Climates, Past Landscapes and Civilizations

American Geophysical Union Chapman Conference

Santa Fe, New Mexico, USA

21 - 25 March 2011

AGU Chapman Conference on Climates, Past Landscapes and Civilizations

Santa Fe, New Mexico, USA
21 - 25 March 2011

Conveners

Peter Clift, University of Aberdeen, UK
Dorian Fuller, University College London
Liviu Giosan, Woods Hole Oceanographic Institution, USA
Rowan Flad, Harvard University, USA
Sam VanLaningham, University of Alaska, Fairbanks
Jim Aimers, Statue University of New York, Geneseo

Program Committee

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AGU Chapman Conference on Climates, Past Landscapes and Civilizations

Meeting At A Glance

Monday, 21 March 2011

1830h – 2230h	Welcome Reception

Tuesday, 22 March 2011

0830h – 0845h	Welcome and Introduction
0845h – 1015h	Climate-Environmental-Societal Interactions – Global Perspective I
1015h – 1100h	Open Post Session and Refreshment Break
1100h – 1215h	Climate-Environmental-Societal Interactions – Global Perspective II
1215h – 1345h	Lunch on your own
1345h – 1515h	Africa
1515h – 1545h	Europe and the North Atlantic I
1545h – 1645h	Open Poster Session and Refreshment Break
1645h – 1745h	Europe and the North Atlantic II
1745h – 1815h	Discussion I

Wednesday, 23 March 2011

0830h – 0945h	Middle East and Eastern Mediterranean
0945h – 1030h	East Asia I
1030h – 1130h	Open Poster Session and Refreshment Break
1130h – 1245h	East Asia II
1245h – 1415h	Lunch on your own
1415h – 1530h	South Asia
1530h – 1630h	Open Poster Session and Refreshment Break
1630h – 1800h	South Asia II
1800h – 1830h	Discussion II
1630h – 2100h	Conference Dinner

Thursday, 24 March 2011

0800h – 1600h	Field Trip – Bandelier National Monument Lunch is provided

Friday, 25 March 2011

0830h – 0915h	Australasia-Pacific
0915h – 1000h	South and Central America I
1000h – 11:00h	Open Poster Session and Refreshment Break
1100h – 1230h	South and Central America II
1230h – 1400h	Lunch on your own
1400h – 1445h	Western North America
1445h – 1615h	Working Group
1615h – 1645h	Open Poster Session and Refreshment
1645h – 1745h	Working Group Overviews
1745h – 1830h	Discussion III

SCIENTIFIC PROGRAM

MONDAY, 21 MARCH

1830h – 2030h **Welcome Reception**

TUESDAY, 22 MARCH

0830h – 0845h **Welcome and Introduction**

Climate-Environmental-Societal Interactions - Global Perspective I
Presiding: Sanjeev Gupta, Rowan K. Flad
Sunset Room

0845h – 0930h **William F. Ruddiman** | Late Holocene CO2 And CH4 Increases: Natural Or Anthropogenic? *(INVITED)*

0930h – 0945h **Davis A. Basil** | Can climate change explain the spread of farming during the Neolithic revolution?

0945h – 1000h **G M. Kondolf** | Sediment Yield Increases/Decreases from Direct Human Action and Climate Change

1000h – 1015h **Kevin Anchukaitis** | Synchronous megadrought in Asia and North America during the last millennium

1015h – 1100h **Open Poster Session and Refreshment Break I**
Pavilion

P-1 **Angela S. Jayko** | Holocene paleoenvironments and transient indigenous occupation sites in the Owens River watershed, SW Great Basin

P-2 **Jeff Jorgensen** | Getting into shape: a simple, rapid, and low-cost method to identify Pacific salmonid (*Oncorhynchus* spp.) vertebrae to species

P-3 **Thomas Raab** | Reconstructing past landscapes – The use of modern open-cast lignite mining

P-4 **Frank Kiwalabye** | Vulnerability and Effects of Climate change to older people in Africa

P-5 **Brian M. Fagan** | "The Great Warming: An Archaeologist looks at ancient climate change, or: The STory of the Silent Elephant in the Room

P-6 **Amy E. Draut** | Climate variation, landscape cover, and aeolian sand mobility on the Navajo Nation, southwestern U.S

P-7 **Lincoln Steinberger** | Recent human interaction with environment in a tropical rainforest mosaic, North Queensland, Australia

P-8 **Hideaki Maemoku** | Was the Ghaggar River Mighty Saraswati during Mature Harappan Period?

P-9 **Takahiro Miyauchi** | Late Holocene geomorphic coastal changes affecting the mutation of bay-facing Harappan sites of the Indus civilization, Gujarat, India

P-10 **Germain Bayon** | Intensified weathering and anthropogenic deforestation in Iron Age central Africa

P-11 **Emma Gatti** | Hydrological response to the Toba super-volcano ash fallout in the Middle Son Valley, Western India: palaeo-environmental and archaeological implications

P-12 **Yama Dixit** | Holocene Palaeoclimate History of the Plains of NW India Inferred from Palaeo-Lake Riwasa

P-13 **Dengke Hu** | Variation in Holocene East Asian Monsoon Strength Reflected by Deep Sea Sediment in the South China Sea

P-14 **Jaime L. Bach** | Use of Maritime History to Assess Local Perceptions and Reactions to Climate Change on the Island of Tabiteuea Maiaki

P-15 **Jago Cooper** | Living with Extreme Weather in a Stable Climate: A long-term perspective on human-climate relationships in the Caribbean

P-16 **Tom Vanwalleghem** | Interpreting climatic and anthropogenic effects on soils and sediments: coupling soil formation and soil erosion

P-17 **Amy E. Hessl** | Fire, Land Use and Climate Change in Central Mongolia During the Last 400 Years

P-18 **Gail L. Chmura** | The Human Trigger for Development of Tree Islands in the Florida Everglades

P-19 **Max B. Berkelhammer** | Indian Monsoon failure during the 4.2k Event

P-20 **Elaine Matthews** | Non-climatic controls on malaria: A historical study of the US, Italy and Sri Lanka

P-21 **Hugo A. Loaiciga** | Climate variability, people, water, and energy: from Mayan to solar-thermal desalination of seawater

P-22 **Janina Körper** | Application of paleoclimatic simulations in a geoarchaeological framework – two case studies along the Nile

P-23 **Emilie Gauthier** | From first Caribou to Norse sheep: impact of grazing in south Greenland

P-24 **Pavla Zackova** | MACROFOSSIL EVIDENCE OF HUMAN IMPACT ON VEGETATION DURING THE LATE GLACIAL-HOLOCENE FROM EXTINCT LAKE ŠVARCENBERK, SOUTHERN BOHEMIA, CZECH REPUBLIC

P-25 **Aurel Persoiu** | A Holocene Perspective On Interactions Between Social And Environmental Processes In NW Romania, Central Europe

P-26 **Tim Beach** | Perennial Wetlands of the Ancient Maya: Testing Models of Human-Nature Interactions

P-27 **Emilie Gauthier** | ULTIMAGRI Project: from pristine to anthropogenic Greenland landscape

P-28 **Neil Pederson** | Neither New York City nor Atlanta are Prepared for a Return to Historical Drought

P-29 **Michael Staubwasser** | Holocene Indus Drought Cycles, the 4.2 ka Event in Asia, and the Search for a Mechanism

P-30 **Liviu Giosan** | From the Blue Danube to the Black Sea: Climate-Landscape-Human Interactions in the Lower Danube Basin

P-31 **Nivedita Mehrotra** | Holocene vegetation – climate and evidence of early Rice cultivation in Southern Tripura, India based on Palynological analysis

P-32 **Jun'ichi Okuno** | The role of hydro-isostasy for Holocene sea-level changes and coastal evolution in the southern Indus region, Gujarat, India

P-33 **Barry V. Rolett** | Holocene Sea-level Change and Neolithic Cultural Response in Southeast China

P-34 **Charly Massa** | Quantification of medieval and modern human driven erosion due to agriculture on a south Greenland lake system

P-35 **Ravindra N. Singh** | Humans, environment and the decline of the Indus Civilisation:Investigating relationships between Land, Water and Settlement on the plains of NW India

P-36 **Allen M. Gontz** | The preservation of New England paleo-landscapes – links to past societies and sea-level change

P-37 **Jussi Baade** | Irragric anthrosols: artifacts of human adjustment to arid conditions – Examples from the Tibetan Himalaya and the coastal desert of Peru

P-38 **David Rhode** | Climate and its Effects on Small-Scale Societies in the Bonneville Basin, western North America

P-39 **Edwin R. Hajic** | Geology and Geoarchaeology of the Baodun Culture Paleolandscape, Sichuan Province, China

P-40 **Sam VanLaningham** | Holocene Indus River Pathways Inferred from Nd Isotopes and the relationship between the Fluvial Landscape and the Harappans

P-41 **Lu Liu** | Analyzing Past Drought and Predicting Future Drought with Comprehensive Drought Indices for Arkansas-Red River Basin

P-42 **Daniel Cadzow** | Hunter-Gatherers, Horticulturalists, and Climate?

P-43 **Gay Jane Perez** | The Changing Philippine Land Cover and Climate as Observed from Space

P-44 **Amy Prendergast** | A palaeoclimatic framework for the Late Pleistocene and Early Holocene occupation of North Africa

P-45 **Christopher T. Simmons** | Investigating the role of changes in the meridional overturning circulation on the Holocene carbon cycle and climate-vegetation dynamics

P-46 **Nao Miyake** | Vegetation changes since the middle Holocene around Lake Rara, western Nepal

P-47 **Irina P. Panyushkina** | Climate and Siberian Scythians: Tree-ring evidence of summer temperature variability linked to nomadic resources

P-48 **Yemane Asmerom** | Holocene climate variability and cultural modalities in the southwestern USA

Climate-Environmental-Societal Interactions - Global Perspective II

Presiding: Sanjeev Gupta, Rowan K. Flad
Sunset Room

1100h – 1145h **Brian M. Fagan** | The Great Warming: An Archaeologist Looks at Climate Change, or the Story of the Silent Elephant in the Room *(INVITED)*

1145h – 1200h **J Robert Gibson** | The potential Impact of paleoclimatology and archeology on mankind's willingness to make sacrifices to mitigate future climate change

1200h – 1215h **Carsten Lemmen** | Are Holocene climate events irrelevant for, or are they triggers of the Neolithic transition?

1215h – 1345h Lunch

Africa

Presiding: Tina L. Thurston, Jim Aimers
Sunset Room

1345h – 1400h **Stefan Kröpelin** | High-resolution evidence of Holocene climate change in the Sahara and correlation to human-environment interaction

1400h – 1415h **Kathleen Nicoll** | A New Synthesis of Records of Quaternary Palaeoenviromental Change and Geoarchaeology in the NE Sahara

1415h – 1430h **Mark G. Macklin** | When the Nile ran dry: rethinking people river-environment interactions in Sudanese Nubia 5000 BC – AD 500

1430h – 1515h **Peter B. deMenocal** | What caused the mid-Pliocene aridification of Africa? *(INVITED)*

Europe and the North Atlantic I
Presiding: Liviu Giosan, David Montgomery
Sunset Room

1515h – 1530h **Daniel Veres** | A Six Thousand Year Geochemical Record of Atmospheric Metal Deposition in an Ice Core from Scarisoara Cave, Apuseni Mountains, Romania

1530h – 1545h **Manuela Schlummer** | Human Induced Hillslope Sediment Storages in Central Europe

1545h – 1645h **Open Poster Session and Refreshment Break II**

Europe and the North Atlantic II
Presiding: Liviu Giosan, David Montgomery
Sunset Room

1645h – 1700h **Thomas A. Raab** | Mining as a factor of prehistoric and historic landscapes change in Central Europe

1700h – 1715h **Tina L. Thurston** | The Political Ecology of Iron Age, Medieval and Early Modern Ulster, Northern Ireland

1715h – 1730h **Bianca B. Perren** | Agriculture and climate from the Norse landnám to the present: the biological response to human activities at Igaliku, South Greenland

1730h – 1745h **Paul Aharon** | Rainfall Variability and the Rise and Fall of the Mississippian Chiefdoms: Evidence from DeSoto Caverns (Alabama, USA) coeval stalagmites

1745h – 1815h **Discussion I**

WEDNESDAY, 23 MARCH

Middle East and Eastern Mediterranean
Presiding: Michael Staubwasser, Raymond Bradley
Sunset Room

0830h – 0915h **Harvey Weiss** | Quantifying Collapse: Abrupt Climate Change, Regional Abandonments, Habitat-Tracking, and the Humean Counterfactual *(INVITED)*

0915h – 0930h **Mark R. Besonen** | Increasing Evidence for a Pronounced, Mid-1st Millennium A.D. Desiccation Event in the Eastern Mediterranean

0930h – 0945h **Simone Riehl** | Mid-late Holocene agricultural system transformations in the northern Fertile Crescent: archaeobotanical, geoarchaeological and philological evidence

East Asia I
Presiding: Sam VanLaningham, Harvey Weiss
Sunset Room

0945h – 1000h **Dorian Q. Fuller** | When did climate changes encourage rice agriculture, and when did rice agriculture encourage climate change?

1000h – 1015h **Brendan M. Buckley** | The Societal Impact of Southeast Asian Hydroclimate Variability Over the Past Millennium

1015h – 1030h **Zhongyuan Chen** | Neolithic and delta of China

1030h – 1130h **Open Poster Session and Refreshment Break III**

East Asia II
Presiding: Harvey Weiss, Sam VanLaningham
Sunset Room

1130h – 1215h **Robert L. Bettinger** | Climate and Human Behavioral Change: The Last 100,000 Years in the Loess Plateau of North China *(INVITED)*

1215h – 1230h **Bing Hong** | Chinese Civilization and Climate Change

1230h – 1245h **Suzanne A. Leroy** | Climatic and sea level changes in the south and middle basins of Caspian Sea at 4 cal. ka BP

1245h – 1415h Lunch

South Asia
Presiding: Peter Clift, Emma Gatti
Sunset Room

1415h – 1430h **Cameron Petrie** | Humans, environment and the decline of the Indus Civilisation: investigating relationships between Land, Water and Settlement on the plains of NW India

1430h – 1445h **Liviu Giosan** | Landscape Dynamics in the Indus Basin: From Harappa to the Flood of 2010

1445h – 1500h **Richard H. Meadow** | The 4.2kya Abrupt Climatic Event and the Indus Civilization

1500h – 1515h **Sanjeev Gupta** | Large-scale river channel shifts on the western Indo-Gangetic Plains: Implications for Harappan civilisation

1515h – 1530h **Toshiki Osada** | "Environmental change and the Indus civilization": a report on the major outcome of our RIHN project (2007-2011)

1530h – 1630h **Open Poster Session and Refreshment Break IV**

South Asia II
Presiding: Suzanne A. Leroy, Ravindra N. Singh
Sunset Room

1630h – 1715h **John W. Day** | Post-Glacial Coastal Margin Productivity and the Emergence of Complex Societies *(INVITED)*

1715h – 1730h **Rita P. Wright** | Human Geography and the Impact of Climate Change in the Upper Indus Valley: Convergent Data from Stable Isotopes, CORONA Imagery, and the Paleobotanical Record

1730h – 1745h **Atsunori Nakamura** | Mid-Late Holocene Asian monsoon reconstruction using a sediment core obtained from Lake Rara, western Nepal

1745h – 1800h **Peter Clift** | Evolving Holocene Drainage Geometries and Environmental Conditions in the Indus River Basin

1800h – 1830h **Discussion II**

1830h – 2100h **Conference Banquet Dinner**

THURSDAY, 24 MARCH

0800h – 1600h **Bandelier National Monument**

FRIDAY, 25 MARCH

Australasia-Pacific
Presiding: Zhongyuan Chen, Peter B. deMenocal
Sunset Room

0830h – 0845h **Yair Rosenthal** | Controls on hydrologic variability in the Indo-Pacific region during the past two millennia

0845h – 0900h **Patrick T. Moss** | Historical and Pre-Historic Human Environmental Impacts on the Sub-Tropics of eastern Australia

0900h – 0915h **Sean Ulm** | Naïve Island Landscapes: People and Environmental Change in the South Wellesley Archipelago, Gulf of Carpentaria, Australia

South and Central America I

Presiding: Dorian Q. Fuller, J Robert Gibson
Sunset Room

0915h – 0930h **Francis J. Magilligan** | Sensitivity of floodplains and cultural systems to extreme events: agrarian strategies, adaptation, and geomorphic responses to El Niño floods in the Peruvian Atacama Desert

0930h – 0945h **C. Fred T. Andrus** | Upwelling, productivity, and fish regime shift related to coastal Andean civilization

0945h – 1000h **David W. Stahle** | Mesoamerican Dendroclimatology

1000h – 1100h **Open Poster Session and Refreshment Break V**

South and Central America II

Presiding: Dorian Q. Fuller, J Robert Gibson
Sunset Room

1100h – 1145h **Jed O. Kaplan** | On the Sensitivity of the Global Terrestrial Biosphere to Human-Induced Soil Degradation Over the Holocene, with Implications for Sustainability and Societal Change

1145h – 1200h **Jim Aimers** | Drought and the Ancient Maya Collapse

1200h – 1215h **Elizabeth Rushton** | Palynological evidence for climatic shifts and changes in landscape at the Mayan city of Lamanai, Belize, ca. 1500 BC to AD 1500

1215h – 1230h **Matthew S. Lachniet** | Climate of Central Mexico since the rise of the Aztecs: testing climate hypotheses for famine and disease epidemics

1230h – 1400h Lunch

Western North America

Presiding: Amy E. Draut, G M. Kondolf
Sunset Room

1400h – 1415h **Victor J. Polyak** | Paleoamerican climate in southwestern North America

1415h – 1430h **David M. Rubin** | Differences In Human/Landscape/Climate Interactions In Grand Canyon 1-2 Millennia Ago And The Present

1430h – 1445h **Mark Boslough** | Impact did not Cause Climate Change, Extinction, or Clovis Termination at 12.9 ka

1445h – 1615h **Working Group**

1615h – 1645h **Open Poster Session and Refreshment Break VI**

1645h – 1745h **Working Group Overviews**

1745h – 1830h **Discussion III**

ABSTRACTS

listed by name of presenter

Aharon, Paul

Rainfall Variability and the Rise and Fall of the Mississippian Chiefdoms: Evidence from DeSoto Caverns (Alabama, USA) coeval stalagmites

Aharon, Paul[1]; Dhungana, Rajesh[2]; Aldridge, David E.[3]; Lambert, Joe W.[4]; Phillips, Joseph H.[5]

1. Geological Sciences, University of Alabama, Tuscaloosa, AL, USA
2. University of Alabama, Tuscaloosa, AL, USA
3. University of Alabama, Tuscaloosa, AL, USA
4. University of Alabama, Tuscaloosa, AL, USA
5. University of Alabama, Tuscaloosa, AL, USA

Archeological records from the southeast USA attest to the rise and growth of the Mississippian chiefdoms between AD 800-1000 and their decline between AD 1450-1577. Ceremonial mounds, the most characteristic artifacts of the chiefdoms, ceased by the end of the 16th century. The factors that promoted the emergence and abrupt decline of the Mississippian polities continue to be a subject of heated debate among researchers. Warfare, resource depletion and epidemic diseases brought by the European expeditions are the most prominent factors invoked. The hypothesis that climate change may have impacted the history of the chiefdoms has so far received little attention because of the scarcity of contemporaneous local and regional paleoclimate records. Here we report newly acquired proxy climate records archived in three coeval stalagmites from DeSoto (Kymulga) Caverns in Alabama and address the question of whether climate variability may have been implicated in the rise and demise of the Mississippian polities. Oxygen and carbon isotope records, absolutely dated by the 230Th radiometric method, offer biennially resolved time series of the past two millennia. Monitoring studies of the DeSoto cave environment and concurrent deposition of aragonite stalagmites have established that inter-annual rainfall variability is the dominant factor controlling the observed stable isotope phase transitions. Power spectra analysis of the data offers compelling evidence that decadal (24 and 36 yrs) and centennial (~200 and ~640 yrs) periodicities in rainfall variability were persistent in the southeastern USA over the past two millennia. Evaluation of coherency and phase between solar variability recorded by atmospheric radiocarbon in tree-rings and the wet/dry intervals archived in the stalagmites suggests a cause and effect relationship. The following lines of evidence argue that wet/dry transitions were likely to impact the evolution of the Mississippian societies: (i) The time of emergence and growth of the Mississippian chiefdoms and their agricultural transition to a dependency on corn, a warm and wet weather crop, coincide with a period of increased annual rainfall amount from a 44% below to a 15% above present value over the AD 500-1000 interval; (ii) A sharp drop of about 37% below present level in rainfall occurred between AD 1000-1200 followed by a brief rainfall recovery to present levels at AD 1300; (iii) Abandoned villages and downstream movement of populations that occurred long before the DeSoto Expedition from AD 1539-1542 were contemporaneous with the documented decline in rainfall and enhanced drought conditions after AD 1300 that culminated at around AD 1650. Thus wetter conditions than present may have promoted corn agriculture during the growth of the chiefdoms whereas food shortages, caused by failed corn crops under sever drought conditions, may have played a much greater role in the demise of the Mississippian chiefdoms than previously recognized.

Aimers, Jim

Drought and the Ancient Maya Collapse

Aimers, Jim[1]

1. Anthropology, SUNY Geneseo, Geneseo, NY, USA

For nearly a century, hypotheses about the causes of the lowland Maya collapse of the ninth century A.D. have reflected contemporary concerns. Recently a number of environmental scientists and archaeologists have evoked climate change and drought to explain the Maya collapse and a number of other periods of decline or abandonment in Maya history. In this paper I argue that many of the arguments about drought and collapse simplify or misrepresent the archaeological data, or rely on outdated archaeological research on the Maya. Closer collaboration between physical scientists and archaeologists is needed to better align the climate data with current archaeological evidence.

Anchukaitis, Kevin

Synchronous megadrought in Asia and North America during the last millennium

Anchukaitis, Kevin[1]; Buckley, Brendan[1]; Cook, Edward[1]; Tierney, Jessica[1]; Jungclaus, Johann[2]; D'Arrigo, Rosanne[1]; Ammann, Caspar[3]

1. Lamont Doherty Earth Observatory, Columbia University, New York, NY, USA
2. Max Planck Institute for Meteorology, Hamburg, Germany
3. National Center for Atmospheric Research, Boulder, CO, USA

We investigate persistent multidecadal droughts identified from tree-ring records from Asia and North America since the Medieval epoch. Severe drought in the middle of the 14th century in Vietnam, India, and China occurred at the same time as drought conditions in North America and anomalously wet periods in eastern tropical Africa. We use these proxy paleoclimate records to find analog simulated conditions within a multimodel ensemble

of millennial-length forced atmosphere-ocean general circulation models. The best model analogs are associated with warm tropical Pacific sea surface temperatures, a colder Indo-Pacific warm pool, the warm phase of Pacific decadal variability, and a colder North Atlantic and southern ocean. We compare these simulated broad-scale anomalies with existing high resolution marine proxy records. Possible changes in atmosphere and ocean circulation collectively associated with large-scale, severe and persistent monsoon drought are diagnosed, as are differences between model analogs identified under natural and anthropogenic forcing regimes.

Andrus, C. Fred T.

Upwelling, productivity, and fish regime shift related to coastal Andean civilization

Andrus, C. Fred T.[1]; Etayo-Cadavid, Miguel F.[1]; Sandweiss, Daniel H.[2]; Reitz, Elizabeth J.[3]; Hodgins, Gregory W.[4]; Jones, Kevin B.[5]

1. Department of Geological Sciences, University of Alabama, Tuscaloosa, AL, USA
2. Climate Change Institute/Department of Anthropology, University of Maine, Orono, ME, USA
3. Department of Anthropology/Museum of Natural History, University of Georgia, Athens, GA, USA
4. NSF-Arizona Accelerator Mass Spectrometry Laboratory, University of Arizona, Tucson, AZ, USA
5. United States Geological Survey, Reston, VA, USA

Multiple proxies suggest that significant changes in El Niño-southern oscillation (ENSO) occurred during the time of the Moche civilization along the North Coast of what is now Peru. It has been hypothesized that this ENSO variability contributed to political upheaval in the 6th - 8th centuries. New molluscan radiocarbon reservoir age data suggest there may have been variable and diminished coastal upwelling during at least part of this time. Upwelling drives much of the marine productivity in this region, and marine resources were a foundation of Andean coastal economies. It is therefore tempting to argue that in addition to the other challenges presented by variable El Niño frequency, intensity, and duration, critical marine resources periodically became scarce for the Moche. However the impact of any such change may have been more complex than simple loss of resources. Unlike many other regions where long-term intense fishing pressure has resulted in changes to the age, growth, and trophic structure of fish populations, there is little evidence for overfishing in coastal Peru until historical times. It does not appear that the carrying capacity of the local marine ecosystems was met, even considering the relatively high coastal human population densities during this time. However, regime shift (e.g. anchovy versus sardine dominance) has been documented in both modern and ancient Peruvian fisheries. Such shifts can result from ENSO variability and the consequences of these shifts would have been felt by those who depended on fish as a protein source. Assessing such a regime shift may be challenging in complex urban archaeological sites such as are common with the Moche. This is due to a variety of factors ranging from taphonomic loss of small zooarchaeological remains to trophic level preferences among different status groups in these sites. However investigation into the potential impacts of climate change to fisheries may give useful insight into the economic and political challenges faced by the Moche.

Asmerom, Yemane

Holocene climate variability and cultural modalities in the southwestern USA

Asmerom, Yemane[1]; Polyak, Victor J.[1]

1. University of New Mexico, Albuquerque, NM, USA

The Americas, as the most recent sites of human occupation and cultural development, offer a special natural laboratory to study the interaction of climate and culture. This is particularly true for the Southwestern United States where there have been over a century long cultural and anthropological studies coupled with broad climatic and environmental investigations. Recent results from high-resolution speleothem-based climate studies of the Holocene provide unique opportunity to look at the question afresh. Although Holocene climate variability has not been as dramatic as that we (Asmerom et al, 2010) and others (Wagner et al., 2010) have reported during the last glacial, it was nevertheless significant. Coming out of the Pleistocene-Holocene transition, we reported a prolonged wet period, about 1000 years past the end of the Younger Dryas. Our isotopic and speleothem growth and gray scale data show that this was followed by a very arid period during the early Holocene. The early to middle Holocene was particularly arid than any other time during the Holocene. There was a noteable shift towards wetter conditions in the late Holocene, starting around 4000 years ago. Climate over the late Holocene, although wetter, was more variable compared to the rest of the Holocene, in which overall wetter conditions are punctuated by arid episodes. Holocene climate variability can be attributed to changes in insolation at the millennial scale, solar at the centennial to multi-decadal scale and variability in the PDO phase and changes in the strength and modalities of ENSO. The interplay between PDO and ENSO is particularly noteworthy. For example, decadal scale arid phases, such as the drought of the 1950s are characterized by the coincidence of the negative PDO phase and La Nina phase of ENSO. Although it is difficult to attribute causality, the coincidence between climate transitions and changes in cultural modalities is impressive. The transition to hyper-arid conditions during the later part of the early Holocene coincides with changes from big game hunters to hunter gatherer subsistence. The change to agricultural communal life occurred during the transition to wetter conditions around 4000 years ago. In shorter time-scales, we show that pueblo cultural stages coincide with rapid changes in climate, the abandonment of dwellings, such as Chaco Canyon being a dramatic example of that.

