NESSC DAY 2021

The 6th annual Netherlands Earth System Science Centre conference

MAY 26, 2021 |
WEDNESDAY |
13:00 – 17:00+ |

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PROGRAMME

13:00 – 13:05

Opening by NESSC scientific director, Prof. Dr Jack Middelburg

13:05 – 13:15

Get to know your NESSC colleague (1)

13:15 – 14:00

Presentation by keynote Speaker, Prof. Dr Kate Freeman, Penn State University

14:00 – 14:35

Theme 1 presentations by:

Thomas Hessilt: Future increases in lightning-ignited boreal forest fires because of coincident increases in dry fuels and lightning.

Anna Wallenius: High methane production potential in the sediments of marine Lake Grevelingen after summer hypoxia.

Jessica Venetz: Microbial methane oxidation in the water column of marine Lake Grevelingen.

14:35 – 15:00

Theme 2 presentations by:

Yord Yedema: Spatial distribution of lipid biomarkers, dinoflagellate cysts and pollen in coastal marine surface sediments in the northern Gulf of Mexico.

Anne Kruijt: Coastal carbon transfer in the past – a box model study.

15:00 – 15:10

Get to know your NESSC colleague (2)

15:10 – 15:20

Break

15:20 – 15:45

Theme 3 presentations by:

Gerrit Müller: River Particulates Matter – Towards a new perspective on the role of rivers in oceanic mass balances.

Laura Pacho: New proxy relations for the benthic foraminiferal Nodosariida: Dentalina flintii, Dentalina sp, and Lenticulina calcar.

15:45 – 16:40

Theme 4 presentations by:

Meike Scherrenberg: ANICE2.1 Last Glacial Maximum forced with a climate matrix containing CESM1.2 LGM and PI time-slices.

Tobias Agterhuis: Deep-sea warmth across two early Eocene hyperthermal events from clumped isotope paleothermometry.

Chris Fokkema: Climate variability in the equatorial Atlantic during the early Eocene Greenhouse World.

Louise Fuchs: Identifying the drivers of vegetation change on the Chinese Loess Plateau over the last 200,000 years

Addison Rice: Negligible lateral transport bias in Mediterranean Sea surface temperature (SST) proxies based on particle tracking simulations.

16:40 – 16:55

Theme 5 presentation by:

Max Brils: Improved model representation of the contemporary Greenland ice sheet firn layer.

16:55 +

Closing, followed by social activities.

PRESENTATIONS

PROF. DR KATE FREEMAN:

Sedimentary organic matter contains a rich archive of information about past climates and environments. Fire can disturb and stabilise modern ecosystems, although evidence for its role on deep timescales has been limited or ambiguous. With new ways to study past fire signals using polycyclic aromatic hydrocarbons (PAHs), I will explore how distributions and isotope signatures of these compounds allow us to test if wildfire accelerated the rise of grasslands, and to trace the redistribution of carbon weathered from soils and sedimentary rocks during past climate upheavals.

THOMAS HESSILT:

Future increases in lightning-ignited boreal forest fires because of coincident increases in dry fuels and lightning

Fire is the most important landscape disturbance in the boreal forest of North America. The boreal region is the largest terrestrial biome and stores approximately 35 % of the global soil carbon (C). Burned area has increased over the last decades and is projected to increase further in the future, potentially altering boreal forest ecosystems. Approximately 90 % of the burned area in the region originates from lightning-caused wildfires. It is important to understand drivers of lightning-induced wildfires to evaluate the consequences of future changes in lightning activity and ignition efficiency. Here, we evaluated lightning ignition efficiency, i.e. the probability of lightning strikes to start fires, for Alaska and Northwest Territories between 2001 and 2018 in function of three sets of drivers: lightning characteristics, topography and fire weather. Further, we projected the lightning ignition efficiency under the RCP8.5 scenario and combined it with predictions of future lightning activity to assess future lightning ignition. The logistic model demonstrated an overwhelming influence of fire weather on lightning ignition efficiency (area under the curve > 0.83), whereas lightning characteristics and topography contributed relatively little to the model performance. We found that short-term drying of the organic soils is the most important requirement for a lightning strike to start a fire. The average lightning ignition efficiency for Alaska and Northwest Territories increased with 54 ± 32 % and 44 ± 44 by 2100. Combined with future projections of lightning activity, we predicted a total increase in lightning ignition of up to 230 ± 20 % by 2100. Future increases in lightning ignitions in boreal forest will likely induce additional burned area in regions with C-rich peatland and permafrost soils. Our research showed that the increased availability of dry fuels and increases in lightning will reinforce each other leading to more boreal fires and consequent C emissions.

