NESSC Days 2022

November 10-11
Kontakt der Kontinenten
Amersfoortsestraat 20
3769 AS Soesterberg


Welcome to NESSC Day 2022!

This year we are located in the scenic forest area in the Utrechtse Heuvelrug. Hotel Kontakt der Kontinenten is a former Mission House, where the original inhabitants of these buildings were missionaries and nuns. Our main conference room is Saint John, adjacent to the Konnect Lounge (reserved for us) and the Konnect restaurant.

The majority of our reserved accommodation can also be found on the ground floor. Early check-in will be offered if the room is ready, however, in some instances, this will not be possible – so this can be arranged in the 4:40pm break.

Event Map:

PROGRAMME OVERVIEW

PROGRAMME

Thursday November 10th

- 10:00 -10:40 Coffee and bag storage (early check-in available on a case-by-case basis)
- 10:40 -11:00 Welcome by Scientific Director
- 11:00 -12:00 Keynote Speaker:
  - Prof. Dr. Michiel van den Broeke
- 12:00 -12:40 Theme 3 Introduction and presentations by:
  - Gerrit Muller
  - Laura Pacho.
- 12:40 -13:30 Lunch
- 13:30 -15:10 Theme 1 Introduction and presentations by:
  - Anna Wallenius
  - Geert Hensgens
  - Inga Hölscher
  - Jessica Venetz
  - Wytze Lenstra
- 15:10 -15:20 Break
- 15:20 -16:40 Theme 2 Introduction and presentations by:
  - Anne Kruijt
  - Bingjie Yang
  - Junjie Wang
  - Yord Yedema
- 16:40 -17:00 Check-in and Poster set-up
- 17:00 -19:00 Posters and social drinks
- 19:00-20:30 Dinner
- 20:30+ Boardgames and instruments by the bonfire

NESSC

NESSC Days 2022

Friday November 11th

- 9:00 -10:00 Theme 4 Introduction and presentations by:
  - Louise Fuchs
  - Arthur Oldeman
  - Meike Scherrenberg
- 10:00 -11:00 Theme 5 Introduction and presentations by:
  - Amber Boot
  - Max Brils
  - Shruti Setty
- 11:00 -11:10 Break
- 11:10 -12:40 Grant writing and Career workshop – Oscar Vliet
- 12:40 -13:30 Lunch
- 13:30 -15:00 Team Building Activity
- 15:00 -15:30 Prizes (Poster/Presentation)
- 15:30+ Borrel

PRESENTATIONS AND ABSTRACTS

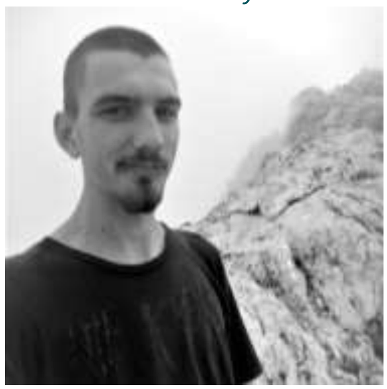
Prof. Dr. Michiel van den Broeke
Utrecht University - BETA

Deglaciation stages of ice caps and ice sheets

The melting of ice caps and ice sheets is not a regular process. We can distinguish various stages of deglaciation, some of which are reversible, but others are rapid and quasi-irreversible. In this presentation we travel to the polar regions, where the largest ice masses are found, and categorise their various stages of deglaciation, the million dollar question being: how far are the big ice sheets of Greenland (7 m sea level rise equivalent, SLE) and Antarctica (58 metre SLE) from their respective ‘points of no return’?

Gerrit Müller MSc

Utrecht University - GEO



Exploring coastal silicate weathering through a kinetic batch model

G. Müller, A. Sluijs, J.J. Middelburg
Department of Earth Sciences, Faculty of Geosciences, Utrecht University

Silicate weathering reactions on land transform atmospheric CO2 into alkalinity (as HCO3-), which is delivered to and sequestered in the ocean, acting as a long-term (> ~ 50 ka), negative climate feedback. Such weathering reactions continue in the (coastal) ocean, but the direction of related element cycling can reverse when proceeding in the marine environment. This is because the coupled precipitation of cation-rich clays ('reverse weathering') is highly favored in this highly saline and alkaline environment and is commonly supported by biogenic silica dissolution and by reductive Fe-Mn oxide dissolution related to organic matter degradation. The dominance of either 'forward' or 'reverse' weathering processes varies across different coastal marine sites, fueling speculation about governing factors of these diagenetic weathering reactions and about their coupling to carbon cycling and climatic stability.

To test existing theories, constrain process controls and assess knowledge gaps, we constructed a simple process-based batch model of equilibrium solution chemistry and kinetic solid-fluid interactions in mobile mud belts. This model can reasonably reproduce field observations from the Amazon delta, including pH, dissolved species concentrations and inferred processes. A series of model experiments suggests that direction, magnitude and stoichiometry of biogeochemical fluxes related to marine silicate weathering depend on (I) availability and nature of highly reactive particulate Si, Al, and Fe sources, (II) on organic matter degradation and related changes in solution chemistry and (III) on transport phenomena (and temperature). Nature and availability of Si, Al, and Fe sources (I) are at least partly controlled by terrestrial weathering and climate, possibly driving a positive climate feedback. However, complex responses to changes in input sediment composition and sedimentation dynamics are expected, confounding our current understanding of weathering feedbacks in the Earth system. A quantitative global treatment requires improved knowledge of coastal and riverine sediment composition and dynamics, and of kinetics and thermodynamics of solid-fluid interactions.

