ICAM8 Abstracts
Climate and the Cryosphere

Sea-Ice history in the Central Arctic during the last 800 ky (based on distribution of the heavy minerals)

Alexey A. Krylov & Matt O'Regan

akrylow@gmail.com

Heavy minerals (density > 2.89 g/cm3) are transported from the broad Arctic shelves and deposited on the submarine ridges of the Arctic Ocean by ice-rafting. The heavy mineral assemblages on the Arctic shelves differ in composition, and therefore, can be used as a proxy for sea-ice drift and the relative influence of seasonal and pack (multi-year) ice in the central Arctic. Here we present heavy mineral data (grains size 0.1-0.05 mm) from IODP-302 (ACEX) hole 4C on the central Lomonosov Ridge. 18 samples, spanning the last 800,000 years have been analysed.

A clear tendency towards an increase in clinopyroxene (a proxy for Kara Sea sediments) over hornblende (a marker for eastern Laptev Sea-East Siberian Sea) is observed. The content of clinopyroxenes, in general, increases upward, while hornblende, on the contrary, decreases. The results of the study suggest that pack ice dominated in the interval of 20-7 MIS (+ 5e ?!); pack and seasonal ice prevailed in 6 and 2 MIS; a reduced sea-ice cover existed during 5a, 3 and 4 MIS.

Ice-shelf damming in the glacial Arctic Ocean: Dynamical regimes of a basin-covering kilometre-thick ice shelf

Johan Nilsson, Martin Jakobsson, Chris Borstad, Nina Kirchner, Göran Björk, Raymond T. Pierrehumbert, & Christian Stranne

nilsson@misu.su.se

Recent geological and geophysical data suggest that a 1 km thick ice shelf extended over the glacial Arctic Ocean during Marine Isotope Stage 6, about 140 000 years ago. Here, we analyse the development and equilibrium features of such an ice shelf. We find that the dynamically most consistent scenario is an ice shelf with a nearly uniform thickness that covers the entire Arctic Ocean. Further, the ice shelf has two regions with distinctly different dynamics: a vast interior region covering the central Arctic Ocean and an exit region towards the Fram Strait. In the interior region, which is effectively dammed by the Fram Strait constriction, there are strong back stresses and the mean ice-shelf thickness is controlled primarily by the horizontally integrated mass balance. If the surface accumulation and mass flow from the continental ice masses are sufficiently large, the ice-shelf thickness grows to the point where the ice shelf grounds on the Lomonosov Ridge. Using a one-dimensional ice-dynamic model, the stability of equilibrium ice-shelf configurations without and with grounding on the Lomonosov Ridge are examined. We find that the grounded ice-shelf configuration should be stable if the two Lomonosov Ridge grounding lines are located on the opposites sides of the ridge crest. This result shares similarities with the classical result on marine ice-sheet stability of Weertman, but interactions between the Amerasian and Eurasian ice-shelf segments modifies the cross-ridge mass flux and its response to deglaciation.

Multi-decadal ocean-atmosphere interactions in the Western Arctic Ocean - Insights from a marine sediment core from Herald Canyon

Matt O'Regan, Henrik Swärd, Martin Jakobsson, & Christof Pearce

matt.oregan@geo.su.se

Multi-decadal to centennial scale variability in the natural climate system is particularly difficult to assess, but required to properly assess anthropogenic forcing. While a number of recent studies have identified multi-decadal variability in historical sea-ice records, supporting evidence of this is lacking from most marine geological studies. In 2014, the Swedish, Russian, US Arctic Ocean Investigation of Climate, Cryosphere, Carbon Interactions (SWERUS-C3) expedition on icebreaker Oden recovered a remarkable sediment core (SWERUS-4PC1) from the Herald Canyon in the western Arctic Ocean. This record, obtained from a drift deposit in Herald Canyon, contains a persistent and strong, multi-decadal signal of bottom-water current speed over the past 3000-4000 years. These variations may be related to either upwelling of Atlantic waters into Herald Canyon, or brine rejection during periods of intense sea ice growth in the Chukchi and East Siberian Seas. Here we present the initial sedimentological and oceanographic framework for the core, and using preliminary results from radiocarbon dating investigate the frequency of variability and potential links to external climate forcing.

