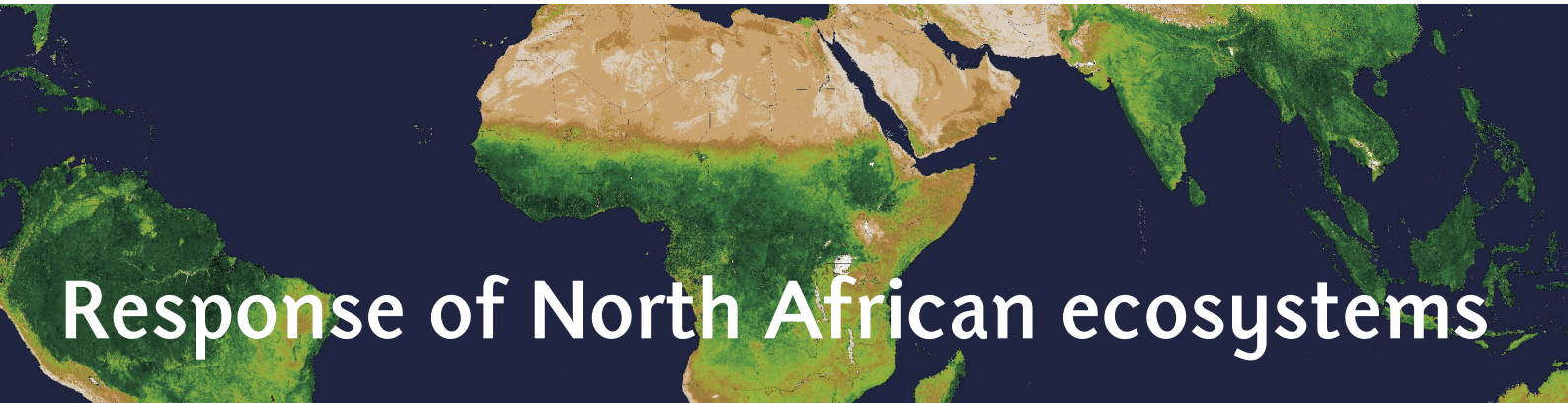


Response of North African ecosystems

to abrupt climate change

13 - 16 November 2007

MARUM - Center for Marine Environmental Sciences

University of Bremen

Bremen

Germany

(funded by a DFG-MARUM unforeseen grant)

Program

Welcome in Bremen !!!

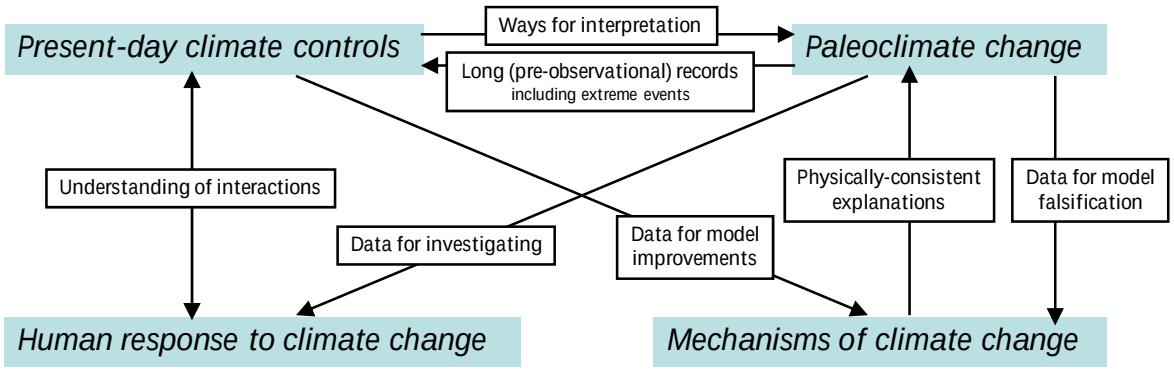
Dear workshop participant,

We would like to welcome you to Bremen, and especially to this workshop that brings together leading international scientists in African palaeoclimate reconstruction, from the marine and terrestrial realms, archaeology, palaeoclimate modelling as well as experts in atmospheric sciences. The workshop aims to explore the role of Africa in global climate change throughout the geological past, the present and the future. Consequences for marine and terrestrial ecosystems will be illuminated.

The workshop is structured into four working groups that can be represented as follows:

Some possible interactions between the working groups

(arrows mean “provides…”)



We look forward to this workshop and hosting you in Bremen!

The organizers,

Jan-Berend Stuut (jbstuut@marum.de)
Stefan Mulitza (smulitza@uni-bremen.de)
Matthias Prange (mprange@palmod.uni-bremen.de)

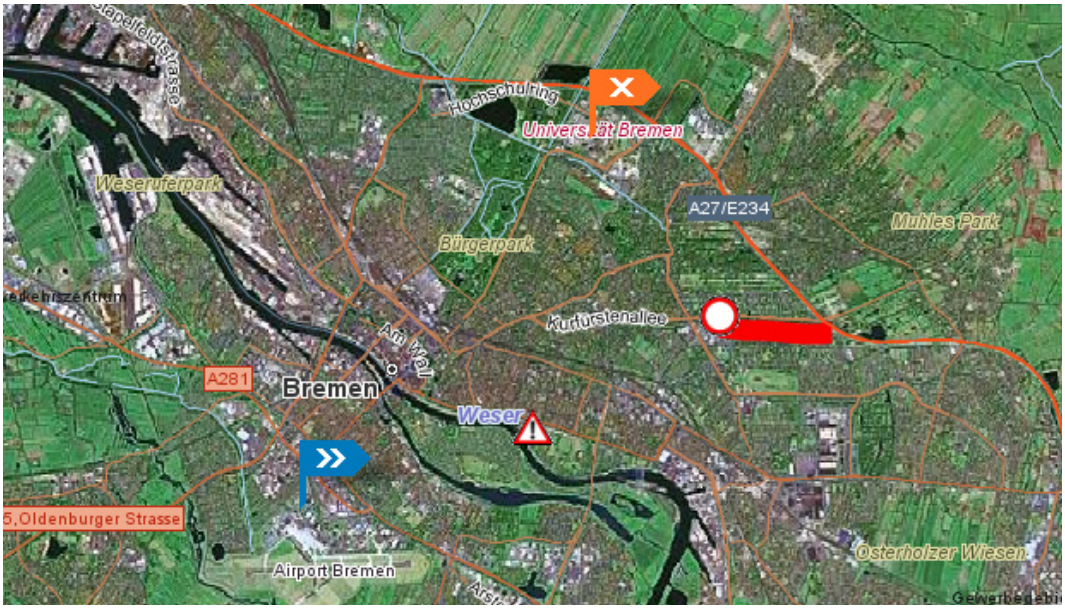
In this program book you will find some additional tips to find your way around in the city of Bremen, at the campus of the University of Bremen, and in the MARUM – Center for Marine Environmental Sciences.

Index:

During the workshop you can access the internet through the MARUM WLAN, using the *username:* xxxxxxxxx

and *password:* xxxxxxxxx

Map of Bremen:



The workshop will take place on the second floor of MARUM, which is located on the campus of the University of Bremen, in the Leobener Straße (see map on page 5). Here we will also have our (coffee) breaks, as well as dinners on Wednesday and Thursday. There are several possibilities to have lunch at the campus, like e.g., the Mensa and several restaurants around it.

The bad news is: the Campus of the University of Bremen is exactly on the other side of the city from the airport...

The good news is: there is a direct tram connection between campus and airport through line 6 (see time schedule on next page). The tram stop is directly opposite the airport’s exit. See map of the campus on page 5 for a closer look at where to find the MARUM building. Easiest would to get off at the second-last stop at the campus called “Zentralbereich”.

This ride will take you through the center of the city, pass also through central station, and takes about half an hour. Buy your tickets at the tram driver’s (~2.10 Euro)

Any taxi will of course also take you to the campus (~25 Euro).

The MARUM building is within walking distance from both the Atlantic and Munte hotels (see map on next page).

Useful phone numbers:

Hotel Atlantic	+49 (0) 421 – 246 70
Munte Hotel	+49 (0) 421 – 220 20
Jan-Berend Stuut	xxxxxxxx
Stefan Mulitza	xxxxxxxx

Time schedule of tram line 6 from the airport to the campus:

6 Bahn

Abfahrt ab Flughafen
über Theater am Leibnizplatz
Domsheide
Hauptbahnhof (Main Station)
Riensberg
Richtung Universität/ Klagenfurter Str.