ANNA WALLENIUS:

High methane production potential in the sediments of marine Lake Grevelingen after summer hypoxia

Coastal ecosystems are a significant source of the potent greenhouse gas methane methane, contributing to up to 75% of marine methane emissions. Methanogenic archaea produce methane in the deeper anoxic sediments using fermentation end products as substrates. Usually, methanogenesis occurs mainly in the deeper sediments where sulfate is depleted. In marine sediments, most of the produced methane is removed by methane oxidation coupled to sulfate reduction. In coastal systems, sulfate concentrations are often low and methane is not removed as efficiently. Additionally, high organic matter load and prolonged periods of anoxic bottom waters may create favourable conditions for methanogenesis, often enabling methane to escape into the water column and potentially to the atmosphere. This study investigated potential methane production rates and pathways in the sediments of marine Lake Grevelingen, NL after a period of bottom water anoxia in summer. Sediment cores sampled and sliced in September 2020 were used for incubation experiments to measure the methane production potential in different sediment layers from the top 5 cm to a depth of 40 cm. Incubations were amended with various methanogenic substrates, i.e. acetate, hydrogen and carbon dioxide, methanol, and methanol and hydrogen. The highest methanogenesis rate after 7 days of incubation was observed close to the surface at 5-10 cmbsf where porewater profile showed sulfate still to be present. Methanogenesis was enhanced in all incubations amended with methanogenic substrates, but acetate addition resulted in the highest measured methane production over time. Follow-up studies including the analysis of the microbial community structure based on 16S rRNA and mcrA gene sequencing will help to further elucidate the identity of methanogenic microorganisms. Selected metagenome studies will provide insight into the potential methanogenic pathways responsible for methane production in these sediments and help us to understand the factors affecting methane emissions.

JESSICA VENETZ:

Microbial methane oxidation in the water column of marine Lake Grevelingen

Coastal ecosystems are biogeochemical hotspots for marine methane emissions. Particularly during summer hypoxia, methane production can exceed methane consumption in the sediment, resulting in a net methane efflux to the overlying water column. The oxidation of methane in the water column is therefore critical to mitigate emissions. However, the dynamics of methane oxidation in coastal ecosystems are not well understood.

Here, we combined water column geochemistry with potential methane oxidation measurements to investigate the fate of water column methane in marine Lake Grevelingen during summer stratification. Methane concentrations peaked at 53 µM in bottom waters and rapidly decreased in the oxycline. This points towards an active methanotrophic community at the methane-oxygen counter gradient. High methane oxidation was measured at all sampling depths, even below and above the methane-oxygen interface. This might indicate that the methanotrophic community can rapidly adapt to in-situ changes in oxygen or methane availability, which we are currently testing in the laboratory. We conclude that methane oxidation in the water column is an important pathway to mitigate methane emissions from Lake Grevelingen and that the capacity of the water column methanotrophic community to adapt to fast changes in water column geochemistry may be a crucial factor in sustaining an effective water column methane filter.

YORD YEDEMA:

Spatial distribution of lipid biomarkers, dinoflagellate cysts and pollen in coastal marine surface sediments in the northern Gulf of Mexico.

