CCA 2017

Climate Change in Africa: Evidence, mechanisms and Impacts Past and Present

Marrakesh, Morocco 6-11 November 2017

Abstracts Volume

Welcome To CCA 2017!

Nowhere is the need for climate change assessment more urgent than in Africa. The continent combines the most climate vulnerable societies, ecosystems, and agrosystems on Earth, with the largest uncertainties in 21st century climate predictions. Yet, a vibrant scientific community is making fast advances in a broad range of environmental sciences.

The objective of this international workshop, hosted by the University of Marrakesh, Morocco, one year after the COP22, is to bring together African scientists and their international peers from complementary fields to build long-term synergies between climatology and ecology, millennial scale and modern observations, modelled and observational data, in global and African contexts.

During 3 days of scientific sessions and discussions, followed by a 2 day field excursion to Moroccan desert and oases, we will summarize the current progress on short and long-term trends in African climate, the interactions between climate and ecosystems on millennial to seasonal time scales, and the impacts of climate change on forests and crops productivity. The workshop is aimed to be a friendly and interactive experience to foster discussion, synthesis, future research actions, and publications on specific questions including:

Is the African climate currently within or beyond the pre-industrial natural variability?

How sensitive are African ecosystems and agrosystems to climate

change? Can we quantify the climate-vegetation feedback in Africa?

How is African climate linked to the rest of the world and external forcings?

Institutions of the organizing Committee

Abdelfattah Benkaddour: UCA, Marrakech, Morocco
Ali Rhoujjati: UCA, Marrakech, Morocco

Matthieu Carré: LOCEAN Paris, France

Ilham Bouimetarhan: Marum, Bremen, Germany

Rachid Cheddadi: ISEM, Montpellier, France
Majda Nourelbait: ISEM, Montpellier, France

Acknowledgment of sponsors

Programme Timetable

18h - 20h	**Monday 6th November 2017 - Registration and Ice breaker**	
08h45 - 9h30	**Tuesday 7th November - Opening of the Symposium**	
S 1: Climate change mechanisms in Africa		
9h30 - 10h00	**Keynote speaker:** DEMENOCAL Peter, Columbia university, NY, USA.	
Break (10h10 - 10h30)		
10h30 - 10h50	HOPLEY P. J.	Links between orbital forcing and interannual rainfall variability from a South African speleothem.
10h50 - 11h10	TROMEL Silke	More extreme precipitation over Africa - a statistical analysis of observational and reanalysis data for probability assessments.
11h10 - 11h30	ZIELHOFER Christoph	Millennial-scale fluctuations in Saharan dust supply across the decline of the African Humid Period.
11h30 - 11h50	SHEEN K. L.	Skilful prediction of Sahel summer rainfall on inter-annual and multi-year timescales
11h50 - 12h10	NICHOLSON Sharon E.	Two centuries of rainfall variability over Africa.
12h10 - 12h30	SARR Alioune Badara	Multi-model analysis of the West African monsoon: intra-seasonal variability and the monsoon onset.
Lunch (12h30 - 14h00) - Poster session		
S 2: Climate impacts on eco- and agro-systems		
14h00 - 14h30	**Keynote speaker:** STONE Daithi, Berkeley, California, U.S.A.	
14h40 - 15h00	NICOLL Kathleen	Reconstructing climate change, surface water storage & cultural resilience within the NE Sahara.
15h00 - 15h20	KIAHTIPES Christopher A.	Sustainability and Resilience in the Congo Basin: A Natural History Perspective.
15h20 - 15h40	PHILIPPON Nathalie	What will become the contrasted solar radiation conditions under which forests grow in Central Africa ?
15h40 - 16h00	VERVER Gé	Development of the West-African Climate Assessment and Dataset (WACA&D).
Break (16h00 - 16h30)		
16h30 - 16h50	LINSTÄDTER Anja	Climate impacts on ecosystem functions and services provided by African ecosystems : Lessons from Sub-Saharan Africa
16h50 - 17h10	LEZINE Anne-Marie	Lake Bambili, Cameroon: 90 000 years of montane forest history in central Africa.
17h10 - 17h30	MIGLIORE Jérémy	Exploring genomic imprints left by past climate changes in Tropical Africa.
17h30 Poster session		

Wednesday 8th November 2017		
S 3: Tropical teleconnections and Monsoon systems		
9h00 – 9h30	**Keynote speaker :** BRACONNOT Pascale, LSCE, Paris, France.	
9h40 – 10h00	POMPOSI Catherine	Exploration of West and Southern Africa precipitation responses during recent El Niño events.
10h00 – 10h20	AIT BRAHIM Yassine	Speleothem-based Climate Reconstructions and Teleconnection Patterns during the Last Millennium in NW Africa.
Break (10h20-10h50)		
10h50 – 11h10	FOERSTER E. Verena	Between wet, dry and hyperarid: Climatic changes during the last >500 ka in the Chew Bahir basin, a key HSPDP site in southern Ethiopia.
11h10 – 11h30	KRÄMER Hauke	Detecting trends, rythms and transitions during the Late Quaternary in southern Ethiopia using Recurrence Quantification Analyses
11h30 – 11h50	SKONIECZNY Charlotte	Simultaneous responses of organic carbon turnover and silicate weathering to past hydroclimate changes in Central Africa
11h50 – 12h10	CARRÉ Matthieu	Anthropogenic forcing brings Sahel drought to unprecedented level in the past 1600 years
Lunch (12h10 – 14h00) – Poster session		
S 4: The Mediterranean region		
14h00-14h30	**Keynote speaker:** ROBERTS Neil, University of Plymouth, Plymouth, UK	
14h40 – 15h00	ROGERSON Mike	Speleothem records of rainfall in central North Africa: 500,000 years of history, and fluid inclusion evidence for changes in atmospheric moisture transport.
15h00 – 15h20	KIRO Yael	Past droughts and flooding in the Levant as indicators of changes in Mediterranean and African climate.
15h20 – 15h40	STEIN Moerdechai	Climate conditions of desert dust transport from the Sahara- desert to the last interglacial Red Sea-Dead Sea from Nd-Sr compositions of sediment cores.
15h40 – 16h	YOCHANAN Kushnir	The climate of Interglacial Africa and its links to the East Mediterranean.
Break (16h – 16h20)		
16h20 – 16h40	ZERBONI Andrea	North African land surface responses to Holocene climate variability: an assessment.
16h40 – 17h00	FLETCHER William	Timescales and drivers of Holocene environmental change in the Middle Atlas, Morocco: Insights from the Lake Sidi Ali palaeoecological record
17h00 – 17h20	JAOUADI Sahbi	Eastern Maghreb Holocene climate changes and their drivers during the Holocene: An assessment based on palaeoecological record from Southern Tunisia
17h20 – 17h40	CHEDDADI Rachid	Past climate changes in Northern Morocco and the persistence of species in microrefugia
17h40 – 18h00	FRANÇOIS Louis	Refining plant traits in vegetation models using forest inventory and LAI measurements. An application to the modelling of Cedrus atlantica in the Rif Mountains with the CARAIB model
18h Poster session		
20h – CCA 2017 – DINNER		

Thursday 9th November 2017		
S 5: Land-Ocean links		
8h30 - 9h00	**Keynote speaker**: SCHEFUß Enno, Marum, Bremen, Germany	
9h10 - 9h30	ZHAO Xueqin	Oceanic variability in the southern Benguela upwelling system: implications for increased Agulhas leakage during late Holocene.
9h30 - 9h50	NICHOLSON Sharon E	Land-ocean links over tropical Africa.
9h50 - 10h10	LOFTUS Emma	Southern Cape seasonal sea surface temperatures and hemispheric wind dynamics.
Break (10h10-10h30)		
10h30 - 10h50	ZABEL Matthias	New insights toclimate variability and its driving forces in southern Africa–the RAiN project.
10h50 - 11h10	TOSSOU G. Monique	Dynamic of vegetation and palaeo-environments on middle and late Holocene in Benin
11h10 - 11h40	**Keynote speaker:** DUPONT lydie, Marum, Bremen, Germany	
11h050 - 12h10	**End of workshop and information about the excursion.**	
Lunch		

Thursday 9th November 2017	13h: EXCURSION depart

Saturday 11th November 2017	18h: EXCURSION return

Oral presentations (S1):

Climate change mechanisms in Africa

Credit: Google maps

Links between orbital forcing and interannual rainfall variability from a South African speleothem

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2 Environmental Change research Centre, Department of Geography, University College London, Gower Street, London, WC1E 6BT, UK.
3 Met Office, Maclean Building, Benson Lane, Wallingford, Oxfordshire, OX10 8BB, UK.

Abstract

Interannual variability of African rainfall impacts local and global communities, but its past behaviour and response in future climate projections are poorly understood. This is primarily due to short instrumental records and a lack of long high-resolution palaeoclimate proxy records. Here we present an annually-resolved 91,000 year Early Pleistocene record of hydroclimate from the early hominin-bearing Makapansgat Valley, South Africa; novel confocal microscopy methods were used to image and measure annual laminae in a flowstone. Changes in speleothem annual band thickness are dominated by precession over four consecutive orbital cycles with strong millennial-scale periodicity. The frequency of interannual variability (2.0-6.5 year oscillations) does not change systematically, yet its amplitude is modulated by the orbital forcing. These long-term characteristics of interannual variability are reproduced with transient climate model simulations of water balance for South Africa from the Late Pleistocene to Recent. Based on these results, we suggest that the frequency of interannual variations in tropical net rainfall is likely to be stable under anthropogenic warming, but that the size of year-to-year variations may change. We see an orbitally-forced increase in the amplitude of inter-annual climate variability between 1.8 Ma and 1.7 Ma coincident with the first evidence for the Acheulean stone tool technology.

More extreme precipitation over Africa - a statistical analysis of observational and reanalysis data for probability assessments.

[1] **TRÖMEL Silke**, [1] STOCKHAUSEN Benedikt, [1] SIMMER Clemens

1 Auf dem Hügel 20, Meteorological Institute, University of Bonn, Bonn, Germany.

Abstract

Reliable estimates of e.g. changes in the probability of precipitation occurrence within a month from observed time series needs adequate statistical methods. Estimates are reliable when a-priori assumed statistical assumptions are fulfilled. Since precipitation does not follow Gaussian statistics, we apply a generalized time series decomposition technique, which allows for arbitrary underlying probability density functions (PDF). The signals, which may be any structured components like trends etc., are then detected in at least two instead of only one parameter describing the PDF. We estimate trends and seasonal components in both parameters simultaneously with a modified stepwise regression procedure and separate the precipitation time series into a statistical and a deterministic component. The interpretation of monthly precipitation time series as realizations of Gumbel-distributed random variables with time-dependent scale and location parameters generates a complete analytical description of the time series and allows to quantify the probability of exceeding optional upper or lower thresholds, respectively, for any time step of the observation period.

The GPCC Global Precipitation Climatology Centre dataset reveals only in the Sahel - most pronounced in spring and summer - significant negative trends in the probability of exceeding the 90% percentile during the period 1901 - 2010; i.e. small monthly precipitation sums are further decreasing. The Modern Era Retrospective-Analysis for Research and Applications (MERRA) dataset, however, suggests for the period 1979-2013 significant increases in the probability of exceeding the 90% percentile, especially at the west and east coast as well as south of the equator. Note these results are not conflicting but can be explained by the different observation periods covered. The Sahel, but in addition also the inner tropics, show strong negative trends in the more recent time period covered by MERRA except in winter. Thus, especially during the more recent time period, higher precipitation amounts decreased but became more likely along the coasts.

Both, the GPCC and the MERRA dataset and thus both observation periods show significant and seasonally different changes in the probability of occurrence of a ‘wet month’, defined as a month with more than 6 mm accumulated precipitation. According to MERRA the most pronounced positive trends happen in summer and autumn along the Atlantic Ocean coast of Namibia. Over the Sahara desert and the Sahel, the probability of occurrence of a ‘wet month’ decreases most pronounced in winter and spring. In summary, pronounced changes occur off the ITC with mostly negative tendencies overland. Single positive tendencies are detected in East Africa and the western part of South Africa.

Millennial-scale fluctuations in Saharan dust supply across the decline of the African Humid Period

1 **ZIELHOFER Christoph ,** 1 SUCHODOLETZ Hans von, 2 FLETCHER William J., 1 SCHNEIDER Birgit, 3 DIETZE Elisabeth, 1 SCHLEGEL Michael, 4 SCHEPANSKI Kerstin, 5 WENINGER Bernhard, 6 MISCHKE Steffen, 7 MIKDAD Abdeslam.

1 Physical Geography, Leipzig University, Germany.
2 Department of Geography, University of Manchester, United Kingdom.
3 GFZ German Research Centre for Geosciences, Potsdam, Germany.
4 TROPOS – Leibniz Institute for Tropospheric Research, Leipzig, Germany.
5 Institute of Pre- and Early History, Cologne University, Germany.
6 Faculty of Earth Sciences, University of Iceland, Reykjavík, Iceland.
7 Institut National des Sciences de l'Archéologie et du Patrimoine, Rabat, Morocco.

Abstract

The Sahara is the world's largest dust source with significant impacts on trans-Atlantic terrestrial and large-scale marine ecosystems. Contested views about a gradual or abrupt onset of Saharan aridity at the end of the African Humid Period dominate the current scientific debate about the Holocene Saharan desiccation.

In this study, we present a 19.63 m sediment core sequence from Lake Sidi Ali (Middle Atlas, Morocco) at the North African desert margin. We reconstruct the interaction between Saharan dust supply and Western Mediterranean hydro-climatic variability during the last 12,000 yr based on analyses of lithogenic grain-sizes, XRF geochemistry and stable isotopes of ostracod shells. A robust chronological model based on AMS 14C dated pollen concentrates supports our multi-proxy study. At orbital-scale there is an overall increase in southern dust supply from the Early Holocene to the Late Holocene, but our Northern Saharan dust record indicates that a gradual Saharan desiccation was interrupted by multiple abrupt dust increases before the 'southern dust mode' was finally established at 4.7 cal ka BP. The Sidi Ali record features millennial peaks in Saharan dust increase at about 11.1, 10.2, 9.4, 8.2, 7.3, 6.6, 6.0, and 5.0 cal ka BP. Early Holocene Saharan dust peaks coincide with Western Mediterranean winter rain minima and North Atlantic cooling events. In contrast, Late Holocene dust peaks correspond mostly with prevailing positive phases of the North Atlantic Oscillation.

We suggest that increases in Northern Saharan dust supply do not solely indicate sub-regional to regional aridity in Northwest Africa but might reflect continental aridity at a trans-Saharan scale. In particular, our findings support major bimillennial phases of trans-Saharan aridity at 10.2, 8.2, 6.0 and 4.2 cal ka BP. These phases coincide with North Atlantic cooling and a weak African monsoon.

Skilful prediction of Sahel summer rainfall on inter-annual and multi-year timescales

1 SHEEN, K.L., 2 Smith, D., 3 Dunstone, N. J.

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2 Met Office Hadley Centre, FitzRoy Road, Exeter, Devon, EX13PB, UK.

3 Met Office Hadley Centre, FitzRoy Road, Exeter, Devon, EX13PB, UK.

Abstract

Summer rainfall in the Sahel region of Africa exhibits one of the largest signals of climatic variability, and, with a population reliant on agricultural productivity, the Sahel is particularly vulnerable to major droughts such as occurred in the 1970s and 1980s. Rainfall levels have subsequently recovered, but future projections remain uncertain. Here we show that Sahel rainfall is skilfully predicted on inter-annual and multi-year (i.e.~ 5 years) timescales, and use these predictions to better understand the driving mechanisms. Moisture budget analysis indicates that on multi-year timescales, a warmer north Atlantic and Mediterranean enhance Sahel rainfall through increased meridional convergence of low-level, externally sourced moisture. In contrast, year-to-year rainfall levels are largely determined by the recycling rate of local moisture, regulated by planetary circulation patterns associated with the El Nino-Southern Oscillation and the Indian Ocean. These results also have implications for how the character of the Sahelian summer rains respond to global climate patterns: the impact of the Pacific ocean may be largely manifest in the frequency of rainy days in the Sahel, whereas the north Atlantic and Mediterranean, may be expected to affect the median intensity of rainfall events. Our findings aid improved understanding and forecasting of Sahel drought, paramount for successful adaptation strategies in a changing climate. These results have recently been published in Nature Communications: ‘Skilful prediction of Sahel summer rainfall on inter-annual and multi-year timescales’, Sheen et al., 2017.

Two centuries of rainfall variability over Africa

1 **NICHOLSON Sharon E.**

1 Florida State University

Abstract

This paper presents two types of long-term records for Africa: regional gauge data time series extending from 125 to 160 years and semi-quantitative gauge+proxy records for 92 regions and covering the years since 1800. Emphasis is on describing the decadal scale variability, but the questions of drivers of this variability and regime changes are also considered. The analyses are based on roughly 3000 Africa stations and thousands of historical documentary entries.

Multi-model analysis of the West African monsoon: intra-seasonal variability and the monsoon onset

1 **SARR Alioune Badara** and 1 CAMARA Moctar

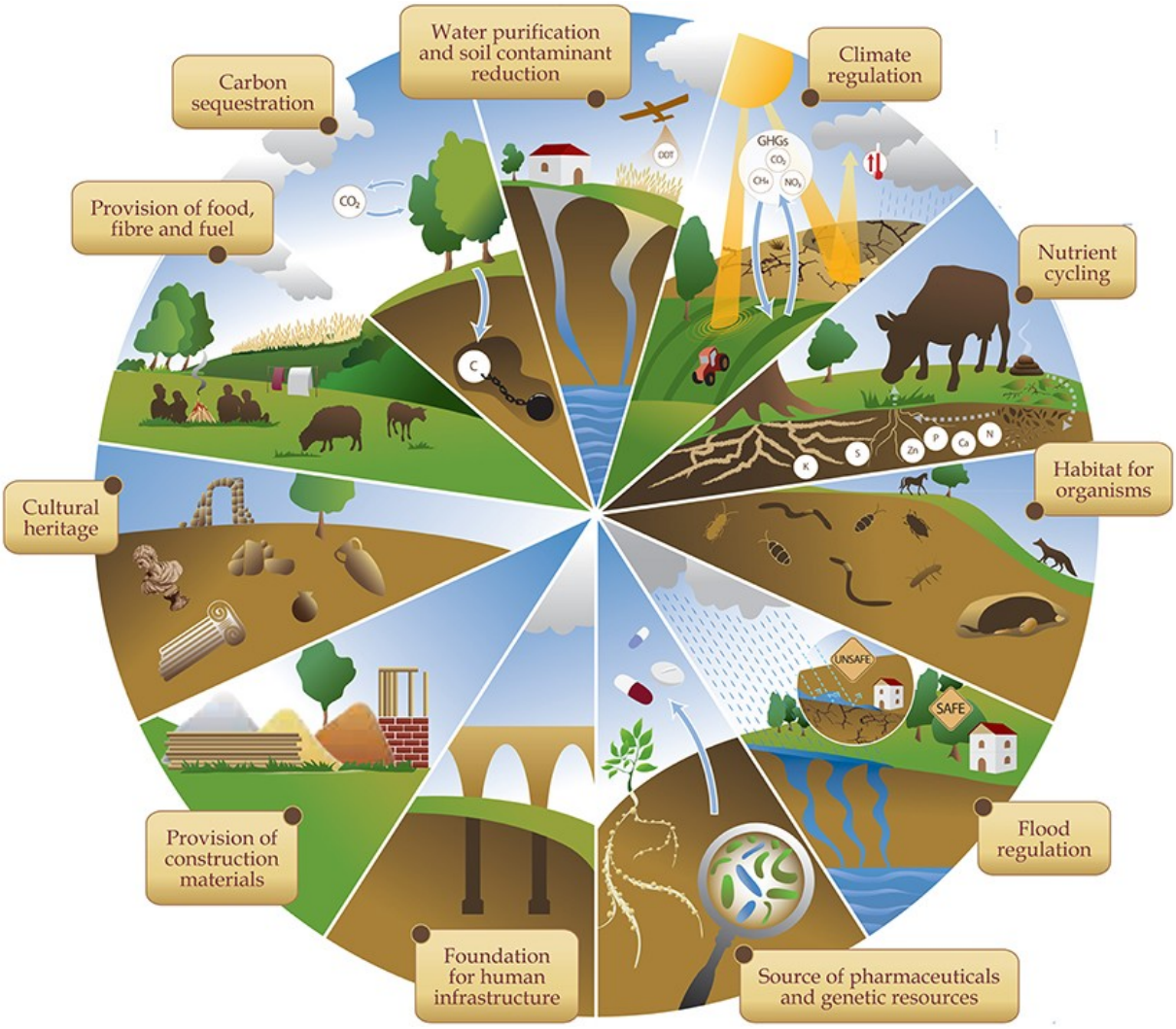
1 Laboratoire d'Océanographie des Sciences de l'Environnement et du Climat (LOSEC), Université Assane Seck de Ziguinchor; BP: 523; Ziguinchor-Senegal

Abstract

The economy in West Africa and particularly in the Sahel region depends primarily on agriculture. Most of its agricultural productivity is achieved during the monsoon season (July-September) which is the period when the greatest amount of rain is recorded. The goal of this paper is to study the intra-seasonal variability of the West African monsoon using five (5) regional climate models (RCMs) involved in the CORDEX (Coordinated Regional climate Downscaling Experiment) program. These RCMs have a horizontal resolution of 0.44° × 0.44° (about 50 km) and are forced and initialized to their lateral boundaries by ERA-Interim reanalysis of the European Centre for Medium-Term Weather Forecast (ECMWF). The results show that the intra-seasonal variability of the west African monsoon is well reproduced by RCMs despite the presence of some biases. The analysis of the dynamics of the West African monsoon shows that almost all models simulate a strong increase of the heat flux over the Sahara especially on its western part which promotes a strong increase of the monsoon flow over the Sahel. This low-levels monsoon flow increase may induce an enhancement of the low-levels specific humidity and the convective activity over the Sahel just after the mean onset date.

