TERRA NOSTRA

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PAST GATEWAYS

Palaeo-Arctic
Spatial and Temporal Gateways

Third International Conference and Workshop
May 18th – 22nd, 2015
in Potsdam, Germany

CONFERENCE PROCEEDINGS
TAGUNGSBAND

Photos: T. Opel, H. Meyer

http://www.geol.lu.se/pastgateways

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

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PAST Gateways (Past Spatial and Temporal Gateways)
Third International Conference and Workshop at Alfred Wegener Institute in Potsdam, Germany, May 18-22

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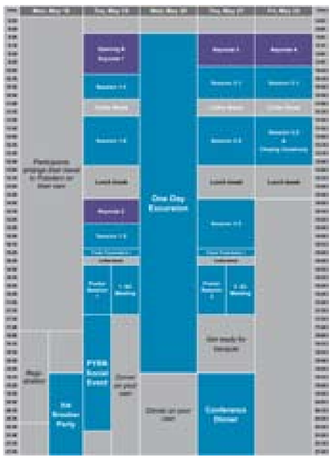

Schedule and detailed programm *from page 10 on*

Scientific Programme

Abstracts & Adresses

All abstracts & adresses to quickly look up *from page 20 on*

Welcome to the PAST GATEWAYS Conference

The Organizing Committee of the PAST Gateways (Palaeo-Arctic Spatial and Temporal Gateways) Third International Conference and Workshop welcomes you in the beautiful city of Potsdam! The PAST Gateways conference will be held from 18-22 May 2015 hosted by the Alfred Wegener Institute (AWI) Helmholtz Centre for Polar and Marine Research at the science campus on the historical Telegrafenberg in Potsdam.
The study of past Arctic environments, especially in the periglacial realm, is one of the key research topics at the AWI in Potsdam since the foundation of the research unit in 1992. Hence, this will be notable in the conference programme as many of our young researchers use the opportunity to present their research.

PAST Gateways is an IASC endorsed network research programme, the scientific goal of which is to understand Arctic environmental change during the period preceding instrumental records and across decadal to millennial timescales. The focus of the six year programme is on the nature and significance of Arctic gateways, both spatial and temporal, with an emphasis on the transitions between major Late Cenozoic climate events such as interglacials to full glacials and full glacial to deglacial states, as well as more recent Holocene fluctuations.

There are three major themes to the programme: (1) Growth and decay of Arctic Ice Sheets; (2) Arctic sea-ice and ocean changes, and (3) Non-glaciated Arctic environments, which have been expanded for the conference by the topic (4) Holocene Arctic environment. Abstracts of all oral and poster presentation as well as background information to the conference (excursions, conference dinner etc.) can be found in this abstract volume.

The Organizing Committee would like to thank all those who have contributed to the success of the conference. A special acknowledgement goes to the sponsors of this PAST Gateways conference: the German Science Foundation (DFG), the Bolin Centre for Climate Research, the International Permafrost Association (IPA), the International Arctic Science Committee (IASC) as well as Picarro Inc., ThermoScientific and Beta Analytics.

Welcome in Potsdam and enjoy the conference.
Your Local Organizing Committee

Steering committee

Anne de Vernal, Canada, Université du Québec à Montréal
Camilla S Andresen, Denmark, Geol. Surv. of Denmark and Greenland
Colm O'Cofaigh (chairman), United Kingdom, Durham University
Grigory Fedorov, Russia, Arctic and Antarctic Research Institute
Hanno Meyer, Germany , Alfred Wegener Institute
Helena Alexanderson (webmaster), Sweden, Lund University
Jason Briner, USA, State University of New York at Buffalo
Kari Strand, Finland, Thule Institute
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Nina Kirchner, Norway, Stockholm University
Renata Lucchi, Italy, Insti. Naz. di Oceanografia e di Geofisica Sperimentale
Riko Noormets, Estonia, The University Centre in Svalbard
Roger Urgeles, Spain, Institut de Ciències del Mar

Local organizing committee

Hanno Meyer
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Bernhard Chapligin
Diedrich Fritzsche
Karina Schollän
Thomas Opel
Frank Günther
Josefine Lenz
Michael Fritz
Georg Schwamborn
Lutz Schoenicke
Gabriela Schlaffer

Sponsors & Partners

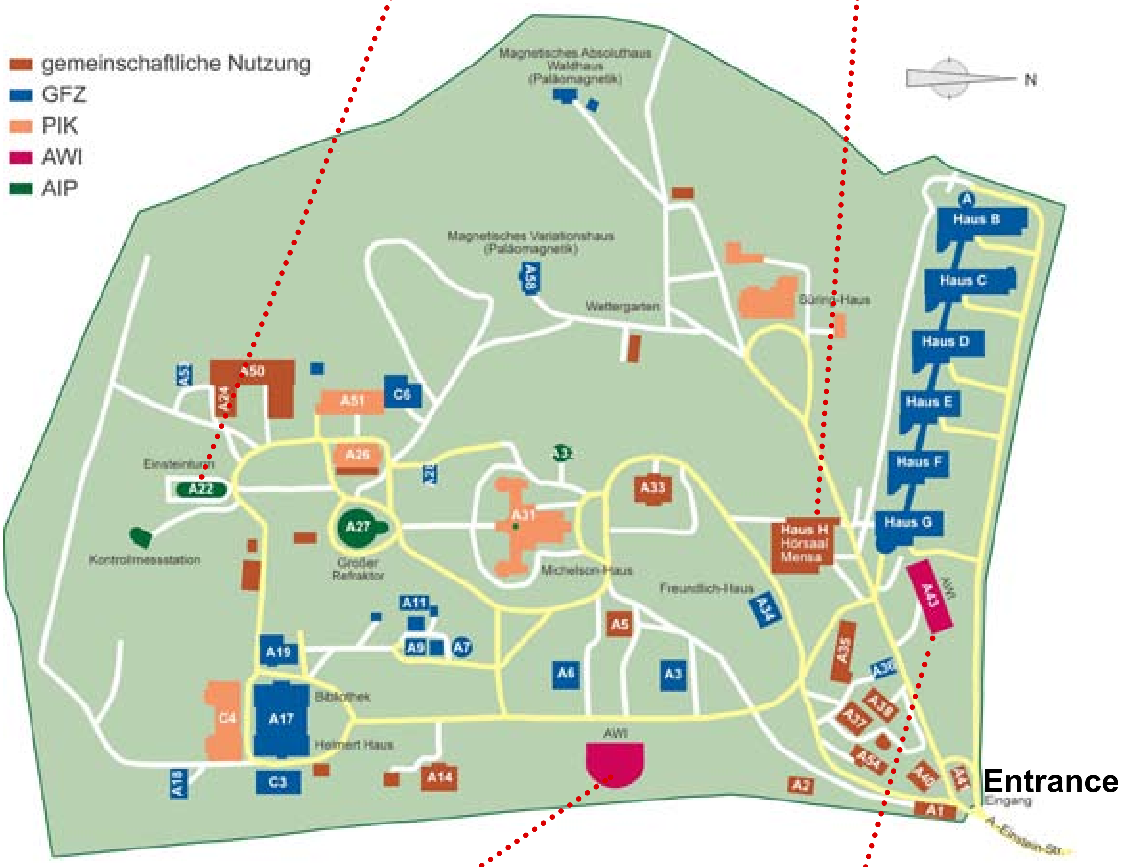
We gratefully thank the following partners for their support:

Einsteintower

For Visitors
The historical, attraction is an astrophysical observatory built by Erich Mendelsohn and worth a look.

Building H: Conference location / cantine

Entrance Hall: Conference office, Ice Breaker
Lecture Hall: Oral Sessions and awards
Foyer: Poster sessions, coffee breaks, Ice Breaker



A45: AWI building

Offices
Labs: Wet chemistry, Sediment, Pollen, Microbiology

A43: AWI building

Seminar Room
Offices
Stable Isotope Laboratory (Cellar)

Potsdam

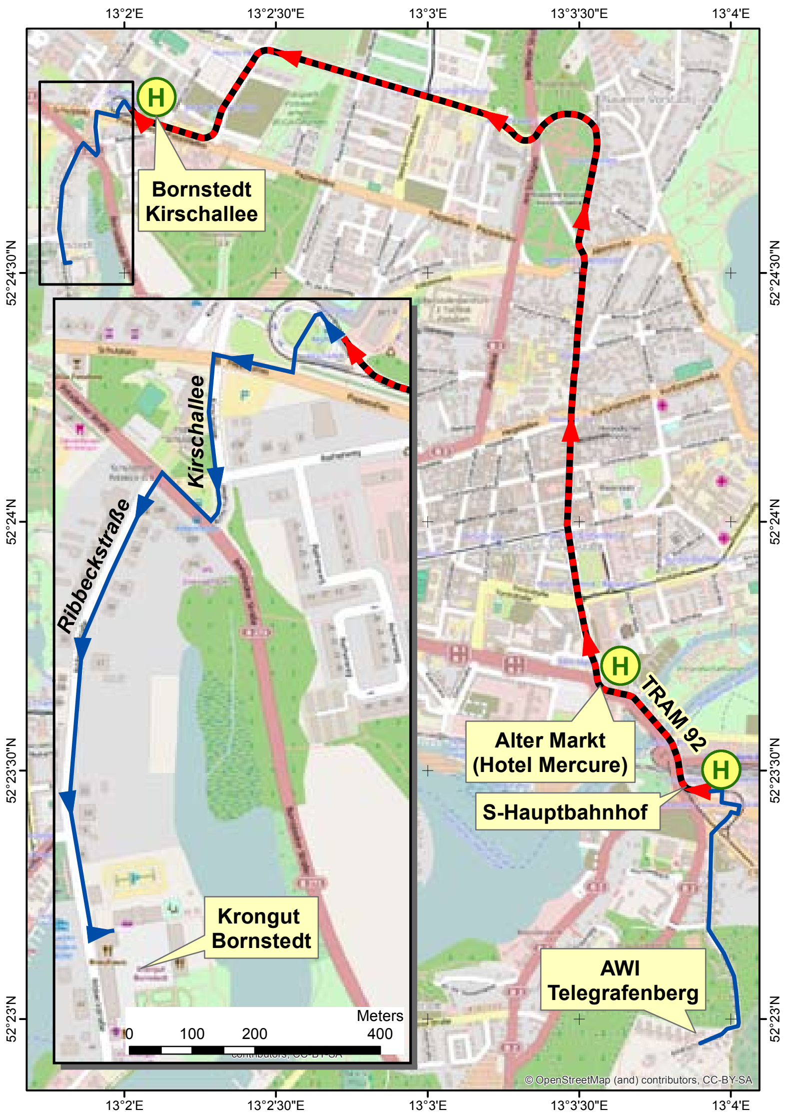
Without a doubt, Potsdam is one of the most beautiful cities in Germany. Adding to the cultural ambience, the capital city of the State of Brandenburg is a natural destination to satisfy varied interests and demands. Potsdam‘s most popular site is the Schloß Sanssouci palace, located in the park to which it gives its name. The former summer residency of prussian King Frederick the Great was built in the 18th century. Not only the palace and the surrounding Sanssouci park make your visit worthwhile. Great parts of the city of Potsdam have been recognised as UNESCO world's heritage in 1990. The Alexandrowka, the Holländisches Viertel (the Dutch Quarter) and the Weavers‘ Quarter - the historic sections of the city - provide the flair of a city steeped in European tradition. The Babelsberg Filmpark and the Biosphäre nature experience exhibit, are all special attractions which will make your visit to Potsdam a very pleasurable experience.

Conference Dinner at Krongut Bornstedt

Thursday, May 21, 19:00 (7pm)

The Bornstedt Crown Estate is a former royal estate and, today, a tourist attraction in the Potsdam borough of Bornstedt. It belongs to the ensemble of palaces and gardens of Sanssouci Park, which is a UNESCO World Heritage Site. Today the Bornstedt Crown Estate is a reflection of the Brandenburg-Prussian economy. Visitors can learn about the tradition of Prussian handicrafts; for instance, the Bornstedt tradition of brewing beer dating back to 1689 and has been revitalized in the year 2002. Our home-brewed beer is called “Bornstedt Buffalo” and is very popular with our guests.

Travel: Going down from the Telegraphenberg you best take the Tram (No. 92) from Potsdam main train station (in front of the building) and stop at “Bornstadt Kirschallee”. From there it's about 250m to walk. (see map to the right).



Natural and Cultural Heritage of Potsdam by Bike

Bernhard Diekmann, AWI Potsdam

Wed, May 20; Start: 8:30am at Hotel Mercure, End: 18:30 (6:30pm)

There are three reasons to visit Potsdam: (1) the historical heritage of Prussian kings and emperors, (2) the dense concentration of manifold fields of research, and (3) the wonderful landscape around Potsdam, which was shaped during the last ice age until today.

There is no better opportunity rather than biking in spring to get a physical and mental impression of landforms and culture of the region. Preformed by natural processes, the country around Potsdam was modified by human activity in historical times.

The about 30 km long bike trip will lead us along rivers, lakes, and over hills, flanked by Prussian palaces, traditional villages, and open-air restaurants. Depending on weather conditions and physical fitness, the following stopps are planned (see map, more handouts will be provided during the day trip):

1) Start at Hotel Mercure, May 20, 2015, 8:30am.

2) Biking over the Havel River terrace through the historical city of Potsdam to Sanssouci Palace, situated at the margin of an endmoraine.

3) The unique landscape of the Glindow Alps is man-made and was formed when an intensive tile and brick-making industry resided here. Clays of glaciolacustrine origin were exploited that appeared as squeezed streaks in older groundmoraine.

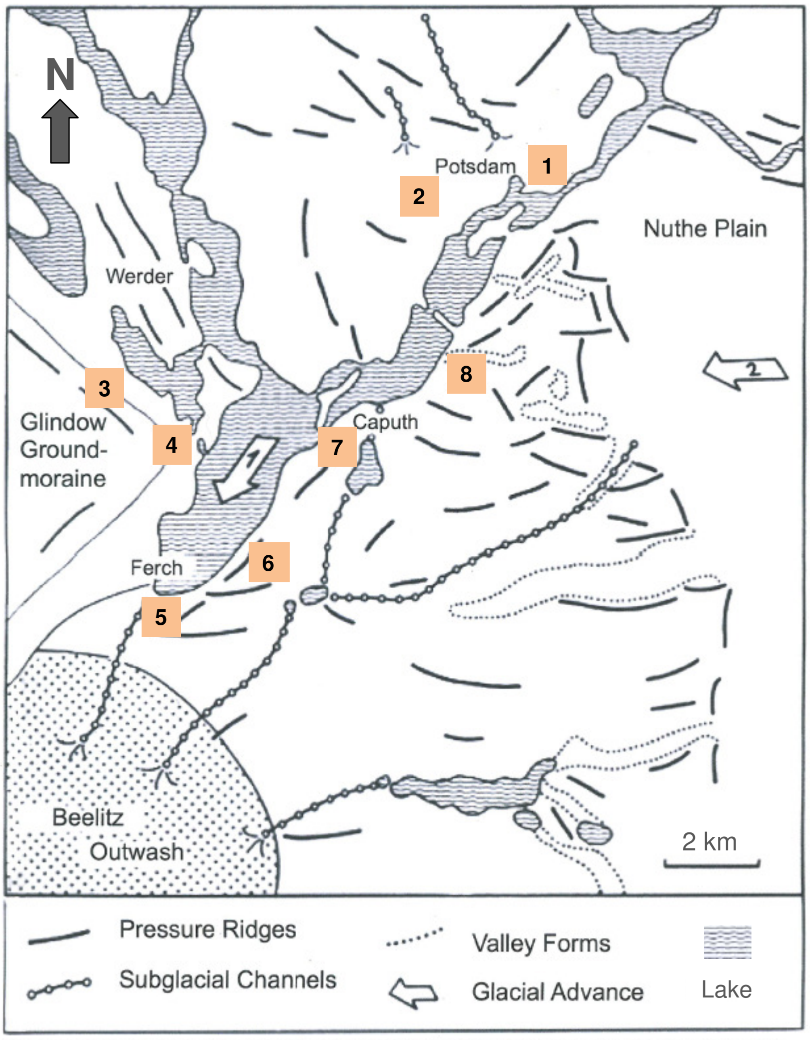
4) Petzow Castle at the western shore of Lake Schwielow represents a mixture between Italian Castle and English Tudor style and was built in 1825. It is placed in a 15-hectare landscaped park around a small lake, which represents part of a former meltwater channel.

5) The village of Ferch at the southern end of Schwielow Lake is situated at the former outwash mouth of the Lake Schwielow glacial tongue. In postglacial times, Lake Schwielow formed as a proglacial lake and Ferch became a wetland area that includes well preserved peat sequences of Holocene age.

6) Outlook from Wietkiekenberg, a marginal moraine of the Lake Schwielow glacial lobe.

7) The wonderful village of Caputh once was the summer resort of Albert Einstein. Lake Caputh represents a former kettle lake bounded by kames hills.

8) The shores of Lake Templin were shaped by ice contact and periglacial processes. Today it is the site of a Brandenburg tavern with tasty domestic beer and food. Way back to Mercure Hotel by 18:30 (6:30pm).



Glacial landforms around Potsdam. Modified from: Weiße in, Schröder, 2001, Geologie von Berlin und Brandenburg, Nr. 4: Potsdam und Umgebung), 275 pp., Selbstverlag Geowissenschaftler in Berlin und Brandenburg e.V., ISBN 3-928651-09-9.

Quaternary Geology and Geomorphology by Bus

Olaf Juschus, HNE Eberswalde

Wed, May 20; Start: 8:30am at Hotel Mercure, End: 18:30 (6:30pm)

The field trip will take us by bus to the southern margin of the (last) northern glaciation. We will visit interesting sites of the regional Quaternary geology and geomorphology around Luckenwalde and Baruth, situated to the SE of Potsdam.

This region was repeatedly overrun and covered by Scandinavian Ice Sheets (SIS). The last glaciation took place during the LGM, where the last/most recent SIS reached its furthest extent to the south. An incompletely formed chain of terminal moraines mark the Brandenburg ice stage.

The most recent glacier had its greatest environmental impact due to large quantities of released meltwaters. Many subglacial channels, massive proglacial sands and huge meltwater streamways (Urstromtäler) were formed at that time. The corresponding till is comparably thin and patchy. Parts of the relief were already formed during the older Saalian ice age (MIS 6).

0) Start at Hotel Mercure, May 20, 2015, 8.30 am.