Sedimentary instabilities associated with cryospheric oscillations over the Lomonosov Ridge, Arctic Ocean

Lara F. Pérez, Thomas Funck, Martin Jakobsson, Matt O'Regan, Tove Nielsen, Finn Mørk, & Katrine J. Andresen

lfp@geus.dk

Variability of the cryosphere in Polar Regions leads to large changes in the tectonic and oceanographic settings that, in turn may influence major changes of the global climate. The Lomonosov Ridge extends across the central Arctic Ocean and constitutes a double-sided passive continental margin, seismologically inactive according to the earthquake catalogue of the International Seismological Centre (ISC). Detailed interpretation of the sparse available sub-bottom profiles in the area shows, however, the occurrence of mass transport deposits (MTDs). These MTDs are represented as transparent to semi-transparent acoustic bodies in the upper 50 m of the sedimentary record. The most recently deposited MTDs are concentrated along the central Lomonosov Ridge, adjacent to areas where the crest is <1000 m deep. The shallowest areas are here characterised by the presence of an acoustically transparent unit with similar facies as the MTDs, which previously has been interpreted as reworked sediments due to grounding ice. This layer is thinner at the central Lomonosov Ridge (~8 m) than close to the Siberian margin (~24 m), where it is also covered by a thicker acoustically stratified layer (~4 vs ~12 m). At the Siberian margin, vertical structures of about 8 m height and with a diameter of <200 m are referred to as pagodas. They may be related to vertical fluid migration associated with gas hydrates or permafrost destabilisation. The waxing and waning ice shelves and deep drafting icebergs over the Arctic Ocean could generate MTDs in the vicinity of grounding-ice areas and features such as pagodas may form after the retreat of thick ice.

Glacially induced volcanic activity on the island of Jan Mayen?

Eiliv Larsen, Astrid Lysså & Ármann Höskuldsson

Eiliv.larsen@ngu.no

The Beerenberg volcano in the northern part of the island of Jan Mayen is presently covered by an ice cap with several outlets. No active glaciers exist in the south part of the island. All historically dated/known volcanic eruptions have taken place in the Beerenberg area, but numerous lava flows and pyroclastic deposits are also found in the south.

During the Last Glacial Maximum (LGM) the entire island was ice-covered with greatest thickness over the south. Ice in the north likely was not much thicker than today. TCN dates indicate that the LGM glacier had started to waste back by 19-18 ka BP and that coastal areas deglaciated 13-12 ka ago. During the middle Holocene and the Little Ice Age (LIA), glaciers in the Beerenberg area expanded well beyond their present margins. Holocene glacier expansion likely was much more restricted in the south. Thus, ice was thickest and most extensive during LGM over the south, and over the north during LIA

Our preliminary data indicate that volcanic activity was greatest in the south during the LGM deglaciation and in the north during the LIA deglaciation, thus seemingly linking glacier unloading and volcanic activity. We therefore hypothesise that pressure reduction by glacial unloading caused bubble formation and decreased density in shallow magma resulting in increased likelihood of volcanic eruptions.

History of the Arctic-Pacific oceanic interaction based on sediment records from the Chukchi-Alaskan margin

Leonid Polyak, Geoffrey Dipre, Seung-Il Nam, Masanobu Yamamoto, Kenta Suzuki, Emma Oti, Joseph Ortiz, & Anton Kuznetsov

polyak.1@osu.edu

Impacts of the Pacific oceanic and atmospheric system on the Arctic Ocean result in accelerated sea-ice retreat and related climate changes. Past records from the Pacific sector of the Arctic are key for understanding the history of these interactions. Sediment cores from the Chukchi-Alaskan margin give insights into this history from both long-term (Plio-Pleistocene), stratigraphically compressed records, and high resolution records of the last ~10 ka. The oldest, early Pliocene sediments indicate seasonal only sea ice, strong currents, and high water acidity, similar to expected future Arctic Ocean conditions. A pronounced change at ~5 Ma is interpreted as the onset of Pacific-Arctic throughflow via the Bering Strait (BS). Early Quaternary deposits atop a Pliocene unconformity indicate stepwise sea-ice expansion and growth of ice sheets culminating in a major climatic shift during the Mid-Pleistocene Transition, ~0.8 Ma. Younger Quaternary sediments show glacial cyclicity controls and mostly perennial sea-ice conditions. More recent records are relevant for tracking modern climate variability. A depocenter at the Alaskan margin provides high resolution records for sediment delivery by the Alaskan Coastal Current originating from the Bering Sea and controlled by the Aleutian Low (AL) pressure center. Results from the last several centuries indicate a persistent role of the AL in the BS inflow and a complex interaction of its different branches. More proxy studies are underway to reconstruct the history of this circulation system and its relationship with sea ice extent.