Rivers form a crucial part in the global carbon cycle by transferring terrestrial organic carbon (TerrOC) from land to the coastal zone. Upon burial in marine sediments, TerrOC may be a significant long-term carbon sink. However, much remains unknown about the dispersal of different types of TerrOC in the marine realm upon fluvial discharge, and the influence of this terrestrial input on coastal marine productivity, mostly due to the use of bulk OC parameters that do not reach the required level of source- and process-specific information. This study aims to characterize TerrOC in marine surface sediments along transects offshore the Mississippi and Atchafalaya river mouths using sediment bulk properties, pollen and lipid biomarkers. The latter allow to disentangle contributions of higher plants (long-chain odd numbered n-alkanes) and soil, fluvial and marine (branched and isoprenoid GDGTs, long-chain diols, alkenones) produced organic matter. Additionally, dinoflagellate cysts are used to assess the marine productivity in the coastal zone. Our data show that soil-derived OC (indicated by the Branched and Isoprenoid Tetraether (BIT) index) and pollen grains are most abundant near the Mississippi river mouth and decrease rapidly further offshore, while n-alkanes remain abundant also in deeper waters. Dinocysts indicate higher abundances of autotrophic species in the open ocean, while heterotrophic species are dominant near shore, reflecting enhanced nutrient input from land and higher marine productivity close to shore, as supported by C/N ratios of the bulk sediment and the higher soil OC and pollen. Based on our multi-disciplinary approach we show that different types of TerrOC have distinct dispersal patterns upon discharge, highlighting the benefit of including lipid biomarkers and palynology in addition to bulk sediment data to characterize the OC pool in marine sediments.

ANNE KRUIJT:

Coastal carbon transfer in the past – a box model study.

The shelf represents a relatively small fraction of global oceanic area but plays an important role in the global carbon cycle because of high production and burial of organic matter and calcium carbonate. Biological processes on the shelf can greatly alter the partial pressure of dissolved CO2, causing disequilibrium with the atmosphere and fluxes significantly larger than those in the open ocean. Also the transport of major ions from land to open ocean is mediated by shelf processes. Available models resolving the governing processes are typically designed to simulate specific regions. Global carbon cycle models typically implement all shelf processes in one simple box. Global earth system models typically impose a flux of riverine export products from land directly into the open ocean without accounting for processes in the coastal zone. However, the global role of the coastal zone in the carbon cycle on various time scales remains poorly quantified, partly due to the large variability in continental margin environments, hampering proper understanding of past, present and future global carbon cycle dynamics. We develop a new coastal zone model that links river biogeochemistry with open ocean models, focusing on the transfer of carbon. Our first approach represents a box model in which number, size and depth of boxes can be varied. We apply global fluxes of carbon into the system and include functions describing first order organic and inorganic carbon processes in each of the boxes. With this conceptual model of the coastal zone we aim to test the effect of changes in bathymetry, temperature and light attenuation on the way carbon is transferred through the coastal interface, suitable for paleo and future applications.

GERRIT MÜLLER:

River Particulates Matter – Towards a new perspective on the role of rivers in oceanic mass balances.

Rivers transport and modify products from terrestrial weathering and erosion, representing the dominant input flux of most oceanic mass balances. Global-scale quantification of this riverine input flux has focused on dissolved (and sorbed) loads and reactive organic particles. The mass of inorganic riverine detritus exceeds the mass of dissolved loads by a factor of 5, but related particles are traditionally assumed to be inert or to react too slowly to influence biogeochemical cycling. However, published rates of major and trace element release in dedicated experiments question this assumption. Therefore, we assess the role of particles in the Earth system in detail. With GloRiSe (https://essd.copernicus.org/preprints/essd-2021-19), a quasi-global database on river sediment composition, including major, minor and trace elements, as well as mineralogical and petrographic composition, we provide basic data to this assessment.