Oral presentations (S2):

Climate impacts on eco- and agro-systems



Credit: FAO

(http://www.fao.org/resources/infographics/infographics-details/en/c/284478/)

Reconstructing climate change, surface water storage & cultural resilience within the NE Sahara

1 NICOLL Kathleen

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Abstract

One important approach to understand climate-vegetation feedback in Africa is to assess former patterns of environmental change in context of the archaeological record, which provides long-term insights about human adaptation and resilience. Ongoing syntheses of the emerging records from the Egyptian Sahara and surrounding region relate archaeology, paleoclimatology and ecology with millennial scale and modern observations. Although this area is currently the hyperarid core of the Sahara (MAP <100 mm), Quaternary records in this region attest to significantly different hydrological conditions due to precessional insolation forcing around 9800 BP. In the past, the region had “pluvial periods” of enhanced rainfall that supported soils and steppe grasslands, groundwater-fed lakes, rainwater-led playa lakes, springs and (now defunct) tributaries that once flowed to the Nile. Rapid climate change (RCC) has linked to social change in the eastern and central Sahara and across the Near East and surrounding regions (Sudan, Anatolia, central Syria, southern Israel, Mesopotamia, Cyprus), especially during the ‘long’ 4th millennium (~4500-3000) BCE when the region significantly aridified. In the Late Holocene, certain sub-environments in this region were able to sustain activities longer than others, but the Saharan region largely became inhospitable as surface water resources diminished, and populations moved to the Nile River corridor. The modern population relies significantly on irrigation strategies, both locally and at the massive scale, including groundwater pumping in Kharga and the Sudan, and the New Valley Project (also called the Toshka Project), an extensive system of canals that carries water from the Nile impoundment of Lake Nasser into the Western Desert area. Tracking the regional water systematics and quantifying the sensitivity of this region to hydroclimatic changes is critical in a globally warming world, especially in consideration of the highly populated Nile River Corridor.

Sustainability and Resilience in the Congo Basin: A Natural History Perspective

1 **KIAHTIPES Christopher A.**

1 Universität zu Köln, Institut für Ur- und Frügheschichte, Forschungsstelle Afrika, Jennerstraße 8 50823 Köln, Germany.

Abstract

In Africa, one of the most significant obstacles for meeting the dual challenges of sustainable development and biodiversity conservation is a lack of long-term studies of ecological and cultural responses to climatic change. This is especially so for the diverse, but increasingly threatened tropical forest zone. While paleovegetation reconstructions and studies of other climate proxies have demonstrated that there are important linkages between coupled ocean-atmospheric systems and the rain forest biome in tropical Africa, the spatial distribution of such studies in this region shows a strong bias towards marine records and lacustrine records closer to the Atlantic coast. The Congo Basin covers an area larger than India, but at the time of this writing there are fewer than six published pollen studies of Pleistocene or Holocene age from this region, none of which come from the extensive forest zone of the Democratic Republic of Congo.

Addressing the spatial gaps in paleovegetation and paleoclimatic studies in tropical Africa is necessary to better characterize modern climatic variability and to improve assessments of the sensitivity of African ecological and agricultural systems to climate change. Furthermore, developing case studies of vegetation responses at the relatively smaller scales of sub-basins or individual river catchments yields insights into long-term anthropogenic impacts that are harder to distinguish in marine or lacustrine records. Deep tropical peat deposits cored during recent fieldwork in the Mai Ndombe and Equateur provinces of the Democratic Republic of Congo yielded basal radiocarbon dates spanning from the Last Glacial Maximum (*ca*. 20 kya) through the Holocene (*ca*. 11 kya - present). Preliminary palynological analysis of these deposits provides the first data points documenting variability in tropical forest responses to major climatic changes and characterizing the ecological impacts of major cultural developments in the interior forests from the Democratic Republic of Congo during the last 20,000 years.

What will become the contrasted solar radiation conditions under which forests grow in Central Africa?

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Abstract

In the last millennia, the forests of Central Africa have experienced successive phases of expansion and contraction. From 4000 BP the forest block has retracted towards the equator in favor of savannas. By ~2000 BP, it was fragmented into several refuges from which it then recolonized the whole region.

What could be the future state of this forest block due to climate change is uncertain because the climate of Central Africa itself is among the least studied and less well understood. Actually most of the studies dedicated to Central Africa's climate focus on the current variability and future changes in rainfall and temperatures, although the mean climate is still poorly known, in particular its spatial disparities across the region. By focusing on the incoming solar radiation which is not a well known parameter, yet important for plants functioning, and on the diurnal time scale, which is not a well known time scale, yet crucial in equatorial areas, we highlight different climatic zones across Central Africa which match particularly well with the spatial distribution of the various forests types encountered. Applied to outputs from past and future climate scenarios, this novel approach developed for studying the current mean climate of Central Africa, might bring new perspectives for studies related to forests' vulnerability.

Development of the West-African Climate Assessment and Dataset (WACA&D)

1 **VERVER Gé**, 2 KAMGA Foamhoue Andre, 1 TANK Albert Klein, 1 SCHRIER Gerard vd, 3 UNDEN Per.

1 Royal Netherlands Meteorological Institute (KNMI), De Bilt, The Netherlands.
2 African Centre for Meteorological applications for Development (ACMAD)
3 Swedish Meteorological and Hydrological Institute (SMHI).

Abstract

Climate change in Africa has serious impacts on food security, water management, health and other sectors. To be able to anticipate and increase resilience to these changes, assessments are needed with a focus on climate extremes with large impacts, like delays in the rainy season onset, droughts or excessively wet periods. Access to meteorological observations from the past and present is essential, but unfortunately lacking in large parts of Africa.

The International Climate Assessment and Dataset (ICA&D) facilitates the collection and QC of observations, as well as the analyses and assessment of climate evolution in a certain region. It supports the Global Framework of Climate Services (GFCS). ICA&D provides, in a user-friendly way, basic climatological observations, derived user-oriented climate indices, trends and return periods. It provides a historical climatological perspective that is essential for impact studies (e.g. health, agriculture, water management, risk assessment), validation of climate and seasonal forecast models, and calibration of satellite observations. For Europe, an even more comprehensive description of the climate is obtained by regional re-analyses, in which the historical observations are assimilated into regional models to generate a consistent and detailed three dimensional description of the atmospheric state.

ICA&D is currently implemented in Europe (ECA&D), and further developed as part of the regional re -analysis project UERRA, which also includes data rescue activities to improve data coverage in Northern Africa. Other ICA&D implementations are operational in Southeast Asia (SACA&D) and South America (LACA&D). All ICA&D activities now include a high-resolution gridded data with daily temperature and precipitation data for e.g. verfication and calibration of regional climate models. An implementation for Western Africa is being proposed as part of a larger project with the CREWS (Climate Risk and Early Warning) initiative.

In this workshop, we will present ICA&D and the CREWS project for West Africa. The goal is to discuss with the participants the functionality of the ICA&D system to serve climate analyses, climate (impact) research and development of early warning systems for Western Africa. We also foster collaboration between countries in the region both with providers of the observational data, as well as with researchers and developers of climate services.

Climate impacts on ecosystem functions and services provided by African ecosystems : Lessons from Sub-Saharan Africa

1 **LINSTÄDTER Anja.**

1 Range Ecology and Management Group, Botanical Institute, University of Cologne, Germany.

Abstract

In Africa´s drylands, plant growth is mainly limited by low and variable rainfall, which constrains agricultural activities to livestock production. Thus, livelihood security relies heavily on forage provision from near-natural vegetation. A sustainable management requires a profound understanding of how ecosystem structure and functioning responds to changing climate and land-use. However, this ecological understanding is still surprisingly poor. In my talk I will give an overview on my various research activities in Africa's savannas and grasslands that aim at improving this critical understanding. My research combines space-for-time substitutions for climate change with experimental approaches, in particular experimental droughts.

As an example for a space-for-time-substitution, I will present results from several studies carried out along a steep spatial gradient of climatic aridity across West Africa's Sudanian savannas, from northern Ghana to central Burkina Faso. Here we used forage quantity (aboveground biomass), forage quality (metabolisable energy) and their product (metabolisable energy yield) as proxies for forage provision. Linear mixed-effect models and structural equation modelling were used to explore relationships between multiple environmental variables and ES proxies. We found that fluctuating weather conditions (antecedent rainfall) were most important for aboveground biomass. Our finding that antecedent rainfall was more important for forage provision than climatic aridity implies that the effects of changing climate may in a given year be overridden by current season's precipitation. The observed importance of land-use and vegetation properties implies that well-conceived adaptation strategies could mitigate potential negative effects of climate change.

Lake Bambili, Cameroon: 90 000 years of montane forest history in central Africa

1 **LÉZINE Anne-Marie**, 2 IZUMI Kenji, 2 KAGEYAMA Masa and 3 ACHOUNDONG Gaston.

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2 Laboratoire des Sciences du Climat et de l'Environnement/IPSL, CEA-CNRS-UVSQ-UMR8212, CE Saclay, l'Orme des Merisiers, 91191 Gif-sur-Yvette Cedex, France.
3 Institut de Recherche Agricole pour le Développement, Yaoundé, Cameroun.

Abstract

Mountains of Central Africa are particularly suitable for paleoenvironmental and paleoclimatic studies because they host a large number of sites favorable to the preservation of sedimentary archives. Moreover, they are true "hot spots" of biodiversity that harbor environments known to be extremely sensitive to climate change.

Lake Bambili (Cameroon) yields an exceptional pollen series which documents for the first time the history of the Equatorial montane forests and their vulnerability facing climate change over the last 90 000 years with a resolution of decades to centuries.

Here we discuss several aspects such as the evaluation of plant diversity, of biome distribution and of up and down movements of the upper treeline in relation to climate and CO2 changes. Quantitative reconstructions of relevant climate parameters are addressed via inverse modeling approach and model simulations.

This research is funded by the French ANR (IFORA et C3A project), the Belgium BELSPO (AFRIFORD project) and the IGFAGCR Belmont Forum (VULPES project) in close collaboration with IRD and IRAD in Cameroon.

Exploring genomic imprints left by past climate changes in Tropical Africa

1,2 MIGLIORE Jérémy, 1 LEZINE Anne-Marie, 2 HARDY Olivier J.

1 Laboratoire d'Océanographie et du Climat : Expérimentations et Approches Numériques (LOCEAN), UMR 7159 CNRS / UPMC / IRD, Université Pierre et Marie Curie, BP 100, 4 place Jussieu, 75005 Paris (France)
2 Université Libre de Bruxelles (ULB), Evolutionary Biology and Ecology (EBE), CP 160/12, 50 avenue F.D. Roosevelt, 1050 Bruxelles (Belgium)

Abstract

Understanding the evolutionary history of Tropical African forests is a prerequisite to predict their resilience capacity to ongoing and future environmental changes. According to palaeoecological proxies, the story of African forests is closely linked to Plio-Pleistocene climate oscillations: the contraction of forest cover during cold and dry glacial periods was counterbalanced by its expansion during warmer and wetter interglacial episodes. However, the role of climate as motor of evolution of tree species is difficult to assess with palaeoecology at a fine taxonomical scale, and there is still much uncertainty regarding the spatio-temporal species turnover, the intensity of past forest fragmentation, the size and location of forest refugia during glacial maxima. Phylogeography can thus be a key proxy to study the response of trees to past climate changes, since genetic lineages bear the signal of past range dynamics and population size fluctuations (e.g., population bottlenecks, expansion, and/or migration).
In this context, we are studying the evolutionary history of three key species belonging to distinct functional groups. In Central Africa we included the rainforest long-living and shade-tolerant tree *Greenwayodendron suaveolens* (Annonaceae), and the pioneer and short-living tree *Musanga cecropioides* (Urticaceae). With the VULPES project, we focus on the afromontane *Podocarpus latifolius* (Podocarpaceae), patchily distributed in Eastern and Central African highlands. While populations of lowland rainforest species are expected to have expanded during interglacial periods and have retracted and fragmented during glacial periods, the opposite pattern is expected for populations of montane species. Genomic data were developed using next generation sequencing tools through both the capture of chloroplast genomes and nuclear DNA microsatellites genotyping on an extensive sampling, covering the distribution range of each taxon. The high levels of polymorphism detected provide a very detailed phylogeographical signal to infer the evolutionary history of populations. Both populations of *Greenwayodendron* and *Musanga* are characterized by distinct phylogroups, geographically distributed. These populations could have been fragmented into a restricted number of refugial areas in the past that seem to display diverse demographic signatures. Molecular dating provide a more precise temporal framework for comparing speciation and the diversification of each phylogroup, and the role of their life history traits in terms of resilience during glacial/interglacial oscillations. Including *Podocarpus* trees, the role of tropical mountains as museums/cradles of biodiversity, the latitudinal connections between Eastern and Central Africa, and the effects of habitat fragmentation will thus be discussed.

Oral presentations (S3):

Tropical teleconnections and Monsoon systems

Credit: RC & MC (Senegal)

Exploration of West and Southern Africa precipitation responses during recent El Niño events.

1 POMPOSI Catherine, 2 GIANNINI Alessandra, 3 KUSHNIR Yochanan, 4 BIASUTTI Michela, 5 FUNK Chris, 6 SHUKLA Shrad

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6 Climate Hazards Group (CHG), 4717 Ellison Hall, University of California, Santa Barbara Santa Barbara, CA, 93106.

Abstract

The El Niño Southern Oscillation (ENSO) is a leading mode of interannual precipitation variability throughout the semi-arid tropics, which includes parts of West and Southern Africa. Interannual precipitation variability linked to ENSO can have drastic impacts on agricultural systems and food resources. This highlights a need for increased information regarding ENSO's links to sub-seasonal to seasonal precipitation variations in such precarious regions. The present work describes two case studies on recent precipitation variability during warm ENSO events (El Niño) for the West African Monsoon season (June-September) and the austral summer rainy season (December-February) in Southern Africa. Using a blending of observational and model data, it is found that for West Africa, recent El Niño years have resulted in wetter than normal conditions when the sub -tropical Atlantic plays a modulating role and increases moisture supply to the region. For Southern Africa, it is found that the probability distribution of precipitation varies according to the strength of El Niño events. Strong El Niño events show a much clearer tendency for drying than moderate or weak events, which have smaller absolute magnitude anomalies and larger spatial heterogeneity in the precipitation response. A dynamical exploration of the various precipitation responses is also completed for the two regions. Finally, my talk will lastly explore the channels by which seasonal forecasting information is disseminated locally and utilized by the Famine Early Warning Systems Network in Africa to ward off potential food security crises.

Speleothem-based Climate Reconstructions and Teleconnection Patterns during the Last Millennium in NW Africa

1,2 **AIT BRAHIM Yassine**, 3 SIFEDDINE Abdelfettah, 2 CHENG Hai, 4 WASSENBURG Jasper A., 3 KHODRI Myriam, 5 CRUZ Francisco W., 1BOUCHAOU Lhoussaine

-

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Abstract

Herein, we present new paleoclimate records from two well dated Moroccan speleothems. Our stalagmites were sampled from Ifoulki cave in the Western High Atlas Mountains in SW Morocco and Chaara cave in the Eastern Middle Atlas Mountains in NE Morocco. The new paleo-records cover the last 1000 years with a high resolution and reveal substantial swings of dry and humid periods with decadal to multidecadal frequencies. The Medieval Climate Anomaly (MCA) is characterized by generally dry conditions, while wetter conditions are recorded during the Little Ice Age (LIA) and a trend towards dry conditions during the 20th century. These observations are consistent with regional climate signals, providing new insights on common climate controls and teleconnection patterns in NW Africa. We emphasize that the hydro-climate conditions in Morocco remained under the influence of the Atlantic Multidecadal Oscillation (AMO) and the North Atlantic Oscillation (NAO). At longer timescales, we hypothesize that the generally warmer MCA and colder LIA influenced the regional climate in NW Africa through interactions with local mechanisms, such as the Sahara Low, which weakened and strengthened the mean moisture inflow from the Atlantic Ocean during the MCA and LIA respectively.

Between wet, dry and hyperarid: Climatic changes during the last >500 ka in the Chew Bahir basin, a key HSPDP site in southern Ethiopia

1 FOERSTER Verena E, 2 ASRAT Asfawossen, 3 COHEN Andrew S, 4 DEINO Alan, 5 DEOCAMPO Daniel M., 6 DUESING Walter, 6 GUENTER Christina, 7 JUNGINGER Annett, 6 KRAEMER Hauke, 8 LAMB Henry F, 8 ROBERTS Helen M, 1 SCHAEBITZ Frank, 6 TRAUTH Martin H.

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4 Berkeley Geochronology Center, Berkeley, USA,
5 Georgia State University, Department of Geosciences, Atlanta, USA,
6 University of Potsdam, Institute of Earth and Environmental Science, Potsdam, Germany,
7 Eberhard Karls Universität Tübingen, Department of Earth Sciences, Tübingen, Germany,
8 Aberystwyth University, Department of Geography and Earth Sciences, Aberystwyth, UK

Abstract

As a contribution towards an enhanced understanding of human-climate interactions, the Hominin Sites and Paleolakes Drilling Project (HSPDP) has cored six predominantly lacustrine archives of climate change spanning much of the last ~3.5 Ma in East Africa. All five sites in Ethiopia and Kenya are adjacent to paleoanthropological key sites encompassing diverse milestones in human evolution, dispersal, and technological innovation. The 280 m-long Chew Bahir sediment records, recovered from a tectonically-bound basin in the southern Ethiopian rift in late 2014, cover the past 550 kyr of environmental history, a time period that is marked by intense climatic changes and includes the transition to the Middle Stone Age, and the origin and dispersal of modern Homo sapiens.

We will present the outcome of lithologic and stratigraphic investigation of the composite core, first interpretations of high resolution MSCL and XRF scanning data, as well as initial results of detailed multi-proxy analysis of the Chew Bahir cores. These analyses are based on more than 14,000 discrete subsamples, including grain size analyses and X-ray diffraction. An initial chronology, based on Ar/Ar and OSL dating, allows the first reconstructions of dry-wet cycles during the last ~550 ka. Both geochemical and sedimentological results show that the Chew Bahir deposits are sensitive recorders of changes in climate in the area. First statistical analyses point towards phases that are marked by abrupt climatic changes, whereas several long-term wet-dry oscillations reveal variations mostly in the precession (~15-25 kyr), but also in the obliquity (~40 kyr) and eccentricity frequency bands (~90-120 kyr).