Laura Pacho Sampedro MSc

Royal Netherlands Institute for Sea Research (NIOZ)

Multi-elemental calibration of proxy-relationships in different groups of benthic foraminifera.

Laura Pacho1; Lennart de Nooijer1; Gert-Jan Reichart1,2
1 Royal Netherlands Institute for Sea Research (NIOZ) and Utrecht University, Texel.
2 Department of Geosciences, Utrecht University, Utrecht

The uptake of elements in foraminiferal shell carbonate is studied ever since Element/Ca ratios were shown to reflect the environment. For paleoreconstructions, for instance, Mg/Ca values of fossil foraminifera are used as a tool to reconstruct seawater temperatures. Whereas this works well using single species, studies targeting the biology involved in trace element uptake showed large variability in the Mg/Ca (up to two orders of magnitude) between species and also differences in the relationship to temperature between species. This strongly suggests that different species use fundamentally different biomineralization mechanisms in the formation of their shell calcite. Strongest contrast in element uptake is observed between species belonging to the Miliolida and the Rotaliida, which are also phylogenetically distant. This might imply that trace elemental uptake is also reflecting phylogenetic distance.

To test this hypothesis, a set of experiments was performed comparing the Mg-incorporation in the phylogenetically distant species Spirillina sp (Spirillinida), Sorites sp (Miliolida) and Cymbaloporetta sp (Rotaliida). For none of these species average Mg/Ca and dependence on temperature is presently known. Based on the comparison between these three foraminifera, it is possible to test the general applicability of Mg/Ca as a temperature proxy across foraminifera and to what extent Mg/Ca-temperature relations are genetically conserved. This is particularly important when paleotemperature reconstructions have to be based on extinct species. Since the Mg/Ca of the seawater is known to vary over geological timescales and has an impact on Mg partitioning as well, these species were also cultured over a range of seawater Mg/Ca values in a parallel experiment. The quantified effects of Mg partitioning on both temperature and seawater Mg/Ca for these foraminifera will improve paleotemperature reconstructions.

Anna Wallenius MSc

Radboud University

Methane cycle out of balance: methanogenic microorganisms triumph over anaerobic methanotrophs in the anoxic sediments of a eutrophic marine lake.

Anna J. Wallenius1, Olga M. Zygadlowska2, Wytze K. Lenstra2, Niels A.G.M. van Helmond2, Paula Dalcin Martins1, Caroline P. Slomp2 and Mike S.M. Jetten1

1Department of Microbiology, Radboud Institute for Biological and Environmental Sciences, Radboud University Nijmegen, The Netherlands

2Department of Earth Sciences, Utrecht University, The Netherlands

Coastal ecosystems contribute to the vast majority of global marine methane emissions. Frequently fluctuating conditions such as eutrophication and hypoxia can shift the balance between methane production and oxidation, potentially leading to methane escaping to atmosphere. Here, we investigated the microbial methane cycle in the sediments of Lake Grevelingen, Netherlands, by identifying potential pathways used for methane production and oxidation and key microbial players.

Sediments were collected after summer hypoxia (2020) for methanotrophic and methanogenic incubations with various substrates. In addition, DNA was extracted for 16S rRNA gene amplicon and metagenome sequencing.

Our analysis revealed high relative abundances of methanogenic archaea (15-80 %), with members of hydrogenotrophic Methanomicrobiaceae and metabolically flexible Methanosarcinaceae dominating at every depth. High methanogenesis rates were detected throughout the top 60 cm of the sediment, despite high sulfate reduction rates near the sediment-water interface. All added substrates increased total methane yield, supporting genomic findings that various methanogenic pathways are active in these sediments. Methane oxidation was observed only with sulfate amendment in the zone where methane-oxidizing archaea from ANME-2 clade were most abundant, strongly indicating potential for sulfate-dependent methane oxidation. As ANME-2 reads did not exceed 15% of relative abundance and were absent at most depths, this indicates the prevalence of methanogens over methanotrophs.

Thus, the methane biofilter in the sediment is not efficient enough to prevent high methane fluxes from the sediment to the water column in late summer in this coastal ecosystem.

Dr. Geert Hensgens
Vrije Universiteit

Arctic methane dynamics

TBA

Inga Hölscher MSc

Royal Netherlands Institute for Sea Research (NIOZ)

Distribution of bacteriohopanepolyols in the Gulf of Mexico water column after a deepwater oil spill

The Deepwater Horizon blowout in 2010 in the Gulf of Mexico released ca. 4.4 x 106 barrels of oil, and ca. 1010 moles of methane into the Gulf of Mexico. Methane is a greenhouse gas, which can substantially contribute to global warming, but microbial oxidation may affect the release of methane to the atmosphere. Gas discharged into the water column has been shown to stimulate the immediate growth of methanotrophs. Aerobic methane oxidation (AMO) performed by methanotrophic bacteria plays an important role as final methane sink before it reaches the atmosphere. Bacteria performing AMO synthesize specific bacteriohopanepolyols (BHPs) that are used as lipid biomarkers, such as 35-aminobacteriohopanetetrol, 35-aminobacteriohopanepentol, and 35-methylcarbamate-aminoBHPs.