Baade, Jussi

Irragric anthrosols: artifacts of human adjustment to arid conditions – Examples from the Tibetan Himalaya and the coastal desert of Peru

Baade, Jussi[1]

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In semi-arid to arid regions irrigation agriculture represents a creative human adjustment to the environmental conditions. Using additional ground- or surface water sources enables societies to establish arable farming systems in otherwise hostile environments and gain a measure of adaptability against climatic fluctuations. When surface water is used for irrigation the diversion of water and suspended sediment to the fields results in the development of irragric anthrosols (ATir). Often these sediments content other artifacts like charcoal and pottery fragments which can be used for age determination. Surprisingly, publications where irragric anthrosols have been used to determine the onset of irrigation agriculture in a specific region are difficult to find. A search in Google Scholar returned only 20 hits. The scarcity of reports on irragric anthrosols is most probably due to the novelty of the term in the global soil description system, where irragric anthrosols where introduced with reference to a soil survey in Yemen from 1983. A re-analysis of soil profiles from other areas where stream discharge is used for irrigation, will probably reveal that this soil type is much more abundant than presently perceived. Here we present the results of investigations of irrigation terraces in the Tibetan Himalaya and in the coastal desert of southern Peru. The investigations in the Tibetan Himalaya focused on the upper Kali Gandaki valley (2,500 m to 4,000 m asl.), Mustang, Nepal. The region is characterized by a mixture of operational and abandoned irrigation terraces. Dating of the up to 4 m thick irragric anthrosols showed that irrigation and arable farming started here ca. 2,500 cal. BP. The persistence of irrigation agriculture over more than two millennia demonstrates the robustness and sustainability of this technique at the edge of the Tibetan Plateau. The mixture of operational and abandoned terraces indicates that processes of regional or global extent, like climate change, might not be accountable for the abandonment of specific sites. Geomorphologic analysis of the conditions of abandoned sites revealed that debris flows, deep seated mass movements and Holocene river incision disrupting feeder canals can explain the abandonment of specific sites. In the hyper-arid coastal desert of southern Peru irragric anthrosols cover an area of ca. 14.000 ha at the foot of the Andes in the catchment of the Rio Grande de Nasca. Basal ages of the up to 3,8 m thick anthrosols in the Palpa Valley indicate a start of irrigation agriculture around 3.500 years ago and a more or less continuous expansion of the irrigation system to its present extent. The sedimentary record provides evidence for erosion and sedimentation during extreme runoff events, but there is no indication of widespread abandonment of irrigated fields related to the cultural changes documented for this area. Comparing the sedimentation rates of irragric anthrosols at these two contrasting sites reveals minimum long term rates of 0.3 and 2.0 mm a-1, and maximum rates of 3.0 and 36.0 mm a-1 for the Peruvian and the Tibetan site, respectively. In this paper these findings will be compared to published results from other sites.

Bach, Jaime L.

Use of Maritime History to Assess Local Perceptions and Reactions to Climate Change on the Island of Tabiteuea Maiaki

Bach, Jaime L.[1]

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As vulnerable areas of the world face the effects of global climatic change, local inhabitants perceive of and react to those changes in relation to their previous understanding of their environment. In a society with limited written documentation, other sources must be relied upon in order to compare current situations to past realities. On the island of Tabiteuea Maiaki, within the Pacific island-nation of the Republic of Kiribati, the maritime history of the local culture can be examined as a source of information to expose the contrasts between past and present, through the analytical use of the archaeological record, historical artifacts, and oral traditions. Through the implementation of a three-month pilot study conducted during 2010, preliminary results can be deduced regarding the local perceptions of and reactions to climate change on the island of Tabiteuea Maiaki. Local perceptions, derived from the previous uses of their atoll environment and narratives past down from their ancestors, were compared to current observations in order to show the changing variables to which the islanders are reacting with traditional strategies and innovative techniques.

Basil, Davis A.

Can climate change explain the spread of farming during the Neolithic revolution?

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It has been proposed that the development and spread of settled agriculture from the Middle East to the north and west of Europe during the early and middle part of the Holocene was influenced by climate change. This can be considered in terms of either a 'push' from a deteriorating climate in the source regions, or the 'pull' of an improving climate in destination regions. We investigate this climate change hypothesis using a new updated version of the Davis et al. (2003) pollen-based reconstruction of Holocene climate. This new dataset includes over 20% more sites from across Europe, with particular improvements in data coverage for Central Europe. Climate derived from over 800 pollen sites was assimilated onto a uniform spatial grid and time-step based on a 4-dimensional interpolation technique

composed of 3-dimensional space plus time. This method retains temporal fidelity by focusing the reconstruction onto a particular time-step, helping to avoid the temporal blurring of the 'time-slice' approach. Dating control is provided by over 5000 radiocarbon dates, together with other independent chronological controls such as laminations and tephra. The changing suitability of the climate for various crops has been mapped to provide a measure of agricultural potential during the Holocene for the European region. We then compare these maps with the archaeological and pollen-based record of agricultural development.

http://arve.epfl.ch/

Bayon, Germain

Intensified weathering and anthropogenic deforestation in Iron Age central Africa

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The rainforest in central Africa experienced a major crisis in the third millennium before present. Between about 2800 and 2200 cal yr BP, mature evergreen trees were abruptly replaced by savannas and other pioneer formations. This event is well-documented in numerous palynological and geochemical records from lake sediments in Cameroon, Congo and Gabon. The general consensus is that the forest disturbance was caused by a regional climate change. But there is also evidence for human activities in the Central African rainforest during the third millennium BP. In particular, the major episode of forest clearance was contemporaneous with the Bantu expansion, one of the most significant migration and cultural transformation in human history. At that period, the migration of Bantu-speaking agriculturalists originated from near the modern Nigeria-Cameroon border led to diffusion of novel agricultural practices and iron smelting technology across sub-Saharan Africa. Although the generally accepted view is that the onset of dryer conditions in the second half of the third millennium BP established a favorable environment for the settlement of Bantu farmers across Central Africa, archeological evidence, such as the widespread occurrence of buried charcoal at sites dating back to the early Iron Age, suggest that human may have had an environmental impact on the forest at that period. Whether the Bantu farmers played an active role in the Central African rainforest crisis hence remains an open question. In this study, we present geochemical records (core scanner XRF elemental profiles, Nd and Hf isotopes) from two marine sediment cores recovered off the Congo River, that permit the reconstruction of chemical weathering intensity in central Africa for the last 40,000 years. The data indicate a pulse of intensified weathering centered around 2500 years ago, contemporaneous with the rainforest crisis. Evidence that this weathering event departs significantly from the long-term weathering fluctuations related to the Late Quaternary climate suggests that it was not triggered by natural climatic factors solely. Instead, we propose that the migration of Bantu-speaking agriculturalists across sub-Equatorial Africa at that time had a more pronounced environmental impact than initially thought.

Beach, Tim

Perennial Wetlands of the Ancient Maya: Testing Models of Human-Nature Interactions

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Geoarchaeological research in the wetlands of northern Belize from 2000 to 2009 revealed two new models of soil formation and Maya wetland agriculture as adaptations to landscape inundation and aggradation in the Archaic through Post Classic. Based on a widespread paleosol sequence formed through the Mid Holocene above the perennial water-table, the Maya were farming this landscape as early as 4500 BP in the Archaic Period and into the Maya Preclassic (3000-1700 BP). The water table began to inundate these paleosols by 2500 BP, gradually submerging and burying the paleosol with Histosol layers, erosion-induced sediments, flood alluvium, and gypsum precipitated from sulfate- and calcium-saturated water. We present two conceptual models of landscape evolution based on scores of excavations with multiple lines of evidence. These models show that the ancient Maya responded to environmental change in both piecemeal and preplanned, large-scale efforts to build 900-meter-long ditches to carve out new land for agricultural uses during the Classic Period (c. 1700-1100 BP). We then test these models in two new regions studied in 2009-2010 again based on water and soil chemistry and soil morphology, pollen, phytoliths, macrofossils, and multiple radiocarbon dates. All lines of evidence suggest Maya wetland fields formed by complex natural, environmental changes and heterogeneous human adaptations to these changes to reclaim the fields for multiple crops and other uses.

Berkelhammer, Max B.

Indian Monsoon failure during the 4.2k Event

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The 4.2k Event is arguably the largest abrupt climate excursion to influence the tropics and subtropics during the

Holocene. Rapid shifts to sustained drought conditions between 4.0 and 4.2k have been clearly noted in records from across the Middle East, southeastern Europe, N. Africa, North America and in parts of southern China. There is strong evidence that climatic changes during this time played an influential role in the near-synchronous collapse or reorganization of a number of major civilizations including the Harrapan and the Old Kingdom of Egypt. Despite the careful documentation of the event, there is currently no prevailing hypothesis of its likely climatic origins. Particularly intriguing in this respect is that its signature appears confined between the tropics and mid latitudes with no pronounced changes in the high latitudes, implicating a mechanism that both originated and remained near to the tropics. Here we present continuous δ18O measurements between 3650 to 7940ka from an absolutely-dated speleothem taken from what is currently the rainiest place on Earth; Cherrapunji, India. The record provides clear evidence of an extremely rapid shift in Indian Summer Monsoon (ISM) strength between 4059 and 3860ka. The sampling interval during the excursion is less than 10 years and the timing of the onset and termination are both constrained by radiometric dates with 30 years uncertainty. The magnitude of ISM changes are substantially larger than anything observed during both the multiple millennia preceding the event and throughout the most recent 5 centuries, based on a second nearby late Holocene speleothem record. Reasonable constraints on the scale of ISM changes at this time are inferred using both results from an isotope-enabled GCM simulation and the empirical δ18O-precipitation amount relationship from this region. We use this new evidence of ISM changes during the 4.2k Event as a catalyst to discuss whether changes in the monsoon may have been instrumental in propagating atmospheric anomalies across the tropics and mid-latitudes during this time. We rely on modern observations and modeling of the global atmospheric response to weak ISM years and compare this to the pattern of locations known to have pronounced 4.2k signatures.

Besonen, Mark R.

Increasing Evidence for a Pronounced, Mid-1st Millennium A.D. Desiccation Event in the Eastern Mediterranean

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Lake Kournas, a ~25 m deep lake in western Crete, has provided a sedimentological and geochemical record that documents decadal and centennial-scale climate variability within the Eastern Mediterranean region over the last 6000 years. Oxygen isotope values from the Kournas basin sediments indicate generally drier conditions in the mid-Holocene between ~6000 and 1800 B.C. Minimum δ18O values, suggesting wetter conditions, occurred between 1800 and at least ~1300 B.C. Around A.D. 400, a pronounced desiccation event, the largest noted at Kournas over the length of the record, dropped the lake level by at least ~11 m. This event exposed lacustrine deposits, and allowed them to be downcut leading to a gap in the sediment record at shallower water depths. The timing and magnitude of this event is supported by a companion record from the Limnes basin, a sinkhole depression ~35 km northwest of Kournas on the Akrotiri Peninsula. A catastrophic earthquake in western Crete in A.D. 365 may also have affected the hydrology of the Kournas and Limnes basins (uplift during the earthquake has been estimated at nearly two meters in the area surrounding the lakes). However, a climatic explanation is favored here as it coincides with an increasing body of evidence that demonstrates the existence of this mid-1st millennium desiccation event throughout the Eastern Mediterranean region, and perhaps further afield. Additional paleo records which register this event include an unpublished record from Marmara Gölü, a broad, shallow lake in central western Turkey which abruptly lowered, and went completely dry after the middle of the 5th century A.D. Similarly, Nar Gölü, a crater lake in central Turkey with an annually-laminated sedimentary sequence, provides a stable oxygen isotope record which registers the largest desiccation event of the last 1700 years toward the end of the 5th century A.D. The Nar Gölü record has been linked via teleconnections to both North Atlantic winter climate, and the Indian Monsoon during summers. Additional evidence for this aridity event also comes from recent, ultra-high resolution work on a speleothem from Soreq Cave, Israel which shows a general period of drying in the Levant region from A.D. 100-700 with strong fluctuations around A.D.

100, 400, and 500. Overall, this mid-1st millennium A.D. event may not be as wide-spread as other well-known Holocene abrupt climate change events, but at the local scale for affected regions, it appears that it might have reached a catastrophic magnitude. Though this event is not specifically linked with any societal impacts at this point, it does generally correspond with the decline and fall of the Roman Empire; thus, it would have applied a strong environmental stress to a system already in great flux.

Bettinger, Robert L.

Climate and Human Behavioral Change: The Last 100,000 Years in the Loess Plateau of North China *(INVITED)*

Bettinger, Robert L.[1]

1. Anthropology, University of California - Davis, Davis, CA, USA

While concern over global warming has increased scientific interest in, and funding for scientific research on, modern climate change and its effect on modern society, it remains that the effect of past climate change on past societies is still poorly understood. Archaeologists have traditionally invoked climate to explain such revolutionary changes as the origins of agriculture without demonstrating the connection between climate change and the environmental constraints that are actually limiting the cultural system in question. Sophisticated modeling of cultural processes, reliable climatic proxies, and high quality archaeological data are equally essential in this endeavor. Some of the possibilities, complexities, and challenges in connecting human behavior and climate change are illustrated in relation to three landmark transitions over the last 100,000 years in the Loess Plateau of North China: 1, Appearance of anatomically modern humans; 2, Response to the Last Glacial Maximum; 3, Origins of millet agriculture.

Boslough, Mark

Impact did not Cause Climate Change, Extinction, or Clovis Termination at 12.9 ka

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We present arguments against an extraterrestrial impact as the agent for an abrupt climate change at the 12.9 ka Younger Dryas boundary, terminal Pleistocene extinctions of N. American megafauna, and the supposed termination of the Clovis culture. Our rejection of this hypothesis is based on multiple independent lines of reasoning and evidence. **Physical impossibility:** There is no mechanism that can cause a comet to explode at a sufficient altitude for continental-scale destruction, and no physical process that can sufficiently disperse fragments. **Statistical impossibility**: The *a priori* probability of the extraordinarily-configured impact swarm is effectively zero. **Lack of physical model:** No physics-based model has been proposed for the putative impact/airburst that can be subjected to scientific scrutiny. **Lack of physical evidence:** There are no craters or unambiguous impact markers of the correct age in N. America. **Irreproducibility:** Pt-group analyses failed to confirm the meteoritic signature identified as high Ir concentrations in bulk sediments and in magnetic spherules. There are no peaks in magnetic grains or microspherules in sediments corresponding to the claimed event. Hex diamonds could not be identified. Carbon spherules have morphologies and internal structures identical to fungal sclerotia, and carbon elongates represent arthropod coprolites. **Archeology:** Archaeological, geochronological, and stratigraphic data fail to provide evidence of a demographic collapse of post-Clovis human populations **Stratigraphy:** There are no regional stratigraphic marker beds or other indicators of regional geomorphic instability at 12.9 ka; black mats are time-transgressive in arid western N. America. **Extinctions:** The dung fungal (*Sporormiella*) proxy for megafaunal presence indicates that some Pleistocene megaherbivores declined from 14.6 to 13.7 ka, well before the proposed impact; the chronology of extinction for over half remains unresolved.

Paleoclimate/paleoecology: N. American charcoal and pollen records show rapid changes in vegetation and fire regimes, consistent with the climate changes at both the beginning and end of the Younger Dryas interval. The paleo records, however, do not show evidence of continental-scale wildfire at any time during the last glacial-interglacial transition (15 to 10 ka). Premature and continued invocation of an exceedingly rare external agent, without adequate evidence, to explain climate change, extinction, and supposed human population collapse distracts from our effort to understand the complex links and cascading effects of environmental variability on society.

Buckley, Brendan M.

The Societal Impact of Southeast Asian Hydroclimate Variability Over the Past Millennium

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We have recently produced robust reconstructions of climate from Southeast Asian tree rings that span most of the past millennium. The longest of these is a nearly 900-year reconstruction of March-May Palmer Drought Severity Index (PDSI) from the Vietnamese cypress Fokienia hodginsii from the montane forests of southern Vietnam. The second is a 550-year PDSI reconstruction from northern Vietnam at Mu Cang Chai, from the same species and of the same season. Our third record is a 440-year inferred reconstruction of monsoon season (June-Sept) PDSI from northwestern Thailand teak. These three records reveal periods of episodic drought and pluvials that often lasted decades and coincided with key periods of social upheaval across Southeast Asia, in particular the early 15th century Khmer demise at Angkor and the late 18th century collapse of all major kingdoms across the region. We are using these records to reconstruct flood patterns in the Tonle Sap Basin, and estimate the historical food potential of the largest rice agriculture and fishery system in Indochina. We are currently processing collections of Fokienia from Vietnam and Laos that span from 12 to 23 degrees north latitude, and these will allow us to analyze the spatial variability of hydroclimate over Indochina. Links to ENSO variability and other dynamical causes are highlighted, particularly on decadal time scales. We introduce recently translated historical documentation from ancient chronicles of the Lan Na, Pagan, Siamese and Dai Viet kingdoms that corroborate key periods of droughts, famines, floods, disease and pestilence. In several instances, severe climate anomalies were directly linked to periods of greatest social turmoil. We also apply these climate reconstructions to issues of societal vulnerability in the modern period, in order to build probabilistic predictors of drought for use in rural landscapes. We have demonstrated in simulation that these predictors have skill in improving inter-annual crop and farm-structure choices, and we are developing tools to help reduce risk-averse behavior by rural smallholders, helping to move them away from subsistence thresholds and enhancing community resilience. Our research therefore connects paleoclimate and historical information with present and future vulnerability reduction in Southeast Asia through a long-term perspective on climate variability, and an improved understanding of coupled human and natural systems.

Cadzow, Daniel

Hunter-Gatherers, Horticulturalists, and Climate?

Cadzow, Daniel[1]

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Can hunter gathers and non-intensive horticulturalists have significant impacts on large-scale environmental systems? If so, what are the impacts, how are they made in non-state level and pre-metallurgical societies, and how far into that past can they be projected? To answer these questions we must also know how human activities relate to the proxy data used in paleoenvironmental reconstructions. This will require input from many fields. Current research by ecologists and resilience theorists challenge many age-old assumptions about how social- and ecological-systems interact. Ethnologists and archaeologists are showing how long-term aggregations of daily practices of non-intensive horticulturalists can influence socioecological ecological settings at large scales. These insights call for new and innovative analyses of ethnohistoric literature and other sets of data for evidence that was overlooked or misinterpreted during past investigations. This includes evidence of large-scale clearings for settlement and agriculture and broadcast biomass burning. This research uses data and theory used by archaeologists, ethnographers, historians, ecologists, and paleoecologists to build a model that illustrates how Stone Age people can influence environments at scales that have the potential to affect climate. Those investigating the carbon cycle, and its role in trapping energy near the earth's surface, are finding the terrestrial reservoirs of carbon to be significant. They are also finding practices like biomass burning to be effective at mobilizing the carbon stored in these reservoirs. It is therefore possible that humans have for thousands or even tens of thousands of years played a significant role in redistributing terrestrial reserves of carbon thereby influencing the changing climate. This paper

will describe my proposed dissertation research, which consists of the excavation of sediment cores from the vicinity of key sites that are well documented archaeologically and historically. The cores will be analyzed for changes in pollen, phytoliths, and charcoal as they relate to documented changes in habitation, population sizes, and practices. This research is necessary because the assumption that humans caused changes in these proxy data is as tenuous as the assumption that humans had no impact.

Chen, Zhongyuan

Neolithic and delta of China

Chen, Zhongyuan[1]

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This paper tends to use geoarchaeological approach to discuss the kinship of Chinese Neolithic evolution to delta formation, including the Yangtze (Changjiang), Zhujiang (Pearl) and Yellow (Huanghe) River deltas. The exiting database has revealed numerous Neolithic settlements (>1000) on the Yangtze delta coast, initiating mostly from 7000 – 4000 years BP. The established spatial and temporal migration of the settlements of three major cultural stages represents delta-coast topographic change in response to the Holocene sea-level rise. The gradually stabilized coastline from early to mid-late Holocene provides a habitable selectivity for our ancestors, who had engaged in the rice cultivation since 7000 years ago, the timing of the Holocene delta initiation. The early sparsely- and loosely-distributed to late clustered settlements with emergence of highly-sophisticated ancient city and hydro-dykes on the selected portion of delta coast highlights the significance of environmental control. In comparison, instability of the Yellow river channel due to over-siltation and associated floodings made most Neolithic settlements inhabitable on the delta coast, but those on the river-channel terraces with less influence of the Holocene sea level fluctuations. Limited Neolithic settlements of the Zhujiang delta mostly occurred on the inner estuarine coast, or on the island coast, which are primarily pre-Quaternary bedrocks exposed in the mid of estuarine bay. Topographically, these settlements were habituated at places with 1-2 m higher than the surrounding lowlands. Of note, the Holocene climate warming also helped promote the coastal civilization, as represented by rice cultivation and associated cultural development. The earlier rice cultivation in the Yangtze delta of subtropical-temperate zone than that of the Zhujiang of subtropical setting probably meant the differences of monsoonal function and food diversity. Virtually, the established Neolithic settlement patterns of the Chinese deltas reflect the regional uniqueness of physical setting. These are determinant in controlling the advancement of the Chinese Neolithic civilization on the delta-coast, primarily from low-level agricultural farming to societal sophistication.

Chmura, Gail L.

The Human Trigger for Development of Tree Islands in the Florida Everglades

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During the last glacial, the vegetation of South Florida was arid steppe distributed across a karst landscape. Over the Holocene rising sea levels caused the water table to rise, eventually creating a landscape with saturated soils and a "river of grass", i.e., marsh vegetation dominated by sawgrass. The modern Everglades also contains elevated areas that serve as islands of terrestrial vegetation, many high enough to support trees. The slightly higher elevation (1-2 m) and vegetation diversity of the islands provides refuge for wildlife avoiding seasonal high waters and the islands are highly valued as hotspots of diversity within the Everglades system. Sediment coring for paleoecological studies indicated that peats of the islands were younger and shallower than those of the surrounding marsh, supporting a widely held belief that the tree islands formed over localized high points in the underlying carbonate bedrock. More recent discovery of a hard mineral layer perched within the peat soils of many islands reveals that depth to bedrock, and age of islands has been misinterpreted, calling for a new theory of tree island development. The ~40-75 cm thick layer, a "pedogenic calcrete" is composed of reprecipitated calcium carbonates and calcium phosphates interspersed with bone, charcoal, and human artefacts. Below is a midden with cultural artefacts that date to the origin of the Everglades wetland system about 4,000 years ago. It is likely that early human occupation on the landscape was responsible for development of the Everglades large tree islands as well as island stability and productivity. The elevated surfaces of middens provided refuge for terrestrial vegetation as surrounding soil became saturated. Bones in the middens provided additional bulk as well as phosphorous for plant growth in the otherwise phosphorous-depleted wetland. These better soil conditions allowed establishment of trees which were key to development of the perched mineral layer. Trees are known to play a major role in pedogenic calcrete formation, particularly in areas with pronounced wet and dry seasons, such as the Everglades. Transpiration by the trees draws carbonate-rich water through the soil and carbonates and phosphates excluded from the roots are deposited within the rooting zone. Our research indicates that this process probably began with establishment of trees on the island and is an ongoing process. Fire is a regular phenomenon in the Everglades, resulting in combustion of peat soils. Because it does not burn, the calcrete layer protects the underlying soil, maintaining elevation and allowing regrowth of terrestrial vegetation. Ironically, it is human disturbance that now threatens these valuable ecosystems. Urban development has displaced much of the Everglades

and water control systems threaten the remainder. The calcrete layer is subject to dissolution under extended flooding and if not maintained by tree growth. This is likely occurring in South Florida's water control districts today, where high water levels are maintained and tree islands are disappearing.

Clift, Peter

Evolving Holocene Drainage Geometries and Environmental Conditions in the Indus River Basin

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While there is general agreement that the SW Asian monsoon strengthened during the Early Holocene and then progressively weakened after ~8 ka there continues to be debate concerning how quickly the environment dried and whether this may have controlled the rise and fall of early human societies in western India and Pakistan. While rapid drying has been proposed at the time when the Harappan Culture appears to have ended such models ignore the important role that river in a dry, desert environment play in sustaining life. In this study we attempted to reconstruct changing environmental conditions and fluvial patterns around the western edge of the Thar Desert since ~10 ka. Clay mineral assemblages are sensitive to weathering processses and we record a shift towards more smectite and especially kaolinite after 8 ka, indicating more chemical weathering. This trend became more intense after 4.5 ka when the last evidence for an active river was found in the region close to the archeological sites. The intensifying chemical weathering reflects the lack of sediment transport and new sedimentation, despite the more arid conditions. Dating by U-Pb methods of zircon grains extracted from sands cored and trenched from the flood plain in Pakistani Punjab shows age populations that are inconsistent with sediment sourced from either the Sutlej or the modern Ghaggar-Hakra, which presently lie closest to the desert. We suggest that in the Early-Mid Holocene the area of heaviest Harappan Settlement was one of significant fluvial confluence. The Sutlej and an independent Beas River flowed much closer to the Thar Desert than they do now. Moreover, we propose that the Yamuna, which now flows east into the Ganges, must have contributed to the sediment flux in the recent geological past, although the precise age of capture is, so far, not yet well determined. The end of the Mature Harappan Phase of settlement around 1900 BCE appears to shortly postdate the end of major river flow in the region, as the Sutlej migrated north, capturing the Beas. This change in the course of the Sutlej, together with the probable loss of the Yamuna resulted in the much smaller Ghaggar-Hakra being unable by itself to maintain significant flow into the desert, especially in the context of a weakening summer monsoon. The effect of this reorganization may have been as catastrophic to agriculture as the proposed abrupt weakening of the summer monsoon rains.