Gültig vom 13.10.2007 bis 07.03.2008

BSAG Infotelefon VBN 01805 - 826 826

Uhr	Montag bis Freitag											Samstag						Sonn- und Feiertag				Uhr
4	55											48$_d$										4
5	10	25	40	55								08$_d$	28$_d$	48$_d$				08				5
6	08	18	28	38	A3	48	58					08$_d$	28$_d$	48$_d$				12$_d$	42$_d$			6
7	08	13^K	18	23	28	33	38	A3	48	53	58	08	28	48				12$_d$	24	42		7
8	03	08	13	18	23	28	33^K	38	A3	48	53	08	28	48	58			12	42			8
	58																					
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11	08	18	28	38	48	58						08	18	28	38	48	58	08	28	48		11
12	08	18	28	38	48	58						08	18	28	38	48	58	08	28	48		12
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22	08	28	44									08	28	44				08	28	44		22
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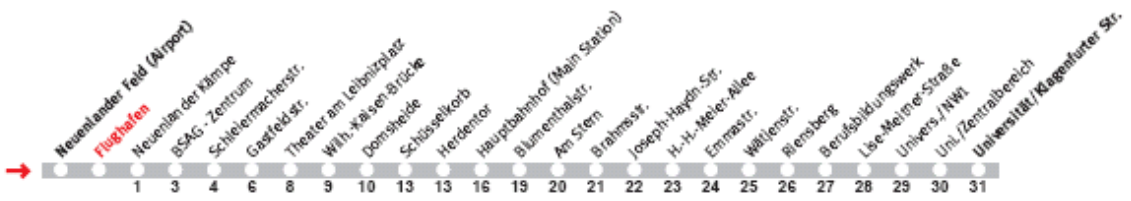
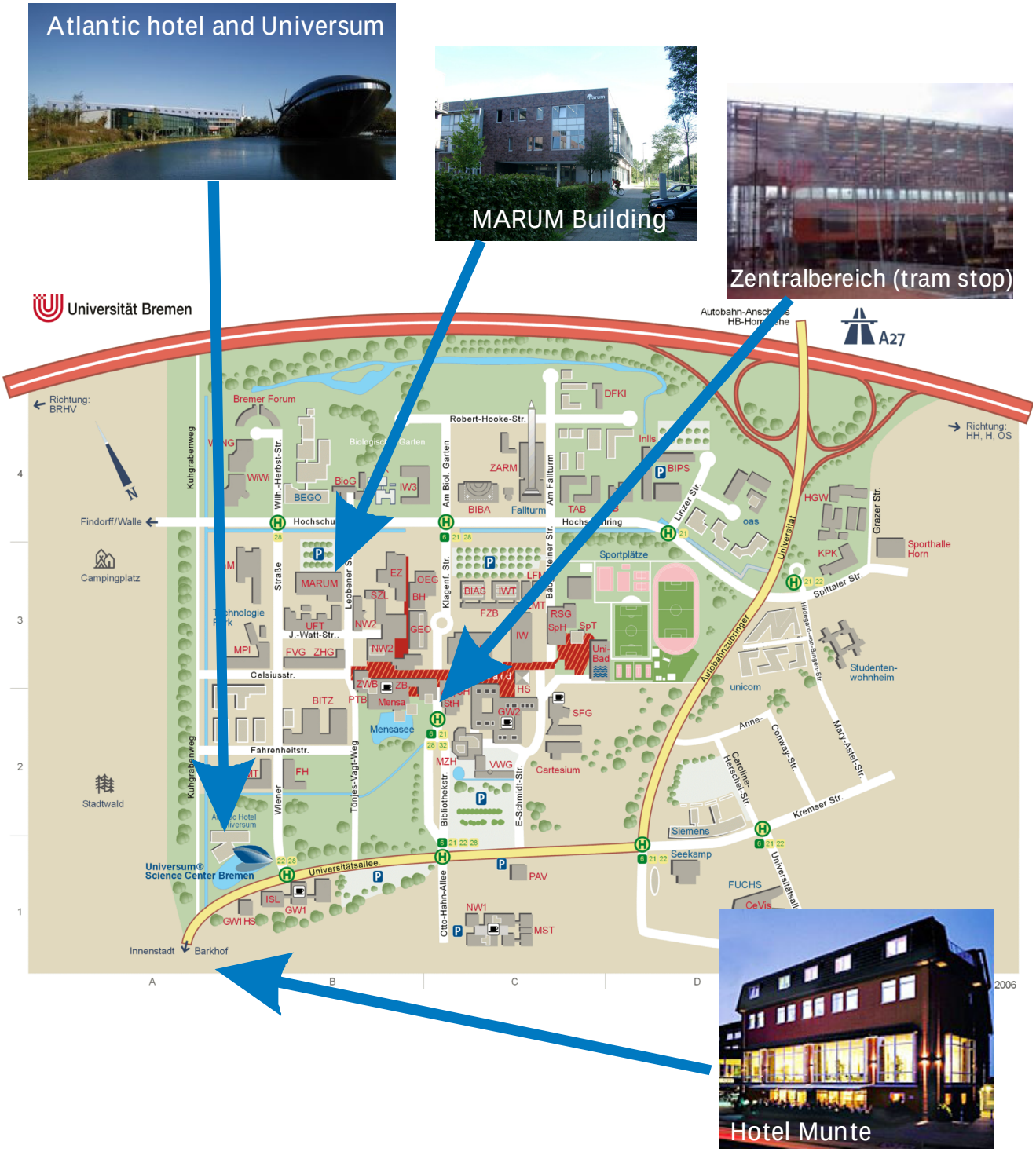
= Freitag
= Fahrt in der Zeit vom 15.10.2007 bis 21.12.2007 und vom 07.01.2008 bis 08.02.2008
= Fahrt in der zeit vom 15.10.2007 bis 07.03.2008
K = Kein Niederflurfahrzeug

a = Montag-Donnerstag
= bis BSAG -Zentrum
= bis Domsheide

b = bis Hauptbahnhof (Main Station)
c = bis Hbf /weiter wie Linie 1 bis Geschäftsstelle Neue Vahr
d = bis Riensberg



Simplified map of the University Campus:



Workshop program:

Tuesday 13 November 2007

All day		Arrival of participants
19.30 -		Ice-breaker in MARUM

Wednesday 14 November 2007

9.00 – 9.15	Welcome and introduction to the workshop	

Theme 1: Present-day climate controls and weather systems

9.15 - 9.35	Sharon Nicholson	The myths and realities about North African climate: a new look at present controls....
9.35 - 9.55	Kerry Cook	Dynamics of the West African Monsoon: Present Day, African Humid Period, & Abrupt Transition
9.55 - 10.15	Peter Knippertz	Meteorological conditions for dust mobilization in the Sahara
10.15 - 10.45	Coffee break	
10.45 - 11.05	Andrea Sealy	The impact of dynamic vegetation on desert dust and Sahel precipitation
11.05 - 11.25	Jost Heintzenberg	Effect of Saharan dust on the energy balance, weather & climate
11.25 - 11.45	Andreas Fink	Analyses of present-day high-impact weather events associated with the West African monsoon
11.45 - 12.30	Discussion	
12.30 - 14.00	Lunch break	

Theme 2: Paleoclimate change (terrestrial & marine evidence)

14.00 - 14.20	Henry Lamb	Pleistocene desiccation of Lake Tana, source of the Blue Nile
14.20 - 14.40	Lydie Dupont	Over 30 000 years of vegetation development and climate change in Angola
14.40 - 15.00	Tom Johnson	Megadroughts and D-O Events in the African tropics during the past 150 kyrs (Lake Malawi)
15.00 - 15.20	Dirk Verschuren	Climate change on the East African equator: tropical & high-latitude climate forcing
15.20 - 15.50	Coffee break	
15.50 - 16.10	John Peck	Lake Bosumtwi (Ghana) sedimentary records of environmental change
16.10 - 16.30	Raphaël Sarr	Sea-level and climatic changes evidenced by microfaunas in Retba Lake (Senegal)
16.30 - 16.50	Gerhard Schmiedl	Paleoclimate reconstructions from eastern Mediterranean sediment cores
16.50 - 17.10	Helge Arz	Glacial and Holocene climate variability at the northeastern rim of Africa: the northern Red Sea
17.10 – 17.30	Short break	
17.30 - 18.15	Discussion	
18.15 - 19.00	Short presentations	Chris Scholz, Katharina Neumann, Isla Castañeda, Holger Kuhlmann
19.00 -	Dinner at MARUM	

Thursday 15 November

Theme 3: Human response to climate change

9.00 - 9.20	Stefan Kröpelin	Latitude-dependent human response to Holocene climate change in NE Africa
9.20 - 9.40	Peter Breunig	Late Holocene cultural change in West Africa
9.40 - 10.00	Katharina Neumann	The third millennium BP Central African rainforest crisis and the Bantu question
10.00 - 10.30	Coffee break	
10.30 - 10.50	Cullen Hendrix	The smoking gun? Climate change, interannual resource variability and conflict in Africa
10.50 - 11.10	Heiko Paeth	Climate models and regional climate change in Africa - implications for food security & health
11.10 - 12.00	Discussion	
12.00 - 13.30	Lunch Break	
13.30 - 15.00	Short presentations	Julien Michel, Roberto Pierau, Syee Weldeab, Jean Nizou, Stefan Mulitza, Matthias Prange, Ute Merkel
15.00 - 15.30	Coffee break	

Theme 4: Mechanisms of climate change in Africa

15.30 - 15.50	Bette Otto-Bliesner	PMIP2 coupled simulations of the Mid-Holocene and Last Glacial Maximum West African climate
15.50 - 16.10	Victor Brovkin	Interactions between local and large-scale feedbacks in North Africa
16.10 - 16.30	Martin Claussen	Climate and vegetation change in North Africa –interpretation by climate system models
16.30 - 16.50	Zheng-Yu Liu	Simulating the transient evolution of northern Africa climate-ecosystem in the Holocene....
16.50 – 17.20	Break	
17.20 - 18.15	Discussion	
18.15 - 19.00	Break	
19.00 -	Dinner at MARUM	

Friday 16 November

9.00 - 10.30	Discussion in working groups I
10.30 - 11.00	Coffee break
11.00 - 12.30	Discussion in working groups II, and writing down of recommendations
12.30 - 14.00	Lunch break
14.00 - 16.00	Presentation working groups & discussion, wrap up & closure

List of invited talks:

(Wednesday 16.^{50} – 17.^{10})

Glacial and Holocene climate variability at the northeastern rim of Africa: the northern Red Sea

Helge Arz
GFZ Potsdam, Germany

Abstract

As a desert-surrounded, semi-enclosed marine environment, the northern Red Sea suffered extreme oceanographic changes in the past resulting in an amplification of paleoclimate signals in the marine records. Since paleoenvironmental data from this region are still rare, high-resolution Gulf of Aqaba and Red Sea paleorecords provide an important link to, e.g., climate reconstructions from northeast Africa, the Eastern Mediterranean, and the Arabian Desert region.