To examine the role of AMO, sinking particulate matter was collected 35 km N and 54 km NE of the Deepwater Horizon in two sediment traps deployed before and three months after the blowout. Using ultra high-pressure liquid chromatography-high resolution mass spectrometry, we analysed BHPs in the sediment-trapped material. In the sinking particulate matter increased abundances of AMO-derived BHPs were detected until December 2022, five months after the closure of the leakage. AMO-derived BHP abundances decreased to similar values as before the blowout, in January 2023, six months after the closure of the leakage. Our data suggests that AMO-derived BHPs, in November and December 2022 seem to be the remnants of an active marine methanotrophic bacterial community in the water column after the blowout. This suggests an in-situ marine origin of AMO-derived BHPs, such as 35-aminobacteriohopanepentol, after an extreme gas emission event. To better understand water column methanotrophs and the lipids they produce, sampling during, and directly after an extreme gas emission event are necessary. To furthermore trace past water column AMO, it is necessary to study processes leading to preservation of AMO-BHPs in the sedimentary record.

Jessica Venetz MSc

Radboud University

Versatile methanotrophs form an active methane biofilter in the oxycline of a seasonally stratified coastal basin

Jessica Venetz[1] , Olga M. Żygadłowska [2] , Wytze K. Lenstra[2] , Niels A.G.M. van Helmond[2] , Guylaine H.L. Nuijten[1] , Anna J. Wallenius[1] , Paula Dalcin Martins[1] , Caroline P. Slomp[1, 2] , Mike S.M. Jetten[1] and Annelies J. Veraart[3]

[1]Department of Microbiology, Radboud Institute for Biological and Environmental Sciences, Radboud University, Nijmegen
[2]Department of Earth Sciences, Faculty of Geosciences, Utrecht University, Utrecht
[3]Department of Aquatic Ecology and Environmental Biology, Radboud Institute for Biological and Environmental Sciences, Radboud University, Nijmegen

Coastal and estuarine-shelf ecosystems contribute up to 75 % of marine methane fluxes to the atmosphere The quantification of methane emissions from these ecosystems remains challenging due to the dynamic nature of the occurring biogeochemical processes. For instance, the potential and drivers of microbial methane removal in the water column of seasonally stratified coastal ecosystems and the importance of the methanotrophic community composition for ecosystem functioning are not well explored. Here, we combined depth profiles of oxygen and methane with 16S rRNA gene amplicon sequencing, metagenomics, and methane oxidation rates at discrete depths in a stratified coastal marine system (Lake Grevelingen, The Netherlands). Three amplicon sequence variants (ASVs) belonging to different genera of aerobic Methylomonadaceae and the corresponding three methanotrophic metagenome-assembled genomes (MOB-MAGs) were retrieved by 16S rRNA sequencing and metagenomic analysis respectively. The abundances of the different methanotrophic ASVs and MOB-MAGs peaked at different depths along the methane oxygen counter-gradient and the MOB-MAGs show a quite diverse genomic potential regarding oxygen metabolism, partial denitrification, and sulfur metabolism. Moreover, potential aerobic methane oxidation rates indicated high methanotrophic activity throughout the methane oxygen counter-gradient, even at depths with low in situ methane or oxygen concentration. This suggests that niche-partitioning with high genomic versatility of the present Methylomonadaceae might contribute to the functional resilience of the methanotrophic community and ultimately the efficiency of methane removal in the stratified water column of marine Lake Grevelingen. Ongoing analysis of monthly samplings will give further insight into the geochemical drivers and succession of the water column methanotrophic community and the capacity for sustaining effective methane removal.

Dr. Wytze Lenstra

Utrecht University- GEO

Gene-based modeling of methane oxidation in coastal sediments: constraints on the efficiency of the microbial methane filter

Wytze K. Lenstra[a], Niels A.G.M. van Helmond[a,b], Paula Dalcin Martins[b,c], Anna J. Wallenius[b], Mike S.M. Jetten[b], and Caroline P. Slomp[a,b]

[a]*Department of Earth Sciences −Geochemistry, Utrecht University, 3508 TA Utrecht, The Netherlands*

[b]*Department of Microbiology, RIBES, Radboud Institute for Biological and Environmental Sciences, Radboud University Nijmegen, 3525 AJ Nijmegen, The Netherlands*

[c]*Faculty of science and engineering, University of Groningen, 9747AG Groningen, the Netherlands*

Microbial-mediated methane (CH4) oxidation strongly regulates the release of CH4 from aquatic systems to the atmosphere. Coastal sediments are typically characterized by high rates of CH4 production but typically release little CH4 because of efficient sedimentary CH4 oxidation.. This CH4 oxidation is predominantly coupled to oxygen and sulfate reduction. The quantitative role of other electron acceptors, such as iron and manganese oxides, is largely unknown.