The Chew Bahir record will help us to decipher climate variations on different time scales as a consequence of orbitally-driven high-latitude glacial-interglacial shifts and variations in greenhouse gases, variations in Indian and Atlantic Ocean sea-surface temperatures, as well as local variations in solar radiation. The ~550 kyr record of environmental change in East Africa will ultimately help us to test current hypotheses regarding the impact of climate variability on human evolution, dispersal and technological innovation.

Simultaneous responses of organic carbon turnover and silicate weathering to past hydroclimate changes in Central Africa

1**SKONIECZNY Charlotte**, 2 BAYON G, 3 SCHEFUß E, 4 MOLLENHAUER G, 2 TOUCANNE S, 5 BOUILLON S, 6 THIÉBLEMONT D, 2 ETOUBLEAU J, 2 CHÉRON S, 7NONNOTTE P, 7ROUGET M.-L, 2GERMAIN Y, 2PONZEVERA E, 2 DENNIELOU B, 8 MARRET F.

1 GEOPS_Université Paris-Sud_Orsay_France,
2 IFREMER_Géosciences Marines_Plouzané_France,
3 MARUM_University of Bremen_Bremen_Germany,
4 AWI_Bremerhaven_Germany,
5 E&ES_ K.U. Leuven _Leuven_Belgium,
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Abstract

Recent studies on riverine discharge of large monsoon-dominated watersheds in Africa have greatly improved our understanding of the response of organic carbon turnover and weathering of silicate rocks to past hydrological changes (e.g., Schefuß et al., 2016; Bastian et al., 2017). While these findings have important implication for the global links between climate, continental erosion and carbon cycle in the past, the relationships between the organic and inorganic sediment fractions preserved in marine sediment records of past African river discharges are not yet well understood. Here, to provide better insights into potential linkages, we investigated a marine sediment core from the Eastern Equatorial Atlantic Ocean that provides a record of past precipitation changes as well as terrigenous organic carbon (source, age, type and freshness) and clay fraction (provenance, chemical weathering) compositions. This multi-proxy approach was conducted on core MD03-2708cq (01°10.33'S; 08°19.01'E, 920mbsl) located off the Ogooué River mouth (Gabon) between the Sanaga and the Congo River basins on the Gulf of Guinea margin. We show that during the last deglaciation (from 18ka to mid-Holocene), when significant changes in precipitation occurred in Central Africa (Schefuß et al., 2005), both organic carbon turnover and silicate weathering responded simultaneously to hydroclimate changes. Because rivers play a critical role in connecting terrestrial, oceanic and atmospheric carbon reservoirs, these findings emphasize on the importance of erosion processes in intertropical river basins to the global carbon cycle, with implications concerning future African and global hydroclimate change scenarios.

Bastian et al., 2017 - Scientific Report, doi: 10.1038/srep4431

Schefuß et al., 2005 - Nature, doi:10.1038/nature03945

Schefuß et al., 2016 - Nature Geoscience, doi:10.1038/NGEO2778.

Anthropogenic forcing brings Sahel drought to unprecedented level in the past 1600 years

1**CARRE M.**, 2AZZOUG M., 3CAMARA A., 4CHEDDADI R., 5GAYE A., 1JANICOT S., 1KHODRI M., 1LAZAR A., 1LAZARETH C.E., 1MIGNOT J., 6WADE M.

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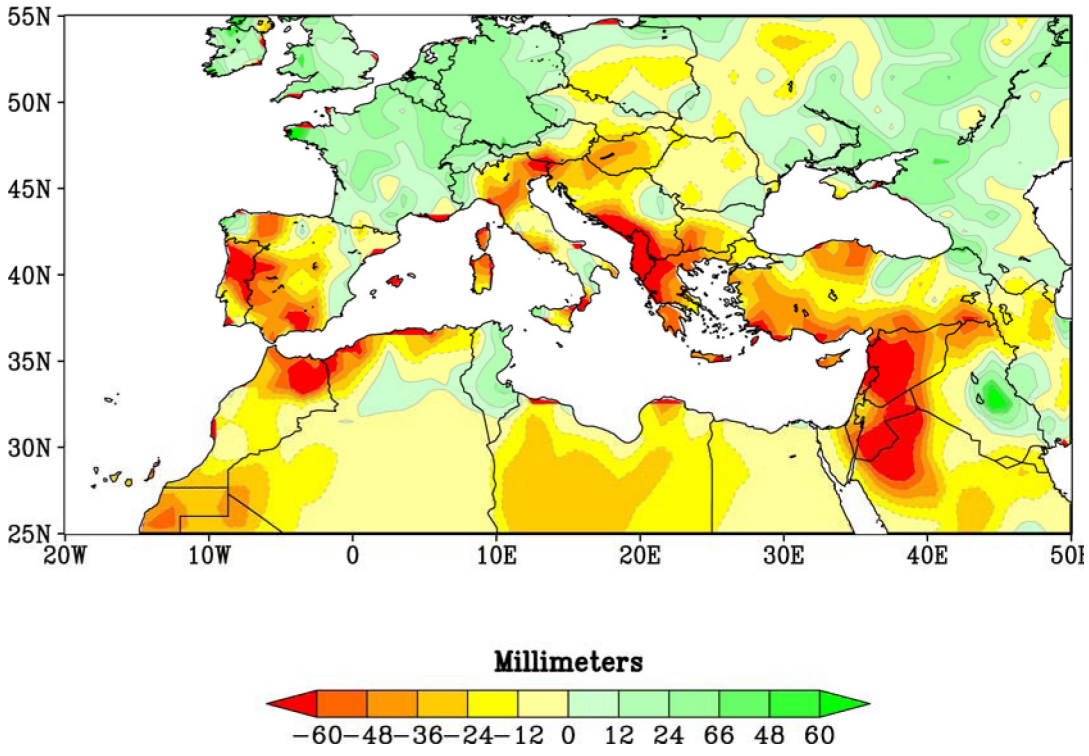
Abstract

The future response of Sahel rainfall to anthropogenic global warming is still highly uncertain because of climate model difficulties in simulating the West African Monsoon, and because of the shortness and scarcity of observational climate data in the region. Robust instrumental records of rainfall in the Sahel extend back to ~AD 1900. During this period, rainfall variability is primarily dominated by multidecadal variability associated to the Atlantic multidecadal oscillation. A multi-centennial perspective is required to properly assess the relationship between the slow global warming trend and the Sahel hydroclimate, and to compare the current climate to pre-industrial connditions. We present here a new record of hydrologic conditions over the past 1600 years in Senegal, obtained from stable oxygen isotope analyses ($\delta^{18}O$) in archaeological shell middens in the Saloum Delta. Regression analyses show that rainfall in this location co-varies with rainfall of the whole Sahel band on seasonal to decadal timescales, supporting this record as representative of Sahel conditions. During the preindustrial period, the region was relatively humid, with maximum humidity reached between AD 1500 to AD 1800, during the coolest period of the last two millennia, referred to as the Little Ice Age (LIA). A strong and significant negative correlation is observed at the centennial scale between global temperature records and our record of Sahel humidity. This is in direct contrast with the relationship observed elsewhere in the northern tropics, where the LIA is generally associated to dry conditions as a response to a southern shift of the Intertropical Convergence Zone (ITCZ). Our results show that the processes linking the ITCZ and the West African Monsoon (WAM) at the centennial timescale are more complex than previously thought. In the context of the past 1600 years, the Western Sahel appears to be experiencing unprecedented drought conditions, resulting from a rapid aridification since AD 1800 that points to local and global anthropogenic forcings. This new long-term perspective suggests that the recent relative recovery of rainfall in the Sahel may just be a short-term phase. Although climate forcings have evolved through the past 1600 years and may not apply in the future, our record does highlight that Sahel aridity of the industrial period is beyond the natural variability and supports scenarios of increasing risk of catastrophic Sahel droughts if global temperature keeps rising.

Oral presentations (S4):

The Mediterranean region



Reds and oranges highlight lands around the Mediterranean that experienced significantly drier winters during 1971-2010 than the comparison period of 1902-2010. Credit: NOAA

Read more at: https://phys.org/news/2011-10-human-caused-climate-major-factor-frequent.html#jCp

Monsoon-Mediterranean climate inter-relations in North Africa and Southwest Asia over a hierarchy of timescales.

1 **ROBERTS Neil**

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Abstract

Major changes have occurred in the spatial extent of both tropical "monsoonal" and mid-latitude westerly precipitation zones during the current interglacial period. Regions between latitude 15˚ and 40˚ have received moisture from both - or from neither - of these sources at different times during the last ~10 millennia. The Saharo-Arabian arid zone possesses broadly distributed palaeo-limnological and palaeo-vegetation data sets, making it well suited for tracing past changes in north-south moisture gradients. This potential was recognised three decades ago by Fontes and Gasse (1991) in their pioneering PALYDAF project. In this paper I use modern and palaeo-precipitation data across latitudinal transects to track the respective influences of "monsoonal" and westerly (Atlantic-Mediterranean) moisture sources over different timescales.

At the present-day, there is no interaction between summer and winter rainfall regimes in North Africa, where a true arid zone exists between 20˚ and 30˚N associated with the descending limb of the Hadley Cell circulation. During the early-mid Holocene, orbital forcing led to a strengthened monsoonal circulation, which resulted in a pronounced expansion in the zone of summer rainfall in the Old World sub-tropics. Beyond the northern limit of "monsoonal" rains, lake, cave and marine isotope data show that the climate was also wetter than today, especially in the east Mediterranean. The Hadley Cell circulation was therefore squeezed from both sides of the Saharo-Arabian arid zone at the same time. This synchronous “wetting up” stands in contrast to the last millennium, including the instrumental period, when precipitation variations in the monsoon and Mediterranean climate domains have been largely decoupled. This suggests a scalar relationship between the amplitude of hydro-climate change and its spatial footprint (i.e. bigger magnitude changes affect larger areas), potentially linked to feedback effects involving land cover and moisture recycling (e.g. Perez-Sanz et al., 2014).

- Fontes, J.-C. and Gasse, F. (1991) *Palaeogeog, Palaeoclim, Palaeoecol*. 84, 191-215.
- Gasse, F. and Roberts, C.N. (2004) In: H. F. Diaz and Bradley, R.S. (eds.). *The Hadley Circulation: Present, Past & Future.* Kluwer, Dordrecht, pp. 313-345.
- Perez-Sanz, A., G. Li, P. González-Sampériz, and S. P. Harrison 2014, Evaluation of modern and mid-Holocene seasonal precipitation of the Mediterranean and northern Africa in the CMIP5 simulations. *Clim. Past*, 10, 551-568

Speleothem records of rainfall in central North Africa: 500,000 years of history, and fluid inclusion evidence for changes in atmospheric moisture transport

1 ROGERSON Mike, 2 DUBLYANSKI Y., 3 HOFFMANN D.L., 2 LUETSCHER M. and 2 SPÖTL C.

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Abstract

Atmospheric latent heat is a major component of global and regional climate energy budgets and changes in its amount and distribution are key aspects of the climate system to constrain. Equally, in mid- and low latitude regions, the aspect of past climate change that has had the most impact on landscapes and ecosystems is changes in the water cycle. Rainfall in semi-arid regions is also amongst the climate parameters human society is most sensitive to. Constraining past water cycle changes within the arid mid-latitudes is therefore a globally significant research priority. Here, we present new evidence for periods of increased rainfall periods through the last 500,000 years derived from Tunisian speleothems. We also present speleothem-based fluid inclusion, strontium isotope and stable isotope data for a record in northeastern Libya spanning MIS 3 and demonstrating 15 newly identified humid periods during this time-period. Comparison to modern rainfall isotope data shows that fluid inclusion water is likely unmodified rainfall water, but that waters of significantly different composition are preserved in at least two families of inclusions. The whole population of measurements indicates that more than one rainfall system is represented in the fluid inclusion dataset, with moisture advection from both the west (Atlantic) and the east (Levant). We discuss different scenarios which can explain this geochemical behaviour, including changes to sources, rainfall seasonality and impact from the amount effect. Demonstration of humid periods during MIS 3 in Cyrenaica are of great significance to understanding human populations and migration through central North Africa, and we discuss the implications of the changes in the annual cycle we observe to regional human prehistory.

Past droughts and flooding in the Levant as indicators of changes in Mediterranean and African climate.

1 KIRO Yael, 1 KUSHNIR Yochanan, 1 GOLDSTEIN Steven L.

1 Lamont-Doherty Earth Observatory, Columbia University.

Abstract

The Mediterranean climate of the past decades is characterized by a drying trend, which is attributed to climate change, and is expected to continue into the future. The cause of the drying in the Eastern Mediterranean is related to the decrease and weakening of Mediterranean winter storms. Despite the drying trend, observations show increase in the intensity of storms and flooding, particularly in the northern edges of the Saharan-Arabian desert belt, as a result of an increase in the Red Sea Trough frequency. The ICDP Dead Sea Deep Drilling Project (DSDDP) reveals thick sections of halite, representing the most arid intervals of the last interglacial (Marine Isotope Stage 5e) and the Holocene. During that time the average runoff in the Dead Sea watershed decreased to 30-50% of the present runoff (pre-1964) over thousands of years, reaching 20% of the present runoff in the most arid intervals, spanning decades. The most arid times, however, are associated with an increase in flash floods and precipitation in the northern edges of the Saharan-Arabian desert belt. These are evident from 234U/238U ratios in authigenic minerals in the DSDDP cores that show a shift to southern and eastern sources of the Dead Sea. This reflects a significant decrease in Mediterranean winter storm activity, which is the most dominant system in the present Levant climate, and an increase in Active Red Sea Trough activity. Climate model runs of the last interglacial agree with the observations and show significant changes in precipitation between 125 and 120 thousand years ago as a result of the large changes in insolation. The model shows a decrease in winter precipitation at 120 thousand years, when the thickest salt layer occurs in the DSDDP cores, and an increase in fall precipitation due to relative increase in tropical rainfall.

Climate conditions of desert dust transport from the Sahara- desert to the last interglacial Red Sea-Dead Sea from Nd-Sr compositions of sediment cores

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Abstract

The sediments deposited at the depocenter of the Dead Sea comprise high-resolution archive of hydrological changes in the lake's watershed and record the desert dust transport to the region. This paper reconstructs the dust transport to the region during the termination of glacial Marine Isotope Stage 6 (MIS 6; ~ 135-130 ka) and the last interglacial peak period (MIS5e, ~ 129-116 ka). We use chemical and Nd and Sr isotope compositions of fine detritus material recovered from sediment core drilled at the deepest floor of the Dead Sea. The data is integrated with data achieved from cores drilled at the floor of the Red Sea, thus, forming a Red Sea-Dead Sea transect extending from the desert belt to the Mediterranean climate zone. The Dead Sea accumulated flood sediments derived from three regional surface cover types: settled desert dust, mountain loess-soils and loess-soils filling valleys in the Dead Sea watershed termed here "Valley Loess". The Valley Loess shows distinct 87Sr/86Sr ratio of 0.7081 ± 1, inherited from dissolved detrital calcites that originate from dried waterbodies in the Sahara and transported with the dust to the entire transect.
Our hydro-climate and synoptic conditions reconstruction illustrates the following history: During glacial period MIS6, Mediterranean cyclones governed the transport of Saharan dust and rains to the Dead Sea watershed, driving the development of both mountain soils and Valley Loess. Then, at Heinrich event 11, dry western winds blew Saharan dust over the entire Red Sea - Dead Sea transect marking latitudinal expansion of the desert belt. Later, when global sea-level rose, the Dead Sea watershed went through extreme aridity, the lake retreated, depositing salt and accumulating fine detritus of the Valley Loess. During peak interglacial MIS 5e, enhanced flooding activity flushed the mountain soils and fine detritus from all around the Dead Sea and Red Sea, marking a significant "contraction" of the desert belt. At the end of MIS 5e the effect of the regional floods diminished and the Dead Sea and Red Sea areas re-entered sever arid conditions with extensive salt deposition at the Dead Sea.

The climate of Interglacial Africa and its links to the East Mediterranean

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Abstract

During the last interglacial, between 130 ka and 115 ka (or MIS 5e), marked variation occurred in climate of Africa in response to changes in summer insolation. The climate response to insolation variations have been simulated by coupled climate models that indicate advance and retreat of the African summer monsoon system. Models also simulate changes in winter precipitation within the Mediterranean Basin and the surrounding land areas. These climatic changes left their imprint in a sediment core extracted from the bottom of the Dead Sea (DS) lake, in the Eastern Mediterranean Levant. Here, we examine key results from the analysis of the DS core that provide robust evidence to concomitant changes in the regional climate. Moreover, the core analysis provides clues as to the reliability of climate model simulations of the African climate response to insolation variations during the last interglacial and the overall links between the African climate system and the climate of the Eastern Mediterranean.

The core analysis displays a wet period during the summer insolation peak at 125 ka that is consistent with model results (here the NCAR CCM3) that exhibits a marked northeastward penetration of the African summer monsoon into the East Mediterranean. The wetting is also supported by the model results that show an increase in winter precipitation in the entire Mediterranean Basin. The model simulations indicate that as Northern Hemisphere summer insolation weakens there is a return to a summer monsoon system that is confined to its present latitudes. At the same time, the DS core exhibits extremely arid intervals indicated by thick salt deposits. The most arid period starts around 120 ka, when according to climate models there is also a decrease in winter precipitation in the Mediterranean Basin. Interestingly however, we find evidence that during this MIS5 interval, there is a relative increase in intense precipitation events and flooding surrounding the DS, at the northern edges of the East Mediterranean desert belt. This is indicated by a high 234U/238U ratio in the lake sediments. The model 120 ka simulation shows that the African Monsoon intensifies during the fall season with appearance of intense tropical convection activity over east Africa (Ethiopia). In the present climate, desert flooding events occur during the fall associated with similar East African fall monsoon activity thus the change in the Uranium isotope ratio appear to lend further support to the climate model reliability.

North African land surface responses to Holocene climate variability: an assessment

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Abstract

In current literature, the term 'African Humid Period' (AHP) is used uncritically to denote the Early to Middle Holocene climate during 11–5.5 ka. In the Sahara, this phase is marked by northward expansion of the African monsoon across the southern and central Sahara, generating higher precipitation and a more abundant plant cover. The term AHP implies a ubiquitous wet phase. However, the reality is more complex. Some parts of North Africa were not wetter than they are today. Furthermore, fluctuations in late Quaternary White Nile flood levels reveal considerable hydrologic variability during this phase, recorded also in fluctuating lake levels in East Africa, with episodes of prolonged aridity during the so-called AHP.

In the Sahara, the onset of this phase and its environmental dynamics are relatively well known, thanks to a large number of studies carried out at many sites using a variety of proxy evidence. There is far less agreement on when and how rapidly or slowly the AHP might have ended towards 5 ka, chiefly owing to a lack of well-dated and continuous continental stratigraphic sequences. Marine sediment cores seem to show an abrupt end to the AHP, but inland sites show a diachronous response from north to south and from east to west. The local geomorphic response to climate change was also highly variable.

Growing information is also available for the human responses to landscape changes in North Africa during this climatic transition. Much recent archaeological literature links the transition to aridity to the collapse of civilizations, abandonment of regions, and demographic drops. In spite of data from selected contexts, this deterministic view has often been assumed in the archaeological reconstructions of past cultural trajectories in the Sahara, overshadowing local developments, cultural adjustments, and signs of continuity in human occupations. In this contribution, we review the available literature in regard to the AHP, and critically evaluate proxy data, which more directly record changes in the landscapes. Finally, we offer a different perspective on the effects of the Mid -Holocene climatic transition on prehistoric and historic populations and highlight their contribution to late Holocene societal re-organization.