Taking the advantage of very different depositional systems within the Gulf of Aqaba and the northern Red Sea - from proximal terrigenous to distal oligotrophic sedimentation, from well oxygenated to anoxic environments - we draw on proxy data for past surface ocean properties and continental climate from several high resolution sediment cores from the region (cores GeoB 5804-4, GeoB 5810-2 from the northernmost part of the Gulf of Aqaba and cores GeoB 5836-2, GeoB 7804-3, and GeoB 5844-2 from the northern Red Sea).

Methods such as stable oxygen isotope measurements on tests of planktic and benthic foraminifera and of pteropod shells, alkenone paleotemperature estimates, grain size determination of the terrigenous sediment fraction, and semi-quantitative x-ray fluorescence logging have been applied in a very high temporal resolution to the sediment cores.

Proxy data suggest a distinct freshening of the surface ocean between ~9.8 and 6.25 thousand years ago. Terrigenous sediment composition and its supply rate to the Gulf of Aqaba changed dramatically at the end of this early to mid Holocene low-salinity period, which is reflected by a strong decrease in sedimentation rates and clay content as well as a shift in the dominant mode of sediment transport pointing to a significant increase in regional aridity. Furthermore, several multicentennial-scale variations can be observed in both the marine and continental proxies. A correspondence of the records with e.g. North Atlantic proxy record of changes in drift ice and 14C tree ring data suggest a broad teleconnective response to Holocene variations in solar output probably involving long-term changes in AO/NAO-like anomaly pattern throughout the Holocene.

One very special paleoclimate archive in the northern Red Sea is the anoxic sediment from the brine-filled Shaban Deep. Sediments retrieved from this basin are partly laminated. The laminated interval between 6400 and 4200 years BP documents multidecadal to centennial

variations in the carbonaceous (coccoliths) versus siliceous (diatoms) sedimentation and generally lines up with variations in solar activity. At 4.2 ka the lamination in the sediment disappears probably relating to a major “evaporation event” causing enhanced deep-water formation and ventilation of the small basin. The timing and strengths of the environmental changes ~4.2 ka, suggests that this event is the regional expression of the major drought event at 4.2 ka BP, which is widely observed in the neighbouring regions, and that strongly affected Middle East agricultural civilisations.

Proxy records from the northern Red Sea reaching further back into the last glacial period record and amplify well known millennial-scale climate events from the North Atlantic realm implying a strong atmospheric teleconnection to the North Atlantic Climate. Due to the restricted exchange with the Indian Ocean, the Red Sea environment is, however particularly sensitive to changes in global sea level. This, in conjunction with our high resolution proxy records from the northern Red Sea contributes to the general discussion on causes and consequences of glacial millennial-scale climate fluctuations.

(Thursday 9.[20] – 9.[40])

Late Holocene cultural change in West Africa

Peter Breunig
J.W.Goethe-Universität, Frankfurt am Main, Germany

Abstract

This paper is focussed on cultural developments of the last two millennia BC with particular reference to the Nigerian situation. Archaeological research revealed three abrupt changes in the cultural development, which might have had a climatic background. The first change is stimulated by the desiccation of the Sahara from about 2000 BC onwards. Pastoral communities were pushed out from the southern Sahara into less arid environments further south, commencing a period of flourishing agropastoral occupation. Another change concerns the collapse of this occupation in the early 1st millennium BC. The most significant change took place a few centuries later around the middle of the 1st millennium BC. Its most conspicuous attributes are an increase of the population density and a productive economy.

(Thursday 15.^{50} – 16.^{10})

Interactions between local and large-scale feedbacks in North Africa

Victor Brovkin

Potsdam Institute for Climate Impact Research, Germany

Abstract

Analysis of climate-vegetation interaction in North Africa is mostly carried out with atmosphere-ocean models coupled to dynamic global vegetation models (DGVMs) which simulate large-scale changes of vegetation cover in response to climate. However, DGVMs do not explicitly include small-scale feedbacks between vegetation, resources and landscape heterogeneity in ecosystems. Such small-scale feedbacks may lead to self-organized landscape structures and resource optimization in ecosystems (von Hardenberg et al. 2001, Rietkerk et al. 2004). For example, local scale feedback between vegetation and rainwater infiltration into the soil can support different large-scale regimes: a vegetated and desert regime, independent of vegetation feedback to atmospheric circulation. At the same time, another local feedback between leaf economy traits and nutrients availability enhances nutrients recycling in drylands providing stabilizing effect on vegetation cover. Accounting for small-scale feedbacks may significantly alter dynamics of coupled atmosphere-biosphere systems and lead to earlier/later shifts between vegetated and desert regimes on multiple scales (Scheffer et al. 2005). Potential significance of local scale interactions calls for their inclusion, even in simplistic form, into coupled climate-vegetation models.

References

von Hardenberg J, Meron E, Shachak M, Zarmi Y (2001) Diversity of vegetation patterns and desertification. Physical Review Letters, 8719, doi: 10.1103/PhysRevLett.87.198101.

Rietkerk M, Dekker SC, de Ruiter PC, van de Koppel J (2004) Self-organized patchiness and catastrophic shifts in ecosystems. Science, 305, 1926–1929.

Scheffer M, Holmgren M, Brovkin V, Claussen M (2005) Synergy between small- and large-scale feedbacks of vegetation on the water cycle. Global Change Biology, 11, 1003–1012.

(Thursday 16.[10] – 16.[30])

Climate and vegetation change in North Africa – interpretation by climate system models

Martin Claussen

Meteorological Institute & Max Planck Institute for Meteorology, Hamburg, Germany

Abstract

In this presentation, climate system modelling of North African climate and vegetation will be reviewed and open questions will be addressed.During the past decade, it has been shown that Charney's desert-albedo feedback, which might not be valid for the Sahelian because of moderate changes in albedo in this region, seems to work for Saharan dynamics. Obviously, long-term climate change in North Africa cannot be explained without considering biogeophysical feedback. However, models predict rather different patterns of mid-Holocene Saharan greening. In particular, it is not yet whether there was there an East-West gradient in humidity and vegetational coverage and what could have caused this gradient.

It has been hypothesized that biogeophysical feedback in North Africa seems to amplify the effect of climatic precession and, presumably, also the effect of anthropogenic CO2 emissions on North African summer monsoon. Work in progress suggests that climatic precession will be seen in North African climate and vegetation change even during the next 50 ky when changes in orbital parameters tend to be small.

Finally, it has been hypothesized that the (presumably) positive biogeophysical feedback could explain the fast expansion of the Sahara at the end of the North African humid period. In many models, the biogeophysical feedback exhibits complex dynamics including multiple steady states and bifurcations. But in detail, all models seem to differ. To resolve this question, independent palaeobotanic and palaeoclimatic estimates of Holocene changes in Saharan vegetation and rainfall are needed.

(Wednesday 9.^{35} – 9.^{55})

Dynamics of the West African Monsoon: Present Day, African Humid Period, and the Abrupt Transition

Kerry H. Cook

Cornell University, USA

Abstract

Atmospheric dynamics of the West African monsoon system is reviewed, including a discussion of the dynamical features that support today’s precipitation distribution over the Sahel. This system is compared with that of the African Humid Period (AHP), when monsoon rains reached north into the present day Sahara. Regional model simulations indicate that the flow across the Guinean coast was not very different from today during the AHP, and that much of the support for the strong AHP rainfall north of about 15°N is related to a weakening of the African easterly jet and a strengthening of the low-level westerly jet that brings moisture onto the continent from the Atlantic Ocean. Finally, the implications for abrupt climate change are discussed by exploring interactions between the strength of the African easterly jet and vegetation.

(Wednesday 14.^{20} – 14.^{40})

Over 30 000 years of vegetation development and climate change in Angola (Ocean Drilling Program Site 1078)

Lydie Dupont
MARUM, University of Bremen, Germany

Abstract

The distribution of pollen in marine sediments is used to record vegetation change on the continent. Generally, a good latitudinal correspondence exists between the distribution patterns of pollen in the marine surface sediments and the occurrence of the source plants on the adjacent continent.

A high-resolution, radiocarbon-dated sedimentary record from the tropical southeast Atlantic off the coast of Angola allows investigation of land–sea interactions. We compare proxies of continental conditions (pollen assemblages) with alkenone-derived sea surface temperatures. The pollen assemblages suggest considerable changes in the vegetation since 30 ka that can be related to changes in the strength and latitudinal position of the atmospheric and marine frontal systems, i.e. the Congolian Air Boundary and the Angola-Benguela Front.

After the cool and dry climate of the last glacial a change to more humid conditions started very early in Angola (~22 ka), which is much earlier than the rise in sea surface temperatures of the East Atlantic. The early amelioration might be related to the early warming on Antarctica. Between ~9 and 15 (around Heinrich Event 1), low sea surface temperatures indicate a northern position of the Angola-Benguela Front implying permanent upwelling along the coast and strong SE trade winds. Conditions were cool but probably not arid. During this early stage there is a different development in Angola than in the Congo Basin or in West Africa where the climate was cold and dry. After Heinrich Event 1, the climate in Angola became wetter and warmer and possibly even wetter than during most of the Holocene. In contrast to the situation in NW Africa no return to glacial conditions was found for the Younger Dryas period. The Holocene started with dry forest and Miombo woodlands expanding while rain forest elements retreated. After a disturbance around 8 ka *Podocarpus* forest dominated until ~4 ka. During this period, either Miombo woodland or wetter types of rain forest replaced open savannah vegetation. The savannahs returned and became increasingly important after ~4 ka and again after 2 ka, which roughly parallels the development in NW and central Africa. During the last 2 ka forest growth probably was patchy with many light-loving and fire hardy trees.