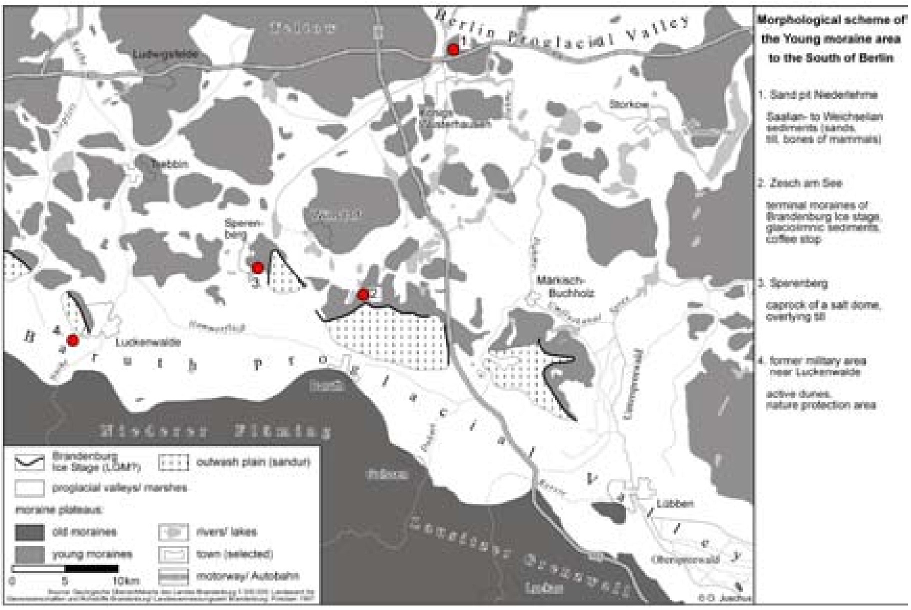
1) Active sand pit Niederlehme – The sand pit near Niederlehme contain a typical succession of Quaternary deposits for the young moraine area to the south of Berlin. At the bottom of the outcrop deposits of Saalian age are found. Typical for the lower till is an origin of the boulders from the ground of the Baltic Sea. These older deposits are overlain by comparably coarse-grained glaciofluvial material, the so called "Rixdorf Horizon". These gravels contain bones of huge mammals as well as other remains of the old, proglacial landscape. On top of the succession you will find a thin and patchy till of Weichselian age containing pebbles mainly originating from Sweden.

2) End moraine landscape near Zesch am See – Except some short oscillations the Brandenburg ice stage marks the southernmost border of the SIS during the LGM. Typical for this ice stage is an alternation of well-pronounced ridges of terminal moraines and huge gaps in between almost without any traces of the end moraine. Close to the small village Zesch am See, you see well developed ridges reaching 50 m in relative height. We will take a small walk to the top of the terminal moraine. Nearby, you will visit an outcrop with glaciolimnic deposits, which was developed behind the terminal moraine shortly after the ice started to melt.

3) Old quarries of Gypsum near Sperenberg – Close to the small town of Sperenberg there are several quarries where gypsum was excavated from the medieval period until 1957. It is one of only six outcrops with real hardrock in the whole province of Brandenburg. This geological feature developed by the movement of a salt dome, when salt of Upper Permian age jacked through all of the overlying rocks. Only the uppermost 1.5 m show a different gravel composition, which is typical for Weichselian deposits. A borehole was drilled in 1867 which held the depth world record at that time: reaching for the first time a depth of more than 1 km. From the top of the hillside, there is a beautiful view across the Baruth ice marginal valley.

4) The last stop of our trip is the area of an old military test site. Through the ages it was used by the Prussians, by the Wehrmacht as well as by the Red Army. The latter left the region in 1994. Since that time, the area is strongly protected for nature conservation. As a special feature there is an active dune, which was a part of an old, lateglacial dune complex.

5) Way back to Potsdam, Arrival at Mercure Hotel app. 18:30 (6.30 pm).



Morphological scheme of the young moraine area to the south of Berlin, with marked stops (red)

Conference Schedule - Overview

Time	Mon, May 18		Tue, May 19		Wed, May 20	Thu, May 21		Fri, May 22	Time
8:30	*Participants arrange their travel to Potsdam on their own*				**One Day Excursion**				8:30
8:45									8:45
9:00			Opening & Keynote 1			Keynote 3		Keynote 4	9:00
9:15									9:15
9:30									9:30
9:45									9:45
10:00						Session 2-1		Session 3-1	10:00
10:15			Session 1-1						10:15
10:30									10:30
10:45									10:45
11:00			Coffee Break			Coffee Break		Coffee Break	11:00
11:15									11:15
11:30			Session 1-2			Session 2-2		Session 3-2 & Closing Ceremony	11:30
11:45									11:45
12:00									12:00
12:15									12:15
12:30									12:30
12:45									12:45
13:00			Lunch break			Lunch break		Lunch break	13:00
13:15									13:15
13:30									13:30
13:45									13:45
14:00			Keynote 2			Session 2-3			14:00
14:15									14:15
14:30									14:30
14:45			Session 1-3						14:45
15:00									15:00
15:15									15:15
15:30			Poster Presentation 1			Poster Presentation 2			15:30
15:45			Coffee Break			Coffee Break			15:45
16:00			Poster Session 1	1. SC Meeting		Poster Session 2	2. SC Meeting		16:00
16:15									16:15
16:30									16:30
16:45									16:45
17:00									17:00
17:15									17:15
17:30			**PYRN Social Event**	*Dinner on your own*		*Get ready for banquet*			17:30
17:45									17:45
18:00	*Regi-stration*								18:00
18:15									18:15
18:30					*Dinner on your own*				18:30
18:45									18:45
19:00		**Ice Breaker Party**				**Conference Dinner**			19:00
19:15									19:15
19:30									19:30
19:45									19:45
20:00									20:00
20:15									20:15
20:30									20:30
20:45									20:45
21:00									21:00
21:15									21:15
21:30									21:30

Keynote Presentations

Lecture hall (building H)

Keynote 1: **Tuesday, May 19, 9:30-10:10**

Lev Tarasov

The last Northern hemispheric deglaciation: missing ice, data/model challenges, and opportunities

Keynote 2: **Tuesday, May 19, 14:00-14:40**

Volker Rachold

Future Priorities for Arctic Research

Keynote 3: **Thursday, May 21, 9:10-9:50**

Julian Murton

Permafrost history and environmental change at the margin of Beringia and the Laurentide Ice sheet, Tuktoyaktuk Coastlands, western Arctic Canada

Keynote 4: **Friday, May 22, 9:10-9:50**

Marit-Solveig Seidenkrantz, Camilla S. Andresen, Antoon Kuijpers, Marie-Alexandrine Sicre, Kaarina Weckström, Hui Jiang, Longbin Sha

Variability of late Holocene ocean and atmosphere circulation in the Labrador Sea and North Atlantic region - or why that which does not fit, fits extra well!

Tuesday, May 19, 2015

Opening and Keynote Lecture, 9:10-10:10

Lecture hall (Building H)
Conveners: Colm O'Cofaigh, Evan James Gowan

Lev Tarasov (9:30-10:10)

The last Northern hemispheric deglaciation: missing ice, data/model challenges, and opportunities

Session 1-1, 10:10-10:50

Lecture hall (Building H)
Conveners: Colm O'Cofaigh, Evan James Gowan

10:10 – 10:30 1-1-1 Katharina Teresa Streuff, Colm Ó Cofaigh, Jerry Lloyd, Riko Noormets
The geomorphological and sedimentary record of the Holocene evolution of Jakobshavn Isbræ in Disko Bay, West Greenland

10:30 – 10:50 1-1-2 Martin Margold, Chris R. Stokes, Chris D. Clark
Ice Stream Dynamics during Deglaciation of the Laurentide Ice Sheet

Coffee Break, 10:50-11:20

Session 1-2, 11:20-13:00

Lecture hall (Building H)
Conveners: Colm O'Cofaigh, Evan James Gowan

11:20 – 11:40 1-2-1 Renata G. Lucchi, Leonardo Sagnotti, Patrizia Macrì, Francisco J. Flores, Elena Colmenero-Hildago, Angelo Camerlenghi, Michele Rebesco
Evidence of the deep marine record of the MWP-1a on the NW-Barents Sea continental margin: Support from palaeomagnetic data

11:40 – 12:00 1-2-2 Elena V. Ivanova, Ivar O. Murdmaa, Emelyan M. Emelyanov, Elvira A. Seitkalieva, Eleonora P. Radionova, Galina N. Alekhina, Sergey M. Sloistov
Deglaciation of the last Scandinavian-Barents Ice Sheet and variations in the Atlantic water inflow into the Barents Sea

12:00 – 12:20 1-2-3 Riko Noormets, Teena Chauhan, Anne Flink, Oscar Fransner, Nina Kirchner, Kelly Hogan, Julian Dowdeswell
Deglaciation of the Svalbard-Barents Sea Ice Sheet in the northern Barents Sea, east of Svalbard

12:20 – 12:40 1-2-4 Lilja R. Bjarnadóttir, Monica C.M. Winsborrow, Karin Andreassen, Mariana S.R. Esteves, Calvin S. Shackleton
The influence of subglacial hydrology on glacial dynamics during deglaciation of the central Barents Sea

12:40 – 13:00 1-2-5 Ekaterina Kaparulina, Juho Juntilla, Juho Pekka Lunkka, Kari Strand
Onland deglaciation and provenance changes in SW Barents Sea sediments over the Late Glacial - Holocene

Lunch Break - 13:00-14:00

Keynote Lecture, 14:00-14:40

Lecture hall (Building H)
Conveners: Camilla Andresen, Josefine Lenz

Volker Rachold
Future Priorities for Arctic Research

Session 1-3, 14:40-15:20

Lecture hall (Building H)
Conveners: Camilla Andresen, Josefine Lenz

14:40 – 15:00 1-3-1 Valery Astakhov
Late Quaternary glaciation of arctic and subarctic Urals

15:00 – 15:20 1-3-2 Henning A. Bauch, Robert F. Spielhagen
Spatial shifts in North Eurasian ice sheet extent since the Middle Pleistocene

Poster Presentation 1, 15:20-15:40

Coffee Break, 15:40-16:00

Poster Session 1, 16:00-17:30

see details on the poster presentation on page 17-18

PYRN Social, 17:30-21:30

Wednesday, May 20, 2015

One Day Excursions, 8:30-18:30

see details on the different excursions on page 8-9

Thursday, May 21, 2015

Keynote Lecture, 9:10-9:50

Lecture hall (Building H)
Conveners: Hanno Meyer, Yaroslav Ovsepyan

Julian Murton

Permafrost history and environmental change at the margin of Beringia and the Laurentide Ice sheet, Tuktoyaktuk Coastlands, western Arctic Canada

Session 2-1, 9:50-10:50

Lecture hall (Building H)
Conveners: Hanno Meyer, Yaroslav Ovsepyan

9:50 – 10:10	2-1-1	Thomas Opel, Thomas Laepple, Hanno Meyer, Martin Werner, Alexander Yu Dereviagin, Sebastian Wetterich **Ice-wedge record of Arctic winter temperatures over the past two millennia – long-term and recent warming in the Siberian Laptev Sea region**

Session 2-1 (cont.):

10:10 – 10:30 2-1-2 Michael Fritz, Juliane Wolter, Natalia Rudaya, Olga Palagushkina, Larisa Nazarova, Michael Krautblatter, Jaroslav Obu
Ice wedge polygon development on different temporal and spatial scales in the northern Yukon, Canada

10:30 – 10:50 2-1-3 Frank Günther, Guido Grosse, Sebastian Wetterich, Benjamin M. Jones, Viktor V. Kunitsky, Frank Kienast, Lutz Schirrmeister
The Batagay mega thaw slump, Yana Uplands, Yakutia, Russia: permafrost thaw dynamics on decadal time scale

Coffee Break, 10:50-11:20

Session 2-2, 11:20-13:00

Lecture hall (Building H)
Conveners: Hanno Meyer, Yaroslav Ovsepyan

11:20 – 11:40 2-2-1 Tatiana Kuznetsova, Lutz Schirrmeister, Vladimir Tumskoy
Pleistocene - Holocene terrestrial palaeoenvironmental changes at the coasts of the Dmitry Laptev Strait (Laptev Sea Region, Arctic Siberia)

11:40 – 12:00 2-2-2 Ekaterina Nosevich, Tatyana Sapelko, Mikhail Anisimov, Yuriy Kurochkin
The appearance of pollen on the archipelago Franz-Josef Land of the Arctic Ocean

12:00 – 12:20 2-2-3 Josefine Lenz, Guido Grosse, Benjamin Jones, Michael Fritz, Sebastian Wetterich
Past landscape and permafrost dynamics in Arctic Alaska based on sedimentary records

12:20 – 12:40 2-2-4 Biljana Narancic, Reinhard Pienitz, Bernhard Chapligin, Hanno Meyer
Postglacial environments of Nettilling Lake basin (Baffin Island, Canada) inferred by the geochemical and biological proxies

12:40 – 13:00 2-2-5 Boris K. Biskaborn, A Hansche, D Subetto, L Pestryakova, U Herzschuh, L Heinecke, P Vakhrameeva, S Savelieva, B Diekmann
Environmental variability in northeastern Siberia inferred from lake sediment records

Lunch Break - 13:00-14:00

Session 2-3, 14:00-15:20

Lecture hall (Building H)
Conveners: Nina Kirchner, Magdalena Łącka

14:00 – 14:20	2-3-1	Helena Alexanderson, Jonas Svensson, Kristian Westlund, Heidi T. Ryen, Jon Y. Landvik, Leif V. Jakobsen **Lagoons, beaches and sea-level change on NW Svalbard**
14:20 – 14:40	2-3-2	Matt Strzelecki, Witold Szczucinski, Antony Long, Nick Rosser, Thomas Lawrence, Agata Buchwal, Maria Drewniak, Stuart Dunning, Paulina Cwik **Catastrophic events shaping Arctic coasts - impact of tsunamis and ice-berg roll waves on coastal evolution in Greenland**
14:40 – 15:00	2-3-4	Anders Romundset, Naki Akcar, Ola Fredin, Fredrik Høgaas, Christian Schlüchter **Early thinning and recession of the Scandinavian Ice Sheet in southernmost Norway - new chronological constraints from cosmogenic 10Be -dates**
15:00 – 15:20	2-3-4	Kate Dennis, Renato Winkler, John Hoffnagle **Applications of cavity ring-down spectroscopy to paleoclimate, including high-precision analysis of the triple oxygen isotopes in water and water va-por**

Poster Presentation 2, 15:20-15:40

Coffee Break, 15:40-16:00

Poster Session 2, 16:00-17:30

see details on the poster presentation on page 19

Conference Dinner, 19:00-open end

see travel and location details on page 7

Friday, May 22, 2015

Keynote Lecture, 9:10-9:50

Lecture hall (Building H)
Conveners: Kari Strand, Martin Margold

Marit-Solveig Seidenkrantz, Camilla S. Andresen, Antoon Kuijpers, Marie-Alexandrine Sicre, Kaarina Weckström, Hui Jiang, Longbin Sha

Variability of late Holocene ocean and atmosphere circulation in the Labrador Sea and North Atlantic region - or why that which does not fit, fits extra well!

Session 3-1, 9:50-10:50

Lecture hall (Building H)
Conveners: Kari Strand, Martin Margold

9:50 – 10:10 3-1-1 Thomas M Cronin, Rachel Marzen, Lauren DeNinno, Gary Dwyer
Arctic Productivity and Orbital Climate Cycles

Session 3-1 (cont.):

10:10 – 10:30 3-1-2 Martin Miles, Christian Dylmer
Modulations in sea ice in the East Greenland Current during the past two millennia

10:30 – 10:50 3-1-3 Jochen Knies, Irene Pathirana, Patricia Cabedo Sanz, Tine L. Rasmussen, Matthias Forwick, Simon T. Belt
Climate controlled variability of an Arctic sea ice fabric

Coffee Break, 10:50-11:20

Session 3-2, 11:20-12:20

Lecture hall (Building H)
Conveners: Kari Strand, Martin Margold

11:20 – 11:40 3-2-1 Anne de Vernal, Camille Brice, Jade Falardeau, Claude Hillaire-Marcel, Elena Ivanova, Eleonora Radionova, Robert Spielhagen, Nicolas Van Nieuwenhove
Variability of the northward flux of North Atlantic waters through Fram Strait during the Holocene

11:40 – 12:00 3-2-2 Maciej Mateusz Telesiński, Robert F. Spielhagen, Henning A. Bauch
Development of northern Nordic Seas deep convection during the Holocene – implications from surface and bottom water foraminiferal $\delta^{13}C$ records

12:00 – 12:20 3-2-3 Ed Pope, Peter Talling, Julian A. Dowdeswell
Timing and frequency of glacigenic debris flows on the Bear Island Fan – implications for the growth and decay of the Barents ice sheet

Closing Ceremony - 12:20-12:45

Lunch Break - 12:45-13:30

Poster Session 1, Tuesday May 19, 16:00-17:30

Foyer

Amalie E. Cordua, Camilla S. Andresen, Sabine Schmidt, Tod Waight
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A new Quaternary sediment sequence from the eastern Mendeleev Ridge: preliminary stratigraphic subdivision based on IRD and microfossil records

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Christian Valdemar Dylmer, Martin Miles
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First insights into pre-glacial Pleistocene environments in the Arctic Ocean

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Michail Anisimov, Aleftin Barliaev
Analysis of radiocarbon dates collected from the Holocene raised beach sequences on Svalbard and Franz Josef Land

Nataliya Chistyakova, Ekaterina Taldenkova, Yaroslav Ovsepyan, Robert F. Spielhagen, Henning A. Bauch, Anna Stepanova, Monika Segl
Reconstruction of postglacial environmental changes at the eastern Laptev Sea continental margin

Diedrich Fritzsche, Opel Thomas, Meyer Hanno, Merchel Silke, Rugel Georg, Enamorado Baez Santiago Miguel
Late Holocene environmental ice core record from Akademii Nauk ice cap (Severnaya Zemlya)

Graham Lewis Gilbert, Hanne Hvidtfeldt Christiansen
K Fjord-head delta progradation and permafrost aggradation interpreted from a 60 m frozen sediment core, Adventdalen, Svalbard

Margret Christine Fuchs, Sebastian Wetterich, Georg Schwamborn, Lutz Schirrmeister
Geochronologic challenges related to spatial and temporal discontinuities of sediments in permafrost environments: the case of Bol'shoy Lyakhovsky, Siberian Arctic

Guido Grosse, Benjamin M. Jones, Lutz Schirrmeister, Hanno Meyer, Sebastian Wetterich, Jens Strauss, Benjamin V. Gaglioti, Dan H. Mann, Vladimir E. Romanovsky
Late Pleistocene and Holocene ice-rich permafrost in the Colville River valley, northern Alaska

Vera Meyer, Jens Hefter, Lars Max, Enno Schefuß, Ralf Tiedemann, Gesine Mollenhauer
Biomarker records from the eastern continental margin off Kamchatka Peninsula and Eastern Siberia on deglacial variations in sea surface temperature, air temperature, provenance and terrestrial residence times of terrigenous organic matter in Beringia

Georg Schwamborn, Hugues Lantuit, Michael Fritz, Josefine Lenz, Bernhard Diekmann
Validity of the MIS 2 glacial border in the NW Canadian Arctic based on comparing the on- and offshore clay mineral composition

Sebastian Wetterich, Thomas Opel, Hanno Meyer, Natalia Rudaya, Andrej Andreev, Lutz Schirrmeister
Summer and winter proxy data from Ice Complex features in East Siberia dating back to 200 kyr

Juliane Wolter, Hugues Lantuit, Ulrike Herzschuh
Thermokarst lake history and stable tundra vegetation since the 18th century in a Low Arctic setting, Yukon Territory, Canada

Karina Schollaen, Antoni G. Lewkowicz, Hanne H. Christiansen, Vladimir E. Romanovsky, Hugues Lantuit, Lothar Schrott, Dmitry Sergeev, Ma Wei
International Permafrost Association

Hugues Lantuit, Michael Fritz, Juliane Wolter, Josefine Lenz, Georg Schwamborn, Bernhard Diekmann
Paleogeographical investigations along the Yukon Coast

The Fast Full Stokes solver – an accurate, efficient and flexible tool for palaeo-ice sheet simulations

J. Ahlkrona[1,2], P. Lötstedt[1,2], N. Kirchner[2,3], T. Zwinger4, E. Gowan[2,3], R. Noormets[5], J.A. Dowdeswell[6] & T. Benham[6]

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Recent research has revealed that the Svalbard-Barents Sea Ice Sheet (SBSIS) was a highly dynamic ice complex, with ice streams, shifting domes and marine ice margins playing a crucial role for its evolution (Ingólfsson and Landvik, 2012; Stokes et al., 2015). Numerical simulations of the SBSIS have been performed with Shallow Ice Approximation (SIA) models, which are computationally cheap enough to be run over glacial cycles timescales, but are insufficient to accurately determine ice dynamics (Siegert and Dowdeswell, 1995, 2004). Full Stokes (FS) ice sheet models include accurate descriptions of ice dynamics, and would be ideal candidates for modeling the SBSIS. However, they are computationally so expensive that they are restricted to simulations of continental sized ice sheets on sub-millenial time-scales (Gillet-Chaulet et al., 2012, Seddik et al., 2012).