Timescales and drivers of Holocene environmental change in the Middle Atlas, Morocco: Insights from the Lake Sidi Ali palaeoecological record

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2 Institut des Sciences de l'Evolution de Montpellier, Montpellier University, France, 3 Institute of Geography, Leipzig University, Leipzig, Germany,
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5 Institut National des Sciences de l'Archéologie et du Patrimoine, Rabat, Morocco.

Abstract

Northwest Africa represents an important transition zone between the temperate and tropical latitudes where the Atlantic, Mediterranean and Saharan climate systems interact. In the face of projected 21st century climate changes including increased regional heat and drought stress, it is important to understand the nature of environmental response to past climate variability. Palaeoecological records provide vital evidence regarding the timing and nature of past changes in vegetation cover and fire regime and can help improve the assessment of climate vulnerability for key ecosystems and species. Here, drawing on recent studies at Lake Sidi Ali in the Middle (Moyen) Atlas (33°03'N, 5°00'W, 2080 m.a.s.l.) including high resolution palynology in the context of a multiproxy investigation constrained by AMS radiocarbon dating, we present the history of vegetation and fire dynamics for the last 12,000 years at sub-centennial-scale resolution. The record documents a long-term transition from (a) steppic landscapes at the onset of the Holocene, to (b) open sclerophyll vegetation with evergreen *Quercus* in the early Holocene, (c) colonization by montane forest with *Cedrus atlantica* from the mid-Holocene, and (d) incipient matorralization and finally degradation of the forest cover during the Late Holocene. Superimposed on the long-term trends are fluctuations in vegetation cover at millennial and centennial timescales. The record reveals the important influence of climatic drivers at multiple timescales, including orbital (multi-millennial) changes, millennial-scale climate variability linked to North Atlantic cooling episodes, and centennial-scale hydrological fluctuations associated with atmospheric circulation changes similar to the North Atlantic Oscillation. The findings highlight the important interaction of climatic variability at different timescales and renew interest in the still open question of the fundamental forcing factors for rapid climate changes in Africa, including threshold responses to insolation changes, solar variability and internal oscillations in the global climate system. This work highlights the strong exposure of montane ecosystems in Northwest Africa to climate variability and emphasises the important role that palaeoecological investigation must play in the assessment of future climate change impacts.

Eastern Maghreb Holocene climate changes and their drivers during the Holocene: An assessment based on palaeoecological record from Southern Tunisia

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Abstract

Although North African arid lands and desert margins are key areas to understand Holocene climate changes and their drivers between low and high latitude, palaeoecological records from these area are still scarce. In our talk, we will present new pollen and clay minerals data from Southern Tunisia allowing i) to trace the climatic and environmental dynamics in the lower arid bioclimatic belt during the last 8000 years and ii) to discuss the connection between climate events and global drivers during the Holocene.

Both pollen and clay minerals data from Sebkha Boujmel indicate an important long-term aridification trend that initiated between ca. 5.7 and 4.6 ka and ended around 3 ka by the establishment of pre-desert ecosystems. Aquatic pollen grains and clay minerals are sensitive proxies in our record which point to a rapid shift toward aridity coeval with the African Humid Period rapid termination between 5.3 and 4.6 ka. These data may indicate an important impact of the Earth's orbital enhanced insolation generating a humid period in the southern Mediterranean area synchronous with the AHP.

Eight Rapid Climate Changes (RCCs) are recorded in Sebkha Boujmel during the Middle and Late Holocene at ca. 8–7.75, 7–6.5, 5.75–5.5, 4.9–4.6, 3.7–3.25, 3–2, 1.4– 1.1 and 0.4–0 ka BP. Comparison with available palaeoecological records both in the Mediterranean and in the Sahara allow the identification of two major trends. From 8 to 3 ka, five arid events are recorded in Southern Tunisia for which drivers are still to be discussed. These events can more or less be connected with those previously documented further south in the Sahara, such as the end of the AHP, and also to events recorded in the Mediterranean. Since 3 ka, the arid episodes recorded in Sebkha Boujmel sediments are well correlated with the late Holocene North Atlantic Cooling events. Moreover, the climate trend of southern Tunisia during the last millennium (Medieval Climate Anomaly and Little Ice Age) confirms a contrasting climate pattern across the Mediterranean Basin triggered by the differential impact of the North Atlantic Oscillations (NAO) and the Mediterranean Oscillations (MO).

Refining plant traits in vegetation models using forest inventory and LAI measurements. An application to the modelling of *Cedrus atlantica* in the Rif Mountains with the CARAIB model.

1 HENROT Alexandra-Jane, 2 HAMBUCKERS Alain, 1 **FRANÇOIS Louis**, 3 CHEDDADI Rachid, 1 TROLLIET Franck, 4 FETTWEIS Xavier, 1 DURY Marie, 2PORTEMAN Kristof

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Abstract

It appears today established that climate change will alter biodiversity, since the migration speed of many species, especially plants, are presumably too small to follow climate change. Mountain ecosystem floras of Mediterranean regions are particularly vulnerable to the climatic threat, because they combine high ecosystem diversity and large proportion of endemic species, with the risk of reaching the summits of the mountains which would limit their migration. Moreover, these environments are often strongly impacted by man. Being able to identify and predict the areas favourable to the species – microrefugia - becomes crucial in view of the fragmentation of the space devoted to their conservation. Dynamic vegetation models (DVMs) are well-designed tools for performing such projections, since they incorporate the physiological effects of CO2. However, they are usually run at the plant functional type level (PFT), whereas conservation studies require specific projections for each individual species. Thus, some efforts focus now on applying DVMs at species level, refining the definition of morphophysiological parameters from initial PFT traits to specific traits collected in the field or found in trait databases.

Here we simulated the modern distribution of *Cedrus atlantica*, an endangered species of the north Africa mountains with the CARAIB DVM (Dury et al., iForest - Biogeosciences and Forestry, 4:82-99, 2011), over the Rif Mountains. Model results in terms of biomass and NPP are evaluated against data coming from forest inventory and LAI measurements. Morphological traits of *C. atlantica* derived from plant material collected in situ (such as specific leaf area, C:N ratio of leaves, etc) are adapted in the model simulation. CARAIB is run at high resolution using either climatic inputs derived from the Climate Research Unit climate dataset combined with WorldClim climatology at 30 arc sec or the ouputs of a 5 km resolution simulation of the regional climate model MAR (Fettweis et al., The Cryosphere, 7 :469-489, 2013) over the focal area.

Past climate changes in Northern Morocco and the persistence of species in microrefugia

1 CHEDDADI Rachid, 2 HENROT Alexandra, 2 FRANCOIS Louis, 3 BOYER Frédéric, 4 BUSH Mark, 5 CARRE Matthieu, 3 COISSAC Eric, 6 DE OLIVEIRA Paulo, 3 FICETOLA Francesco, 7 HAMBUCKERS Alain, 8 HUANG Kangyou, 5 LEZINE Anne-Marie, 1 NOURELBAIT Majda, 9 RHOUJJATI Ali, 3 TABERLET Pierre, 10 SARMIENTO Fausto, 11 ABEL-SCHAAD Daniel, 11 ALBA-SANCHEZ Francisca, 7 ZHENG Zhuo

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8 School of Earth Science and Geological Engineering, Sun Yat-sen University, Guangzhou, China
9 Université Cadi Ayyad, Faculté des Sciences et Techniques, Laboratoire Géoressources, Marrakech, Morocco 10 Department of Geography, University of Georgia, Athens, GA. USA
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Abstract

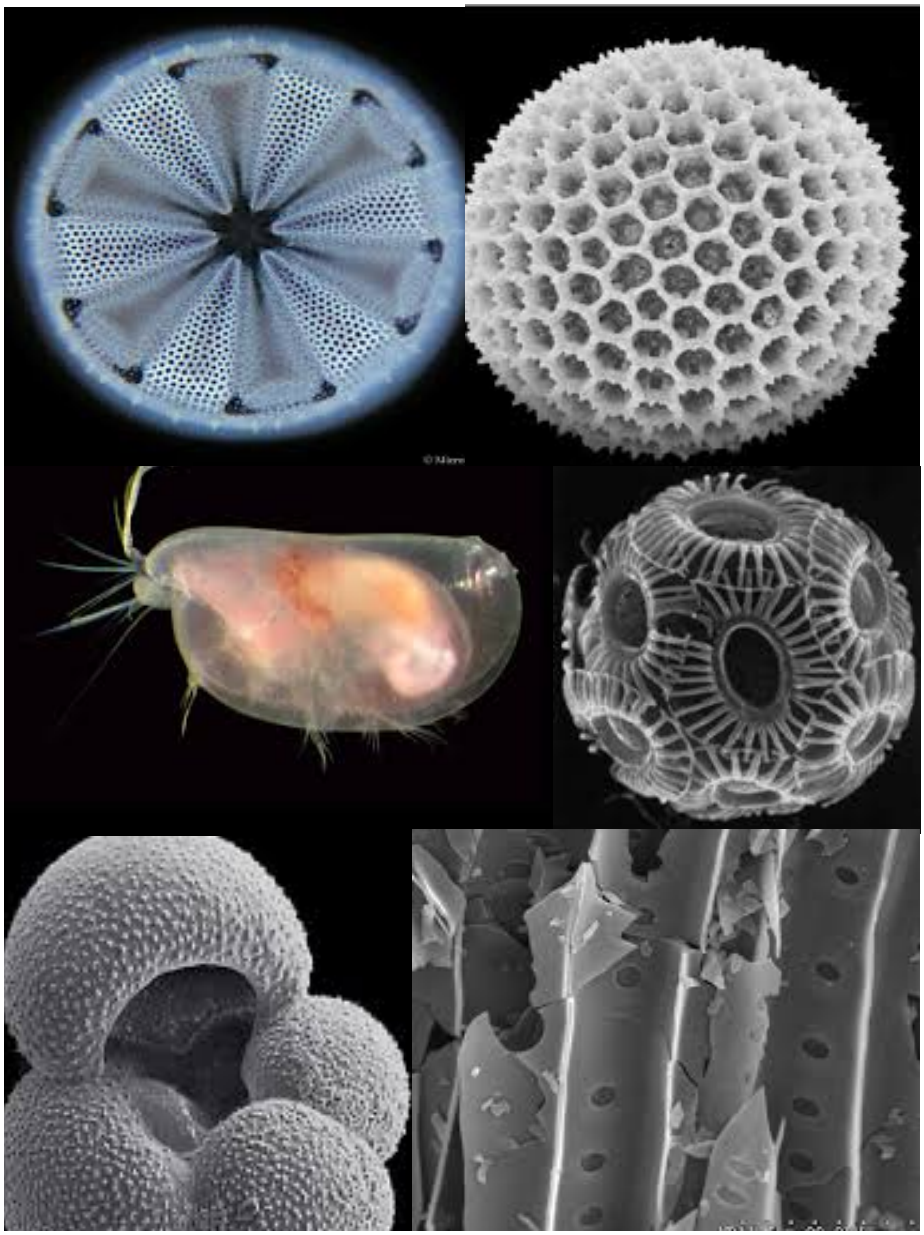
The aim of this study is to reconstruct and interpret the evolving range of Atlas cedar in northern Morocco over the last 9,000 years. A synthesis of fossil pollen records indicates that Atlas cedars occupied a wider range at lower elevations during the mid-Holocene than today. The mid-Holocene geographical expansion reflects low winter temperatures and higher water availability over the whole range of the Rif Mountains relative to modern conditions. A trend of increasing aridity observed after 6000 years BP progressively reduces the range of Atlas cedar and prompts its migration towards elevations above 1400 masl.

To assess the impact of climate change on cedar populations over the last decades, we perform a transient model simulation for the period between 1960 and 2010. Our simulation shows that the range of Atlas cedar decreased by about 75% over the last 50 years and that the eastern populations of the range in the Rif mountains are even more threatened by the overall lack of water availability than the western ones.

Today, Atlas cedar populations in the Rif Mountains are persisting in restricted and isolated areas (Jbel Kelti, Talassemtane, Jbel Tiziren, Oursane, Tidighine) that we consider to be modern microrefugia. Conservation of these isolated populations is essential for the future survival of the species, preserving polymorphisme and the potential for population recovery under different climatic conditions.

Oral presentations (S5):

Land-Ocean links



Molecular paleo-hydrology and controls on African hydroclimate

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Abstract

Next to insolation and human interference shifting temperature pattern on the surface ocean due to ocean circulation changes are a critical controlling factor of African hydroclimate variability due to their effects on atmospheric circulation and moisture transport. Marine sedimentary archives offshore large river catchments and dust source areas offer the opportunity to investigate continental and oceanic climate changes in parallel on the same samples with excellent age control. 'Classical' proxy parameters to assess terrestrial (e.g., pollen, terrigenous elements) environmental and discharge changes as well as marine (e.g., microfossil isotopes and elemental composition) circulation and temperature changes have been complemented by new organic proxy parameters for investigating continental hydrologic (compound-specific hydrogen isotopes) and vegetation type changes (compound- specific stable carbon isotopes, C3/C4 plants). These proxies have been refined over the last decade and provide, in combination with established ones, novel insights into driving forces of African hydroclimate and environments on various spatial and temporal scales.

My talk is divided into a) a short presentation of the potential and significance of compound-specific isotope analyses for understanding past changes in African vegetation cover, atmospheric circulation, and hydroclimate, and b) a discussion of how these analyses can be used to gain better insights into driving mechanisms of hydroclimate and environmental changes using examples of recent studies on marine sediment cores around Africa.

The first published compound-specific stable hydrogen isotope record from offshore the Congo River in 2005 initiated an entire new discipline of molecular hydro-climatology inspiring many careers. Consequently, compound-specific stable hydrogen isotope analyses have experienced an enormous advance regarding technical capabilities and applications. I will give a short overview of processes potentially affecting stable hydrogen isotope compositions of plant lipids and their interpretation. In combination with established proxies for vegetation composition and terrigenous discharge, the molecular-isotopic hydrologic proxy provides a direct view of continental hydro-climatic changes independent from vegetation effects. An adequate interpretation, however, requires understanding of catchment-specific processes, such as transport effects in large river basins.

The second part of my presentation will be a presentation of applications of terrestrial paleo-environmental analyses – molecular-isotopic in combination with established proxy parameters – to unravel controlling factors of African hydroclimate and environmental changes on various temporal and spatial scales. The focus will be on marine sedimentary archives with assessment of ocean circulation and temperature changes to reveal land-ocean interaction processes but also consider other forcing factors. I will discuss examples from recent and ongoing studies from various parts of Africa and covering different time-scales as well as provide an outlook of current open questions and how integrations of proxy and model data could enhance our understanding of climate controlling processes.

Oceanic variability in the southern Benguela upwelling system: implications for increased Agulhas leakage during late Holocene

1 **ZHAO Xueqin**, 1 DUPONT Lydie, 1 SCHEFUß Enno and 1 WEFER Gerold.

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Abstract

The southernmost Benguela upwelling system near the St Helena Bay has been proposed to be affected by various factors. To determine the oceanic variability in the southern Benguela region during the late Holocene, we examined organic-walled dinoflagellate cyst (dinocyst) records from two marine sediment cores located on the southern and northern margins of the southern Benguela upwelling system. Other proxies including alkenone-derived SSTs and coccolithophore assemblage from the same samples were also combined. These proxies show that, from ca. 2000 to 1700 cal. yr BP, intensified upwelling conditions which were indicated by declined SSTs in both cores are probably due to the southward shift of the southern westerlies. Meantime, high representation of a dinocyst based warm water indicator (Group 1) in the southern core GeoB8323-2 probably suggests an inflow of warm water via the Agulhas leakage to the southern mudbelt. Between 1500-1100 cal. yr BP, the higher SSTs and the higher representation of Group 1 dinocysts were only detected in the southern core GeoB8323-2. This indicate less upwelling which is associated with the northward shift of the southern westerlies. The northern core GeoB8331-4 where relatively strong upwelling prevailed might not be influenced by the southern westerlies till after ca. 800 cal. yr BP when they move further north.

Land-ocean links over tropical Africa

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Abstract

Global SSTs and associated circulation patterns are a major force in driving African rainfall on various spatial and temporal scales. This paper examines the associations for four five major sectors of the African continent: the Sahel, the Guinea Coast, central equatorial Africa, the northern Horn of Africa, and East Africa. In many cases, contradictory statements are found in the literature concerning the land-ocean links. This paper demonstrates that part of the discrepancy is a result of systematic changes in the major controls, evoking major regime changes. Further, the controls are very much different for different parts of the rainy season. For example, El Niño appears to reduce Sahel rainfall in the core of the rainy season, but enhance it early and late. Further examples of the diversity in controls are presented for the five regions.

Southern Cape seasonal sea surface temperatures and hemispheric wind dynamics

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Abstract

The southern Cape region of South Africa, situated adjacent to the warm Agulhas western boundary current and retroflexion, and at the interface of the summer and winter rainfall systems, is sensitive to shifts in these regional climate systems. The region has also hosted successful human populations for millennia, and possesses a rich record of modern human evolutionary and cultural history. The abundant cave sequences along the coast offer some of the best opportunities regionally for well-dated, high-resolution climate reconstructions that extend across the last glacial cycle.

Here we present a record of seasonal near-shore sea surface temperatures (SSTs) spanning the Marine Isotope Stage (MIS) 5/4 transition and the Holocene, including the terminal Pleisotocene/Holocene transition, from serial oxygen isotope measurements (δ18O) of a single marine mollusc species (*Turbo sarmaticus*) preserved in coastal archaeological sites. Strong coupling between oceanic and atmospheric conditions in this region means that near-shore SSTs, in addition to reflecting broader conditions in the near-coast Agulhas Current, are also responsive to changes in the frequency of seasonal coastal upwelling. In turn, coastal upwelling reflects the relative incidence of the prevailing easterly and westerly winds, which respectively bring summer and winter rainfall to the subcontinent.

These data link the marine and terrestrial climate domains and provide a new climate archive for an important but understudied climate system. While mean near-shore SST shifts accord well with regional SST trends across this period, the shifts are larger than those recorded in the Agulhas Current from coarser-scale marine sediment records, likely due to the upwelling processes operating in the near-shore zone. Our results also show large shifts in seasonality across the MIS transitions. Periods of suppressed coastal upwelling during the Holocene correspond with regional assessments of decreased rainfall in the summer rainfall region, and such correspondences can also be explored further back in time. The method described here thus offers a more nuanced picture of the long-term relationship between regional SSTs in the Agulhas system and rainfall dynamics for southern Africa, and especially across periods of major global climate change.

New insights to climate variability and its driving forces in southern Africa – the RAiN project

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Abstract

In 2013 the collaborative research project RAiN (*Regional Archives for Integrated iNvestigations*) has started with a German- South African team of scientists to contribute new, geoscientific information for a better understanding of recent climate change and its dynamics in South Africa. The highly complex interplay of different, atmospheric as well as oceanographic factors, controlling the variability of climate in southern Africa, is well expressed in contradicting interpretations of the regional system. RAiN is one of the first projects, which investigates both terrestrial and marine sediment archives in parallel in which the combination of corresponding new information is used to gather a consistent and conclusive understanding of the drivers of climate variability. With this approach, we are able to identify local phenomena, distinguish them from large-scale patterns and to generate the necessary prerequisites for the interpretation of marine archives (signal provenance).

Our data so far reveal that strong local differences along the South African coast exist and do not allow a uniform interpretation of the entire region. Especially the major draining rivers (Orange and Limpopo) can transport primary climate signals from one climatic zone to their deposition in another one. In the same way, contour currents (especially the strong Agulhas current) redistribute supplied material on very long distances offshore. To decipher these processes we apply a multi-parameter (“proxy”) approach, which includes classic methods in sedimentology, mineralogy and palynology together with inorganic and organic geochemical analyses on single components. Most of our results would not have been possible without comparison of samples from terrestrial archives with marine records. Against this background, we will present a compilation of some of our most recent data sets and discuss what we have learned so far about the major driving forces of southern African climate variability and the still open questions.