Cooper, Jago

Living with Extreme Weather in a Stable Climate: A long-term perspective on human-climate relationships in the Caribbean

Cooper, Jago[1]

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This paper presents results from a three year Leverhulme funded research project focused on 'The Archaeology of Climate Change in the Caribbean'. This project has explored the dynamic relationship between relative climatic stability, social development and environmental change on the different islands of the Caribbean. This paper will summarize how the impacts of relative sea level change, precipitation variation and hurricane activity over the past 6000 years in the Caribbean can be considered in light of changing settlement locations, food procurement strategies and household architecture traditions over time. Regional patterns of climatic variability are discussed and key climatic and environmental hazards are identified at local, national and regional scales of analysis. This paper then presents results from an interdisciplinary fieldwork project conducted, in collaboration with the Cuban Ministry of Science, Technology and Environment, in northern Cuba since 2003. This case study uses recently acquired archaeological, paleoclimatic and paleoenvironmental data to provide a detailed local perspective on how past human communities have lived through the impacts of climatic and environmental hazards in northern Cuba over the past 6000 years. This study facilitates an improved understanding of the scaled temporalities with which human communities experience climate variability and how concepts of stability and instability should be approached. The framework for human decision-making is evaluated and the multi-temporal and multi-spatial complexity of social, climatic and environmental change is revealed. This study highlights the conceptual friction between linking thresholds in climate change, tipping points of sudden environmental change and divergent pathways through societal progression. However, the relative resilience of different community lifeways are assessed in light of known climatic and environmental hazards in the region and this provides key lessons of threat and mitigation that have important implications for modern day communities living the Caribbean.

http://www2.le.ac.uk/departments/archaeology/people/cooper http://www.gheahome.org/

Day, John W.

Post-Glacial Coastal Margin Productivity and the Emergence of Complex Societies *(INVITED)*

Day, John W.[1]; Gunn, Joel[2]; Folan, William[3]; Yanez-Arancibia, Alejandro[4]; Horton, Benjamin[5]

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2. Anthropology, University of North Carolin, Greensboro, NC, USA
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4. Natural Resources, Institute of Ecology, Xalapa, Mexico
5. Earth and Environmental Sciences, University of Pennsylvania, Philadelphiq, PA, USA

As relative sea level stabilized following deglaciation after c. 7,000 BP, coastal margin primary and secondary productivity increased by an order of magnitude or more. Animals in the coastal margin were readily available to humans as high quality protein and polyunsaturated fats, necessary components of anatomically modern human nutrition. Within about 500 years of relative sea level stabilization, coastal margins were occupied by Neolithic agricultural and fishing villages. Population densities increased greatly, social ranking appeared, and monumental architecture requiring the mobilization of labor forces were constructed a further half millennium later. Our thesis is that the temporal and spatial pattern and magnitude of increased coastal margin food availability was critical to the evolution of early complex societies. The time between population expansion and the establishment of complex societies varied. Our investigation indicates that this variability was related to the seasonality of local environments and the change from mid to late Holocene global climate.

deMenocal, Peter B.

What caused the mid-Pliocene aridification of Africa? *(INVITED)*

deMenocal, Peter B.[1]; Feakins, Sarah[2]; Eglinton, Tim[3]; Cléroux, Caroline[1]; Arbuszewski, Jennifer[1]

1. Lamont-Doherty Earth Obs, Palisades, NY, USA
2. Dept. of Earth Sciences, University of Southern California, Palisades, CA, USA
3. ETH, Zürich, Switzerland

A wealth of marine and terrestrial paleoclimate records document the progressive drying of North and East Africa throughout the last 4 Ma. Expansion of savannah grasses and prevalence of grazing mammals occurs just after 3 Ma, reaching peak aridity by 1.6 Ma. Because of its relevance to paleoenvironmental changes associated with key events in hominin evolution, the timing and cause of this aridification has drawn great interest. Prior hypotheses for the drying trend have included remote influences from high-latitude ice sheets, reduced CO2, and uplift of the East African highlands, each of which have potential complications. A recent hypothesis was developed in a pair of papers by Cane and Molnar (2001) and Philander and Federov (2003) that emphasizes the importance of changes in tropical SST gradients in controlling the moisture convergence over East Africa. Atmospheric convection and rainfall in the tropics occurs where SSTs are warmest which, today, occurs over the warm pools of the western Pacific and western Atlantic, establishing vertical (Walker) circulation cells that presently limit rainfall over East Africa. Central to this hypothesis is the timing of the emergence of modern Indo-Pacific SST gradients. New and previously-published SST records from the east and west basins of the tropical Atlantic, Indian, and Pacific basins are presented which span the last 4 Ma. These records indicate that the emergence zonal and meridional SST gradients first appeared in the Atlantic near 2.8 Ma, followed by a nearly synchronous emergence of the Indian and Pacific zonal SST gradients near 1.6 Ma. Marine sediment records of African paleoclimate evolution over this time document that Northwestern African dust fluxes increased markedly after 2.8 Ma, whereas driest conditions were established much later in East Africa, near 1.6-1.8 Ma. Recent climate model results by Brierley and Federov (2009) have studied the impact of tropical SST gradient changes on the climate of North and East Africa, and they find that the aridification of North Africa is most sensitive to the development of strong meridional Atlantic SST gradients, whereas the aridification of Eastern Africa is more sensitive to the emergence of zonal SST gradients in the Indian and Pacific basins. These results appear explain some of the puzzling differences between paleoclimate histories of North and East Africa, as well as their shared common late Neogene trend toward drier conditions.

Dixit, Yama

Holocene Palaeoclimate History of the Plains of NW India Inferred from Palaeo-Lake Riwasa

Dixit, Yama[1]; Hodell, David A.[1]; Sinha, Rajiv[3]; Petrie, Cameron[2]

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2. Department of Archeology, University of Cambridge, Cambridge, United Kingdom
3. Department of Civil Engineering, Indian Institute of Technology, Kanpur, India

The Indus Civilization flourished from ~4600 to ~3900 yrs BP across a range of environmental zones that now span the borders of present-day India and Pakistan. Its major urban centres started to decline from ~3900 BP, but the precise reasons for this are still unclear. Climate and/or environmental change has been advocated as one of the major factors, but there is no consensus on this issue.However, extant paleoclimatic reconstructions have typically used proxy data obtained from areas that lie beyond the geographic limits of the Indus Civilisation, and it is questionable whether such data can be used to reconstruct the paleoclimate of the subcontinent or of any of the environmental zones inhabited by Indus Civilisation

populations. The plains of NW India lie across the boundary between arid and semi-arid zones and the archaeological research has suggested that this was one of the most intensively settled regions in the periods before, during and particularly after the floret of the Indus Civilisation. The precise climatological and environmental conditions affecting this region during the mid-late Holocene remain largely unknown, and to remedy this, we have dated and analysed sediment samples obtained from cores and pit sections from a paleo-lake bed at Riwasa in Haryana plains, India. Riwasa is a dry lake bed that once existed in a very steep rainfall gradient (200-600mm) near some of the important archaeological sites in this region. When the lake contained water, its hydrology was likely highly sensitive to changes in the balance of precipitation and evaporation. It is thus well-suited for a paleoclimatic study in relation to the cultural evolution of the Indus Civilisation. Below the top soil, the upper ~3 meters of this lake bed contains silty clay, carbonate-rich sediments with abundant freshwater gastropod and ostracod shells. The calcium carbonate content and the (> 63micron) particle concentration indicates the presence of a massive hard ground underlying the top one metre of the sediemnts. Split cores have been analysed using an XRF core scanner and high-resolution sampling has been carried out on two cores and an exposed standing section through the Riwasa lake sequence. Samples of ostracods and gastropods have been used for AMS radiocarbon dating and δ18O and δ13C isotope analysis. Results have confirmed the existence of a wet phase during the early Holocene but have also indicated that there was great variability in oxygen isotope ratios of individual ostracod valves within a single sample. Such large variability in shell isotopic composition suggests that there were frequent lake level fluctuations caused by flooding during wet periods and evaporative enrichment during dry times, typical of a playa lake. The Riwasa record constitutes the first isotope proxy record of local paleoclimate change from the plains of NW India.

Draut, Amy E.

Climate variation, landscape cover, and aeolian sand mobility on the Navajo Nation, southwestern U.S

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Native Americans of the southwestern U.S. live on ecologically sensitive semiarid to arid lands with limited resources. On the 65,000 km2 Navajo Nation, southern Colorado Plateau, one-third of the land surface is covered by sand dune deposits. Higher temperatures, changing precipitation (drought for the past 14 years), and the spread of exotic plant species are transforming the landscape, negatively impacting residents, many of whom continue to live a traditional, subsistence lifestyle. During the past decade of drought, the spatial extent of sand susceptible to mobilization has increased appreciably. Sand dune migration rates in this region can exceed 35 m/yr, and regionally significant dust storms are now common. Aeolian sand mobilization from formerly stabilized ground surfaces endangers housing and transportation, jeopardizes grazing lands, and impacts regional air quality. For people to continue to inhabit this area successfully, we must understand the processes that are rapidly altering these drylands and develop mitigation strategies. We present results from a 2-yr field study in a 0.124 km2 region of the Navajo Nation, identifying the influence of ephemeral fluvial sediment supply, livestock grazing, and climate patterns (seasonal monsoonal rains, and an El Niño event) on aeolian sand transport, vegetation abundance and assemblage, and the extent of biologic soil crust. Sand mobility and transport were substantially greater during the drier, non-El Niño year than during the El Niño year. Plant cover increased significantly as a result of summer monsoon rains, as did biologic soil crust. In addition, the rains produced a 10 m3/s flood in an ephemeral wash, and contributed to proportionally greater increase of invasive Salsola (Russian thistle) than of other types of vegetation. Salsola generally composed a greater proportion of plant cover in the part of the study area with heaviest livestock use. We suggest a conceptual model wherein monsoon-caused floods (in summer and fall) supply sand that is subsequently entrained by wind (with most transport occurring the following spring), forming aeolian dunes downwind of the wash. It is proposed that negative feedback occurs in the seasons following intense monsoon rains, such that the increased aeolian sand supply after monsoon flooding destabilizes new vegetation that initially thrived because of monsoon rainfall, and contributes to increased dune mobility. Against a backdrop of warmer, drier climate (less vegetation overall), the increased aeolian sand transport and dune migration resulting from monsoonal floods would thus further compromise living conditions for traditional cultures in the southwestern U.S.

Fagan, Brian M.

"The Great Warming: An Archaeologist looks at ancient climate change, or: The STory of the Silent Elephant in the Room

Fagan, Brian M.[1]

1. Lindbriar Corporation, Santa Barbara, CA, USA

What lessons about climate change can we learn from the experience of our forebears? The warmer world of the Medieval Warm Period (c. A.D. 800 to 1250) helped Europe to prosper and the Norse to sail to North America. But Little known global droughts brought centuries of aridity to the western United States, caused much of Ancient Maya civilization to implode, and rippled across South America and Asia, sometimes with catastrophic results. The events of the Medieval Warm Period may help us understand a near and more distant future where severe droughts will affect millions of people, especially those in arid and semi-arid lands. By delving into the little known history of humans

and water, the presentation shows how our relationship to this most precious of resources has changed profoundly since the Industrial Revolution. By promiscuous deep pumping, we have raised our vulnerability to water shortfalls to dangerous levels. Finally, I look ahead at some of the strategies that will allow us to thrive in an era of increasingly scarce water supplies.

Fagan, Brian M.

The Great Warming: An Archaeologist Looks at Climate Change, or the Story of the Silent Elephant in the Room *(INVITED)*

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1. Lindbriar Corporation, Santa Barbara, CA, USA

What lessons about climate change can we learn from the experience of our forebears? The warmer world of the Medieval Warm Period (c. A.D. 800 to 1250) helped Europe to prosper and the Norse to sail to North America. But Little known global droughts brought centuries of aridity to the western United States, caused much of Ancient Maya civilization to implode, and rippled across South America and Asia, sometimes with catastrophic results. The events of the Medieval Warm Period may help us understand a near and more distant future where severe droughts will affect millions of people, especially those in arid and semi-arid lands. By delving into the little known history of humans and water, the presentation shows how our relationship to this most precious of resources has changed profoundly since the Industrial Revolution. By promiscuous deep pumping, we have raised our vulnerability to water shortfalls to dangerous levels. Finally, I look ahead at some of the strategies that will allow us to thrive in an era of increasingly scarce water supplies.

Fuller, Dorian Q.

When did climate changes encourage rice agriculture, and when did rice agriculture encourage climate change?

Fuller, Dorian Q.[1]

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Recent archaeobotanical evidence allows the first systematic assessment of the evolution of morphological domestication traits in rice populations of the Lower Yangtze during the middle Holocene, while a recently compiled database allows use to place the spread of early rice agriculture in its macro-regional and chronological context in Asia. This paper will assess the evidence for the evolution of rice cultivation, including the evidence for wet-field systems (from preserved fields and weed flora), and the evolution of morphologically domesticated rice (spikelet basesm grain metrics) against the evidence for climatic and vegetational change in the Yangtze region of China. This suggests that while directional changes in vegetation may have helped to constrain subsistence options increasingly towards rice, social pressures also contributed towards rice domestication, and there is no smoking gun that a single climatic event drove the origins of rice agriculture. The evidence for separate slow start to Indian rice cultivation will be briefly reviewed. Nevertheless, once established (by 6000 BP) rice agriculture promoted larger populations and the cultivation of rice spread widely to North China and subsequently to Southeast Asia, Korea, Japan. The spread of rice shows two periods of punctuated major expansion, in the third millennium BC (4500-4000 BP) and in the first millennium BC (ca. 2500 BP), and the latter clearly associated with an increase in irrigated paddy rice. A model of the spread of rice in these periods can be correlated with increased methane levels in the atmosphere. Thus while the spread of rice can be seen to have affected global climate it is less clear that earlier climatic changes were responsible for the beginnings of rice agriculture.

http://www.ucl.ac.uk/rice/

Gatti, Emma

Hydrological response to the Toba super-volcano ash fallout in the Middle Son Valley, Western India: palaeo-environmental and archaeological implications

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The climatic and environmental impacts of the Youngest Toba Tuff (YTT, 74 kyr +/- 2 BP) eruption from Toba volcano, Northern Sumatra, are hotly debated in the literature. Intense global cooling and the onset of a glacial period has been attributed to aerosol and ash emitted by the eruption, although recent studies suggest that the impacts were far less severe. Following this theme, it has also been suggested that the YTT eruption played an important role in shaping the genetic diversity of modern human populations. The Middle Son Valley, India, was the first locality in the Indian Subcontinent reporting presence of YTT. The ash extends for more than 30 km and forms a discontinuous but constant layer, showing in few selected sites primary deposits topped with secondary re-washed ash and eolian sediments. The ash has been investigated since the '90s to assess both the global palaeo-envrionmental and human impact of the Toba eruption, with discordant results. Nevertheless, the exact position within the alluvial stratigraphy and absolute dates relative to the Quaternary sediments surrounding the ash are still unclear. Here we report on the stratigraphic context of ash layers present in alluvial deposits in the area Rehi-Ghoghara-Khutiali, in order to assess the validity of the YTT as chronostratigraphic marker for palaeo-environmental and archaeological studies. Using stratigraphic logs and sedimentological reconstruction, we

have studied the lithostratigraphic units of the receiving environment at the time of the eruption and the river evolution after the ash fall-out. Facies associations have been used to determine the geomorphology of the river and a new hydrological, geomorphologically constrained model for the Son River is proposed. The model demonstrates that due to the river conformity and landscape characteristics, the YTT associations in the Middle son Valley, except one, are not a reliable tool for chronostratigraphic correlation.

Gauthier, Emilie

From first Caribou to Norse sheep: impact of grazing in south Greenland

Gauthier, Emilie[1]; Massa, Charly[1]; Bichet, Vincent[1]; Perren, Bianca[1]; Petit, Christophe[2]; Richard, Hervé[1]

1. Chrono-environnement laboratory, UMR 6249/CNRS, University of Franche-Comté, Besançon, France
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Radiocarbon dating, pollen and non-pollen palynomorph analyses from a sediment core were used to establish the timing and effects of farming activities around Lake Igaliku, Eastern Settlement, South Greenland. Usually, the absence of agro-pastoral impact before the medieval colonization by Europeans provides an opportunity to understand the development of farming activity in a pristine landscape. However, large herds of grazing herbivore, as early as 8000 cal. BP, could have a first impact on vegetation evolution. From 8000 to 4000 cal. BP, a pollen record from Lake Igaliku shows that vegetation is dominated by Juniperus and Salix. Increases in coprophilous fungi (e.g. Sporormiella, Sordariaceae, Cercophora, Podospora) suggest grazing herbivores, probably caribou, in the surrounding area. The arrival of caribou in north Greenland (Peary Land) is dated to 8000 cal. BP (Bennike, 1997); however, their first occurrence in South Greenland has never been demonstrated and this analysis could be the first evidence of their presence as soon as 8000 cal. BP. These grazing herbivores had an impact on vegetation: each increase in coprophilous fungi is related to decrease in Juniper, and a clear increase in Selaginella and Cyperaceae. The onset of Betula glandulosa development corresponds to a decrease in coprophilous fungi and evidence of grazing herbivores remain scarce until the settlement of Norse farmers by the end on the 10th century AD (Gauthier et al. 2010). Settlers arrived in a landscape dominated by Betula glandulosa, Betula pubescens and Salix. Decrease in Betula pubescens and Juniperus and the rise in coprophilous fungi are the first evidence of human settlement. The presence of Norse settlers and livestock is clearly recorded from the 11–12th century A.D.: increasing frequencies of Selaginella, Cyperaceae, Norse apophytes (Rumex acetosa type and Ranunculus acris type) and coprophilous fungi. This colonization phase is followed by a period of decreasing human impact at the beginning of the 14th century, with a decrease in Selaginella, Cyperaceae, weeds, apophytes and coprophilous fungi suggesting a reduced grazing pressure. The regrowth of Salix and Betula and the disappearance of anthropogenic indicators except Rumex acetosa type between the 15th and 18th century demonstrate the abandonment of the settlement, until the development of contemporary agriculture in the 20th century.

Gauthier, Emilie

ULTIMAGRI Project: from pristine to anthropogenic Greenland landscape

Bichet, Vincent[1]; Petit, Christophe[2]; Gauthier, Emilie[1]; Massa, Charly[1]; Perren, Bianca[1]; Richard, Hervé[1]; Vannière, Boris[1]; Monna, Fabrice[3]; Millet, Laurent[1]

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In view of the current global warming and the likely increase in human impacts on natural systems, looking at past models provides opportunities to explore the complex relationship between climate and human societies. Therefore, the historical development of agriculture on the southwestern coast of Greenland presents an exceptional study model to examine the transition from a pristine to an anthropogenic landscape. The ULTIMAGRI project, based on multi-proxies analyses of lake deposits, aims to examine the environmental legacy of Norse agriculture (985-1450 A.D. – Medieval Warm Period) and its collapse, and the limited reestablishment of farms in the late 20th century (ca 1920 A.D. – today). During two summer field seasons (2007 and 2009), a dozen lakes have been cored in the two main archaeological and modern farming areas (Norse "eastern" settlement – Narsaq district 61°N - and "western" settlement – Nuuk district, 64°N). In order to investigate detailed and continuous palaeoenvironmental archives, sediments were cored from the central part of the lakes from a floating platform using a long piston corer. Four sequences have been dated with 14C AMS measurements on terrestrial macrofossils, that cover the entire Holocene. For two of them, Igaliku Lake (N61°00'24" - W45°26'30") and Kapisilit Lake (N 64°25'32"- W 50°11'34"), a robust depth-age model (numerous 14C AMS, 210Pb and 137Cs) has been established, focusing on the last two millennia. On these two cores, a suite of biological and physical proxies (pollen, non-pollen palynomorphs, diatoms, chironomids, magnetic susceptibility, grain size distribution, mineralogy, geochemistry, C and N isotopes) is under way. The first results from the Igaliku sedimentary sequence provides a new high resolution insight into historical and modern Greenland sub-arctic farming activities. It suggests that, although farming activities of the Norse are well registered in the sedimentary sequence at Igaliku, the magnitude of the impact of the 4 centuries of Norse agriculture is considerably less than several decades of modern farming in the catchment.

Gibson, J Robert

The potential Impact of paleoclimatology and archeology on mankind's willingness to make sacrifices to mitigate future climate change

Gibson, J Robert[1]

1. Former Director Sustainable Development, John Swire & Sons (HK) Ltd, Hong Kong, Hong Kong

Climate scientists warn our emissions of greenhouse gases will destabilize climate causing a substantial reduction our earth's life carrying capacity. The risks, however, are not clear enough for Governments to take sufficient action. Winston Churchill once said: 'The farther backward you can look, the farther forward you can see'. Do paleoclimatology and archeology have the potential to make the risks from climate change and resource over-exploitation sufficiently 'real' that Government leaders will take action and the public will accept lower living standards? Examples which have impact: 1. The map of the river system in the Sahara 6,000 years ago is one example of paleoclimatology showing the scale of climate changes which may occur. 2. Archeology on Easter Island, as described in Jarrad Diamond's Collapse, provides a graphic example of a society overexploiting the its resources and suffering a population crash. What more can paleoclimatology and archeology do to make the risks 'real' to people before it is too late to avert climate destabilization? Do we have sufficiently clear stories to tell? Are we telling them through a medium which reaches both Leaders and the public? The author is an Accountant who spent four years working on these issues in a conglomerate corporation. He concludes that paleoclimatology and archeology are helpful but much more can be done.

Giosan, Liviu

From the Blue Danube to the Black Sea: Climate-Landscape-Human Interactions in the Lower Danube Basin

Giosan, Liviu[1]

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The Lower Danube basin and the Black Sea coast have been invoked as crucibles of civilization and pathways of cultural and population diffusion from East to West and vice versa. The history of these interactions between humans, landscapes and climate is recorded in the sedimentary deposits of the Danube delta and the Black Sea. Here I present new data and review the status of: (1) the proposed link between the westward migration of the Neolithic cultural package and the Black Sea reconnection to the World Ocean and (2) the landscape and ecosystem modifications brought in by the Medieval deforestation and the Industrial Revolution diffusing eastward with the help of the trade along the Danube. Stratigraphic and paleo-geomorphologic information from Danube delta aided by radiocarbon ages on articulated mollusks constrain the level in the Black Sea before the marine reconnection to ca. 30 m below the present sea level rather than 80 m or lower. I argue that if the flood occurred at all, the sea level increase and the flooded area during the reconnection were significantly smaller than previously proposed. If the link between the Black Sea "flood" and the Neolithic spread of agriculture remains controversial, the Medieval agriculture followed by the Industrial Revolution affected drastically landscapes, humans and ecosystems. I show that legacy sediments and nutrients produced by during these cultural periods and transported along the Danube changed the Danube delta landscape and the Black Sea ecosystem much earlier than previously thought. Human impacts increased dramatically both in the delta and the Black Sea following the increased trade between Eastern and Western Europe after the establishment the European Danube Commission in 1856.

Giosan, Liviu

Landscape Dynamics in the Indus Basin: From Harappa to the Flood of 2010

Giosan, Liviu[1]; Clift, Peter D.[2]

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Abundance of sediment relative to the water discharged by the Indus has been the most important control on the evolution of the Indus alluvial plain during the last 10,000 years. During this time civilizations surged and faded on the Indus alluvial plain interacting with the landscape differently depending on the location in the Indus basin, whether in Punjab, Cholistan, Haryana or Sindh. While its large Himalayan tributaries incised their floodplains in Punjab, the Indus alluvial plain in Sindh has been largely aggradational throughout the Holocene. Consequently, the Indus has repeatedly built stacking mega-alluvial fan-ridges along the entire length of its lower alluvial plain and switched its delta from east to west. In contrast to the cannibalization of Punjabi plain sediments through incision by Himalayan rivers, deposition continued until mid Holocene along the proposed course of the mythical Saraswati River, the Ghaggar-Hakra valley, which appears to have dried up or have been captured before significant incision occurred. We discuss possible scenarios of human-landscape interactions over the last millennia based on new geomorphic, stratigraphic and geochemical data collected in the Indus region, as well as peninsular India during recent projects in the region. Climatic modulation of the water discharge and sediment load on the Indus and its tributaries favoring a highly dynamic landscape emerges as crucial for the development as well as slow disintegration of the Harappan Civilization from ca. 5500 to 3000 years BP. Today, in contrast, almost no water makes it to the Arabian Sea coast and sediment is trapped in reservoirs and along the river as the floodplain is isolated from the river by artificial levees. This new pattern of sediment redistribution inland and the inherited inland fan morphology combines with the increased density of human occupation on a previously unstable dynamic landscape to increase the vulnerability to large floods.

Gontz, Allen M.

The preservation of New England paleo-landscapes – links to past societies and sea-level change

Gontz, Allen M.[1]; Maio, Christopher[1]; Gosselin, David[1]; Wagenknecht, Ekatherina[1]; Mastone, Victor[2]

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The formerly glaciated coastal system of New England has experienced a dynamic sea-level history since the onset of deglaciation about 22 ka. Initially, isostatic depression resulted in a local sea level highstand followed by a rapid regression to a lowstand that varies in elevation from -60 m in Maine to -40 m in Massachusetts between 12 and 14 ka. The close proximity of southeastern Massachusetts to the terminus of the Last Glacial Maximum also resulted in large proglacial lakes during this time. Following the lowstand, a transgression began that continues through the present. Due to the lasting effect of isostatic depression and rebound, rates of sea-level rise throughout New England have been extremely variable when compared to the global averages, especially prior to 6 ka. These variable rates of sea-level rise have affected the New England coastal system in various ways, at times focusing energy on a specific elevation for long or short periods of time. This has resulted in a variable potential for preservation of paleo-landscapes. Ongoing research in coastal Massachusetts is focused on the time period between 10 ka and the present, which represents the immediate post-lowstand transgression to the present. Numerous preserved paleo-landscapes have been discovered, including back-filled and preserved fluvial channels, flood plains, salt marshes, paleo-sols, submerged forests, inlets and beach systems. Our research throughout the Massachusetts coastal system has identified three areas critical in understanding the complex styles of the evolution of the landscape resulting from varying rates of sea-level rise. The Neponset River system exhibits conversion of terrestrial landscapes to submerged sub-tidal lands during times of higher-than-present sea-level rise rates. As the transgression progressed, the Neponset system illustrates the influence of varying landscape preservation potential related to changes in exposure. Further, the entire system is complicated by intense anthropogenic alteration. In addition to the Neponset system, there are two submerged forest sites on the southeastern Massachusetts coast. These forest sites date to ca 2770 ybp and illustrate isolated landscape preservation with tree stumps and paleo-sols. The forest sites, based on comparison to well-established relative sea-level curves suggest they existed at times of slower-than-present sea-level rise rates. The preservation potential of paleo-landscapes and the evidence of human occupation of those landscapes are strongly controlled by antecedent topography, framework geology and the timing and style of sea-level rise. By examining well-preserved examples from the geologic record, we can begin to extrapolate past evolutionary trends into the future as sea-level rise rates increase and, thereby, establish an informed perspective of how present-day coastal landscapes will respond. Additionally, understanding the landscape response will assist in locating areas that possess a high degree of potential for submerged cultural resources and thus provide insight for designing and implementing conservation and preservation strategies.