First, we estimate global averages of major elements in riverine suspended sediment discharged to the ocean. These indicate, that contributions of pristine, reactive source rocks to suspended sediments may be higher than previously thought. Subsequently, a two-step Machine Learning-based approach to regression was developed to upscale these skewed and patchy datasets, enabling a precise global quantification of (inorganic) element and mineral fluxes associated with riverine sediment discharge. Application of this method to the riverine particulate inorganic carbon content (PIC), i.e., carbon hosted by detrital carbonate minerals, results in a global flux of 6.25 ± 0.4 Tmol C/y, about 20% of the dissolved inorganic carbon flux (32 Tmol C/y). Even if only 10 % of these detrital carbonates would dissolve, related fluxes of Ca and alkalinity (and potentially also of Mg and Sr) to seawater would be scalable and may help rectify the puzzling mass balances of these elements. These results confirm riverine particulate carbonate to be quantitatively relevant in global biogeochemical.

LAURA PACHO:

New proxy relations for the benthic foraminiferal Nodosariida: Dentalina flintii, Dentalina sp, and Lenticulina calcar.

The Nodosariata are an ubiquitous and very long lived group of foraminifera, which makes them potentially excellent proxy signal carriers for reconstructing climate change in deep time as well as studying the impact of evolution on such proxy relationships. Until now, however, no such proxy relationships had been investigated for this group. Here we used samples recently recovered from the Gulf of Mexico to make such calibrations. The Gulf of Mexico is a very well-known area for studying the distribution and ecology of benthic foraminifera. This study focuses on the Atchafalaya river mouth and various species of foraminifera from the class Nodosoriata that live there. Within this aim, we obtained the first results analyzing the elemental composition of the shells of three species of benthic foraminifera using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS): Lenticulina sp, Dentalina sp, and Dentalina flintii; at three different depths: 100 m, 300 m, and 600 m. The preliminary results suggest that the trace element incorporation in the shell of these foraminifera could be used for reconstructing environmental conditions, such as temperature and salinity. In addition, results are evaluated as a part of a bigger data-set in an evolutionary context comparing the relationship in shell chemistry and biomineralization mechanisms.

MEIKE SCHERRENBERG:

ANICE2.1 Last Glacial Maximum forced with a climate matrix containing CESM1.2 LGM and PI time-slice

To simulate feedbacks on multi-millennial time-scales in the climate system, a set-up with a two-way coupled ice-sheet-climate model would be ideal. However, fully coupled high resolution Earth System Model simulations that contain at least one glacial cycle are currently unfeasible due to the computation resources required. Alternatively, ice sheet models can be forced by precalculated GCM time-slices. This would allow for the incorporation of long-term feedbacks while using only a comparatively small amount of computational time. This work builds upon and is compared to Berends et al., 2018 who used ANICE and HADCM3 time-slices. Here we compare HADCM3 and CESM1.2 forcing for the last glacial cycle based on time slices for LGM and present-day. The forcing is interpolated between these two end-members based on ice volume and prescribed atmospheric pCO2. Geographic location and volume of the North-American, Antarctic and Greenland ice sheets agree well between HADCM3 and CESM1.2 forcing. Sea level drop at LGM due to the North-American ice sheet is 66 meters for HADCM3 and 69 meters for CESM forcing. The ANICE-HADCM3 North-American LGM ice sheet is thinner and extends further to the east. For the Eurasian ice sheet, the sea level rise is 14 meters for HADCM3 and 29 meters for CESM1.2. This discrepancy can be contributed to a larger ice sheet extent and thickness in CESM1.2 for Northern Europe and Siberia. However, no ice accumulates in the UK for the CESM run.

TOBIAS AGTERHUIS:

Deep-sea warmth across two early Eocene hyperthermal events from clumped isotope paleothermometry.