Dynamic of vegetation and palaeo -environments on middle and late Holocene in Benin

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Abstract

Pollen analysis of four cores, YEV-I, GOHO.00, SOA.00 and DO.00, taken in the coastal area of Bénin shows the existence of mangrove and semi-deciduous forest during the Holocene. Those vegetations underwent many physiognomic changes from the middle to the late Holocene. In the course of the middle Holocene (from 7500 to 2500 years before present (BP)), the mangrove stretched over a large area from the littoral inland. It was tightly closed and almost monospecific, dominated by Rhizophora. On the same time, the forest existed and the actual Dahomey-Gap was occupied by a rich forest of *Ceiba*, *Celtis* and many others forest especies. The climate was therefore of the wet type. During the late Holocene, the mangrove and forest started to regress around 3000 years BP and disappeared about 2500 years BP from the studied sites. The first one has been replaced by swamp meadows dominated by *Paspalum vaginatum* Sw. and a fresh water environment colonised by taxa such as *Persicaria*, *Typha*, *Ludwigia*, and *Nymphaea*. Concerning the forest it is replaced by savanas and open vegetation which are on the origin of a dry wedge called "Dahomey-Gap". This epoch was characterized on the climatic level by a decrease in the level of the lakes, and therefore by a great reduction in precipitation.

Biome changes in Africa with emphasis on savannah and fire

1 DUPONT lydie

1 Marum, Bremen, Germany

Abstract

Pollen records from marine sediments are very suitable for studying the vegetation history of African biomes in relation to global climate change with a focus on large-scale and long-term variability. They provide long well-dated continuous sequences, often integrating large geographical areas, albeit at the cost of much detail. Depending on the research questions and timescales involved such records cover thousands to millions of years. For instance, the development of the African C4 savannah lasted several million years during the Miocene while the response of biomes to global climate changes of the Pleistocene followed the pace of Milankovitch cycles.

Today, the number of analytical tools at our disposal has been considerately expanded. Microscope techniques such as pollen counting teamed up with phytolith and charcoal analysis. Chemically measuring isotopes on single compounds, in particular stable carbon and deuterium of higher plant wax, opened many new possibilities of research. Especially, the combined interpretation of chemical and microscope analysis turns out to be very fruitful studying the development of the African savannah in relation to aridity and fire.

Poster presentations!

Credit: Munch (The Scream!)

Distinct forest evolution at both sides of the Strait of Gibraltar: climate change and anthropogenic forcing

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3 Department of Plant Biology I, Complutense University of Madrid

Abstract

Mountain forests of the Western Mediterranean have undergone a dramatic decline during the last millennia, and they are still threatened by a further one in the next decades. A long-term approach to their evolution could shed light on the drivers of such a fall, as well as about the responses of these forests both to climate and human disturbances. In this study we have analyzed various high-resolution pollen records from Southern Iberia and Northern Morocco, with a major focus on the forests of two relict species, *Cedrus atlantica* (Endl.) Manetti ex Carrière and *Abies pinsapo* Boiss., growing at both sides of the Strait of Gibraltar. Main results highlight the earlier influence of human activities on Iberian forests, which began to fall ca. 4000 years ago, while north-African ones show a later persistence against human disturbances until ca. 2000 years ago. Local extinctions of cedar forests in Rif mountains seem to have occurred very recently due to a high human pressure, while modern environmental protection of *A. pinsapo* in Southeastern Iberia allows a significant recovery of its forests. Increasing aridity and temperatures have reduced the range of both cedar and fir forests, forcing them to migrate upwards or to go locally extinct. Nevertheless, they seem to persist in some suitable areas, showing a good regeneration when anthropogenic influences, mainly overgrazing and burning, are limited. Thus, although climate change remains as the main threat to the future, the adoption of the appropiate conservation measures, like the limitation of human pressure, could ensure the long-term persistence of these forests at both sides of the western Mediterranean.

Impacts of river bank erosion on ecological system as result of climate change in Rdat River, Marrakech, Morocco, North Africa.

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Abstract

Global climate change will impact both of natural systems (ecological systems, hydrological resources, coastal system) and the Human society including human health, food infrastructures …

In Africa most of countries are Poor or developing countries. For that it is considered one of the most vulnerable continents to climate change because of its poor state economic development and low adaptive capacity. In this study, we discussed one of the impact of climate change on ecological system, which is river bank erosion during extreme hydrological events (floods).

River bank erosion is a major management problem in fluvial system. It is a significant source of sediment load in stream for many river around the world including as well as for the study area, Rdat River. With negative impacts on water quality, aquatic life and the loss of land. It can also have adverse impacts on channel morphology and flood carrying capacity further downstream. The total of sediment released in rivers can even have detrimental effects on dams in such cases. All of this impacts can be increased by climate change especially in Africa.

Trends and Spatial Analysis of Temperature and Rainfall Patterns on Rice Yields in Nigeria

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3 Centre for Space Research and Applications, Federal University of Technology, Akure, Nigeria.

Abstract

Trends and spatial analysis of temperature and rainfall on rice yield in Nigeria was carried out. Forty (40) years each of past trends (1970-2010) and future forecast (2011-2050) were conducted with climate data obtained from the International Institute of tropical agriculture (IITA) Ibadan, Nigeria while rice yield data were obtained from the Food and Agriculture Organization (FAO). Six cities, one in each of the six agro-ecological zones which were Calabar, Enugu, Ikeja, Ilorin, Kaduna and Maiduguri were selected. Geographic Information Systems (GIS) mapping for spatial analysis of temperature and rainfall over Nigeria was carried out. Mann-Kendall, Sens' tests and multiple linear regressions were used as statistical tools for analysis. Increasing rainfall trends in Enugu, Ilorin, Calabar, Ikeja, and Maiduguri but decreasing trends were observed in Kaduna while temperature showed increasing trends in all the cities in the last four decades. Future projections showed increasing rainfall trends in Enugu, Calabar, Ikeja, and Maiduguri while decreasing trends were observed in Kaduna and Ilorin just as temperature showed increasing trends in all the cities. Statistically significant positive trends of rice yield, rainfall, and temperature were observed in Ikeja and Maiduguri in the last four decades. Mann-Kendall tests showed that rice yield and temperature had generally statistically significant positive trends in Calabar, Ilorin, Kaduna, and Enugu while rainfall and yield were not significant in Calabar, Enugu, Ilorin, and Maiduguri. Adaptation strategies to genetically modify rice varieties and effective water use strategies (supplemental irrigation) in areas of rainfall deficit are recommended to ensure food security.

Long-term climate forcings to assess vulnerability in North Africa dry argan woodlands

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Abstract

North African dry woodlands constitute mediterranean climatic ecotone ecosystems of vital importance for human livelihoods and local biodiversity. To improve the basis for managing these key ecosystems, we selected a Tertiary relict woodland (*Argania spinosa*) in order to clarify the sensitivity to long-term climate change and discuss the impact of long-term human land use for the distribution of dry woodlands in North Africa.

To assess whether the argan woodland is in equilibrium with current climate, we used species distribution modelling (SDM) to estimate its potential range. Then, SDM was used to estimate its potential distribution during the Last Glacial Maximum (LGM; 21,000 BP) and the Middle Holocene (Mid-Holocene; 6,000 BP). Model predictions for past scenarios were compared with Quaternary palaeorecords to evaluate their accuracy. Finally, we forecasted changes in the potential range to year 2080 to assess its likely future range dynamics.

At the LGM, suitable areas occurred at more southern latitudes, where the Sahara Desert currently lies, while suitable areas in the Mid-Holocene shifted northwards, occupying areas similar to those of today. The estimated past distributions are consistent with palaeorecords, providing evidence for the important role of Quaternary climate changes in driving dry woodland range dynamics. The current range-filling constitutes 44% of the potential distribution, probably primarily reflecting anthropic land-use effects. Future climate change is forecast not to cause latitudinal/altitudinal range shifts, but rather an overall range contraction.

The models reflect the high sensitivity of the dry woodland ecosystem to past climate changes, in agreement with palaeorecords. The estimated climatic sensitivity also predicts severe range contraction during future climate change. Consequently, management strategies for dry woodlands should be developed to facilitate their in situ survival, particularly by reducing the currently intensive human pressure.

Sedimentological and mineralogical evidences of climate change during lower cretaceous (Hauterivian- Barremian) in central Tunisia

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Abstract

The present study investigates the influence of climate variability on the sedimentology and mineralogy of the Lower Cretaceous succession of the Bou Hedma formation (jebel Meloussi, central Tunisia). The Bou Hedma Formation (Hauterivian to Barremian) displays clear variations in terms of thickness and facies. Vertical evolution of facies leads us to distinguish six Units. The Lower Unit is formed by the stacking of detrital sequences exhibiting, locally, a reverse grading. However, the uppermost part is marked by the alternation of detrital deposits and carbonates traducing noticeable climate changes. Detailed study based on microscope investigation of limestones, pick of washed clays and grain size analysis helps for presenting the main sedimentological processes. Features of the paleocurrent pattern of the depositional environment combined to lithofacies analysis traduce a settling on a shallow platform, submitted to continental supply. The clay paragenesis highlights predominant illite, kaolinite and some chlorite which advocates a prominent humid climate. However, the uppermost part is, obviously, distinguished by the occurrence of illite and the presence of mixed layers (smectite-chlorite (corrensite)). The occurrence of smectites and the predominance of carbonates and evaporites in the major part of the Upper Unit advocates a warmer climate and a transgressive trend of the Bou Hedma deposits.

Evidence of climate change/variability in Africa: drought growing seasons in two agro-climatic zones of Nigeria

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Abstract

This study examines evidence of climate change/variability in Africa which results to severe drought during growing seasons. Using two agro-climatic zones of Nigeria as a case study the study presented the rural farmers' perceptions of impacts and their adaptation strategies to climate change. The study area is one of the principal farming regions in the country. The study used both quantitative and qualitative methods were used. The results show the following: (1) The extreme drought events has been increased during the period of study with annual rainfall decrease of about 2-4 mm per year, but much more in the locations around the Guinea savanna. (2) That rainfall amount is highly variable in the growing months with CV-RA > 30. The results showed more near average rainfall in Ibadan (1984, 1991 and 2007) and Osogbo (1990, 2005, 2006 and 2007) with 0.1 < SRA > 0.1 compared to other stations. (3) The probability that dry-spell will exceed 3, 5 and 10 consecutive days is very high with 0.62 < p >0.8 in all the stations. These findings imply that rainfall is much more reliable from the month of May till July (CV-RD < 0.30) but less reliable in the months of March, August and October with CV-RD > 0.30. It is apparent that farmers in these agro-climatic zones have a clear understanding of drought within the growing seasons and their perceptions fundamentally mirror climatic trend from historical weather data. The findings from this study can help farmers and agricultural extension service to have better understanding of recent change in onset, duration and cessation of rainfall and choice of planting data and crop variety.

Climate change in Africa: Evidence and Impacts, Past and Present

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Abstract

This multidisciplinary topic aims to better exanimated the quality of the water and sediment in the watershed of the Oued Lihoudi (watershed of Sebou). Although the level of industrial activities is relatively less high in the watershed of the Oued Lihoudi, the use of his course of main water to make the household of solid waste and wastewater without prior treatment, from the city of Sefrou and villages located along its trajectory, threatens the state the quality of its waters and sediments. It is as well as a systematic study of the status of pollution in this course of water compared to the different socioeconomic activities of watershed is becoming a necessity, while knowing that these surface waters are the main source for irrigation.

The knowledge of the physicochemical and bacteriological characteristics of waters, also the mineralogical characteristics, petrographic, and chemical properties of the sediments of the Oued Lihoudi constitute a means of investigation, among others, for the assessment of the risks of pollution and the state of contamination of the surface waters and sediments.

The study focus on the physicochemical and bacteriological characteristics of water, and mineralogical and chemical characteristics of sediments, including temperature, conductivity, pH, turbidity, the TDS, the content of major elements, the COD and BOD5, then the study of nutrients to know the sulfur compounds, nitrogen compounds and phosphates, and finally the concentration of certain heavy metals in the waters and sediments of the Oued Lihoudi (Fe, Cu, Pb, Mn, Cr, Cd).

Stratégies biologiques d'utilisation de l'eau salée dans la perspective de l'irrigation des plantes.

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Résumé

Les changements climatiques enregistrés depuis longtemps sont une véritable préoccupation des chercheurs dans le domaine de l'environnement. Ces changements sont non seulement une menace pour la planète mais ont des conséquences sur la sécurité alimentaire d'une grande partie des populations. Le secteur agricole est entre autre le plus affecté à cause de la sécheresse et de l'indisponibilité de divers facteurs de production comme l'irrigation. Il convient de noter que depuis la fin du siècle passé et le début de ce siècle, les perturbations pluviométriques se résument dans de nombreuses régions notamment dans les zones arides du bassin méditerranéen à une répartition irrégulière et une indisponibilité du volume hydrique. Cette large variabilité pluviométrique conduit à un grand déficit hydrique affectant à la baisse la production agricole. Les ressources actuelles en eau ne suffisent pas pour répondre aux besoins des différents utilisateurs notamment dans le secteur de l'irrigation des espèces agricoles. A cet effet, diverses stratégies sont possibles pour contribuer à la résolution de ces contraintes. L'utilisation des eaux salées comme l'eau de mer peut constituer une approche pour atténuer la pression dans la distribution de l'eau afin de répondre aux besoins de chaque secteur.

Pour répondre à cet objectif, nous proposons les résultats d'une expérimentation menée sur une analyse du comportement de deux espèces halophiles, *Atriplex halimus* L.et *Atriplex canescens*, comme plante modèle pour déterminer le seuil de tolérance à une contrainte saline. Les plantes de ces deux espèces âgées de 120 jours sont soumises à une irrigation à la solution saline composée de NaCl aux concentrations 300 et 600 mM.l-1 de la solution nutritive de Hoagland (1938). Ce comportement est examiné à travers la caractérisation des paramètres hydriques comme la teneur en eau, la teneur relative en eau (Relative Water Content), le déficit hydrique de saturation (DSH) et l'indice de sensibilité relative à la salinité (ISRS). Afin d'apporter plus d'informations sur les réponses des plantes à ce régime hydrique salin, une analyse des teneurs en sodium et en potassium foliaire et racinaire complète cette étude pour évaluer le site d'accumulation de ces cations des plantes des deux espèces.

Les résultats acquis mettent en évidence une variabilité du statut hydrique des deux espèces liée au régime hydrique salin, aux paramètres mesurés et à l'espèce.

The contribution of remote sensing and GIS to the quantification of water erosion in a watershed

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Abstract

For the quantification of water erosion, we have implemented a geographic information system that allows the management and processing of spatio-temporal data in order to produce the map of susceptible areas to water erosion. This is done by adapting the universal soil loss equation (USLE) developed by Wieschmeier and Smith (1978). In order to do this, a land-use mapping is required, using remote sensing, to process and classify the satellite images that cover the study area according to the date they were acquired.

Modeling projected climate change impact on crop water productivity within a Mediterranean watershed in Northern Africa

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Abstract

Playing very strategic socio-economic roles in the area, the Mediterranean area is considered as one of the vulnerable regions for climate change in the world. Providing data about the potential response of different climate change impacts on food production systems and water use efficiency will definitely help on designing future adaptation strategies for agriculture in this region.

In this study, the semi-distributed SWAT model has been applied over R'dom watershed, an agro-sylvo-pastoral basin located in North-Western Morocco, with the aim to simulate the hydrological processes occurring in the study basin as a preliminary step, and then to investigate future climate change impact on two of the major rainfed crops in the study watershed (Wheat and Sunflower). Downscaled CORDEX climate projections were used to generate future hydrological and plants growth simulation for R'dom watershed in the 2031 to 2050 horizon under two Representative Concentration Pathways (RCPs): 4.5 and 8.5.

The main results of climate change scenarios showed that R'dom watershed will undergo significant decrease of water resources availability with more impact under the scenario RCP 8.5.Wheat and Sunflower water productivities could be lower by 21% and 44% respectively in comparison with baseline situation.

This research revealed the vulnerability of wheat and sunflower growing patterns in the R'dom watershed under climate change impact and outlined the relevant need of the implementation of adaptation strategies in order to improve water productivity toward a climate-smart agriculture in the area.

Environment-Climate-Human interactions in southern Morocco during the past 2000 years: inferences from high-resolution marine records- The ECHo project

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Abstract

Understanding past human-climate-environment interactions does not only provide a „baseline“ for comparison with the present anthropogenic climate change but is essential for assessing the vulnerability of landscapes and ecosystems to future climate change. This is particularly important to southern Morocco, presently subject to severe droughts (like in 2016), desertification and land degradation, and likely facing increased climate variability, socio-economic stress, and population pressure in the future. Studies of Moroccan climate and environmental changes have mainly focused on the northern regions of the country mainly based on lake records from the Middle Atlas. In contrast, the environmental history of southern Morocco is largely unknown. In this project conducted by a Moroccan-German team of paleoclimate researchers and paleoceanographers, we aim to reconstruct a 2000-year record of vegetation and hydrological changes for southern Morocco, using palynology, biomarkers, geochemical parameters, macro- and micro-charcoal (fire activity) from marine sediment cores raised from the southern Moroccan continental margin. The two cores have been collected from offshore Cap Ghuir and Cap Jubi off NW Africa at ~31°N and 29°N within one of the World’s most important systems of marine upwelling with strong surface ocean productivity. Our multiproxy study consists on comparing the signals of various proxies in samples from the continent and the marine realms in order to understand the significance of the signals recorded in marine sediments, needed to interpret adequately past variations. Riverine and surface marine samples have been collected along the south Moroccan coast including the Tansift and Sous Rivers to track terrigenous sediments found offshore for a comprehensive comparative source-to-sink study in order to define the effects of climate change and rainfall rates on the local environment and on natural resources. Integrating results from different parameters will allow an adequate reconstruction of the climatic, oceanic (sea surface temperature, marine productivity) and environmental changes as well as the vegetation evolution during the last 2000 years with allowing for a detailed land-ocean correlation.

Spatio-temporal rainfall analysis of the central part of northern Algeria as a tool for sustainable development

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Abstract

From an economic point of view, the climate is one of the essential elements for both decision-maker and single business manager; it presents one of the most decisive factors in the success of a strategy set in place. Hence the pressing need to know and understand all of its different aspects. Strategy for development and financial management of watersheds could be analysed in the light of the changing climatic conditions. These strategies can however reduce their long-term resilience in a less storm climate. A key priority is pressing researchers to understand all the different aspects of climate especially in arid and semi-arid areas. In this study, we propose a statistical and geostatistical approach to characterise a yearly rainfall data, for the period 1986-2007, collected from rain-gauging stations across the central part of northern Algeria. The results show that the rainfall distribution takes a Platykurtic shape. Moreover, geostatistics results indicate the existing of a nuggets effect (15000) and that the isohyets follow a Strong North South gradient. Finally, this study provides useful information to help decision-makers for watershed management and may afford a clear vision for sustainable development in future.

Impacts of the reforestation of the Sahel-Sahara interface on thermal extremes in the Sahel

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Abstract

The impact of the reforestation of the Sahel-Sahara interface on the spatio-temporal distribution of thermal extremes in the Sahel (West african region lying between 11°N and 18°N) is studied using the International Centre for Theoretical Physics (ICTP, Italy) regional climate model (RegCM4). We performed a simulation with the standard version of the RegCM4 model followed by another one using the modified version of the same model taking into account the incorporated forest. The impacts of the vegetation change on heat waves is assessed by analyzing the difference between both runs. We analyzed the seasonal variability of seven (7) thermal indices recommended by the World Meteorological Organization (WMO) such as the frequencies of warm days, very warm days and warm nights as well as the number of hot days, tropical nights, heat waves and warm spell days.

The meteorological conditions associated with the change in these heat thermal indices are analyzed as well.

This work shows that the vegetation change may impact positively some regions like the reforested area by reducing the occurrence of thermal extremes; while other Sahel regions such as the eastern part of the central Sahel, could suffer from it because of the increase of thermal extremes.

Climate change since the last glacial period in Lebanon and the persistence of Mediterranean species

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Abstract

The Near East, including Lebanon territory, is considered as a hotspot of biodiversity as well as a refugial area in the Mediterranean. Lebanon is a territory which represents the southernmost edge of the range of some valuable plant species such as firs and cedars. Genetic studies suggest that it is crucial to evaluate the climate changes and their impacts at the rear edge of relict populations of species such as those found in Lebanon.