In order to enable palaeo-ice sheet simulations to be performed at a level of accuracy that has become standard in prognostic, centennial time-scale simulations focusing mostly on the contribution of ice sheets to sea level rise (Bindschadler et al., 2013), we have developed the Fast Full Stokes solver.

The Fast Full Stokes method (Ahlkrona et al., 2015) is a new tool for ice sheet modeling that is obtained from coupling a FS model with a SIA model. The coupling is designed to retain the exactness of the FS and the computational cheapness of the SIA model, and makes the Fast Full Stokes model a potentially viable tool for palaeo-simulations.

We demonstrate efficiency and flexibility of the Fast Full Stokes solver for an idealized ice sheet including migrating ice streams, and show accuracy for a conceptual simulation of a Svalbard based palaeo ice sheet. Future applications will target simulations of the deglaciation history of the SBSIS.

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Lagoons, beaches and sea-level change on NW Svalbard

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Littoral deposits are important recorders of past sea-level change. Their elevation, geomorphology, sedimentology and age allow the reconstruction of past relative sea levels and coastal conditions during certain times. For example, flights of raised beach ridges are evidence of rapid regression and – in formerly glaciated areas – indicate isostatic land uplift due to a prior large-scale glaciation. Transgression, on the other hand, is more typically represented by features such as lagoons and estuaries.

Here we will present data from littoral deposits that provide new information about relative sea-level change and coastal conditions in NW Svalbard since the mid Holocene and we will discuss their causes and implications. Northwestern Spitsbergen has been a key area for reconstructing Holocene sea-level change for the Svalbard area (Forman et al. 2004). The dominant littoral features here are raised beaches, which formed during regression after the last deglaciation, such as on Brøggerhalvøya (Forman et al. 1987). However, there are also features that indicate transgression or sea-level stillstands, both in the past and in the present. The presence of an ongoing transgression (cf. Forman et al. 1987) is supported by the strong predominance of lagoons and estuaries compared to beach ridge plains, as revealed by a remote-sensing based inventory of present-day coastal features in NW Svalbard (Westlund 2014). We are also able to place further constraints on a mid-late Holocene high relative sea-level event (Forman et al. 1987, 2004), based on new data from Tønsneset in the inner Kongsfjorden. Ground-penetrating radar (GPR) profiles and excavations reveal buried lagoons and palaeosurfaces beneath an active berm-ridge (Svensson 2009), and absolute ages of the different stratigraphic units provide improved age control of the event.

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Analysis of radiocarbon dates collected from the Holocene raised beach sequences on Svalbard and Franz Josef Land

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Relative sea level reconstruction for the region of Svalbard and Franz Josef Land is a pivotal paleogeographic problem. This issue has been extensively discussed during the last 55 years (Dibner, 1961, Grosswald et al., 1973, Glazovskiy et al., 1992, Naslund et al., 1994, Forman, 1997, Lubinsky et al., 1998, and other). The authors of the big review put out in 2004 (Forman et al., 2004) united a considerable part of published radiocarbon dates collected from the raised-beach sequences. This article was devoted to the analysis of postglacial emergence pattern and glacial retreat in the Holocene. The authors estimated emergence isobases for the Barents Sea area since 5000 and 9000 BP. These isobases reflect the glacioisostatic emergence. Over the past period, new dates were published (Dymov et al., 2005, Bolshiyanov et al., 2009, Gusev et al., 2013, Anisimov et al., 2014). Glacial isostatic origin of Holocene emergence is called into question in some publications (Bolshiyanov et al., 2009, Gusev et al., 2013).

In this article we have united all published previously radiocarbon dates collected from raised-beach sequences on Svalbard and Franz Josef Land adding also the new dates we received during our research. We have made the analysis and provided the reconstructions. Special features of dated material were taken into account. 4 categories were distinguished from the dataset: driftwood, whalebone (together with walrus bone), seaweed and shell (with breakdown to species). The dataset includes more than 500 dates overall. Number of dates on seaweed appeared to be negligible.

Elevation-age relation diagram (see Fig. 1) deciphers the following peculiarities:
- Dates on driftwood concentrates in the upper part of the diagram. The approximating trend line most probably indicates Holocene relative sea level;
- Dates on shell and whalebone are mostly below this line. Evenaged samples were collected at different heights above sea level – the variance of heights ranges up to 60 meters. It is caused by particular qualities of mollusks bioenvironmental conditions.
- The major part of dates on shell occurs between 10,000 BP and 8,600 BP with the peak between 9,400 BP and 9,200 BP that most probably indicates favorable bioenvironmental conditions for mollusks during this period.

It is obvious that different mollusk species live at different depths, which can vary from 0 to 50 meters, and even to 500 metres in some cases. It is hardly possible to distinguish precisely the depth of living for the mollusk sample. For this reason it is crucial to take into account special features of sedimentation conditions of the period shells were deposited. What is more, we suggest that the remarkably low amount of dates on shells younger than 8,000 BP (see Fig. 1) could be explained by the fact that its enclosing sediments are below the sea level now.
Whalebones are found in this area as a whole skeleton and separately as well. Their present elevation could possibly indicate both the location of an old seashore or deeper parts of the bottom.

The same conclusions could be applied to driftwood dates. Driftwood samples taken from berms of raised beaches appear to be the most reliable indicators. In these cases, a sample indicates slightly overestimated seashore height. It is caused by the fact that these samples of driftwood were deposited under sea storm conditions. Unfortunately, dates do not form the ideal line on the diagram. This leads to considerable difficulties in data interpretation.

As a result of the analysis, some considerable conclusions were made:
- Use of dates on shells for seashore location determination provides tens of meters error. Composition and structure of enclosing sediments as well as possible error diapason should be taken into account;
- Seashore location determination is most dependable when dates on driftwood from berms of raised beaches are used;
- Estimating emergence isobases based on the dates on shells do not provide clear and convincing results, but a chaotic field of points. On the other hand, the analysis of radiocarbon dates for driftwood allows to show several emergence isobases for this territory at 3000, 5000 and 7000 BP (see Fig. 1). Unfortunately, there are not more than 20 points used in every diagram.

It is noteworthy that we did not intend to prove or disprove the idea of glacioisostasy. However, our results have something in common with conclusions made by Forman and co-authors. (Forman et al., 2004) We suppose that there is discordance in emergence rates of different parts of islands and do not deny that it is caused by post-glacial rebound partially complicated with block emergence.

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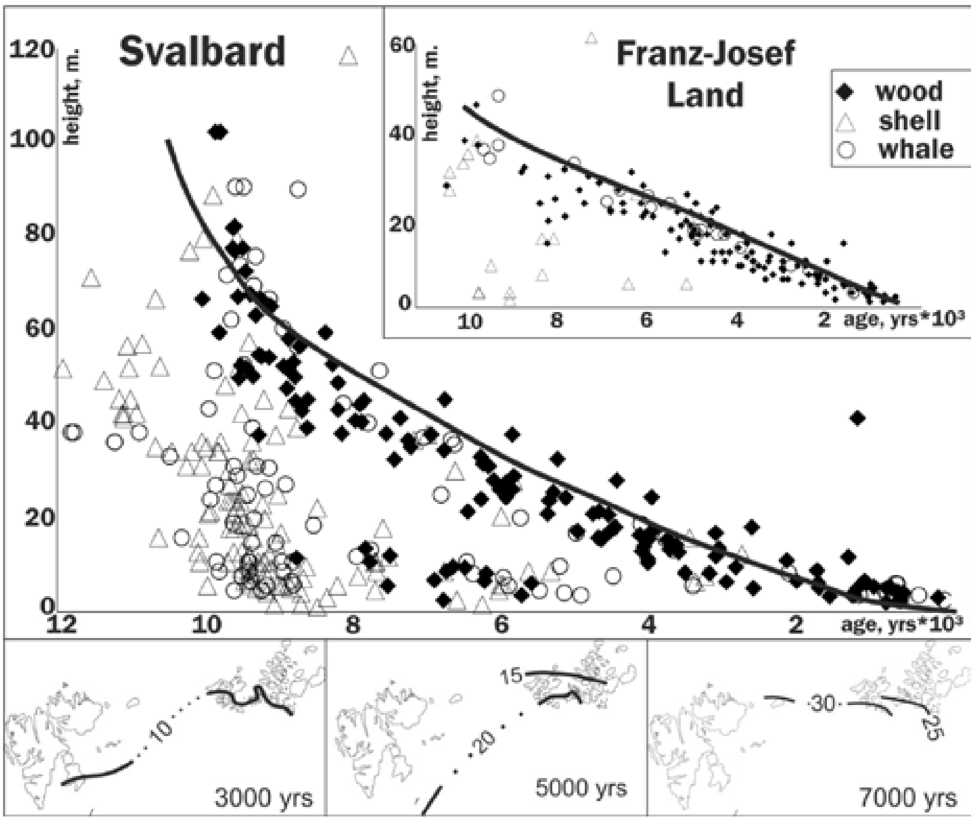

Fig. 1. Breakdown of radiocarbon dates of Holocene raised beaches sequences of Svalbard and Franz Josef Land archipelagos to the types of dated material and the emergence isobases using the dates for driftwood at 3000, 5000 and 7000 ^{14}C yr.

Late Quaternary glaciation of arctic and subarctic Urals

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Traditionally the Urals have been viewed as a major ice dispersal centre based on the Uralian composition of erratics scattered in the adjacent plains. For the Middle Pleistocene additional sources of inland ice on the arctic shelf were inferred from exotic boulders found on flat mountain summits 1000 m high. However, fresh non-Uralian moraines discovered in the 1970-s around the northern tip of the Polar Urals demonstrated that in the Late Pleistocene the range was circumvented by southbound ice streams (Astakhov, 1979). Later the former presence of foreign ice in the Urals was confirmed by the finds of horseshoe-shaped moraines at altitudes 250 to 560 m inserted into the mountains from the north-west (Astakhov et al., 1999). The latest longitudinal ice flow is also indicated by southern vectors of boulder trains in the surficial till (Shishkin, 2007). Now it is evident that Late Pleistocene ice streams from the Kara shelf intruded into the northernmost Polar Urals almost up to 67°N blocking and assimilating small local glaciers (Fig.). The thickness of the foreign ice is estimated from altitudes of cryoplanation terraces which could develop only above the glacier trimline. The trimline descends from 400-560 m at the northwestern tip of the Urals to 200 m on the river Bol. Usa indicating ice thickness decrease from 300-400 m to 70-80 m along the 100 km longitudinal stretch. These facts are strongly supported by geological mapping of the narrow part of the Urals between 67 and 65,5°N showing a very limited extent of local tadpole-shaped moraines which do not occur farther than several kilometers from the mountain front. Judging by the fresh hummocky moraines alpine glaciers coalesced to form an Alaskan type ice sheet only in the western piedmont at the foot of the highest and widest massif of the Peri-Polar Urals between 64 and 65°N. The eastern, less humid slope is practically devoid of local glaciation traces (Fig.).

In the 1950-60-s the last glacial maximum in the Urals was attributed to the Early Valdai, but later, under the influence of the `old` radiocarbon dates, the paradigm shifted to the MIS 2 age of the main ice advance. The latest data on chronometry of the uppermost glacial complex totally disagree with that fashionable idea of the 1970-80-s. Thus, large boulders dated by cosmogenic 10Be yielded ages in the range of 28 to 14 ka BP (mean 21 ka) only not farther than 1 km from the extant miniglacier Chernov (Fig.). Downstream along the glacial trough large boulders have ages 60 to 50 ka (mean 58±3 ka). This is obvious evidence of insignificant size of Late Weichselian glaciers on the western slope of the Polar Urals (Mangerud et al., 2008). No such young moraines have been found on the eastern slope.

A relative antiquity of the last major ice advance is indicated by OSL dating of marginal sandurs. 13 dates, the mean value of 73 ka, are obtained from the sandur east of the horse-shaped moraine of a foreign glacier inserted into a mountain valley (Bol. Kara in Fig.) (Nazarov et al., 2009). The glaciofluvial sands on the margin of the morainic apron on river Bol. Usa (Fig.) yielded similar ages of 67 to 63 ka BP in accord with the above 10Be dates. The MIS 4 age also agrees with 14C values ca 40 ka BP (11 dates) from alluvium incised into the latest varved formation at Palaeolithic site Mamontovaya Kurya (Svendsen et al., 2014).

The dates imply that alpine glaciers that survived south of the Kara ice were not younger than MIS 4. This fact sheds light also on the origin of large eastern moraines beyond the small morainic loops of the maximum alpine glaciation (Fig.). Earlier these large subdued and soliflucted moraines have been taken for traces of the Late Pleistocene Uralian glaciation. But they have no symmetric counterparts on the wetter western slope. This paradox is stressed by the natural lack of young moraines on the lee eastern slope of the Peri-Polar Urals as counterparts of the moraines of the south-western piedmont (Fig.). This excludes a Uralian origin for the large eastern moraines. They must have been left by trans-Uralian ice streams derived from a thick European ice sheet retreating to the north-west in the late Middle Pleistocene.

Thus, the last glacial maximum of the Urals was reached in the MIS 4 time. The main invasion of inland ice from the Kara Sea found disjointed alpine glaciers that coalesced to produce a piedmont ice sheet only in the south-west of the considered region.

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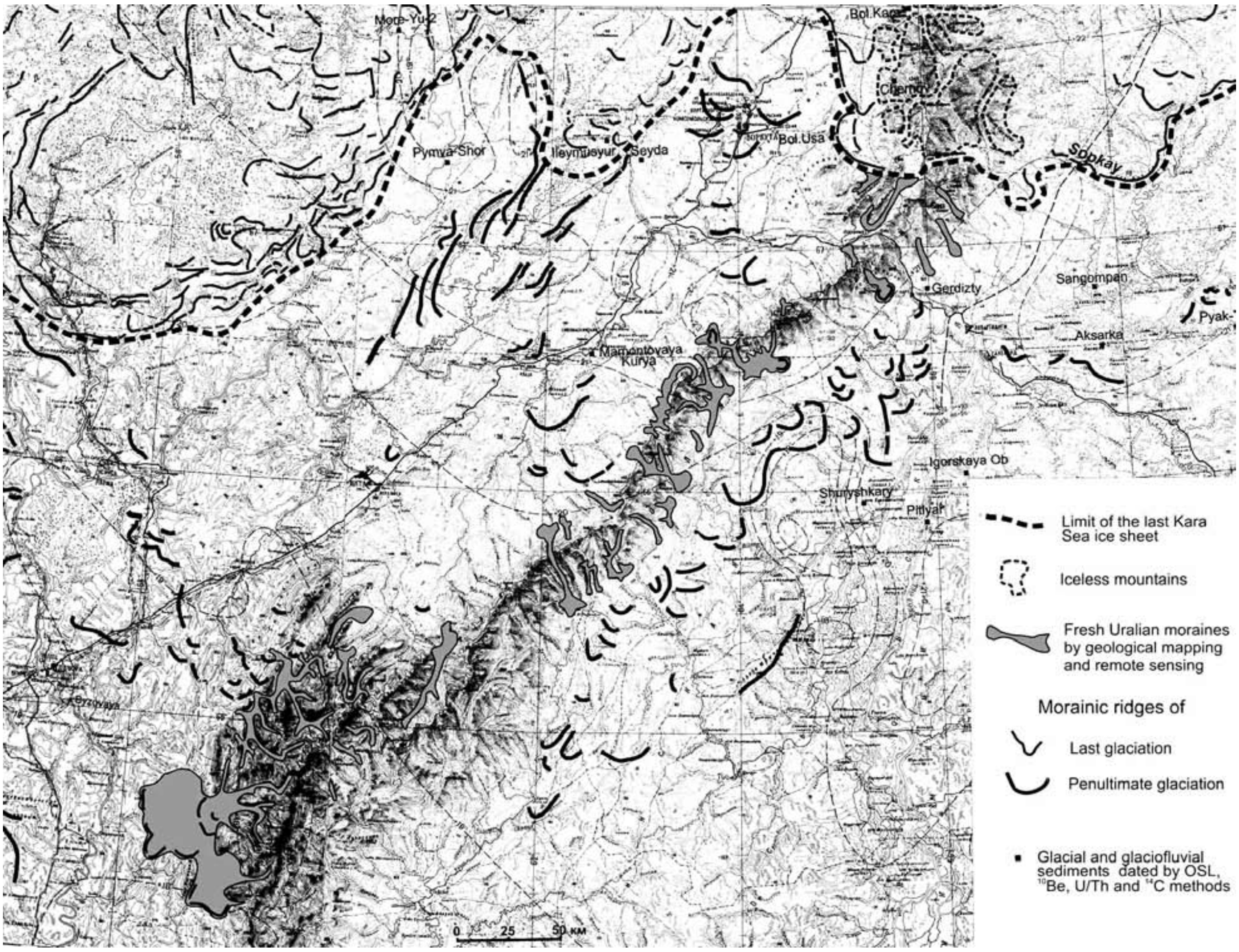

Fig. Surficial glacial features in the Polar and Peri-Polar Urals.