Here, we present a reactive transport model (RTM) for sediment CH4 dynamics that includes geochemical and microbial dynamics to assess the microbial constraints on the efficiency of sedimentary CH4 oxidation under transient scenarios. We applied this RTM to a data set for a brackish coastal site with oxic bottom waters and sediment that is rich in CH4 and metal oxides. With the RTM we show that upto 10% of the CH4 produced in the sediment is oxidized by metal oxides while the remainder is removed through oxidation with oxygen and sulfate. We also show that in-situ cell specific rates and doubling times for CH4-oxidizing micro-organisms ultimately determine the efficiency of the microbial CH4 filter. In the model, the slow growth rate of anaerobic CH4 oxidizing microbes limits the ability of the microbial CH4 filter to quickly adjust to transient changes at the sediment-water interface, thereby leading to periodic benthic release of CH4. A sensitivity analysis shows that the capacity of sediments to oxidize CH4 deteriorates upon environmental perturbations such as deoxygenation and eutrophication. As a consequence, oxidation of CH4 in the water column will become increasingly important for the mitigation of CH4 release from aquatic systems to the atmosphere in the future.

Anne Kruijt MSc
Utrecht University - GEO

Is day-length limiting coral reef growth? – A box model approach to coral reef calcification changes in the Cenozoic

Shallow coral reefs are presently typically found in (sub)tropical waters between latitudes 30°S and 30°N and reefs in the past are often characterized by these limits. To understand what determines this habitat, we need to know what sets the limits to coral reef calcification. How fast a coral can grow and calcify, greatly depends on the $CaCO_3$-saturation state of the water (Ω), as well as the sea water temperature (SST) and availability of light for their photosynthesizing symbionts. The optimum SST for most coral reefs is 26-27 °C and corals grow best in oligotrophic waters, where light can penetrate to the bottom.

During the Middle Miocene (17 to 14 Ma ago), SST was globally about 3-4°C higher than today, with SSTs of above 15°C reaching 60°N. However, coral reefs are not found in the geological record at these latitudes. The role of day-length in coral reef calcification is not yet well established, but we hypothesize that the day-length and thus daily available radiation here was limiting coral reef growth.

To test this, we have developed a new ocean margin model focusing on coral calcification in the shallow marine realm. The study is ongoing, but our first results show that in a hot house climate calcification rates drop quickly above 50° N and S, suggesting day length here indeed sets the limit to coral reef calcification. Further work will include the testing of different global temperature ranges and different temperature dependencies of the algal symbionts.

Dr. Bingjie Yang

Royal Netherlands Institute for Sea Research (NIOZ)

Distribution of long-chain diols in the Baltic Sea and its application in paleoenvironmental reconstruction

Bingjie Yang1, Helena L. Filipsson2, Karl Ljung2, Stefan Schouten1,3
1 NIOZ, Royal Netherlands Institute for Sea Research, Department of Marine Microbiology and Biogeochemistry (MMB), and Utrecht University, Den Burg, The Netherlands
2 Department of Geology, Lund University, Lund, Sweden
3 Utrecht University, Faculty of Geosciences, Department of Earth Sciences, Utrecht, The Netherlands

Long-chain diols (LCDs) are lipids produced by microalgae and occur widely in lakes, rivers and marine environments. A series of proxies based on the distribution of LCDs in the sea has been widely used to reconstruct the paleoenvironment, such as the Long Chain Diol (LDI) index1 for paleotemperature reconstruction, the fractional abundance of C32 1,15 diol (FC32 1,15)2 for tracing riverine input, and Diol Index (DI)3 for salinity. However, the LCDs' distribution and its related environmental proxies in brackish water environments are not well studied. In this study, we investigated the occurrence and distribution of LCDs in surface sediments and one sediment core from the Baltic Sea, and explore the relationship between their distributions and environmental factors including salinity, nutrient concentrations and sea surface temperature (SST).

The surface sediments from the Gulf of Bothnia, the Gulf of Finland and the Baltic proper are dominated by the C32 1,15 diol with a relative abundance between 38% and 75%, and it decreases towards the North Sea. Additionally, no correlation is observed between the relative abundance of C30 1,15, which the DI index is based on, and the salinity in the Baltic Sea. However, the relative abundances of C28 1,13, C32 1,15 and C30 1,13 diol correlate with salinity. Based on this, we propose a salinity index that expresses the abundance of C28 1,13 diol relative to those of C32 1,15, C30 1,13 and C28 1,13 diol. The salinity index shows a strong positive correlation with the sea surface salinity ($r^2=0.7594$, $p<0.001$). Besides, the relative abundances of C28 1,13 and C30 1,13 diol which the LCD index is based on1 show no correlation with SST in the Baltic Sea. Therefore, the LCD cannot be applied to reconstruct the temperature here.