Three fossil pollen records, encompassing the Holocene and partially the last post-glacial period, were collected in Lebanon. Temperature and precipitation variables were reconstructed using the modern ranges of the Eastern Mediterranean plant taxa identified in the fossil pollen records and their related modern climate. We quantified the mean January temperature (Tjan) and both winter (Pw) and summer (Ps) precipitation.

Tjan shows a strong correlation with the global temperature changes retrieved in the NGRIP Greenland ice core. The amplitude of ca. 8°C between the Younger Dryas (YD) period and the Holocene is coherent with climate reconstructions from the Eastern Mediterranean. The overall amount of precipitation was lower during the YD than during the Holocene but the contrast between Pw and Ps was much more reduced (less than 2 times) during the YD than during the Holocene (up to 8 times). Such different seasonal contrast compare to the present day is coherent with other climate proxies from the Levant that tend to indicate the presence of moisture during the last glacial period. In effect, the low Pw during the YD reflects the replacement of the forest ecosystem by a more shrubby or herbaceous vegetation.

During the last glacial period, Lebanon was not under a typical Mediterranean climate such as the one we know today, i.e. with a strong precipitation and temperature contrast between summer and winter seasons, but rather under a less contrasted climate. Mediterranean species persisted in this area due to the low amplitude of temperature change between the last glacial period and the Holocene as well as to an availability of moisture throughout the year instead of an occurrence mainly during the winter season as is the case today.

Reference

Cheddadi, R., & Khater, C. (2016). Climate change since the last glacial period in Lebanon and the persistence of Mediterranean species. Quaternary Science Reviews, 150, 146–157.

Trends, rhythms and transitions during the Late Quaternary in southern Ethiopia.

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Abstract

This project aims at statistically analyzing the long (~278 m) sediment record of the Chew Bahir basin, as part of the ICDP-funded Hominin Sites and Paleolakes Drilling Project (HSPDP). The aim of the project is (1) to establish a robust age-depth model for the sediment cores, (2) to correlate the Chew Bahir record with other records within and outside HSPDP, (3) to detect trends, rhythms and events in the environmental record of the basin, and (4) identify recurrent, characteristic types of climate transitions in the time series, as compared with the ones of the other HSPDP sites and climate records outside HSPDP. The work presented here will provide first results of age-depth modelling, including cyclostratigrphy, of the long Chew Bahir cores. Second, it gives an overview of the first results from evolutionary spectral analsis to detect changes in the response of the Chew Bahir to orbital forcing during the last 550 kyr. Third, the results of a change point analysis will be presented to define the amplitude and duration of past climate transitions and their possible influence on the development of early modern human cultures.

Economic Water Management under Climate Change Impact

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Abstract

The recent statistics show a clear downward trend in global and per *capita* availabilities of water due in particular to climate change. In addition to the recurring droughts that Morocco experienced during the last two decades, this tendency is accentuated by an unceasingly increasing demand, in particular under the effect of the demographic pressure and the economic development. In a context of scarcity and a limitation of potential resources not yet mobilized, Morocco is confronted with the need of changing its supply policy to a demand management one. The implementation of such policy requires the adoption of new management instruments and new institutional forms of organization. Accordingly, the present study proposes a tool of modeling and decision-making support which integrates the economic, institutional, hydrological and agronomic aspects. The proposed approach is based on optimization techniques and positive mathematical programming to calibrate an empirical model. Using climate change impact scenarios, this integrated economic model is tested for the basin of Souss-Massa. These simulations include changes in water availability and economic conditions, as well as demand management policy. The study results show that the demand management policy at the river basin level should take into account the regional specificities. The basin's water resources are substitutable and water management policy cannot ignore this aspect and should integrate surface and groundwater resources at the same time. In drought conditions, the water marginal value 'shadow price' increases considerably such that water pricing policy alone cannot result in a rational and a sustainable use of the resource.

Assessing climate change vulnerability and local adaptation strategies in adjacent communities of the Kribi-Campo coastal ecosystems, South Cameroon

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Abstract

Climate change vulnerability assessment is becoming increasingly important especially in coastal areas that are highly vulnerable to extreme climatic events, such as storms or flooding.

This study assesses vulnerability to climate change and local adaption strategies in the Kribi-Campo coastal area.

Variables of exposure, sensitivity and adaptive capacity are described and assessed based on the community's perception and biophysical evidence. Historical changes in rainfall and temperature variables, mangrove cover and occurrence of extreme climatic events are taken as indicators of exposure. Losses of property and income structure are used as indicators of sensitivity. Human, natural, social, financial and physical assets are used as elements of adaptive capacity. Focus group discussions were held with key informants in 12 settlements, and a survey was conducted with 150 household representatives (14 Bagyeli pygmies and 136 Bantou) to gather perceptions on climate change and adaptation strategies.

Results show evidence of increased -vulnerability due to decreasing rainfall and irregular rainfall patterns, increasing occurrences of extreme climatic events and increased levels of coastal erosion. These have resulted in several effects, most significantly in the decline of agricultural production, reported by 57% of respondents, and damages to housing reported by 30 % of respondents. Adaptive capacities are low. More than 60% of respondents do not use any adaptation strategy. All sectors considered, the identified responses to climate related phenomena include early harvesting of crop, farm abandonment, change of productive activity, change of farm location, house reinforcement.

The study concludes that households living here are susceptible to the possible impacts of climate change. Income diversification, mangrove afforestation and climate education should be considered as priorities for adaptation in this area.

A 30,000-year record of vegetation and fire history from the Soutpansberg, South Africa

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Abstract

Pollen and charcoal analysis are used to investigate climatic and anthropogenic drivers of vegetation and fire dynamics through the past ~30,000 years in the Soutpansberg, South Africa, an area of exceptional botanical and cultural diversity. Proxy evidence is supported by a chronology derived from five radiocarbon ages, and a *Pinus* pollen stratigraphic marker-horizon. Relatively warm and dry conditions are inferred from the dominance of open grassland vegetation in the earliest part of the record. During the Last Glacial Maximum (LGM), an expansion of *Podocarpus* forests, together with an increase in fynbos elements, suggests a shift to cool, subhumid conditions. The pollen data suggest persistence of cooler conditions until ~12,000 cal yr BP, becoming warmer thereafter. Between ~4000 and 1500 cal yr BP, conditions became warmer and drier, inferred from an increase in dry savanna. A marked increase in charcoal content after ~4000 cal yr BP broadly coincides with the arrival of the first agriculturalists in the area ~3000 cal yr BP. A shift from savanna to fynbos vegetation together with expanded forests implies a return to cool and moist conditions from ~1500–400 cal yr BP. Arid savanna persists from ~400 cal yr BP to the present, implying warmer and drier conditions towards the present day. A recent decline in arboreal taxa, including *Podocarpus*, from ~250 cal yr BP may be linked to the arrival of European settlers in the area.

Satellite Study of Tropical Teleconnections, Monsoon Variability & Development of Monsoon Depression Model Through Dynamic & Morphological Studies of Mesoscale Convective Systems over African Oceanic Regions (Indian Ocean & SE-Atlantic Ocean).

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Abstract

Attempt has been made to study Monsoon Energetics, Monsoon variability over African Oceanic regions comprising Indian Ocean & SE-Atlantic Ocean by analyzing Cloud and Monsoon Depression fields and Mesoscale Convective systems during Summer Monsoon by using TIROS-N & Geostationary Satellite imageries. The study examines Satellite imageries with emphasis on the large scale kinematic and thermodynamic behavior of selected mesoscale Convective Systems, e.g. intense Cloud Cluster s, Depressions & Thunderstorms by making use of aircraft and conventional data over the domain. The values of characteristics, e.g. lifetime, distribution, trajectories, size and three dimensional structure, i.e., vertical extent of these systems would be computed in order to develop a Medium Range Forecasting Model for South East African Monsoon & Asian Monsoon as well Cyclonic Storms over tropics. Kinematic features of Disturbed Phases were studied in a LaGrange an frame to identify the evolutionary features of an associated Monsoon Depression. The Time Series plot of Surface Pressure Gradient between selected station falling at almost the same longitude were plotted in order to correlate with the Disturbed Phases vis-a-vis evolution features of a Monsoon Depression. kinematic features of the Disturbed Phases were correlated with the extracted Sea Surface Temperature (SSTs) to bring out a few optimum values of these to develop Depression Model. Following Cloud Cluster studies of Goswami ; the two plausible models of Monsoon Depression studies have been postulated in terms of Cluster Coalescence Theory (CCT) and Giant Cluster Theory (GCT). Thermodynamic structure of Monsoon Depression developed by computation of deep convective mass transport inside the Cloud Cluster through Cloud Tracer Analysis. Next, the Tropical teleconnections and Monsoon systems Would be investigated through Correlation of African Monsoon, Morphological and Dynamical properties of Cyclonic Storms & Tele-connection of SH features e.g. Depressions, Cyclonic Storms with the identical features of NH to be investigated through Geostationary Satellite Imageries & LIDAR.

The Middle Eocene Climatic Optimum (MECO) and the Eocene Oligocene transition (EOT) in southern Tethys as evidences of past climate changes in Africa : Multidisciplinary and high resolution study to link African climate to global changes.

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Abstract

The Eocene Era, with high atmospheric CO2 and crutial climatic events, constitute the perfect analogue to the present day Hothousse conditions. An advanced study of the Eocene climate changes are becoming an increasingly important issue to understand the response of the Earth's climate system to anthropogenic fossil fuel burning.Awareness of the need for multidisciplinary and high resolution study on the southern Thetys margin to detect the differential response of the climatic processes between high latitude zones, where most of studies were conducted, and low latitude zones (Africa in our case) has resulted in the use of stable isotopes, XRF, magnetic susceptibility (MS), nannofossils and foraminifera assemblages to link Africa climate to external forcings (Earth's orbital parameters) and to the rest of the world.
This study was carried out aiming to track climatic change in southern Thetys through the sampling of two major geological domains : Mid-Eocene recifal carbonate, which is known as a highly sensitive ecosystem and Eocene-Oligocene boundary as one of the biggest extinction event in the geologic time.
These Two sections covering a unique expanded Eocene section including the Middle Eocene Climate Optimum (MECO) and the Eocene-Oligocene Transition (EOT). A total of 1000 samples was studied by different proxies and with multiple spectral analysis and statistical techniques such as: Continuous Wavelet Transform, Evolutive Harmonic Analysis, Multi-taper method and Average Spectral Misfit, were used to reach an optimal astronomical interpretation. Foraminifera and nannofossil assemblages shows very similar variations to the stable isotopes, XRF and MS variations, therefore, climatic variations are very likely captured in our records.
All of these data provide new insights in the timing and duration of paleoceanographic events in south Tethys and their relation to orbital influences. Orbital tuning of our record provides ages for the MECO and EOT that are consistent with GPTS2012. Based on awerestudy, we demonstrate how climatic changes in Africa were triggered by orbital parameters. In addition, our data point to direct link between ecosystems events and climatic changes.

Air-sea exchanges of Greenhouse Gas in africa’s coastal seas

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Abstract

The emission of greenhouse gases (GHG) by human activity increases the natural greenhouse effect. The 3 most important GHGs are CO_2, CH_4 and N_2O, so it is imperative to better understand their formation and flow. It is recognized that inland waters (rivers, lakes) are important sources of these GHGs to the atmosphere. In this work several data and measurements of sea air fluxes of these greenhouse gases are carried out for the African continent in the coastal zones. The air-sea exchanges of CO_2 in the African estuaries and continental shelves are evaluated. Most continental shelves, and those at high latitude, are under-saturated in CO_2 and CO_2 from the atmosphere in all seasons. Water temperature, the spreading of river feathers, upwelling, and biological production, pCO_2 in the shelves. Overall, the world's continental shelves absorb 0.4 PgC yr^{-1} from the atmosphere.

Relevant source area of pollen and pollen productivity estimates from KwaZulu-Natal Drakensberg, South Africa.

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Abstract

For any given site containing pollen rich sediments, it is important to consider the sources of that pollen, and the means by which it arrived at its preservation site to better interpret the pollen assemblage and infer past vegetation. This study presents estimates of the Relevant Source Area of Pollen and Relative Pollen Productivity in the KwaZulu-Natal Drakensberg, South Africa, a palaeo-ecologically significant region of southern Africa, using specialised models of pollen dispersal and deposition. Modern pollen spectra from soil surface samples were extracted from three dominant vegetation communities, and vegetation data were collected around each sample point using a 3-tiered ring surveying approach. Fall speeds of key taxa were calculated using Stokes Law for spherical pollen grains and Falck's assumption for ellipsoidal grains. Pollen and vegetation data were subjected to Extended R-value analysis to calculate Relevant Source Area of Pollen and Pollen Productivity Estimates. Results showed RSAPs of approximately 100 - 150 m for all three communities. Productivity estimates revealed Poaceae to be significantly more productive than herbaceous and shrub taxa, while arboreal taxa were significantly higher in productivity relative to Poaceae. Findings demonstrate that pollen models have a strong place in South African pollen research and are needed for fossil pollen interpretation from this important ecological and cultural palaeoecological region of southern Africa.

Paleohydrological changes recorded from a small Moroccan Middle Atlas pond during the last 6000 Cal yrs BP.

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Abstract

Precipitation over the Middle Atlas Mountains, considered as one of the main Moroccan Natural water Towers, is known to be sensitive to climatic changes. It is then crucial to better understand the past precipitation changes under different environmental conditions in order to elaborate scenarios and programs that will protect these areas from future changes. Lacustrine archives could provide continuous, scalable and datable records of climatic and hydrologic changes in such area.

The present research is based on a 3 m sequence cored at Flower Lake (32° 59' 04''N, 5° 27' 13'' W, 1554 m asl) which is, nowadays, a small pond lying on the Liasique calcareous dolomites of the tabular Middle Atlas. A high-resolution geochemistry (X-ray (XRF) with 500 µm spatial resolution) and sedimentological (facies distribution and grain size) studies of this sequence are supported by five coherent and calibrated radiocarbon dates.

The preliminary results give a reconstruction of the environmental changes that occurred in the Middle Atlas region during the last ~6 cal kyrs BP.

Sedimentological facies distribution is well correlated with XRF elemental variability: i) clastic sediments intervals are rich in Si, K, Ti and Fe; ii) calcareous facies show the highest intensity of Ca and Sr/Ti. These two facies and geochemical data most probably reflect phases of low lake levels alternating with period of positive water balance. The complex Mn contents behavior could be to the changes of redox conditions at the water-sediment interface in the lake.

Before 2500 yrs BP, low Ca contents coincided with an important detrital input characterized by high Si, K, Ti and Fe values. This could be related to more humid conditions with higher erosion of the surrounding landscape.

The relative high Ca and Sr contents during the last 2500 yrs BP could be connected to drier conditions. Precipitation of Ca carbonates occurs in shallow waters due to high evaporation and photosynthetic activity of charophytes algae and other aquatic plants.

These preliminary interpretations will be compared with additional proxies, available datasets of lakes sediments and other regional palaeoclimatic archives, especially speleothem from Middle Atlas caves.

Thermal stress impact on agriculture: implication for same crops production in Morocco

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Abstract

The evolution of climate in Morocco will be continuing by an increase in temperature of 1.1 °C and a reduction of precipitations about 4 % in the year 2020. This climate change could have negative impacts on several ecosystem services of the region like vegetal cover. The vulnerability of this later is increasing with climate change impact, in particular agriculture south regions facing to high thermal and drought. So extremes thermal and drought can reduce reproduction and growth rates, and limit the geographical range of species. Using the indicators of thermal stress (Tmax & Tmin) is generally accepted to assess species respond in an individualistic manner to climate. This paper combined remote sensing based data layers including climate data and modeling indicators stress will be attribute to assess risk-levels of climate change potential vulnerabilities on crops types and their subsequent consequences at local and sub-regional scales for time horizons. The main aim is to i) develop models of thermal, in order to quantify the vulnerability of vegetal cover, ii) estimate the tolerance response of biomes or species in relation to temperature for a projected climate in near term (2010- 2025 years), and iii) identify which of the species or biomes are likely to be affected by climate changes and which regions are more vulnerable facing to climate impacts.

Unlocking the secretes Behind the Paleo-climatic Changes on the Quaternary Sediments of Lake Chad Basin and its Implication on Lake Level Fluctuation using isotope Geochemistry

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Abstract

The geodynamics along with the fluctuation of lake level and its implication on fishery and other ecological resource management within the Lake Chad cannot be overemphasized. During the Quaternary the Chad Basin experienced fluctuations of severe aridity and wetness events, This resulted in ca. 600m thick sediment deposition within the Megachad area,. The present Lake Chad is a closed lacustrine system with depths on the average of > 10 m and all waters draining the Mega Chad basin empties into the Lake Chad covering an area of ca. 30000sq Km. Acurate records of lake level changes in the Lake Chad through limnological study of sediment coring is missing.

Therefore, a set of 8 samples (derived mainly from interbeds of clay, silty clay and sands) collected through two 5 meter deep pits in Duguri Island of Lake Chad were limnologically analyzed to see evidence of repeated changes in lake level. Another set of 20 samples of mainly clayey sand and calcerous shales and derived from 2 wells located within the Megachad basin were also analysed. Samples containg fossilized fragments of shells were subjected to isotopic studies on C, O, H and spore and pollen analysis. Also trace elements were analyzed for provenance of sediment into the present day Lake Chad.

Based on this study, isotopic baseline provenance data for Lake Chad is established. Variations on the isotopic values of O and H reveals alternation of dry and wet periods which complies with movement of the Intertropical Convergence Zone (ITCZ) which controls the West African Monsoon climate. The Lake Surface Temperature though influenced by atmospheric condition varies from 25 to 28.6°C.

A 34-year climatology of West-African MCS during summer period from a Long Term Tracking Database

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Abstract

West Africa is known for severe drought which occurred between 1970s and 1980s with some important consequences. This region is also known for its monsoon and its large and strong mesoscale convective systems. Some of these convective systems are known as squall lines with a complex degree of organization. These organized convective systems, although minor in terms of occurrence, contribute strongly to the seasonal cumulative rainfall and to the nebulosity.

The Analysis of these sub-population of MCS is important to better understand the recent evolution of west-african climate regime.

This study is based on the morphological parameters of the convective systems identified and tracked by a tracking algorithm called TOOCAN from the geostationary infrared data. The tracking algorithm has then been processed on the infrared imagery of METEOSAT first and second generation from 1983 to 2016 in order to build a long term database of convective systems. A quality control has been applied on this database and the missing infrared images, as well as the tracking interruptions have been flagged in order to ensure robust tracking outputs.

For the purpose of this study, we focus on the summer period (June, July, August and September, denoted JJAS) which constitute the core of the rainfall season. The main morphological characteristics of the MCS are then analyzed and we will show their evolution from the last drought periods up to today corresponding to an increasing period of flooding episodes. We will focus on the sahelian and the sudano-Guinean region, in order to examine these evolutions in relation to the regional climate specificities.

Characterization of the atmospheric boundary layer (ABL) on Guinea under the conditions of deep convection: focus on Conakry rainfall.