Spatial shifts in North Eurasian ice sheet extent since the Middle Pleistocene

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Circum-arctic land regions and adjacent ocean basins hold clues of varying ice sheet sizes through time. Understanding these records correctly is therefore an important asset to better appreciate Quaternary climate change also within a much broader global context. Marine sediment core data from the polar and subpolar and North Atlantic show a stepwise trend of decreasing fluxes of iceberg-rafted debris (IRD) during major glaciations of the last 500 ka, i.e., marine isotope stages (MIS) 12, 6, and 2. Strongest IRD deposition occurred in MIS 12 (Elsterian), while it was lower in MIS 6 (Saalian) and 2 (Weichselian). These marine results of iceberg discharge rates from the western European margins, in particular, point to significant temporal changes in the ice-sheet coverage over northern Eurasia. Like in northern Europe, field data from Russia provide evidence for several major pre-Weichselian glaciations. Although their southern maximum limits were likely asynchronous in certain places, it seems evident that these ice sheets not only pre-date the Saalian time, they also extended much farther south than at any time later. In spite of that, it was the Saalian glaciation which, for the first time, also reached the North Eurasian shelf edge, forming an almost 2000 km long calving line. The discharge of icebergs from this Saalian ice margin is clearly reflected in Arctic Ocean deep-sea sediments by massive IRD-rich layers in MIS 6, deposited on top of older, usually more fine-grained sediments.

The observed asymmetric developments between the subarctic regions and the Arctic Ocean proper during the last 500 ka indicate a variable yet systematic migration of southern glaciation limits towards the north, accompanied by a western and northern shift of glaciation centers. These geographical shifts were likely forced by major changes in oceanic heat transport which essentially influenced the pathways of atmospheric moisture transfer across northern Eurasia during glacial maxima.

Late Quaternary sediment supply variability at the Mendeleev Ridge (Arctic Ocean): Insights from grain-size distribution and ice-rafted debris composition

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This study is based on long sediment cores from the central Arctic Ocean recovered during the ARK-XXIII/3 Expedition of RV “Polarstern” in 2008 (Jokat, 2009). Coring sites are located along a profile at ca. 77° N across the Mendeleev Ridge: PS72/340-5 (2349 m water depth), PS72/342-1 (820 mwd), PS72/343-1 (1227 mwd) and PS72/344-3 (1257 mwd). This area is considered to be the frontal zone between the two major systems of surface currents in the Arctic Ocean, the Beaufort Gyre and the Transpolar Drift. Therefore, these sites can be used to study changes in the ocean circulation. Core records span the last 200 ka according to the current age model (Stein et al., 2010). Over this time period, contribution from different IRD source areas is estimated to reconstruct sediment pathways and paleoceanographical settings.

Grain-size distribution in marine sediments was investigated to help identify different ways of particle transport. For the grain-size and other analyses, cores were sampled at changes in lithology and/or colour to represent all the lithostratigraphic units. Coarse fraction (>63 µm) was isolated via wet sieving. Sand and gravel were separated via dry sieving. Grain-size distribution in the fine fraction (<63 µm) was analyzed using the Micrometrics Sedigraph 5100 facility at the Otto Schmidt Laboratory for Polar and Marine Research (Arctic and Antarctic Research Institute, St. Petersburg, Russia). The output dataset comprises of mass concentrations for the grain sizes from 0.16 to 63 µm, measured with increasing step of 0.3 to 3 µm. The cumulative data were used to determine the contents of silt (2-63 µm) and clay (< 2 µm). After that sizes were recalculated into phi (Ø) values for comparison with the other Arctic Ocean studies. Parameters of the grain-size distribution such as mean size, sorting and skewness of the fine fraction were calculated and analyzed after Blott and Pye (2001) using the logarithmic (original) Folk and Ward graphical method.

In marine sediment cores from the Amerasian Basin of the Arctic Ocean, especially at the Northwind and Mendeleev Ridges, distinct pink and pink-white carbonate-rich layers with common occurrence of rock clasts are used as lithostratigraphic boundaries (Clark et al., 1980). To determine the origin of clasts in the studied cores, petrographic analysis of extracted grains 0.5-2 and > 2 mm is carried out using microscope observation. Treatment with HCL solution is applied to check for the presence of carbonate component. Clast types are classified following the published studies from the Arctic Ocean which utilized the same size fractions (Bischof et al., 1996; Phillips and Grantz, 2001; Taldenkova et al., 2010). Results will be compared to the composition of larger dropstones which were previously described individually in thin sections. Additionally, changes in the IRD composition will be compared to mineralogy and isotope geochemistry of clay fraction of the same sediments investigated at the Alfred Wegener Institute.

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Environmental variability in northeastern Siberia inferred from lake sediment records

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Remote lake sites in northeastern Siberia provide valuable archives of natural climate change, because of the minor or even unexisting influence of human impact in the past to sub-recent time. To gain insight into the spatio-temporal climate variability in Arctic Russia, we investigated multiple parameters from lake sediments in the Lena Delta area and its hinterland: diatoms, pollen, grain-size distributions, organic contents and its isotopic composition, as well as elemental and mineralogical compositions. Here we refer to sediment core material from thermokarst lakes with focus on Lake Kyutyunda (N 69.6°; E 123.6) in the sub-Arctic zone. The sediment core is dated back to ca. 38,000 years BP and reveals evidence of the Younger Dryas cold and dry period, the Holocene Thermal Maximum (HTM), subsequent cooling and recent climate change. Our results exhibit a direct link between the limnological, ecological, and sedimentological development and the regional climate variability. Comparison of our record with the literature available provides further evidence of the time-transgressive nature of the HTM timing in eastern Siberia as it appeared in the early Holocene at the north, and in the middle Holocene at the south of the study region. The HTM thus reveals a temporal delay from north to south. This spatio-temporal pattern can be linked to regional environmental features that influence the global climate system, providing evidence of teleconnection between the North Atlantic region and north-eastern Russia. Our findings show that the spatial and temporal variability of the HTM in the Lena Delta area and its hinterland were linked to the westerlies, which brought cold air from the north Atlantic region where deglaciation processes still influenced the climate until the Laurentide ice sheets vanished about 7 kyr BP.

The influence of subglacial hydrology on glacial dynamics during deglaciation of the central Barents Sea

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Numerous studies from the Barents Sea have used geomorphic mapping of the seabed to identify palaeo-ice streams and describe their retreat dynamics. The fast flow of ice streams is believed to be facilitated through basal lubrication by subglacial meltwater. Glacial dynamics both influence and are influenced by changes to the distribution and/or abundance of subglacial meltwater. Despite this, and somewhat paradoxically, very few descriptions of meltwater features exist from the central Barents Sea. Recent findings of such features from this area will be briefly reviewed and described, and their influence on palaeo-ice dynamics explored. Subglacial conditions are known to vary spatially and temporally, here we examine what the distribution and type of glacial geomorphic features on the seabed can tell us about such variability during the deglaciation of the central Barents Sea. Furthermore, the significance of this variability as deglaciation progressed will be explored within the framework of existing reconstructions of deglaciation.

Reconstruction of postglacial environmental changes at the eastern Laptev Sea continental margin

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Postglacial paleoenvironmental variability in the Laptev Sea region was primarily caused by the interaction between Atlantic-derived water (ADW) inflow, freshwater inputs and changes in sea-ice extent and sea level. High-resolution investigations of IRD, planktic and benthic foraminifers, ostracods and stable isotope composition of foraminifers were carried out on AMS^{14}C-dated sediment cores PS2458-4 and PS51/118-3 from the eastern Laptev Sea continental margin (983 and 122 m water depth, respectively). The basal extrapolated age of core PS2458-4 is 17.6 cal.ka. The basal dating of core PS51/118-3 is 10960 yrs BP (Bauch et al., 2001). Several intervals matching to certain changes in past environments can be distinguished.

The beginning of the late glacial-early deglacial period (~17.6-14.9 cal.ka) in core PS2458-4 is marked by sharp negative spikes in the $\delta^{18}O$ and $\delta^{13}C$ values of benthic foraminifers evidencing a water freshening event that ended around 17 ka. The whole interval is characterized by a very low total abundance of microfossils indicating cold-water conditions with heavy sea-ice cover and low food supply. This is also evident from biomarkers records (Fahl, Stein, 2012). A relatively strong subsurface inflow of cool ADW along the Laptev Sea continental slope is suggested by the occurrence of subpolar planktic foraminifers and a high relative abundance of the Atlantic-water indicating benthic foraminiferal species Cassidulina neoteretis.

The Bølling-Allerød warming (14.9-12.9 cal.ka) is characterized by an increasing abundance and diversity of all fossil groups giving evidence for an amelioration of environmental conditions. Biomarkers indicate reduced sea-ice cover and high productivity (Fahl, Stein, 2012). Warmer climate resulted in a growing fluvial influence as seen from a high representation of Elphidium clavatum, as well as a growing total organic carbon (TOC) content (Fahl, Stein, 2012). A strong inflow of chilled subsurface ADW is evidenced by the highest representation of C. neoteretis.

The Younger Dryas (YD) is represented in high temporal resolution in core PS2458-4. It starts with a freshwater event at 12.9-12.7 cal.ka, recorded as a sharp negative spike in the $\delta^{18}O$ of planktic foraminifers (Spielhagen et al., 2005). It is now found to be coincident with negative spikes in $\delta^{18}O$ and $\delta^{13}C$ of benthic foraminifers, a drastic reduction in the total abundance of all microfossils and formation of authigenic vivianite concretions. The latter two facts point to anaerobic conditions at the seafloor. All these features imply a strong freshwater input at the YD onset that produced water stratification and reduced bottom water ventilation. TOC concentrations, which in the Laptev Sea are largely related to the input of terrestrial organic matter with river runoff and coastal abrasion, are low and the recorded biomarkers point to a reduction of river runoff and an increase in sea-ice cover extent in response to the surface water freshening (Fahl, Stein, 2012). Therefore we assume that the inflowing freshwater was of glacial origin and probably related to the outburst of the North American Lake Agassiz to the Arctic Ocean at about 12.9 cal.ka (Murton et al., 2010). The freshwater input in combination with the discharge of multi-year ice to the North Atlantic reduced the inflow of ADW to the Arctic. In our record this is seen in the abrupt faunal change in the composition of microfossils after the freshening event, i.e., the sharp reduction in the percentage of C. neoteretis and the increase in the proportion of Arctic opportunistic species Cassidulina reniforme and E. clavatum.

A gradual environmental amelioration during the younger part of the YD is evident from the growing abundance and diversity of microfossils suggesting higher productivity and less sea ice. At 11.5-12.5 cal.ka the core site was located close to the summer sea-ice marginal zone with increased seasonal productivity as evidenced by the appearance of Nonion labradoricum.

The early Holocene (11.5-9 cal.ka) is characterized by surface water warming and diminished sea-ice cover as suggested by the most abundant and diverse microfossil assemblages at both sites. The seasonal sea-ice margin likely shifted northward. However, the overall environment at site PS51/118-3, as suggested by the predominance of E. clavatum and river-proximal species, was cold-water marine with a stratified water column due to a considerable fluvial input.

During the mid-late Holocene (<9 cal.ka) a drastic reduction in the total abundances of all microfossil groups is observed in core PS2458-4. Likewise, the sediment interval of core PS51/118-3 correlative in age to 7.4-8.2 cal.ka is barren of microfossils and has a particularly fine-grained composition. This might have been caused by an enhanced river runoff event that resulted in a growing sea-ice cover extent. In core PS2458-4 at approximately the same time a negative spike in the planktic δ18O record and the formation of authigenic vivianite concretions also suggest a freshwater input.

After 7.4 cal.ka a simultaneous increase in IRD and a considerable decrease in the total abundance of microfossils in both cores point to a cooling and larger sea-ice cover extension on the eastern Laptev Sea continental margin similar to the trend previously recorded in the west (Taldenkova et al., 2010).

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Sediment cores from inner UpernavikIsfjord: preliminary results

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During the past decades, the Greenland ice sheet has experienced a marked increase in mass loss resulting in an increased contribution of the Greenland ice sheet to global sea level rise. The three largest outlet glaciers in Greenland have increased their discharge, accelerated, thinned and retreated between 1996 and 2005: after 2005 they have slowed down again although not to previous levels. Geodetic observations suggest that the rapid increase in mass loss from the north-western part of the ice sheet occurred during 2005–2010 (Kjeldsen et al. 2013).

Warming of the subsurface water masses off Greenland may have triggered the acceleration of outlet glaciers from the Greenland ice sheet (Straneo & Heimbach, 2013). The North Atlantic subpolar gyre, which transports water to South-East and West Greenland via the warm Irminger Current, warmed in the mid-1990s. Increased inflow of warm subpolar waters likely led to increased submarine melting of those glacier fronts that terminate in fjords.

However, due to the lack of instrumental data beyond the past 20-30 years it is difficult to evaluate if this was an outstanding event or if it was part of a recurring phenomenon acting on inter-annual, interdecadal or centennial timescales. The main objective of this project is to extend the record of glacier variability and oceanographic changes beyond the past 20-30 years by analyzing marine sediment cores from the vicinity of the glacier complex terminating in UpernavikIsjord. These cores were collected during a cruise led by the Geological Survey of Denmark and Greenland in August 2013 and here we present some first results.

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Arctic Productivity and Orbital Climate Cycles

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Marine sediment records from central Arctic Ocean submarine ridges (Northwind, Mendeleev, Lomonosov) show a close relationship between orbital-scale climatic oscillations and microfaunal and geochemical proxies that reflects a long-term link between glacial history and marine biological productivity. Over the last 550 kiloannum (ka), glacial to interglacial cyclostratigraphy is observed in grain size, bulk density, color, mineral content, manganese concentrations, organic geochemistry, calcareous microfossil concentrations and foraminiferal $\delta^{18}O$ records. To understand the climate-cryosphere-productivity relationship, we reconstructed Arctic biological productivity from benthic foraminiferal and ostracode assemblages from 15 sediment cores using a stacking procedure that has been applied to construct a composite global deep-sea marine oxygen isotope stratigraphy. In addition, we reconstructed Arctic bottom water temperatures using Mg/Ca ratios in benthic ostracodes. Both the productivity and Mg/Ca data show the Arctic experienced a series of highly productive interglacials (MIS 5, 7e, 9e, 11e) and interstadials (MIS 3, 5a, 5c, 7a, 7c, 9c, and 11c) of roughly equal magnitude every ~20kyr. These periods signify minimal ice shelf and sea-ice cover and maximum marine productivity. Rapid transitions in productivity are seen during shifts from interglacial to glacial climate states. Discrepancies between the Arctic orbital cycles and global climate, sea-level and ice-volume curves are explained by abrupt growth and decay of Arctic ice shelves and asynchronous polar cryosphere behavior in the two hemispheres.

Variability of the northward flux of North Atlantic waters though Fram Strait during the Holocene

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The Holocene sediments of cores collected in the eastern Fram Strait (MSM5/5712-2: 78°55'N, 6°46'E), and the northwest and northeast of Svalbard (PS2863-1: 80°33.47'N, 10°18'E; S-2528: 80°41'N; 29°37'E) were analysed for their palynological content. Preliminary results indicate rich palynomorph assemblages characterized by high concentrations of dinocysts and relatively high species diversity, which permitted the reconstructions of sea-surface parameters such as summer temperature (SST) and salinity in addition to the seasonal extent of sea-ice cover. Comparison with similar data from other cores from the Nordic Seas then provided indications on the respective influence of low salinity meltwaters and the surface flow of North Atlantic waters (NAW) to the Arctic Ocean through the eastern Fram Strait. Major features observed at the 3 study sites include a notable increase in salinity during the early Holocene. In the eastern Fram Strait, maximum salinities are reached at ca 8.5 ka, pointing to high NAW-northward flow at the surface. However, salinity continued to increase until ~3 ka northeast of Svalbard, suggesting either dilution of NAW with meltwater and/or the subduction of the NAW mass North of Fram Strait until the late Holocene. Summer melt of Arctic sea ice inducing low surface salinity and strong stratification in northeast of Svalbard can be evoked. These new data also illustrate some regionalism in SST with long term cooling in eastern Fram Strait (see also ref. 1) during the Holocene, while the northeastern Svalbard core recorded a slight SST increase until about 3 ka, concomitantly with a sea ice cover decrease. Finally, during the late Holocene, after 3 ka, sea surface conditions with clustered values in SST, salinity and sea ice cover prevailed at the 3 sites, all indicating a cooling trend with possibly a lesser flux of NAW through the Fram Strait. This late Holocene decrease of the NAW flux towards the Arctic coincides with maximum production of Labrador Sea Water (ref. 2), thus indicating a correlative enhancement of westwards NAW branch in the North Atlantic.

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Applications of cavity ring-down spectroscopy to paleoclimate, including high-precision analysis of the triple oxygen isotopes in water and water vapor

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Over glacial and interglacial cycles, ice core records can provide important insight into past climate and atmospheric conditions. Traditionally, ice core isotope measurements have been made using Isotope Ratio Mass Spectrometry (IRMS), while over recent years performance improvements in laser-based absorption technologies, for example Cavity Ring-Down Spectroscopy (CRDS), have made this technology increasingly relevant to the paleoclimate community. Common ice core measurements include water isotope $\delta^{18}O$, $\delta^{2}H$ and the secondary parameter, deuterium excess (d-excess), along with gas bubble concentration measurements of CO_2 and CH_4. There is also increasing interest in high precision measurements of triple oxygen isotopes ($^{18}O/^{16}O$, $^{17}O/^{16}O$). ^{17}O-excess, defined as the anomaly in ^{17}O from the Global Meteoric Water Line (GMWL), is of particular interest to the paleoclimate community and atmospheric scientists that study the present day to understand past atmospheric dynamics, because it is sensitive to kinetic fractionation processes while being nearly invariant to temperature. As a result it provides a path to disentangling the competing effects of fractionation at the source region, during transport, and in the formation and deposition of precipitation. However, signals in ^{17}O-excess are small, typically requiring a precision of ~ 5 per meg (0.005 ‰). While $H_2{}^{17}O$ absorption has been measured before in commercial laser-based absorption instruments, the absorbance feature is small and influenced by the broad tail of the $H_2{}^{16}O$ spectrum. The resultant precision is inadequate for distinguishing samples from the GMWL, and therefore high precision ^{17}O-excess measurements have previously been obtained by the time-consuming process of converting H_2O to O_2 and then analysing the O_2 gas via dual-inlet IRMS. Here we show how innovations in CRDS now enable ^{17}O-excess measurements directly from water, with precision equivalent to IRMS. Recent experience has also demonstrated long-term reproducibility and accuracy on the VSMOW-SLAP scale. Finally, we will discuss how this level of ^{17}O-excess performance can apply to paleoclimate research.

Holocene modulations in the Earth's largest ice and freshwater pathway – the East Greenland Current

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Sea ice is a critical component of the Earth's climate system. An important aspect is the Arctic sea ice and freshwater exported through Fram Strait and transported towards the North Atlantic Oceanvia the East Greenland Current (EGC). Despite its importance, the long-term natural variability of theEast Greenland Ice(EGI) is not well established. Previous paleo research in this region has been fragmentary, often focused on isolated records.And while previous syntheses of the history of Arctic sea ice and climate provide a broad spatial overview, few records from the EGC pathway have been included; moreover the temporal emphasis of emerging new sea-ice syntheses ison broad time slice reconstructions.

There have been no comprehensive effortsfocused specifically on constraining and understanding changes in the EGI. This has been partly due to limited data records in the EGC pathway; however the increasing number of Holocene records recently developed for sea ice and ocean proxies along and within the vicinity of the EGC pathway nowopens up for an opportunity to more comprehensively identify changes and linkages in an important and exceptionally complex regional system.