Gupta, Sanjeev

Large-scale river channel shifts on the western Indo-Gangetic Plains: Implications for Harappan civilisation

Gupta, Sanjeev[1]; Sinha, Rajiv[2]; Ajit, Singh[2]; Carter, Andrew[4]; Mason, Philippa[1]; Murray, Andrew[5]; Yadav, G.[3]; Buylaert, Jan-Pieter[5]; Thomsen, Kristina[5]; Ferrat, Marion[1]

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The distribution of settlements in ancient societies is commonly linked to the courses of large river systems. The Bronze Age Harappan civilisation is no exception with the major sites of Harappa and Mohenjo-Daro located along the Indus river system. However, the largest collection of Harappan archaeological sites are associated with the postulated surface trace of a large palaeo-river channel in the drainage divide tract between the Ganges and Indus river systems, where no major river currently flows. It has been proposed that this palaeo-channel was occupied by a major river sourced in the Himalaya, and that this river provided water resources to sustain the extensive Harappan sites located along its ancient course. The abrupt abandonment of urban centres here at ~3500 BP has been explained by explanations such as river diversions and abrupt monsoon weakening. These hypotheses have remained untested because the stratigraphy and chronology of the postulated palaeochannel has never been determined. Here we present an integrated study of the Ghaggar-Hakra palaeochannel based on detailed analysis in NW India. We use a combination of satellite image analysis, subsurface geophysical analysis and detailed sediment coring to analyse the large-scale planform geometry, and detailed sedimentary and stratigraphic nature of the postulated palaeochannel in NW India. In particular we focus our analysis on a tract of the proposed channel adjacent to the major Harappan urban centre of Kalibangan in Rajastan State. We present an investigation of satellite imagery data which when coupled with resistivity sounding data reveal the presence of a thick, and extensive sandbody in the subsurface beneath the postulated surface trace observed on satellite imagery. Extensive drilling into this sandbody reveals its sedimentology and stratigraphy, and confirms that it does indeed represent a fluvial sand package up to 30 m thick, comprising multiple stacked channel packages. We use optically stimulated luminescence dating techniques to

develop an age model for the stratigraphic succession, thus providing an independent link to the presence of Harappan archaeological sites along the margins of the palaeochannel. To understand the sources of the Ghaggar palaeochannel in NW India we use U-Pb ages of detrital zircon grains to determine links with modern river sediments and possible bedrock sources in the Himalaya. This is coupled with rare-earth element analysis of bulk sediment samples which provides an alternative constraint on sediment provenance. We will consider how changes in the course of the palaeochannel may have influenced settlement patterns of the Harappan civilisation in present day NW India. Our studies here will permit correlations to be made with similar studies being conducted in other sectors of the Harappan palaeoenvironmental realm.

Hajic, Edwin R.

Geology and Geoarchaeology of the Baodun Culture Paleolandscape, Sichuan Province, China

Hajic, Edwin R.[1]; Flad, Rowan K.[2]; Bennett, Gwen[3]

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The Minjiang River deposited a regional fan in the Sichuan Basin upon leaving the Tibetan Plateau at Dujiangyan. Rice agriculture on the fan has been productive for at least two millennia. The Baodun Culture (2500 – 1750 BC) occupied the fan, leaving a modest number of walled villages and extensive scatters of cultural debris that today are found both on the modern land surface and in buried contexts. A geomorphic and geoarchaeological investigation of the contexts of Baodun cultural remains was undertaken to help understand the distribution and types of Baodun sites, and reconstruct a history of landscape evolution. This investigation has shown that between drainage ways, the fan surface consists of elongated, gradually descending spurs that terminate in nose slopes above valley junctions. These spurs are underlain by 1.5 to 2.5 m of fine grain material over a fan core of cobble gravel that was deposited by about 16,000 C14 yrBP. Two fine grain stratigraphic units cap the fan. The lower unit consists of one or more alluvial upward fining sequences of fine sand to silt loam and is altered by a moderately to well-drained, moderately to weakly expressed buried soil that was truncated by an episode of soil erosion. Morphologically, the soil is an alfisol. Baodun cultural deposits are associated with the A horizon, where preserved, and uppermost B horizon of the buried soil. Walls of at least some villages are built atop the buried soil. The upper unit consists of crude thin beds of clay to silty clay loam, interpreted as a rice paddy facies, altered by a very weakly developed, cumulic soil with post- Baodun cultural deposits. Depending on landscape position, the upper unit can have additional relatively thin, very fine grain alluvial upward fining sequences beneath the rice paddy facies. Where not buried, Baodun cultural deposits are exposed by soil erosion, such as on shoulder slopes of spur side and nose slopes, or man-made landscape alteration. Construction of walled Baodun villages just pre-dates or is coeval with the stratigraphic discontinuity between fine grain units; an apparent shift to intensive rice agriculture on the fan occurs shortly thereafter. Construction (ca. 255 BC) of a hydrologic structure at Dujiangyan was designed to manage water and sediment caliber delivered to the fan. Walled city construction, if not for defense, may reflect a response to earlier initial attempts at hydrological engineering. The episode of widespread soil erosion of the forested buried soil surface may have been triggered by a significant shift in climate that made the fan more attractive for rice agriculture. However, effects of hydrological engineering may have contributed to establishment of the stratigraphic discontinuity.

Hessl, Amy E.

Fire, Land Use and Climate Change in Central Mongolia During the Last 400 Years

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Mean temperatures in Mongolia have increased ~1.7°C from 1940 to 2001 and may be the driver of observed increases in the frequency and aerial extent of forest and steppe fires over the last c. 50 years. However, a longer record of fire is necessary to put recent increases in fire into their historical perspective, particularly considering the long and varied history of land use change in Mongolia. Unlike North Americans, Mongolians never practiced broad-scale fire suppression. Instead, land uses including nomadic pastoralism, collection of non-timber forest products, and small-scale logging have influenced local fuels and ignitions for millennia. Historical variability in Mongolia's fire regime is a counterpoint to fire regimes in arid forest systems of North America where fire suppression has played an important role in recent decades. Thus, the overall goal of our research is to document and quantify relationships between fire regimes, climate, and human land use in Mongolia for the past four+ centuries using tree-ring and historical data. Here, we present fire history research from Mongolia based on fire scar records from four sites spanning a 300 km north-south transect from forest-steppe to taiga. Our results suggest that: 1) an extensive natural archive of fire history records exists in Mongolia suitable for testing hypotheses about climate, fire and human land use; 2) little synchrony in fire events occurred across sites prior to the late 20th century indicating that local scale drivers, such as human land use and ignitions, may be important factors in

constraining Mongolian fire regimes; and 3) there has been little change in fire frequency in recent decades. A more comprehensive network of fire history sites spanning variability in human land use and climate is currently being built that will more fully test our hypotheses regarding climate change and fire. This spatially extensive, long-term fire history network could potentially lead to new hypotheses regarding the role of land use intensity in moderating the impacts of climate change on fire regimes.

Hong, Bing

Chinese Civilization and Climate Change

Hong, Bing[1]; Hong, Yetang[1]; Zhu, Yongxuan[1]; Wang, Yu[1]; Cai, Chengcheng[1]

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Chinese civilization (CCZ) has long history and splendid culture. One of the important characters of CCZ is the diversity of its origin. The three ancient cultures, including the Yellow River basin culture, Yangtze River basin culture and northern nomadic culture, formed finally CCZ after a long fusion process. The diversity leads to another distinctive feature of CCZ, namely the continuity of birth and development of the civilization. During more than 5000-year history the mainstream of civilization has never been interrupted.The comparison between the chronology of Chinese main dynasties and the temperature record inferred from the Jinchuan peat cellulose δ18O shows that on centennial timescale the evolutional process of CCZ in general occurred in the warmer climatic condition. The warmer and drier period is just the period of prosperity and development for the civilization. For instance, the establishment time of Xia Dynasty, the first dynasty in Chinese history, is 2070 BC. This time just points to a turning point from a temperature decreasing to an increasing in the δ18O record. The Shang Dynasty lasting around 600-year generally was in the warmer and drier climate. During this period China completed its transition from the Neolithic to Bronze Age, and created the first characters known as Oracle bone script. The following around 800-year (from the Western Zhou to the Warring States) also had the warmer and drier climate condition. It was a very famous period of ideological and cultural prosperity in Chinese history. Occurrence of the different philosophies, including confucianism, taoism, legalism, mohism, had laid the foundation for the Chinese spirit civilization. In the period of Qin and Han Dynasties roughly corresponding to the Roman Warm Period the unification of both Chinese characters and metrology had been completed. The world's first movable type, compass and powder used in war occurred in the Song Dynasties corresponding to the Medieval Marm Epoch of Europe. It is likely that the warmer and drier climatic condition is more suitable for the survival and cultural activity of ancient people, and also for agricultural production activity. Abruptly climatic deterioration seems to be often linked to agricultural failures and instability in the ancient society. The peat δ18O record indicates a large-scale climate abnormality in the period from about 3000 to 2000 BC corresponding to the archaeological Longshan era. It possibly resulted in a meaningful fusion process between the Chinese cultures. Both the Hongshan culture in the northern China and the Liangzhu culture in the lower reaches of Yangtze River collapsed to 2200 BC. However the Yellow River basin culture in the late Longshan era had obviously contained the characteractics of both the nomadic culture and the Yangtze River basin culture, and eventually was developed into the unified CCZ marked by the establishment of the Xia Dynasty. The abnormal climate variation occurred round about 4.5 cal. ka BP appears to be an important gateway on the road of civilization evolution. Any ancient civilization would be called a halt unless it could show sufficient ability to resist the severe climate change in the period.

Hu, Dengke

Variation in Holocene East Asian Monsoon Strength Reflected by Deep Sea Sediment in the South China Sea

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Climate has evolved since the Last Glacial Maximum simultaneously with the development of human society, and this is especially true in the region of the Pearl River delta in southern China, which was an area of early settlement and is one of the most densely populated regions on the modern Earth. In southern China warming at the onset of the Holocene is linked with intensification of the summer East Asian Monsoon (EAM). Stable isotope variations in speleothems, together with lake records from sub-tropical southeastern China have been used to provide detailed reconstruction of the regional climate conditions. However, the precise pattern of EAM intensification in this area remains unclear and even the reliability of using $\delta^{18}O$ to identify monsoon strength over shorter scale has recently been questioned. Alternatively, monsoon strength can be traced using proxies of chemical weathering and physical erosion. Stronger summer monsoons generate more physical sediment transport potential in rivers, while wetter climate conditions can cause stronger chemical weathering. The upper 10 meters of Ocean Drilling Program Site 1144 was analyzed for variations in the composition and volumes of sediment flux to the northern South China Sea. Grain size shows no coherent response to changing monsoon intensity and is likely controlled by a number of factors, including sealevel. Magnetic susceptibility shifts rapidly from ~50×10^{-6} SI before 11 ka to ~200×10^{-6} SI after that. This reflects a

change in the composition of the sediment to increased magnetite contents. Ti/Ca and clastic MAR mirror sediment delivery. In addition, hematite/goethite, smectite/(illite+chlorite) and $^{87}Sr/^{86}Sr$ are linked to chemical weathering intensity. All these proxies show a peak at 10 ka and then a rapid decrease to 8 ka after which these proxies remain steady. CIA shows very little variation but K/Rb falls during 10–8 ka probably indicative of stronger chemical weathering. K/Rb increases more slowly after 10 ka and this compares closely with the speleothem records from Dongge Cave and suggests a common control by both temperature and monsoonal rainfall. The short-lived responses of the other proxies correlate more closely with salinity records from the same area and suggest that these may be better monsoon rainfall proxies than the speleothems. Hence, clastic MAR and Ti/Ca values point to a period of very intense summer monsoon at 11–8 ka, which caused rapid erosion and sediment transport, while at the same time increasing chemical weathering. Our K/Rb data raise the possibility of a further gentle decrease of chemical weathering from 8 to 5 ka that is not captured by the physical sediment flux proxies.

Jayko, Angela S.

Holocene paleoenvironments and transient indigenous occupation sites in the Owens River watershed, SW Great Basin

Jayko, Angela S.[1]

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Variation in climate since the end of the Pleistocene has left a record of waning springs and wetlands and increasing desertification resulting in the hyper-arid salt flats of Death Valley and adjacent basins today. Although the ecosystems and distribution of water in the landscape has changed substantially during the last 10,000 years, the region has also been effectively continuously occupied. The paleoenvironmental record from stratigraphic sections in northern Panamint Valley indicates that vestiges of the last glacial lake was desiccating ~12,575 +- 40 ka and succeeded by large spring complexes and wetlands that persisted until ~10,050 +- 50 ka. Small village sites identified by rock rings surrounded by abundant lithic scatter and rock alignments in desert pavement are present on pavemented alluvial fan surfaces adjacent to buried paleowetlands complexes that are now covered by ~2 m of playa deposits. The closest surface water to these village sites is presently ~15-20 km. Archeological studies by E.L. Davis from the late 1960's and early 1970's report Clovis culture (~11,500 RCYBP) points associated with the early Holocene wetlands deposits in northern Panamint Valley. Fossil mollusks from the late Pleistocene-early Holocene wetlands at ~470 m studied by D. Taylor (1986) occur today in mountain springs at ~1524 m (5000') higher elevation for the same latitude as the Panamint basin occurrences, which appears to be primarily a temperature, or mean annual temperature, controlled faunal distribution. Paleospring complexes have been identified throughout the Panamint basin watershed along the range fronts and associated with active fault zones. Small village sites along abandoned paleo-stream channels and former lakes are found elsewhere in the region. Population concentrations in the arid regions appear to have been larger and more sedentary during several large Holocene pluvial events. The modern hyper-arid basins and adjacent ranges were sparcely occupied by small, highly mobile family groups that seasonally migrated between established low-land and highland areas prior to European/American migration into the region. Resources from the entire range of accessible watershed elevations were utilzed.

Jorgensen, Jeff

Getting into shape: a simple, rapid, and low-cost method to identify Pacific salmonid (*Oncorhynchus* spp.) vertebrae to species

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Knowledge of historical zoogeography and patterns of resource use by past cultures can be limited by a lack of identifiable physical remains. In the Pacific Northwest USA, anadromous Pacific salmonids (*Oncorhynchus* spp.) are important components of the ecosystems they inhabit. Their life history strategies integrate survival across both freshwater and marine environments. Their past and present zoogeographic extents reflect their responses and adaptations to habitats, climate regimes, and other important natural and anthropogenic drivers. Pacific salmonids are culturally important, now and in the past. Their remains are commonly found in archaeological sites, but remains usually contain few elements that can be used to identify them to species. Vertebrae are often present but they aren't readily identified beyond the genus level. Ancient DNA analysis has the potential to overcome these limitations, but it is costly and destructive. Building on previous work, we developed a simple, rapid, and low-cost method to identify *Oncorhynchus* vertebrae to the species level with relatively high precision and accuracy based on characteristics of vertebral shape (i.e., vertebra length, height, and the length×height^{-1} ratio). We assembled a modern collection of over 4,000 vertebrae from seven anadromous US West Coast Pacific salmonids (Chinook salmon *O. tshawytscha*, chum *O. keta*, coho *O. kisutch*, pink *O. gorbuscha*, sockeye *O. nerka*, coastal cutthroat *O. clarki clarki*, and steelhead *O. mykiss*). We used linear discriminant analysis, classification and regression trees (CART) and random forests models to classify vertebrae to species. CART performed the best, with between 73-78% correct species

assignments overall (range among individual species and across two vertebra types, 36-100%). When we lumped species into groups based on vertebral shape similarity (chum, coho, and steelhead comprised one group; pink and sockeye made up another group; Chinook salmon and cutthroat were their own distinct groups because of their dissimilarity to each other and to the species groups), performance increased to 92-96% correct species assignments overall (range, 89-100%). We have begun a validation study using ancient DNA techniques to evaluate the performance of our classification models on ancient (ca. 1,000 - 3,000 ybp) *Oncorhynchus* vertebrae excavated from a midden in the Wenatchee River Basin (tributary to the Columbia River, USA). These tools can assist reconstructions of the historical biogeographic extent of salmonid species and can illuminate past cultural resource utilization with more detail than has previously been available. Geographic expansion of these tools to sites along the entire North Pacific Rim could potentially be achieved by incorporating specimens from western Pacific *Oncorhynchus* species.

Kaplan, Jed O.

On the Sensitivity of the Global Terrestrial Biosphere to Human-Induced Soil Degradation Over the Holocene, with Implications for Sustainability and Societal Change

Kaplan, Jed O.[1]; Krumhardt, Kristen M.[1]

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Much of the Earth's land surface has been subject to long-term impact on vegetation and soils for millennia, and the role of human-induced soil compaction and erosion on observed changes in vegetation over the Holocene is the subject of lively debate. We simulated the response of vegetation cover, the terrestrial carbon cycle, and the suitability for cropland and pasture to changes in soil physical properties using a state-of-the-art global vegetation model driven by a new global scenario of anthropogenic land use and land cover change over the Holocene. Holding all other biotic and abiotic parameters constant, we ran a serious of simulations approximating realistic changes in soil texture, depth, and stoniness as a function of human impact. Our model results show that over the course of the Holocene, human-induced soil degradation led to substantial changes in vegetation cover, particularly in semiarid regions and at biome boundaries. Forests occur on the deepest and least dense soils, while grasslands or deserts develop when soils become very shallow and/or dense. Transition states between these two extremes consist of various types of open woodland and xerophytic shrubland. Both changes in forest cover, which affects aboveground biomass, and changes in soil physical properties, which affect soils' ability to bind organic matter, have a substantial impact on total terrestrial carbon storage. Furthermore, human impact early in the Holocene created conditions where degraded soils inhibited establishment of new vegetation and suppressed carbon sequestration later in time. Degraded soils that are simulated with lower water holding capacity and lower organic matter content result in lower suitability for crop and pasture, partly feeding back on anthropogenic land use by increasing per capita land use requirements. Our model simulations show that soil degradation leads to certain regions of the world (Mediterranean, South Asia) becoming progressively less productive and suitable for agriculture through the Holocene, resulting in more and more land coming under anthropogenic influence as overall land quality decreases. Early anthropogenic deforestation and soil degradation resulted in emissions of at least 350 Pg C between 8 ka and the Industrial Revolution, an amount that implies that the earth today is much warmer than it otherwise would have been.

http://arve.epfl.ch

Kiwalabye, Frank

Vulnerability and Effects of Climate change to older people in Africa

Kiwalabye, Frank[1]

1. Youth Crime Watch Uganda, Kampala, Uganda

Climate change affects the fundamental requirements for health clean air, safe drinking water, sufficient food and secure shelter. It not only affects the older people but the entire human race. The aim of this presentation is to examine the impact of climate change on population mainly older people from and within Africa. It attempts to gauge the extent of loss of livelihood in the affected areas due to climate change. Social and economic factors are a great factor in increasing the vulnerability of some older people who are exposed to the negative impacts of climate change. Socioeconomic disadvantages restrict the capacity of individuals to avoid the negative health impacts of climate change, mitigate those impacts, or cope with them if they cannot be mitigated or avoided. Older populations are among the most at risk due to decreased mobility, changes in physiology, and more limited access to resources, all of which may limit adaptive capacity among older and more vulnerable people. Older, vulnerable populations face adaptive challenges to their new environments, with potentially far-reaching implications for health as well as for societal strategies to cope with climate change effects at both the population and policy level.

Kondolf, G M.

Sediment Yield Increases/Decreases from Direct Human Action and Climate Change

Kondolf, G M.[1]

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Climate change is likely to have substantial effects on runoff and sediment yield in many areas, but in most landscapes the scale of these changes is dwarfed by impacts of human settlement and resource exploitation. The impacts of deforestation, agricultural expansion, mining, and other such human activities are well known to produce significant

increases in erosion and sediment yield from catchments, with consequent impacts on river channels. Less widely recognized, but becoming more important in many landscapes, is the loss of water storage capacity from reservoir sedimentation, and the consequent downstream 'sediment starvation' in rivers. In some developed countries, reduced human pressure on rural landscapes following migration to cities has decreased sediment yield by an order of magnitude, not abruptly as the case below a newly-constructed dam, but over a period of decades as afforestation occurs. Ideas about 'river restoration' based on notions of returning to a pre-disturbance condition become difficult to resolve when the earliest record of channel conditions may reflect an already strong signal of human impacts on sediment yield. Moreover, the classification of sediment as a 'pollutant' under some environmental laws inhibits societal response to problems of sediment starvation in rivers. The Mekong River basin presents a compelling case study of ongoing changes to sediment flux in a coupled human-natural system. Erosion and sediment yield from the mountainous catchment is likely to increase due to climate change (e.g., increased intensity of rainfalls) and from ongoing development of formerly sparsely-settled and lightly-exploited regions. These increased sediment yields however, will be mostly trapped in the more than 100 significant reservoirs that are recently built, under construction, or planned in the basin. Based on an analysis of estimated sediment yields from various parts of the Mekong basin and a network analysis of cumulative sediment trapping, this extensive network of dams will reduce the sediment load in the lower river to less than 30% of its pre-dam value. Reduced suspended sediment loads and nutrient flux will undermine the river-floodplain system that currently supports the world's most productive fluvial fishery and important subsistence agriculture throughout the floodplains of Cambodia and Vietnam. Likewise, reduced nutrient flux will likely impact the fishery offshore of the Mekong Delta (analogous to the fishery collapse observed in the Mediterranean Sea following closure of the Aswan High Dam). Coastal erosion and flooding of the Mekong Delta will be exacerbated by the combined effects of climate-change-induced sea level rise and dam-reduced sediment loads, as sediment deposition can no longer offset subsidence and marine transgression.

Kröpelin, Stefan

High-resolution evidence of Holocene climate change in the Sahara and correlation to human-environment interaction

Kröpelin, Stefan[1]; Melles, Martin[2]; Karls, Jens[2]; Kuper, Rudolph[1]

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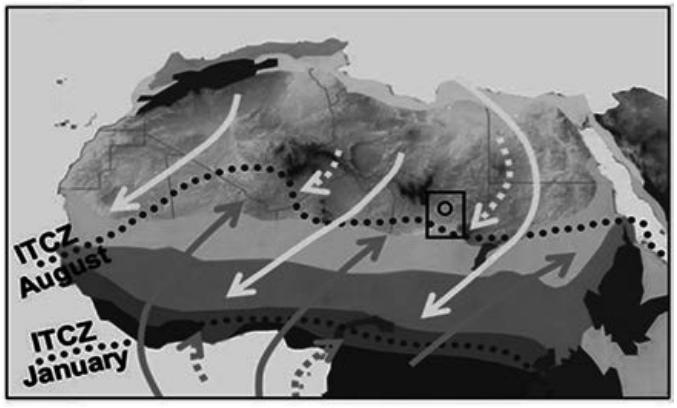
A recently extracted core from the bottom of Lake Yoa at Ounianga Kebir in remote Northern Chad (19°N-20.5°E) provides the first continuous record of climate variations in the Sahara from the onset of the early Holocene humid period to the present (spring 2010). Due to its geographical position at the exit of a mountain-bound corridor funnelling the dominant trade winds, Lake Yoa has acted as a sink for geological and biological proxies such as dust or pollen originating in the upwind regions of Northeast Africa including Libya, Egypt and Northern Sudan. The c. 16m long sequence contains the most complete and detailed terrestrial climate archive in the earth's major desert. For the most part, it features varved lamination at subannual resolution. A previous 7.5m short core provided detailed data on the gradual desiccation of the Sahara and related aquatic ecosystem change during the past 6,000 years (Kröpelin et al. 2008) but did not allow, e.g., for correlation with archaeological evidence suggesting a major climate transition at about 7,300 years ago that caused the retreat of human occupation into ecological niches and the exodus to southerly regions (Kuper, Kröpelin 2006). The new sequence extends the data base to the dawn of the "Green Sahara" which followed the late Pleistocene hyperarid desert. Ongoing multiproxy analyses open up various perspectives to correlate climate variations with socio-economic transformations of human societies from the early Holocene reoccupation of the Sahara to its possible current "regreening" as a consequence of global warming. The data will also be used to test the terrestrial impact of proposed abrupt climate incidents such as the "8.2 ka event"; to evaluate the concept of the so-called "African Humid Period" deduced from oceanic cores (deMenocal et al. 2000); and to better understand cultural transitions in the prehistory of the Eastern Sahara and in the subsequent predynastic and Pharaonic civilisations in the Nile valley. Kröpelin S. et al. (2008). Climate-Driven Ecosystem Succession in the Sahara: The Past 6000 Years. Science 320: 765-768. DOI: 10.1126/science.1154913 Kuper R., Kröpelin S. (2006). Climate-Controlled Holocene Occupation in the Sahara: Motor of Africa's Evolution. Science 313: 803-807. DOI: 10.1126/science.1130989 deMenocal P. B. et al. (2000). Abrupt onset and termination of the African Humid Period : rapid climate responses to gradual insolation forcing. Quat. Sci. Rev. 19, 347-361.



Position of Lake Yoa in the Sahara and prevailing winds

Körper, Janina

Application of paleoclimatic simulations in a geoarchaeological framework – two case studies along the Nile

Körper, Janina[1]; Berking, Jonas[2]; Bebermeier, Wiebke[2]; Slaby, Maria[3]; Wagner, Sebastian[4]; Cubasch, Ulrich[3]; Alexanian, Nicole[5, 6]; Seidlmayer, Stephan[5, 6]

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Within the framework of an interdisciplinary research cluster focusing on space and knowledge of ancient civilizations the interactions of man and environment are investigated using a multi-methodological approach including archaeological and geographical field work as well as modeling of environmental processes. Goals of the research cluster are to gain knowledge of how civilizations reacted to changing environmental conditions and to explain the processes leading to environmental changes. Two case studies from the arid to hyperarid Eastern Saharan landscapes of Egypt and Sudan will be presented. The first case study deals with environmental changes in Egypt. The agriculture of the Ancient Egyptian civilization depended almost entirely on the Nile waters and floods and therefore on the climatic conditions in the Ethiopian highlands, where the Nile floods mainly origin. In the late Old Kingdom and after the Old Kingdom (approx. 4,300-4,000 BP) agricultural land and settlements were covered by meter thick eolian sand sheets, pointing to changing environmental conditions, affecting the local population. A transient simulation of the last 6000 years with the coupled ocean-atmosphere model ECHO-G provides the basis for the comparative analysis of mid to late Holocene drought conditions in the Memphitic region and the Ethiopian highlands. Drought indices based on simulated monthly mean precipitation and potential evaporation reveal a trend towards drier conditions in the whole catchment area of the Nile. This trend is more pronounced in the Ethiopian Highland than in the Memphite region and explained by less moisture availability in the respective rainy seasons due to geographical shifts of the main precipitation regimes. The second case study deals with environmental changes in central Sudan. The ancient Meroitic city of Naga is located 40 km south of the river Nile. The global general circulation model ECHAM5 is employed to investigate climatic shifts that may affect the rainwater availability. Time-slice experiments with a spectral horizontal resolution of T106, corresponding to a 1.1°x1.1° longitudinal and latitudinal grid, were implemented to investigate the statistics of the intensity of rainfall events. Here, the reoccurrence times of rainfall events passing a certain threshold derived from a rainfall-runoff model is investigated. The results show that the frequency of the reoccurrence of rainfall events sufficient for water harvesting and irrigation purposes was significantly higher 3000 years ago than for the last 2000 years. These case studies show that especially the investigation of changes in the seasonal cycle or daily rainfall statistics based on paleoclimatic model simulations provides an added value for geoarchaeological projects.