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Abstract

In West Africa, deep convection shows marked variability with convective mesoscale systems, squall lines, but also local storms or smallsystems (Dione et al., 2013). It is often associated with African Easterly Waves (AEWs) (Thorncroft et al., 1995). Its triggering also depends on surface heat flux and soil moisture (Findell et al., 2003, Taylor et al., 2006). The temporal evolution of sensitive and latent heat fluxes is strongly influenced by rushing elements (Guichard et al., 2012). Indeed, since the end of the 1960s, the annual total rainfall recorded in the West African region had suddenly changed from very wet situation to another dry one with an unprecedented deficit (Fontaine and Janicot, 1993). Guinea also has known this situation, especially during the period 1981 to 2010 considered for this work, where from 1981 to 1991 was a very dry decade. Despite this deficit, Guinea continues recording heavy amount of precipitations mainly in its capital (Conakry). Meteorological observations data and monthly climatologic tables (MCTs) of Guinea show that the rainfall of Conakry varies on average between 3300 and 4000 mm/year. Some studies like with Sall et al., 2006; Béavogui et al., 2011 have attempted to highlight this particular situation in Conakry attributing it to the orographic effect (foehn) due to the existence of the mountain range of Kakoulima (1007 m) located in 50 km on the east of Conakry. According to Jenkins et al., 2003, the presence of vortex over the Guinea coast which is almost stationary, creates a return situation of the convective systems in Conakry. In these previous studies, the rainfull dynamic regimes in Guinea were not well documented to better understand this maximum, hence the interest of this work. The general objective of this research is to better understand and explain the origin of the maximum precipitations recorded in Conakry and highlight the relationship with the atmospheric boundary layer. To achieve this goal, we would like to understand the rainfall dynamic regime of Conakry, but also explain the orographic and coastal effects. For this purpose, we study the different rainfall regimes of the four natural regions of Guinea and their respectives synoptic stations. Finally, to determine the maximal precipitation recorded at the coast (Boké, Kindia, Conakry) by transporting zonal moisture flows, meridian, divergence of moisture flows and precipitable water. We have shown that seasonal and annual rainfall are maximal in the coast (Conakry) in July-August, exceeding those of the other Guinean synoptic stations with a annual cumulated rainfall oscillating between 3000 and 4000 mm. In the lower layers (psurfaces-850hpa), we have also shown that the transport of the moisture meridian flux zonal and the convergence of the moisture flow indicate an important contribution from ocean and convergence in the coast (lower guinea). The presence of maximum values of precipitable water over Conakry confirms the high moisture fluxes found in the coast. This flow would known foehn effect on the Kakoulima range and the Fouta massifs creating a return of the systems on Lower Guinea. It favorises a convergence of the flow which would be at the origin of maximum precipitation in Conakry.

The results on the divergence of the moisture fluxes are consistent with those of Rémi et al., 2010, which states that, on the ocean, the flows are essentially divergent in the vicinity of high pressure centers (they export moisture) and converging at the ITCZ level, at the meeting of the trade winds.

La Réponse Spatio-temporelle de l'Arganeraie de la région de Taroudant au changement climatique

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Résumé

L'arganier (du nom scientifique *ArganiaSpinosa*), est l'essence forestière incontournable du grand Sud-Ouest marocain. Aujourd'hui, la plus grande concentration d'arganiers se trouve dans la plaine de Souss. Il s'agit d'une zone semi-aride dont le couvert arboré est largement dominé par l'arganier, qui pousse de façon sauvage en forêt clairsemée et il peuple l'essentiel de ses paysages arides aux brumes fréquentes et lui imprime une physionomie bien particulière.

L'importance de la forêt de l'arganier pour la région s'exprime sur plusieurs plans. A part qu'elle joue un rôle crucial dans la régulation du climat, elle joue aussi un rôle environnemental autant que frein pour l'érosion et la désertification, et un rôle socio-économique puisqu'elle représente une source incontournable pour le pâturage, l'huile d'argan, bois de construction et de chauffage. Dernièrement, il s'est montré que la forêt d'arganier régresse en termes de superficie et surtout de densité. En réponse a ça des mesures urgentes ont été prises par les autorités pour sa préservation et surtout sa valorisation à l'échelle nationale et internationale.

De cette étude diachronique, basée sur les images satellitaires (1985, 2002, et 2016), ressort que les changements climatiques qu'a connue la région ces dernières décennies marqués surtout par des années de sécheresse sévères, ont un impact négatif sur la surface et la densité d'arganiers. Ainsi, on a constaté une régression de la surface occupée par l'arganeraie et surtout une diminution de la densité qui passe de 99300 hectare en 1985 à 40300 hectares en 2016.

Development of a chronostratigraphic framework for the Quaternary of southern Africa

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Abstract

The Quaternary System (last 2.58 Ma), characterized by both significant climate change and the development and spread of human and other species, has been examined in much detail in order to define the timings of different climatic phases within this System, and the regional to global synchroneity of these phases. This effort is underpinned by the principles of chronostratigraphic correlation put forward by the International Commission of Stratigraphy, a commission of the International Union of Geological Sciences (IUGS). The Subcommission on Quaternary Stratigraphy has chronostratigraphic charts for many regions of the world but southern Africa is notably missing. This is a critical omission, given the importance of the region in hominin evolution during the Quaternary. Here, we propose procedures for, and a preliminary chronostratigraphic subdivision of, the later part of the Quaternary System of southern Africa (south of ~15oS). A key difference between southern Africa and many other parts of the world is that the Quaternary has no regional glacigenic expression (either morphologically or chronostratigraphically), meaning that glacial-interglacial terminology for Quaternary environmental changes are not meaningful. As such, we use Antarctic Isotope Maxima from the Vostok record as a starting point, providing a high resolution regional temperature curve for a regional comparison. The methodology we have adopted integrates multiple published climatic/environmental proxies from many existing sites and records in southern Africa. We look for evidence of a significant system change in the record, corresponding to some kind of threshold-like effect that is of regional scale, synchronous, and does not correspond to merely local variability. The system change should be manifested in several different proxies and should be constrained by some geochronometric control. We also use archaeological evidence (technological and/or cultural) as a valid proxy. Results of this analysis are broadly consistent with the Quaternary chronostratigraphic framework for other parts of the world, but some differences, similarities, and problems remain due to the poor spatial and temporal resolution of southern African records for this period.

Land surface processes in the central Sahara and implications for the interpretation of lithic scatters

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Abstract

Land surface processes including subaerial weathering, erosion and pedogenesis are important in shaping the land surface of the central Sahara over long Quaternary timescales. Sediment and soil stratigraphies can allow for the reconstruction of successive erosional and depositional events that record the impacts of climate on the land surface. We apply this principle to the analysis of land surface features in the Messak plateau (SW Libya, central Sahara), where lithic scatters are common between the clasts of the desert pavement. Many previous observations of lithic scatters, however, do not consider the role of land surface processes in modifying lithic distributions and concentrations over time. In addition, some clasts reported as lithics are actually natural ventifacts shaped by aeolian activity. Evidence for the role of land surface processes also comes from examination of soil stratigraphies, which shows that episodes of land surface erosion (by deflation and occasional flash floods) followed by aeolian sediment deposition and pedogenesis can lead to complex condensed pedostratigraphies. This can help explain the presence of mixed lithic assemblages. This study highlights the linked relationships between different land surface processes, and how stratigraphic records of these processes are developed over time. This kind of analysis is vitally needed in the central Sahara, and other active deserts, in order to avoid misinterpreting archaeological evidence and making unfounded claims about Quaternary human occupation of Saharan landscapes.

EFFECT OF CLIMATE CHANGE ON THE PIEZOMETRIC EVOLUTION AND STATE OF WATER QUALITY OF THE BENI AMIR GROUNDWATER (TADLA, MOROCCO)

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Abstract

The study area is characterized by a semi-arid climate and by an agricultural dualism, the bour and the irrigated. Under these conditions, there is an irregularity of precipitation and a variability of recharge of the groundwater, which undergoes overexploitation and deterioration of the quality of its waters.

This work provides an overview of the problem of management of water resources in the Tadla and describes a comparative approach to the spatial distribution of piezometry during the period 2010-2015 and the spatial variation of the concentrations of the various elements allowing the estimation of the groundwater physicochemical quality.

A study of the variation of the water table in the study area was made using the piezometric data from the period 2010-2015, in order to see the sensitivity of the water table to climatic vagaries that has known the region. In parallel with the piezometric study, a hydrogeochemical study was carried out to determine the state of the water quality and to detect the zones of contamination which negatively influences the groundwater quality.

The comparison of the piezometric states revealed that the variation of the piezometric level between 2010 and 2015 is not regular throughout the zone. A rise in the piezometric level was observed in some places, while some regions recorded a decrease in the water table.

On the other hand, the spatial variation maps of the concentrations of the different elements showed significant concentrations of nitrates in the irrigated perimeter due to the irrational use of fertilizers and pesticides that the farmers add in order to increase the productivity of the parcel.

Seasons caracterisation with wind profiles observed by VHF radar in northern Benin

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Abstract

The variability of the West African monsoon had socio-economic and environmental impacts on populations. This variability is closely linked to atmospheric circulation, which also plays a dominant role in the organization of the monsoon. These experimental results provide information on the dynamics of winds through the features of the jets. Data are provided by a VHF wind profiler radar installed in Benin, precisely Nangatchori (9°6472N, 1°7411E) during AMMA measurement campaign (2006-2007).

This study shows the presence of the African Easterly Jet (AEJ) in the middle troposphere (2.5-5km). It shows also the presence of the Subtropical Jet (STJ) and the Tropical Easterly Jet (TEJ) in the upper troposphere(10km). The patterns obtained let distinguish two great seasons characterizing the Hydrometeorological Observatory of Ouémé Upper Valley.

Hierarchical Agglomerative Clustering (HAC) applied to the wind mean velocity and frequency of direction at 10 km associated to the monthly rain confirms existence of two great seasons: one dry season (November to March) and wet season (April to October). The wet season is characterized by three phases: the pre-wet phase (April, May, June), the heart of the wet season (July, August, September) and the post-wet phase (October).

Detecting trends, rythms and transitions during the Late Quaternary in southern Ethiopia using Recurrence Quantification Analyses

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Abstract

This project aims at statistically analyzing the long (~278 m) sediment record of the Chew Bahir basin, as part of the ICDP-funded Hominin Sites and Paleolakes Drilling Project (HSPDP). The aim of the project is (1) to establish a robust age-depth model for the sediment cores, (2) to correlate the Chew Bahir record with other records within and outside HSPDP, (3) to detect trends, rhythms and events in the environmental record of the basin, and (4) identify recurrent, characteristic types of climate transitions in the time series, as compared with the ones of the other HSPDP sites and climate records outside HSPDP. The work presented here is related to (3) and (4) respectively, and will provide an introduction to recurrence plots and their quantification analysis adapted to the Chew Bahir data.
The different aspects of recurrence can help to identify and characterize subtle changes in systems dynamics. Besides the identification of transitions, recurrence methods can help to provide a better understanding of the underlying process of these transitions by statistically describing the dynamical characteristics, e.g. the predictability, determinism and complexity of the dynamical system. For example, the characteristic block structures in the recurrence plot can be used to identify different types of intermittency. In general, changes between different dynamics are visually well expressed in recurrence plots. The introduction of selected recurrence quantifiers (such as recurrence rate, determinism, or laminarity) together with a running window approach has paved the way for a quantitative recurrence analysis of transitions and therefore allow a classification of different transition types. We present first results of such recurrence based classification, analyzing the sediment records of the Chew Bahir basin (CB01 & CHB14).

Unique challenges facing cities in developing nations and the Global South, Morocco as an example

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Abstract

In the near future, the settlement patterns of our world will surely move towards a diversified and urbanized geographical structure. But, worldwide, there is only one megatrend, essentially the unavoidable transition to multimillion megacities, be it monocentric large urban agglomerations or complex largescale polycentric settlement constellations which needs call for strategic insights into many aspects of urban dynamics. Modern metropolitan areas in an open and globalizing economy are centers of creative ideas, innovative technologies, sustainable developments and socioeconomic wealth. They play a leading role in the future of an urbanized world, but they are also confronted with outstanding challenges, such as far-reaching demographic transformations (in particular, ageing, rapid population rise in many continents, and unprecedented migration flows). Environmental degradation and climate change (in particular, greenhouse gases, scarce resources, water management), unequal social contribution (in particular, unemployment and poverty, cultural-ethnic tensions), and ever-rising mobility trends (in particular, commuting, long-distance travel, complex urban logistic changes). A slightly illustrative overview of such trends and challenges facing Moroccan cities will be discussed.

In this proposal we will try to discuss the interaction between urbanization and the environment at the national level and highlights existing environmental conditions, with emphasis on air, water, and land pollution. The bilateral relationship between urbanization and the environment is elucidated through an analysis of the water supply, liquid waste management, solid waste management, and energy sectors.

Estimating the economic impacts of climate change on agricultural water management indicators: a case study from Tadla in Morocco.

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Abstract

Climate change has been strongly dealt with in the economic literature in recent decades. In many semi-arid regions of the world, especially in Africa, issues related to climate change including water resources scarcity are crucial to overcome obstacles to development. The value of water increases and presents itself as a quantitative and qualitative constraint to its domestic, industrial and particularly agricultural use. Given the multidimensional and multi-scalar nature of climate change, this research proposes an integrated agronomic, economic and hydrologic modelling for the Tadla sub-basin in Morocco to assess the potential economic impacts of climate change on agricultural water management in this region. This tool permits to predict interannual variations of selected socio-economic water management indicators from 2014 to 2050. The simulated climate scenarios include the RCP (Representative Concentration Pathway) 4.5 and RCP 8.5 scenario, taking into account the main crops, water resources, and the socio-economic context of the study area. The results show that climate change can have an impact by reducing the total agricultural profit calculated across the Tadla sub-basin (by about -0.34% and -0.44% each year according to RCP 4.5 and RCP 8.5 climate scenarios, respectively) and by increasing irrigation water shadow price progressively. Overall, this research helps improve understanding the potential economic impacts of climate change and to guide stakeholders in their choices in terms of future adaptation policies.

Assessing the impacts of climate change on hydrological parameters in the Garoua Benue River Basin (Central Africa) using Regional Climate Model REMO.

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Abstract

Global climate changes will have significant impact on local and regional hydrological regimes, which will affect ecological, social and economical systems. However, climate change impact studies on hydrologic regime have been relatively rare until recently, mainly because Global circulation models, which are widely used to simulate future climate scenarios, do not provide hourly or daily rainfall and temperature reliable enough for hydrological modeling and the low resolution of the output from large scale GCMs. Nevertless, more reliable series corresponding to future climate scenarios can be derived from GCMs outputs using the so called ”downscaling techniques”. This study examined the impacts of future changes in climate on hydrological parameters (precipitation, temperature, potential evapotranspiration and streamflows) in the Garoua Benue River Basin, North Cameroon, using historical and representative concentration pathways (RCP2.6, RCP4.5 and RCP8.5) of the regional climate model REMO forced by two general climate models: the Europe-wide Consortium Earth System Model (EC-Earth) and the Max Planck Institute-Earth System Model (MPI-ESM). This data was used to force the HBV-Light conceptual rainfall-runoff model to simulate stream flow in the reference period (1981–2005) and in the future middle (2041–2065) and late twenty-first century (2071–2095). A Monte-Carlo approach to calibration was used to obtain best parameter sets of HBV-Light model which reproduced observed stream flow very well with the values of E_{NS} and R_2 greater than 0.80 and 0.90 respectively and the values of RVB less than 10% during the calibration, validation and application periods. Depending on climate sensitivity, scenarios and Global climate models, annual rainfall is expected to decrease in the range of 1-14% and increase of temperature and annual potential evapotranspiration between 8-18% and 9-30% respectively during the two future periods. Under the same conditions, the climate change on annual stream flow was significant with the decrease range between 5-60%. Future development planning in the valley must take into account their effects.

Past climate changes and their impacts on plant ecosystems over the last 6000 years in the Middle Atlas, Morocco

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Abstract

This presentation displays some of the environmental consequences of past climate change that have occurred in the Middle Atlas, Morocco. This study aims at reconstructing past climate changes and their impacts on plant ecosystems during the last 6000 years. It is based on a multidisciplinary approach that involves pollen, geochemical, isotopes and sedimentological analyses.

In addition to these bio- and geo-chemical, elements mean January temperature (T_{jan}), annual precipitation (P_{ann}), winter (P_W) and summer (P_S) precipitation, and a seasonal index (SI) have also been quantified from a fossil pollen record.

During the Last 6000 years, climate has changed within a low temperature and precipitation range with a trend of aridity and warming towards the present. The changes reconstructed in our record between 6 ka cal BP and today tend towards aridity. The main ecosystem changes correspond to a noticeable transition in the conifer forest between the Atlas cedar and the pine forest which has impacted the sedimentation type and its composition in the lake. We have also observed major changes in the ecosystem composition, the carbon isotopic contents of organic matter ($\delta^{13}C$), the total organic carbon and nitrogen amount, and the carbon to nitrogen ratio (C / N) after ca. 3750 cal BP.

Vegetation Response to Past and Present Climate change in Nigeria

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Abstract

Part of the projections of the current climate change is that the tropics would be one of most vulnerable regions to the effects of climate change. To test this hypothesis, the response of forest and savanna vegetation types to past episodes of climate change namely the Mid Holocene optimum (*ca*. 8500-5000 kya) and Late Holocene dry phase (*ca.* 4500-2000 Kya) in southern and north-central Nigeria was investigated.

During the Mid Holocene, the forest in southern Nigeria became extensive and diverse such that this vegetation belt moved slightly northwards; the savanna vegetation in north-central Nigeria was predominantly dry but occasional humid conditions existed. During the Late Holocene, in the southern parts, forest vegetation generally decreased but in certain areas, especially wetlands and/or those with reliable hydrological systems, parts of the forest recovered subsequently. On the other hand, savanna became drier, more open and cooler.

Although human occupation of the forest (*ca.* 11 Kya) is older than that in the savanna (*ca*. 5000 Kya), it was not until the Late Holocene that human impact on the environment in both biomes became significant, the savanna being worse hit. The significance of this is that the savanna is comparatively more likely to be sensitive to climate change, and with more devastating impact on its human population.

Vegetation response to rainfall variability in spiny forest - Southwestern Madagascar

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-

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Abstract

The island of Madagascar is known for its incredible biodiversity, but also the environmental change it has experienced during the late Holocene. Massive extinction and ecosystem degradation are noticed in the different vegetation from rainforest to the spiny forest. However, they are still poorly understood and the impact of climate, especially rainfall variability in shaping the vegetation is practically unknown. Our research aims to evaluate the variation of rainfall in Southwestern region, Madagascar and the consequences it had on the spiny forest ecoregion. Rainfall records were obtained through the analysis of carbon isotope in baobab rings and the vegetation was reconstructed with pollen analysis in sediment cores. Preliminary results suggest that there was a variation of rainfall during the last 700years with a tendency of increase in precipitation amount in the last century. This correlates with the increase in the rate of tree taxa and the reduction of the dry-adapted taxa in the reconstructed vegetation. In the last 4400 years, the vegetation has changed from a savanna woodland to a diverse bush xerophytic before currently become a less diverse forest like ecosystem. Additional radiocarbon dates would be performed on tree and sediment cores in the next three months in order to obtain a high-resolution reconstruction for both rainfall and vegetation.

Climate and Fire History during the last 24000 years Cal. BP, Ifrah Lake, Middle Atlas, Morocco.

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Abstract

The microcharcoal study related to past climate change in North Africa remains poorly documented. A multidisciplinary study using mineralogy, geochemistry and traces of fire (microcharcoal) at Ifrah lake sediments (*33° 33'N*, *04° 56'W*, *1610 m a.s.l* - Middle Atlas, Morocco) offers new perspectives for a better understanding of climate change since the last glacial maximum to the present. From 24,000 to 13,000 cal. yrs BP, the microcharcoal concentration was very low in conjunction with a low fire activity and a cold climate. The phase between 13,000 and 10,800 cal. yrs BP is a period of transition. The beginning of the middle Holocene (between 10,800 and 4500 cal. yrs BP) is characterized by an increase in the concentration of microcharcoal particles. A peak of the particles is observed at 107 cm (ca 8200 cal. yrs BP). This phase is marked by a strong fire activity during a dry period. The upper Holocene (between 4500 and 1700 cal. yrs BP) marks the return of wet climatic conditions showed by a moderate decrease in the concentration of microcharcoal particles.

Analyze of hydrometeorological extremes, and their representation in regional models

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Abstract

Climate models are consistent when it comes to simulate the distribution of changes in temperature or precipitation over large spatial scales (tropics, mid and high latitudes, continents over the oceans). However, on the scale of a particular region, the divergence of models is significant, which is a problem when it is desired control studies leading to relevant adaptation measures.