Here we present the preliminary results of a data-synthesis research project focused on constraining and improved dynamical understanding of Holocene sub-centennial to millennial modulations in the EGC.In addition to constraining time-transgressive changes during earlier warm periods such as the Holocene Climatic Optimum (HCO), we investigate rapid changes such as the 8.2 ka cooling event, down streamindications (EGI) of suggested mid-Holocene hysterisis in the Arctic sea-iceand the subsequent neoglacial cooling in the late Holocene. Modulations within the last 1–2 k such as the Medieval Climate Anomaly (MCA), Little Ice Age (LIA) and Early Twentieth Century Warming (ETCW) are the focus of a companion presentation (Miles and Dylmer, PAST Gateways 2015).

These goalsare addressed through a targeted and integrated data synthesisof spatially dispersed and disparate (marine core, lacustrine core, ice core and other) paleo recordsfrom along or in proximity to the EGIpathway, i.e.,Fram Strait, Greenland Sea, around Iceland and along the shelves to the east and west of Greenland. These are comprised of existing and emerging records indicative of sea ice and ocean conditions based on multiple proxies. We compiled and evaluated detailed metadata on over ~180records, and based on multiple criteria have selected 25–30 records covering in most cases the full Holocene. These records provide the means to evaluate modulations in the EGC sea-ice cover during the Holocene,and to explore linkages toregional changes in ocean circulation.

Late Weichselian and deglacial ice sheet configurations and dynamics inferred from submarine landforms and sediment cores in north-eastern Svalbard

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During the Last Glacial Maximum (LGM), the Barents Sea was covered by a grounded marine-based ice sheet. The glacial landforms on the seafloor of the Barents Sea have been studied at its southern and western parts (Andreassen et al. 2008, Winsborrow et al. 2010, Ottesen et al. 2007), whereas the ice sheet configuration and dynamics of eastern Svalbard are less well-known, mainly due to more persistent sea ice cover. Recent work has suggested a northward flowing ice stream in the Kvitøya Through whereas in the throughs south of Nordaustlandet an overall eastwards ice flow direction has been documented (Dowdeswell et al. 2010).

In this study, marine geophysical data and sediment cores collected in 2011 during a cruise on the research vessel Helmer Hanssen have been used to study the glacial history of eastern Svalbard (Fig. 1a). The multibeam data cover a relatively small transect across the eastern part of Erik Erikssen Strait (Fig. 1b).

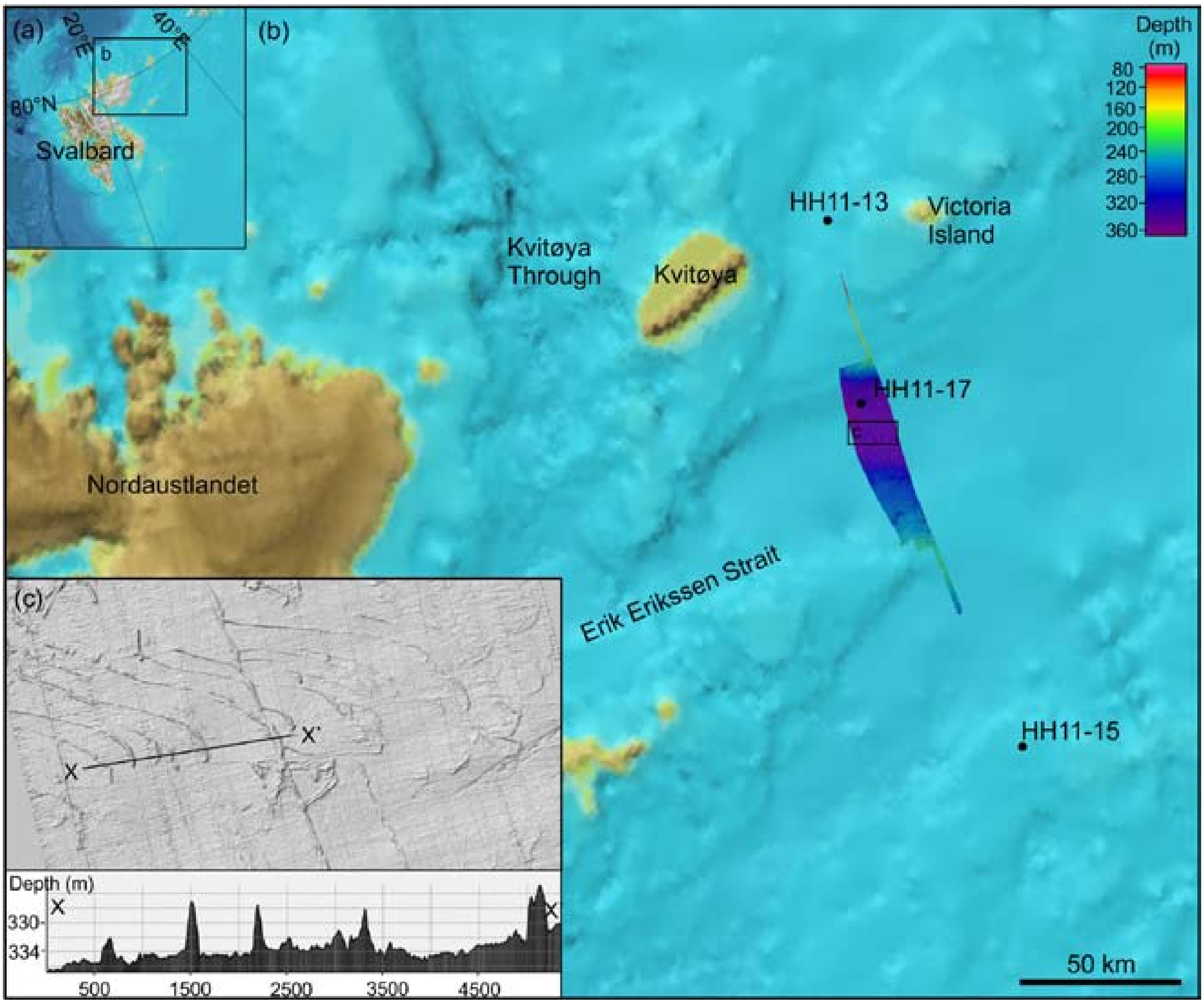

Fig. 1. (a) Location of the study area. (b) Coverage of the multibeam data and the location of the three sediment cores. Color scale applies for the small area studied in this work. Background map is from IBCAO, version 3.0 (Jakobsson et al., 2012). (c) A zoom in on the arcuate recessional moraine ridges together with a bathymetric cross-profile of the ridges.

The submarine landforms in Erik Erikssen Strait can be divided into three groups indicative of (1) subglacial, (2) ice-marginal and (3) deglacial environments. The first group consists of streamlined landforms, such as glacial lineations and mega-scale glacial lineations. The ice-marginal landform assemblage consists of ice-flow transverse recessional moraine ridges and unique, semi-regularly spaced moraine ridges (Fig. 1c). These, in plan form arcuate ridges, have been interpreted to form near the grounding line of a rapidly retreating marine based ice sheet, probably in an ice stream setting. The ridges are connected to a long, straight ice flow-transverse ridge. The shape, semi-regular spacing and symmetrical profile indicate that the ridges might have formed through sediment squeeze into basal crevasses, similar to the formation of crevasse squeeze ridges in surging glacier settings. The deglacial landform assemblage consists of several generations of cross-cutting iceberg ploughmarks reaching down to 335 m below the present sea level. In the southern part of the data set, a large multikeeled iceberg has excavated a 6 km long and up to 20 m deep scour.
The streamlined bedforms record two different ice flow directions in the study area, with a primary flow direction towards the E and a secondary (less distinct) flow direction toward SE or NW. The timing of these ice flow events is unknown, but most likely they represent two different late Weichselian ice flow events, which could be explained by migration of the ice divide or by the switching on and off of different ice streams.

The three sediment cores recovered approximately 2 m of marine mud each. The sediments featured laminations or sand layers/lenses in the lower halves of the cores, whereas the upper halves were composed of relatively uniform marine mud. Samples of benthic foraminifera and shells from the sandy sediments at the base of the cores HH11-17 and HH11-15 give ages of 30 and 46 ka cal BP, respectively. These old ages probably indicate the presence of older reworked sediments in the basal parts of the cores.

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Ice stream dynamics and its implications on the sedimentary processes on the continental shelf edge and slope north of Nordaustlandet, Svalbard

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The configuration and dynamics of former Svalbard-Barents Sea Ice Sheet (SBIS) have been investigated on the outermost continental shelf and slope offshore Northern Nordaustlandet, Svalbard (Fig. 1a-b).

Various types of glacial landforms were distinguished in the swath-bathymetric data, such as different types of iceberg ploughmarks and gully-channel systems (Fig. 1c).

The iceberg ploughmarks have varying dimensions, orientations and cross-cutting relationships, and are typically present across the entire outer shelf down to a modern water depth of 360 m. They are normally several kilometres long, 40-150 m wide and 1-20 m deep (Fig. 1c). In the northern Kvitøya trough, ploughmarks up to 2.4 km long, 110-200 m wide and 12-25 m deep were observed in multibeam data. These iceberg ploughmarks were most likely formed by the grounding of icebergs produced through extensive calving during the retreat of the SBIS across the northern Svalbard shelf. This infers that calving played a significant role in the regional deglaciation of northern Svalbard margin in the Late Weichselian.

A set of ploughmarks was also recorded just off the shelf edge in the central study area in water depths of 450-560 m (Fig. 1c, box 1). These ploughmarks are 3-4 km long, 120-200 m wide and 2.5-10 m deep. They are curvi-linear and mostly parallel to each other with a NE-SW orientation. These ploughmarks have been generated by a grounding of large, multi-keeled icebergs or several icebergs frozen into sea ice and drifting in concert (sikusak). The icebergs most likely originated from large glaciers farther east (Fig. 1c, box 1).

The set of ploughmarks with the largest dimensions was recorded in the water depth of 360-600 m in the westernmost part of the study area (Fig. 1c). The individual ploughmarks in this set are linear to curvi-linear with long axis orientation of SW-NE. The dimensions of the ploughmarks vary from 20000×1200×90 m to 14000×400×20 (length-width-depth). This set of ploughmarks is a part of the same set described by Dowdeswell et al., (2010) where they also interpreted the source of the icebergs to Franz Victoria and St. Anna ice streams.

Two sets of V-shaped gullies have been distinguished between 840 and 2900 m depth on the continental slope (Fig. 1c). The westerly set of gullies is the larger one. Its total width covers 30 km but extends beyond the limits of the study area. The spacing between the gullies varies from 3000 to 7000 m. The depth of the individual gullies varies from 150 to 500 m. These gullies merge down-slope and form large channel system (Fig. 1c). Stronger multibeam backscatter returns from the bottoms of the gully-channel systems compared to the surrounding area suggest that they could be currently active sediment transport paths from the shelf, across the slope to the abyssal plain resulting in the formation of coarse sediment lag there. This process was probably even more active during the glacial when the ice sheets extended to the shelf edge.

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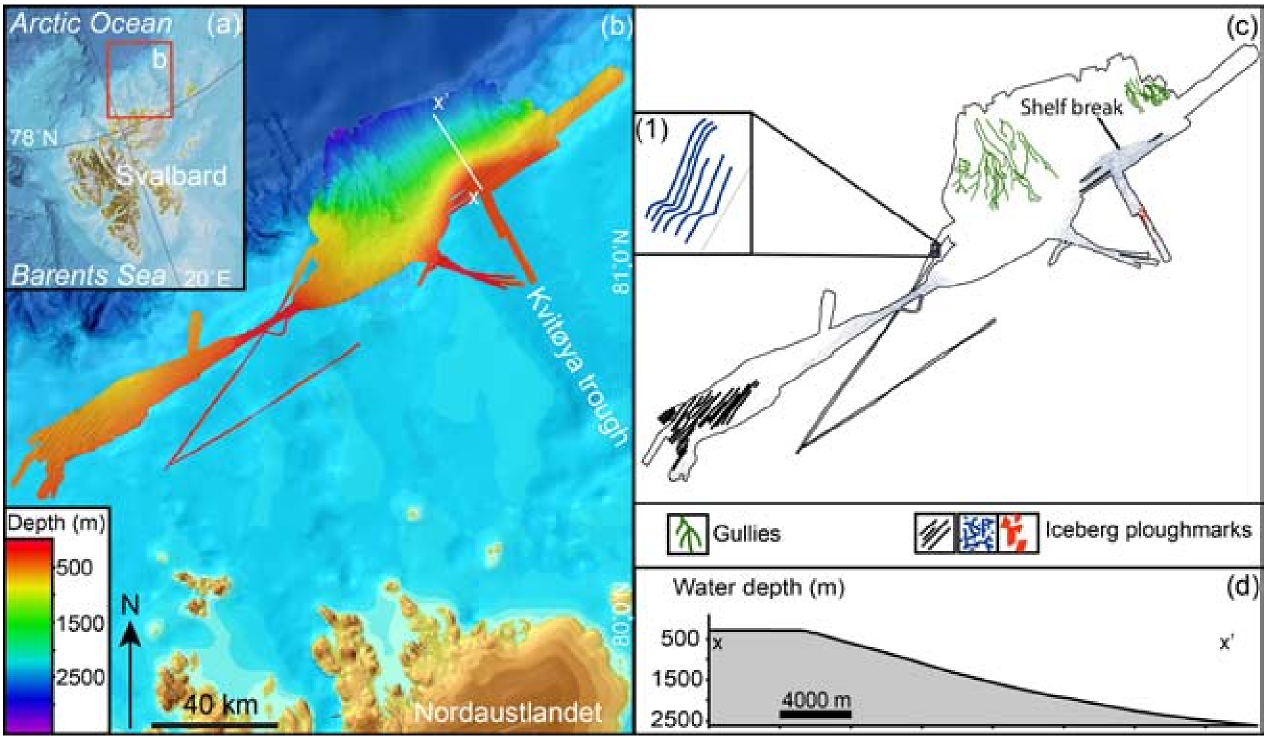

Figure 1. Location of study area north of Nordaustlandet, Svalbard (a). (b) Bathymetry of the study area covering part of the outer shelf and the continental slope north of Nordaustlandet. (c) Interpretation of the landforms distinguished in the study area. The blue colored ploughmarks are the most common type which generally is present on the outer shelf down to a modern water depth of 360 m. The relatively large ploughmarks in the northern Kvitøya trough are marked by the red color. Inset (1) shows the iceberg ploughmarks at 450-560 m depth. The black colored set of ploughmarks in the westernmost part of the study area is a continuation of the ploughmark set described by Dowdeswell et al., 2010. (d) Bathymetric profile of the continental slope across the central part of the Kvitøya TMF between the two prominent sets of gullies.

Ice wedge polygon development on different temporal and spatial scales in the northern Yukon, Canada

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Ice wedge polygons (IWP) are amongst the most typical permafrost phenomena in Arctic lowlands. Within the northern hemisphere, IWP are thought to occupy between 250,000 km² (Minke et al., 2007) and 2,600,000 km² (Mackay 1972) of the tundra and boreal forest, which accounts for 3 to 31% of the arctic land mass including glaciated regions. Besides the wide spatial distribution, IWP have stored large quantities of organic carbon and nitrogen on geological timescales and are therefore regarded as greenhouse gas sinks. Continuous organic matter accumulation and preservation due to syngenetic permafrost aggradation make arctic polygon mires an excellent climate and environmental archive.

Here we present the results of a multidisciplinary palaeoenvironmental study on IWP in the northern Yukon, Canada. High-resolution laboratory analyses were carried on a permafrost core together with the overlying active layer (233 cm length) which was drilled in 2012. Based on 14 AMS radiocarbon dates spanning the last 5,000 years, we report high-resolution ground ice stratigraphy, stable water isotopes ($\delta^{18}O$, δD), sedimentary data including grain size distribution and biogeochemical parameters (OC, N, C/N ratio, $\delta^{13}C$), as well as pollen and diatom assemblages. This is accompanied by high-resolution remote sensing data based on airborne LIDAR and on underground investigations using electrical resistivity tomography in different resolutions.

The studied low-centered IWP indicates that the whole IWP field was established after a shallow lake had drained at about 3200 cal BP. The diatom assemblage in the lower part of the sedimentary record is dominated by planktonic and pioneer species and by those preferring alkaline conditions. Ice-wedge cracking in water-saturated sediments started immediately after lake drainage and led to the formation of a polygon mire. Downward closed-system freezing of the talik is indicated by continuously decreasing $\delta^{18}O$ (δD) values, a $\delta^{18}O/\delta D$-regression-slope below the Global Meteoric Water Line and a negative relationship between δD and D excess.

On the one hand, pollen assemblages in lake sediments have captured a regional signal of vegetation composition and climate. On the other hand, we assume that after lake drainage the pollen record represents a very local signal as it is dominated by the local plant communities growing in the IWP. Therefore, we suggest that the ability to infer regional climate information on temperature and precipitation is good for lake sediments but weak for the overlying peat record. This is indicated by a sudden dominance of Cyperaceae pollen after the transition from lake sediments into terrestrial peat of the IWP.

Other IWP along the mainland coast of the Yukon suggest a high temporal diversity in polygon mire origin and behavior. IWP beyond the late Wisconsin glacial limit are mostly high-centered with strong signs of degradation. Coastal cliff exposures with deeply thawed ice wedge surfaces and secondary or even tertiary IW generations support this view. Ice wedge casts dating back until 8,400 cal BP (Fritz et al., 2012) indicate previous periods of ice wedge degradation and meltout. Intermediate forms of IWP (neither low-centered nor high-centered) dominate the mainland coast of the Yukon on the rolling ground moraines. Glacial outwash plains at the former glacial border host mostly low-centered IWP. On Herschel Island, we find many generations of IW and corresponding sedimentary records in the centers although IWP are not as frequent on the high-relief endmoraine, which is Herschel Island, than on the relatively flat mainland coast of the Yukon. Holocene IWP have mostly a surficial expression whereas the older late Wisconsin/Pleistocene/glacial IWP are often buried under a 0.7 to 1.5 m thick sediment cover. Higher than modern summer air temperatures, presumable during the Holocene thermal maximum, caused deeper thaw and led to a truncation of late Wisconsin/Pleistocene/glacial IW. This suggests that remote-sensing based estimations of arctic-wide IWP coverage will give conservative numbers as buried IWP systems will remain invisible.