In the sediment core from a fjord-like inlet to the Baltic Sea located on the southeast coast of Sweden, the salinity index proposed in this study indicates decreasing salinity over the last 5500 years, which is in concert with the relative sea level decreasing due to isostatic rebound. Considering that freshwater from river runoff can be a major driver at the location near the river mouth, the salinity index could potentially reflect changes in riverine organic matter input after the coast stabilized. However, both the BIT index, a proxy for soil organic matter, and the C/N ratio suggest an increase in the terrestrial organic matter input responding to farmland expansion over the last 600 years, but no change is observed in the riverine organic matter input indicated by our new proxy.

References

1 Rampen et al. (2012) Geochim. Cosmochim. Acta. 84, 204–216.
2 Lattaud et al. (2017) Geochim. Cosmochim. Acta., 202, 146-158.
3 Versteegh et al. (1997) Org. Geochem. 27, 1-13.

Dr. Junjie Wang
Utrecht University - GEO

Accelerated nitrogen cycle in global inland waters in the Anthropocene

Junjie Wanga, Alexander F. Bouwmana,b, Lauriane Vilmina,c, José M. Mogollónd, Arthur H. W. Beusena,b, Wim J. van Hoeka, Xiaochen Liua, Philip A. Pikae, Jack J. Middelburga*
a Department of Earth Sciences, Utrecht University, Princetonlaan 8a, Utrecht, The Netherlands, 3584CB
b PBL Netherlands Environmental Assessment Agency, P.O. Box 30314, The Hague, The Netherlands, 2500GH
c Deltares, P.O. Box 177, Delft, the Netherlands. Postcode: 2600MH
d Department of Industrial Ecology, Leiden University, Leiden, The Netherlands, 2300RA
e Faculty of Science, Earth and Climate, Free University of Amsterdam, de Boelelaan 1105, Amsterdam, the Netherlands, 1081HV
**Corresponding author: Junjie Wang (j.wang3@uu.nl)*

Rivers play an important role in the global nitrogen (N) cycle. However, globally the form-explicit N budget and consistent estimates of N processing fluxes in river basins remain unknown, particularly their changes with the changing human activities, climate, and other environmental conditions. In this study, we comprehensively quantified the spatiotemporal changes in global inland-water N cycle (input, retention, export and in-stream processing fluxes) for the period 1900-2010 using the updated integrated assessment model IMAGE-DGNM including the mechanistic DISC in-stream biogeochemistry module. This model keeps track of N supply from the land and transport along the river continuum through different waterbodies, couples oxygen conditions with N dynamics, and is extensively validated against long-time-series observations in various rivers and different locations within rivers. For the period 1900-2010, total N (TN) inputs, retention and export from global river basins have increased, and due to enhanced retention, TN river export increased less rapidly than TN inputs. The increase in TN retention is mainly due to the increasing denitrification and burial. Organic N (ON) dominated TN inputs to inland waters, with increasing proportions of NO_x^- (nitrate+nitrite) and NH_4^+ (ammonium) during 1900-2010. NO_x^- dominated river TN export to oceans, with increasing proportions of NH_4^+ and ON. The difference between the forms in the inputs and export is caused by mineralization (transforming ON to NH_4^+) and nitrification (transforming NH_4^+ to NO_x^-), which both more than doubled during 1900-2010. Consequently, in the 2010, the highest N concentrations were in Europe, southern North America, and southern and eastern Asia, with the highest NH_4^+ scattered in headwaters and middle reaches of rivers with rapid mineralization and coastal population centers, and the highest NO_x^- and ON in large areas of intensive agriculture and in middle and lower reaches of rivers, particularly in reservoirs.

Yord IJedema Msc

Utrecht University - GEO

Influence of mineral associations on terrestrial particulate organic matter transfer and dispersal in the northern Gulf of Mexico

Yord Yedema1, João Trabucho Alexandre1, Jorien Vonk2, Francesca Sangiorgi1, Francien Peterse1
1Department of Earth Sciences, Utrecht University, Utrecht, The Netherlands
2Department of Earth Sciences, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands

River-dominated continental margins receive large inputs of terrestrial organic carbon (TerrOC). This TerrOC can potentially form a long-term sink for atmospheric CO2 upon burial in continental margin sediments, thereby forming a key part of the global carbon cycle. Only part of the TerrOC that is deliv-ered to the coastal zone is deposited on the seafloor and its sequestration efficiency depends on its type and composition. However, the composition and quality of TerrOC on the seafloor is usually not determined, hampering estimates of its contribution to carbon sequestration on the continental mar-gin. Moreover, TerrOC is thought to form associations with mineral surfaces, protecting it from degra-dation, but it is not fully known to which extent these associations persist in the marine realm and if TerrOC types preferentially bind to certain minerals.