(Wednesday 11.^{25} – 11.^{45})

Analyses of present-day high-impact weather events associated with the West African Monsoon

Andreas H. Fink

Institute of Geophysics and Meteorology, University of Cologne, Germany

Abstract

Our understanding of atmospheric teleconnections governing the year-to-year and decadal rainfall variability in the West African Monsoon (WAM) regions have advanced substantially in the recent two decades. Primary forcing factors are anomalies in the surface heat content of the major tropical ocean basins: most importantly the Atlantic Ocean, then the Pacific and Indian Oceans in this order. Most recent work has demonstrated that warm sea-surface temperatures (SST) in the eastern Mediterranean Sea are at least as important as cold Pacific SSTs in favouring enhanced rainfall in the Sahel region. The role of the continental land surface characteristics in modifying the SST forcing is still controversial.

The link between remote and local natural, as well as anthropogenic forcing factors for the climatological rainfall in West Africa is established by statistical or complex modelling studies. The matrix of weather processes that transfer the multitude of simultaneous forcings to individual rainfall events, which are often high-impact weather events, remains, however, elusive. Thus, studies that investigate the types of rainfall in West Africa and their synoptic and dynamic evolution have to complement the above-mentioned teleconnection studies.

The present contribution will highlight some recent advancement in the understanding of the dynamic causes of selected high-impact weather events. Among them are organised convective systems, mostly *squall lines,* which contribute to about 80-90% of the rainfall in the Sahel. A small fraction of them develops into *tropical cyclones* over the eastern Atlantic. The latter are known as “Cape Verde” hurricanes and are the source of more than 2/3 of the major hurricanes that make landfall along the US coast. A third extreme weather type is associated with tropical-extratropical interactions that can cause extreme, simultaneous rainfall events north and south of the Sahara outside the wet monsoon season. It is speculated that the latter may also explain part of the centennial climate variability over northern Africa.

(Wednesday 11.^{05} – 11.^{25})

Effect of Saharan dust on the energy balance, weather & climate

Jost Heintzenberg

Leibniz-Institute for Tropospheric Research, Leipzig, Germany

Abstract

The presentation begins with an overview of the influence of dust on the energy balance of the Earth system including a discussion of recent results of the SAMUM experiment in Morocco 2006 in comparison to earlier data on the optical properties of mineral dust. Then examples from the SAMUM campaign will be given relating Saharan dust to the freezing of super-cooled clouds over Morocco. With an enlarged weather model the dynamic atmospheric feedbacks on dust production will be demonstrated with an episode of dust outbreak from North Africa to Europe. After discussing additional dust-climate-feedbacks present speculations on future dust and its influence on climate will conclude the lecture.

(Thursday 10.^{30} – 10.^{50})

The Smoking Gun? Climate Change, Interannual Resource Variability and Conflict in Africa

Cullen S. Hendrix, Sarah M. Glaser

University of California, San Diego, USA

Abstract:

The conventional discourse relating climate change to civil conflict focuses on long term trends in temperature and precipitation that define ecosystems and their subsequent impact on human access to renewable resources. Because these changes occur over long time periods, they may not capture the proximate factors that trigger conflict. We demonstrate this using data on civil conflict and rainfall variance from 41 countries in Sub-Saharan Africa. We further review the relevant literature on climate and conflict with a particular emphasis on identifying sources of environmental data that display relatively large interannual and intrannual variance, as these data are more likely to capture environmental "trigger mechanisms," which would help to predict the specific timing of conflict in countries otherwise characterized by a high baseline probability thereof.

(Wednesday 14.40 – 15.00)

Megadroughts and D-O Events in the African Tropics During the Past 150,000 Years: Results from the Lake Malawi Drilling Project

Thomas C. Johnson[1], Christopher A. Scholz[2], Andrew S. Cohen[3], John King[4], Erik Brown[1]

[1]Large Lakes Observatory and Department of Geological Sciences, University of Minnesota Duluth, USA
[2]Department of Earth Sciences, Syracuse University, USA
[3]Department of Geosciences, University of Arizona, USA
[4]Graduate School of Oceanography, University of Rhode Island, USA

Abstract

The tropics play a major role in global climate dynamics, and probably impact the subtropics of North Africa. We present a record of East African climate since 150 ka, based on two drill sites in Lake Malawi, East Africa (ca. 11° S, 35°E). Our record from the central basin shows periods of severe aridity between 135 and 75 thousand years (kyr) ago, when the lake's water volume was reduced by at least 95%. Surprisingly, these intervals of pronounced tropical African aridity in the early late-Pleistocene were much more severe than the Last Glacial Maximum (LGM). We observe a shift to more humid conditions over much of tropical Africa after 70 kyr ago, coincident with diminished orbital eccentricity, and a reduction in precession-dominated climatic extremes. Our 75,000-year record from the north basin of Lake Malawi indicates rapid shifts between discrete climate modes related to abrupt warming (D-O) events observed in Greenland. Although the timing of the Malawi events cannot be determined exactly, our age model implies that they occur prior to their Greenland counterparts, consistent with southward excursions of the Intertropical Convergence Zone during Greenland stadials.

(Wednesday 9.55 – 10.15)

Meteorological conditions for dust mobilization in the Sahara

Peter Knippertz

University Mainz, Germany

Abstract

Airborn mineral dust from the Sahara plays an important role in a multitude of physical, chemical, and biological processes reaching from an influence on the Earth's radiation budget to human health. A quantitative simulation of the global dust cycle with numerical models is still a challenge, in particular due to uncertainties in the emission term that relate to both limited knowledge about the state of the soil and to problems in generating sufficiently high near-surface wind speeds in the models.

This paper aims to give an overview of the different meteorological processes that produce such strong winds in the Sahara and tries to assess their representation in numerical models. The covered meteorological systems range from microscale dust devils and convective dust plumes over meso-scale cold fronts and moist convective outflow boundaries to synoptic-scale wintertime low pressure systems. It will be shown that one of the most critical processes is the evaporation of precipitation in the dry and hot desert air that creates quickly spreading and highly turbulent pools of cold air.

(Thursday 9.^{00} – 9.^{20})

Latitude-dependent human response to Holocene climate change in NE Africa

Stefan Kröpelin

University of Cologne, Germany

Abstract

Geological and archaeological archives in the now hyper-arid Eastern Sahara of Egypt, Sudan, Libya and Chad suggest a consistent model of how past environmental changes, over a coherent region of sub-continental scale, have affected human societies throughout the Holocene. After the onset of semi-arid conditions in the north and semi-humid conditions in the south at c. 8,500 B.C.E., the desert margin shifted up to 800 km north to latitude 24° N, bringing monsoonal rainfall to most of the former desert. This fundamental climatic change from terminal Pleistocene hyper-arid conditions to savannah-type vegetation, and the formation of lakes and temporary rivers resulted in the rapid dissemination of wild fauna and the swift reoccupation of the entire Eastern Sahara by prehistoric populations. Relatively stable semi-humid environments prevailed over the following 3,200 calendar years between 8,500-5,300 B.C.E. The subsequent southward retreat of monsoonal precipitation can be tracked to the present by the discontinuance of aquatic deposits at decreasing latitudes and by the distribution of occupation sites which both indicate gradual desiccation and environmental deterioration, notwithstanding transitory climatic perturbations at the desert margins. The southward movement of human settlement implied significant changes in the pattern of behaviour and land-use as a response to regional environmental differences. Mobility was the key to survival and has driven prehistoric societies from foraging to a multi-resource economy and specialized pastoralism. The desiccation of the Sahara triggered the emergence of pharaonic civilization along the Nile, influenced the spread of pastoralism throughout the continent, and affects sub-Saharan Africa to the present day.

(Wednesday 14.^{00} – 14.^{20})

Pleistocene desiccation of Lake Tana, source of the Blue Nile

Henry F. Lamb

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Abstract

Lake Tana, Ethiopia’s largest lake, is the source of the Blue Nile, a river of key importance to the origin of ancient Egyptian and eastern Mediterranean civilisations, and critical to current sustenance of northeast African states. Although 2000 km shorter than the White Nile, high summer discharge of the Blue Nile contributes more water to the main Nile below their confluence at Khartoum, and a vastly greater proportion of transported sediment. Despite the Blue Nile’s significance, very little is known about the Late Quaternary history of its headwaters, in marked contrast to the wealth of information about the history of Lakes Victoria and Albert, at the headwaters of the White Nile.

High-resolution seismic survey, combined with palaeoecological core data from Lake Tana, shows that the lake was dry at ~17 cal ka, at the time of Heinrich event 1. Shallow water and *Cyperus* swamp occupied the central part of the lake basin between 16.7 and 15.1 cal ka. As the lake subsequently refilled, open-water evaporation from the large, closed, shallow water body caused a rise in salinity, followed by an abrupt return to freshwater conditions at 14.7 cal ka, when the lake surface reached the level of the Blue Nile outflow. Simulations of Lake Tana’s response to varying precipitation emphasize the severity of drought required to desiccate the lake, and suggest that the peat and shallow-water sediments at the base of the central core were formed when rainfall was at most 40% that of the present day.

Desiccation of both the Blue and White Nile headwaters coincides with Heinrich event 1, when icebergs flooded the North Atlantic, and disrupted the Atlantic conveyor that exports heat northwards from tropical waters. Seismic reflection data indicate at least three earlier Late Pleistocene desiccation events in Lake Tana, suggesting that severe and widespread drought has affected northeast Africa in response to previous Heinrich events. I will present some preliminary results from a 92 m core drilled from Lake Tana in January 2007, as a test of this hypothesis.

