Welcome to Bremen !!!

Dear workshop participant,

Welcome!

We cordially welcome you to Bremen, and especially to this workshop that brings together leading international scientists in mineral-dust research from the marine, polar, and terrestrial realms, remote sensing, palaeoclimate modelling as well as experts in atmospheric sciences. The workshop aims to explore recent developments in the understanding of the role of mineral dust in the earth system. In addition, by the end of this workshop, we would like to come up with recommendations for future research towards a better understanding of processes that play an active role in dust emission, transport and deposition, and approaches to study the role of mineral dust in global climate.

Background

After the first ADOM workshop (ADOM1 was held in 2009 in Hyères-les-Palmiers, France, 2009), and following up on the results of the DUSTSPEC workshop (held in Lamont, USA, 2010), it is recognised that there is a specific need for an integration of datasets of dust deposition on land and in the ocean. In addition, we need to understand the processes that lead to dust emission, dispersal, and deposition.

A specific focus in this workshop will be put on what we can learn from aeolian dust records about the dynamics and variability of large-scale atmospheric circulation during the geological past. As a regional and strategic target, activities in this workshop will focus on the low-latitude circulation where records of desert loess and dust accumulation in ocean sediments provide a comprehensive database. The workshop will explore strategies to derive quantitative and physically consistent synoptic reconstructions by integration of dust records, climate observations, and model simulations.

This Workshop

This workshop is a joint effort of the PAGES working group ADOM (Atmospheric Dust during the last glacial cycle: Observations and Modeling) and of MARUM-Bremen and is sponsored by MARUM, PAGES, and INQUA.

The workshop is structured into two days of presentations, followed by a half day where we will work in discussion groups to come up with recommendations for future research.

In this book you will find all the information about the workshop, as well as practical information for your stay in Bremen.

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

The organizers,

Jan-Berend Stuut (MARUM-NIOZ)
Ute Merkel (MARUM)

Denis-Didier Rousseau (ADOM-PAGES)
Gisela Winckler (ADOM-PAGES)
Paul Vallelonga (ADOM-PAGES)
Thorsten Kiefer (ADOM-PAGES)

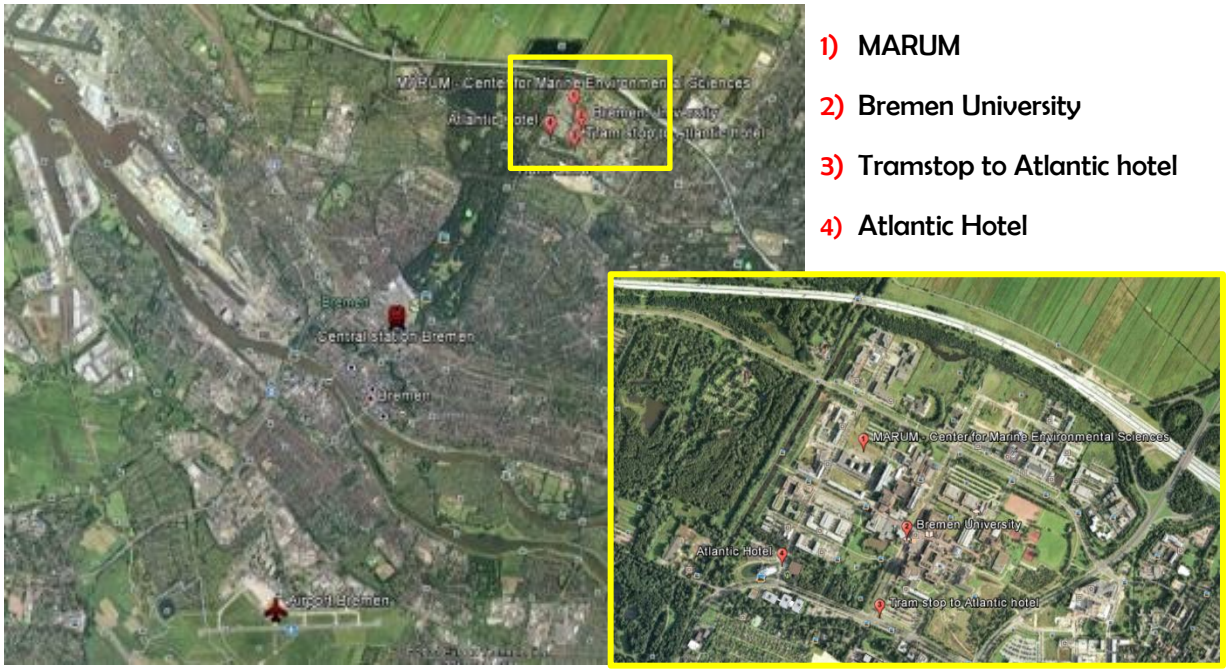
Contact us through: dust2011@marum.de

Find latest updates at: www.marum.de/dust-workshop2011.html

Index:

MARUM – Center for Marine Environmental Sciences offers access to the eduroam-WLAN. Alternatively, you can connect to the MARUM-WLAN, for which you'll find your personal voucher on page 61.

Map of Bremen:



1) MARUM
2) Bremen University
3) Tramstop to Atlantic hotel
4) Atlantic Hotel

The workshop will take place on the second floor of MARUM, which is located on the campus of the University of Bremen, in the Leobener Straße (see campus map on page 6). Here we will also have our ice-breaker drinks, lunches, and dinners.

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

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

This ride will take you through the center of the city, pass also through central station, and takes about half an hour. Buy your tickets at the tram driver's (~3 Euro)

Any taxi will of course also take you to the campus (~30 Euro).

The MARUM building is within walking distance from the Atlantic hotel (see page 6).

Useful phone numbers:

Hotel Atlantic	+49 (0) 421 – 246 70
Jan-Berend Stuut	+49 (0) 173 – 217 2008 (mobile)
Ute Merkel	+49 (0) 172 – 583 9185 (mobile)

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

6 Tram

Abfahrt ab Flughafen

Richtung Universität

VBN - Serviceauskunft 01805 - 826 826 (14 Ct./Min. aus dt. Festnetz, aus dem Mobilfunknetz max. 42 Ct./Min.)
Gültig ab: 20.10.2011

BSAG Partner im VBN

Uhr	Montag bis Freitag	Samstag	Sonn-/Feiertag	Uhr
4	55	48r		4
5	10 25 40 55	08r 28r 48r	08h	5
6	08 18 28 38 49 55	08r 28r 48r	12r 42r	6
	08 18 28 38 48 58			
7	01 07 13 19 25 31 37 43 49 55	08 28 48	12r 42	7
	08 13 18 23 28 33 38 43 48 53 58			
8	01 07 13 19 25 31 37 43 49 58	08 28 48 58	12 42	8
	03 08 13 18 23 28 33 38 43 48 53 58			
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	03 08 13 13b 18 23 28 33 38 43 48 53 58			
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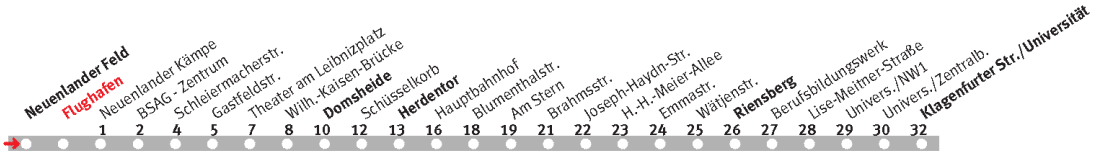
21	08 28 48	08 28 48	08 28 48	21
22	08 28 44	08 28 44	08 28 44	22
23	14 44	14 44	14 44	23

In den Sommerferien wird nach Ferienfahrplan, Heiligabend/Silvester nach Sonderfahrplan gefahren!

