precipitation are largely controlled by the amount of precipitation. Previous records show that the Asian monsoon intensity has varied dramatically during the past, exhibiting increased intensity during interglacial or interstadial periods and decreased intensity during glacial or stadial periods. We present $\delta^{18}\text{O}$ records from Marine Isotope Stages 5a-5b and the last Deglaciation, which suggest that globally warmer periods were characterized by a more intense Asian Monsoon. Large shifts in speleothem $\delta^{18}\text{O}$ occurred at the same time as rapid climate changes observed in Greenland, Antarctica, and the marine record. Due to the complicated systematics of stable isotopes in precipitation in the monsoon regions, we use trace element and uranium isotopic data to support our interpretation of $\delta^{18}\text{O}$ as a paleomonsoon proxy. Initial ($^{234}\text{U}/^{238}\text{U}$) ratios and U, Sr, and Ba concentration are positively correlated with $\delta^{18}\text{O}$ in the speleothems. This lends support to the use of $\delta^{18}\text{O}$ in speleothems as a paleoprecipitation proxy, since during drier periods, when $\delta^{18}\text{O}$ of precipitation is high, evaporative enrichment and increased residence time of vadose groundwaters is expected to lead to increased trace element concentrations and a greater degree of ^{234}U leached out of crystal lattices. We also present growth band thickness data that support our results. Through this multi-proxy approach to paleoclimate reconstruction, there is a strong potential for improvement in the understanding and, hence, applicability of stable isotope and trace element variations in cave calcite deposits from monsoon regions.

PP31A-03 0830h

Sensitivity to Uncertainties and Change in the Tropical and Subtropical Ocean During the Last Glacial Maximum: Reassessment of the CLIMAP LGM.

Nicklas G Piasias¹ (541-737-5213; piasias@coas.oregonstate.edu)Steve Hostetler² (541-737-8928; steve@coas.oregonstate.edu)Alan C Mix¹ (541-737-5212; mix@coas.oregonstate.edu)¹College of Oceanic and Atmospheric Science Oregon State Univ, 104 Ocean Admin Bldg, Corvallis, OR 97331-5503, United States²US Geological Survey, Dept. of Geosciences 104 Wilkinson Hall, Corvallis, OR 97331-8564, United States

The CLIMAP (1981) reconstructions of sea surface temperature (SST) of the Last Glacial Maximum (LGM) ocean have stimulated significant research and controversy. Some geochemical tracers, and the presence of glaciers in areas such as Hawaii and New

Guinea, suggest that the CLIMAP SSTs may be biased in the tropics and subtropics. Here we assemble available data and use a statistical approach to correct for hypothetical biases. We generated new global monthly SST estimates at the LGM as boundary conditions for general circulation model simulations to evaluate sensitivity of global climate to these uncertainties in SST reconstructions. The revised SST estimates are based on the premise that the faunal and floral gradients that underlie the CLIMAP reconstructions reflect ocean temperature gradients and frontal positions, but the transfer function that translates these faunal gradients to SST have biases. We developed a strategy to systematically correct for two biases: 1) low sensitivity of faunal SST estimates at the warmest sites and 2) underestimation of SST where the pycnocline is strong within the euphotic zone. The hypothetical corrections to the published SST fields (August and February) can be expressed by the following equation: $SST_{Adjusted} = (1+a)*SST_{CLIMAP} + b*(density_{0m}-density_{100m}) + c$ Parameter **a** adjusts temperatures for bias as a function of temperature, **b** corrects for bias associated with steepness of pycnocline and **c** shifts the mean SST for the reconstruction. For density gradients, we use modern atlas values of density at 0 and 100m water depth. This equation was applied to the $2^\circ \times 2^\circ$ grid of CLIMAP SST fields. Experiments using GENESIS have been run to examine the effects of the warm-pool and pycnocline biases. Results show significant improvement in comparisons of surface temperatures to independent climate estimates from oceanic and terrestrial records. Preliminary analyses of the model runs suggest show that at latitudes greater than 35° the climate response to changes in the warm pool or in the subtropical gyres are similar, whereas there is marked improvement in the model fit to data in the tropics with changes in the warm pool temperatures.