Lachniet, Matthew S.

Climate of Central Mexico since the rise of the Aztecs: testing climate hypotheses for famine and disease epidemics

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We present a new high resolution (<3 yr) oxygen isotope stalagmite record from the Sierra Madre del Sur that documents seven centuries of climate variability in Mexico. The aragonite stalagmite is precisely dated (uncertainties ≤10 years) by nine U-series ages over the past seven centuries. The longest sustained dry period (high $\delta^{18}O$ values) occurred between 1810 and 1930 A.D., peaking at ca. 1910 A.D. A more severe but shorter dry period happened between 1630 and 1650 A.D. Wettest conditions (lowest $\delta^{18}O$ values) occurred between 1380 and 1490 A.D., and again between 1550 and 1595 A.D. The 1450s were a legendary time of famine in highland Mexico (the "One Rabbit" famine), and correspond to the longest sustained period of low $\delta^{18}O$ values over the past seven centuries. Low $\delta^{18}O$ values at this time may reflect cold and wet conditions and more frequent polar outbreaks that reached subtropical Mexico, an interpretation that is supported by historical data that document unseasonal frosts, flooding in the basin of Mexico, and successive years of maize crop failure. In contrast to the 1450s, the height of the Aztec empire between 1480 and 1519 prior to Spanish conquest was associated with average climate conditions within an ~60-year interval (1490-1550 A.D.) of climate stability. We test the hypothesis that climate anomalies are correlated with post-conquest disease epidemics (Acuña-Soto et al., 2000), but find that four out of five epidemics were associated with a near-normal climate state in Mexico. Only the "Cocolitzli" epidemic of 1576, when nearly 2 million indigenous people perished, was associated with wetter-than-average conditions. Further analysis of the full 2,200-year-long stalagmite $\delta^{18}O$ record will permit additional hypothesis testing of late Holocene climate forcing on Mexican rainfall and civilizations.

Lemmen, Carsten

Are Holocene climate events irrelevant for, or are they triggers of the Neolithic transition?

Lemmen, Carsten[1]

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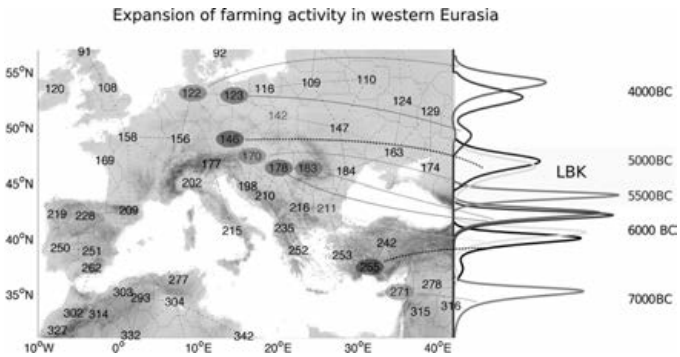
First farming communities established in Europe between 7000 BC and 3000 BC; a clear spatiotemporal trend from older southeastern to younger northwestern dates can be found in archaeological dates. The process, however, and the triggers of the Neolithic transition are unknown or at the least heavily debated. Most probably, European early agriculture was allochtonous and introduced from the Near East and Anatolia; but were it people who moved and outplaced the indigenous hunter-gatherer groups or admixed with them? Or, was it just material and information that moved—-the ``Neolithic Package''—-consisting of domesticated plants and animals and the knowledge of its use? What triggered the northwestward expansion and what controlled its timing and pacing? Extreme climate events during the Holocene have been suggested as causal factors for, e.g., migration waves. I show with the Global Land Use and technological Evolution Simulator (GLUES)—-a socio-technological model for regional potential population and innovation—-a consistent explanation of the European Neolithic. I identify regions where the onset of agriculture was insensitive to climate variability as seen in a database of globally 130 high-resolution climate proxies. I quantify migration and information flows between all 70 simulation regions which form part of the European Neolithic and demonstrate the importance of cultural diffusion for Northern Europe. At the same time, the sensitivity of the timing of the regional transitions to climate variability is assessed. I conclude that climate variability merely mediates the Neolithic transition in Europe. It was not a trigger, it was not causal and certainly not a necessary precondition for these first agricultures.

http://www.hzg.de/institute/coastal_research/structure/operational_systems/KOE/topics/topics/002162/index_0002162.html



The expansion of farming from Southeast to Northwest Europe, as simulated with the Global Land Use and technological Evolution Simulator GLUES. For each of the highlighted regions along a line from the Levante to Northern Germany, the differential change in the percentage of farming as the predominant life style is shown on the right of the map.

Leroy, Suzanne A.

Climatic and sea level changes in the south and middle basins of Caspian Sea at 4 cal. ka BP

Leroy, Suzanne A.[1]

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Nowadays the Caspian Sea (CS) receives most of its water from the Volga River drainage basin. However during the Late Pleistocene and Early Holocene, the Amu-Daria, via the Uzboi, flew into the south basin of the CS. A sill separates the two basins and shows signs of overspill. Reconstruction of past salinities, hence past sea levels, is done here from dinocyst assemblages in a range of cores from the deep basins. The results indicate that the middle basin underwent at 4 cal. ka BP a change from the high stands of the Late Pleistocene (Late Khvalynian) to intermediate levels, typical for a large part of the Holocene (Neocaspian). For the southern basin on the contrary, the Late Pleistocene levels were lower with the sill separating the two basins. The sea level rose at the beginning of the Holocene to also drop to the same Neocaspian levels at 4 cal. ka BP. The different sea levels during the Late Pleistocene are explained by different sources of meltwater and the role of the sill. The rather late drop of sea level at 4 ka is suggested to be due to a later flow of meltwater water from the Amu-Daria - Uzboy than the Volga. Indeed it is expected that the Eurasian icesheet meltwater decreased drastically at the Pleistocene–Holocene transition. The western Pamir Hindu-Kush region, where early Holocene glaciers are fed by monsoon rain, produced large volumes of meltwater in the first part of the Holocene, via the Amu-Daria and Uzboy system. In conclusion, first a possible flow from the middle to the south basin might have existed during the Late Khvalynian with the middle basin of the Caspian influenced by the climate of middle-high Eurasian latitudes whereas the south basin is under the influence of the climate over the western Himalayas. Secondly, the rather late drop of the CS level at 4 ka must have had an immense influence on regional climate. Other lakes such as the Aral Sea and Lake Van tend also to show a reduction of sea levels at approximately the same time. A link with civilisation collapses at 4.2 cal. ka is also examined. This global event caused the Harappan and the Akkadian collapses in the Indus basin and Mesopotamia.

Liu, Lu

Analyzing Past Drought and Predicting Future Drought with Comprehensive Drought Indices for Arkansas-Red River Basin

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This study examines the past drought for Arkansas-Red River Basin with Standardized Precipitation Index (SPI), Palmer Drought Severity Index (PDSI), and Standardized Runoff Index (SRI), and predicts the future drought occurrence with the same indices for the 21st century. Historical climate data of 1900-2009 were archived to drive the drought indices calculation, and projected A2, A1B, and B1 climate data from 16 statistically downscaled Global Climate Models (GCM) were applied in drought occurrence frequency and affecting area prediction. The results show that widespread drought took place in the 1930s, 1950s and 1960s, which reconciles with the historical climate record of the U.S.. The three major droughts in the 20th century greatly impacted local agricultural production and intensified economic impacts from the Great Depression. Predictions haven't been finished by this stage, but the upcoming results for the 21st century will have tremendous implications in regional water management and could assist minimizing agricultural loss due to drought.

Loaiciga, Hugo A.

Climate variability, people, water, and energy: from Mayan to solar-thermal desalination of seawater

Loaiciga, Hugo A.[1]

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This paper will review and present novel methodologies for analyzing the complex, feedback-type, dependence of humans on water for agriculture and societal survival, as well as methods to cope with natural hazards driven by climate and water availability on land. It will be shown that climate-water-human interactions have hinged largely on climatic variability at various temporal scales, protracted droughts being a key natural hazard that has affected human survival and well being. The paper will present examples of (a) Mayan demise by long droughts, (b) 20th century adaptation in parts of the United Sates to variations in aquifer recharge due to large inter-annual variability of precipitation and concomitant population growth,(c)adaptation strategies to mitigate coastal urban flooding by sea-level rise in parts of Mexico, and (d)sustainable possibilities for water supply in coastal communities that could rely on seawater desalination by means of solar-flux powered distillation cells.

http://www.geog.ucsb.edu/~hugo

Macklin, Mark G.

When the Nile ran dry: rethinking people river-environment interactions in Sudanese Nubia 5000 BC – AD 500

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Joint archaeological and geomorphological research within an 80 km-long reach of the Nile Valley in northern Sudan, centred on the town of Dongola, has identified several former river courses along which are located many hundreds of archaeological sites, the majority of which date to the Kerma Period (c. 2500 to 1500 BC). What distinguishes our geoarchaeological investigations from similar studies elsewhere in the Nile Valley, and also from those in Mesopotamia and in the Indus Valley, is the luminescence dating of river channel and floodplain sediments that adjoin archaeological sites. This has enabled changes in settlement patterns to be precisely matched with independently dated phases of river activity, including those periods when channels ceased to flow. Contrary to much previous research on early agricultural societies dependent on floodwater farming in the Nile Valley and other parts of the Old World, the Kerma culture continued to flourish during the environmental crisis centred at around 2000 BC – with the number of settlements actually increasing in the period from 2050 to 1750 BC. The Kerma culture, however, ended abruptly 500 years later, coinciding with a major anabranch of the River Nile becoming inactive shortly before 1400 BC. The continuity and success of the Kerma agriculturists in the Dongola reach was associated with a favourable combination of local alluvial landforms and hydrology that persisted for about 1000 years. These conditions included a network of anabranching river channels with well developed levees, which conveyed moderate-sized seasonal flows ideally suited to support floodwater farming on an extensive scale, in some instances, more than 12 km to the east of the present course of the River Nile. However, when flows stopped >400 km2 of formerly irrigated farmland in the northern Dongola reach became unusable, probably within a few years. This would have had a catastrophic impact on local farming communities and the urban centres, such as the city of Kerma, they supplied. Indeed, this area was only very recently brought back into agricultural production in the second half of the 20th century with the introduction of diesel-powered groundwater pumps. While causal links

between cultural and climate changes in the Nile Valley have been proposed, the results of this study indicate that the nature and dynamics of local alluvial environments are likely to have been a critical factor in determining whether climatic fluctuations and associated changes in hydrology represented an opportunity or a hazard for riparian communities and floodwater farmers.

Maemoku, Hideaki

Was the Ghaggar River Mighty Saraswati during Mature Harappan Period?

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It is well known that huge urban civilization, such as Mohenjo-daro and Harappa, flourished in the Indus Valley between 2500 -1900 BCE, however most cities were abandoned during the following post-urban Harappan period. Many reasons for the declination of Harappan culture have been estimated since 19th century, for example invasion of hostile ethnic group, huge earthquake, devastative flooding, climate change etc. “The Lost Saraswati” hypothesis would be one of major estimations for the declination. The mighty Saraswati River described in the “Rig veda” as a powerful goddess of large river, is believed to have disappeared after glorious period of Harappan culture. One of the leading candidates for present remnant of lost Saraswati is the Ghaggar-Hakra River that originates in the Lower and Sub Himalayas of northwestern India. It flows westerly in the Punjab plain and disappears into Cholisthan deseart as a dried river bed. Naruse(1974) and Yashipal et al.(1980) said the Ghaggar had used to connect with glacial area in the Higher Himalayas through the Sutlej or Yamuna River course, however been disconnected by piracy due to crustal uplift or rejuvenation of adjacent river. We have tried to examine the hypothesis from the view point of chronology of flood plains and sand dunes distributed along the Ghaggar River. First we compared the size of present flood plain of large rivers originated in glacial area with that of the Ghaggar, and got to know that the size of flood plain became wider in proportion to the volume of annual river flows. It means that present size of flood plain of the Ghaggar can be formed by present volume of annual river flow. Next we measured the oldest age of sand dunes limiting the size of present flood plain by using OSL dating method. Finally we resulted that the Ghaggar was not the mighty Saraswati during mature Harappan period because sand dunes on either side of the Ghaggar had been formed before that.

http://www.chikyu.ac.jp/indus/Indus_project/index.html

Magilligan, Francis J.

Sensitivity of floodplains and cultural systems to extreme events: agrarian strategies, adaptation, and geomorphic responses to El Niño floods in the Peruvian Atacama Desert

Magilligan, Francis J.[1]; Goldstein, Paul S.[2]

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2. Anthropology, UC-San Diego, La Jolla, CA, USA

Recent research highlights the links between climate and culture change in agrarian societies, especially in climatically sensitive areas such as desert riverine environments. Most commonly, water availability is seen as the dominant environmental stressor to agriculture, specifically through climatic events that cause extreme droughts or floods. The agrarian significance of changes in floodplain geomorphology, though, is often overlooked. Agricultural development in pre-Columbian Andean societies also had specific relationships to local geomorphic conditions within valley systems. Climate events, particularly catastrophic El Niños, also alter floodplains and potentially limit the availability of arable land. Here we evaluate the cultural and settlement responses to the long-term geomorphic evolution of the Rio Moquegua floodplain in the Peruvian Atacama Desert. The susceptibility of floodplains to extensive re-working by large floods associated with El Niño events highlights the importance of erosion and regeneration of planting surfaces, especially in arid regions where the availability of arable land is limited and floodplains are one of the critically few areas where agriculture can exist. We assemble a paleoflood chronology for mainstem and tributary sections and ascertain the variation in ENSO frequency and magnitude during the past ca. 20 ka. Because of the inherent watershed structure and regional climatology, mid-valley tributaries of the Rio Moquegua only flood during El Niño episodes and thus provide an important proxy of extreme El Niños while the mainstem records both La Niña and El Niño episodes. El Niño floods appear to have been pronounced during the Late Pleistocene and up to at least the Younger Dryas while evidence of large El Niño floods is lacking in tributary systems during the Mid-Holocene. Moreover, detailed mapping of streambank erosion during the 1998 El Niño flood indicates up to 2 ha of floodplain loss per river km for an estimated 50-yr flood. Terrace chronologies along mainstem reaches indicate that more than 70% of the valley surfaces are younger than ~ 1-2 ka, again suggesting widespread Late Holocene floodplain re-working. Systematic archaeological settlement pattern survey permits detailed analyses of agrarian strategies during the Formative (1800 BC - AD 500) and Middle Horizon (AD 500-1000) periods, with distinct settlement “niches” in terms of agricultural practices and longitudinal position in the drainage and lateral location relative to the floodplain. Settlement patterns suggest that the Huaracane, Wari, and Tiwanaku cultures had distinct relationships to the floodplain in terms of settlement and agrarian strategies. Thus not every cultural group within the Valley had the same vulnerability to

different climatic or hydrologic hazards, especially those associated with large ENSO events.

Massa, Charly

Quantification of medieval and modern human driven erosion due to agriculture on a south Greenland lake system

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2. ArScAn, UMR CNRS 7041 Archéologies et Sciences de l'Antiquité, Université de Paris 1, Paris, France
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Lake deposits are widely used to study climate changes and human impact on landscapes. In the case of the Norse settlements of Greenland (985-1450 AD) only a few studies use lake records to evaluate the effect of agricultural practices on soil erosion (Fredskild, 1973, 1978, 1992 ; Sandgren and Fredskild, 1991), the more recent works focusing on peat records (Edwards et al. 2008 ; Schofield et al. 2010), archaeological trench (Schofield et al. 2008) and soil section (Buckland et al. 2009). These previous studies indicate an increase in erosion during the Viking colonization which can be attributed to agropastoral activities. But they suffer from dating bias on bulk samples or sedimentary hiatus that do not allow reliable quantification of inflows of eroded material. Thus, the unresolved questions about the role of overgrazing and soil erosion in the collapse of the Greenland Norse society still need precise quantification of sediment flux from the study of lake sequences in archaeological context. To resolve this problem a suite of biological and physical proxies from the sediments of Lake Igaliku (N61°00'22", W45°26'28") were used to examine the environmental impact of Norse and modern farming activities in South Greenland. Lake Igaliku is situated circa 2 km northwest from the medieval site of Gardar which is known to be the largest medieval farms of Greenland, and was easily accessible for Norse farmers and grazing mammals. Currently a modern sheep farm complex lies in the lake catchment. This enables an in-depth study of the comparative effects of medieval and modern agricultural activities upon an otherwise pristine sub-arctic landscape. Analyses of the sediment sequence include pollen and non-pollen palynomorphes analysis, high-resolution grain size measurements, high-resolution geophysical (Multi Sensor Core Logger) and geochemical core scanning (XRF core scanner), X-ray radiography, ICP-MS and organic geochemistry. The chronology of the sequence is established on 14 AMS 14C measurements (including 11 dates on terrestrial macro-fossils) along the upper 125 cm of the core and completed by lead 210 and caesium dating for the most recent sediment. This robust chronology allow, with a statistical bootstrap method, to estimate the sedimentation rates and its uncertainty over 3000 years. Age-depth model derived sediment flux and independent proxies of detritism as the concentration of titanium or the Corg:N atomic ratio confirm that the erosion caused by medieval and modern land use is significantly greater than natural erosion over the last 3 millennia.

Matthews, Elaine

Non-climatic controls on malaria: A historical study of the US, Italy and Sri Lanka

Matthews, Elaine[1]

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Malaria was widely distributed throughout tropical and temperate environments for many centuries. It was eradicated from most temperate regions by 1940 without aggressive antimalarial efforts and under stable climate conditions. Widespread use of DDT following its 1946 introduction to subtropical and tropical countries in the mid-1940s further produced striking reductions in malaria cases and, by the 1960s, had resulted in the eradication or radical reduction of the disease in 37 countries where it had been a serious health problem. Many tropical and subtropical countries still or again carry high burdens of malaria. A suite of changing conditions conflate to provide positive feedbacks on the post-1960s spread and severity of malaria. 1) Drug and insecticide resistance are increasing. 2) Human migrations prompted by warfare and the search for employment and food are increasing which can expose non-immunes to the disease. 3) Malaria-endemic areas are expanding due to re-emergence of the disease in places where it was previously eradicated or because malaria vectors, Anopheles mosquitoes, are returning to regions previously cleared of the vector. 4) Urban malaria is on the rise fueled by rapid growth of poor urban populations in conjunction with rapid adaptation of malaria vectors to urban sites. 5) Mosquito control have declined in many countries where it had contributed to reduction is malaria burden. 6) Many countries are host to development projects involving water-management components, such as irrigation works, often resulting in the introduction or exacerbation of water-related diseases. Although changing mean climate, and perhaps shorter-term climate variations such as El Nino events, play a role in transmission of malaria, climate is one player in a large and complex suite of interacting controllers that is itself in continuous transition. We report results from a historical study of malaria in the US, Italy and Sri Lanka designed to identify the impact of non-climatic factors on distribution, incidence and trends in malaria morbidity and mortality in these countries.

Meadow, Richard H.

The 4.2kya Abrupt Climatic Event and the Indus Civilization

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A 4.2kya calBP abrupt climatic event is attested in proxy records from localities across the world. The proposal of Weiss and others (e.g., Weiss et al. 1973, Staubwasser & Weiss 2006) that this event severely affected ancient civilizations has established a research agenda throughout Eurasia for the past 2 decades. Results from these investigations have led to a refinement in our understanding of cultural responses to rapid climatic change. Habitat tracking is increasingly seen as a major factor in the rearrangement of peoples and political structures, especially across regions with significant environmental diversity that include zones that are only marginally productive for agriculture and pastoralism. One region that remains intractable as far as our understanding of human settlement systems and their relation to changing climate, weather, and river regimes is that of the greater Indus Valley. In spite of the efforts of Madella & Fuller (2006) and Prasad & Enzel (2006) to bring some order to the chaotic paleoclimatic and paleoecological evidence, progress in our understanding of the interactions between human societies and their changing landscapes is severely hampered by a scarcity of high quality data, both environmental and cultural. The period of the Indus (Harappan) Civilization, that includes the 4.2kya event, is rather poorly understood in detail. From the first recognition in the 1920s that there existed an Indus Civilization, it has been a cultural phenomenon often conceptualized as a monolith both spatially and temporally. As this paper underlines, it was no such thing. There was marked regional variability as well as important changes through time. These are well attested where there have been excavations that have stressed the importance of radiocarbon dating the remains of short-lived organics from secure archaeological contexts. At ancient settlements such as Harappa in Punjab (Pakistan), where there are long occupational sequences, it is increasingly clear that past excavations overwhelmingly recovered remains from ca. 4.2 and 3.9kya and that relatively little is known about the first 3–4 centuries of what was a 700 year dynamic and regionally differentiated cultural phenomenon. Because little attention has been paid to change in material culture during the period of the Indus Civilization, it has been difficult to break down the results of settlement surveys into when during the ca. 4.6–3.9kya period a site was occupied. Thus it is impossible to monitor changing settlement in Harappan landscapes over time and to evaluate the effects of the 4.2kya climatic event on the contemporary peoples of northwestern South Asia. Recent excavations suggest that there were significant changes beginning at that time, possibly with habitat tracking into the better-buffered areas of the Indus alluvium from surrounding environmentally marginal zones. Indeed, major sites such as Harappa appear to have reached their greatest size beginning at about 4.2kya.

Madella, M. & D.Q. Fuller, 2006. Quaternary Science Reviews 25: 1283-1301. Prasad, S. & Y. Enzel, 2006. Quaternary Research 66: 442-453. Staubwasser, M. & H. Weiss, 2006. Quaternary Research 66: 372-387. Weiss, H. et al., 1993. Science 291: 609-610.

Mehrotra, Nivedita

Holocene vegetation – climate and evidence of early Rice cultivation in Southern Tripura, India based on Palynological analysis

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Climatic reconstruction based on various proxies would be useful to understand long-term climatic changes and their relationships with other events. Studies related to proxies such as pollen from dated subsurface sediments of Holocene not only aid an advantage of reconstructing climate based on past vegetation but also provide insight to mark the advent of agriculture in the region on the basis of size variation among wild and cultivated grasses, ratio of arboreal and non arboreal pollen grains and other marker pollen grains indicator of cultivation. For the present study palynological analysis was carried out from southernmost part of the Tripura, India in the radiocarbon dated 1.20 m deep sediment profile. The pollen grain of mixed assemblage of angiosperm, ferns and conifers are recovered from this profile are good in number, except at the bottom of profile sample which is almost devoid of pollen grains. Based on the representation of the pollen taxa recovered, vegetation and extent of human invasion vis-à-vis climate from southern Tripura was examined during the time span of last 7000-4000 yr. B.P. The results shows that during this time span, the area is occupied by moist deciduous forest under warm humid climate with intermittent changes in precipitation regime i.e. comparatively low humidity around 6.8 kyr B.P. and 3.7-3.8 kyr B.P. Evidence of land clearance and agricultural aspect in this region during this time period was also examined. While a clear indication of human impact in the documentation remains equivocal, the presence of large sized grass pollen over 50μ may be indication of the rice cultivation and its presence from 5.7 kyr. B.P. suggests cultivation of rice at this region from mid Holocene and thus the human impact in the region, which would have been one of the primary reasons for ecological changes in this region.

Miyake, Nao

Vegetation changes since the middle Holocene around Lake Rara, western Nepal

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5. Yamagata University, Yamagata, Japan
6. Tribhuvan University, Kathmandu, Nepal
7. National Institutes for the Humanities, Kyoto, Japan

Vegetation changes since the middle Holocene were investigated using pollen and plant macrofossil records in a core sediment (Rara09-4) (29.5347° N, 82.0933° E and 3,000 m a.s.l.) from Lake Rara in western Nepal. The pollen record was divided into two local pollen assemblage zones (I and II), even though it was co-dominated by Quercus and Pinus, with Abies, Picea and Betula pollen throughout the core. In zone I (ca. 6,000 to 3,000 yr B.P.), Quercus pollen had high values of more than 50% of total tree pollen. On the other hand, zone II (ca. 3,000 yr B.P. to present) is characterized by the decrease in Quercus pollen and increase in Pinus pollen. Most of fossil Quercus and Pinus pollen grains were Q. semecarpifolia and P. wallichiana types, based on their SEM identification. Fossil leaves of Q. semecarpifolia type were founded frequently in the both zones. Macroscopic charcoal influx increased progressively in zone I. Based on these fossil records and spatial patterns of forest vegetation in the present, during the mid to late Holocene, Q. semecarpifolia and P. wallichiana predominated in the forests mainly on the south-facing slopes, whereas especially on the north-facing slopes evergreen conifer forests consisting of Abies and Picea with Betula were established. The decline of Q. semecarpifolia and dominance of P. wallichiana in zone I may have been caused by changes in fire regimes associated with combined effects of climate changes and intensified land-use activities around the lake.

Miyauchi, Takahiro

Late Holocene geomorphic coastal changes affecting the mutation of bay-facing Harappan sites of the Indus civilization, Gujarat, India

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3. Applied Sciences, Kochi University, Kochi, Japan
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5. Archaeology, Rajasthan Studies, Udaipur, India

The Indus civilization is one of the four great ancient civilizations, which developed around the Indus River and along the northern coastal area of Arabian Sea ca.8500 to 3300 years ago. This age is geologically called Holocene which is characterized by the glacio-eustatic sea level change after the last glacial termination. Therefore, the mature of bay-facing Harappan sites was significantly influenced by vertical and horizontal shifts of coastlines. We inspected late Quaternary geomorphic developments related to the relative sea level change around two representative sites, Lothal site and Kanmer site in Gujarat, India, analyzing geological data and Corona satellite images together. The obtained results indicated that the ancient Lothal town developed on the low-lying alluvial flood plain which appeared on tidal flats through about 4 m of relative sea level fall after Holocene transgression peak, acquiring shipping by water. Yet the successive sea level fall around 2 m likely led to impossibility of shipping, therefore the Lothal might rapidly decline as a port town. Most of about 6 m relative sea level fall in late Holocene is probably originated from hydro-isostatic crustal uplift, and it controlled geomorphic evolution and vicissitudes of bay-facing Harappan sites.The Lothal site (ca.2500-1900 B.C.) is in the Cambay coastal plain which is characterized by geomorphic configuration of present and emerged tidal mud flats locally overlain by flood plains. Two late Quaternary marine terraces (MT1 and MT2) composed of emerged tidal flats are recognizably elevated in 15m and 10m. MT1 is assigned to MIS5 stage and MT2 to MIS1 stage (Prasad and Gupta, 1999). The settlement town, 12 m in elevation, is exactly founded on the artificial mound of flood plain over MT2-forming marine sediments. This geomorphological condition and the dockyard adjacent to the town imply that the ancient Lothal town had located and developed with marine trading by shipping transportation, using the surrounding channel system. As the sea level had relatively fallen several meters afterward, shipping itself had become impossible even at high tide and the town likely declined. The Kanmer site several thousand years B.C. is situated on the cuesta mound (32m in elevation) about 7 km inland from the Little Rann which is a brackish marsh, especially invaded by sea water in summer wet season. Even though mid Holocene transgression reached to inland further than the present coastline of the Rann, shipping transportation was probably difficult due to relative steep river profile and horizontal distance of about 5 km between Kanmer site and the mid Holocene coastline. The land and shipping transportation was probably used together. As the Rann was reduced by relative successive marine regression, the distance by land transpiration increased and shipping trade decayed gradually. Thus, ancient Kanmer town might have been finally abandoned.