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Late Holocene environmental ice core record from Akademii Nauk ice cap (Severnaya Zemlya)

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Ice cores are established as archives for environmental changes since many years. On Severnaya Zemlya, the easternmost archipelago with considerable glaciation in the Eurasian Arctic, a 724 m long ice core has been drilled on Akademii Nauk the largest ice cap there. Stable water isotope and major ions concentrations in this ice core are presented (e.g. Fritzsche et al., 2005, Opel et al., 2013). They represent more than 3000 years of regional climate and environmental history. A well-known depth-age relationship is necessary for a paleoclimate interpretation of the data. In a first approach the dating was performed by counting of annual cycles of stable isotopes well-preserved in the core even though overprinted by the effect of percolating melt water from summer surface melting. The depth-age scale produced by counting has been matched to volcanic eruption events with well-known ages detectable in the sulphate record of the core. This approach has some disadvantages due to the fact that the pattern of stratospheric volcanic events recorded in well-dated ice cores from Greenland and Antarctica is influenced by rather regional tropospheric eruptions as in our case probably in Iceland and Kamchatka, partly less precisely dated. The depth-age relationship has therefore to be proofed by an independent method. The isotope ^{10}Be is produced by cosmic radiation in the Earth's atmosphere. Its residence time there is about one year, shorter than it is for ^{14}C, for which reason variability of ^{10}Be in archives like glaciers is much higher compared to ^{14}C. The production rate of both radionuclides is depending on the solar activity. Their concentrations were used for the reconstruction of heliomagnetic variations in the past and can be vice versa used for dating of ice cores. Today, accelerator mass spectrometry (AMS) allows measurements of ^{10}Be in ice cores. Its concentration is depending on the geomagnetic coordinates of the location of its production, transport and deposition mechanisms, accumulation rates etc. Therefore, local differences in ^{10}Be concentrations are observed (Berggren et al., 2009). Here, we present ^{10}Be concentrations measured by the team of DREsden AMS (DREAMS) (Akhmadaliev et al., 2013) in discrete Akademii Nauk ice core samples of about 300 g. Our ^{10}Be record shows its general potential to validate our depth-age model matching the 10Be concentration pattern to that of Greenlandic ice cores as well as ^{14}C production reconstruction.

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Geochronologic challenges related to spatial and temporal discontinuities of sediments in permafrost environments: the case of Bol'shoy Lyakhovsky, Siberian Arctic

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Ice-bearing Quaternary deposits in permafrost environments comprise valuable archives of paleoenvironmental and palaeo-landscape dynamics over several glacial-interglacial cycles (e.g. Andreev et al., 2011). Information on past conditions manifest in the mineralogical, organic and ice inventories. Precipitation and surface run-off control the formation of ground ice that characterise sediments in permafrost environments, while air temperatures govern to which depth the deposits freeze or thaw. Hence, the preservation or degradation of distinct stratigraphic units depends basically on (a) climatic conditions during formation, (b) their decoupling from the active layer depth and (c) past relief conditions. This means that sequences of stratigraphic units deliver not necessarily a continuous record of changing climate and additionally, vary laterally due to differing but synchronous process regimes.

The discontinuous records preserve information on specific paleo-conditions as a series of individual sediment units. Especially unit contacts provide valuable evidences on the changes in landscape dynamics or, in case of distinct boundaries, non-sedimentation or even erosional periods. Such potential hiati complicate the stratigraphic interpretation of paleo-environmental proxies that primarily allow the distinction of climatic conditions and hence, only provide relative information on timing. Apart from discontinuities, it is the permafrost thaw (thermokarst) that promotes degradation processes as an additional challenge for lateral stratigraphic correlations. Melting ground ice induces surface subsidence during warmer interstadial and interglacial periods. Resulting basins and valleys within older deposits create new accumulation areas, while underlying sediments transformed or were (partly) consumed. This complicates stratigraphic interpretations and highlights the need of numeric age control to confirm or refine chrono-stratigraphic relations of similar sediments or consecutive sediment units on regional scale.

With this contribution, we discuss the challenges for establishing late Quaternary geochronologies of arctic permafrost sequences using the example of Bol'shoy Lyakhovsky Island (New Siberian Archipelago). The island exposes sequences at its southern coast that are among the oldest dated Quaternary terrestrial permafrost deposits (e.g. Andreev et

Figure 1: Exposures representing the main stratigraphic units west (section A and B) and east (section C and D) of the Zimov'e River at the southern coast of Bol'shoy Lyakhovsky Island.

al., 2004; Schirrmeister et al., 2002; Fig. 1). Various proxies for paleo environmental reconstruction unravel at several generations of cold- and warm-stage permafrost accumulation and degradation since about 200 ka. However, the stratigraphic context is ambiguous due to the vertical discontinuity and lateral differences in geocryological characteristics, especially for units older than the MIS 3 Interstadial. For example, a sediment unit locally named as Kuchchugui Suite records stadial conditions attributed to floodplain sedimentation during of the MIS 4 and/or the MIS 6. West of the Zimov'e River mouth (section A and B in Fig. 1, overview of dating results in Fig. 2) the unit lies above the interstadial Yukagir Ice Complex (MIS7a, Th/U age of ~200 ka; Schirrmeister et al., 2002); and below the extensive Yedoma Ice Complex (MIS3, ^{14}C ages of >55 ka to 22 ka BP; Wetterich et al., 2004, 2011). AMS radiocarbon ages of this Kuchchugui Suite yield >53 ka to 42 ka BP and IRSL dates 57 - 77 ka (e.g. Andreev et al., 2004). Together with the Zimov'e strata as the coarse-grained lower boundary underlying the Kuchchugui (IRSL age of ~130 ka; Andreev et al., 2004), the Kuchchugui itself may be associated to the MIS4. In contrast, the lithostratigraphic context differs east of the Zimov'e River (section C and D in Fig. 1 and 2). Towards the Vankina River mouth, a Kuchchugui-like floodplain deposit suggests to predate the Eemian Interglacial because of its stratigraphic position below the Buchchagy Ice Complex that was dated by $^{230}Th/U$ to 130-80 ka (unpublished data). The characteristic limnic deposits attributed to a Last Interglacial lake stage show overlapping IRSL ages of 90 – 120 ka (Andreev et al., 2004). These lake deposits are exposed in both sections, east and west of the Zimov'e River, while no equivalents of the Buchchugui Ice Complex could be found west of the Zimov'e River. The missing stratigraphic contact of the Kuchchugui above (in agreement to IRSL ages west of the Zimov'e River) or below (in agreement to stratigraphy below the Buchchagy Ice Complex east of the Zimov'e River) the lake deposits limit interpretations of stratigraphic positions or reliability of dating results.

Despite inherent discrepancies when comparing results from different dating methods based on different physics and zero event, one central problem is that dating methods are generally not well established on frozen material and refer to differing permafrost components. Here, we cannot give the ultimate answer, but rather aim to highlight and discuss the advantages and drawbacks of the different dating techniques applied in our study area, including AMS radiocarbon, luminescence and radioisotope $^{230}Th/U$ methods.

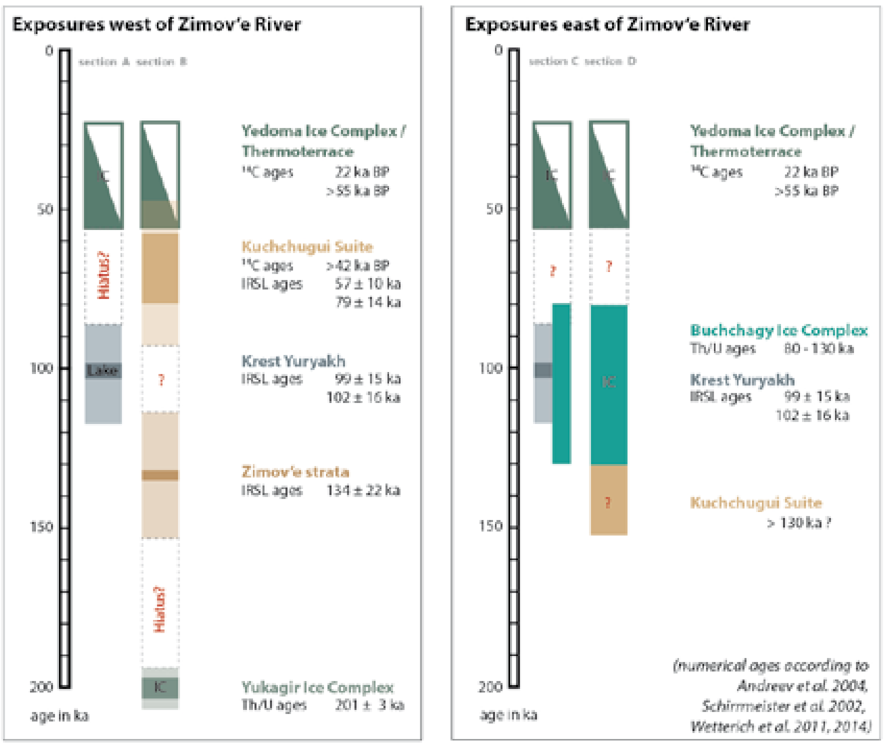

Figure 2: Summary of dating results for the main stratigraphic units west and east of the Zimov'e River at the southern coast of Bol'shoy Lyakhovsky Island.

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A Younger Dryas glacier readvance/retreat on Greenland's north coast, and notes on the ice sheet's response to YD cooling/warming

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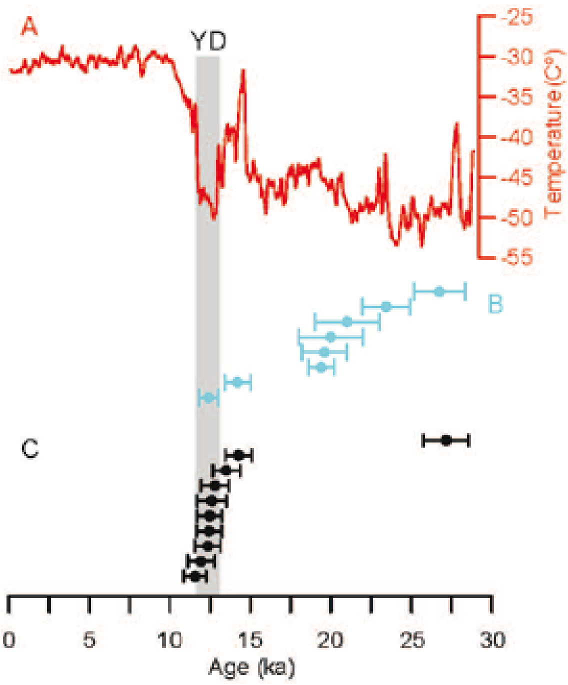
On Greenland's northernmost coast, facing the Arctic Ocean, large terminal moraines block the mouths of all major valleys leading to the coast, showing that there was a readvance of glaciers from the North Greenland ice cap shortly after LGM. Here we present a new set of 10 10Be exposure dates on erratic boulders and cobbles from terminal moraines in three neighboring valleys along a 50 km stretch of the coast. The average of the ages for each of the three moraines from west to east are 12.8±0.6, 12.1 ±0.7, and 12.8±0.7 kaBP, all centered within the Younger Dryas (YD, 12.8-11.7 kaBP). Since boulders on a moraine may take some time to settle, shielding is a potential source of error, and the ages should be considered as minimum. Before the moraines were formed the valleys were occupied by glaciolacustrine lakes, and 8 OSL dates from the lacustrine sediments show a spread, from 12.4 to c. 30 kaBP. The duration of the lakes is a few thousand years, and the large spread must be caused by incomplete bleaching of the sediment grains during rapid sedimentation. These ages are therefore maximum for the deposition of the sediments, with the youngest age - 12.4±0.6 ka BP - as the most reliable. Therefore, in combination the two data sets therefore indicates that the moraines most likely were formed and abandoned during YD.

Nowhere is the YD climate oscillation seen more clearly than in the ice cores from the top of the Greenland Ice Sheet. Here O18, Deuterium, and N15, give a detailed record from the rather slow cooling-start to the abrupt warming-end, accompanied by reduction and then rapid increase in precipitation - in some periods with a resolution down to annual changes. How did these changes translate into ice margin behavior along the ice sheet's perimeter? This knowledge would be of importance for putting the ice sheet's response to ongoing rapid warming in perspective. In many areas, both east and west, the ice margin was on the shelf, and oscillations of the margin are difficult to study. However, in recent years records straddling YD, or a part of it, have been reported from several locations both in east and west Greenland. The evidence comprises moraines on land, coring and seismic investigations in fjords, and marine cores, and dated by exposure dating and C14. Surprisingly, in most of the investigated areas there is no sign of advance or stagnation, but of retreat. This is also indicated by high amounts of meltwater and land-derived detritus in marine cores adjacent to the shelf. A major exception to this is the East Greenland Fjord Zone where glaciers advanced in the fjords, probably along a 800 km stretch of coast. The advance may have begun before YD and ended some time after. The ex-



planation for the ice margin behavior has generally been sought in changes in the Atlantic Meridional Overturning Circulation (AMOC), bringing warm subsurface water in contact with the ice margins, and overruling the atmospheric cooling especially in the south and west, while in the east AMOC reduction resulted in prolonged sea ice cover and higher seasonality – and glacier readvance. However, in our area at the coast of the Arctic Ocean sea ice has been pervasive throughout, and there is no evidence for increased precipitation during YD. We therefore, in agreement with recent studies on the ice cores, suggest that this remote area is far removed from the "North Atlantic fingerprint", which influenced the ice margins to the south, and the North Greenland advance/retreat during YD was simply a result of the temperatures. It should also be noted that the ice cap covering the North Greenland mountain range was a local ice cap without dynamic connection to the ice sheet, and therefore may have responded more directly to temperature change. These results further substantiate that the relation between the large scale regional climate record from the ice cores and what went on at the ice margins is not straightforward, and may not be so in the future.

Fjord-head delta progradation and permafrost aggradation interpreted from a 60 m frozen sediment core, Adventdalen, Svalbard

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Adventdalen is a glacial and periglacial-modified valley located within the continuous permafrost zone in central Spitsbergen. Extensive previous permafrost research from this environment makes it an ideal location for further studies of permafrost and landscape development since the last glacial maximum (LGM).

A reconstruction of antecedent environmental conditions in Adventdalen has been developed using cryostratigraphic, chronological, and sedimentary evidence from a 60 m frozen sediment core in combination with existing knowledge regarding sea-level variations and glacial history. The core was retrieved in September 2012 as part of the UNIS CO2 Lab summer drilling programme at the Adventdalen well park at (9 m.a.s.l., 78°12'N, 15°49'E). Encompassing the interval between the terrain surface and Cretaceous bedrock, Carolinefjellet Fm., at ca. 60 m depth, this core forms the basis for the first comprehensive description of Holocene permafrost and sedimentary development in Adventdalen.

The presence of cryostructures in the core allows for the determination of the nature of permafrost aggradation and conditions under which the sediment accumulated. Three main cryostructures have been identified in the Adventdalen permafrost core: pore ice, layered ice, and ice lenses. The distribution of these ice types in combination with the dating results indicates that permafrost aggradation at this site began ca. 4 ka – once the ground was exposed subaerially. In addition to cryostratigraphy, detailed sediment analysis has resulted in a facies model, permitting inference of changes in depositional environments. To establish high resolution temporal variations in sedimentation rates 42 samples were selected for dating. Optically stimulated luminescence (OSL) was the primary method used; however, a few samples were selected for 14C AMS dating to obtain a complete chronostratigraphy, from intervals where OSL dating was not possible.

Presently, the lower areas of the Adventdalen valley are dominated by a wide braided river plain, which drains into the Adventfjord. Since the LGM this river system and its associated delta has prograded ca. 10 km from the head of Adventdalen to its present position. Core sedimentology and chronology indicates that during the LGM, a fast-moving ice stream, located in Adventdalen, removed all unconsolidated sediments, leaving only a 1 m thick layer of till. Following deglaciation, marine conditions dominated during the early Holocene during which time mud was deposited from suspension. This quiescent interval was infrequently punctuated by the deposition of sediments from hyperpycnal flows and ice-rafted debris. The transitioning to delta-driven sedimentation occurred at ca. 5 ka, during which time a high sedimentation rate of ca. 40 m/ka is reconstructed. This interval is characterized by a general upwards coarsening and thickening of beds and a concurrent reduction in bioturbation intensity and trace fossil diversity. Establishment of modern, aeolian dominated sedimentation took place ca. 4 ka ago, and coincides with the onset of conditions favorable to permafrost aggradation at the coring site. This conclusion suggests that permafrost in the lower valley bottoms throughout Svalbard is likely a Late Holocene phenomenon.

Model of the late glacial Svalbard Ice Sheet using a coupled approximation of the full Stokes method

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Previous attempts to model paleo-ice sheets have been hampered due to the long time scales that they persist for, and inadequacies in accurately capturing their dynamics (Kirchner et al., 2011). In order to overcome the complexity of ice dynamics over these time scales, paleo-ice sheets have generally been modelled using a simplification of the equations of stress, known as the shallow ice approximation (SIA). This approximation works well in areas with small longitudinal stresses, but do not accurately capture the true nature of ice sheets at domes, ice streams and margins (Ahlkrona et al., 2013a,b). In order to determine the true dynamics of an ice sheet, the complete equations of stress, known as full Stokes, must be solved. However, this is computationally expensive, and can only be applied at centennial time scales for full ice sheets.

In this presentation, we show the initial results of a new approach to modelling ice sheets using a coupled approximation of the full Stokes method. It is applied to a late glacial configuration of the Svalbard-Barents Sea Ice Sheet, when the ice sheet was restricted to the Svalbard archipelago and surrounding areas. This method automatically partitions the ice sheet into areas where full Stokes is necessary to capture proper ice sheet dynamics, and areas where the SIA is sufficiently accurate (see Alkrona et al., 2015). The results of the simulation capture the expected dynamics of the ice sheet, including location of paleo-ice streams and the direction of flow. In these areas, the SIA is inadequate, and produces velocity values that are too high, and ice flow directions that do not match geomorphic indicators. In areas closer to the centre of the ice sheet, the SIA is sufficiently accurate to characterise the dynamics. The results of this method match geological constraints on ice flow, and is computationally cheap enough to run at centennial to millennial year time scales.

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Late Pleistocene and Holocene ice-rich permafrost in the Colville River valley, northern Alaska

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Ice-rich permafrost is wide-spread in Arctic lowlands and foothills, including northern Alaska. A unique type of permafrost, the ice-rich, late Pleistocene syngenetic yedoma permafrost associated with a Mammoth-Steppe environment, is found across the Beringian Arctic and Subarctic (Schirrmeister et al., 2013). Similar deposits have been described for northern Alaska in a loess belt along the northern foothills of the Brooks Range (Carter, 1988; Kanievsky et al., 2011). Yedoma deposits are emerging as a valuable terrestrial paleo-environmental archive for the late Pleistocene in unglaciated high latitudes. Cataloguing the extent and nature of ice-rich yedoma will help constraining our paleo-environmental understanding of the Beringian region. Further, these deposits rich in soil organic carbon are a key player in the global carbon cycle. They sequestered organic matter for several ten thousand years and thaw during warm periods such as the early Holocene resulted in rapid partial release of this carbon to the atmosphere as methane and carbon dioxide. Hence, data on the current distribution and characteristics of yedoma will improve our paleo-environmental picture of the Mammoth-Steppe ecosystem, enhance assessments of the vulnerability of deep permafrost carbon, and improve studies focusing on impacts of thawing permafrost on climate change.