PP31A-04 0845h

Modelling Eurasian Iceberg Tracks, Sedimentation Rates and Meltwater Inputs to the Norwegian-Greenland Sea in the Late Weichselian

Ros M Death¹ (ros.death@bris.ac.uk)Martin J Siegert¹ (M.J.Siegert@bristol.ac.uk)Grant R Bigg² (grant.bigg@sheffield.ac.uk)Martin Wadley³ (m.wadley@uea.ac.uk)¹Bristol Glaciology Centre, School of Geographical Sciences, University Road, Bristol BS8 1SS, United Kingdom²University Of Sheffield, Department of Geography, University Of Sheffield, Winter Street, Sheffield S10 2TN, United Kingdom³University of East Anglia, Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, United Kingdom

Modelling iceberg discharge from ice sheets is critical to evaluating their role in perturbing the state of the oceans during glacial periods. We model the iceberg flow paths, sediment discharge and meltwater supply to the Norwegian-Greenland Sea during the last glaciation in order to identify how the break-up of the Eurasian Ice Sheet affected the ocean. Results from a numerical ice sheet model, an atmospheric general circulation model, and an ocean model are used to provide iceberg production rate, wind field and surface current pattern inputs to an iceberg trajectory model. The model then determines how icebergs issued by the Eurasian Ice Sheet flow across the ocean and eventually melt out. Calculations are made for several periods during the last deglaciation, including an LGM run, a Holocene (modern) run, and several time periods in between. The results show the time-dependent spatial evolution of iceberg tracks across the northern ocean. Importantly, the model indicates the rate and distribution of meltwater to this potentially important region of the North Atlantic. Sedimentation results are compared with IRD records in order to evaluate the likelihood of various model scenarios.

PP31A-05 0900h

Testing Methods for Reconstruction of Degree of Calcite Saturation/Changes in Carbonate Ion Concentration in the Deep Sea Over the Last 25000 Years

Figen A Mekik¹ (616-331-3020; meki@gsu.edu)Paul W Loubere² (paul@geol.niu.edu)David E Archer³ (d-archer@uchicago.edu)¹Grand Valley State University, Department of Geology, Allendale, MI 49401, United States²Northern Illinois University, Department of Geology and Environmental Geosciences, De Kalb, IL 60115, United States³University of Chicago, Department of Geophysical Sciences, Chicago, IL 60637, United States

Reconstruction of changes in deep-sea calcite saturation is key to testing proposed mechanisms for changing atmospheric CO₂ content on the glacial/interglacial timescale. The reconstruction has been hampered by difficulty in finding adequate quantitative proxies for calcite dissolution at the seabed. We test the sensitivity of two methods in estimating % calcite dissolved at the sea floor, and we examine the application of these methods to reconstruction of calcite saturation/carbonate ion concentration from the LGM to Present in the Eastern Equatorial Pacific [EEP]. The methods we examined are the G. menardii fragmentation index of Mekik et al. [2002] and the foraminiferal weight index of Broecker and Clark [2001]. The first method is calibrated to estimate % calcite dissolved at the seabed, the second method is calibrated to estimate downcore changes in carbonate ion concentration. Combination of the first method with reverse modeling using the Muds geochemical model and estimates of paleo-organic carbon flux allows downcore estimates of paleo-delta calcite. We examined the response of the proxies to modern calcite saturation using Archer's gridded geochemical data and found that foraminiferal weights for most species so far tested have little relationship to delta calcite. However, *N. dutertrei* shows a consistent pattern with most weight loss early in the dissolution process [when % calcite dissolved is less than 40%] and relatively little specimen weight change as delta calcite drops below zero. The menardii index, by contrast, shows strong linear sensitivity in the negative delta calcite range. These results indicate that the specimen weight method is most sensitive at higher delta calcite values; while the menardii index is most responsive in undersaturated conditions. Application of the methods downcore in the EEP reveals a consistent LGM to Present pattern in two cores for the menardii-reverse modeling approach to estimating paleo-delta calcite. The dutertrei-weight method yields opposite results for the two cores even though they must sample the same deep Pacific water mass. The discrepant results support work which indicates that specimen weight is influenced by foraminifera habitat upper ocean ecology [sub-species] and geochemistry [pCO₂].

PP31A-06 0915h

Simulated Changes in Extreme Temperature and Precipitation Events at 6 ka

Noah S Diffenbaugh¹ (ndiffenbaugh@es.ucsc.edu)Jason L Bell¹ (jbell@es.ucsc.edu)Lisa C Sloan¹ (lcsloan@es.ucsc.edu)¹Department of Earth Sciences, University of California, Santa Cruz, 1156 High Street, Santa Cruz, CA 95064, United States