Moss, Patrick T.

Historical and Pre-Historic Human Environmental Impacts on the Sub-Tropics of eastern Australia

Moss, Patrick T.[1]; Tibby, John[2]; McGowan, Hamish[1]; Barr, Cameron[2]; Marshall, Jonathan[3]; McGregor, Glenn[3]; Petherick, Lynda[1]; Daus, Tamara[1]

1. School of Geography, Planning, & Environmental Management, The University of Queensland, Brisbane, QLD, Australia
2. Geographical and Environmental Studies, The University of Adelaide, Adelaide, SA, Australia
3. Department of Environment and Resource Management, Brisbane, QLD, Australia

Profound environmental change has occurred within the south east Queensland region over the late Quaternary period, with the most recent change being associated with European settlement of the region in the 1820s that has resulted in significant deforestation, alteration in fire regimes and increased sedimentation linked to urbanisation, agricultural and mining activities. Archaeological records of Aboriginal settlement for the region extend back to at least 20,000 years and provide evidence of an increase in the intensity of occupation over the last 5,000 years. Recently, a number of palaeoecological records (i.e. pollen, charcoal and diatoms) have been examined from North Stradbroke Island, the second largest sand island in the world. These records, taken from a variety of perched lakes, window lakes and wetlands, provide a continuous picture of late Quaternary environments for the Sub-Tropics of eastern Australia. In particular they offer insight into the impacts of alterations in fire regimes and water extraction associated with European settlement, as well the possible impacts of Aboriginal people on the region's landscape and the possible drivers for Holocene intensification of this occupation. In addition, a new record from the Nerang River, located on the nearby mainland, has been completed and this provides a comparison between late Holocene (last 4,000 years) with Marine Isotope Stage 5e (~130,000 to 120,000 years ago) environments, which may shed some more light into the relative impacts of natural climatic change and human activity on the region's landscapes.

Nakamura, Atsunori

Mid-Late Holocene Asian monsoon reconstruction using a sediment core obtained from Lake Rara, western Nepal

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The Asian monsoon is an important component of the Earth's climate system to understand regional and global climate dynamics. Geological proxies have been indicating of gradual decrease of its intensities through the Holocene that was attributed as changes in insolation in the summer due to the Earth's orbital parameters. Although overall pictures of monsoon reconstructions are consistent among proxies that is stronger summer monsoon at mid-Holocene than the present, the detailed structures are still different from each other. In particular, millennial to centennial structures of monsoon intensities record during the Holocene is still under debate (eg., Overpeck et al., 2007). Therefore understanding mechanisms of monsoon required high-resolution paleoclimate records, and hence we present a new sediment core record from Lake Rara, western Nepal (29°32′N, 82°05′E). Lake Rara is located at 3,000m above sea level and has a maximum water depth of 168m. Summer climate is controlled by the moist southeasterly monsoon that derives most of the annual precipitation in the region. Thus the lake is one of the ideal locations to reconstruct monsoon variability using various proxies in the sediment. We studied past monsoon intensities using major elements variations in the sediments. The age model of the sediment core is based on 14C dating on leaves using Accelerator Mass Spectrometry (AMS). Concentrations of major elements were measured by X-ray Fluorescence Analysis (XRF). We then reconstructed temporal variations of the chemical weathering index (CIA) in sediment source area and the degree of bottom-water redox conditions (MnO/Al2O3) respectively proxies of precipitations and wind strengths at the site. The paper will present evolution and variability of the Asian monsoon during the Mid- to Late- Holocene.

Overpeck, J. T. and Cole, J. E. (2007): Lessons from a distant monsoon. Nature, 445, 18, 270-271

Nicoll, Kathleen

A New Synthesis of Records of Quaternary Palaeoenviromental Change and Geoarchaeology in the NE Sahara

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Is there synchroneity between the oceanic and terrestrial realms as interpreted from various proxy records for palaeoenvironmental and geoarchaeological change in the northeastern Sahara? Offshore records suggest that the ~15 ka cal BP onset and the ~5.5 ka cal BP termination of the "African Humid Period" was a rapid response to gradual insolation forcing, manifested by enhanced aeolian transport offshore. Although there is general agreement that an enhanced Afro-Asian monsoon profoundly affected the water balance of the continental landmass, it is evident that the delivery and tempo varied by location. A synthesis of available floral, faunal, and cultural records for the onset of wet conditions in Egypt and Sudan includes 500+ published radiocarbon (Nicoll, 2004) and OSL dates (Nicoll, unpublished) from cultural contexts and various fluvio-lacustrine and aeolian stratigraphies (Haynes et al., 1997; Nicoll et al., 1999). At its wettest "monsoonal maximum" ~10 - 6 ka cal BP, the interior of North Africa was a marginal drought-prone environment, barely sustaining human activities and a meager steppe-shrub desert flora/fauna with some Sudano-Sahelian elements. The Eastern Saharan records reflect enhanced aeolian activity ~7 ka cal BP, and the drying out of the African interior commenced in advance of terrigenous dust flux to the ocean. Recurrent dry phases in the Eastern Sahara are associated with cultural abandonment, deflation, and sedimentation of aeolian sand in southern Egypt and Sudan. Stratigraphic records from this highly continental location reflects ascendant global, oceanic, and atmospheric changes, as well as other local feedback mechanisms that cannot be gleaned from the ocean archives. Abrupt hydroclimatic changes influenced resource availability across NE Sahara, and fostered technological innovation and adaptation. The complex responses of the prehistoric Desert Peoples is apparent; their resilience is manifested by migrations to and linkages with the emerging Pharonic civilization in the Nile Valley ~ 5 ka cal BP. References Cited Nicoll, K. 2004. Records of Recent Environmental Change and Prehistoric Human Activity in Egypt and Northern Sudan. Quaternary Science Reviews 23: p.561-580. Nicoll, K. 2001. Radiocarbon chronologies for Prehistoric Human Occupation and Hydroclimatic Change, Egypt and Sudan. Geoarchaeology: An International Journal. v. 16: p. 47-64. Nicoll, K.; Giegengack, R.; Kleindienst, M.R.; 1999. Petrogenesis of Artifact-Bearing Fossil-Spring Deposits from Kharga Oasis, Egypt. Geoarchaeology: An International Journal. v. 14: p. 849-863. Haynes, C.V. Jr; Maxwell, T.A.; El Hawary, A.; Nicoll, K.A.; Stokes, S.; 1997. An Acheulian Site Near Bîr Kiseiba in the Darb el Arba'in Desert, Egypt. Geoarchaeology: An International Journal, v.12: p. 819-832.

Okuno, Jun'ichi

The role of hydro-isostasy for Holocene sea-level changes and coastal evolution in the southern Indus region, Gujarat, India

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The sea-level rise of about 120 m during the last deglaciation had a significant impact on the development of prehistoric human civilization, and the effect of subsequent crustal movement also significantly constrained the development of prehistoric human society. However, the geological environment along the southern coast of the Indus region is the result of complex interactions between sea-level change and tectonic crustal deformation in Quaternary. On the other hand, studies of sea-level change in Holocene show major differences among curves for different locations in the world punctuating the importance of regional factors in shaping sea-level change. Local sea-level curves reflect global eustatic changes, regional isostatic adjustments of the crust to changing ice and ocean volumes and regional, tectonically controlled, crustal movement. In this study, we evaluate the relative contribution of each of these factors to the Holocene sea-level change along the coast of Gujarat, India, and reconstruct the transition of the palaeobathymetry in this region in order to consider the relationship between sea-level and the Indus civilization. In relatively tectonically stable areas far from former ice sheets the primary reason for fluctuations of sea-level through the last deglaciation has been the exchange of mass between the ice sheets and the oceans; as the Late Pleistocene ice sheets melted, water was added to the oceans and global rise in sea-level occurred. This is the eustatic component. Furthermore, in response to the changing surface loads of ice and water, the crust responds by uplift under the formerly ice-loaded areas, and by subsidence where the ocean load increases. Thus the total sea-level change is the sum of these eustatic and isostatic contributions. If we can simulate crustal deformation in association with glacio-hydro isostasy accurately, the theoretical relative sea-level curves are obtained. High-resolution numerical models that represent the spatial and temporal variability of sea-level change and shoreline evolution have been developed over recent years that give good representations of sea-level change and which have been used to separate the tectonic contributions from the eustatic and isostatic factors. Our prediction that hydro-isostatic contribution of sea-level for about 7000 years at the Gujarat coast is about 5 m. This value is consistent with the archaeological and geomorphologic evidences along the coast of Gulf of Cambay. According to predictions of sea-level curve in this region, spatial distribution of sea-level high stand in Holocene is dependent on the viscosity model and Holocene eustatic sea-level change significantly. These resluts indicate that the comparison between the model sea-level curve and the archaeological observations also enable to

conclude that the viscosity structure and eustatic sea-level change for the last 7000 years.

Osada, Toshiki

"Environmental change and the Indus civilization": a report on the major outcome of our RIHN project (2007-2011)

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I have been conducting the Indus project, officially titled "Environmental change and the Indus civilization", at the Research Institute for Humanity and Nature (RIHN), Kyoto, Japan, since 2007. This research project examines the social character and environmental context of the Indus civilization, and attempts to determine how they are related to the civilization's short life and rapid decline. In particular, we aim to evaluate the impact of environmental change on the subsistence economy and trade network that sustained the Indus civilization's urban system. Our research will also provide data on the long-term processes of climate change in South Asia. Such data will help us develop historical perspective on, and practical understanding of, contemporary environmental problems in the region. Our project is divided into five research groups: (1) the Palaeo-Environmental Research Group (PERG); (2) the Material Culture Research Group (MCRG); (3) the Subsistence System Research Group (SSRG); (4) the Inherited Culture Research Group (ICRG); and (5) DNA Research Group (DRG). They integrate cultural and biological data obtained from archaeological excavations and other field activities, palaeo-environmental data obtained from satellite imagery and field study, and original accounts obtained from ancient texts. Important subjects of study investigated so far include: ancient climate change; avulsion of the Ghaggar River; the palaeocoastline of Gujarat; and palaeo-seismic activity. In this conference I will first draw an outline of our project and present a brief summary of the major outcome of our research. Following my introductory presentation, other members of our team will discuss the specific research results in more detail.

Panyushkina, Irina P.

Climate and Siberian Scythians: Tree-ring evidence of summer temperature variability linked to nomadic resources

Panyushkina, Irina P.[1]

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Climate is an indirect but immediate factor inevitably affecting vitality of nomadic populations by triggering changes in supply of important ecosystem services (e.g. forage and water). Research on synergy of environmental change and behavioral adaptation of Scythian horsemen inhabiting the Eurasian steppe during the first millennium BC (Iron Age) is not restricted to archaeological evidence alone. In the Altai Mountains, tree rings from kurgans of the Pazyryk archaeological culture have contributed to a breakthrough in temporal precision and resolution of absolute dating of the Early Eurasian Nomads (Panyushkina et al. 2007). Seemingly, floating well-replicated tree-ring chronologies used in the dating capture early-summer temperature signal based on calibration of local climate with modern tree rings from the Altai upper tree-lines. Generally, mobile pastoralism as an economic strategy has been emerging throughout the cooling and drying climates of Inner Eurasia since roughly 3200 BC. The Iron Age economy of the Altai was deeply grounded in seasonal migration of horsemen with their herds between winter lowland pastures and summer high-mountain pastures. The vertical movement of herds is highly dependent on when growing season begins. Anomalies of growing-season length might be understood from variance assessments of the summer temperature proxies. Using statistical analysis of tree rings sensitive to June temperature from 4 sites across the Altai Mountains we estimated frequency and power of tree-ring width fluctuations. The results were analyzed in regard to climate-driven change in nomadic resources and the eastward migration of the Pazyryk people between 710 BC and 240 BC. Our tree-ring records suggest a stable climate period occurred at 710 BC with warm summers between 570 BC and 530 BC. This time is coincides with a wave of nomadic tribes invading the Altai region (Koryakova & Epimakhov 2007). A summer cooling occurred between 550 and 380 BC, showing an unstable state of climate with a large number of outliers The last century of the records was not only the warmest but had two the coldest decades as well. Tree-ring width variance was much greater than during the previous centuries. Spectral analysis of tree rings shows changes in frequency bands toward the end of the records. The summer temperature extremes may link to diminishing forage productivity of grasslands due to high transpiration (higher quartile) or shortened grazing season (lower quartile). The persistent instability of the summer temperatures and changes in seasonality lead to environmental change that forced the horsemen to search for new surviving strategies. In the highest pastures of the Altai, medico-biological analysis of Ukok's mummies indicated great physical stress among Pazyryk people around 320-280 BC (Molodin et al. 2000), which could be related to poor adaptation of the population to unfamiliar environment. The inferred degradation of environment most likely contributed to the exodus of the Pazyryk people by ca. 240 BC. Thus, the results provide independent evidence for Iron Age environment and human interaction indicating climate is a major force in pastoral migrations across the Altai.

Pederson, Neil

Neither New York City nor Atlanta are Prepared for a Return to Historical Drought

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Forecasts of drought paint a dire picture for future civilizations, even for cities in humid environments with significant and seasonally-consistent precipitation. Yet, recent studies indicate that major population centers in the eastern U.S. seem to be consuming more water than what their systems can supply in early-global warming conditions. For example, New York City (NYC) declared a series of water restrictions during a recent era of abundant moisture. Further underscoring this paradox, there has been a reduction in water consumption since 1979. In a more extreme case, Atlanta, GA's (ATL) water supply was reduced to less than three months and other nearby population centers were estimated to have only to 30 to 100 days of water remaining during a recent two yr drought. The era of increased water supply issues in both regions also coincide with increased litigation over water rights between competing states. The period of litigation could be a harbinger of the future as meteorological records indicate a significant reduction of drought in the NYC region since the early-1970s and generally moist conditions in the ATL region from the early-1960s to mid-1990s. We update drought history for the NYC and ATL water supply regions to put the paradox of relatively moist conditions coupled with increasing water supply threats in a long-term context. Using nested reconstruction techniques, improved spatial density of tree-ring records (including the first tree-ring records from north Georgia, the watershed region for ATL) and a multi-species approach, we have produced stronger and more stable tree-ring based reconstructions over prior efforts for both regions. Specifically, our results indicate that the use of multiple species, including non-traditional species such as Liriodendron tulipifera, Betula lenta and Carya spp., improves reconstruction skill. While the new reconstructions improve upon previous efforts in a statistical sense, they reveal similar patterns of historical drought variation. For example, the mid-1960s drought in the NYC region and the mid-18th century drought in the ATL region dominate both records as the most intense or severe droughts. However, both updates underscore meteorological records by showing that recent decades are among the most moisture-abundant within the last 400 years. Both records also show a higher frequency and duration of drought prior to the 20th century. Thus, the new drought reconstructions give further support to the idea that the recent droughts in major cites in moisture-abundant regions are experiencing human-triggered drought, not extraordinary climatological drought. Therefore, with future warming and increased evaporation, it is likely that neither NYC nor ATL are prepared for the next significant drought resembling anything like the pre-20th century era.

Perez, Gay Jane

The Changing Philippine Land Cover and Climate as Observed from Space

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Despite having Manila Observatory, which is one of the oldest meteorological stations in the world, there is a general paucity of climate data in the Philippines and available data provide very little information about the changing land cover and climate in the country. Point measurements suggest trends in surface temperature and rainfall that are greater than those from global averages but we don't know if these trends represent average changes for the entire country. Also, the Philippines is among the top ten countries in the world with high deforestation rate, with 9.8 million hectares (M Ha) of forest lost from 1934 to 1988. The remaining forest cover, as estimated in 2003, is only 7.2 M Ha, which comprises 24% of the total Philippine land area. This study takes advantage of available satellite data sets to gain insights into the interannual changes in surface parameters in the country during the last decade. Among the surface parameters are the Normalized Difference Vegetation Index (NDVI), surface temperature, albedo, rainfall, and soil moisture. The key sensors that we use are the Moderate Resolution Imaging Spectroradiometer (MODIS), which provides NDVI and surface temperature data and the Advanced Microwave Scanning Radiometer (AMSR-E), which provides rainfall and soil moisture data from 2002 to the present. Multi-year averages of NDVI during dry and wet seasons show large seasonality of vegetation as observed by Terra/MODIS during the 2000 to 2010 period. During dry seasons the NDVI values are shown to be relatively high in elevated areas. These high values represent areas that are normally covered by trees, representing either old virgin forest or relatively new forest. Highly urbanized regions show little seasonal change while the low-lying areas show significant increase from the dry to the wet season. The NDVI averages derived from the first 5 years of MODIS data show patterns that are very similar to averages in the following 5 years. The difference in the averages, however, indicates a considerable decline in vegetation, including forested areas, over the ten-year period. Such decline suggests a continuation of the 3% decrease in agricultural farm areas estimated previously through manual surveys for the period 1991 to 2000. Similar studies using the same sensor show significant increase in surface temperature during the same period. It is apparent that satellite data is a powerful tool for making spatial and temporal inventory of natural resources amid the changing climate. The 250-meter resolution MODIS data provide a good enough resolution for assessing the general characteristics of vegetation in any region of the world. We validate our interpretation of the data through the use of near coincident high-resolution data such as those provided by Landsat and Formosat-2. For

improved assessment of the change, the data record was extended from 10 years to about 30 years through the use of AVHRR 1 km data that has been available since 1981. Future work will include similar studies for other Southeast Asian countries to assess how the climate and land cover has been changing for the entire region.

Perren, Bianca B.

Agriculture and climate from the Norse landnám to the present: the biological response to human activities at Igaliku, South Greenland

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A multiproxy high-resolution record from Lake Igaliku, South Greenland, was generated to evaluate the in-lake biological response to both Norse (950-1450 AD) and modern (post-1920 AD) agricultural disturbance, and its paleoclimatic context. Diatoms and C and N stable isotopes show perturbations consistent with the timing of the latter part of the Norse occupation of the area (after 1300 AD) and with recent agricultural activities (after 1980 AD), superimposed upon long term climatic variations (e.g. Little Ice Age, post-1990 AD warming). While the response to Norse agriculture is subtle in nature, with slight changes to diatom phytoplankton and C:N ratios, the biological response to the last 3 decades of modern sheep farming is marked, with drastic changes in diatom assemblages, C and N isotopes, and a sharp increase in scaled chrysophytes. Indeed, the lake environment of the last 30 years is unmatched by any of the late Holocene. The driver for recent changes is likely a combined response to both a warming climate and intensification of agricultural practices. Neither warm temperatures nor agricultural disturbance together during the Norse landnám were sufficient to create the marked changes observed in the modern lake environment. These results are in direct contrast to the notion that the Greenland Norse caused the widespread destruction of their pastoral landscape. This study represents the first use of diatoms and isotopes from lake sediments to evaluate Norse impacts in Greenland.

Persoiu, Aurel

A Holocene Perspective On Interactions Between Social And Environmental Processes In NW Romania, Central Europe

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The study of interactions between past social and environmental processes became increasingly important over the past decades, especially in the context of the continuous and amplified human stress on the natural environment. Whereas the human impact upon the environment is generally accepted by the scientific community (at least in its broader outline), the reverse, i.e. the impact of environmental changes upon human society is still in debate. To date, no such studies have been performed on the territory of present-day Romania, an area of particular interest for the dynamics of European human societies in the Holocene, as this region was the gate to Europe for most of the civilization advances and human migrations over the past ca. 10000 years. In this paper, we present a multi-proxy investigation of the interactions between social and environmental processes over the past ~10000 years in NW Romania. δ18O and δ2H in cave ice, δ18O and δ13C from speleothemes, multi-proxy analyses on six pollen sequences and fluvial evidences are used to reconstruct past climatic and environmental changes. Geochemical analysis of cave ice, archaeological and documentary evidence provide a measure of the dynamics of human groups and societies over this interval. The climate of the region experienced a slow warming from early Holocene to ~5.5 ka BP, followed by a gradual cooling towards the present (interrupted by a warm and wet period at 3.2 ka BP). A series of rapid coolings occurred at 8.3 ka BP, 7.0 ka BP, 5.2 ka BP, 4.7 ka BP and 2.8 ka BP. A warm and dry Medieval Warm Period was followed by an unstable and somewhat cooler Little Ice Age. The pollen records indicate that humans have produced changes on the landscapes since the Neolithic (c. 8000 cal. yr BP) but an increase in pollen types associated with habitat transformation by humans i.e., rise in agriculture, grazing, enrichment of soils occurred from ~3.5 ka BP onwards and intensified over the last 1000-500 years. Archaeological evidence shows that human occupation was present over the entire interval, with a sharp increase in the early Holocene and a slight drop in the late Bronze Age, followed by a moderate increase, and again interrupted during the Dark Ages Cold Period. The same archeological data indicates that environmental stress was not a major factor affecting social dynamics in this area. However, as this region was on the track of most population invasions towards Europe, we

consider that, although climate and environment might have affected the size and dynamics of population, repeated migrations kept the area well inhabited, with social dynamics ultimately masking the effects of environmental stress. This hypothesis was tested by analyzing in detail the interactions between social and environmental processes in a marginal social group for the past 1500 years, the results indicating that cultural change and environmental determinism both had an important role in its dynamics.

Petrie, Cameron

Humans, environment and the decline of the Indus Civilisation: investigating relationships between Land, Water and Settlement on the plains of NW India

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It is generally believed that a range of factors contributed the collapse of the urban phase of the Indus civilisation in the 2nd millennium BC. There has been considerable debate about the role of the hydrology of the plains of NW India in these processes. However, researchers are faced with a range of environmental and climatic parameters such as shifting rivers, aridification, changing rainfall patterns etcetera, that may or may not have played a role, and at present, much of the evidence is equivocal. There has also been relatively limited attention to the relationship between the landscape of human settlement and human response to that landscape. The multi-disciplinary Land, Water and Settlement project involves scholars from institutes in India and the UK, and has been integrating a range of archaeological and earth science based investigations on the plains of NW India since 2007. This includes remote sensing of archaeological sites based on the existing databases of archaeological sites, reconnaissance of Harappan and later period sites in western Uttar Pradesh (UP) and Haryana, excavations at several archaeological sites and detailed archaeological and geoarchaeological surveys of the hinterland of the urban site of Rakhigarhi and the large town site of Banawali. These results of these surveys and excavations have revealed important evidence for developing settlement dynamics, landscape formation and hydrology that are critical for our understanding of the rise, decline and transformation of the Indus Civilisation and will be presented.

Polyak, Victor J.

Paleoamerican climate in southwestern North America

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Earliest well-documented human occupation of North America (Paleoamerican cultures) occurred during the transition from glacial to interglacial environment. Data from a Fort Stanton Cave stalagmite (FS2) indicate that this climatic transition started 1000 to 1500 years prior to the age of Clovis archeological materials in southwestern North America. Before 15,000 years ago, southwestern North America underwent ~40,000 years of distinctly cooler and wetter climate. The Clovis people, the earliest well-documented humans in southwestern North America, likely experienced the biggest shifts in climate relative to all other cultures. Growth records and geochemical data from speleothems of New Mexico caves suggest that a terminal Pleistocene drought that included the 'Clovis drought' may have been as effectively dry or drier than some of the Holocene. The transition from glacial to interglacial environment was temporarily interrupted by the Younger Dryas stadial, but our data indicate that the Younger Dryas, while wetter and cooler than the middle Holocene and the ~2000-year period immediately preceding this event, was still significantly drier than the glacial period. The Folsom and Midland cultures were largely coincident with the Younger Dryas, and likely enjoyed climatic conditions wetter and cooler than those in the middle and much of the early Holocene. From roughly 12,000 to 10,000 years ago several late Paleoamerican cultures lived during somewhat wetter climate compared to the early to middle Holocene and the terminal Pleistocene drought. From the speleothem-based records, the period in the early to middle Holocene from 10,000 to 7000 years ago was the driest period in southwestern North America in the last 55,000 years. Probably as a result, cultures changed from Paleoamerican to Desert Archaic tradition. Changes in cultures from early Paleoamerican to late Paleoamerican to early Archaic seem to be coincident with and probably resultant from climatic shifts related to (1) the glacial to interglacial transition coincident with the Bølling-Allerød interstadial, (2) a brief interruption of the onset of Holocene-like climate by the Younger Dryas stadial, and (3) about 1500 years of extended wetness beyond the end of the Younger Dryas in the earliest Holocene.

Prendergast, Amy

A palaeoclimatic framework for the Late Pleistocene and Early Holocene occupation of North Africa

Prendergast, Amy[1]

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From the Late Pleistocene to the Holocene, remarkable changes in human behavior and society can be gleamed from the North African Mediterranean archaeological record. These changes include elements that connote behavioral modernity such as the use of personal ornamentation and the development of complex stone tool technologies, and changes in lifestyle such as the adoption of farming. Given its position between Sub-Saharan Africa and Europe, North Africa is also likely to have served as a vital stepping stone in the migrations and dispersal of anatomically modern humans to Europe. Some contend that these changes and migrations were stimulated by major shifts in climate and environment. Evaluation of this hypothesis requires high-resolution analysis of local and regional climate records paired with well dated archaeological sequences. The Haua Fteah in Libya provides an ideal laboratory to test this hypothesis as the cave contains one of the longest and most important sequences of human occupation in North Africa as well as abundant material for paleoenvironmental reconstruction. This paper presents the results of ongoing research on the mollusc assemblage from the Haua Fteah. This research forms part of the "Cultural transformations and environmental transitions in North African prehistory" (TRANS-NAP) project in which re-excavation of the Haua Fteah is combined with geoarchaeological studies in the wider landscape and the application of multiple paleoclimate proxies. Marine and terrestrial molluscs are abundant throughout the sequence from the Neolithic period (~4500 years ago) to the Libyan Pre-Aurignacian (>90,000 years ago). So far, stable isotope analyses of the topshell Osilinus turbinatus and the pulmonate snail Helix melanostoma have allowed the construction of paired marine and terrestrial climate curves covering rapid and profound climatic variations from the last glacial maximum, through the deglacial and into the Early Holocene. The combination of stable isotope analyses with shell micromorphology has allowed monthly resolution at key periods within these climate curves to assess the importance of seasonality in climate change. Furthermore, analysis of stable isotope edge values from the shells has allowed a reconstruction of changing shellfish foraging strategies throughout the archaeological sequence. Situating the archaeological record of cultural change within a high-resolution framework of changes in climate and environment allows an examination of of how people responded to these changes.