Here, we report on cryostratigraphical, lithological, geochemical (stable isotopes of ground ice), and geochronological characteristics from six perma-

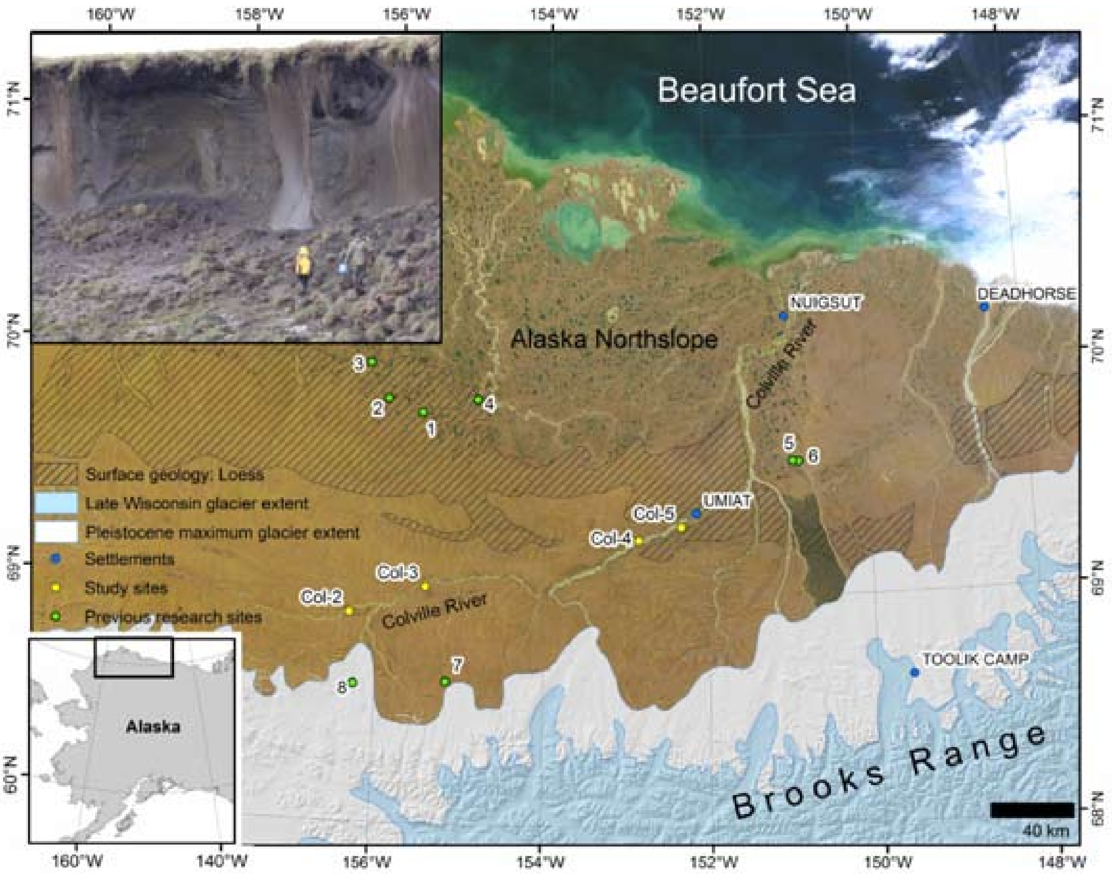

Fig. 1: Location of permafrost sites covered in this study (yellow dots, COL-sites) and sites of previous research (green dots) in the foothill region of northern Alaska.

frost exposures formed in thaw slumps and on river bluffs that were sampled along the Colville and Titaluk rivers (Fig. 1). In two exposures we found only Holocene deposits, while in three large exposures thick (>10m) yedoma deposits were encountered. Our radiocarbon-based geochronology indicates that the yedoma deposits at the largest exposure (COL-5, Fig. 1) formed at least since the mid-Wisconsin (ca. 36 ka). The studied section on the Titaluk River ("Carter Section") contains yedoma and fluvial deposits with ages up to 40 ka. The yedoma deposits are discordantly covered by Holocene peat-rich deposits in pockets, representing shallow local thermokarst structures. These deposits were then again refrozen as indicated by ice wedges up to the base of the modern active layer. The late Pleistocene and Holocene lithologies are dominated by silty grain-size fractions, but underlying deposits either contain an increasing fraction of pebbles and boulders. This is likely associated with paleo-fluvial deposits (COL-5, Fig. 1). In another exposure, unrounded stones likely are associated with the presence of a weathering crust above bedrock (COL-4, Fig. 1). At the site COL-2 (Fig. 1) deep permafrost thaw, possibly during the early Holocene development of the Colville floodplain, is indicated by the presence of ice-wedge casts filled with peaty deposits. Stable isotope analyses of wedge ice show strong geochemical differences between Holocene and late Pleistocene ice wedges. Late Pleistocene ice wedges have a significantly depleted δD values down to -244.5 ‰, while Holocene ice wedges reach up to -161 ‰. $\delta^{18}O$ values range from -19.8 to -30.4 ‰ for Holocene and late Pleistocene wedge ice, respectively.

Landscape-scale analysis of the depth of thermokarst features (lakes and basins) based on high resolution digital elevation data suggests a widespread distribution of thick, ice-rich yedoma deposits in the study region and allows refining coverage maps beyond the currently suggested extent of the loess belt. Our findings, in combination with studies of other investigators in the area, suggest that yedoma, deposited throughout the mid- and late- Wisconsin, was widespread in the northeastern part of Beringia despite nearby glaciation. The glaciation to the south (Brooks Range), east (Laurentide ice sheet) and north (Arctic ocean or Beaufort Sea shelf ice) likely created a highly continental cold climate for this narrow, unglaciated region of Alaska's North Slope with intense periglacial weathering and transport processes, but nevertheless provided a sufficient base for a thriving Mammoth Steppe ecosystem (Mann et al., 2013).

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The Batagay mega thaw slump, Yana Uplands, Yakutia, Russia: permafrost thaw dynamics on decadal time scale

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Ice-rich permafrost that formed in glacial periods of the Quaternary is highly vulnerable to thaw under ongoing climate change and anthropogenic disturbance. Permafrost degradation processes such as thermokarst, thermo-denudation and thermo-erosion are actively shaping modern periglacial landscapes.
Retrogressive thaw slumps – also referred to as thermo-cirques – represent a highly dynamic geomorphologic feature in ice-rich permafrost regions. These rapidly forming landforms consist of a steep headwall surrounding a gently inclined slump floor where sediment erosion and accumulation takes place simulatenously and develop as a result of rapid permafrost thaw over several decades. Thaw slumps are commonly found in permafrost areas with near-surface, thick ground-ice layers that are susceptible

to thermo-denudation and subsequent mass displacement through cryogenic landslides (Leibman et al., 2008). Thaw slumps are particularly frequent along riverbanks and coastlines in the Northwest American and West Siberian Arctic, where they are typically initiated by lateral erosion of the bluff toe. In these regions, buried glacier ice (massive ground ice) bodies or ice-rich glacial till have been mapped. Given their exceptional size of up to 40 ha in area and 25 m high headwalls, so-called mega slumps in northwestern Canada represent primary terrain destabilization features with different environmental settings than surrounding areas (Lantuit et al., 2012), but are a significant source for sediment and solute delivery to adjacent lakes and streams (Kokelj et al., 2013). However, in East Siberia, retrogressive thaw slumps have been described in the syngenetic Late Pleistocene Ice Complex (Yedoma) permafrost deposits, where massive ice wedges and segregated intrasedimentary ice results in total volumetric ice contents of up to 80-90%. Such retrogressive thaw slumps in syngenetic permafrost were investigated for example on the coastal area of the Dmitry Laptev Strait (Are et al., 2005). However, Yedoma deposits are also found on slopes of the Verkhoyan Mountain Range (Slagoda, 1991) and in valleys of surrounding foothills (Grosse et al., 2007) beyond the Yedoma main distributional range in the coastal lowlands of the Laptev and East Siberian seas.

The Batagay mega slump is at least two times larger than any previously described thaw slump, has been discovered near the village of Batagay, and has been the subject of some recent cryostratigraphical analysis (Kunitsky et al 2013). It exposes a profile of Yedoma deposits, reaching a thickness of 7 to 22 m in that area (Slagoda, 1991) and underlying ice-rich periglacial alluvial sand deposits of around 60 m thickness (Kunitsky et al., 2013). The observed rapid development of thermo-denudation at rates of up to 15 m per year, poses the question of whether the larger portions of the entire region between the Verkhoyan and Cherskiy mountain ranges may be more vulnerable to deep and rapid thaw following disturbances such as forest fires or forest clearance. Using a set of historical remote sensing data, Kunitsky et al. (2013) suggest that depression-like structures on the Kirgillyakh-Khatyngnakhskoy Mountain saddle begin in the early 1970s. The initial disturbance causing rapid thermo-denudational development of the Batagay mega thaw slump started at the end of the 1980s.

Here we present data from a remote sensing investigation of the mega slump (. in order to assess the planimetric dimensions and its recent expansion rates. We acquired very high resolution satellite imagery from QuickBird, IKONOS, KOMPSAT-2, WorldView-1 and WorldView-2, spanning a timeframe from 2006 to 2014. Aerotriangulation of the entire dataset was performed to ensure consistent co-registration between images. In addition, for terrain correction through ortho-rectification and for volumetric analyses of the entire mega slump, we derived an accurate digital elevation model (DEM) with 2m ground resolution from along and across track WorldView stereo imagery. The height difference between the headwall and the outflow of the slump into the Batagay river is 145 m along a distance of 2300m, while the slump maximum width is 800 m. Our analysis doesn't show any signs of erosion slowdown along a headwall that is up to 86 m high. Comparison of the DEM with a reconstructed paleo-surface revealed that the slump has carved into the rolling topography to a depth of up to 73 m. The current size of the Batagay mega slump is >81 ha, while it had thawed >24.2 × 106 m³ of ice-rich permafrost through 2014. This huge amount of sediment released from the slump episodically dams up the Batagay river, forming a large temporary lake which then may discharge catastrophically. Geological on-site investigations and further geomorphometric analyses of this locality in conjunction with inter-annual and seasonal change detection observations will allow relating headwall retreat rates to local and regional controls on mega slump development and will help to identify potential areas susceptible to megaslump formation in non-glaciated regions.

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The western Laptev Sea: High-resolution sea ice distribution and river run-off variability from post-glacial to present.

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Here, we provide a high-resolution reconstruction of sea-ice cover variations in the western Laptev Sea, a crucial area in terms of sea-ice production in the Arctic Ocean and a region characterized by huge river discharge. Furthermore, the shallow Laptev Sea was strongly influenced by the post-glacial sea-level rise that should also be reflected in the sedimentary records.

The sea Ice Proxy IP25 (Highly-branched mono-isoprenoid produced by sea-ice algae; Belt et al., 2007) was measured in two sediment cores from the western Laptev Sea (PS51/154, PS51/159) that offer a high-resolution composite record over the last 18 ka. In addition, sterols are applied as indicator for marine productivity (brassicasterol, dinosterol) and input of terrigenous organic matter by river discharge into the ocean (campesterol, ß-sitosterol).

The sea-ice cover varies distinctly during the whole time period and shows a general increase in the Late Holocene. A maximum in IP25 concentration can be found during the Younger Dryas. This sharp increase can be observed in the whole circumarctic realm (Chukchi Sea, Bering Sea, Fram Strait and Laptev Sea). Interestingly, there is no correlation between elevated numbers of ice-rafted debris (IRD) interpreted as local ice-cap expansions (Taldenkova et al., 2010), and sea ice cover distribution. The transgression and flooding of the shelf sea that occurred over the last 16 ka in this region, is reflected by decreasing terrigenous (riverine) input, reflected in the strong decrease in sterol (ß-sitosterol and campesterol) concentrations.

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Deglaciation of the last Scandinavian-Barents Ice Sheet and variations in the Atlantic water inflow into the Barents Sea

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Herein we present a series of five time-slice reconstructions of the deglaciation of the Scandinavian-Barents ice sheets from the Last Glacial Maximum to the early Holocene. The reconstructions are based on our own and published data mostly from the northern and western parts of the Barents Sea but also from the deeps and coasts of Baltic Sea. They include the intervals ~17-15, ~ 14, ~ 12-11.7, ~ 11.4-11.1 and ~10.5-10.3 cal ka BP which have better coverage by our and published data than other intervals of deglaciation. A special emphasis in our study is focused on the connections between the Barents and Baltic seas, on one hand, and the North Atlantic, on the other hand, during the deglaciation, in particular to changes in the intensity of Atlantic water inflow along the Eurasian continental margin and into the Barents Sea troughs. To get a robust chronology only the data on AMS-14C dated cores have been used. We applied the following main paleoproxies: (1) occurrence of glaciomarine sediments in the cores as an indicator of the ice-sheet retreat from their locations, (2) high IRD (>100 microns) content and angular shape of lithic grains as a signature of iceberg rafting, (3) high abundance of benthic foraminiferal species Cassidulina teretis as a proxy of enhanced subsurface-to-bottom Atlantic water inflow into the

Barents Sea troughs and depressions, (4) high sea-surface temperatures as indications of increased Atlantic water input in the surface layer. In addition, high-resolution seismic, isotopic, geochemical and other data have been considered where available. The considerable inflow of the Atlantic water along the Eurasian continental margin, at the depth ~300-600m, is inferred at the end of early deglaciation, i.e. at Heinrich event (H-1), when the Atlantic meridional overturning is generally supposed to be weak. The major part of the Barents Sea basin was still covered by the ice sheets, whereas several isolated ice lakes at the southern periphery of the retreating Scandinavian Ice sheet have finally united to form the Baltic Ice Lake. The input of the subsurface Atlantic water into the western and northern Barents Sea troughs had significantly intensify the ice sheet decay. The Bølling-Allerød interstadial (14.6-12.9 cal ka BP) was characterized by a more vigorous Atlantic meridional overturning circulation and a corresponding increase in Atlantic water inflow into the Barents Sea which is well documented in benthic fossil assemblages from the Erik Eriksen and Franz Victoria troughs, and as well from the Ingøydjupet Depression. The Baltic Ice Lake remained a dammed-up isolated basin during the deglaciation, until 11.7 cal ka BP, when its level dropped and the water drained into the North Sea. At Preboreal, 11.7-10.7 cal ka BP, the lake was replaced by a brackish Yoldia Sea which had a limited connection with the North Sea through the Närke Strait. In the Barents Sea, the next increase in Atlantic water input into the shelf depressions occurred at the end of Younger Dryas and Preboreal along with the extensive sea-ice cover on the surface. The iceberg rafting was over by Preboreal in the Eric Eriksen Trough, and somewhat later, in the early Holocene, in the Franz Victoria Trough. The strongest Atlantic water inflow in subsurface and bottom layers was characteristic of the early Holocene, from11.3 to 9 cal ka BP. The Yoldia Sea became a dammed lake again during the next Ancylus stage (~10.7-8 cal ka BP) which was over at the end of deglaciation with a formation of the brackish Littorina Sea. The latter, in turn, was connected to the North Sea via the Danish Straits. Thus, our reconstructions demonstrate the temporal variability of the Atlantic water inflow along the margin of retreating ice sheets and of the Baltic Sea link to the ocean during the deglaciation. We also suggest changes in the thickness of the Atlantic water layer within the water column. The study is supported by the Russian Science Foundation project 14-50-00095 and OSL project 15-08.

Onland deglaciation and provenance changes in SW Barents Sea sediments over the Late Glacial - Holocene

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Three shallow sediment cores located in Nordkappbanken, South-western Barents Sea have been studied for sediment components to reconstruct behaviour of the ice sheets around the Barents Sea region in relationship with the sediment provenance changes over the Late Glacial - Holocene time. These sediments consist typically of glaciomarine sediments and diamictons overlain by a thin layer of Holocene sediments. The marine sediment components including clay and heavy minerals can be seen as reliable recorders for source area environmental conditions, providing valuable information for reconstructions of past ice sheet dynamics in high latitudes.

We studied variations in terrigeneous input, including clay minerals distribution, geochemical composition of heavy minerals and occurrence of ice-rafted debris (IRD) to obtain critical information on distribution, transport, pathways and sources of the Barents Sea sediments which are still relatively sparsely known. The Barents Sea region can be seen as the confluence area between the Scandinavian (SIS) and Barents Sea (BSIS) ice sheets thus the onset of deglaciation and the following development can be evaluated by determining the sediment provenance changes and prevailed transport agents along time.

Sedimentary analysis includes main clay minerals content by X-ray diffraction, IRD counting from X-ray radiographs and source rocks indicative heavy minerals compositions obtained by Electron Probe Microanalyzer (EPMA). This analysis could provide integrated information over time for climate fluctuation during deglaciation including the Younger Dryas cooling and the following Holocene warming. Furthermore, this integrated study could elucidate the components of sea-ice and iceberg drafting in sediment transport and was the melting of the SIS and its streaming much involved in this.

Preliminary results show variations in content of clay minerals in sediments. The Barents Sea sources of kaolinite are referred to Franz Josef Land sedimentary rocks and paleosols, possible some submarine rocks outcropping on the sea floor1,2 or to a lesser extent the Fennoscandian Shield weathering crusts. This can be supported by the characteristic lithologies of IRD and heavy mineral contents. Suggested provenances for specifically garnet minerals could be those high-grade granulite belts of the northern part of the Fennoscandian Shield.

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Climate controlled variability of an Arctic sea ice fabric

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Deep water formation in the Arctic-Atlantic gateway (AAG) is supported by high-salinity water (brine) rejection due to high sea ice production in coastal polynyas. The sinking of cold saline water caused by high sea ice production in Arctic coastal polynyas maintains the cold halocline layer in the Arctic Ocean and thus contributes to the global conveyor belt. The Storfjorden polynya in southern Spitsbergen is regarded as an important sea ice factory, however, its role in the formation of North Atlantic Deep Water (NADW) during the present interglacial (Holocene) is not yet fully understood. Here, we show that sea ice coverage in the Storfjorden has varied over the last 6500 year. Frequent periods of sea ice melting and freezing in the polynya illustrated by high sediment entrainment, surface water productivity and enrichment of terrigenous-derived organic matter between 6.5 and 3.5 ka has stimulated frequent episodes of deep water renewal. A gradual decline in sediment freezing process coincides with more permanent sea ice coverage after 3.5 ka. Overflow of brines were reduced during this interval, which timely corroborate a gradual change/slow down of northward advection of deep waters off the Svalbard coast and the Nordic Seas. During the same time, a southward shift of the marginal ice zone (MIZ) is recorded in the Fram Strait. The factory restarted at the end of the Little Ice Age (LIA).

Mid to Late Holocene evolution of sea ice distribution and primary production on the East Greenland Shelf and the NW Fram Strait

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Over the last decades, the extent and thickness of Arctic sea ice has changed dramatically and much more rapidly than predicted by climate models. Based on this alarming observation, the reconstruction of natural variability of past sea-ice cover and its forcing became a major focus of international scientific research. Here, we present a high-resolution biomarker approach over the last 4 ka from the East Greenland Shelf to investigate the interrelationship between sea-ice cover, meltwater/freshwater discharge and primary productivity. The phytoplankton-derived sea-ice proxy IP25 (Belt et al., 2007) points to a late Holocene cooling trend initiated around 1.5 ka which is interrupted by a period of reduced sea-ice cover centred around 1 ka. The latter might be related to the well known Medieval Warm Period. Our new results from the East Greenland Shelf will be compared with similar records from the Fram Strait area published by Müller et al., (2012). These data give information about differences and/or similarities of sea-ice variability and changes in productivity in the area influenced by the cold East Greenland Current and the warm Westspitsbergen Current, respectively. First data suggest a time lag of the Neoglacial cooling between western (Greenland side) and eastern (Westspitsbergen-side) of Fram Strait, as also proposed by Müller et al. (2012).