Paleoenvironmental archives record a range of information about past environments. Three key influences shaping paleoclimate records at a given time plane are the mean state of the climate system, interannual variability, and the frequency and seasonality of extreme climate events. We have employed a high resolution regional climate model (RCM) to test the sensitivity of extreme climate events to 6 ka orbital forcing, using western North America as a case study. Extreme precipitation and temperature events were defined by the distribution of daily precipitation and temperature values in the control simulation. Simulated anomalies (6 ka - control) in the number of extreme precipitation events per year were positive throughout the RCM domain, as were anomalies in the percent of annual precipitation delivered by extreme precipitation events. These annual-scale positive anomalies in extreme precipitation were driven by changes in the seasonality of extreme precipitation events at 6 ka, with January, October and November showing the greatest positive anomalies in percent of monthly precipitation delivered by extreme precipitation events. The frequency and length of extreme temperature events in the western United States was also sensitive to 6 ka orbital forcing. Positive anomalies in the frequency of extreme maximum daily temperature values occurred inland in the RCM domain, with peak anomalies of 24 days/year centered over the Great Basin. Likewise, the number of days/year in which the maximum daily temperature exceeded 32°C increased over land by 24%, with the average heat-wave up to 12 days longer in the 6 ka simulation than in the control simulation. Finally, mean first and last freeze dates were later inland in the 6 ka simulation than in the control simulation.

PP31A-07 0930h

A Coral Perspective on Holocene Climate Variability in the Western Pacific Warm Pool

Terrence M. Quinn¹ (727-553-1658;quinn@marine.usf.edu); Frederick W. Taylor² (512-471-0453; fred@utig.ig.utexas.edu); R.Lawrence Edwards³ (612-626-0207;edwar001@umn.edu); George Burr⁴ (520-621-8411; burr@physics.arizona.edu); HaiCheng³ (612-626-0207; cheng021@umn.edu);Yue-Gau Chen⁵ (886-2-2369-7648;

ygchen@ccms.ntu.edu.tw)

¹College of Marine Science, University of South Florida, 140 Seventh Avenue South, MSL 119, St. Petersburg, FL 33701, United States²Institute for Geophysics, The John A. and Katherine G. Jackson School of Geosciences, The Univ. of Texas at Austin, 4412 Spicewood Springs Rd., Austin, TX 78759-8500, United States³Department of Geology and Geophysics, University of Minnesota, 310 Pillsbury Drive Southeast, Minneapolis, MN 55455, United States⁴NSF Accelerator Facility, Department of Physics, University of Arizona, 1118 E. 4th Street, PO Box 210081, Tucson, AZ 85721, United States⁵Dept. of Geosciences, National Taiwan University, No.1, Sec. 4, Roosevelt Road, Taipei 106, Taiwan

The Western Pacific Warm Pool (WPWP) serves as a heat engine for Earth's climate and as a major moisture source for its hydrological cycle. Studies of the instrumental record document that variations in the thermal and hydrologic properties of the WPWP have global ocean and atmospheric ramifications. Coral-based climate records have been exploited in other regions of the tropical oceans, yet such records are rare from the WPWP despite the fact that proxy climate records from the WPWP are recognized as among the most critical targets for future paleoclimate research. We have begun to address this recognized need by generating monthly resolved proxy records of thermal and hydrologic variability in the WPWP via paired determinations of $\delta^{18}\text{O}$ and Sr/Ca in fossil corals from Tetepare, Western Solomon Islands ($8^{\circ}43' \text{ S}$; $157^{\circ}33' \text{ E}$). Thirty-three of the 54 fossil coral cores that were drilled and recovered have been dated by AMS ^{14}C and by TIMS U-series techniques, and these corals range in age from 250 to 12,000 years old. Post-depositional alteration of our Holocene coral samples is judged to be minimal based on mineralogical (XRD), petrographic (SEM) and geochemical criteria (preservation of modern marine initial $\delta^{234}\text{U}$ values). We have initially chosen to generate short time series (~4-5 years) of monthly $\delta^{18}\text{O}$ and Sr/Ca variations from eight of the fossil corals and one nearby modern coral, although some of the cores contain well over 100 annual density bands. Annual cyclicity is observed in both $\delta^{18}\text{O}$ and Sr/Ca in all of the time series generated to this point. Coral $\delta^{18}\text{O}$ data show a general decrease in values during the Holocene from more enriched values of $\sim 4.65^{\circ}/\text{oo}$ at $\sim 10 \text{ Ka}$ to a value of $\sim 5.25^{\circ}/\text{oo}$ in the modern coral. Coral Sr/Ca data indicate $\sim 2^{\circ}\text{C}$ cooler SST w/r to modern values at $10,254 \pm 35 \text{ yr BP}$ and $\sim 1^{\circ}\text{C}$ warmer SST w/r to modern values at $3336 \pm 18 \text{ yr BP}$. The suite of fossil coral samples from Tetepare will ultimately yield multidecadal to centennial length proxy climate time series having subannual resolution that will be used to 1) determine how changes in the mean climate state of the tropics in the WPWP influence the nature of tropical climate variability on inter-annual to centennial timescales during the Holocene; and 2) define the timing and magnitude of abrupt transitions and extremes in Holocene climate in the WPWP and determine how these abrupt changes in the tropics are related to previously defined intervals of abrupt change in the extra-tropics.