00 Fahrten zur Vorlesungszeit (vom 10.10.-23.12.2011 u. 05.01.-17.02.2012)
00 Fahrten zur Vorlesungszeit, nur freitags (vom 14.10.-23.12.2011 u. 06.01.-17.02.2012)
00 Fahrten zur Vorlesungszeit, nur montags-donnerstags (vom 10.10.-22.12.2011 u. 05.01.-16.02.2012)
00 Fahrten zur vorlesungsfreien Zeit (vom 27.12.2011-04.01.2012 u. 20.02.-23.03.2012)

b bis Hauptbahnhof
h bis Domsheide, weiter über Ostertor, Am Dobben zum Hauptbahnhof
r bis Riensberg



Linienverlauf und Fahrzeit in Minuten

20.10.2011 001200 (V) W11

Simplified map of the University Campus:

Workshop program:

Monday 31 October 2011

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

Tuesday 1 November 2007

9.00 – 9.15	Welcome and introduction to the workshop	

Theme 1: Present-day dust, meteorology, and remote sensing

9.15 - 9.35	Ina Tegen	Modelling modern Saharan dust transport and impacts: lessons from SAMUM
9.35 - 9.55	Konrad Kandler	Modern Saharan dust physico-chemical properties – results from SAMUM
9.55 - 10.15	Paul Hesse	Dust sources and land surface/erodibility limitation of dust supply
10.15 - 10.45	Coffee break	
10.45 - 11.05	Wolfgang von Hoyningen-Huene	Dust remote sensing using nadir looking satellite instruments
11.05 - 11.25	Paul Vallelonga	Dust records in Greenland ice cores
11.25 - 11.45	Short presentations	Jan-Berend Stuut, ...
11.45 - 12.30	Discussion	
12.30 - 14.00	Lunch break	

Theme 2: Dust archives (ice cores and marine sediments)

14.00 - 14.20	Anna Wegner	Seasonality in dust records from ice cores
14.20 - 14.40	Hubertus Fischer	Antarctic high-resolution ice-core records of dust transport and mobilization
14.40 - 15.00	Jean-Robert Petit	Climate factors influencing the long-range transport of dust: example from Antarctica
15.00 - 15.20	Joseph Prospero	Long-term trends in African dust transport to the Caribbean: African sources.....
15.20 - 15.50	Coffee break	
15.50 - 16.10	Aloys Bory	Tracing dust provenance in paleoclimate records: mineralogical & isotopic fingerprints
16.10 - 16.30	Rainer Gersonde	Pleistocene dust deposition in the Pacific Southern Ocean
16.30 - 16.50	Gisela Winckler	Dust flux & biological productivity in the eq. Pacific: testing the fertilization hypothesis
16.50 - 17.10	Alfredo Martinez-Garcia	Dust-flux variability in the subantarctic Atlantic over the last 4 million years
17.10 – 17.30	Short break	
17.30 - 18.15	Discussion	
18.15 - 19.00	Short presentations	Inka Meyer, David Naafs ...
19.00 -	Dinner at MARUM	

Wednesday 2 November

Theme 3: Dust archives (terrestrial sediments)

9.00 - 9.20	Maarten Prins	Unravelling terrestrial and marine dust archives: towards an indicator of wind strength
9.20 - 9.40	Hongbo Zheng	Origin of Asian dust: tectonics vs climate
9.40 - 10.00	Slobodan Markovic	One million years of dust dynamics recorded in Serbian loess-palaeosol sequences
10.00 - 10.20	Ludwig Zöller	Terrestrial dust record between tropical and extratropical circulation: Canary Islands
10.20 - 10.50	Coffee break	
10.50 - 11.10	Björn Machalett	Long-term seasonality changes and short-term climate variability in Eurasian loess....
11.10 - 11.30	Denis-Didier Rousseau	European loess sequence, a record of atmospheric changes (ACTES ANR project)
11.30 - 12.30	Discussion	
12.30 - 14.00	Lunch Break	
14.00 - 15.00	Short presentations	Ulrich Hambach, Frank Lehmkuhl, Kay Beets, Zorica Svircev, Stephan Dietrich
15.00 - 15.30	Coffee break	

Theme 4: Modelling dust deposition (modern and palaeo)

15.30 - 15.50	Kerstin Schepanski	Meteorological aspects of dust emission and transport
15.50 - 16.10	Nicolas Heavens	Data analysis, modelling, and interpretation of low-lat. Late Paleozoic dust deposits
16.10 - 16.30	Christine Hatté / DDR	Organic isotopic geochemistry as proxy of past atmospheric circulation
16.30 - 16.50	Adriana Sima	Surface winds in a hierarchy of simulations with the LDMZ atmospheric GCM
16.50 – 17.10	Break	
17.10 – 17.30	Samuel Albani	Holocene dust variability: synthesis from natural archives
17.30 - 17.50	Yves Balkanski	Importance of dust mineralogy for dust radiative effect
17.50 - 18.15	Short presentations	Natalia Sudarchikova, ...
18.15 – 19.00	Discussion	
19.00 -	Dinner at MARUM	

Thursday 3 November

9.00 - 9.20	Yaping Shao	New developments in dust emission parameterization
9.20 – 9.30	Kerstin Schepanski	Contribution to flash floods on interannual variability of dust emission in the Sahara
9.30 – 10.30	Discussion	in working groups I
10.30 - 11.00	Coffee break	
11.00 - 12.30	Discussion	in working groups II, and writing down of recommendations
12.30 - 14.00	Lunch break	
14.00 - 16.00	Presentation	working groups & discussion, wrap up & closure
16.00	Departure of participants	

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Aloys Bory	Tracing dust provenance in paleoclimate records using mineralogical and isotopic fingerprints: additional clues from present-day studies	19
Hubertus Fischer	Antarctic high-resolution ice-core records of dust transport and mobilization	16
Rainer Gersonde	TBA	20
Christine Hatte	Organic isotopic geochemistry as proxy of past atmospheric circulation	36
Nicolas Heavens	Data analysis, modeling, and interpretation of low-latitude dust deposits from the Late Paleozoic	33-35
Paul Hesse	Dust sources and land surface/erodibility limitation of dust supply	12
Konrad Kandler	Modern Saharan dust physic-chemical properties – results from the SAMUM campaigns	11
Björn Machalett	Long-term seasonality changes and short-term climate variability recorded in Eurasian loess: examples from Serbia, Romania, Kazahkstan, and China	29
Slobodan Markovic	One million years of dust dynamics recorded in Serbian loess-palaeosol sequences	26
Alfredo Martinez-Garcia	Dust flux variability in the Subantarctic Atlantic over the last 4 million years	22
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Ludwig Zöller	Terrestrial dust record between tropical and extratropical circulation: the eastern Canary Islands	27-28

List of short presentations and posters:

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Tuesday 9.15 – 9.35

Modelling modern Saharan dust transport and impacts: lessons from SAMUM

The role of mineral dust aerosol as climate factor which itself strongly depends on climate conditions has received considerable attention in recent years. The Sahara desert in northern Africa is the world's largest source of dust aerosol, changes in emission and transport patterns therefore need to be understood in order to fully understand its role in the climate system. Field studies like the recent SAharan Mineral DUst experiment (SAMUM), which was carried out in the years 2006 and 2008 at locations in Morocco and Cape Verde, respectively, aimed at improving the estimates of dust radiative forcing caused by Saharan dust. However, many aspects of the variability of atmospheric dust loads remain poorly understood. Regional-scale models help to understand processes involved in dust emission, transport and deposition, and are suited for comparisons with results of field studies. Models of modern atmospheric dust still often show considerable deviations from observations. One cause can be inadequacies in simulated meteorological fields that are used to compute dust emission fluxes. In contrast to global-scale dust models, regional dust models are expected to better reproduce individual dust events due to their higher grid resolution. Still, the representation of dust emission events that are related to precipitation events (haboobs, density currents) is problematic at grid resolutions that require parameterization of wet convection processes. New remote sensing products, together with the observations from recent field studies promise an improved understanding of dust regimes and are expected to lead to considerably improved dust models.

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Tuesday 9.35 – 9.55

Modern Saharan dust physico-chemical properties: Results from the SAMUM campaigns

The modern Saharan mineral dust received an increasing amount of attention in the research community during the last decade. A number of large field campaigns performed in and west of Africa took place. Amongst them, the Saharan mineral dust experiment SAMUM, running from 2004 to 2011, focused on the dust direct radiative impact. During the SAMUM experiment, a wide range of physic-chemical properties of the modern Saharan aerosol were determined. The experiment was performed in two major field campaigns of four weeks, one close to the source in southern Morocco, the other one in the medium-range transported – and thus, slightly aged – dust aerosol on Cape Verde. Both locations were supplied with considerable amounts of Saharan dust during the campaign, while the dust originated from different sources. The sources during the desert campaign were located in south-eastern Morocco, Algeria, and Tunisia, whereas the ones for the Cape Verde experiment were situated more south, coastal Mauritania and the eastern Mail/western Niger dust corridor.
Saharan aerosol is a complex mixture of mineral dust and anthropogenic compounds. Its composition depends on the particle size and the processing history. While it is transported westward across the Atlantic Ocean, marine components – gaseous as well as particulate – add up to the aerosol complexity. Also, omnipresent anthropogenic compounds like soot or sulfate- and nitrate-precursors are adjoined. In addition to an ordinary admixture, interaction between the added components and the dust occur, which can impact for example the iron solubility of the base minerals and/or leading to iron compound recrystallization and changing bio-availability.
This presentation reports on aerosol size distributions and mass concentrations and on the mineralogical composition. In detail, various properties determined by electron-microscopic single particle analysis like chemical composition, the particle mixing state and shape of the particles as well as derived properties like the aerosol complex refractive index are discussed.
In terms of microphysical properties, the most striking difference between Saharan aerosol in Morocco and Cape Verde is naturally the loss of the largest particles (> 20 µm diameter). Connected to this loss, we observe as a result a change in mineralogical composition, as quartz and feldspar components – forming usually the large particle – are depleted. Particularly in the clay mineral composition, the calcite and total iron content there is evidence of the different source regimes for Cape Verde and Morocco, related to the source's top soil mineral contents. That depletion is also reflected in absolute mass concentrations and concentration variability, which largely decrease from Morocco to Cape Verde. In terms of internal particle mixing, we have an – expected, but surprisingly low – increase in the dust/sulfate mixing. Already in Morocco, dust/sulfate mixtures are quite common, which leads to the speculation that these particle mixtures already exist in the top soil, either by in-situ processing or by short-range transportation (e. g., repeated resuspension). The mixing state with respect to sea-salt is nearly unmixed, which is reported to change on the dusts further transport, i. e. to America. It is most probably related to a rather non-cloudy transport to Cape Verde. Reflecting the complex chemical composition, the spectral refractive index of the aerosol is a function of particle size, but in addition, a poly-disperse refractive index distribution exists for each particle size. The shape distribution of the particles was determined from their two-dimensional projection. There are no significant differences between different locations in particle shape, but a slight dependence of particle shape on chemical composition exists. Incorporating these data in a radiation transfer model shows that the particle's asphericity leads to an additional negative top of the atmosphere radiative forcing, compared to the assumption of sphericity.