Poster session

The Holocene dynamic retreat of Petermann Glacier

Martin Jakobsson, Larry A. Mayer, Kelly A. Hogan, Alan Mix, Anne Jennings, Joe Stoner, Björn Eriksson, Kevin Jerram, Rezwan Mohammad, Christof Pearce, Brendan Reilly, & Christian Stranne

martin.jakobsson@geo.su.se

The Petermann 2015 Expedition with Swedish icebreaker Oden mapped ca 3100 km2 of the seafloor bathymetry and collected >6000 km of sub-bottom profiles in the Petermann Fjord and the adjacent Hall Basin of Nares Strait, northwest Greenland. The seafloor at the margin of one of the smaller outlet glaciers draining into the Petermann Fjord and selected shallow areas along the coast were in addition mapped using the small survey boat RV Skidbladner, equipped with a high-resolution shallow-water multibeam. Furthermore, 36 sediment cores and 46 CTD (Conductivity-Temperature-Depth) profiles were retrieved. The seafloor morphology in Petermann Fjord and the adjacent Hall Basin is dominated by an assemblage of remarkable, well preserved, submarine glacial landforms, which provides information about the Petermann Glacier's Holocene retreat. In this presentation the retreat dynamics based on the interpretation of the submarine glacial landforms will be presented and discussed. The landforms show that the seafloor geology played a major role in controlling where the glacier halted during its retreat from Hall Basin into Petermann Fjord. A large grounding-zone wedge demonstrates that the glacier stabilized at the entrance to fjord for a considerable time, perhaps for as long as 1100 years as indicated by nearby dated land records. The submarine landforms furthermore show that the final retreat from the fjord mouth was likely driven by marine ice cliff instability. The Holocene retreat is characterized by abrupt events driven by glacial dynamics rather than a steady retreat.

Early Holocene iceberg and meltwater pulses from the eastern Laurentide Ice Sheet

Christof Pearce, Anne Jennings, John Andrews, James Williams, & Marit-Solveig Seidenkrantz

christof.pearce@geo.au.dk

The gradual demise of the Laurentide Ice Sheet during the last deglaciation was characterized by large-scale and abrupt glacial events along its eastern margin. During the early Holocene, several episodes of iceberg and meltwater release originated from glacial advances and retreats mostly from the Hudson Strait region. Evidence for these events are found in marine sediment cores from the Labrador Sea region as increased input of ice-rafted debris and detrital carbonate. These events are especially clear at sites proximal to Hudson Strait and downstream of the Labrador Current on the Labrador Shelf. We present signals for several early Holocene ice sheet instabilities from marine sediment cores. The layers were investigated using a multi-proxy approach consisting of high resolution X-ray fluorescence (XRF) core scans, grain size analysis, quantitative X-ray diffraction (XRD), and biomarker analysis. The presence of detrital carbonate was most clearly found from elevated calcium – strontium ratios based on XRF core scanning results and further confirmed by increased content of calcite and dolomite and an ancient biomarker composition. The widespread signature of these glacial events can be used for correlation of climate archives over a large geographic area. We propose that by detailed fingerprinting of the composition of these layers, they can be used as time-synchronous correlation tools, which may be used to infer past leads and lags in climatic and oceanographic variability as well as help to unravel unknown past marine radiocarbon reservoir ages in the Labrador Sea.

This will be a poster presentation in the "Climate and the Cryosphere" session.

Environmental changes in the Arctic Ocean over the past 8 million years recorded in Fe-Mn oxide crusts from the Lomonosov Ridge flank.

Christian Knudsen, Paul Bierman, Robert Frei and Paul Knutz

ckn@geus.dk

A Fe-Mn oxide encrusted rock was dredged from the Eurasian flank of the Lomonosov Ridge at c. 3 km water depth in 2012. Be isotope dating show that the crust was precipitated from Arctic Ocean seawater over the past 8 million years and thus represents an archive of paleo-oceanographic and paleo-climatic changes.

The 15 cm thick oxide crust was subject to high-resolution geochemical microprobe analyses. In addition, 30 samples were analysed for their Sr, Pb, Nd and O isotopic composition as well as trace elements content. The crust is laminated with alternating FeMn oxides and laminae rich in clay minerals. The FeMn oxide composition varies from 50/50 to almost pure Fe oxide. Redox sensitive elements such as U, Th and Ce provides information on seawater oxygen fugacity, and a change to more oxygen-rich bottom water conditions from about 2 Ma is inferred from U/Th and Ce/La ratios.

The isotope data provides additional insight into seawater composition and paleo-oceanographic environment and of the deep Arctic Ocean. A decrease in εNd of -9,5 to -10 from 8 to ca. 4.5 Ma and a further shift over the last 2 Ma to a recent value of -11.5 is attributed to enhanced contributions from North Atlantic inflow. The increasing North Atlantic contribution from 2 Ma is also observed by a change in 206Pb/204Pb from c. 18.3 to 18.7. Earlier studies points to an opening of the Fram during Early Miocene, but our results suggest that the inflow of North Atlantic surface waters did not have a large impact on the composition of bottom waters in the Eurasian Basin before about 2 Ma.

This will be a poster presentation in the "Climate and the Cryosphere" session.