Raab, Thomas

Reconstructing past landscapes – The use of modern open-cast lignite mining

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In the opencast mine Jänschwalde, Lower Lusatia (Brandenburg, Germany) Germany's probably largest archaeologically investigated charcoal production area was discovered. The charcoal was presumably used nearby in the iron works of Peitz where bog iron ore was smelted since 1567. Meanwhile remnants of more than 400 circular upright hearths are prospected and excavated. According to rough calculations about 800 ha of woodland were necessary to charge those piles. Charcoal burning and related activities certainly had tremendous environmental impacts and led to a large-scale devastation of the landscape. Remnants of charcoal piles and topsoils buried under up to 150 cm thick eolian sediments prove the remobilization of Quaternary sands as a consequence of clearing for charcoal production. By law large-scale surveys and excavations have to be carried out in the forefield of the five km wide opencast mine to document all archaeological findings. In combination with the excellent outcrop situation the archaeological investigation offers ideal conditions to study the soils and paleosoils. Therefore recently, a joint research project was launched for interdisciplinary long-term paleoenvironmental research and to reconstruct the anthropogenic landscape change in southern Brandenburg. To develop a model of former land use different data are combined and blended, which are included step wise, using the Geographic Information System ArcGIS (ESRI). The physio-geographic conditions (e.g., topography, soils, geology, hydrology) will be examined with regard to the location of archaeological findings, particularly the location of the charcoal hearths. To perform a landform analysis and for visualization a Digital Elevation Model (DEM) based on airborne laser scanning data will be used. In addition, historic maps are evaluated which are available from the year 1767 onwards. The model will be supplemented with data from ongoing geomorphological and pedological investigations, dendrochronological ages of the remnants of charcoal hearths, buried soils and sediments and information of past vegetation from palynological research. Bönisch, E., Rösler, H., Schopper, F., Raab, T. & Raab, A. (accepted): Pre-industrial Charcoal Production in southern Brandenburg and its impact on the environment. – Proceedings of the 1. International Landscape Archaeology Conference, 26-28th January 2010, Amsterdam. Landscape & Heritage, Amsterdam University Press.

Raab, Thomas A.

Mining as a factor of prehistoric and historic landscapes change in Central Europe

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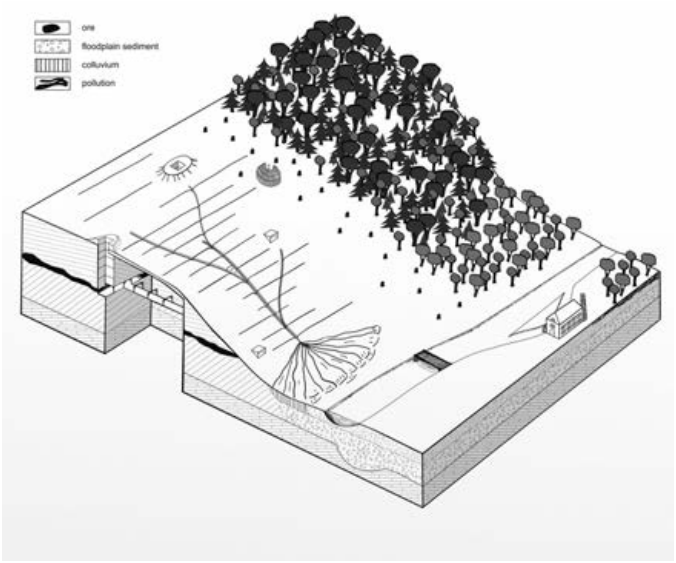
During the Holocene period, under the influence of increasing human activities and pressures, the landscape in Central Europe changed from a natural towards a cultural landscape. Herewith, a main driving factor was mining. Here, we present a synthesis of results from several case studies carried out in the Vils River valley, East Bavaria, Germany, which was one of the leading iron mining regions of the 15th century. To supply the demand for energy and ores of the smelters on the floodplains, charcoal and ores had to be transported from the charcoal piles and mines located on the plateaux to the river valley floor. The transport of the materials on unpaved paths on the valley slopes initiated linear soil erosion and therewith gullies up to 5 m in depth were formed. At the footslopes, the eroded material accumulated as colluvial sediments and formed alluvial fans. Further transported material reached the river and was re-deposited on the floodplain. By physical, chemical, and mineralogical parameters 3 facies of floodplain sediments could be distinguished. Flood loam of up to 4 m depths forms the major part of the alluvial sequence. Age determinations (14C, IRSL, tree-ring analysis) prove an increasing accumulation of flood loam in the last millennium which correlate with the beginning of mining activities in the catchment. On the upper reaches of the Vils River, historic lead mining left behind heavy metal contaminations in the alluvial soils of more than 20.000 mg/kg. The lead distribution on the floodplain has a strong correlation with the location along the river of former processing sites. The results prove that historic mining landscapes are not only characterized by the visible relicts of former human activities, such as landforms but may also contain 'hidden legacies'. Hence, for a sustainable land use, there is a need to acquire more knowledge over the floodplain histories seen in mining regions. RAAB, T. & A. RAAB (in press): Impacts of Early Land Use and Mining on River Landscapes. - ALBERT, M.-T. (ed.): World Heritage and Cultural Diversity. RAAB, T., K. HÜRKAMP & J. VÖLKEL (in press): Stratigraphy and chronology of Late Quaternary floodplain sediments in a historic mining area, Vils River valley, East Bavaria, Germany. - Physical Geography.



A synthesis of mining-induced landscape changes (adapted from Raab & Raab, in press)

Rhode, David

Climate and its Effects on Small-Scale Societies in the Bonneville Basin, western North America

Rhode, David[1]

1. Desert Research Institute, Reno, NV, USA

Examples of dramatic effects of climate change on complex, hierarchical and state-level societies, such as the Moche or the Maya, have been widely reported and discussed. Less prominently considered are the effects of climate change on small-scale societies having less complex organizational structures and smaller effective populations, such as hunter-gatherers. People in these societies, it is often thought, maintain generalized subsistence orientations, with low population densities relative to carrying capacity, and are sufficiently mobile to target available resource patches over wide home ranges, so that the effects of significant climate change are buffered. In this view, climate change is not a significant factor in the dynamics of human foraging systems. Another line of thought, however, suggests that such societies are significantly limited by climate-driven environmental perturbations, that privation is often at the door, and that the characteristics of high mobility, low effective population levels, and general or flexible subsistence orientations identified above are in fact a product of those limiting factors. Insights into the effects of climate change on small-scale societies are best learned from long-term archaeological records. Here, I consider the Holocene archaeological and paleoecological records from the Bonneville Basin, western North America. These records document significant climate-driven paleoenvironmental fluctuations during the Holocene, evidence for substantial variation in population, and shifts in subsistence orientation. The extent to which human populations in the Bonneville Basin were buffered from, and/or dramatically affected by, Holocene climatic fluctuations is examined.

Riehl, Simone

Mid-late Holocene agricultural system transformations in the northern Fertile Crescent: archaeobotanical, geoarchaeological and philological evidence

Riehl, Simone[1, 4]; Pustovoytov, Konstantin[2, 3]; Dornauer, Aron[2]

1. Senckenberg Forschungsinstitut Frankfurt, Tübingen, Germany
2. Institut für Vorderasiatische Archäologie, Freiburg, Germany
3. Institut für Bodenkunde und Standortslehre, Hohenheim, Germany
4. Institut für Ur- und Frühgeschichte, Tübingen, Germany

The region of the northern Fertile Crescent experienced dramatic changes in the political and cultural life of its societies during the period of mid-late Holocene (ca. 5000-3000 cal BP). The role of these changes in the mode of agricultural production and land use as well as their interrelationship with climate still remains poorly understood. In this study we use an interdisciplinary approach based on archaeobotanical, geoarchaeological and philological data from a series of archaeological sites in the northern Fertile Crescent to highlight the transformations of agricultural systems and their potential triggers. The charred seed record from cultural layers suggests change in crop cultivation at the Early Bronze Age (EBA) - Middle Bronze Age (MBA) boundary such as disappearance of flax and wine in many places as well as a strong reduction in emmer and einkorn production. The general pattern of the MBA manifests itself also in the Late Bronze Age sites, whereas the Iron Age sites show new changes such as a wide spread of free-threshing wheat and a return of flax. These changes have been paralleled by fluctuations of the stable carbon isotope composition of charred organic matter in seeds and the dynamics of irrigation networks documented by pedosediment profiles in the field as well as by textual sources. These changes in agricultural strategies might have been a response to the regional climate changes, specifically to the desiccation trend toward the end of the EBA.

Rolett, Barry V.

Holocene Sea-level Change and Neolithic Cultural Response in Southeast China

Rolett, Barry V.[1]

1. Anthropology, University of Hawaii, Honolulu, HI, USA

Seafaring across the Taiwan Strait began approximately 5,000 years ago and involved open-sea voyages over distances of at least 130 km. Early Holocene rapid sea-level rise preceded the emergence of open-sea voyaging and greatly transformed the coastline. What was the role of early Holocene environmental change in the development of seafaring? I investigate this problem by the comparison of Neolithic cultural response in two coastal areas of southeast China: the lower reaches of the Yangtze River and the Fuzhou Basin. For the mouth of the Yangtze River, previous research by Y. Zong, Z. Chen and others suggests that the formation of a mega-delta with fertile land encouraged early Neolithic rice farming. However, on the Fujian coast opposite Taiwan, sea-level rise created a large estuary in the Fuzhou Basin, but no deltaic plain or other land suitable for irrigated rice agriculture (Fig. 1). The estuary setting, together with the lack of land suitable for rice paddy agriculture, inhibited intensive food production but favored the development of seafaring. Palaeogeographic reconstruction of the Fuzhou Basin is based on the analysis of recently collected sediment cores.

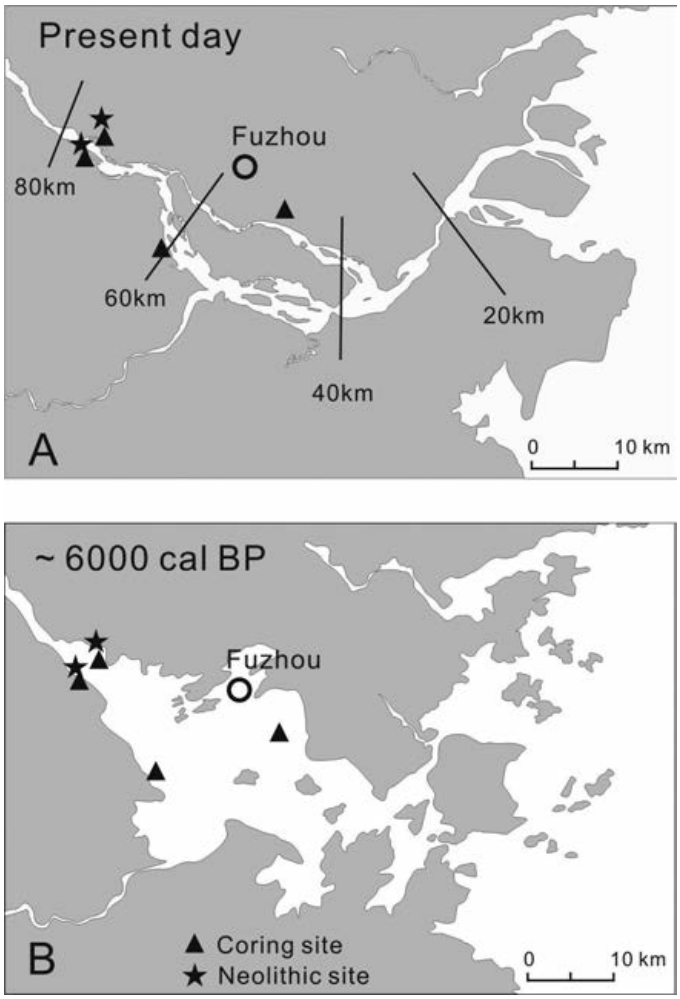


Fig. 1 Map of the Fuzhou Basin (Fujian, China) showing the present day environmental setting and a palaeogeographic reconstruction for the time period around 6000 cal BP.

Rosenthal, Yair

Controls on hydrologic variability in the Indo-Pacific region during the past two millennia

Rosenthal, Yair[1]; Oppo, Delia W.[2]; Linsley, Braddock K.[3]; Tiereny, Jessica E.[4]

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2. Department of Geology and Geophysics, WHOI, Woods Hole, MA, USA
3. Department of Atmospheric and Environmental Sciences, SUNY-Albany, Albany, NY, USA
4. Geology, LDEO, Palisades, NY, USA

Seasonal climate variations in the Indo-Pacific Warm Pool (IPWP) and southeast Asia regions are dominated by hydrologic fluctuations due in part to migration of the Intertropical Convergence Zone (ITCZ) and the seasonal march of the monsoons. However, large departures from climatology, linked to the interannual events (e.g., ENSO, IOD) and longer-term variability result in unexpected droughts and flooding, often with dire economic consequences. On multi-decadal to centennial time scales these systems exhibit a very complex interplay. Understanding the controls on these mechanisms in the past- whether caused by variations in regional sea surface temperatures, tropical Pacific dynamics, or remotely driven by high latitude climate – is important not only for examining their influence on regional landscape and human developments but also for predicting their response to future climate change. This requires the development of high-resolution paleoclimate data sets to compare with detailed climate model simulations assesing different mechanisms. Here we assess the hydrologic variability in the IPWP region by reconstructing sea surface temperature and salinity in high-resolution sediment cores from the Indonesian seaways using paired δ18O and Mg/Ca measurements in planktonic foraminifera. These, and additional records of hydrogen isotopic ratios of terrestrial higher plant leaf waxes (δDwax), stored marine sediments, provide detailed reconstruction of IPWP hydrologic variability through the last two millennia. We show that hydrologic variability in the western region of Indonesia is anti-correlated with a monsoon reconstruction from Southeast Asia, indicating that intervals of strong East Asian Summer Monsoon activity are associated with a weaker Indonesian monsoon consistent with migrations of the ITCZ. The centennial-scale oscillations in our data follow known changes in Northern Hemisphere climate (e.g. the Little Ice Age and Medieval Warm Period) implying a dynamic link between Northern Hemisphere temperatures and IPWP hydrology. Comparison with records to the east and paleo-ENSO indicators suggests that the in the western region the influence of ENSO variability is overwhelmed by shifts in the ITCZ.

Rubin, David M.

Differences In Human/Landscape/Climate Interactions In Grand Canyon 1-2 Millennia Ago And The Present

Rubin, David M.[1]; Draut, Amy E.[1]

1. USGS, Santa Cruz, CA, USA

People have interacted with the landscape and water of the Colorado River in Grand Canyon for thousands of years. We studied sediment deposits where 1000-2000 years ago, people lived along the river, farmed the floodplains, and built roasting pits in the sand dunes blown inland from dry areas of the riverbed. Sedimentologic interpretation of sand and silt deposits along the river reveals evidence of those human activities and interactions with the landscape. Sediment deposits record floods from snow melting in the Rocky Mountains, transport of sand from river bars to dune fields at times when the river flow was low, slopewash and gullying from local monsoon rainfall, and fires built or set on the floodplains for agriculture or other purposes. Today the Colorado River in Grand Canyon is regulated by Glen Canyon Dam. The dam eliminates the natural seasonal variations in river flow. Consequently, peak annual discharges are only a fraction of those of natural floods, and base flows are much greater than predam low flows. The quantity of sand supplied by the Colorado River to Grand Canyon has been reduced by more than 90% by the dam, with only 10% being supplied by local tributaries between the dam and Grand Canyon. As a result of the reduced sediment load, reduced peak discharges, and higher base flows, less dry sand is accessible on the riverbed for eolian transport. Consequently, dune fields along the river are less active, and gullying of river terraces is more pronounced. As a result of these human-induced changes, the landscape of the present river corridor differs substantially from the past.

Couplets of fluvial and subaerially reworked deposits. Fluvial sediments are light in color and contain subaqueous ripples. Subaerial deposits include beds that are dark with charcoal and bioturbated. Scale bar is 10 cm long; radiocarbon age is 40 BC to AD 330 AD.

Ruddiman, William F.

Late Holocene CO2 And CH4 Increases: Natural Or Anthropogenic? *(INVITED)*

Ruddiman, William F.[1]

1. Univ. of Virginia, Raphine, VA, USA

The debate over natural versus anthropogenic explanations for late-Holocene CO2 and CH4 increases continues. One argument against anthropogenic control is that too few farmers lived millennia ago to generate large amounts of these gases, prior to the post-1500 AD population explosion. Most land-use modelers implicitly adapt this view by running simulations that assume little or no past change in per-capita land clearance, but archeological and historical evidence refutes this assumption. Seminal 1965 and 1981 books by Ester Boserup synthesized evidence that per-capita land use fell by a large amount (likely over an order of magnitude) during the Holocene as farmers moved from land-intensive shifting cultivation to labor-intensive small plots. Historical-era support for Boserup's view comes from records of land use in Europe and China that document ~4-fold decreases in per-capita clearance and cultivation during the last 2000 years. For pre-historical times, Dorian Fuller and colleagues documented the spread of rice irrigation across southern Asia and found that the total area of irrigated rice paddies and their CH4 emissions increased long before the human population increase. In Europe, Jed Kaplan and colleagues used historical land-use records that showed extensive regional clearance by 2000 years ago. Their work also indicates that other areas such as southern Asia with even higher population densities were already extensively deforested by 2000 years ago and that anthropogenic CO2 emissions rose long before the increase in human population. This emerging evidence from archeology and history invalidates the constant per-capita assumption used by land-use modelers and thereby undercuts their arguments against the anthropogenic hypothesis. Another argument is the small size of the decrease in δ13 of atmospheric CO2 during the last 7000 years, which limits net pre-industrial release of terrestrial carbon to ~50 Gt. Based on this constraint, the Bern group infers very little pre-industrial CO2 input from anthropogenic deforestation, but their analysis assumes that just 40 Gt of carbon were withdrawn from the atmosphere and stored in boreal peat. In contrast, a well-respected estimate by Nevil Gorham (1991) and a new synthesis by Zicheng Yu (2010) indicate that total carbon storage in peat during the last 7000 years was ~300 Gt. This larger estimate of C burial requires much greater emissions of terrestrial carbon to balance the δ13CO2 budget than the Bern group proposed. Models indicate that natural processes (carbon exchanges from changing monsoon circulations and increased CO2 fertilization) can only supply a few tens of Gt of this carbon deficit, leaving anthropogenic emissions as the major viable source. The evidence of large C burial (at least 300 Gt) in boreal peat during the last 7000 years undermines the δ13CO2 argument against the anthropogenic explanation. Mother Nature, the ultimate arbiter, has also weighed in on this debate. Similar intervals early in previous interglaciations (when humans were not a significant factor) show downward CO2 and CH4 trends. With downward gas trends prevailing in a climate system that was fully natural, Mother Nature's verdict seems clear: the upward Holocene trends were anomalous, and thus anthropogenic.

Rushton, Elizabeth

Palynological evidence for climatic shifts and changes in landscape at the Mayan city of Lamanai, Belize, ca. 1500 BC to AD 1500

Rushton, Elizabeth[1]

1. Geography, University of Nottingham, Nottingham, United Kingdom

A core from the New River Lagoon, northern Belize was analysed for palynological data as well as charcoal concentrations and presence of gastropods to reconstruct changes in landscape during the period ca. 1500 BC to AD 1500. The combination of these data sets with previously published diatom, stable isotope and mineralogical and major elemental data enabled the reconstruction of shifts in climate from moist to drier conditions and land-use change. Moist conditions occur at the earliest point in this record, indicated by the presence of wet climate indicators, crops and arboreal taxa, and this concurs with the record of wet conditions in the mid-Holocene from the wider region. The pollen, gastropod and charcoal record highlights evaporative conditions ca. 390-300 BC and a period of substantial anthropogenic building at Lamanai ca. 170 BC to ca. AD 270. This period of development matches the other paleolimnological and archaeological records from the site. There is some evidence of drying during the Maya 'hiatus' ca. AD 530-590 and also the Maya 'collapse' ca. AD 900, although the impact on the vegetation signal is limited. This research supports the assertion that Lamanai was insulated from climatic shifts due to its location by the New River Lagoon, further emphasising the need for greater geographic and temporal sensitivity when exploring the terminal-Classic Mayan 'collapse'. Anthropogenic forest clearance and some subsequent recovery are visible in the record from this site, as is a possible shift in agricultural practise from a focus on 'urban orchards' to a more field based system ca. AD 1200. The record from the New River Lagoon is somewhat limited as it does not give high resolution data for the locale of Lamanai, and is not as sensitive as the decadal resolutions from other reconstructions from the region. However, it does provide a broad record of vegetation, land-use and climate change over a period of three thousand years that adds detail to, and clarifies the other environmental record from Lamanai, and contributes to an to an appreciation of the coupled cultural and environmental history of the region.

Schlummer, Manuela

Human Induced Hillslope Sediment Storages in Central Europe

Schlummer, Manuela[1]; Hoffmann, Thomas[1]; Dikau, Richard[1]

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Soil is a major resource of past and modern civilizations and thus a major link in human-environmental interactions. The introduction of agricultural techniques in Central Europe during the early Neolithic (about 7500 BP) persistently affected soil erosion and thus resulted in strong soil degradation with negative impacts on the development of human societies. Hillslope deposits, derived from human induced soil erosion, provide a valuable archive to study the human impact on soil erosion and soil degradation. Historical soil erosion research in Central Europe yielded numerous small scale studies on hillslope deposits caused by agricultural land use. However, a large scale synoptic analysis of of human induced hillslope sediment storages in areas under agricultural activity and a modelling approach for the regional distribution of these sediments are still missing. Thus the objectives of this paper are (i) to understand the large scale human impact on soil erosion in Central Europe during the Holocene, (ii) to identify the major controlling factors of soil erosion and deposition, and (iii) to model spatial patterns of human induced hillslope deposits for different cultural periods. A sediment database for Central Europe has been compiled containing all available data from published local studies on human induced hillslope deposits (sediment depths, volumes, dated ages, sedimentation rates). Data from 41 catchments, slope hollows and other geomorphometric settings (ranging from 10^{-3} to 10^{3} km^2) have been included in this study and compared with archaeological information regarding the duration and degree of human impact. Results from regression analyses show a strong power law between storage volume (V, km^3) and catchment area (A, km^2)($V = bA^c$). The scaling exponents for colluvial and alluvial storage volumes reveal no differences. Furthermore, sediment storage in loess covered catchments, which are characterised by long and intense land use, is only slightly higher compared with catchments dominated by other lithologies and low human impact. Based on these results, we derive the following theoretical assumptions: (i) On hillslopes (slope face and footslope) sediment deposits produced by human induced soil erosion show a nonlinear scaling behaviour. (ii) This scaling behaviour is similar to that of the downstream sediment sinks of the system (alluvial sediments). (iii) Lithology of the underground material exerts a minor influence on sediment storage volumes despite large differences in land use history. Currently, DEM-based analyses are applied to understand the influence of geomorphometric parameters on the scaling effects of human induced soil erosion sediment storage. Further, we will determine spatial patterns of these deposits in small catchments for different cultural periods of the Holocene using historical land use data. To validate our model we will select well studied "key-catchments", for which adequate sediment budget data with high spatial and temporal resolution are available.

Simmons, Christopher T.

Investigating the role of changes in the meridional overturning circulation on the Holocene carbon cycle and climate-vegetation dynamics

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2. Geography and Urban Planning, Concordia University, Montreal, QC, Canada

The role of natural processes and human land use in the 20 ppm CO2 increase during the Holocene has been a source of considerable scientific debate in recent years. In order to assess the contribution of natural processes (excluding wetlands and coral reefs), the University of Victoria Earth System Climate Model (UVic ESCM) v. 2.9 was used to investigate the Holocene's natural carbon cycle (excluding land use) from 8000 to 150 years BP. The equilibrium simulation with prescribed forcing for 8000 BP yielded an oscillatory solution from which three sets of initial conditions were obtained with different ocean circulation states. Furthermore, another set of initial conditions were derived from a steady-state equilibrium solution obtained for the model from 21000 BP. These different starting points were applied to transient simulations forced by time-varying orbital parameters, land ice, and prescribed winds. A number of sensitivity studies were also carried out. These include forcing atmospheric carbon to follow the Taylor/Law Dome trends, using different prescribed winds, artificially injecting carbon into the atmosphere for 1000-2000 year intervals, as well as changing the model land ice distribution in Antarctica. The model results with freely-varying atmospheric CO2 produce a decline in atmospheric CO2 to 245-253 ppm over the course of the Holocene instead of the increase to 280 ppm (as observed in Antarctic ice cores). However, the magnitude of the decline depends strongly on initial conditions and the centennial and millennial-scale variability in overturning in the Southern Ocean. In particular, centennial-scale changes in the Southern Ocean produced temperature-precipitation climate feedbacks that led to significant vegetation shifts in central Asia. If part of the climate system during this time period, they may have influenced the human migration patterns in this region. Furthermore, their net effect is to decrease ocean uptake efficiency of CO2, and the number of these high-frequency events is crucial to understanding the impact that human land use emissions would have had on net changes in atmospheric CO2. It was also found that atmospheric CO2 has a nearly 10 ppm sensitivity to changes in Antarctic land ice due to the former's influence on the meridional overturning circulation. Despite the importance of winds on the meridional overturning circulation, we find that they have a relatively minor effect for most simulations when

compared to using the NCEP wind climatology. However, the carbon injection experiments (roughly approximating human land use) suggest that carbon initially released in the atmosphere can, through feedbacks, lead to as much as a doubling of the initial injection, depending strongly on the timing of the release.

Singh, Ravindra N.

Humans, environment and the decline of the Indus Civilisation:Investigating relationships between Land, Water and Settlement on the plains of NW India

Singh, Ravindra N.[1, 2]; Petrie, Cameron A.[2, 1]; French, Charles I.[2, 1]

1. Department of AIHC & Archaeology, Banaras Hindu University, Varanasi, India
2. Department of Archaeology, University of Cambridge, Cambridge, United Kingdom

It is generally believed that a range of factors played a part in the collapse of the urban phase of the Indus civilisation and the subsequent reappearance of urbanism in the 1st millennium BC. There has been considerable debate about the role of the hydrology of the plains of NW India in these processes. However, researchers are faced with a range ofenvironmental and climatic parameters such as shifting rivers, aridification, changing rainfall patterns etcetera, that may or may not have played a role, and at present, much of the evidence is equivocal. There has also been relatively limited attention to the relationship between the landscape and human settlement. The multi-disciplinary Land, Water and Settlement project involves scholars from a range of institutes in India and the UK, and it has been incorporated a range of archaeological and earth science based investigations on the plains of NW India since 2007. This paper will introduce the project and review the archaeological investigations that have been carried out between 2007 and 2010. This includes remote sensing of archaeological sites based on the existing databases of archaeological sites, reconnaissance of Harappan and later period sites in western Uttar Pradesh (UP) and Haryana, excavations at Alamgirpur, two sites close to Masudpur, and the site of Burj, as well as detailed surveys of the hinterland of the urban site of Rakhigarhi and the large town site of Banawali.