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Tuesday 9.55 – 10.15

Dust sources and land surface erodibility limitation of dust supply

The Australian continent supplies dust to low latitudes of the Indian Ocean through the northwest dust path in Austral winter/spring, carried by southeast trade winds. However, the Quaternary record of dust deposited in eastern Indian Ocean sediments is much lower than the southeastern dust path and predictions made by dust transport models. The models also predict relatively higher dust levels in the northwest dust path than either ground-based or satellite-based observational studies have found.

One reason for this disparity may simply be that the models do not constrain the supply of erodible dust particles sufficiently and thus over-predict dust entrainment. The western half of the Australian continent is likely to have a poor supply of erodible particles for several reasons: (1) it has very low relief and very low erosion rates, (2) the land surfaces are known to be very old and duricrusted over large areas, (3) although large areas are covered with sand dunes these mostly lie over bedrock, stony and duricrusted surfaces (see 1 and 2) which is exposed in interdunes, rather than erodible sediments. Recently Bullard et al. (2011 in press, JGR) have developed and applied a geomorphic classification of surface dust emissivity to several desert areas, including the Lake Eyre Basin of Australia. In this paper Bullard et al.'s scheme is extended to the entire Australian continent (except the humid east coast). The mapping is based on interpretation of Landsat TM mosaics and has some limitations: not all of the Bullard et al. divisions could be mapped but the high and intermediate level dust emitting surfaces (according to the scheme) were mostly mappable. Good agreement was found between the new map and Bullard et al.' map of the Lake Eyre basin.

However, the map does not provide a clearcut difference in geomorphology which would simply explain the low levels of dust in the northwest dust path. The map shows large areas of low emissivity bedrock, rocky and duricrusted surfaces but also large areas of dunefields (intermediate emissivity). There is a smaller area of ephemeral lake basins, but this high emissivity unit is still widespread. The most likely explanation for this gap in observed and predicted emissivity is that the mapping scheme (as developed and as applied) does not capture important aspects of surface characteristics, particularly in ephemeral lakes. The distribution of lunettes adjacent to lakes seems to indicate that lakes in the centre and southeast of Australia are long-term areas of deflation but that this is not the case in northern Australia. This difference is most likely the product of both climatic/hydrological and topographic factors.

Wolfgang von Hoyningen-Huene

Tuesday 10.45 – 11.05

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Dust remote sensing using nadir looking satellite instruments

Desert dust aerosol and the dust outflow of West Africa is a major impact on climate and bio-geological processes in the affected regions of Atlantic Ocean. Thus the dust outflow and its deposition is scientific interest. Therefore satellite observations of the dust transport and the dust deposition are required.

The remote sensing of desert dust is a specified version of general aerosol remote sensing, using optical properties of desert dust. For ocean and dark land surface conditions this is part of the most remote sensing approaches for aerosol optical thickness (AOT), like the Bremen AErosol Retrieval (BAER). Thus the temporal variation of the dust outflow from West Africa can be monitored with nadir looking spectral satellite radiometers, like SeaWiFS, MERIS or MODIS in terms of the AOT. Long term observations of monthly averages of AOT over the West Africa and the Northern Atlantic using SeaWiFS data give the variation of dust transport out of Africa since October 1997.

Correlations between dust AOT and sediment deposition from sediment traps show, the AOT self is not directly connected with the dust deposition. However, fist investigations showed, the temporal-regional change of dust AOT can be used as an indicator for the fall out of aerosol along the transport path.

With: Marco Vountas[1)], Jongmin Yoon[1)], Gerhard Fischer[2)], John P. Burrows[1)]
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Tuesday 11.05 –11.25

Dust records from Greenland ice cores

Since the first deep ice core drilling at Camp Century in northwest Greenland, an array of ice core records from across Greenland have been assembled, documenting the regional and hemispheric climate variability since the last interglacial - the Eemian. The recovery of an undisturbed Eemian climate record from Greenland continues to be an elusive goal, although the journey continues to produce novel findings.

The study of dust and dust-related impurities in Greenland ice has slowly developed in detail: from the initial observations of an annual signal, to the definition of a spring dust peak and the identification of systematic phasing between dust, temperature proxies and other impurities. Analysis of Strontium and Neodymium isotopes in snowpack and ice cores has allowed dust provenance to be traced, clearly demonstrated the dominance of central Asian deserts as the primary source of dust deposited in Greenland. The development of sensitive dust particle size measurements by coulter counter has refined models of dust transport in the Northern Hemisphere. The exceptional stratigraphy deduced by Continuous Flow Analysis of the NGRIP ice core allows the investigation of dust variability on annual timescales: annual layer counting in Greenland ice has been conducted using stratigraphic proxies including dust, chemical impurities and optical detection of cloudy bands in the ice. The relation between cloudy bands - only observed in glacial ice - and microparticle concentrations is a field of ongoing research, as is the role of dust content in large-scale ice sheet flow dynamics, ice crystal boundary movement and in-situ gas production in the ice.

The latest chapter in the story of Greenland ice core drilling is the NEEM ice core - drilled in northwest Greenland between 2008 and 2010 and opening another window on the history and dynamics of the Greenland ice sheet. In addition to the exciting perspectives NEEM will offer on the climate of the Eemian, the drilling program employs the latest developments in continuous flow analysis as a technique for the measurement of dust and other impurities in ice - all carried out in the field. The presentation will focus on our understanding of dust and climate dynamics from Greenland ice cores, and the perspectives that the NEEM ice core will contribute.

With: Anders Svensson[1], Matthias Bigler[2], Ernesto Kettner[1], Giuliano Bertagna[1], and Erik Warming[1].
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Tuesday 14.^{00} – 14.^{20}

Seasonality in dust records from ice cores

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Tuesday 14.^{20} – 14.^{40}

Antarctic high-resolution ice-core records of dust transport and mobilization

Continuous Flow Analysis on Antarctic ice cores provides unprecedented records of mineral dust tracers in Antarctic ice cores. The lack of contamination of this method together with its very high resolution allows for the reliable reconstruction of long-term glacial and interglacial dust concentration changes as well as in its interannual variability. Here we will present dust records from three ice cores from different regions on the Antarctic ice sheet. The joint information from these three sites allows to quantify transport and dust mobilization changes on interannual to orbital time scales as well as to constrain the relative importance of different dust sources in different time intervals and at different locations.

Jean-Robert Petit

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Tuesday 14.40 – 15.00

Climate factors influencing the long-range transport of dust: example from Antarctica

Questions rise for simulating and interpreting the 5 fold marine and the 50-to-70 fold dust enhancement observed from Antarctic ice core records during the past glacial interglacial cycles. Amongst uncertainties the respective contribution from the sources, from the transport that should be consistent for aerosols of different origin are challenging.

A semi-empirical model has been developed to reproduce the large glacial-interglacial changes of Antarctic dust and sodium concentrations (Petit, J.R. and B. Delmonte, 2009). The model uses a life-time parameter that depends on the high troposphere temperature (given by stable isotope content of Antarctic ice) which drives the global hydrological cycle and the atmospheric cleansing; which was applied to conceptual pathways for aerosols.

The model reproduces most of the increase in dust concentrations during cold periods with respect to Holocene climate, as observed in Epica Dome C (EDC) and Vostok ice records, on the basis of synergetic changes of three factors associated with temperature (source, transport efficiency, accumulation rate over Antarctica). As supportive results, our model provide source amplitude (up to X 4) and mimics the pattern of a south Atlantic marine record covering the last 300,000 yrs (Martinez-Garcia, 2008) along with consistent 3-5°C atmospheric temperature change over the Southern Ocean. The calculated source changes (mostly Patagonia) share the pattern of the sea ice extends over the south Atlantic, this latter likely constraining the South American climate.

When applied to the sodium, the concentration changes could be reproduced by our model by using two main factors (accumulation rate and transport efficiency) while the source effect is not discernable from an atmospheric temperature effect.