(Thursday 16.30 – 16.50)

Simulating the Transient Evolution of Northern Africa Climate-Ecosystem in the Holocene: The Abrupt Change and its Mechanism

Liu, Z.[1], Y. Wang[2], R. Gallimore[1], F. Gasse[3], T. Johnson[4], P. deMenocal[5], J. Adkins[6], M. Notaro[1], I. C. Prentice[7], J. Kutzbach[1], R. Jacob[8], P. Behling[1], L. Wang[1], E. Ong[1]

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Abstract

One of the greatest climate-ecosystem changes in the last 10,000 years occurred in North Africa. A green Sahara in the early to mid-Holocene changed to a present day desert, with a great reduction in vegetation cover and lake area. Moreover, this dramatic desertification occurred abruptly in the mid-Holocene within centuries (deMenocal et al., 2000). Although the overall desertification is recognized to be caused by orbital forcing (Kutzbach and Otto-Bliesner, 1982), with feedbacks from land and ocean, it has remained poorly understood why this desertification occurred so abruptly. Based on the study from an intermediate climate-vegetation model, Claussen et al. (1999) proposed that the abrupt collapse is caused by a strong positive vegetation feedback on climate. However, it remains unclear why the abrupt desertification did not occur in other similar climate-vegetation models. Here, we study North African desertification in the first transient Holocene simulation of the coupled climate-ecosystem in a synchronously coupled general circulation atmosphere-ocean-vegetation model FOAM-LPJ (Liu et al., 2007).

Our model successfully simulated the major abrupt vegetation collapse in the southern Sahara at about 5ka, consistent with the proxy records. Local precipitation, however, shows a much more gradual decline with time. The vegetation change in northern Africa is clearly driven by local precipitation decline and strong precipitation variability. In contrast, the change of precipitation is dominated by internal climate variability and a gradual monsoonal climate response to orbital forcing. In addition, minor vegetation changes are also simulated in different regions across northern Africa.

The model simulated a reduced seasonal cycle of SST and a gradual annual mean surface cooling in the subtropical North Atlantic towards the latest Holocene. The SST response is caused largely by the insolation forcing, while the annual mean cooling is also reinforced by the increased coastal upwelling near the east boundary. The increased upwelling results from a southward retreat of the North Africa monsoon system, and, in turn, an increased northeasterly trade wind. The simulated changes of SST and upwelling are also largely consistent with recent marine proxy records, albeit with a weaker magnitude in the model.

The collapse of North African vegetation in the model is associated with strong climate variability, rather than positive vegetation feedback (Liu et al., 2006): the abrupt collapse of vegetation is caused by a nonlinear vegetation response to a precipitation threshold in the presence of strong climate variability. The feedback of vegetation cover on the net annual rainfall in the model is negative in the mid-Holocene, because the bare soil evaporation in the monsoon season overwhelms the transpiration in the early monsoon season in a wet climate such as the mid-Holocene (Notaro et al., 2007). The simulation implies that the ecosystem may collapse abruptly while the climate system experiences a much gradual transition. The implication to paleoclimate modelings and observations are also discussed.

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(Thursday 9.40 – 10.00)

The third millennium BP Central African rainforest crisis and the Bantu question: Seasonality as a factor for population movements

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Abstract

The "Bantu question" is one of the key topics in African prehistory. It has been suggested (Schwartz 1992) that the initial spread of Bantu speaking populations through the Central African rain forest was connected with a climatically induced destruction of the forest ecosystems in the third millennium BP, but archaeological and palaeoenvironmental data were insufficient to describe this process in detail. We present here the results from a multidisciplinary project in southern Cameroon, combining archaeobotanical, palynological, and linguistic data. The high-resolution pollen profile Nyabessan shows a distinct shift from evergreen forest to pioneer formations around 2500/2400 cal yr BP. The dominance of Trema orientalis, a pioneer well adapted to desiccation, points to a much more accentuated seasonality between 2500 and 2300 cal yr BP. Diatom data of Lake Ossa in the same region indicate high precipitation for this period, but nevertheless, the forest could not persist, due to a harsher dry season during the boreal winter months. A more accentuated seasonality offers a conclusive explanation for the presence of the savanna crop pearl millet (Pennisetum glaucum) in southern Cameroonian archaeological sites, dated to 2400-2200 cal yr BP. There is also linguistic evidence for an introduction of a western Bantu term for pearl millet into the rain forest. The archaeobotanical and palaeoenvironmental data provide a chronological marker for this process, because cultivation of pearl millet was only possible during a short period of pronounced seasonality in the second half of the third millennium BP.

(Thursday 9.15 – 9.35)

The myths and realities about North African climate: a new look at present controls and interannual variability

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Abstract

Our understanding of the factors governing climate in North Africa and its interannual variability has dramatically changed during the 30-some years following the GATE (GARP Atlantic Tropical Experiment) of 1974. Unfortunately, much of the new understanding has never been passed along to other disciplines. Many studies of past climate utilize the underlying but false assumption that rainfall is produced by the Intertropical Convergence Zone, a surface meeting of the dry Saharan air and moist "monsoon" air. A corollary to this concept is that the convergence triggers the ascent needed to produce clouds and rainfall. Thus, changes in the surface convergence zone control the seasonal cycle, interannual variability, etc. In reality, the primary controls on rainfall lie much higher in the atmosphere: the African Easterly Jet (AEJ) of the mid-troposphere and the Tropical Easterly Jet (TEJ) of the upper-troposphere.

The rainbelt (often mistakenly referred to as the ITCZ) lies between the axes of the two jets. The seasonal cycle is related to the seasonal changes in these jet streams. The latitudinal of the rainbelt, which governs the length of the rainy season, is essentially the distance between the axes of the two jets. The location of the rainbelt is dicated primarily by the location of the AEJ. The intensity of the rainbelt (how much falls within the season) is dictated mainly by the intensity of the TEJ. These features may be related to what happens at the surface, but much more over the ocean surface than over the land. Interannual variability can be examined and explained in this same framework: changes in the location, extent and intensity of the rainbelt.

Another important change in our understanding of North African climate is the realization that the rainfall within this zone is not produced by local convection, but by very large mesoscale convective systems. These are much less sensitive to surface conditions than is isolated, local convection (e.g., the typical afternoon thunderstorm). Their diurnal cycle is also quite different.

These new findings do not nullify the understanding we have reached with respect to the impact of land surface proceses on climate or on the links between ecosystems and climate. However, they create a new framework into which our knowledge of land surface processes, ecosystem dynamics, and climate-vegetation relationships must be merged. Despite the new view that emphasizes the upper atmosphere as a "driver", it is still relevant to ask whether land-use change or "desertification" impacts climate or modulates its short or long-term variability. However, the questions must be posed differently.

(Thursday 15.30 – 15.50)

PMIP2 Coupled Simulations of the Mid-Holocene and Last Glacial Maximum West African Climate

Bette L. Otto-Bliesner

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Abstract

Global coupled climate models run for future scenarios of increasing atmospheric CO_2 concentrations give a range of responses of global and regional climate changes. Projected changes in the African monsoon vary considerably among models. The second phase of the Paleoclimate Modeling Intercomparison Project (PMIP-2) was launched in 2002 to coordinate coupled ocean-atmosphere (OA) and ocean-atmosphere-vegetation (OAV) simulations and data syntheses for the Last Glacial Maximum and mid-Holocene. The LGM, approximately 21,000 years ago, is a glacial period with large changes in the greenhouse gases, sea level, and ice sheets.

The mid-Holocene, approximately 6000 years ago, is during the current interglacial with primary changes in the seasonal and latitudinal distribution of incoming solar radiation (insolation) caused by known changes in orbital forcing. PMIP2 OA simulations for the LGM and the Mid-Holocene have been performed by respectively 6 and 9 modeling groups. In addition, three modeling groups have performed PMIP2 OAV simulations for the mid-Holocene. The simulated responses of the West African climate to these two past climate forcings will be presented.

(Thursday 10.^{50} – 11.^{10})

Climate Models and Regional Climate Change in Africa – implications for food security and health

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Abstract

The severe drought during the second half of the 20th century has demonstrated that livelihood in Africa is highly sensitive to climatic conditions. From previous studies the complexity of the key factors in African climate variability can be inferred. This presentation discusses the various key factors and highlights the need of more complex scenarios to assess the human influence on African climate. In particular, the effect of ongoing land-use changes in the course of population growth, shifting cultivation and overgrazing has to be taken into account. New ensemble simulations with a regional climate model are presented, which are subject to increasing greenhouse-gas concentrations and land cover changes. The model predicts dryer conditions, near-surface warming and an intensification of heat stress. There is indication that reforestation and regional protection of natural vegetation may be more effective for mitigating climate change in Africa than reduced greenhouse-gas emissions. Finally, the implications of these projected climate changes for agricultural production in tropical West Africa and the occurrence of Malaria are modelled.

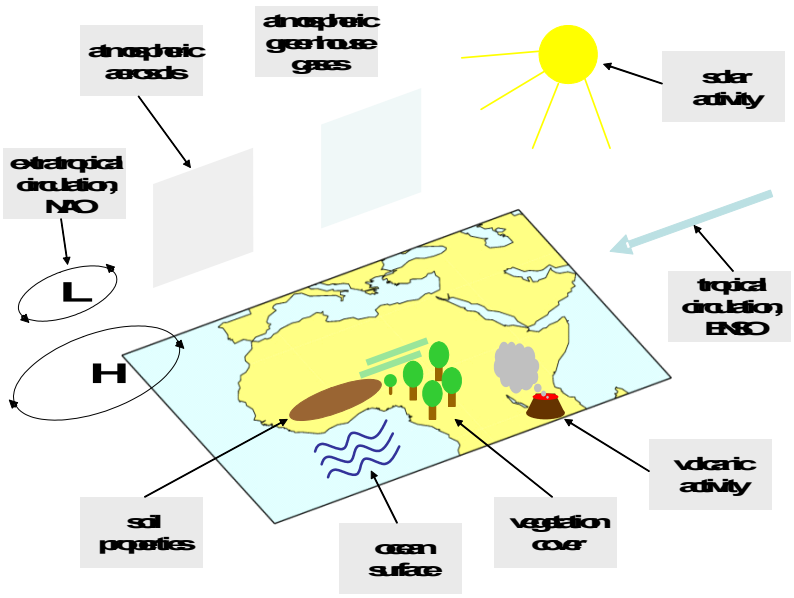

Figure 1. Presumed natural and anthropogenic factors in African climate.