PP31A-08 0945h

Arctic/North Atlantic Oscillation impact on sea-surface temperature trends during the Holocene: alkenone thermometry, instrumental data and coupled atmosphere-ocean climate simulations

Jung-Hyun Kim¹ (+49 421 218 8929;

jungkim@allgeo.uni-bremen.de)

Stephan J. Lorenz² (+49 40 41173 102;

lorenz@dkrz.de)

Norel Rimbu¹ (+49 421 218 7185;

nrim@geo.palmod.uni-bremen.de)

Gerrit Lohmann¹ (+49-421-218-2835;

gerrit@palmod.uni-bremen)

Ralph R. Schneider³

(r.schneider@epoc.u-bordeaux1.fr)

¹University Bremen, FB5 Geowissenschaften, Klagenfurterstrasse, Bremen 28359, Germany²Max-Planck-Institute for Meteorology, Model and data group, Bundesstrasse 55, Bremen 20146, Germany³Université de Bordeaux I, Département de Géologie et Océanographie, Talence Cedex 33405, France

To better assess anthropogenic impact on post-industrial climate, it is essential to reconstruct reliable surface temperature distribution patterns in a long-term perspective. Here we show a global spatial pattern of long-term sea-surface temperature (SST) trends over the last 7,000 years solely based on alkenone-derived SST records and coupled atmosphere-ocean transient climate simulations. Our modelling strategy uses a technique for transient simulations with a state-of-the-art general circulation model, where we accelerate the very slow time scale of the Earth's orbital parameters to enable simulations of the whole Holocene. Reconstructed alkenone SST records in the North Atlantic realm show that a continuous SST decrease in the Northeast Atlantic over the last 7,000 years was accompanied by a persistent warming over the western subtropical Atlantic, the eastern Mediterranean Sea, and the northern Red Sea. Our transient ensemble simulations over the last 7,000 years show similar spatial distribution pattern. Based on the analysis of the instrumental data and of model experiments, we show that SSTs during the Holocene can be attributed to a continuous weakening of a Northern Hemisphere atmospheric circulation pattern similar to that of the Arctic/North Atlantic Oscillation (AO/NAO) at present. This implies that the AO/NAO plays not only an important role for short-term climate changes during the present but also for long-term climate trends during the Holocene.

PP31B MCC: Level 1 Wednesday 0830h

Southern Ocean Climatic Evolution: The Marine Geologic Record I

Posters (joint with OS, C, GC)

Presiding: D A Warnke, California

State University; N Exxon, Geoscience

Australia; G M Filippelli, Indiana

University-Purdue University

Indianapolis

PP31B-0250 0830h POSTER

Integrated Study of Ice-Rafted Debris, Temperatures, and Stable Isotopes on a Spliced Record (piston cores and ODP Site 177-1090) From the South Atlantic

Detlef A. Warnke¹ (1-510-885-4716;dwarnke@csuhayward.edu); Lora Teitler¹(lteitler@csuhayward.edu); Sabine Becquey²

(sbecquey@awi-bremerhaven.de); Rainer

Gersonde² (rgersonde@awi-bremerhaven.de);Kathryn Venz³ (venz@ufl.edu); David A Hodell³

(dhodell@geology.ufl.edu)

¹California State University, Hayward, 25800 Carlos

Bee Blvd., Hayward, CA 94542

²A.W.I., Columbusstrasse, Bremerhaven 27515, Germany³University of Florida, 241 Williamson Hall, Gainesville, FL 32611, United States

We have conducted an integrated study of ice-rafted debris (IRD) and stable isotopes on a spliced record (TN057-6-PC4/ODP Site 177-1090, about 43° S , 9° E) raised on the Agulhas Ridge, in the South Atlantic. The site is just north of the northern boundary of the present-day Polar-Front Zone (PFZ), and is in a very sensitive location to record both ice-rafting and stable-isotopic-ratio changes. Our combined record reveals a pattern of ice-rafting episodes that may be characteristic for the subantarctic South Atlantic, at least for locations N of the PFZ. Ice rafting occurs during the waxing stages of each glaciation, and ends at, or before, the peak of each glaciation. IRD peaks are also associated with strong stadials during "cold" interglacials, e.g. MIS 7. A little IRD shows up during the entire interval studied here, from the Holocene to mid-MIS 14. We suggest that the IRD record at this site is essentially a temperature record on glacial-interglacial timescales. If the temperature is low enough, enough icebergs survive to melt at this location. If the temperature is too warm, only an occasional iceberg survives to deliver debris. A peculiar aspect of the combined record is the fact that during Ice-rafting events (IREs), the planktic oxygen-isotopic ratios are higher at the end of an