Finally, once the temperature factors are removed, dust and sodium residual signals contain processional component which are in opposite phase. This may reflect the influence of the summer insolation amplitude both on the strength of the South American summer monsoon (that would decrease dust emission) and on spring meridional temperature gradient at middle-high southern latitudes (that would increases cyclogenis and sodium source).

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Tuesday 15.^{00} – 15.^{20}

Long-term trends in African dust transport to the Caribbean: African sources, changing climate, and future scenarios

Aerosol studies were begun on Barbados in 1965 and continue to this day. Over much of this record there was a strong negative correlation between dust concentrations in Barbados and rainfall in the Sahel-Soudano (SS) region of North Africa. In retrospect this correlation was largely driven by three distinct periods in the early record: the period of high rainfall and low dust transport in the mid-to-late 1960s; the first drought in the early 1970s; and the extremely intense drought of the early 1980s.

During this period transport showed promising relationships to various climate indices: e.g., El Niño, NAO, AMO. However, since the early 1990s there have been large year-to-year changes in SS rainfall but there is no consistent relationship to dust on Barbados or between dust and common climate indices. Furthermore, over the entire record there is a strong shift in seasonal dust transport, most notably, a great increase in winter and spring transport compared to the pre-drought and early drought period. These trends seem to suggest that there have been profound long-term changes in dust emissions and transport. A possible contributing factor could be increased population and land use in the SS region. As to the future, the IPCC 2007 multi-model projections of rainfall in Africa show drier conditions in the North but they could not produce a consensus in the SS region. The absence of a clear relationship between dust transport and African-Atlantic climate and the uncertainties in climate projections make it impossible to anticipate how transport to the Caribbean might change in the future.

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Tuesday 15.^{50} – 16.^{10}

Tracing dust provenance in paleoclimate records using mineralogical and isotopic fingerprints: additional clues from present-day studies

Dust records retrieved from ice and sediment cores represent some of our most valuable evidence for modifications of atmospheric circulation on various times scales over the last few Pleistocene glacial and interglacial climate cycles. These data also contribute to the documentation of changes in continental paleo-environments (e.g., changes in aridity), changes in iron inputs to the ocean, as well as changes in the hydrological cycle. Interpreting ice and sediment-core dust records, and using them for modelling purposes, requires firstly a good understanding of the dust provenance and its possible temporal variability. Specific intrinsic tracers such as clay mineralogy, major and trace elements, and radiogenic isotopes (strontium, neodymium, lead) have been used for this purpose, with variable effectiveness.

One difficulty lies in the fact thatthese measurements require significant amount of mineral particles and can thus only be obtained at low temporal resolution, either because of the low dust concentration in ice cores or because of the low mass accumulation rates and bioturbation in marine sediments. As a result, dust samples extracted from ice and sediment cores for provenance investigation average long periods of time and may reflect mixtures from various source areas, complicating the interpretation of the data. Still, provenance tracers (clay mineralogy and Sr-Nd isotopes in particular) made possible for instance the discrimination of which continents provided most of the dust deposited in remote locations such as Greenland and Antarctica during the dusty glacial stages. The locations of the contributing source areas, however, were not precisely identified. During the low-dust, interglacial periods, provenance has proven more difficult to establish unambiguously, even at broad (i.e., continental) geographic scales. In other aeolian deposits, such as Asian loess or marine sediments off West Africa, the provenance of the dust is still poorly constrained, despite the fact that these archives are located close to the highest dust-emission areas in the world.
Characterization of dust provenance (using mineralogical and isotopic fingerprints) at present, which can be achieved at much higher resolution and benefit from remote sensing data and well-constrained GMC outputs, may provide valuable clues for our understanding of dust provenance in paleoclimate records. We review some investigations carried out in Greenland and Antarctica over the last decade, and present new results from the West African margin. We discuss the extent to which these present-day time series may help us calibrating our paleo-dust provenance proxies, and improving our understanding of dust provenance in paleoclimate records.

With: Skonieczny, Bout-Roumazeilles, Grousset and Biscaye

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Tuesday 16.10 – 16.30

Pleistocene dust deposition in the Pacific Southern Ocean

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Tuesday 16.30 – 16.50

Dust flux and biological productivity in the equatorial Pacific: Testing the dust-fertilization-hypothesis in the paleo record

The equatorial Pacific constitutes one of the three major high---nutrient---low chlorophyll (HNLC) regions, where the biological pump is relatively inefficient at transferring carbon from the atmosphere to the deep sea. Growth of phytoplankton and their nutrient consumption have been shown to be stimulated by the addition of iron. Because aeolian dust is a substantial source of iron, changes in dust input have the potential to affect the ecosystem structure and carbon cycle in this iron---limited region. One of the main factors limiting our understanding of how climate, dust and export production are linked is the lack of reliable dust flux records in the equatorial Pacific as well as longstanding discrepancies among specific paleoproductivity reconstructions. Efforts to quantify dust-related impacts on climate and ocean biogeochemistry in the equatorial Pacific region have been limited by uncertainty as to the magnitude and even sign of glacial- interglacial dust flux changes. Here, we present combined proxy records of dust fluxes (from Winckler et al., 2008) and paleoproductivity proxies measured at three different sites spanning the breadth of the tropical Pacific. Comparing the productivity with the dust flux records allows us to check the effect of changing dust, i.e. iron input on export production. The combined records allow us to check John Martin's "dust-fertilization- hypothesis" which suggests that higher iron deposition during cold climate stages over iron-limited remote regions of the ocean could lead to more efficient nutrient utilization, thereby increasing the efficiency of the biological pump. Assessing the past response to natural variability in dust input is important particularly in the context of the continued strong interest in exploring large-scale artificial iron fertilization of the ocean as a geo-engineering option to mitigate global warming.

Reference

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With: Robert F. Anderson

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Tuesday 16.50 – 17.10

Dust-flux variability in the subantarctic Atlantic over the last 4 million years

Dust plays an important role in global climate by influencing the radiative balance of the atmosphere, and by supplying iron and other essential limiting micronutrients to the ocean. Indeed, paleoclimatic records and modeling studies suggest that the mechanism of iron "fertilization" may have contributed to up to 20-40 ppm of the atmospheric CO_2 decrease observed during late Pleistocene ice ages. However, its role in longer-term climate change is less well constrained. Here, we use a combination of organic and inorganic proxies to quantify dust fluxes and marine export production in the Subantarctic Atlantic (ODP Site 1090) during the last 4 Myrs. We show that dust deposition and marine export production in the Subantarctic Atlantic increased in step with global ice volume though the major climatic transitions of the Pliocene-Pleistocene. These observations suggest that iron fertilization may have potentially contributed, in combination with other processes, to increase the amount of carbon sequestered in the deep-ocean acting as a positive feedback amplifying the climatic response to orbital insolation forcing through the Quaternary.

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Wednesday 9.^{00} – 9.^{20}

Unravelling terrestrial and marine dust archives: towards a direct indicator record of wind strength

One of the outstanding problems of dust flux reconstruction from physico-chemical properties of marine and terrestrial sediment records stems from the fact that most sediments are mixtures of sediment populations derived from different sources and transported by different mechanisms. We have formulated an approach to tackle the mixing problem which combines (i) grain size analysis of the siliciclastic sediment fraction and (ii) decomposition of sets of grain-size distributions with the end-member modelling algorithm EMMA [1] to characterise the different sediment transport processes and pathways. Here we report on several Late Quaternary dust records extracted from marine (e.g., Arabian Sea [2], Atlantic [3]) and terrestrial sedimentary archives (e.g, Chinese loess [4]) to indicate that a genetically meaningful decomposition of grain-size distributions can be accomplished with EMMA.

The grain-size distributions of Chinese loess–paleosol sequences provide information on sediment provenance, transport pathways and East Asian monsoon variability. The unmixing results in conjunction with loess accumulation rate estimates reveal that two contrasting dust supply patterns were active over the Loess Plateau during the last two glacial-interglacial cycles [5-7]: (i) a background sedimentation pattern that was dominant during interglacial periods, especially over the central and southern parts of the Loess Plateau, is reflected by the constant flux of the fine-grained loess component, (ii) an episodic, highly variable dust input pattern, that was dominant during glacial periods throughout the Loess Plateau and noticeable during interglacial periods mainly over the northern Loess Plateau and almost disappearing over the southern Loess Plateau, is reflected in the admixture of two coarse-grained loess components.