(Wednesday 15.^{50} – 16.^{10})

Lake Bosumtwi (Ghana) sedimentary records of environmental change

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Abstract

Located at 06°32'N and 01°25'W, Lake Bosumtwi occupies a 1.07 Ma meteor-impact crater in Ghana, West Africa. This hydrologically closed lake has a water budget sensitive to the precipitation/evapotranspiration balance and is located beneath the path of the seasonal migration of the ITCZ. Therefore, Lake Bosumtwi is ideally situated to provide a long sedimentary record of monsoon and ecosystem variability from continental West Africa. In addition, the anoxic bottom water allows for the preservation of laminated sediments and the potential for high-resolution (annual) paleoclimate reconstruction. Scientific drilling using the GLAD-800 system recovered 1,833 m of lacustrine sediment from 14 separate drill holes. Drilling in the crater's annular moat yielded a 291-m long sediment section that spans the full 1 Ma history of the lake. At this site, above brecciated bedrock, is a section of impact-glass bearing accretionary lapilli representing the final fallback following impact. In addition to the age of the impact event, the overlying 291 m of lacustrine sediment is dated by radiocarbon, optically stimulated luminescence, and paleomagnetic methods.

Multiproxy analysis of the lacustrine sediment section reveals contrasting lithologies varying at orbital timescales. Organic-rich sediment having low concentrations of low-coercivity magnetic minerals is associated with many interglacial and interstadial periods. In contrast, mineral-rich sediment having high concentrations of single-domain, high-coercivity magnetic minerals (hematite and/or greigite) characterizes glacial and stadial intervals. Elevated aerosol dust export from arid Sahel sources, possibly accompanied by enhanced magnetic-mineral diagenesis during lake-level lowstands, is interpreted to have produced this high-coercivity magnetic signature. This dust proxy record from Lake Bosumtwi is similar to dust records from marine cores off the coast of West Africa and provides additional constraints on identifying glacial-interglacial variability in the 1 Ma long lacustrine sediment sequence.

Sedimentologic properties also indicate intervals of pronounced aridity in the Lake Bosumtwi region. Within a sediment sequence that is comprised mostly of laminated mud are intervals of non-laminated sediment having increased density, decreased organic content and a high-coercivity magnetic mineral assemblage. Some of these massive layers

contain slump-folding and intraformational mud clasts. These lithologies are interpreted to represent lake-level lowstands when a diminished West African summer monsoon resulted in decreased moisture balance and lake-level regression. Some of the Lake Bosumtwi lowstands correlate in timing to Heinrich events and reveal linkages between high- and low-latitude processes. The most recent desiccation of Lake Bosumtwi at c.70 kyr is consistent pronounced aridity elsewhere in tropical Africa as recorded by major lake-level lowstands in Lakes Malawi and Tanganyika.

(Wednesday 16.[10] – 16.[30])

Sea level and climatic changes evidenced by microfaunas (foraminifers, ostracods) in the Holocene of the Retba Lake (Senegal, West Africa)

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Department of Geology, Faculty of Sciences and Techniques, University Cheikh Anta Diop of Dakar, Senegal

Abstract:

The Retba Lake is located 30 km NE of Dakar (Senegal). The surface water body is hypersaline (120 g/l to 340 g/l). Only halophilic bacteria that give its pink colour to the lake live in the bottom of its edges. The study of marine incursions based on foraminifers and ostracods assemblages is carried out in a sediment core taken at the edge of the lake. A total of 37 foraminifers and 23 ostracods species have been identified. Most of them are known in the modern estuaries and lagoons of Senegal and the Gulf of Guinea. The four assemblages of foraminifers and ostracods identified in the same levels of the core correspond to different stages of the evolution of the lake.

Foraminifer assemblages are dominated by *Ammonia parkinsoniana* and *A. tepida*. First association (F1) at the base of the core indicates a lagoon slightly opened to the sea, under a relatively humid climate. The second (F2) has the richest and most diversified fauna with a high proportion of coastal, marine benthic and planktonic species (10 %) that indicate a small marine gulf. The third (F3) oligospecific assemblage is typical of a closed and hyperesaline lagoon under a dry climate. The fourth association (F4) again contains coastal, marine benthic and scarce planktonic species (3 %) indicating an evolution to a saltier and more open lagoon under dry climate. The disappearance of planktonic foraminifers at the top of the core indicates the closure of the lagoon under drying climate.

Ostracods assemblages are dominated by *Cyprideis nigeriensis* and corroborate data from foraminifers with complementary indications. The first association (F1) composed of *C. nigeriensis*, *Neomonoceratina iddoensis* and *Aglaiocypris gambiensis* characterises a slightly opened lagoon with its edges covered by mangrove swamps under humid climate. The second (F2), with mainly *C. nigeriensis*, *N. iddoensis* and "marine species" is the richer and more diversified and evidences a marine little gulf bordered by mangrove swamps under humid climate. The monospecific association F3 with *C. nigeriensis* indicates a drying confined lagoon under an arid climate. The oligospecific association (F4) at the top with *C. nigeriensis* and *Pseudoconcha omatsolai* is typical of a slightly open saline lagoon under dry climate.

All the biocenotic indicators make evidence of two marine intrusions in the Retba Lake associated with climatic changes during Late Holocene. The first and stronger marine intrusion evidenced by F2 associations is dated between 1417 and 1251 years B. P. It corresponds to the maximum of the Saint-Louisian (2000 to 1000 years B. P.) widespread marine deposit in the Senegalese coastline. Dry climate leading to the disappearance of mangrove swamps took place after this episode (F3). The more recent marine intrusion (F4) happened under dry climate and took place between the closure of the Retba Lake (250 years B. P.) and the present.

(Wednesday 16.30 – 16.50)

Paleoclimate reconstructions from eastern Mediterranean sediment cores

Gerhard Schmiedl
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Abstract

The marginal Mediterranean Sea represents one of the key areas for paleoceanographic studies since hydrographic and sedimentation processes respond in a sensitive way to climate changes of the adjacent continents. Most of the published studies addressed the processes responsible for the deposition of sapropels in the eastern Mediterranean Sea during the Neogene. Sapropel formation is closely associated with insolation-driven maxima of the African monsoon system. Further, the sapropel characteristics exhibit spatial differences and seem to be affected by abrupt climate fluctuations. New sedimentological, micropaleontological, and geochemical records from Late Glacial to Holocene sediments of different sub-basins of the eastern Mediterranean Sea provide insight into the influence of both northern and southern climate variability.

The development of clay mineral assemblages in the Levantine Sea and South Aegean Sea reflects changes in the Nile discharge and African dust input. In this area, the establishment of pluvial conditions in the Nile catchment during the early to middle Holocene resulted in a substantial rise in smectite/illite ratios. In the late Holocene, stepwise aridification of the southern borderlands caused an increase in windblown sediment material and a decrease in Nile suspended material. The African humid period also controlled the long-term oceanographic changes in the eastern Mediterranean Sea as reflected by foraminiferal faunal and stable isotope records. Short-term changes in eastern Mediterranean deep-water formation and marine ecosystems are intimately linked to abrupt climate variability of the northern borderlands while abrupt changes in North African hydrology only had a regional impact.

(Thursday 10.45 – 11.05)

The Impact of Dynamic Vegetation on Desert Dust and Sahel Precipitation

Andrea Sealy

NCAR Boulder, USA

Abstract

In this study we examined the interaction of vegetation dynamics with desert dust and Sahel precipitation using an atmospheric general circulation model. Our simulations were conducted with the Community Atmosphere Model coupled with the Dynamic Global Vegetation Model (CAM/DGVM) forced either by observed sea surface temperature similar to the model configuration used for the Atmospheric Model Intercomparison Project (AMIP) or coupled with interactive SST from the Slab Ocean Model (SOM). Some cases of simulations included dust feedback, and other cases did not include dust feedback. Comparison of CAM/DGVM to uncoupled CAM simulations suggests that there is a response of precipitation and dust to dynamic vegetation. The interaction with and response of dust and precipitation to dynamic vegetation also appears to vary with observed SST forcing versus interactive SST.

(Wednesday 15.^{00} – 15.^{20})

Climate change on the East African equator:

a particular combination of tropical & high-latitude climate forcing

Dirk Verschuren

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Abstract

Recent documentation of African 'megadrought' periods punctuating the early part of the last glacial period (130-70 kyears BP; ~MIS stage 5) is generating much interest into the question why these droughts were more severe than the tropical aridity prevailing during either the last glacial maximum (~21-16 kyears BP) or the peak of the penultimate glaciation (~140-130 kyears BP). A new long climate-proxy record from equatorial East Africa, based on the reflection-seismic stratigraphy of the sedimentary infill in crater Lake Challa near Kilimanjaro, provides information on how rainfall contributions from both the northwesterly and southwesterly Indian Ocean monsoons, due to twice-yearly passage of the ITCZ, and relatively modest seasonal and long-term variation in equatorial insolation have shaped the region's climate history. Differences in climate patterns between equatorial East Africa and northern and southern tropical Africa help to constrain the role of precessional insolation forcing in the mentioned megadroughts; and contrasts between equatorial East Africa and equatorial West Africa during the later part of the last glacial period (70-21 kyears BP; ~MIS stages 4 and 3) help elucidate the role of Atlantic Ocean meridional circulation in exporting northern high-latitude climatic variability to the tropics. Together these records improve understanding of how local insolation forcing and the long-distance influence of high-latitude glaciation cycles have interacted to shape tropical climate history.