The early Eocene (56–48 Ma) hothouse experienced the highest CO2 levels of the Cenozoic, as well as the occurrence of multiple transient global warming events, so-called hyperthermals. The deep ocean is the largest heat reservoir in the climate system and not subject to local seasonal, latitudinal and geographical induced variations in temperature. Hence, deep water temperatures compromise a robust setting to estimate global mean temperatures. However, available δ18O and Mg/Ca-based deep-sea temperature estimates rely on uncertain assumptions. Here, we apply the carbonate clumped isotope paleothermometer (Δ47) on early Eocene benthic foraminifera to evaluate South Atlantic deep-sea temperatures across two hyperthermal events (ETM2 and H2; ~54 Ma). Our measurements indicate warmer deep water conditions (13.2±1.9 95% CI °C for background state) than estimated based on foraminiferal δ18O (~9°C), while they reveal similar hyperthermal warming (>3 °C). These Δ47-based overall higher deep ocean temperatures provide new evidence for high Equilibrium Climate Sensitivity during the past warm climate of the Eocene.

CHRIS FOKKEMA:

Climate variability in the equatorial Atlantic during the early Eocene Greenhouse World.

The factor of extratropical amplification of climate change presents a major uncertainty in Earth's response to periods of global temperature change. Despite numerous quantification studies, the uncertainty in the extra-tropical amplification factor has not been significantly reduced in the last decades, partly because the relative contributions of albedo and atmospheric feedbacks remain unknown. Our approach to narrow down extratropical amplification is based on high resolution temperature reconstructions over orbital-scale climate variability across past warm climates. In addition, the high resolution allows us to investigate variability of extratropical amplification through time. We here apply this method to the Early Eocene Climatic Optimum (EECO), a multi-million-year period of globally warm climate dotted with multiple transient periods of extreme warming and pCO2 rise. As the EECO is considered to represent ice-free conditions, this period is ideally suited to isolate the effect of atmospheric feedbacks. Our ~4ky resolution TEX86-based sea surface temperature (SST) and bulk carbonate stable isotope records of the ~2Ma study interval across the EECO onset at Ocean Drilling Program Site 959 (Eastern Equatorial Atlantic) depict the expected long-term early-Eocene climate trend and the superimposed highly variable early-Eocene climate. We identify multiple warming events for which TEX86 biomarker paleothermometry indicates transient tropical surface ocean warming of ~1-2 °C relative to background climate. Next, we will use our high-resolution equatorial SST data to assess extratropical amplification of climate change through comparison to SST reconstructions from high latitudes and the deep ocean.

LOUISE FUCHS:

Identifying the drivers of vegetation change on the Chinese Loess Plateau over the last 200,000 years

The Chinese Loess Plateau (CLP) is regarded as one of the best continental paleoclimate archives, as cycles of warm, wet interglacials and cool, dry glacials have been recorded in a sequence of alternating layers of loess and paleosol. Changes in the bulk organic carbon isotopic composition (δ13CTOC) have revealed shifts in the relative occurrence of C3 and C4 plants in the past. Although increased temperatures generally lead to an expansion of C4 vegetation, increased humidity has an opposite effect, as does pCO2. In spite of this contradiction, the absence of independent records prevents identification of the drivers of past vegetation change in this region.

Here we present combined records of temperature, precipitation, and vegetation type during the past 200,000 years based on the distribution and isotopic value (δ13C and δ2H) of plant waxes (long chain n-alkanes) and temperature-sensitive soil microbial membrane lipids (brGDGTs) stored in the Lingtai section of the CLP. Glacial-interglacial temperature variability is faithfully recorded by the brGDGTs at this site. However, fluctuations in plant wax-δ13C are only minor (<2‰). We thus infer that temperature and pCO2 are not the primary drivers of vegetation change, although growing season temperatures may have been consistently too low for C4 vegetation to thrive due to the relatively high elevation of our site (>1300 m). Instead, variations in the average chain length (ACL, a plant functional type indicator) and plant wax-δ2H records mainly explain the small δ13C variations, indicating that the precipitation-evaporation ratio thus leads differences in C3 vegetation type.