A genetic interpretation and the paleoclimatic significance of the mixing model for the Chinese loess-paleolsol records is provided by comparison of the modelled loess components with modern dust samples in terms of their grain-size distribution and flux rates, and by the distribution patterns of the loess components across the Loess Plateau reconstructed for the last two glacial-interglacial cycles. The sandy and silty loess components represent the coarse dust fraction supplied by (modified) saltation and short-term suspension processes over the proximal part of the Loess Plateau during major dust outbreaks in spring. The low-level winter monsoon (north-westerly wind system) is the likely transporting agent for these dust events. A clayey loess component represents the fine dust component supplied over the entire Loess Plateau by long-term suspension processes during major dust outbreaks and as part of a background supply system. The clayey loess component in the glacial loess deposits is dominantly supplied during major dust outbreaks by the north-westerly winter monsoon, whereas the clayey loess component in the interglacial paleosols is mainly supplied by non-dust-storm processes, possibly with a significant contribution by the high-level subtropical jet stream (westerly winds).

Characterisation of the coarse dust component – which is supplied by (modified) saltation and short-term suspension processes during major dust outbreaks in spring – allows for a reconstruction of winter monsoon variability. However, a prerequisite for an accurate reconstruction of wind-strength variability on the basis

of loess grain-size distributions is that no significant changes in the location of the dust source area (determining the source-to-sink distance) has taken place through time. These conditions are met at a specific location, the Mangshan Plateau. The Mangshan Plateau is located on the south bank of the Huang He (Yellow River) just west of the city of Zhengzhou, well outside the Loess Plateau in central China. A mixing model of the grain-size data indicates that the loess deposits are mixtures of three loess components. Comparison of the mixing model with existing models established for a series of loess–palaeosol sequences from the Loess Plateau [5-7] indicates that the Mangshan loess has been predominantly supplied from a proximal dust source, the Huang He floodplain, during major dust outbreaks [8]. The high accumulation rates, the composition of the loess components, and especially the high proportions of the sandy loess component support this. Owing to its specific geomorphologic setting and the exceptionally high accumulation rates, the Mangshan loess record provides a high-resolution archive of environmental and climate change [9] and specifically of East Asian Winter Monsoon variability. The Mangshan loess grain size derived wind strength record shows close similarities with the downwind Chinese speleothem $\delta^{18}O$ records. The observations indicate that intensified winter monsoon conditions during glacials and stadials could account for these close similarities. And as a remarkable feature we infer that the fine-grained end-member, predominantly present during the interglacials and interstadials, actually represents the background input from the remote inner Asian deserts which function as dominant dust source area of the deposits found at the Chinese Loess Plateau, and the dust that finally ends up in the Greenland Ice Sheet.

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Wednesday 9.20 – 9.40

Production of Asian dust: tectonic versus climate

Asian dust plays a major role in contributing to the world dust system, and in turn modulating global climate. Asian dust presumably originates from the deserts in Asian interior, yet the formation and evolutionary history of the deserts remain debated. In this paper we present sedimentological evidence from the southern margin of Tarim Basin (Taklimakan Desert) to determine the age of the formation of the desert, and to envisage the mechanism in which dust is produced through a series of tectonic, fluvial, sedimentological and eolian processes.

Cenozoic sedimentary successions along the southern margin of the Tarim Basin, western China, reach up to 10 km in thickness. The two studied sections, the Yecheng and Aertashi, comprise ca. 4.5 km and ca. 7.0 km of clastic sediments respectively. The base of the Yecheng section is palaeomagnetically dated to be at about 8 Ma. Age control of the Aertashi section is based on 87Sr/86Sr measurements (for the basal marine bed), together with magnetostratigraphy and regional stratigraphic correlation. The lower part of the sections is mainly composed of fine-grained mudstone and fine sandstone, which makes up the Wuqian Group (Miocene). The palaeoenvironment is low-energy, meandering and braided streams. The middle part is composed of red mudstone, sandstone with thin conglomerate beds, which makes up the Artux Formation (Pliocene). The palaeoenvironment is a distal- to mid-fan environment. The uppermost part of the section, known as the Xiyu Formation (Plio-Pleistocene), consists of cobble and boulder conglomerate intercalated with massive siltstone lenses, which formed as proximal alluvial fan and eolian deposits. Neogene red beds passing upward into upward-coarsening conglomerate and debris-flow deposits record the change in palaeoslope related to uplift of the northern margin of Tibetan Plateau.

The formation of eolian dunes at ca. 8 Ma, and underlying playa lake deposits (as at Aertashi), may indicate an arid, enclosed basin in the southern Tarim after this time. Sedimentological characteristics, together with grain size distribution and geochemistry of siltstone bands in the Xiyu and Artux Formations, point to an eolian origin. This indicates that the Taklimakan Desert and the regional climate regime may have been fully developed by the Early Pliocene, if not earlier. The onset of eolian sedimentation in the southern Tarim Basin coincided with uplift of the northern Tibetan Plateau, as inferred from the lithofacies change. Tibetan Plateau uplift resulted in the shift of sedimentary environments northwards into the southern Tarim Basin, and could well have triggered the onset of full aridity in the Taklimakan region as a whole.

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Wednesday 9.40 – 10.00

One million years of dust dynamics recorded in Serbian loess-palaeosol sequences

Loess deposits in the Vojvodina region, northern Serbia, are among the oldest and most complete loess-paleosol sequences in Europe. These thick sequences contain a detailed paleoclimatic record from the late Early Pleistocene. Based on the correlation of detailed magnetic susceptibility (MS) records from Vojvodina with the Chinese loess record and deep-sea isotope stratigraphy we here reconfirm and expand on a stratigraphic model of the Vojvodinian loess-paleosol chronostratigraphic sequence following the Chinese loess stratigraphic system.

Variations in MS, dust accumulation rates, and the intensity of pedogenesis demonstrate clear evidence for a Middle Pleistocene climatic and environmental transition. The onset of loess deposition in Vojvodina also indicates a direct link between dust generation in Europe and that in the interior of Eurasia since the Early Pleistocene. The youngest part of the Early Pleistocene and oldest part of the Middle Pleistocene is characterized by relatively uniform dust accumulation and soil formation rates as well as relatively high magnetic susceptibility values. In contrast, the last five interglacial-glacial cycles are characterized by sharp environmental differences between high dust accumulation rates during the glacials and low rates observed during soil development. The data presented in this study demonstrate the great potential of Vovjodina's loess archives for the reconstruction of continental Eurasian Pleistocene climatic and environmental evolution.

Loess-paleosol series preserved in northern Serbia are exceptionally complete and as such represent one of the most detailed European terrestrial climatic records available, made especially valuable by their spatial extent. The better preservation of Serbian loess in comparison to that to the north and west is most likely related to the continuous presence of much drier climatic conditions in this region and the persistence of stable 'plateaux' of accumulation. This relatively dry climate in Vojvodina may also further explain why the loess climate record there is similar to Chinese records. A direct correlation between Serbian and Chinese loess magnetic susceptibility (MS) records suggests the possibility of a link between long-term environmental change in Europe and Asia. A key similarity between Serbian and Chinese loess records is the remarkable trend to increased interglacial aridity over the course of the Middle Pleistocene. Furthermore, this trend is in sharp contrast to the globally integrated marine oxygen-isotope record, suggesting that this record does represent the true long-term environmental trends observed in continental mid latitude Eurasia over the Pleistocene. This observation is even more important because the consequences of future climate change need to be modelled for specific continental regions in order that the impact on humans can be predicted. The information derived from the marine record appears not to characterise what happens over the Eurasian continent.

With: Ulrich Hambach, Thomas Stevens, Mladjen Jovanović, Ken O'Hara-Dhand, Biljana Basarin, Huayu Lu, Zorica Svirčev, Ian Smalley, Tivadar Gaudenyi, Björn Buggle, Michael Zech, Igor Obreht & Ludwig Zöller

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Wednesday 10.^{00} – 10.^{20}

Terrestrial dust record between tropical and extratropical circulation: the eastern Canary Islands

The position of the Eastern Canary Islands at the southernmost margin of the westerly-influenced Mediterranean climate zone in the east of the north-hemispheric subtropical North Atlantic Ocean, 100 to 160 km off North Africa, allocates them a key role in studying present and past circulation patterns. Mio-Pliocene volcanic (basaltic) massifs are dissected by deep trough-shaped valleys, some of which were dammed by Lower to Middle Pleistocene lava flows and tephra layers to form closed pans locally called "vegas". These vegas have acted as sedimentary traps filled with aeolian, fluvioaeolian, and colluvial sediments reflecting direct or indirect input of Saharan dust. To a minor degree volcanic fallout has also filled the vegas. At present, the Canary Islands are influenced by three wind systems: trade winds of the Hadley circulation, Atlantic westerlies, and easterly Saharan winds. Saharan dust is brought to the Canary Islands either by lower-level easterly winds at the front end of Atlantic cyclones on a very southern track ("Calima"), or by the higher level "Saharan Air Layer", a branch of the Saharan Air Layer.
Due to an agricultural technique called "enarenado artificial" the vega sediments are well exposed in several quarries. We investigated sediments from three vegas spanning the past ca. 180 ka to decipher a unique terrestrial archive in the area and to compare our results with those obtained from marine and from other terrestrial archives.