List of short presentations:

(Short presentation: Wednesday 18.[15])

Paleoclimate of the Nile River Delta region based on multiple organic geochemical proxies

Isla S. Castañeda[1], Enno Schefuβ[2], Jürgen Pätzold[2], Jaap S. Sinninghe Damsté[1] and Stefan Schouten[1]

[1]Royal Netherlands Institute for Sea Research (NIOZ), the Netherlands

[2]Department of Geosciences, University of Bremen, Germany

Abstract

In this study, multiple organic geochemical proxies are examined from a Nile River Delta sediment core (GeoB 7702-3) to investigate the paleoclimatic history of the North Africa/Eastern Mediterranean region during the past ~26 cal ka. Sea surface temperatures in the eastern Mediterranean were reconstructed using the TEX_{86} paleothermometer while mean annual air temperature and soil pH of northern Africa were examined from the methylation index of branched tetraethers (MBT) and the cyclisation ratio of branched tetraethers (CBT), respectively. The TEX_{86} record captures global climate events including the Last Glacial Maximum (LGM), Heinrich Event 1 (H1), the Bolling/Allerod and the Younger Dryas (YD). The recently developed Branched and Isoprenoid Tetraether (BIT) index, used to differentiate between marine and terrestrial inputs, closely tracks changes noted in bulk C/N ratios.

Overall, these records indicate greater variability during the Late Pleistocene than during the Holocene, with the highest terrestrial inputs noted at approximately the time of the YD and prior to H1. Although it might be expected that terrestrial inputs should be the lowest during the Late Pleistocene, when the sources of both the Blue and White Nile were severely reduced or desiccated, higher (more terrestrial) BIT values noted at these times may be related to changes in vegetation cover in North Africa.

During the Holocene, a major shift in the BIT index to lower (more marine) values marks the onset of deposition of the S1 sapropel layer. The lower BIT values noted during this interval are caused by a dramatic (order of magnitude) increase in the absolute abundance of crenarchaeol, attesting to enhanced marine productivity at this time. Following deposition of the S1 sapropel, absolute abundances of crenarchaeol are generally higher than during the Late Pleistocene, suggesting increased marine productivity in the eastern Mediterranean throughout the Holocene.

(Short presentation: Wednesday 18.[15])

NW African Humid Episodes during the last glaciation

H. Kuhlmann, H. Meggers, M. Prange, T. Freudenthal, M. Schulz, C. Hensen, K. Vogel
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Abstract

The Sahara is the largest desert of the world with more than 8 Mio km^2. Nevertheless, during the early Holocene the Saharan realm was nearly completely vegetated within the “African Humid Period”. This period started and terminated abruptly and has been attributed to a strengthening of the African monsoon. Our reconstructions of marine productivity and terrigenous input from a sediment core off NW Africa provide a detailed record of subtropical climate from 45,000 to 3,000 years BP. We show that abrupt climatic changes strongly modulated the precessionally forced paleoproductivity-signal off NW Africa. Although the glacial in NW Africa is generally believed to be a dry and cold period, our data indicate wet phases during the insolation maximum in marine isotopic stage (MIS) 3 documented by monsoon generated wadi and river runoff. These glacial “African Humid Episodes” would have offered ecological conditions resembling those of the “African Humid Period” within the Early Holocene. Thus our data indicate that interstadials during MIS 3 provided climatic conditions possible favorable for the establishment of life in the Sahara before the well-known period of the Early Holocene.

(Short presentation: Thursday 13.30)

Sensitivity of the African monsoon to glacial boundary conditions in a comprehensive climate model

Ute Merkel
Department of Geosciences, University of Bremen, Germany

Abstract

Paleoceanographic data and ice core records exhibit evidence for pronounced climate variations on millennial timescales during Marine Isotope Stage 3 (59-29 ky BP). This period during the last glacial exhibits rather regular successions of cold stadials and warm interstadials, the so-called Dansgaard-Oeschger cycles. The rapid transitions between these stadials and interstadials happen within a few decades and are assumed to be associated with large-scale climatic changes such as changes of ocean heat transport and North Atlantic deep water formation. The mechanisms involved in such abrupt climate change, in particular the role of the meridional overturning circulation, are not yet fully understood. So far, it is unclear whether the tropics play a leading role in variations on Dansgaard-Oeschger timescales or whether they respond to high latitude climate changes. We hypothesize that, through rapid atmospheric reorganization, the tropics and in particular the African monsoon could be strongly affected by Northern hemisphere ice sheet configuration and North Atlantic deep water formation during the last glacial. In order to test this hypothesis, we conduct sensitivity experiments using the fully coupled general circulation model CCSM3. The model consists of state-of-the-art atmosphere, land, ocean and sea ice model components and is run at T31 resolution in the atmosphere and nominally 3° in the ocean for the purpose of long integrations. Glacial climate is different from modern climate due to lower greenhouse gas concentrations, different astronomical parameters, a lowering of sea level and a considerably different extent and elevation of continental ice sheets. These glacial boundary conditions are taken into account in our sensitivity simulations. The impact of the glacial forcing on the monsoon circulation will be analyzed from these experiments with respect to a pre-industrial control simulation. In particular, the global-scale simulations allow us to assess seasonal and interannual teleconnections from the other tropical oceans affecting the African monsoon and to examine monsoon variations related to the El Niño/Southern Oscillation under different glacial background states.

(Short presentation: Thursday 13.30)

Tropical carbonates in an environment influenced by upwelling: a tool for reconstructing paleoclimate change

Julien Michel*, Hildegard Westphal* & Karl Gürs°

* Department of Geosciences, University of Bremen, Germany
° Landesamt für Natur und Umwelt, Schleswig-Holstein, Germany

Abstract

The composition of atypical tropical carbonates that form in high-nutrient settings is reminiscent of cool-water or non-tropical carbonates. Misinterpreting such deposits in the rock record results in misleading climatic and paleoceanographic interpretations. A systematic description of high-nutrient tropical carbonates is still lacking, as is a calibration of such deposits required for reliably interpreting occurrences in the rock record. The project presented here therefore aims at contributing to the taxonomic and geochemical calibration of atypical tropical carbonates.

For this task, modern analogues are studied. In the modern world, high-nutrient carbonate settings in the tropics are rare. One such occurrence is the Mauritanian shelf that is under the influence of upwelling. Additionally, Trade Winds introduce high amounts of eolian dust from the Sahara to the shelfal depositional environment, further fertilizing the environment.

Poseidon cruise 346 (Dec. 2006/Jan. 2007) collected a wealth of box cores, gravity cores and grab samples along the Banc d’Arguin (from less than 10 to 150 meters water depth). The sediments collected are characterized by heterozoan carbonate grain associations. They vary from clean coarse-grained, almost pure carbonate sediments to fine-grained sediments with carbonate contents of about 50%. Carbonate components include abundant molluscs, worm tubes and bryozoans, as well as foraminifers and arthropods. Red algae are rare. In the rock record, such sediments could be easily misinterpreted as cool-water or temperate carbonates. Our study aims at characterizing the sediment samples taxonomically and geochemically and at contrasting them with modern temperate and cool temperate carbonates. This approach will provide a calibration for interpreting the rock record at least in the Neogene.

(Short presentation: Thursday 13.30)

Glacial slowdowns of Atlantic meridional overturning triggered multi-millennial droughts in the Sahel

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Abstract

The influence of the large-scale ocean circulation on Sahel rainfall is elusive due to the shortness of the observational record. The continental slope off Northern Senegal is an ideal site to study the history of Sahel drought, because it records the varying input of eolian dust and fluvial sediments from the adjacent African continent. We reconstructed the history of eolian and fluvial sedimentation during the past 57,000 years by analyzing grain-size distributions and Al/Si ratios in a gravity core from the continental slope off Senegal. Our data show that abrupt onsets of arid conditions in West Africa were linked to cold North Atlantic sea surface temperatures during times of reduced meridional overturning circulation. Climate modelling suggests that this drying of the West African Sahel is induced by low-level inflow of dry Saharan air in conjunction with an intensification and southward shift of the mid-level African Easterly Jet (see Prange et al.).

(Short presentation: Wednesday 18.[15])

Phytoliths as indicators for grassland change in Africa

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Abstract

The grass plant family (Poaceae) contributes significantly to African ecosystems. Grasses constitute the majority of the biomass in the savannas and are even found in the understorey of the rain forest. Changes in the composition of palaeo-grasslands are significant for reconstructions of past rainfall and temperatures. In pollen profiles grasses cannot be discriminated below family level; but phytoliths, amorphous silica produced in the grass leaves, can be identified to subfamily and in some cases even to genus and species level. Recent advances in grass phytolith research offers new perspectives for reconstructions of African savannas in the past. An early Holocene phytolith sequence from Mali illustrates the chances, but also the limitations of the method.

(Short presentation: Thursday 13.30)

Deciphering fluvial and aeolian supply in shallow-water sediments off Senegal (NW Africa)

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Abstract

The NW African continental margin is a key location in the global climate system for high resolution climatic reconstructions. The Senegal river and the Trade winds carrying dust from Sahelian and Saharan regions load the continental margin with terrigenous material. We develop a new approach combining grain-size, elemental distribution and mineralogy employed in parallel with end-member modelling to trace dust and riverine sources through the past and understand how terrigenous components record climate changes.

The Core 9504-3 was retrieved at 43 m water depth in front of the mouth of the Senegal River. The high sedimentation rate is dominated by riverine input and thus provides a high-resolution record of climatic changes during the late Holocene.

The bulk sediment was wet sieved and the fraction <63 µm was retrieved. The grain-size distribution of the terrigenous material was checked by a LASER Particle Sizer LS 2000. According to these data and an end-member analysis of the grain-size performed on the bulk sediment in the neighbouring core GeoB9503, we assumed that the fraction <18 µm is related to riverine input whilst the fraction >18 µm is related to aeolian input. On the basis of the grain-size distribution of the terrigenous fraction, a splitting was performed by a settling procedure providing three subfractions: <2 µm, 2-18 µm and 18-63 µm. Major and trace element contents were measured by XRF powder and ICP-OES, and mineral identification and semi-quantification was performed by X-ray diffraction on each subfraction.