ADDISON RICE:

Negligible lateral transport bias in Mediterranean Sea surface temperature (SST) proxies based on particle tracking simulations.

Ocean currents can transport sinking particles hundreds of kilometers from their origin at the ocean surface to their burial location, resulting in an offset between sea surface temperatures (SSTs) above the burial site and the particle's origin. Quantifying this offset in particles carrying molecules used in SST proxies can reduce uncertainty in paleoclimate reconstructions. In the Mediterranean Sea, where δ18O-foraminifera, UK37- and TEX86-based SSTs can exhibit large offsets from surface conditions, understanding the possible contribution of lateral transport to proxy bias can provide additional insight when interpreting paleoclimate records. In this study, Lagrangian particle tracking experiments are performed using the NEMO flow field to simulate transport and allow for a quantitative estimate of transport bias. The model determines the ocean surface origin locations of foraminifera and sedimentary particles that carry alkenones or GDGTs to compare with surface sediment datasets for δ18O-foraminifera, UK37 and TEX86, respectively. A range of sinking speeds appropriate for the export of organic matter (6, 12, 25, 50, 100, 250, and 500 m/d) is used in the model to represent different export modes (i.e., individual coccoliths, coccospheres, aggregates), where the three fastest sinking speeds can also represent sinking foraminifera. Results show that lateral transport bias is generally small within the Mediterranean Sea and cannot explain the large offsets in proxy-based SST reconstructions in this basin. Authors & affiliations: Addison Rice1, Peter Nooteboom2,3, Erik van Sebille2,3, Francien Peterse1, Martin Ziegler1, Appy Sluijs1 1Department of Earth Sciences, Utrecht University, Utrecht, The Netherlands 2Utrecht University, IMAU, Department of Physics, Utrecht, Netherlands 3Centre for Complex Systems Studies, Utrecht University, Utrecht, Netherlands

MAX BRILS:

Improved model representation of the contemporary Greenland ice sheet firn layer.

Recent studies indicate that a declining surface mass balance will dominate the Greenland Ice Sheet's (GrIS) contribution to 21st century sea level rise. It is therefore crucial to understand the liquid water balance of the ice sheet and its response to increasing temperatures and surface melt if we want to accurately predict future sea level rise. The ice sheet firn layer covers ~90% of the GrIS and provides pore space for storage and refreezing of meltwater. Because of this, the firn layer can retain up to ~45% of the surface meltwater and thus act as an efficient buffer to ice sheet mass loss. However, in a warming climate this buffer capacity of the firn layer is expected to decrease, amplifying meltwater runoff and sea-level rise. Dedicated firn models are used to understand how firn layers evolve and affect runoff. Additionally, firn models are used to estimate the changing thickness of the firn layer, which is necessary in altimetry to convert surface height change into ice sheet mass loss. Here, we present the latest version of our firn model IMAU-FDM. With respect to the previous version, changes have been made to the handling of the freshly fallen snow, the densification rate of the firn and the conduction of heat. These changes lead to an improved representation of firn density and temperature. The results have been thoroughly validated using an extensive dataset of density and temperature measurements that we have compiled covering 126 different locations on the GrIS. Meltwater behaviour in the model is validated with upward-looking GPR measurements at Dye-2. Lastly, we present an in-depth look at the evolution firn characteristics at some typical locations in Greenland.

NON-ORAL CONTRIBUTIONS

KOEN PELSMA:

Microbial methane cycling within the canals of Amsterdam

Atmospheric concentrations of methane (CH4) are increasing each year with its concentration reaching a record 1.88 ppm in 2020. Freshwaters are a large source, emitting about 156 Tg CH4 per year. Urban freshwaters are especially impacted by anthropogenic inputs of nutrients, possibly increasing the potential for microbial CH4 production. Indeed, urbanisation has been shown to increase dissolved CH4 concentrations in surface waters. We set out to characterise the microbial community present in the canals of Amsterdam's city centre with a focus on the CH4 cycle. Across the city centre, three locations were sampled for top layer sediment, and five for surface water and canal wall biofilm. Metabolic potentials for methanogenesis and methanotrophy were determined and the microbial diversity was assessed using by 16S rRNA gene amplicon sequencing and full metagenome sequencing. All canals were sources of CH4 and a maximum dissolved concentration of 6 µg CH4 L-1 was observed. Methanogenic activity was established within the first week of sediment incubation. Methanoregulaceae and Methanosaetaceae dominated the sediment methanogenic community, with co-occurring Methanoperedenaceae and Methylomirabilota indicating the genomic potential for anaerobic nitrate- and nitrite-dependent CH4 oxidation. Aerobic methanotrophic activity was observed for the biofilm and top sediment, respectively. In the sediment, this activity was associated with enrichment of "Candidatus Methylospira", while in the biofilm Methylomonadaceae were implicated. Metagenome analysis of the environmental biofilm led to the recovery of a MAG for a putative type I methanotroph of the genus Methyloglobulus. We propose that canals are site of active CH4 cycling and canal wall biofilms may act as a novel CH4 biofilter. Taken together, this work underlines the importance of specialised environmental niches at the nexus of the natural and human-impacted carbon cycle.

DOMINIQUE JENNY:

Oligocene Equatorial Atlantic climate dynamics

The unipolar icehouse of the Oligocene provides an opportunity to study the Antarctic influence on paleoclimate sensitivity and polar amplification due to its range of atmospheric CO2 (≈ 200-1400ppm) and strong climate variability. This is relevant because our current projections of CO2 emissions bring us to similar atmospheric CO2 concentrations as those of the Oligocene. Currently we have very little information about climate sensitivity and polar amplification and their hemispheric symmetry in the unipolar icehouse of the Oligocene and climate conditions in the equatorial realm. Here we present long-term paleo-sea surface temperature (SST) reconstructions from equatorial Atlantic Ocean Drilling Program Site 959, offshore Ghana, based on lipid biomarkers (TEX86). Additionally, we reconstructed variations in paleoceanographic conditions using dinoflagellate cyst assemblages, bulk stable isotopes ratios (δ18O, δ13C) and magnetic susceptibility. The generated data show that the prevailing SST during the Oligocene was surprisingly close to today's (≈ 27°C) and thus up to 4°C colder than what we see at other Oligocene equatorial sites such as ODP Hole 929A, Ceara Rise. The dinoflagellate cyst assemblages contain species indicative of upwelling-driven nutrient abundance, alternating with those suggesting strong stratification. The combined results imply seasonal monsoonal upwelling and stratified waters in the inter-monsoonal time, which could explain the detected temperature discrepancy. Subsequent comparison of our equatorial SST record with general circulation modelling studies and SST records from high latitudes should reveal the polar amplification of warming and climate sensitivity on long and short (orbital) timescales during the Oligocene.

SZABINA KARANCZ:

Quantifying the carbon pump's efficiency in the Benguela Upwelling System during the last 25 ka

Upwelling regions are systems characterized by relatively cold and CO2-rich waters returning from depth to the sea surface. The high dissolved inorganic carbon (DIC) content of these upwelled waters results in an initial decrease in surface pH while the concurrent nutrient supply determines the efficiency of the biological carbon pump in returning CO2 in the form of downward organic carbon transport. This implies that the upwelling rate and nutrient utilization together determine CO2 outgassing. The Benguela Upwelling System offshore Namibia is a major upwelling region, where one of the most productive marine ecosystems exists today. However, studies on upwelling intensity during the last glacial cycle show contrasting signals, indicating an incomplete understanding of regional changes.