Stahle, David W.

Mesoamerican Dendroclimatology

Stahle, David W.[1]; Villanueva Diaz, Jose[2]; Burnette, Dorian J.[1]; Heim Jr., Richard R.[3]; Acuna Soto, Rodolfo[4]

1. Geosciences, University of Arkansas, Fayetteville, AR, USA
2. CENID RASPA, Instituto Nacional de Investigaciones Forestales, Agricolas, y Pecuarias, Torreon, Mexico
3. Climate Services and Monitoring Division, NOAA's National Climatic Data Center, Asheville, NC, USA
4. Departamento Microbiologia y Parastologia, Universidade Autonoma de Mexico, Mexico City, Mexico

Mesoamerica is one of the richest archaeological districts of the ancient world notable for large urban centers, monumental architecture, calendar and hieroglyphic writing systems that in some cases describe and accurately date conquests, dynastic succession, celestial phenomena, weather extremes, and drought. Ancient Montezuma baldcypress (Taxodium mucronatum) trees found in Barranca de Amealco, Queretaro, have been used to develop the first exactly dated, annually resolved paleoclimatic record in Mesoamerica spanning the late Classic, post-Classic, Colonial, and modern eras. This climate-sensitive tree-ring chronology is correlated with precipitation, temperature, drought indices, and crop yields in central Mexico, and has been used to reconstruct the spring-early summer moisture balance over the heartland of the Mesoamerican cultural province for the past 1,238-years (i.e., the Palmer drought severity index for June, AD 771-2008). Spectral analysis of the reconstruction indicates strong and highly significant concentrations of variance at timescales associated with the El Nino/Southern Oscillation, and at multi-decadal timescales potentially associated with climate forcing from the Atlantic Ocean sector. The reconstruction provides the first independent support using high resolution paleoclimatic data from Mexico for the Terminal Classic drought previously identified in the Yucatan with lake sediments and in the Caribbean sector with varved marine sediments from the Cariaco Basin. The reconstruction also documents severe and sustained megadrought during the decline of the Toltec state (1149-1167), the rise of the Aztec state in late 14th century, and during Spanish conquest (1514-1539), providing a new precisely dated climate framework for the study of Mesoamerican cultural change.

Staubwasser, Michael

Holocene Indus Drought Cycles, the 4.2 ka Event in Asia, and the Search for a Mechanism

Staubwasser, Michael[1]

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Previous studies from the northern Arabian Sea off the Indus delta have produced high resolution records of $\delta^{18}O$ from surface dwelling foraminifera and alkenone-based sea surface temperature. The combination of the two records allows to calculate the $\delta^{18}O$ of surface water of the last 5000 years (Fig. 1). Considering the contrast (> 10 ‰) between the

central Arabian Sea and Indus river water, fluctuations are most likely the result of Indus discharge changes. The calculated $\delta^{18}O$ values confirm the earlier interpretation of the foraminiferal record in terms of drought cycles. The 4.2 ka drought event is particularly accentuated. This method, however, has its limits as it requires some assumptions on seasonal distribution of forams and algae, and also results in loss of resolution. Evidence for environmental and cultural change between 4.3 and 3.8 ka BP is abundant in Asia (and elsewhere in the northern hemisphere), but the mechanistic cause of the event is not clear. The event does not appear to be a continent wide drought. For example, no drought is indicated in the Oman stalagmite records. In the northern parts of China, peat and river bank deposits indicate flooding (NE China and Yellow river), and lacustrine sediment composition suggests rising lake levels (Tian Shan). The potentially emerging regional pattern of drought and flood at 4.2 ka BP is currently spotty and blurred by chronological uncertainty. The chronologic accuracy and precision required to obtain a significant pattern for the 4.2 ka BP event is very demanding, particularly because of the apparent cyclic nature of Holocene climate change. Despite the uncertainty, a comparison is tempting between the above picture, the present day long term rainfall distribution and vertical atmospheric flow pattern induced by high tropospheric Rossby waves. This may give an insight into the potential mechanism that caused the 4.2 ka event.

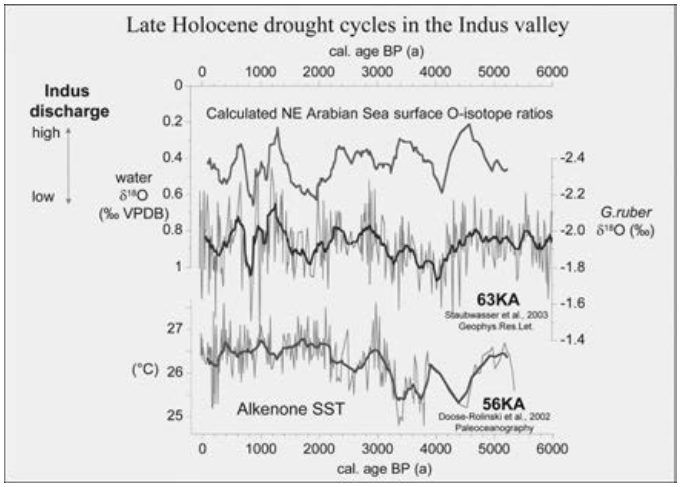

Figure 1: calculated $\delta^{18}O$ of NE Arabian Sea surface water from published data ($\delta^{18}O$ of Globigerinoides Ruber; sea surface temperature from Alkenone measurements).

Steinberger, Lincoln

Recent human interaction with environment in a tropical rainforest mosaic, North Queensland, Australia

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2. Department of Archaeology and Natural History, College of Asia and the Pacific, Australian National University, Canberra, ACT, Australia
3. Archaeology Program, La Trobe University, Melbourne, VIC, Australia

Palaeoecological research has demonstrated the climatically-driven early Holocene expansion of rainforest across the wet tropics region of North Queensland, Australia. Subsequent mid- to late Holocene climatic variability, specifically the intensification of the ENSO system after 5000BP, seems to have made these dense and restrictive rainforest environments more favourable for human occupation. Archaeological evidence indicates low level occupation of rainforests from around 8000BP, with an intensified and unique rainforest Aboriginal culture developing from 2000BP, perhaps in response to the greater climatic variability of the late Holocene. Human occupation of the rainforest environment included a degree of environmental modification: historical evidence suggests that Aboriginal life was anchored to numerous 'open pockets' of grassland or eucalypt woodland within the rainforest matrix. A network of cleared walking tracks throughout the dense vegetation connected these sites to each other, as well as to the coastal lowlands to the east and dry sclerophyll woodlands to the west. The origin of the open pockets is unclear, as is their persistence within a landscape more suited to the dominant rainforest vegetation. The human influence on these pockets, particularly through the use of fire, is a focus of current investigation into the human interaction with rainforest environments in North Queensland. Here we present preliminary results from palaeoecological and archaeological investigation of several of these 'open pocket' sites of the Atherton Tablelands region of North Queensland.

Thurston, Tina L.

The Political Ecology of Iron Age, Medieval and Early Modern Ulster, Northern Ireland

Thurston, Tina L.[1]

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The interdisciplinary, NSF-funded project 'Environment as Agent and Actor in Iron Age, Medieval, and Early Modern Ulster' integrates study of long-term climate change with the record of changing human organization and livelihood during the last two millennia in the former polity of Ulster, now modern Northern Ireland. The Iron Age "Ulster Cycle"

sagas and later texts describe successive waves of intrusion between the 5th-17th c.: Christianization, Viking colonization, Anglo-Norman invasion, and the English Plantation. Each successive regime, as well as local rulers, had different economic and political goals. Successive climate shifts ran parallel to many regime changes, and environment was a substrate for political development: chiefdoms, kingdoms, and empires instrumentalized natural conditions to coalesce, guide policy, and govern, but also to falter, fragment, and reorganize in dissolution/resilience cycles. Climate change often left socioeconomic systems obsolete and propelled change in every sector, also affording protection from or vulnerability to expansionist powers. While the elite-ecological interface is studied, our primary goal is revealing how ordinary communities navigated rising taxation while dealing with climate/environmental change by altering practices and implementing new ideas. While past research relied too much on a distorted record of historic events, archaeological work suffers from the near-zero visibility of a pasture landscape, rendering sites invisible and ordinary prospection impossible. Shifting or persistent regional settlement landscapes often form the best basis for theorizing economic and sociopolitical change, but only a small, scattershot sample of 'visible' aboveground elite compounds and castles are typically studied; extrapolated models and interpretations are thus spurious. The project uses geochemical, remote sensing, and paleoecological methods to resolve zero-visibility issues. In cooperation with Queen's University-Belfast's School of Geography, Archaeology, and Paleoecology, we examine two 20 km2 blocks in Armagh and Tyrone, where socioecological sequences can be well-monitored. In 2008-9, ground-based geochemical survey of ca. 2 km2 was conducted to serve as ground-truthing for a planned airborne hyperspectral mission, as well as IFSAR remote sensing, palynology and macrobotanical analysis to establish conditions surrounding studied communities, complimenting broader extant proxy data and historical phenological observations. Sites were discovered, tested, and AMS dated from which settlement, subsistence, and population dynamics will be deduced. The socioecological landscape is a proxy for and impress of cultural processes, through which we resolve longstanding biases to reveal ordinary livelihoods through time. Climate scholars argue that resolution of current global problems lies partly in comparative study with past responses to environmental turbulence. Governments cannot legislate all behavioral and attitude changes; ordinary people play crucial roles in coping with changing milieus. We emphasize interplay between political efforts and people's practical management of change - interdependence between 'rulers' and 'ruled', especially under conditions relevant to the persistent problems of contemporary postcolonial societies.

Ulm, Sean

Naïve Island Landscapes: People and Environmental Change in the South Wellesley Archipelago, Gulf of Carpentaria, Australia

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When humans enter new landscapes they profoundly change the natural order. These impacts are particularly marked on previously uninhabited islands. It follows that the arrival of people in Australia, the world's largest island, would have inevitably altered the environment. Yet there has been a surprising absence of systematic research aimed at identifying and measuring the impacts of human arrivals on the Australian environment. Obtaining a detailed understanding of the fundamental controls (i.e. human or climatic) on ecosystem processes in relatively spatially and environmentally restricted island environments around the Australian continent provides a basis for approaching the analysis of more complex ecosystems that occur on continents. Here we present preliminary results from the rich archaeological and palaeoenvironmental records of the Wellesley Archipelago in the southern Gulf of Carpentaria to produce integrated models of human-environment interaction over the last 10,000 years. Like other islands across northern Australia, the Wellesley Islands were unoccupied prior to about 4,000 years ago. Three sets of environmental changes affected these islands during the Holocene: (1) rapid eustatic sea-levels rise during the early Holocene with rates of coastal recession in the order of hundreds of metres per year on the gently sloping Gulf of Carpentaria shelf; (2) marked sea-level regression in the last few thousand years due to hydro-isostatic loading of the outer shelf and consequent uplift on the inner margin; and (3) the movement from a relatively stable early Holocene climatic phase to a highly variable El Nino-dominated climate after about 5 ka. Here we investigate the relative roles of coastal dynamics, climate change and culture in the late occupation and mode of use of islands in the archipelago.

VanLaningham, Sam

Holocene Indus River Pathways Inferred from Nd Isotopes and the relationship between the Fluvial Landscape and the Harappans

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Abandoned river channels in the Indus floodplain seen from remote sensing imagery are associated with the most dense cluster of ancient Harappan Civilization sites. This spatial linkage suggests the Bronze Age civilization lived on the banks of a substantial river system that once flowed parallel and to the east of the present-day Indus River. This postulated river fits the description of the mythical Saraswati River mentioned in the Hindu Rig Veda text, although the location of Saraswati remains contentious. It is also not known why the Harappan civilization vanished from the Indus Valley ~4 ka. Thus our research group seeks to determine if the now failed drainages in the Indus floodplain were active at the time of the Harappan occupation and whether drainage reorganization or climate changes led to the Harappan demise. This work specifically addresses what the sources of sediment to the abandoned river were using bulk sediment Nd isotopes (εNd), which are excellent Himalayan source tracers. Preliminary data from the Marrot core site (29.21°N, 72.34°E) indicate that sediments from the abandoned river were initially derived from the Lesser Himalayas (possibly via a larger Sutlej River system) between 10 ka and 5 ka (εNd = -16). Neodymium isotopic composition shifted to less negative εNd values some time between 5 ka and 3 ka (εNd = -13), suggesting reduced input from the Lesser Himalayas or increased input from Greater Himalaya/Kohistan Arc sources. Dune sands with εNd = -11 are also another possible source of less negative fluvial εNd values (zircon U-Pb data support this). Because the change in Nd isotopes is small (but detectable), it suggests drainage capture is an unlikely culprit.These data are more consistent with the hypothesis that reduction in the Asian Monsoon led to a decrease in river discharge (and erosion of the Lesser Himalayas). Incorporation of dune sands is also consistent with aridification and reduced riverine flow in the eastern side of the Indus basin. Thus, the Harappans may have abandoned the lower Indus floodplain for other areas closer to water sources, consistent with previous archaeological findings. Overall, more detailed analyses using Nd isotopes will provide important constraints on the role of monsoon change vs. drainage reorganization and the Harappan exit from the Indus floodplain.

Vanwalleghem, Tom

Interpreting climatic and anthropogenic effects on soils and sediments: coupling soil formation and soil erosion

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The development of landscapes and soilscapes is conditioned by the spatial and temporal interaction between soil erosion and soil formation. While soil formation rates are mainly controlled by climate, soil erosion rates depend both of climatic and anthropogenic factors. The balance between both will control agricultural sustainability. While this is well-known, it remains hard to make long term predictions on agricultural sustainability. Apart from difficulties with respect to correctly assessing erosion and soil formation rates, most standard models used for long-term landscape evolution do not consider variation of the soil parameters. On the other hand, soil erosion and deposition patterns will control the development and characteristics of soil profiles. This complex interaction limits the use of soils and sediment archives to draw conclusions on past environmental changes. To fully understand the interaction between soil profile formation and landscape evolution, and herewith contribute to their interpretation for reconstructing past environmental changes, there is an urgent need for integrated modelling of both processes. A framework is presented here. Based on a mass-balance approach, a model with 4 layers was developed. The model incorporates the main soil formation processes, like physical and chemical weathering, neoformation, translocation of clays and bioturbation. Soil erosion and redistribution is modelled through a cellular automata approach, with feedbacks for vegetations growth and rock cover. The model is applied to scenarios with different combinations of erosion intensity and soil formation intensity. The results illustrate the complex interactions between both and show how sediment export not only depends on climatic or anthropogenic drivers that control erosion rates, but also from the state of the soils. In areas where soils have been depleted, the sediment archive can show decreases in soil erosion rates which do not correspond to real changes in population pressure or climate. Figure 1 shows contrasting sediment export from two scenarios: (a) moderate soil erosion rate and (b) high soil erosion rate. The top graph shows cumulative sediment export per size class and the bottom graph shows yearly rates.

Veres, Daniel

A Six Thousand Year Geochemical Record of Atmospheric Metal Deposition in an Ice Core from Scarisoara Cave, Apuseni Mountains, Romania

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Independent sedimentary records of air-borne metal pollution could provide a strong basis for understanding the development of mining and metallurgy through time. Although the mining region of Transylvania in western Romania represents one of the oldest and productive mining fields of Europe (especially gold), little is known about the extent of mining activities through time (excepting perhaps the widespread field evidence for ore exploitation during the rule of the Roman Empire). Here we present initial geochemical results from a detailed investigation of an ice-core section, approximately six thousand year old, from the ice block contained within Scarisoara Cave, in Apuseni Mountains, Romania. The concentration of metals (ie., Cu, Pb, As, Sb, Sn, Au, Te, Pd, Pt, Rh, Hg) that could be relevant for defining mining activities in the region were determined by ICP-MS techniques, at high resolution. The results indicate that the ice deposit from Scarisoara Cave archives a detailed record of elements representing atmospheric deposition of volatized metals, fly ashes and other particulates related to mining and smelting activities. These pollutants seem to have been derived mostly from the nearby mining fields of Metaliferi Mountains, where polymetallic ores with high contents of copper, gold, silver and lead are widespread. Lead isotope studies are on-going and the new data are expected to provide an accurate evaluation of metal ores and emission source regions, as well as clear insights into the developments of metallurgy in one of the oldest mining regions of Europe. The new data are likely to provide one of the first long records of anthropogenic pollution in Romania and Eastern Europe. Compared with archeological data, the new results could have immediate implications in better constraining the timing, magnitude and extent of mining activities and anthropogenic impact in the mining districts of Transylvania. This work is part of on-going efforts by our working group to explicitly document the anthropogenic impact and the long-term mining and metallurgical history of this region in a securely dated, multi-proxy approach.

Weiss, Harvey

Quantifying Collapse: Abrupt Climate Change, Regional Abandonments, Habitat-Tracking, and the Humean Counterfactual *(INVITED)*

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Abrupt climate changes, century-scale spikes of aridification and cooling, affected West Asia and the Mediterranean at almost millennial intervals: 8.2. 5.2, 4.2, and 3.2 ka BP. The 3.2 ka BP event apart, each abrupt climate change was global, with the visibility of social effects and adaptations a function of the availability and resolution of archaeological records. A multi-proxy paleoclimate stack for the Eastern Mediterranean and West Asia is presented (Figure 1). The 5.2-5.0 ka BP abrupt aridification and cooling event affected the consolidation and collapse of the earliest state-level complex societies in Mesopotamia and Egypt. The 3.2 - 2.9 ka BP abrupt aridification disrupted Mediterranean and Mesopotamian dry-farming and engendered the collapse of the ancient East Mediterranean world. The 4.2-3.9 ka BP abrupt climate change initiated the 300-year drought that generated societal collapses across East and West Asia and the Mediterranean. These included the collapse of the Akkadian Empire and the Old Kingdom, region-wide abandonments and nomadization, and habitat-tracking to riparian, paludal and karstic-spring refugia. High-precision dating and regional settlement surveys permit quantification of the collapse, abandonment, habitat-tracking, and resettlement processes. Moreover, alongside the new paleoclimate proxy records, they illuminate the counterfactual linkage between Holocene abrupt climate changes and adaptive societal collapses: "If C had not occurred, E would not have occurred." Holocene paleoclimatology thereby revises the causal and adaptationist paradigms of anthropological archaeology.

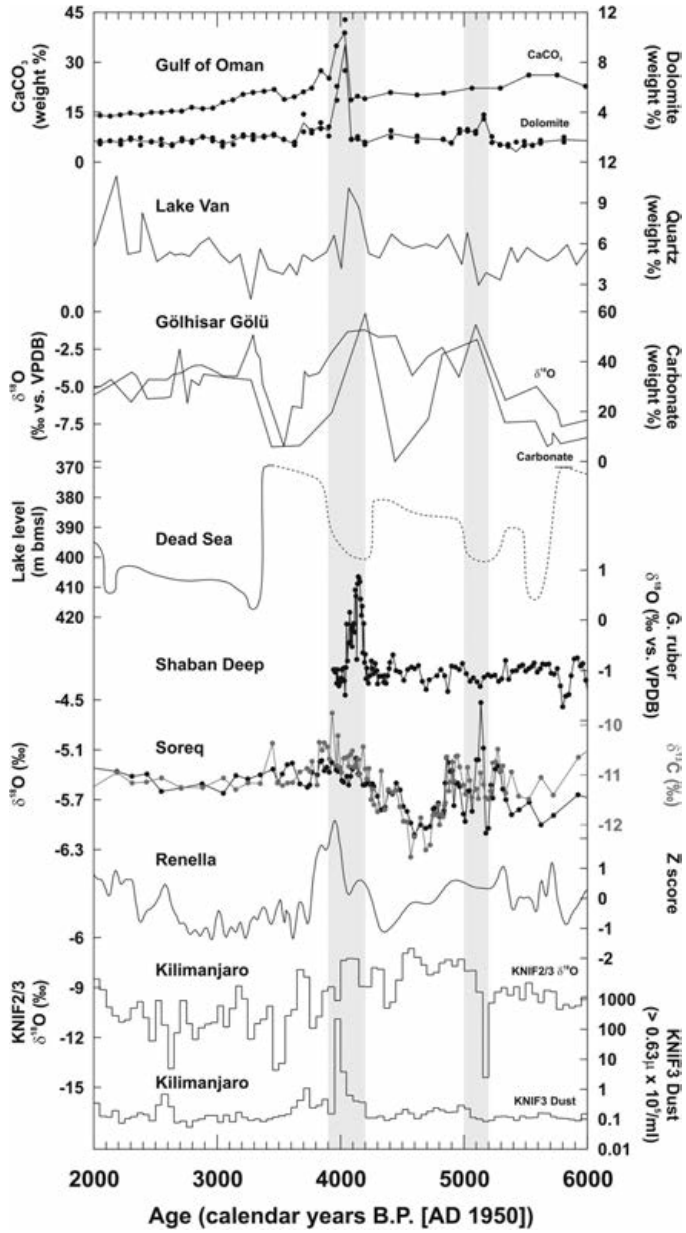

Figure 1. Multi-proxy paleoclimate stack, 5.2, 4.2 and 3.2 ka BP abrupt climate change events, Mediterranean westerlies and Kilimanjaro (H. Weiss and M. Besonen 2009).

Wright, Rita P.

Human Geography and the Impact of Climate Change in the Upper Indus Valley: Convergent Data from Stable Isotopes, CORONA Imagery, and the Paleobotanical Record

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New evidence from a regional study of settlements on the Beas River, a now dry riverbed near the major Indus center of Harappa, complements our earlier publications on climate change and the human ecology of Late Holocene environmental dynamics. These new data include stable isotope analyses, Corona declassified imagery, land use/soil maps, and agricultural cropping patterns. In our earlier publications, we linked global and local climatic cycles of the late third, early second millennia BC, to a period of settlement decline and even abandonment. While global proxy data for the region remain inconsistent with respect to the timing of early and later Holocene conditions and show monsoon weakening at 3500 BC and some differences in early and late Holocene conditions, other indicators that include pollen studies from lakes in northwestern India and relative thicknesses of turbidite varves from coastal cores argue for enhanced winter precipitation during the Indus period with a spike in the record at 2000-1750 cal BC. Initial correlations between settlement geography and climatic signals were based upon deep testing and radiometric dating calibrated to soil formation chronologies, depositional histories of the Beas floodplains and terraces, and the cultural sequences of the Indus mounds. These integrated sequences were then tied to a baseline climatic model (Wright et al, 2008) that considered regional circulation systems and localized variability at gauging stations in the vicinity of the primary sites. These data underscored a trend to relatively stable and moister climates at the onset of settlement in the region, accelerations of channel migration and realignments of the Beas during the peak period of urbanization, and drastic realignments in precipitation and river discharge in the later stages of the civilization. Threshold transitions in the precipitation balance caused disruptions of the drainage net and hydrography that would have produced destabilization of landscapes tied to relocation of populations and abandonments of previously sustained settlements. In this study we consolidate the results of additional methodologies to test the settlement/environmental interpretations that were initially generated by first run field work, sequence chronologies, geomorphic analysis and climatic models. New data sets include higher resolution of relict channel configurations

(observable on Corona declassified imagery and land use/soil maps), shifts in C4 to C3 stable isotope ratios attesting to transitions in vegetation covers (consistent with the passage from semi-arid to arid climatic phases), and paleobotanical successions based on cropping patterns edfsdfand proportions of summer and winter crops. Convergent global and local trends in the data sets bolster arguments for the impacts of climatic dynamics in the realignment of settlements in the Indus civilization during later stages of occupation and the importance of modeling the complexity of climate change, adaptive systems and human responses.

Zackova, Pavla

MACROFOSSIL EVIDENCE OF HUMAN IMPACT ON VEGETATION DURING THE LATE GLACIAL-HOLOCENE FROM EXTINCT LAKE ŠVARCENBERK, SOUTHERN BOHEMIA, CZECH REPUBLIC

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The results presented here are mainly based on the analyses of plant macrofossils collected from sediments of the extinct Lake Svarcenberk. This work is a part of the multi-proxy project on the Late Glacial and Early Holocene environmental history of the cultural landscape, which consider co-evolution of human impacts and natural processes. The first organic deposits began to form during Late-Pleniglacial (ca 16 ka). Macrofossils record consist mainly of oospores of Chara spp. (include Chara strigosa – an indicator of oligothrophic cold water). Salix wood, Potamogeton gramineus fruits were also recorded. The pollen spectra give the evidence of treeless vegetation with an aqatic and wetland species (Myriophyllum verticilatum-type, Potamogeton-type, Sparganium) (POKORNÝ 2002). During the Late Glacial Interstadial (ca 13 ka) organic production increased. Macroscopic remains of oligothrophic macrophytic vegetation (oospores of Charophyta, seeds of Batrachium sp., Potamogeton cf. gramineus) are recognized. The other plant remains suggest reed and tall-sedge beds vegetation (Carex rostrata/vesicaria, Carex cf. diandra, Typha angustifolia/latifolia, Menyanthes trifoliata) in the littoral zone of the lake. Subsequently, decline of plant macrofossils and occurrence of cold water species (Potamogeton praelongus, P. perfoliatus) give an evidence of climatic deterioration. It may correspond to the Younger Dryas. Beginning of the Holocene is well detected by the rapid development of macrophytic vegetation (Batrachium sp., Najas marina, N. minor, Nuphar pumila, Myriophyllum spicatum, Potamogenton filiformis, P. alpinus). The presence of some palatable terrestrial plants macrofossils (Rubus saxatilis, R. idaeus, Trapa natans) may indicate that the Mesolithic settlement existed around this lake. This is also supported by the occurrence of some anthropogenic pollen indicators (Calluna vulgaris, Plantago lanceolata, Cannabis/Humulus-type, Pteridium aquilinum, Corylus avellana) and by the evidence of enhanced influx of charcoal particles (KUNEŠ ET AL. 2008), which also suggests probably use of fire in land clearance. Archaeological excavation give the evidence of chestnut (Trapa natans), hazel (Corylus avellana) and pine wood artifacts (shaft fragment) in around 9500±50 BP. Presence of these taxa support the presumption of introduction by man. During the middle of the Holocene (ca 4 ka) organic production increased rapidly. Recorded macro-remains of Carex echinata, Menyanthes trifoliata indicate that the lake turn a peat bog. Presence of other plant remains, Alnus glutinosa, Frangula alnus, Carex acutiformis, suggest that area was surrounded by Alder Carr. References: KUNEŠ P., POKORNÝ P., ŠÍDA P., 2008: Detection of the impact of early Holocene hunter-gatherers on vegetation in the Czech Republic, using multivariate analysis of pollen data. Vegetation history and Archaeobotany 17:269-287 POKORNÝ P., 2002: A high-resolution record of Late-Glacial and Early-Holocene climatic and environmental change in the Czech Republic. Quaternary International 91:101-122