The aeolian dust fraction (18-63 µm) is dominated by quartz and feldspar (60-97%) whilst the clay minerals are poorly represented (2-25%). The abundance of quartz and feldspar provides high values of major terrigenous elements : Si and K. The trace element values (Co, Cr, Cu, Ni, V) are low compared to the fine fluvial fraction (<2 µm and 2<x<18 µm). The analysed elemental contents of the trace elements, even if they are from a single mineral phase, can hardly be recognized in the X-ray diffraction.

In contrast, the finer riverine material (<2 µm) quartz content is very low (2-4%) and feldspar is absent. The abundance of clay minerals provides the highest Al and Fe values. The second riverine subfraction (2<x<18 µm) is dominated by quartz, feldspar, mica, amphibole and pyroxene (70-90%) which provide high Si values. The high K values are explained by the presence of potassium feldspar.

More than 80% of the total Al and Fe content of the terrigenous bulk sediment is concentrated in the riverine fraction. Furthermore, despite strong variations, Ti is more abundant in the riverine fraction. Over NW of Africa, due to the scarcity of river draining the continent, Fe and Ti are usually used as dust proxies. Our study displays an alternative interpretation for the terrigenous material deposited off Senegal.

The predominance of quartz and potassium feldspar in the two coarser subfractions provides high Si and K values. Si and K are non specific terrigenous elements but display the shift from wetter to dryer conditions during the late Holocene.

The understanding of the distribution of these terrigenous components as an indicator to record climate changes is a major paleoclimatic challenge. This research is still in progress further investigations will also be extended to the slope to determine the variations in sediment sources through the time.

(Short presentation: Wednesday 18.[15])

Hydrological changes in the southeastern African tropics during the deglaciation and Holocene

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Abstract

Hydrological changes in Africa are intensively coupled to the positions of the Intertropical Convergence Zone (ITCZ). Seasonal migrations as well as the mean latitudinal positions of these boundary conditions determine precipitation patterns on the African continent. Many paleoclimatic reconstructions reveal dry conditions in tropical central and northern Africa during the last glacial maximum (LGM) and wetter phases during the Holocene. Unfortunately, only few climatic records are available from South Africa. Currently there is a lack of information on the transition zone between the modern wet tropical belt and the drier southeastern African climate. Here we report on a 6.51 m long sediment core (GeoB 9307-3) off the Zambezi river (18°33.90´S, 37°22.80´E) in 542 m water depth, which was retrieved during RV METEOR Cruise M63/1.

The age model is based on 20 ^{14}C-AMS dates, calibrated after Stuiver and Reimer 1993 assuming a reservoir age of 137 years using the SW Indian Ocean Mean after Southon et al., 2002. The core has max. age of about 16800 cal. years B.P. and shows high sedimentation rates (about 100 cm/kyr) from 14 to 11 kyrs and lower values (<20 cm/kyr) for the last 11 kyrs.

The Fe intensities measured with the XRF Core Scanner high values during the deglacial and after a transition from 12 to 8 kyrs significantly lower values for the rest of the Holocene. High Fe intensities and sedimentation rates during the delgacial imply high river runoff and enhanced precipitation in the catchment area of the Zambezi. This is supported by comparable findings in planktonic foraminiferal Ba/Ca ratios analyzed in the same core (see Schneider et al. this volume). The Younger Dryas (YD) appears as distinct wet phase in the record. Driest conditions were reached between 6,000 and 8,000 years before present. This record reveals an opposite pattern of wetter and drier conditions derived from sediments of Lake Malawi, which is located about 5° north of the Zambezi. Recent model results indicate that the mean latitudinal position of the ITCZ is affected by the interhemispheric temperature gradients and that the ITCZ is shifted towards the warmer hemisphere.

Thus, during cooler periods in the northern hemisphere the ITCZ is shifted southward. Our results are consistent with these model results and give proof for the southward migration of the ITCZ during the LGM and the YD. A striking similarity occurs with the ice core methane records from Antarctica and Greenland, which have also been postulated as an indicator for tropical wetness. Until about 11 kyr BP an in-phase relationship occurs with the Zambezi record. Afterwards an out-of-phase relationship established and persisted through the entire Holocene.

(Short presentation: Thursday 13.30)

Indications for sea-level and short-term climatic changes recorded in turbidite activity, Dakar Canyon, NW-Africa

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Abstract

Numerous canyons are known along the NW-African continental margin and act as conduit for sediment transport into the deep-sea. The mechanisms of gravity-driven sediment transport in submarine canyons during sea level changes have been reported from many regions. However, the relationship of sea level changes and short-term climatic changes with turbidite deposition is poorly documented.

This study focuses on the activity of the submarine Dakar Canyon off Senegal in response to major glacial/interglacial sea level shifts and the variability in the NW-African continental climate. The sedimentary record from the canyon allow us to determine the timing of turbidite events and based on XRF-scanning data as well as the silt size distribution we have identified the climate signal at a sub-millennial time scale in the hemipelagic sediments. Since the late Quaternary the highest frequency in turbidite activity in the Dakar Canyon is confined to major climatic terminations when the remobilisation of sediments from the shelf was triggered by the eustatic sea level rise especially during distinct meltwater pulses. However, episodic turbidite events cannot be explained by rapid sea level changes but they coincide with the timing of Heinrich events in the North Atlantic. During these short term climatic changes a higher dust supply due to the increased continental aridity in the southern Sahara-Sahel zone occurred which is recorded in the Ti/Ca ratio and the silt size distribution. Increased aridity, enhanced wind strength and reduced vegetation cover in the southern Saharan-Sahelian zone may have provided a considerable source for this dust.

(Short presentation: Thursday 13.30)

Inducing Sahel drought by AMOC slowdown: Insights from model studies

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Abstract

A high-resolution Late Quaternary record of terrigenous sedimentation from the continental slope off Senegal provides unique evidence that millennial-scale North Atlantic "Heinrich" cold events (which were most likely induced by abrupt AMOC [Atlantic meridional overturning circulation] disruptions) were synchronous with extremely dry conditions over Sahelian West Africa during the past 60,000 years (see Mulitza et al.). Using the Community Climate System Model (CCSM2), the effect of a freshwater-induced AMOC slowdown on the West African hydrologic cycle is analyzed. In accordance with the paleoclimatic record, a simulated slowdown of the AMOC induces a surface cooling in the North Atlantic realm and drying of the West African Sahel region. This drying is induced by enhanced northerly low-level inflow of warm, dry (low moist static energy) Saharan air in conjunction with an intensification and southward shift of the mid-level African Easterly Jet which carries moisture from the African continent to the Atlantic Ocean. In the CCSM2 water-hosing experiment, the simulated drying affects not only the Sahel, but the entire West African region including the Guinea coast. This is in contrast to previous water-hosing experiments which simulate the formation of a West African precipitation dipole with increasing (decreasing) annual rainfall over the Guinea coast (Sahel) in response to a weakening of the AMOC. Such a dipole pattern, however, is in disagreement with Late Quaternary paleo-level reconstructions of Lake Bosumtwi (Ghana) which indicate dry conditions at the Guinean coast during millennial-scale periods of reduced AMOC (see Peck et al.). Possible reasons for the model discrepancies are discussed.

(Short presentation: Wednesday 18.[15])

Orbital versus Glacial Mode Forcing of East African Climate over the past 150 kyr

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Abstract

In 2005 the Lake Malawi Scientific Drilling Project recovered a continuous sediment record that samples much of the Quaternary. Detailed studies completed to date on sediments deposited during the past 145 ka indicate periods of severe aridity at precessional frequency between 135 and 75 ka, when the lake's water volume was periodically reduced by at least 95 percent. These dramatic drops in lake level (more than 550 m below the modern maximum depth of 700 m), signify markedly arid conditions in the catchment, and are documented in sediment lithology (decreased organic carbon content and increased authigenic carbonate content during severe lowstands), aquatic microfossils (appearance of a littoral ostracode fauna, and saline/alkaline lake diatom flora during extreme low lake stages), as well as in dramatic reductions in catchment pollen production. These intervals of pronounced tropical African aridity in the early late-Pleistocene were much more severe than the Last Glacial Maximum, and are consistent with sediment records from Lakes Tanganyika (East Africa) and Bosumtwi (West Africa).

In all three lakes a major rise in water levels and a shift to more humid conditions is observed after ~70 ka. The transition to wetter, more stable conditions coincides with the relaxation of orbital eccentricity and a reduction in the amplitude of precession. The observed climate mode switch to decreased environmental variability is consistent with terrestrial and marine records from in and around tropical Africa, but these new drill cores provide evidence for dramatically drier conditions prior to 70 ka that have not as yet been detected in marine sediment records. Such climate change may have stimulated the expansion and migrations of early modern human populations.

(Short presentation: Thursday 13.30)

Centennial scale climate instabilities in a wet early Holocene West African monsoon

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Abstract

Ba/Ca in tests of a shallow-dwelling planktic foraminifer, a proxy for riverine runoff, and Mg/Ca-based sea surface temperature estimates reveal centennial-scale instabilities of Holocene West African monsoon precipitation and eastern equatorial Atlantic (EEA) thermal conditions. The long-term Holocene climate trend is characterized by an extremely wet early-mid Holocene and gradual drying during the late Holocene. Superimposed on this trend are numerous centennial scale drops in precipitation during the early-mid Holocene. The greatest declines in early Holocene monsoon precipitation were accompanied by significant SST cooling in the EEA and correlate with drops in air temperature over Greenland and fresh water outbursts into the North Atlantic. This suggests a close link between high and low latitudes during early Holocene climate instabilities. The strong imprint in summer monsoon precipitation suggests that the high latitude events were summer-time phenomena. The late Holocene does not show large amplitude changes in riverine runoff at the centennial level. The relatively stable late Holocene conditions likely reflect a weakening and stabilization of the monsoon system, probably facilitated by vegetation and soil moisture feedback in the Sahel region and by diminished ice sheet influence.

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