The chronology of our vega sediments was established from OSL dating of allochtonous quartz grains back to ca. 125 ka. Beyond this, we used a correlation of kaolinite contents measured in the vega sediments with those measured in nearby marine cores to adopt the marine chronostratigraphy. Time resolution is, however, restricted to the scale of marine stages or substages, whereas shorter cycles such as D/O cycles could not be distinguished clearly.

We used frequency dependent magnetic susceptibility (κ_{fd}) and grain size analysis (Malvern 2600C Laser Analyser) as proxies for past soil humidity and pedogenesis.
Our results indicate that the present aridity of Lanzarote Island (since ca. 8.5 ka) is the exception rather than the rule for the past ca. 180 ka. The period between ca. 75 and ca. 25 ka ago was generally wetter than the Holocene. Humid periods during the past 180 ka appear to be coeval with cold sea surface temperatures in the eastern North Atlantic, as well as with sapropel layers S1 to S6 in the Nile delta, except for S3.

Comparing our results with those from other archives and regarding positive or negative correlations, three scenarios can be discussed to explain the observed changes between more humid and more arid phases: i, higher (winter) precipitation due to more intensive North Atlantic

winter cyclones, ii, higher (summer) precipitation due to a northern advance of the African summer monsoon, and iii, decrease of air temperature causing a relative increase in soil moisture. Scenario ii cannot be precluded but, if at all, took additional effect only for short periods (ca. 2 ka). Our results rather confirm the hypothesis that Late Quaternary climate variability in northwest Africa at the latitude of the Canary Islands was controlled by northern high latitude dynamics. Nevertheless, our conclusions are tentative and further investigations are needed.

Our further research focuses on Fuerteventura Island where we expect to expand the dating range of OSL dating from aeolianites and of TL dating from intercalated lava flows much further back.

Reference: H. von Suchodoletz, H. Oberhänsli, U. Hambach, L. Zöller, M. Fuchs, D. Faust (2010): Soil moisture fluctuations recorded in Saharan dust deposits on Lanzarote (Canary Islands) over the last 180 ka. Quat. Sci. Rev. 29, 2173-2184, doi:10.1016/j.quascirev.2010.05.014

With: Hans von Suchodoletz, Dominik Faust, Ulrich Hambach, Hedi Oberhänsli

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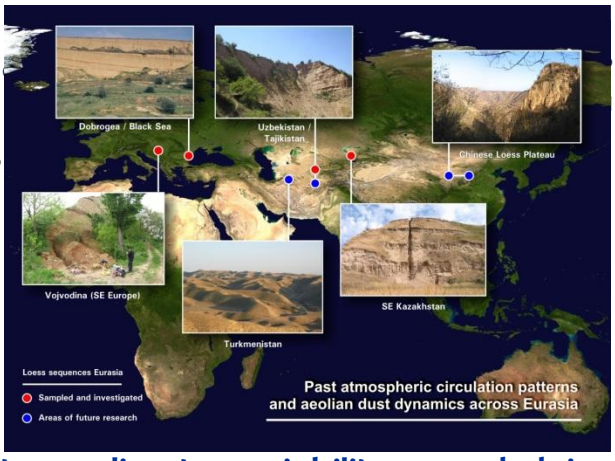
Wednesday 10.50 – 11.10



Long-term seasonality changes and short-term climate variability recorded in Eurasian loess: examples from Serbia, Romania, Kazakhstand, and China

Past climate dynamics associated with the Eurasian continent are well studied. However, the impact of intra-hemispheric-scale climate variability on the entire Eurasian landmass, as well as the self-generated effects of the continent on the global climate system, is still a matter of considerable debate. While western Atlantic polar and tropical air masses penetrate into the continent and are modified and transformed as they cross Eurasia, the interior regions of Eurasia strongly influence Earth's climate system. Significant cooling and heating of Central and High Asia drive interactions between atmosphere and ocean processes and regulate teleconnection patterns of the Northern Hemisphere.

The distribution of Eurasian loess deposits allows interregional palaeoclimatic investigations along a west-east transect across the entire Eurasian loess belt of the Northern Hemisphere, offering the potential to reconstruct Pleistocene atmospheric circulation patterns and aeolian dust dynamics on a wide spatial scale.

This paper utilizes high resolution particle size data from several loess sequences across Eurasia (Serbia, Romania, Kazakhstan, and China) that provide a detailed signal of glacial-interglacial atmospheric dynamics and long term, semi-continuous trends in the aeolian dust record since marine isotope stage 10. In consideration of the modern synoptic atmospheric circulation patterns and aeolian dust transport across the Eurasian landmass, we propose that the observed data reflect oscillations superimposed on a long term signal of seasonality, triggered by changes in duration and permanency of the seasonal shift of the Eurasian polar front during the middle to late Pleistocene. As the activity of the polar front jet is intimately connected with the high level planetary frontal zone (HPFZ), the Eurasian loess archives may also serve as a recorder of intra-hemispheric climate connections in past atmospheric circulation.

Although there are large scale similarities in the dust transport record from numerous sites across Eurasia, the data reveal distinct differences in short-term climate variability along the studied transect from SE Europe over Central Asia to China. In Central and East Asia the observed dynamics in aeolian dust transport closely mirror δ18O and fine dust variations seen in Greenland ice cores, suggesting a correlation with short-term climate oscillations (DO events) recorded therein. An Asian origin of fine aeolian dust preserved in Greenland ice cores has been discussed previously, and recent papers reveal a close link between Asian aeolian dust dynamics and DO events recorded in Greenland ice cores.

In this context, the presented data represent the first Central and East Asian aeolian dust records in which DO events are recorded, providing a means to verify hypothesized links between short-term climate variability recorded in Greenland and associated climate dynamics at Asian dust source areas. Ultimately, the data extend existing theories, suggesting that the Central and High Asian mountains are a crucial element within the sensitive glacier-desert-dust response system in interior Eurasia and may be considered a pacemaker of suborbital global climate changes and an initiator of abrupt climate oscillations in the Northern Hemisphere.

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Wednesday 11.10 – 11.30

European loess sequence, a record of atmospheric changes (ACTES ANR project)

The last climate cycle experienced millennial scale variations corresponding to massive discharges of icebergs in the North Atlantic Ocean and abrupt warmings observed in marine, ice and continental records. These changes are recorded in d18O records in marine and ice-cores but the latter also yield other component of the climate system like mineral aerosols originated from Chinese northern deserts and transported mostly along a zonal dynamics. The ACTES project aims at investigating European loess sequences at 50°N latitude, and by performing model-data comparison to reconstruct how these sequences recorded the millennial scale climate changes by focusing on the emission, transport and deposition of dust which in the present case shows two main origin, local to regional for the coarse material and more distant one for the finest particles. The study shows that the loess sequences are a reliable indirect proxy of the past atmospheric circulation. The presentation illustrates that point through results obtained within the frame of the ACTES project.

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Wednesday 15.30 – 15.50

Meteorological aspects of dust emission and transport

In general, local dust emission is closely related to soil properties and wind speed at surface level. Thus, dust emission can be either limited by lack of high surface wind speeds or surface characteristics. Here, the aspects of meteorological condition on dust emission and its transport will be discussed. For mobilisation of lithogenic soil particles leading ultimately to a dust emission flux surface wind speeds needs to exceed a local threshold dependent on local soil characteristics such as soil texture, vegetation cover, and soil moisture. Therefore, transport of momentum from the atmosphere towards the soil surface is required. Depending on meteorological conditions, this momentum, i.e. in form of wind, downdrafts or gusts, is provided and forces dust emission – or is absent and no dust is uplifted.

Observation and modelling studies highlighted several meteorological conditions which are suitable to provide these high surface wind speeds leading to dust emission on a more or less frequent manner. Here, most prominent meteorological conditions and its relevance for dust emission will be presented.

(1) Nocturnal low level jet, defined as a low-level wind speed maximum at about 500m above ground. Due to frictional decoupling of air close to surface from air above, e.g. indicated by a nocturnal temperature inversion, atmosphere is calm during most of the night, but wind speeds aloft often accelerate to super-geostrophic wind speeds. In case of a downward mixing of the low-level jet layer, strong gusts at surface level are evident able to generate dust uplift. It happens frequently during the morning hours, when solar heating starts and vertical wind shear is strong. This mechanism is able to explain most dust source activations over the Sahara during the morning.

(2) Convective initiated down-drafts, also known as Haboobs. Meso-scale convective systems (MCS) are able to 'produce' outflows generated by evaporative cooling. A pool of cold and consequently dense air is generated within the MCS and due to its density accelerating downwards and continuing spreading out horizontally forming an arcus-like front-edge after reaching ground-levels. High wind speeds are following with this front, able to mobilise dust if soil properties area suitable. Haboobs are a frequent phenomenon over areas with frequent MCS occurrence.