Quantify the impacts of future climate change leads to analyze the capacities of regional climate models to reproduce a relevant regional climatology. We step back from the climate at these scales and the relationship between variables in local and regional scales. Nevertheless, we now have the expertise and data that allow us to develop a scientific approach to study the evolution of extreme situations in the future climate for local and regional scales.

With the CORDEX initiative (Coordinated Regional Climate Downscaling Experiment), scientists are beginning to appropriate these issues and has a special interest in detecting and changing hydrometeorological extremes simulated in regional models. One of the challenges currently limiting the emergence of a consensus on the climatological results and the use of regional models for simulations of impact studies is the lack of harmonized protocol for: (i) define the hydrometeorological extremes (ii) detecting in the models, (iii) analyze relevant way the realism of simulations compared to observations often conducted at spatial and temporal resolutions that are different models.

In this event analysis study hydrometeorological extremes, we would like to use CORDEX data for statistical analysis of extreme events and estimation of potential changes to these extremes to 2050.

First oceanographic buoy deployment in Benin marine coastal waters

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Abstract

Benin is highly exposed to meteorological, oceanographic and extreme climatic impacts, including increasing the spatial and temporal variability of dry and rainy seasons, floods, droughts, strong winds, coastal erosion and sea level rising. To increase community resilience and reduce disasters related to these risks, it was created in 2014 from the project "Système d'Alerte Précoce du Benin (SAP-Benin)" to prevent these risks and produce climate information. In implementing this project, Benin Fisheries and Oceanologic Research Institute (IRHOB) handles the Oceanographic component focuses on rising sea levels and coastal erosion.

In this context, the IRHOB acquired a buoy "Alizé", consisting of a meteorological and oceanographic station and deployed in Benin marine coastal water. It is equipped with several sensors to collect weather data (wind, air temperature, atmospheric pressure, humidity and precipitation) and oceanographic (wave, currents, sea water temperature and turbidity). To date, the IRHOB has a database of these parameters in real time from December 15, 2015, date of the launching of the buoy. It is also envisaged the acquisition of a salinity sensor. The main goal was from these data in real time to forecast at national level to prevent any risk of oceanic disasters that could impact the local population.

Climate variability in the southwestern Mediterranean during Middle to Late Holocene: reconstruction of millennial, centennial and multi-decadal climate cycles

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Abstract

We carried out a high-resolution multiproxy sedimentological and geochemical investigation of a Middle to Late Holocene sequence of sebkha sedimentary filling in southwestern Mediterranean, far from the influence of oceanic circulations. Magnetic susceptibility measurements were performed to provide a proxy for the relative extent of humid and arid climate periods. An age model for the sedimentary sequences was built based on the radiocarbon AMS 14C dating method coupled to the cyclostratigraphic approach. The arid periods are associated with the relatively low values of magnetic susceptibility (MS). These events correspond to dryer intervals which registered both high solar modulation and sun spot number. Events, where flooding activity and hydraulic strength were higher, are characterized by clay filling into the studied depression with high MS values. Informative paleoclimate proxies of Tunisian, Mediterranean, North Atlantic and sun activity, were compared to our main results. Spectral analysis of our results demonstrates periodic changes of ~2500, ~1500, ~1200, ~1000, ~500, ~230, ~131, ~74 years of relatively warm and cold intervals during the Holocene of Mediterranean. We assume that the two prominent cycles of ~1000 and ~500 years are caused directly by solar insolation affecting the Earth surface and enhanced by other still debated atmospheric mechanisms. It seems that the ~1500-year cycle related with the NAO occurs only in the Late Holocene. Three time periods — 4100–5100 and ~900–1900 — cal yr BP correspond to low sun spot number and the most developed humid periods in the sebkha Ennoual.

Environmental dynamics in a Sudanian watershed during the past two millennia (Wanar, Bao Bolon, Senegal).What anthropogenic and hydro-climatic processes?

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Abstract

Research on climate and environmental changes during the last two millennia in West Africa, is very acute because of the scarcity of data over this period and their sparse spatial and temporal coverage. The semi -arid climate of Sudanian Africa has generally precluded the conservation of relevant long term continuous palaeoenvironmental records. However, this period is marked by a continuous enhancement of human impacts on the environment. The watershed scale is quite relevant to an integrated understanding of the cross-roles of the different factors of these changes (hydro-climatic, biotic or anthropogenic).

In Western Central Senegal, an important archaeological phenomenon heightens interest of the cultural and settlement history of the region: the Senegambian megalithism (UNESCO World Heritage - 7th to the 16th century AD). Our palaeoenvironmental research focuses on the site of *Wanar* in the watershed of the Bao Bolon, a tributary of the Gambia River, closely with archaeological excavations (wanar-excavations.jimdo.com). So far, some thirty sections and coring places have been described and/or sampled in an area of 250 km² around the site.

Studies deal with disciplines of geoarchaeology, combining geomorphology, sedimentology and palaeo-biogeography. On the first hand, field geomorphology and satellite imagery interpretation provide a first geomorphological sketch of the study area and grain size analyses allow the characterization of the hydro- sedimentary dynamics and their evolutions. On the second hand, the reconstruction of the history of vegetal landscapes and natural environments is allowed by palaeobiological multiproxies analysis (pollens, palynofacies, diatoms, dendrology and fire signal).

First results document sedimentary archives record up to 5 ky., with distinct units in the cored material. These define various phases of accumulation and incision, with a succession in the environmental conditions. The last two millennia are well documented by a sedimentary unit which span from 1850 cal BP to 550 cal BP. Therefore, studies currently in progress at Wanar enable to reconstruct the evolution of these landscapes and assign an environmental framework to the Senegambian megalithism. It will give information about the dynamic factors linked to human activities (fires, vegetation clearing, agro-pastoral practices) and their imprint on the landscape. The objective is to study the response of an environment faced to human activities, directly or indirectly, linked with the megalithic site. How evolved the environmental conditions? To what extent these populations have influenced the landscape?

Further chronostratigraphic data show an important sedimentary phase hiatus until at least 1850 cal BP, which suggest a strong erosion phase just before our protohistoric records. These results have to be enrich, but at this time, it seems to match a hydro-climatic crisis around 2000 cal BP in West Africa (Lézine *et al.* 2011, Garnier *et al.* 2015, Maley & Vernet 2015, Nash *et al.*, 2016).

Assessing the modern input of aeolian dust into the Moroccan Middle Atlas using a simple web-based method

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Abstract

Aeolian dust is and was an important initator, player and recorder of environmental change. Therefore, assessing recent and former mobilisation, transport and deposition of aeolian dust is an important field of geoecological and paleoenvironmental research. In this context, recent reference values about the pathways of aeolian dust are also mandatory for studies about the former dynamics of aeolian dust.

Using an example from the Moroccan Middle Atlas, this contribution presents a simple method to semi-quantitatively assess the recent dynamics of aeolian dust by combining the results of the web-based BSC-DREAM8b v2.0 dust model with NOAA-HYSPLIT backward trajectories. Doing so, main pathways and approximate quantities of recent dust input towards the Middle Atlas during the annual cycle could be assessed by applying a fast method that can easily be used also by computer novices.

Assessing new ways to reconstruct paleovegetation patterns: The potential of leaf wax-based biomarker analyses in fluvial sediment-paleosol sequences

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Abstract

Traditionally, former vegetation patterns are reconstructed based on pollen analyses of material derived from marine, lacustrine or peat bog sediments. During the last years, also leaf wax-based biomarkers such as long-chain n-alkanes were used in this context. Unlike pollen grains that are very vulnerable to (selective) decomposition in aerobic environments and to mechanical destruction during redeposition, some lipid biomarkers are relatively persistent and well preserved over millennial timescales. Lipid biomarkers were derived from marine and lacustrine sediments or loess-paleosol sequences so far, whereas no studies have explored the potential of leaf wax-derived n-alkanes from fluvial sediment sequences yet. However, whereas the former types of sediments only occur in regions with particular geomorphic and (paleo-)environmental conditions, fluvial sediments are found in most regions of the world. Therefore, leaf wax analyses in fluvial sediments have the potential to strongly enhance our knowledge about former vegetation patterns in different landscape and climate zones that are largely devoid of other types of sediment archives, such as in large parts of arid to hyperarid northern Africa.
Although the presentation deals about a case study from the Alazani River in in the southern Greater Caucasus, we generally see a high potential for this approach for paleaoenvironmental studies in African deserts or semi-deserts. We will present chances and challenges of leaf wax-based biomarker analyses in fluvial sediment-paleosol sequences to reconstruct the paleovegetation by using the example of the upper Alazani River in the southern Greater Caucasus. Generally, the biomarker-derived information from fluvial archives must be divided into (i) a catchment-signal recorded in fluvial sediment layers, and (ii) a local in-situ signal recorded in the alluvial paleosols. This offers the chance to reconstruct paleoenvironmental conditions in both the whole catchment area and at the sampling site. However, several potential archive-related pitfalls have to be addressed when interpreting the leaf-wax pattern from fluvial sediment sequences. These potential challenges will be discussed during this presentation.

EFFECT OF CLIMATE CHANGE ON SURFACE WATER RESOURCES IN THE HAOUZ REGION (MOROCCO)

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Abstract

Climate change significantly impacts the availability of water resources. In order to meet the needs of its population and avoid the shortcomings that can be accentuated in the coming decades, Morocco has put in place its National Water Strategy, established by 2030.
One of the direct consequences of this phenomenon is the quantity of water resources available.
The Haouz plain is among the most sensitive areas. Historically, this area depends on groundwater as the main water resource. At present, this resource is at the limit of overexploitation manifested by a drop in the ground water level. Faced with this problem, rigor in the management of pre-existing resources must precede any other solution. The Haouz is an arid to semi-arid region that suffers from water scarcity due to the scarcity of forecasts and the ever-increasing demand for water due to demographic pressure and The spirit Agricultural activity.
The specific objective of our study is to stand out the elements that characterize the climate variability of the Haouz region, study the evolution of the recent climate through the two main parameters, temperature and precipitation using Average monthly and interannual variation. We have used an updated database on eight extended stations for the most complete series over a period of 45 years from 1970 to 2015. The most complete stations are those of Marrakech and Sidi Rehal.
The annual rainfall in Marrakech and Sidi Rehal is variable and irregular from year to year. The average forecast of 212.8 mm calculated at the station of Marrakech to reach 349.9 mm at the level of Sidi Rehal. The minimum was recorded in (1982-1983) for the station of Marrakech and in (1992-1993) for the station of Sidi Rehal. Maximum rainfall was recorded during the year (1970-1971) for the Marrakech station and (1995-1996) for the Sidi Rehal station. On the other hand, this variant illustrates a downward trend in forecast years for the two-year period during the 1970s and 1990s, compared to the decades of 1990 and 2010.
The temperature contrasts are remarkable, due to diurnal, seasonal or annual variations. In Marrakesh, the annual average calculated from 20.4 ° C (average measured between 1970 and 2015).
Analyzing these results allows us to deduce that water resources are continually decreasing and their quality deteriorates particularly in the southern part of Morocco.

Examples of climate variability during the Pleistocene along the Atlantic Coast

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Abstract

Records of past climate conditions provide data of great importance for understanding environmental changes and forecasting the natural evolution of our interglacial period. Thus, it is essential to determine the climate behavior during the past interglacial periods.

The episodic nature of the Earth's glacial and interglacial periods have been caused primarily by cyclical changes in the Earth's circumnavigation of the Sun. Variations in the Earth's eccentricity, axial tilt, and precession creates alterations in the seasonality of solar radiation reaching the Earth's surface, which influences the climate system, thus impacting the advance and retreat of Earth's glaciers.

Here we present a comparison between previous climate change records covering the Pleistocene period in three sites along the Atlantic Coast (United States, Brazil), the Iberian margin and our ongoing study in the region of Essaouira (Morocco), in which, several samples of both fossil and modern dunes are under study in order to reconstruct Quaternary stratigraphy and sea level history along the Atlantic Coast. Using terrestrial correlations, this study will allow us to document the climatic change in the Atlantic Coast during the Pleistocene era.

Impacts of land use variability on wind erosion flux and nutrients transfers associated at Banizoumbou (south-west of Niger)

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Abstract

At south Niger, wind erosion makes soil and nutrients losses and it remains a major factor of environmental degradation. The landscape of this area is dominated by a juxtaposition of bush fallow with different age and millet field. The aim of this work has been to quantify : i) wind erosion flux during 9 years on a plot at first cultivated (2006 to 2009) then abandoned to be bush fallow (2010 to 2014) and ii) nutrients transfers associated to flux in relation of land use on 3 plots during 2014. Wind erosion was measured by BSNE sand-trap, meteorological parameters (rain, wind velocity and direction) were continuously measured and chemical analyses of soils and flux have been done. Thus it appeared that wind erosion flux exponential decreases with age of bush fallow from 400kg/m (1_{st} year) to less than 50kg/m (5_{th} year). Besides, for simultaneous measurements done in 2014, the herbaceous which covered the old fallow (5 years) reduced wind erosion near to 7 times than millet field. Also, the sum of exchangeable bases (EB) of the soil of this fallow (2.669 Mèq/100g) has been higher than in the soil of field (2.085 Mèq/100g). On the other hand, the flux measured on the fallow had less EB (2.29 Mèq/100g) than which recorded on field (2.47 Mèq/100g). Then, it appeared an important role of wind erosion in the increasing of EB in the soil of old fallow by trapping of flux and EB mobilized since the plots more sensible to wind erosion (field and youth fallow).

Mauritanian experience in the techniques of biological bending of Coastal dunes: Case of Nouakchott

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Abstract

The climates changes had done most measurable effects over the human life. The Mauritanian littoral has been exposed to several human activities with the urban development. To remain these situations the program adaptation of climate change and coastal tried to restore the level of the littoral. The aim of this research is to contribute in the study of biological bending of coastal dune of Nouakchott. The field is located between the *Warf* and the fish market of Nouakchott. We proceed by the method called “quinconce”. This method consists of planting the trees in triangle method followed each other. The three kind of plants used, were the same that it had lived in the field as *Nitratria*, *Tamarix* and *Troyenne Champetre*. The *Nitratria* over 312 plants, 286 lived and 26 dead. For the *Tamarix,* over 181 plants, 171 lives and 10 dead. And *Troyenne Champetre*, over 327, 301 plants lived and 26 died. The local plants made successful result and 90 % of the plants survived in the field. The results show that the plants can adapt to salt sand. This experience has shown the capabilities of the trees to restore the level of the coast ant to protect the cities from the sand wind.

Atlantic forcing of Western Mediterranean winter rain minima during the last 12,000 years

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Abstract

The limited availability of high-resolution continuous archives, insufficient chronological control, and complex hydro-climatic forcing mechanisms lead to many uncertainties in palaeo-hydrological reconstructions for the Western Mediterranean. In this study we present a newly recovered 19.63 m long core from Lake Sidi Ali in the North African Middle Atlas, a transition zone of Atlantic, Western Mediterranean and Saharan air mass trajectories.

With a multi-proxy approach based on magnetic susceptibility, carbonate and total organic C content, core -scanning and quantitative XRF, stable isotopes of ostracod shells, charcoal counts, *Cedrus* pollen abundance, and a first set of diatom data, we reconstruct Western Mediterranean hydro-climatic variability, seasonality and forcing mechanisms during the last 12,000 yr. A robust chronological model based on AMS ^{14}C dated pollen concentrates supports our high-resolution multi-proxy study.

Long-term trends reveal low lake levels at the end of the Younger Dryas, during the mid-Holocene interval 6.6 to 5.4 cal ka BP, and during the last 3000 years. In contrast, lake levels are mostly high during the Early and Mid-Holocene. The record also shows sub-millennial- to centennial-scale decreases in Western Mediterranean winter rain at 11.4, 10.3, 9.2, 8.2, 7.2, 6.6, 6.0, 5.4, 5.0, 4.4, 3.5, 2.9, 2.2, 1.9, 1.7, 1.5, 1.0, 0.7, and 0.2 cal ka BP.

Early Holocene winter rain minima are in phase with cooling events and millennial-scale meltwater discharges in the sub-polar North Atlantic. Our proxy parameters do not show so far a clear impact of Saharan air masses on Mediterranean hydro-climate in North Africa. However, a significant hydro-climatic shift at the end of the African Humid Period (~5 ka) indicates a change in climate forcing mechanisms. The Late Holocene climate variability in the Middle Atlas features multi-centennial-scale NAO-type pattern, with Atlantic cooling and Western Mediterranean winter rain maxima generally associated with solar minima.

Detecting and understanding hydro-climatic, ecological and socio-ecological tipping points: A multi-scale study at the Moroccan desert margin

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Abstract

In this study, we focus on climatic and ecological tipping points in North African lakes and adjacent environments along the present-day desert margins of the Mediterranean region. The western Mediterranean desert margin is considered to be among the most sensitive landscapes to global warming. The major aim of our proposed project is to analyse the environmental variability on the Moroccan mountainous desert margin.

This will enable us explicitly to understand the interactions between hydro-climatic, geomorphological, ecological and socio-ecological tipping points in the region, and furthermore to refine scenarios for future climate changes. A key concern of the planned project is the coupling of different spatial and temporal scales.

We will focus on the two lake sites of Lake Sidi Ali (Middle Atlas) and Lake Tislit (High Atlas) and their adjacent terrestrial geo-ecosystems, including ancient lake shorelines. Our focus on these two sites will result in a NE to SW desert margin transect that encompasses a range of precipitation regimes, with increasing Saharan influence further inland.

Our project will compile (palaeo)hydrological and (palaeo)ecological datasets and integrate them with archaeological, historical and modern land use data, thereby providing reconstruction of past conditions over a range of spatial and temporal scales.

In this project, we will not only provide new scientific results but will also strengthen the Moroccan-German scientific network that will provide a fundamental basis for a future envisioned DFG joint project and an enlarged multi-national research network.

The project will be implemented for 12 months. A bi-national workshop is one of the major milestones of the project. Subsequently, Moroccan and German research teams will conduct surveys to the project key sites at Lake Tislit, Lake Sidi Ali and adjacent terrestrial environments. Our results will be published in a peer-reviewed international journal.

Transport and preservation of marine palynomorphs in nepheloid layers off Cape Blanc (N-W Africa)

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Abstract
Marine palynological archives have proven to be extremely useful to reconstruct climate and anthropogenic induced vegetation changes on the continent and compare these with contemporaneously occurring oceanographic changes. For reconstructing changes in the north-the African climate and environment in relationship with oceanographic changes in the Atlantic Ocean many studies have been executed on palynological records collected from the equatorial Atlantic along the NW African margin. However, to use marine sedimentary palynological associations for establishing adequate oceanographic, environmental and climatic reconstructions, it is essential to know to how and to what extent palynomorphs have been transported from their production site towards deposition. Furthermore, it is important to know if the sedimentary association has been altered during and after deposition, for instance as a result of selective organic matter degradation.
Here we present the first study world-wide that investigates to what extent palynomorphs are being transported during the settling process within the water column off NW Africa. For this we followed the track of marine produced palynomorphs (dinoflagellate cysts) from their production in the upper water column towards deposition in the upper sediments.
We compared the export rain of dinoflagellate cysts collected at in the subsurface water column, to the cyst associations in different nepheloid layers in the water column, the bottom nepheloid layer and surface sediments. Samples have been collected along two onshore offshore transect off Cape Blanc (NW Africa) during active upwelling in November 2015.
We observed highest cyst production at the rim of a newly formed upwelling eddy/filament. Lateral transport of cysts up to 130 km off the shelf break was observed in a nepholoid layer varying in depth between 600-1300 m (shelf break – deep ocean) and in the bottom nepheloid layer. No indication for lateral transport could be documented in a second intermediate nepheloid layer deeper in the water column as well as in the more offshore part of the bottom nepheloid layer.
The effects of lateral transport as registered from the water column was not reflected in underlying sediments. Selective degradation altering the cyst associations was not observed in the water column but the surface sediment cyst association differed considerable from that of the nepholoid layers and the upper water column. Comparison with long term sediment trap time series of cyst production in the region indicate that the surface samples are modified predominantly by species specific post depositional degradation rather than inter-annual variation in transport and/or production of cysts.