Here, we investigate the TerrOC composition in different grain size fractions (>250, 250—125, 125—63, 63—30, 30—10 and <10 µm) of surface sediments along a land-sea transect (15—600 m water depth) in the northern Gulf of Mexico, using bulk properties (TOC, TN, δ13Corg) and lipid biomarkers for plant- (long-chain n-alkanes) and soil-derived OC (branched glycerol dialkyl glycerol tetraethers; brGDGTs). In addition, we use mineral surface area analysis and X-ray diffraction to assess whether different TerrOC types have an affinity for certain minerals. We found that concentrations of lipid bi-omarkers are highest in the smaller (<30 µm) size fractions. In particular, concentrations of n-alkanes are consistently higher in the smaller fractions, suggesting that they form associations with clay miner-als. While brGDGT concentrations also increase towards smaller grain sizes, their molecular signature is constant among size fractions at each site, suggesting that they are well mixed within the sediment. Furthermore, an increase in the degree of cyclisation of the brGDGTs between 50 and 150 m water depth indicates that the initial soil-derived signal is strongly overprinted by an in situ marine contribu-tion in this zone.

Our results show that plant OC is more likely to remain associated with mineral surfaces than soil OC, thereby facilitating its transport further offshore through hydraulic sorting and preferential burial on the shelf.

Louise Fuchs MSc

Utrecht University - GEO

Seasonal bias introduces distinct signatures in monsoon records from loess proxies and biomarkers

Based on paleoreconstructions of the East Asian Monsoon (EAM) climate, the intensity of summer precipitation associated with the EAM is presumed to strengthen in response to ongoing warming. Most reconstructions are based on oxygen isotopes (δ18O) of cave speleothems and on grain size (GS) and magnetic susceptibility (MagSus) in Chinese loess sequences. Strikingly, the speleothem δ18O records is dominated by a precession signal, and lacks glacial interglacial change, which argues for a strong control through changes in summer insolation. The MagSus in the loess shows a glacial interglacial pattern that strongly resembles amplitude and structure of deep sea oxygen isotope records, which in turn suggests a strong relationship with ice volume and global climate change.

To further investigate the distinct cyclicities in the speleothem and loess proxy records, we here generate a 140,000 year long record of plant wax hydrogen isotopes (δ2Hwax) for the Yuanbao section on the western Chinese Loess Plateau. Since δ2Hwax and speleothem δ18O both reflect the isotopic composition of rain water and is analyzed for the same section as the loess proxies, our δ2Hwax record allows us to directly compare all records.

Like the δ18O record, δ2Hwax does not exhibit a strong glacial interglacial variability, but is instead dominated by changes at precession and millennial scale variability. We suggest that the isotopic signal in the precipitation is linked to the summer season, as the plant wax record is biased towards the growing season. Similarly the δ18O of the speleothem record represents a summer signal as suggested in previous studies. The large glacial interglacial amplitude in the MagSus record and its strong link to global ice volume could in turn be related to a strong winter bias in these records. The amplification of winter cooling during globally cool periods with large ice volume is consistent with sea ice and snow cover feedbacks.

Arthur Oldeman MSc

Utrecht University - BETA

Mid-Pliocene not a good analog for future warm climate when regarding atmospheric variability in Northern Hemisphere winter

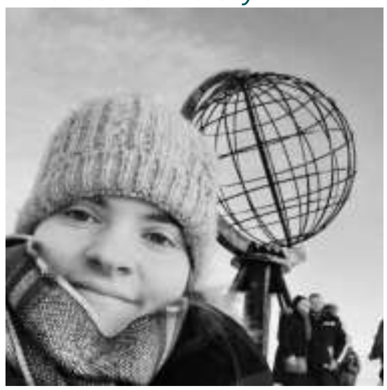
The Pliocene is often considered the 'best analog' for near future climate (e.g. Burke et al, 2018). This notion is mainly based on a similar atmospheric CO_2 concentration and surface temperatures. However, a 'best' analog does not necessarily imply a good analog. We therefore pose the question; to what extent can we treat the mid-Pliocene climate as an analog for a warm future?

We focus on atmospheric dynamics and variability in the Northern Hemisphere winter, for two main reasons: 1. Climate projections are not agreeing on the changes in atmospheric variability we can expect in the future, and 2. The mid-Pliocene exhibits the largest geographical differences to the present-day in the Northern Hemisphere, compared to the Southern Hemisphere. We use the results of simulations from a global coupled climate model, CCSM4-Utrecht, that is a part of PlioMIP2. From a pre-industrial reference simulation (E280), we consider a CO_2 doubling experiment at 560ppm (E560), and a mid-Pliocene 'boundary conditions' experiment at 280ppm (Eoi280).

We consider the sea-level pressure (SLP) using 200 years of January-mean data. In response to the mid-Pliocene boundary conditions, we find a large increase in the mean SLP along with a decreased variance over the North Pacific Ocean. This is accompanied with a weakened subtropical jet over the western North Pacific, as well as increased occurrence of a split jet condition over the eastern North Pacific. These findings are connected to a regime shift in the modes of atmospheric variability in the Northern Hemisphere, where the so-called North Pacific Oscillation becomes the most dominant mode of variability. We do not see tendencies towards similar behavior in the CO_2 doubling experiment. This suggests that the mid-Pliocene is not a good analog for a warm future climate when considering Northern hemisphere winter atmospheric variability.

Meike Scherrenberg MSc

Utrecht University- BETA



How to Melt the North American Ice Sheet

Due to the current rise in global temperatures the Antarctic and Greenland ice sheets are at risk to melt in the future. Full melt of ice sheets has taken place in the past. Ice sheets covered large parts of Eurasia and North America 21 thousand years ago, which have since fully melted. Understanding the mechanisms that lead to the deglaciation of these continents may help us to understand what will happen to Antarctica and Greenland in the future.