(3) Orographic induced gravity currents. Orographic induced clouds might be blown-out at cloud top level due to strong upper-level winds whereby cloud base remains on windward side of the mountain. Cloud particles can be advected into dryer air over the lee-ward side of the mountain, where they evaporate and generate a cold, dense air mass. Like in MCSs, this air mass accelerates downward due to gravity and forms an arcus-like front-edge when reaching ground level. High wind speeds accompanying the front are able to force dust uplift.

(4) Synoptic-scale systems. Baroclinic disturbances and cyclonic systems are related to strong surface winds leading to dust uplift. Due to the horizontal size of these systems, dust emission at regional scale is often observed in presence of these systems. The North African Mediterranean region or Gobi Desert is a prominent area for dust storms initiated by cyclogenesis and/or active cold fronts.

(5) Dust devils. Funnels raising dusty air caused by dry convection are observed over desert areas, but their contribution to atmospheric dust burden is not clear yet.

Dust once mobilised and mixed into the boundary layer is transported within local wind regimes as well as regional and large scale circulation. Transport distance clearly depends on the height of the dust layer, but also on the particle size. Larger dust particles (>60µm) settle down within a day. Whereas particles smaller than 60µm usually are mixed over the entire boundary layer depth by turbulence. At first, transport of dusty air away from the source area is directed by local wind systems, deflected by topography and roughness elements (e.g. vegetation, rocks, and stones). On a larger distance, regional and large-scale circulation pattern dominate the transport direction, during which transport height depends on air mass properties and might change with time. Small dust particles reaching upper tropospheric levels can remain within the atmosphere for 1-2 weeks. As circulation systems change with season, direction but also distance of dust transport varies with season as well. Prominent example is the transport of Saharan dust towards Amazonia during north-hemispheric wind, but towards the Caribbean Sea in summer.

However, besides knowledge on soil characteristics of dust source areas, knowledge on meteorological aspects during dust emission and transport contributes to the understanding of intra- and interannual variability in atmospheric dust burden, but also to estimates of dust source characteristics under changing climate conditions.

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Wednesday 15.50 – 16.10

Data analysis, modeling, and interpretation of low latitude dust deposits from the Late Paleozoic

The most recent period of widespread glaciation prior to the Plio-Pleistocene is thought to have taken place during the Late Carboniferous and Early Permian Periods (~300 Ma). One possible line of evidence for the intensity of glaciation during this period are sedimentary deposits from this era that contain abundant silt and finer particles in inferred paleoenvironments ranging from continental to deep marine settings [1]. Many of these deposits are at extremely low paleo-latitudes (within 15 degrees of the Equator) (Figure 1). Here we will describe ongoing work to combine sedimentological investigations of these deposits with climate modeling in order to reconstruct aspects of the hydrological cycle and atmospheric circulation during this period.

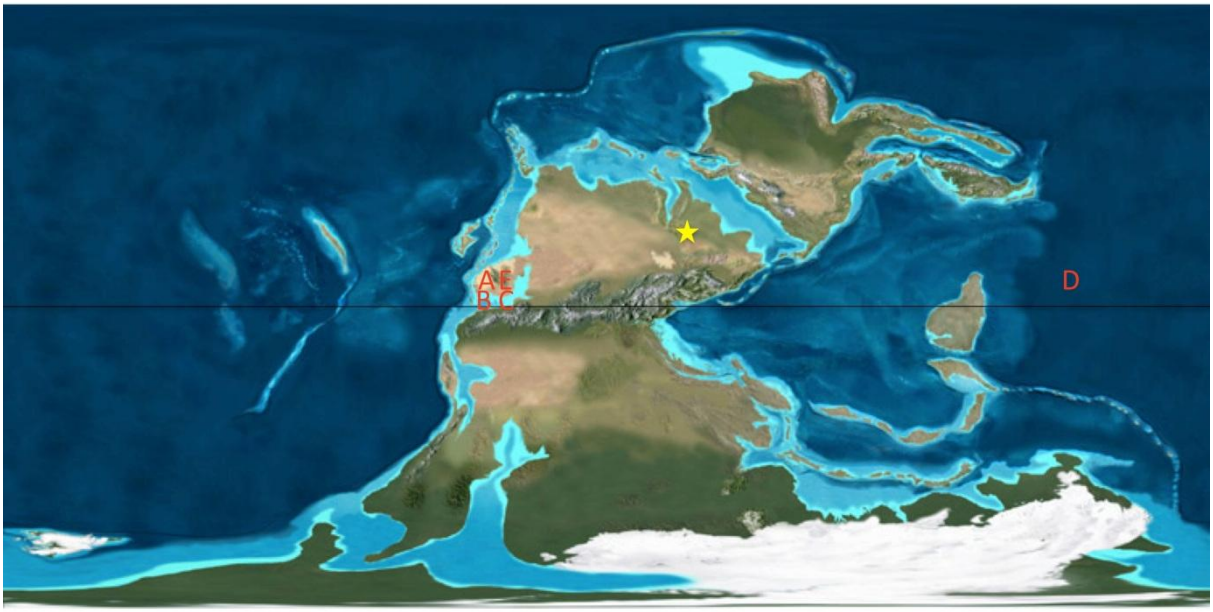

Figure 1: Paleogeographic reconstruction of the Earth during the Early Permian [2]. Letters mark sites of late Paleozoic dust deposition described in this study. A: Maroon Formation, Basalt, Colorado (continental setting); B. Bird Spring Formation, Arrow Canyon, Nevada (coastal marine setting in an epeiric sea); C. "Horseshoe Atoll," Midland Basin, Texas (remote marine setting in an epeiric sea); D. Akiyoshi Limestone, Honshu, Japan (remote marine setting in an ocean basin); E. Abo Formation, New Mexico (continental setting); Yellow star marks approximate location of Bremen.

Sources of Data: Previous modeling studies have sought to reproduce dust deposition rates inferred from ice cores, terrestrial loess deposits, and marine sediment cores in both carbonate and non-carbonate facies [e.g., 3]. In this work, we primarily rely on dust deposition rates (Figure 2) inferred from analyses of non-authigenic silicate minerals in carbonate deposits (B, C, and D in Figure 1) [4,5,6]. These records have good biostratigraphic age control and large potential dynamic range of deposition (due to wide variations in proximity to dust sources). Putative non-authigenic silicates from B, C, and D also contains sand-sized grains. The presence of these grain sizes in D is highly surprising from current physical understanding, yet such grains are observed falling from the sky in modern analog settings [7].

Terrestrial loess deposits from this period are preserved (A,E in Figure 1), but they tend to be barren of fossils and thus much more difficult to date. Detrital zircons from these deposits can be analyzed to identify provenance and show changes in sources between times of high and low deposition [9].

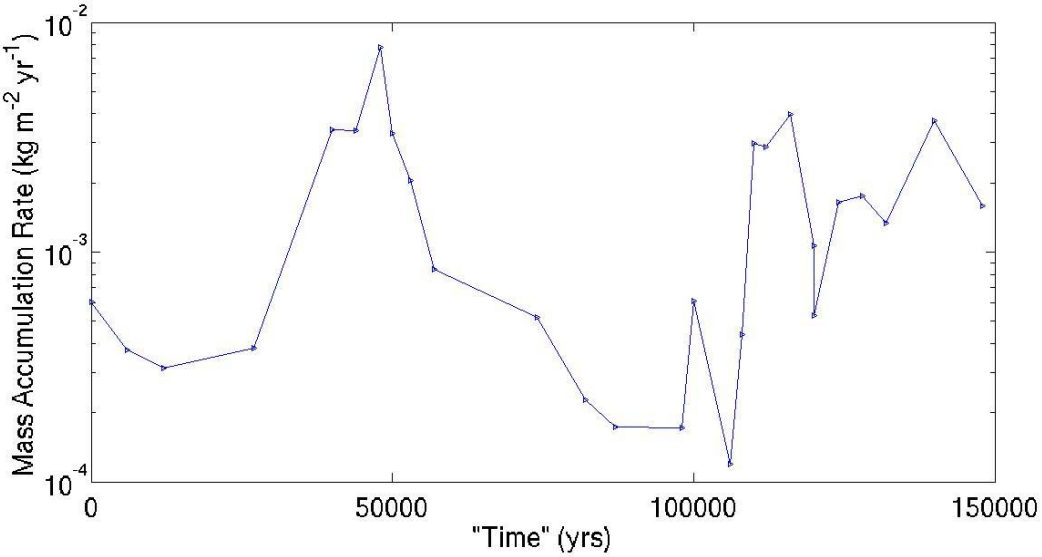

Figure 2: Preliminary estimate of dust deposition rates in a section of the Bird Spring Formation (B in Figure 1). Raw data and dating information is taken from [4,8]. The timescale shown is approximate but suggests wide variability in dust deposition on *O*(100 ka) and smaller timescales.