To accurately reconstruct these processes in the Namibia upwelling region, we apply tracers for the changes of the carbon cycle based on both organic (e.g. δ13C of alkenones) and inorganic (e.g. δ13C, δ11B in foraminifera shell) proxy signal carriers. The δ13C will be measured in both planktic and benthic foraminifera shells to determine vertical gradients of carbon isotopes as a measure of the efficiency of the biological carbon pump. Along with the carbon isotopes, CO2 proxies are used to separately reconstruct individual parameters of the carbonate system, such as pH, pCO2, and [CO32-]. This multi-proxy approach allows quantification of the complete inorganic carbon chemistry and the evaluation of the role of the carbon pump in CO2 outgassing in an upwelling area over the last deglacial when major changes in the carbon cycling occurred globally.

ALLIX BAXTER:

A lacustrine biomarker record of continental temperature in equatorial Africa over the last 170,000 years

Our understanding of Earth's climate history during the Quaternary Period is hindered by a shortage of reliable and independently dated proxy records from continental tropical settings. Long-lived lakes are important archives of past environmental change, because their profundal sediments often contain high amounts of organic matter, which allows the application of diverse proxies to study climate change and other processes occurring within the lake and its surroundings. The ICDP project DeepCHALLA recovered a continuous sediment sequence from Lake Chala in eastern equatorial Africa spanning the last c. 250,000 years (250 kyr). Preserved within these sediments are the fossil membrane lipids of archaea and bacteria, glycerol dialkyl glycerol tetraethers (GDGTs), which form the basis for several paleoclimate proxies. Here we present, in unprecedented high resolution (210 years on average) and with an independently established chronology using a variety of dating techniques, a temperature reconstruction for eastern equatorial Africa from the penultimate glacial maximum (MIS6) to the present, based on variations in the down-core distribution of GDGTs. Temperature history in equatorial Africa over the past 170 kyr shows clear influence of orbital insolation forcing at periodicities of ~41k (obliquity) and ~23k (precession). Overall the long-term trend resembles the temperature record of Antarctica, except that during interstadial MIS5c equatorial Africa was still almost as warm as during the peak interglacial period (MIS5e), while high-latitude regions had already cooled significantly, in line with the ~50 ppm decline in atmospheric CO2. This work demonstrates the potential of lacustrine GDGTs for elucidating the climate history of tropical regions at quaternary timescales, provided the availability of suitable high-quality sediment archives.

EVI WUBBEN:

Eastern Equatorial Atlantic climate variability during the onset of the Miocene Climatic Optimum

The Miocene Climatic Optimum (MCO, ~17-15 Ma) is a relatively warm interval that interrupted the Cenozoic cooling trend. It attracts much scientific attention as it bears analogies with projected near-future climate. Proxy (Mg/Ca and TEX86) data and model simulations show deep-water temperatures up to 8°C higher than at present and atmospheric pCO2 values of 500-600 ppmV. We aim at assessing tropical sea surface temperature (SST) variability on Milankovitch time scales, that, together with global deep-sea temperatures, will provide information on latitudinal temperature gradients and polar amplification under warm climate states. Here, we generated a high-resolution multi-proxy record (bulk sediment oxygen and carbon stable isotopes, magnetic susceptibility, TEX86-derived SST, dinoflagellate cyst paleoecology and quantitative elemental analyses) of deep marine sediments recovered at Site 959 (ODP Leg 159, equatorial Atlantic Ocean) spanning the early- middle Miocene. High-amplitude variations in δ18O and δ13C, MS and SST are paced by 100- and 400 kyr eccentricity cycles. Initial age constraints based on 400 kyr eccentricity tuning, suggest that a ~3°C SST increase at the site, also indicated by a decrease in bulk sediment δ18O, predates the MCO onset at ~17 Ma as identified in the global benthic δ18O record. Diatom biostratigraphy is carried out to provide additional age tie-points. Regionally, increased-carbonate dissolution, export productivity (Babio) and possibly Saharan dust influx characterizes relatively cold intervals (eccentricity minima). SST variability is exceptionally high at orbital time scales, pointing to a highly dynamic MCO even in tropical regions.