IRE compared to the beginning. Further, by comparing our records with the Summer Sea Surface Temperature record of Becquey and Gersonde (2002) for a nearby (respectively the same) site (PS2489-2/ODP177-1090), we see that the temperature is generally very similar at the beginning and the end of an IRE. The same age model provided by Venz and Hodell (2002) was used for both sites, allowing such direct comparisons of the data. Assuming as a working hypothesis that the IRD record is a pure temperature record, and ignoring the salinity effect for the present, then this difference in oxygen-isotopic ratios must be the ice volume effect. For MIS 12, the difference in planktic oxygen-isotopic ratios at the beginning and the end of the IRE is about 1.3 permil, which translates to 130 m sea level equivalent. The present-day temperature at the site is about 10° C (Levitus and Boyer, 1998). To attain a temperature of about 4° C (presently located at about 47° S in this area), as indicated by the SSST record of Becquey and Gersonde (2002) for the IRE during MIS 12, the Polar Front Zone (the zone of major iceberg melting) had to move north by about 4° latitude (about 240 nautical miles), a not unreasonable assumption.

PP31B-0251 0830h POSTER

Support From the Southern Ocean and Equatorial Pacific for the Glacial Shelf-Nutrient Hypothesis

Gabriel M. Filippelli¹ (317-274-3795;

gfilippe@iupui.edu)

Jennifer Latimer¹Richard W. Murray²¹Dept. of Geology, IUPUI, 723 W. Michigan St., Indianapolis, IN 46202-5132, United States²Dept. of Earth Science, Boston University, Boston, MA 02215

The impact of sea level variations on marginal sedimentation and hence biogeochemical sinks has long been recognized, but few quantitative data exists on the oceanic response of the biolimiting nutrient phosphorus (P) to changing depositional sinks. A greater understanding of the sinks and geochemistry of P in marine sediments, together with multi-proxy analyses of a variety of P-related records from the deep sea, indicates that the redistribution of this nutrient from marginal to deep sea sinks during glacial lowstands has had an important impact on the oceanic P cycle. We compared records of P/Ti ratios (an "excess" P proxy) and P accumulation rates from the Southern Ocean (ODP Site 1089) and the eastern equatorial Pacific. The P/Ti records for these widely spaced sites show a remarkable degree of similarity over the last 400 kyr. The P/Ti ratios at both sites exhibit peaks with a 100 kyr periodicity, and a phasing of broad peaks that begins during glacial intervals, reaching maxima just after the glacial-interglacial transition, then decreasing to low values by the beginning of the next glacial interval. These records indicate relatively high "excess" P export occurring about 40-60 kyr after the onset of glacial intervals. P accumulation rates from these sites reveal sharp peaks 40-60 kyr after glacial onset, followed by a slow decline, with some abbreviated peaks, over the ensuing 60-80 kyr. These two semi-independent proxies provide a picture of a potentially globally-coherent signal in the deep ocean marine P mass balance, with increased P export to the deep ocean from shelf weathering and lack of shelf depositional area during glacials. The delay in P accumulation in the deep ocean is due to the slower response time of P (residence time of 10-20 kyr). Given higher recycling of P in the deep sea sink, this redistribution from shelf to deep sea may have resulted in higher oceanic dissolved phosphate concentrations and increased oceanic productivity, especially soon after glacial onset.

PP

PP31B-0252 0830h POSTER

The end of the Early Eocene Climatic Optimum: Evidence for Concomitant Cooling of Southern Ocean Surface Waters and Global Deep Waters From Dinoflagellate Endemism.

Henk Brinkhuis¹ (31302537691;

H.Brinkhuis@bio.uu.nl)

Jeroen Warnaar¹ (31302532638;

J.Warnaar@bio.uu.nl)

Matthew Huber² (mhuber@purdue.edu)James C. Zachos³ (jzachos@es.ucsc.edu)¹Laboratory of Palaeobotany and Palynology, Utrecht University, Budapestlaan 4, Utrecht 3584 CD, Netherlands²Earth Atmospheric Science, Purdue University, 1397 Civil Engineering Bldg., Lafayette, IN 47807-1397, United States