Mass loss of ice sheets can be attributed to three processes: surface melt, basal melt and calving. During the deglaciation of the North American ice sheet, a proglacial lake was formed at the southern margin allowing for ice-water interactions. Here we simulate the deglaciation of the Northern Hemisphere ice sheets using an ice-sheet model to investigate which mechanisms are responsible for deglaciation.

We found that by excluding either or both calving and basal melt North America can still deglaciate fully by present day, suggesting that solely surface melt is sufficient for melting the ice sheet. However, melt is accelerated by low basal friction of floating ice. Low friction leads to high ice velocities, reducing surface topography. This increases surface temperatures enhancing melt. By applying the basal friction of land to floating ice, the North American ice sheet retains an ice volume of 13.3 meters of sea level equivalent by present day.

Amber Boot MSc

Utrecht University - BETA

Effect of plankton composition shifts in the North Atlantic on atmospheric pCO2

The marine carbon cycle is important for taking up carbon from the atmosphere and thereby lowering atmospheric CO2 concentrations. One of the ways the marine carbon cycle transports carbon from the surface to the deep ocean is biological production (net primary production and export production). Once in the deep ocean, carbon can be stored for thousands of years. Biological production is dependent on environmental conditions such as nutrient availability and ocean temperature, which can be affected by increasing atmospheric CO2 concentrations. This can lead to a positive feedback loop, where increasing CO2 concentration decrease biological production which in turn decreases uptake of CO2 by the ocean, effectively increasing atmospheric CO2 concentrations. However, a negative feedback loop is also a possibility. We use an Earth System Model that under a high emission scenario, shows large changes in biological production in the high latitude North Atlantic Ocean which is primarily the result of a shift in dominant phytoplankton type in this region. By using a conceptual carbon cycle model, we identify a feedback loop where the change in biological production is related to a change in atmospheric pCO2.

Max Brils MSc
Utrecht University - BETA

Shifts in atmospheric circulation over Greenland's firn layer lead to changes in its ability to retain meltwater

Since the mid 90s the Greenland ice sheet (GrIS) has been losing mass at an accelerating rate. The GrIS contains enough water to raise the sea level by 7 metres. Thus, the melting of the GrIS poses a potentially large risk. Currently, the GrIS is losing mass through the calving of icebergs and the runoff of surface melt at about equal rates. The contribution of runoff is expected to increase over time as ocean terminating glaciers retreat on land and atmospheric temperatures rise. Luckily, about half of the meltwater does not end up in the ocean but stays on the GrIS. This is made possible by its firn layer. This is a layer of compressed snow that covers about 90% of the GrIS. However, an increase in melt has led to a decrease of the firn's pore space. This in turn leads to a reduced capacity of it to retain meltwater.

It is, however, still unclear if this decrease will continue at the same rate. Moreover, the amount of internal variability of the system is still not properly understood. Here, we present results of our most recent study in which we attempt to answer these questions. Using our model, IMAU-FDM, we analyse the evolution of the firn layer over the past 60 years and relate changes to its pore space to changes in the atmospheric circulation. Most notably, we find that after 2012, the firn in the south and south-east of the GrIS was able to regain some of its lost pore space. We relate these trends to changes in the atmospheric circulation, induced by changes in the strength of the polar jet stream. Our results stress the important role that the large-scale atmospheric circulation plays in the evolution of the firn. Consequently, the amount of internal variability of the firn layer is large.

Shruti Setty MSc

Wageningen University & Research

Dynamic Causality Analysis of the Cenogrid

Cenogrid is a 66 Ma reconstruction of the global carbon cycle and climate, and it is an ideal record to study the causal association of climate-carbon cycle dynamics under different earth system configurations. Here, we employed two causality analysis methods, namely, convergent cross mapping (CCM) and reservoir computing causality (RCC) in a windowed approach to unravel the dynamic causal interaction of the climate-carbon cycle dynamics. Both methods use different techniques, with CCM using nonlinear state space reconstruction, and RCC using an echo state network, to test how well the carbon cycle can predict/estimate the climate, with the assumption that if the climate can predict the carbon cycle, then the carbon cycle causally affects the climate via feedback, and vice-versa. Both methods report similar causal interactions of climate-carbon cycle dynamics over the entire Cenogrid, with few periods of discrepancies between the two methods. One of the main highlights of this analysis is the consistently high causal interaction between the climate-carbon cycle during the early Eocene and Miocene Climatic Optimum illustrated by both CCM and RCC. Furthermore, the analyses point towards the amplification of feedback mechanisms prior to the palaeocene-eocene thermal maximum, olicocene/Miocene transition, and after the start of the Pleistocene. The regions showing low causality, such as palaeocene carbon isotope maximum, middle Eocene transition, are equally intriguing as they suggest that the climate-carbon cycle interactions were negligible. Finally, despite recent advances in modelling and proxy development, it is still difficult to decipher the feedback or interaction intensity among earth system components, and our analyses here show that by employing causality calculation measures, it is viable to extract useful information about intrinsic system mechanisms simply from the time-series observations.