Modeling: We use a version of the Community Climate System Model version 3 (CCSM3) [10] to perform fully coupled simulations of past climate as well as simulation of the emission, transport, and deposition of dust as in [3]. Simulations also make use of new insights into dust size distribution from [11]. Current simulations investigate: (1) the sensitivity of physical climate to variations in greenhouse gas levels, glaciation, sea level, and orbital parameters; (2) changes in dust transport under the variations in (1) assuming a uniformly erodible source (example results are shown in Figure 3); and (3) changes in dust transport assuming particular sources inferred from provenance information and other principles. The presentation will discuss emerging results from these simulations as well as some recent developments in dust modeling and archive analysis from Prof. Mahowald's research group.

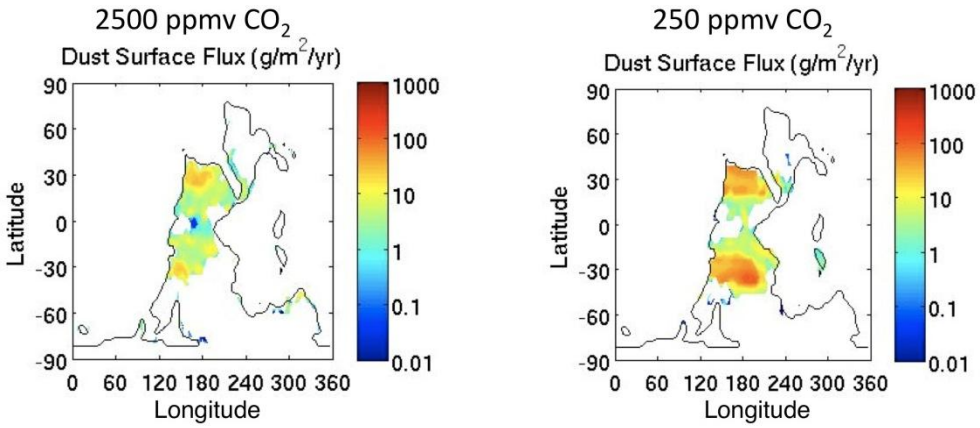

Figure 3: Predicted dust surface flux in two uniformly erodible dust source simulations that primarily differ in assumed greenhouse gas concentrations . Note increase in source intensity at lower greenhouse gas levels.

References:
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Wednesday 16.^{10} – 16.^{30}

Geochemical evidence of a specific atmospheric circulation on Balkan during the last glaciation

Isotopic organic geochemistry (δ^{13}Corg) study has been applied to the Surduk loess-paleosol sequence in Serbia in parallel with other proxy studies like grain size, pedology, paleomagnetism, stratigraphy... The studied record covers the last climate cycle from the last interglacial through the present interglaciation with sedimentation rates as high as 0.6 mm.yr^{-1} at the onset of the Pleniglacial.

The Serbian sequence provides a high temporal resolution isotopic record that characterizes paleoclimate rapid events of the last glaciation in the Middle Danube Valley. Furthermore, it has been shown that, due to the specific sedimentation conditions (high accumulation, cold and arid meteorological conditions) and if adequate chemical treatment is applied to sediment, typical loess δ^{13}Corg nicely reflects the original vegetation isotopic composition. Conversely paleosol δ^{13}Corg can only be interpreted in terms of qualitative paleoenvironmental variations because of pedogenesis impacts on the original vegetation isotopic signature. Organic geochemistry investigations allow also the characterization in terms of environmental parameters (e.g. precipitation annual distribution) of short events recorded concomitantly by all investigated proxies.

Here we highlight here the cornerstone location of the Middle Danube Valley in the past atmospheric circulation pattern. By showing the first definitive punctual occurrence of C4 plants for at least 4 episodes while other loess sequences in western European loess sequences showed presence of the solely C3 plants along the last glaciation, the Surduk d^{13}Corg record underlines quite different atmospheric influences that leaded for drastic aridity during these episodes.

By gathering our record with other continental and Eastern Mediterranean Sea records, we propose a schema of atmospheric circulation that prevailed during these C4 episodes.

(Presented by Denis-Didier Rousseau)

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Wednesday 16.30 – 16.50

Surface winds in a hierarchy of simulations with the LMDZ atmospheric general circulation model

Surface wind is one of the key variables on which dust emission depends. Therefore, to correctly simulate the fluxes of mobilized dust, surface winds must be modeled as accurately as possible. In general, simulated winds underestimate observations, and the model results may be improved by increasing the grid resolution. Here I compare 10m-winds from a hierarchy of simulations with the LMDZ AGCM to the ECMWF winds, which reasonably fit the observations, and are therefore used to drive the aerosol and chemistry module (INCA) of the IPSL climate model. I also compare the seasonality of winds over Sahara in simulations forced by climatological versus interannual sea-surface temperatures. The purpose is to determine the LMDZ configuration best suited for future paleoclimatic simulations.

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Wednesday 17.10 – 17.30

Holocene dust variability: synthesis from natural archives

Mineral dust is both an active component of the climate system, interacting with radiation, clouds and biogeochemical cycles, and a paleoclimate proxy. Climate models can simulate the dust cycle in present, past and future climate scenarios, and help in assessing the impact of dust on climate and the interpretation of paleoarchives, but require validation with data. Natural archives preserving a dust stratigraphy can be used to compile global databases (e.g. DIRTMAP) for such purpose. We are in the process of compiling a database for the Holocene, both in terms of continuous records and a mid-Holocene time slice.
The focus is to select sites with the following charcteristics: (1) have a MAR and (2) a size distribution/range profile with (3) resolution for the Holocene (at least ca 4 ka resolution, possibility of distinguishing early/mid/late Holocene). In addition the site should be (4) representative of longrange dust or a local dust source, provided that this is of wide relevance.
The goal is to develop (and finally also release) a quality-checked database that will be of use to the modelling community, and more generally to those interested in a synthesis of the dust cycle during the Holocene.
The dataset will be finally used in combination with the CCSM climate model, for both equilibrium and transient simulations.
We are looking forward to an inclusive process of compilation of the database, with Principal Investigators contributing their data in a form that meets the database construction criteria, but also participating in the publication(s) accompanying the release of the database.

With: N. Mahowald(2), G. Winckler(3)(4), B. Delmonte(1), V. Maggi(1), D. McGee(5), M.Goman(6), B. Otto-Bliesner(7)
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Wednesday 17.30 – 17.50

Importance of dust mineralogy for dust direct radiative effect

We present a new mineralogical database for erodible soils that distinguishes between the clay and the silt fraction. Each mineral from the database, constitutive of the dust, is then transported in a General Circulation Model (GCM). We compute and present the direct radiative effects (radiative perturbations) due to the individual minerals in present conditions and compare the radiative effects computed with the one where dust is treated without taking into account the differences in soil mineralogy. Changes in top-of-atmosphere, surface and energy stored in the atmospheric column are discussed.
The new mineralogical database is derived using methods from the work of Claquin et al. (1999). It provides the following extensions to this original database:
The database is global in extent: it not only covers actual active erodible areas but also covers areas that are not potential sources in present climate. This opens the path to study:

1. Impacts of mineral dust (solar radiation, cloud ice nucleation, ocean productivity and health)
2. Past and future scenarios

An extensive bibliography allowed identifying 594 soil descriptions from more than 120 bibliographic references in this database. We extended the minerals considered to account for the iron content from soils (both total and soluble iron can be determined). We partition the mineralogy by size classes both within the clay fraction (diameter less than 2 μm) and the silt fraction (2 μm < diam. < 64 μm). The following minerals are mapped over with a 0.5degx0.5deg resolution over the whole globe: Illite, smectite, kaolinite, chlorite vermiculite, feldspars, quartz, calcite, hematite, goethite (for the clay fraction);
For the silt fraction: feldspars, quartz, mica, hematite, goethite, calcite, gypsum (for the silt fraction).
In addition, we derive the iron content for each of these minerals from the total iron for each soil type. The variations in minerals in soils are very large not only from soil type to soil type but also between different regions.
We went on to study how the mineralogy affects the radiative effect from dust. Each mineral was transported separately in the LMDz-INCA GCM. We have mapped the yearly emission, deposition and atmospheric loads of each single mineral. Furthermore, we retrieved from the literature the optical properties of each individual mineral and introduced the computation of their optical depth, asymmetry parameter and single scattering albedo. We show the differences in absorption of the different minerals and distinguish between hematite and goethite, which are the two main iron oxides that influence the atmospheric heating by dust. We show example of results, discuss their significance and perspectives for future work.

Claquin T., M. Schulz, Y. Balkanski, Modeling the mineralogy of atmospheric dust sources, *J. Geophys. Res.*, **104**, 22,243-22,256, 1999.

With:, E. Journet, S. Harrison

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Thursday 9.^{00} – 9.^{20}

New developments in dust emission parameterization

Several schemes have been developed for dust emission parameterization in weather and climate models. I will give a brief summary of these schemes. The talk will then concentrate on the comparison of the predictions of the particle-size resolved dust fluxes using the scheme of Shao (2004) with the JADE measurements of Ishizuka et al. (2009). The model limits and simplifications will be discussed. I will then give an outline of the stochastic dust emission scheme being developed at the University of Cologne.