NESSC Days 2022

LIST OF PARTICIPANTS

Name	Email Address	Institute
Addison Rice	a.h.rice@uu.nl	UU-GEO
Alex Mether	a.b.mether@uu.nl	NESSC Office
Allix Baxter	a.j.baxter@uu.nl	UU-GEO
Amber Boot	d.boot@uu.nl	UU-BETA
Anna Cutmore	anna.cutmore@nioz.nl	NIOZ
Anna von der Heydt	a.s.vonderheydt@uu.nl	UU-BETA
Anna Wallenius	a.wallenius@science.ru.nl	RUN
Anne Kruijt	a.l.kruijt@uu.nl	UU-GEO
Annelies Veraart	a.veraart@science.ru.nl	RUN
appy sluijs	a.sluijs@uu.nl	UU-GEO
Arthur Oldeman	a.m.oldeman@uu.nl	UU-BETA
Bingjie Yang	bingjie.yang@nioz.nl	NIOZ
Bjinse	b.t.dankert@uu.nl	UU-GEO
Caroline Slomp	caroline.slomp@ru.nl	RUN
Chris Fokkema	c.d.fokkema@uu.nl	UU-GEO
Damian Martínez	d.arevalomartinez@science.ru.nl	RUN
Danica Mitrovic	danica.mitrovic@nioz.nl	NIOZ
Darci Rush	darci.rush@nioz.nl	NIOZ
Devika Varma	devika.varma@nioz.nl	NIOZ
Dominique Jenny	d.k.l.l.jenny@uu.nl	UU-GEO
Elena Popa	m.e.popa@uu.nl	UU-BETA
Elisa Guasti	e.guasti@uu.nl	UU-GEO
Ellen Hopmans	ellen.hopmans@nioz.nl	NIOZ
Evi Wubben	e.wubben@uu.nl	UU-GEO
Francien	f.peterse@uu.nl	UU-GEO

Geert Hensgens	g.hensgens@vu.nl	VU
Gerrit Muller	g.muller@uu.nl	UU-GEO
Gert-Jan Reichart	g.j.reichart@nioz.nl	NIOZ
Inga Hölscher	inga.holscher@nioz.nl	NIOZ
Jaap Sinninghe Damste	damste@nioz.nl	NIOZ
Jack Middelburg	j.b.m.middelburg@uu.nl	UU-GEO
Jeremy Emmett	j.emmett@vu.nl	VU
Jessica Venetz	jvenetz@science.ru.nl	RUN
Jingjing Guo	j.guo@uu.nl	UU-GEO
Jorien Vonk	j.e.vonk@vu.nl	VU
Julia Weiffenbach	j.e.weiffenbach@uu.nl	UU-BETA
Junjie Wang	j.wang3@uu.nl	UU-GEO
Katrin Haettig	katrin.haettig@nioz.de	NIOZ
Laura Pacho	laura.pacho.sampedro@nioz.nl	NIOZ
Louise Fuchs	l.fuchs@uu.nl	UU-GEO
Malavika Sivan	m.sivan@uu.nl	UU-BETA
Marcel van der Meer	Marcel.van.der.Meer@nioz.nl	NIOZ
Marjolijn Christianen	marjolijn.christianen@wur.nl	WUR
Max Brils	m.brils@uu.nl	UU-BETA
Meike Scherrenberg	m.d.w.scherrenberg@uu.nl	UU-BETA
Melanie Martyn Rosco	m.martynrosco@vu.nl	VU
Michiel Baatsen	m.l.j.baatsen@uu.nl	UU-BETA
Michiel van den Broeke	m.r.vandenbroeke@uu.nl	UU-BETA
Mike Jetten	m.jetten@science.ru.nl	RUN
Nicky Dotsios	n.dotsios@science.ru.nl	RUN
Nicole Bale	nicole.bale@nioz.nl	NIOZ
Olga Zygadlowska	o.m.zygadlowska@uu.nl	UU-GEO
Rien Aerts	m.a.p.a.aerts@vu.nl	VU

Robin Klomp	r.klomp@uu.nl	UU-GEO
Sara Pino Cobacho	sara.pinocobacho@wur.nl	WUR
Shruti Setty	shruti.setty@wur.nl	WUR
Stefan Schouten	stefan.schouten@nioz.nl	NIOZ
Thomas D. Hessilt	t.d.hessilt@vu.nl	VU
Thomas Röckmann	t.roeckmann@uu.nl	UU-BETA
Tobias Agterhuis	t.agterhuis@uu.nl	UU-GEO
Valentin Heinzelmann	v.p.heinzelmann@vu.nl	VU
Wytze Lenstra	w.k.lenstra@uu.nl	UU-GEO
Xiulan Zong	x.zong@uu.nl	UU-GEO
Yord Yedema	y.w.ijedema@uu.nl	UU-GEO

Utrecht University
Radboud University
NIOZ Royal Netherlands Institute for Sea Research
VU Vrije Universiteit Amsterdam
WAGENINGEN UNIVERSITY & RESEARCH