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Late Quaternary central Arctic Ocean sea-ice variability: First results from biomarker studies of RV Polarstern Cruise PS87 sediment cores

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One of the main characteristics of the Arctic Ocean is the sea-ice cover. With its strong impact on the Arctic's heat balance, it influences not only its direct environment but plays a crucial role in the entire climate system. Regarding the dramatic retreat of Arctic sea-ice during the last decades, it becomes even more important to get a precise knowledge of past sea-ice variability. During RV Polarstern cruise PS87, several sediment cores were taken along the Lomonosov Ridge in the central Arctic Ocean. Here, we present preliminary results of biomarker measurements on three of these cores (PS87/023-1, PS87/030-1, PS87/079-1). For sea-ice reconstructions, we used the ice-algae-derived sea-ice proxy IP25 (Belt et al., 2007), in combination with other biomarkers indicative for phytoplankton/open-water conditions (cf., Müller et al., 2009, 2011). The absence of IP25 and dominantly very low to zero concentrations of phytoplankton biomarkers throughout the studied intervals of the cores gives hint to a more or less permanent ice cover in the central Arctic for at least the past 450 kyr. These results will later be compared with similar records from sediment cores from northern Fram Strait/northern Svalbard continental margin, an area characterized by seasonal ice cover, to be taken during RV Polarstern cruise PS93.1 in summer 2015. These new biomarker records will provide a more detailed insight into the late Quaternary Arctic sea-ice variability.

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Pleistocene - Holocene terrestrial palaeoenvironmental changes at the New Siberian Islands and adjacent areas (Arctic Siberia)

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Compilation and synthesis of all received palaeoecological information and facts will be recognized the changes of terrestrial ecosystem and revelation of time lags of the palaeoenvironmental changes of the different Laptev Sea areas. Several years we were focused on the study of indicators of terrestrial palaeoenvironmental conditions as a higher accuracy of marks of the changing terrestrial environmental conditions. The investigations carried out since 1998 in the frames of the Russian-German Cooperation “System Laptev Sea”.
In general, the taxonomic composition of the mammal bone collection is rather typical for the “Mammoth fauna” of North-east Siberia. Woolly mammoth, horse, reindeer and bison dominate. But different localities have different species distribution that can be explain as differentiation in paleoenvironmental conditions and different genesis of deposits.
Mammal’s collection from the New Siberian Islands contains more than 1200 bones. A total of 115 14C dates were obtained from bone collagen. The largest number of dated bones from Bolshoy Lyakhovsky Island falls within the period between 44 and 32 ka BP, predominantly between 44 and 20 ka BP with no large temporal gaps. It was the period of the favourable environmental conditions (Andreev et al, 2004). At the other New Siberian islands (Kotelny, Belkovsky and Maly Lyakhovsky Isl.) the period between 31 and 20 ka BP contains the largest part of the dated bones and could be favourable for the habitation of the large animals of “Mammoth fauna”. At the locations of the north part of Kotelny Island were find horse’s bones of Holocene radiocarbon age (ca 4.7 ka BP, 3.0 ka BP and 2.8 ka BP). It indicates that paleoenvironmental conditions were suitable for horses during the Late Holocene on the New Siberian Islands.
Mammal’s collection from the south coast of the Dmitry Laptev Strait (Oyagoss Yar) contains more than 2000 bones. Number of bone’s date isn’t much (near 20 14C dates), but they indicate period between 42 and 22 ka BP. Horse’s remains are numerous in the deposits from 35 to 25 ka BP. Probably it was the period of the favourable environmental conditions for horse. Unique find in 2009 year of woolly mammoth mummy of ca 34 ka BP (Boeskorov et al., 2014) confirm our assumption.
Differentiation in periods of largest number of dated mammal bones of “Mammoth fauna” could be explain the changings of the sedimentary conditions near 30 ka BP at the New Siberian Islands and south coast of the Dmitry Laptev Strait. During the period ca 30 - 16 ka BP the sea level decrease down to 100 m. It was the cause of the modification of the base level of erosion. Rivers and ravine systems started penetration to the ancient sediments (Tumskoy, 2012; Konishchev, 2013). Diversity of the periods of favorable paleoenvironmental conditions on Bolshoy Lyakhovsky Island, other New Siberian Islands and Oyagoss Yar indicates the differentiation of geological situations and genesis deposits also.
Horse carcass (ca 4.6 ka BP) from Oyagoss Yar (Boeskorov et al, 2014) makes it clear that paleoenvironmental conditions of Holocene were close at the New Siberian Islands and Laptev Sea coast. The Holocene dates for the horses from Arctic Siberia clearly show that the Pleistocene horse survived in North-East Siberia until approximately 2000 years BP (Lazarev, 1980; Kuznetsova et al, 2001) and the new find represents additional proof of this interesting phenomenon.

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A number of several warmer spells noted on eastern Svalbard during Younger Dryas - a bidecadal resolution of paleoceanographic record of Atlantic Water variability

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The Younger Dryas (YD; c. 12,800-11,500 cal yr BP) was a major climatic event during the transition from the last glacial period into the present Holocene interglacial, characterized by a rapid and short-term temperature decrease. YD event was likely driven by the weakened North Atlantic Meridional Overturning Circulation, a result of the Lake Agassiz outburst or the interaction between the sea ice and thermohaline water circulation leading to a reduction of Atlantic Water transport to the north and a dominance of fresher Arctic Water.
The multi-proxy data from a high-resolution marine sediment record retrieved 100 km east of the mouth of Storfjordrenna (southern Svalbard) show that the heavier δ18O values recorded, e.g., 12,720 cal yr BP and 12,100 cal yr BP, correlate with reduced to absent IRD fluxes, whereas the peaks of lighter δ18O, e.g., 12,450 cal yr BP, 12,150 cal yr BP, and 11,780 cal yr BP, occurred synchronously with significant enhanced IRD fluxes. The lack of IRD, occasionally for several decades, might reflect temporary polar conditions characterised by the formation of perennial pack ice in Storfjorden that locked icebergs proximal to their calving fronts and prevented their movement over the coring site. Contradictory, periods of accelerated AW inflow (e.g. 12,450 cal yr BP, 12,150 cal yr BP, and 11,780 cal yr BP) resulted in massive iceberg rafting and delivery of IRD to Storfjordrenna, thus reflecting more sub-polar conditions. Our records show that Younger Dryas was not uniformly cold and that at least a number of warmer spells occurred on eastern Svalbard.

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Paleogeographical investigations along the Yukon Coast

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The Yukon Coastal Plain is located at the northwesternmost LGM interface between Beringia and the Laurentide ice sheet. The presence of the ice sheet during the Late Pleistocene led to considerable variations in climate and in sea level, but also created favorable conditions for the occurrence of large bodies of what is now ground ice in the permafrost.
In this presentation, we summarize the results from investigations conducted on permafrost exposures, lake sediments, modern vegetation and surficial sediments using sedimentological, biogeochemical, isotopic and palynological methods to reconstruct both the late Pleistocene and the Holocene history of the area. We highlight the issues associated with assessing the origin of ground ice and the need for reconstructing the paleo-history using a methodologically holistic approach.

Modelling the response of two neighbouring Svalbard ice streams to similar climate forcing

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Calving from fast flowing ice streams allow significant loss of ice from ice sheet interiors, with stream dynamics providing a major control on the overall ice sheet configuration. They are also susceptible to non-linear responses to climate, as their stability is partially controlled by subglacial topography. Destabilisation of ice streams can therefore lead to rapid deglaciation, and result in significant sea level rise. Establishing whether these systems responded synchronously or asynchronously to rapid climate change, and how lagged their responses are, is therefore of considerable importance to determining how contemporary ice sheets may respond to future climate change. Investigating the dynamics of former ice streams provides invaluable insight into this.

In this study, we therefore seek to evaluate the impact of rapid climate change following the last glacial maximum on two neighbouring Svalbard ice streams (Kongsfjorden and Isfjorden) using a one-dimensional flowline model. In doing so, we aim to establish the level of synchronicity/asynchronicity of their response to the similar climate forcing they will have experienced. A novel approach to the modelling is taken, which aims to account for the inability of both geochronology/geomorphology and numerical modelling to independently provide definitive ice dynamic reconstructions in and of themselves. Model boundary conditions are defined using contemporary topography and geomorphological evidence of fast flow, and is driven by palaeoclimate data with the isostatic response through time prescribed for.

Geomorphological reconstruction of the dynamics of a SW Greenland tidewater glacier through the Holocene

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Calving from marine terminating glaciers represents a significant ice loss mechanism from ice sheets, currently accounting for 50% and 99% of Greenland and Antarctic ablation respectively. To have confidence in numerical models that aim to simulate centennial to millennial timescale ice sheet dynamics (both past and future), they need to be validated against real-world reconstructions made over similar periods.

For the majority of Greenlandic tidewater glaciers, their Little Ice Age (LIA) readvance has destroyed geomorphological and sedimentological evidence for their fluctuations through much of the Holocene. This limits the utility of these glaciers for investigating their millennial timescale dynamics. The Godthåbsfjord region, centred on Kangiata Nunaata Sermia, SW Greenland provides a rare exception to this, in that an extensive pre-LIA geomorphological record is preserved, alongside a high likelihood of sedimentological evidence for both glacier retreat and advance over the last ~8000 years.

Here, I present preliminary mapping of the pre-LIA geomorphology, alongside a plan for fieldwork that will be conducted in summer 2015, and how this will be integrated into numerical model investigations.

Past landscape and permafrost dynamics in Arctic Alaska based on sedimentary records

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Permafrost-related processes are key ecosystem drivers in the Arctic system and often an indicator for long-term environmental change. Understanding past periods of permafrost degradation and aggradation is crucial to estimate future response of the terrestrial Arctic to climate change.

We collected sediment cores from one thermokarst lake and two drained thermokarst lake basins from the northern Seward Peninsula and the Teshekpuk Lake region (Alaska) to gain insights into past landscape dynamics since the late Pleistocene in these continuous permafrost regions. We applied a multiproxy approach on sediment cores using methods of micropaleontology (ostracods, rhizopods), sedimentology (grain size analyzes, magnetic susceptibility), biogeochemistry (TN, TC, TOC, $\delta^{13}C$), as well as geochronology (AMS radiocarbon dating, tephrochronology).

The environmental evolution of the three study sites coversdifferent temporal scales. Preliminary radiocarbon dating results of three short cores (core ID P_1, P_2 and P_3) from a thermokarst lake North of Teshekpuk Lake revealed mid- to lateHolocene ages with numerous age reversals in spite of well-layered lake sediments. A core-based study (core ID Kit-43) of thermokarst lake sediments on northern Seward Peninsula yieldeda radiocarbon chronology in agreement with stratigraphic sequences; with its base dated to the Last Glacial Maximum at 22,800cal a BP. The third core (core ID Kit-64) from a drained lake basin in the same study region was dated to the Early to Mid-Wisconsin and will be discussed in detail. As observed in aerial and satellite images, GG basin on the northern Seward Peninsula drained in Spring 2005 (Figure 1, Lenz et al., accepted). The corerecovered in spring 2009 has preserved the permafrost re-aggradation after lake drainage with frozen sediment from the lake sediment surface down to a depth of 266 cm (Figure 2). Below 266 cm the unfrozen talik was still existent. The sedimentary record yielded prevailing terrestrial conditions prior to 45,000 a BP. Fine grained, cryoturbated, organic-rich Yedoma deposits indicated harsh and cold climate conditions in central Beringia during the Early to Mid-Wisconsin. An intermediate peaty layer with hydrophilic rhizopods signaled wet conditions by about 44,500 to 41,500 a BP. This potentialinitial thermokarst development was interrupted by deposition of a 1-m-thick layer of tephra which could be associated with the South Kil-

Figure 1:
Infrared aerial image before the drainage (1978, June 25th) and Quickbird satellite image after the drainage of GG basin (2005, August 9th).

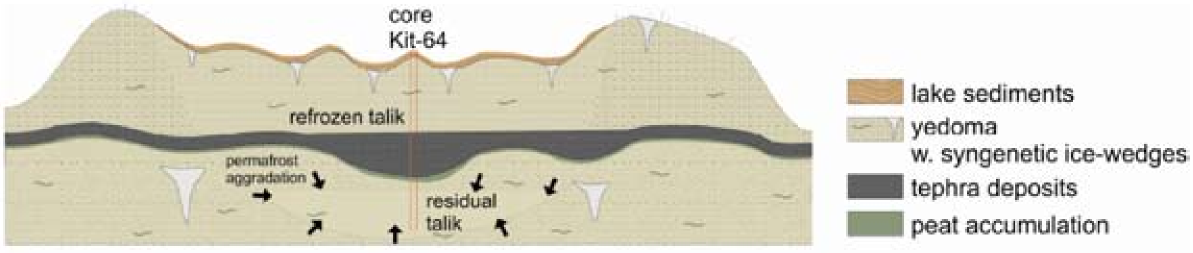

Figure 2:
Cross section of GG basin as derived from analyzed sediment core Kit-64

leak Maar eruption by about 42,000 a BP.The wetland did not re-initiate after the tephra fall-out but terrestrial Yedoma deposition dominated the late Mid-Wisconsin. A sedimentary hiatus was dated to 23,000 to 300 a BP. Here,either a lack of deposition occurred between the Late Wisconsin until the late Holocene or thermokarst-related erosion may have dominated at the study site. In the latter case, theYedoma upland of the modern GG basin has served as sediment source and Late Wisconsin deposits were eroded. The lake forming GG basin evidently initiated about 300 a BP as indicated by distinct lamination,freshwater ostracods (e.g. Fabaeformiscandinaprotzi) and hydrophilic rhizopods (e.g. Cyclopyxiskahli).

Our investigation demonstrates that lake development in the permafrost-affected terrestrial Arctic can be triggered but also interrupted by global climate change (e.g. syngenetic permafrost formation during the Early to LateWisconsin, rapid warming and wetting in the early Holocene), regional environmental dynamics (e.g. nearby volcanic eruptions and tephra deposition) or local disturbance processes (e.g. lake drainage). The present study emphasizes not only that permafrost formation as well as degradation in central Beringia was influenced by processes of local to global scale but also highlights that Arctic lake systems and periglacial landscapes are highly dynamic.

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Present and past flow regime on contourite drifts west of Spitsbergen: preliminary results from Eurofleet 2 PREPARED cruise (June 2014)

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Eurofleets-2 PREPARED cruise was conducted during June 5–15, 2014 on board the Norwegian R/V G.O. Sars to investigate the present and past oceanographic flow regime and patterns around two contourite drifts located in the eastern side of the Fram Strait (south-western margin of Spitsbergen). To achieve the main objective of the project, a full range of time scaled measurements was planned, from instantaneous (CTD) and seasonal (moorings) oceanographic measurements, to the recent (Box corer) and geologic (Calypso core) past record. The successful cruise recovered about 2780 km of underway measurements (hull-mounted ADCP and thermosalinograph); 60 CTD sites along 5 main transects; 22 sites for water sampling at different depths for biogeochemical characterization of water masses; 13 meso-zooplankton samplings carried out by vertical hauls (WP2 net) and 20 by horizontal hauls (Manta net) for the study of the present biological productivity of the area; about 120 km of site

survey including high-resolution multibeam map and sub-bottom profiles for the identification of current-related structures; 5 Box cores; and 2 Calypso piston cores 19.67 and 17.37 m long with an excellent sediment recovery up to 92%. In addition, 3 moorings were deployed for seasonal measurements of water currents direction and velocity, water mass temperature and salinity and to determine the annual amount of local sediment input.
Preliminary onboard analyses outlined the presence of a cold-oxygenated and low salinity water mass moving in the deep northern part of the Storfjorden Trough under the effect of the Corilis force and tide configuration considerably affecting the velocity and bottom distribution of the cold water mass. The long Calypso cores contain the record of the past 20 ka with an exceptionally expanded Holocene sequence (over 5 m-thick) that will allow us to obtain very-high resolution palaeoceanographic and palaeoenvironmental reconstructions in the area.

Evidence of the deep marine record of the MWP-1a on the NW-Barents Sea continental margin: Support from palaeomagnetic data

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The sedimentary record of the deglaciation phase following the last glacial maximum in the Storfjorden-Kveithola Through Mouth Fans (NW Barents Sea), was sampled with 10 piston and gravity cores during the SVAIS and EGLACOM cruises. Three cores collected on the upper continental slope contain a thick (up to 4.5 m) late Pleistocene sequence of finely laminated, fine-grained sediments interbedded with thin sandy layers derived from extensive release of sub-glacial meltwater (Plumites) occurred during the ice-sheet retreat.
Radiocarbon ages obtained at the base and top of this stratigraphic interval revealed deposition occurred during less than 2 centuries at around 15 ky BP, with a very high sedimentation rate exceeding 3 cm y-1. The Plumites appear laterally continuous over the continental margin representing a major event at least at regional scale. We present new insights from palaeomagnetic and rock magnetic analyses that confirm the presence of a prominent, unique event and support to the conclusion made by former studies that assigned such deposit to the deep marine record of the MWP-1a (Lucchi et al., 2013).

Ice Stream Dynamics during Deglaciation of the Laurentide Ice Sheet

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Ice streams rapidly drain large sectors of ice sheet interiors. At present, they account for approximately 50% and 90% of the mass loss from Greenland and Antarctica, respectively, but there are concerns over recent increases in ice discharge. This has been linked to atmospheric and oceanic warming, but the longer-term implications for ice sheet deglaciation are less clear. A key question is whether the activity of ice streams is predictably linked to climate-driven ice sheet mass balance, or whether their activity might accelerate deglaciation. To explore this, we analyse ice streaming during deglaciation of the Laurentide Ice Sheet (LIS) from ~18 to ~7 ka. Following a recent mapping inventory, we bracket the timing of >100 ice streams using existing ice margin chronologies. At the Last Glacial Maximum (LGM), ice streams formed a drainage network similar to modern ice sheets. Numerous ice streams were located in topographic troughs and likely operated for thousands of years from the LGM. These drained the marine-based sectors of the northern and eastern margins of the ice sheet until ~11 ka and show a degree of spatial self-organisation. Other ice streams operated over much shorter timescales and switched on and off, perhaps active for as little as a few hundred years. These include large ice streams that switched positions over sedimentary bedrock at the western and southern terrestrial margins. As the LIS retreated onto its low-relief and predominantly crystalline bedrock interior (after ~11 ka), a smaller number of large ice streams operated that were very wide (50-100 km), and have no modern analogue. Overall, the number of ice streams decreased during deglaciation and they represented a small proportion of the ice sheet circumference. We use simple scaling relationships, based on a data-set of modern Antarctic and Greenland ice stream dimensions and velocities, to estimate the mass loss delivered by ice streams. Our estimated total flux from ice streams is relatively stable until 13 ka and drops rapidly thereafter. We therefore find no evidence for major ice sheet instabilities linked to ice stream activity and conclude that deglaciation was largely driven by surface melt.

Biomarker records from the eastern continental margin off Kamchatka Peninsula and Eastern Siberia on deglacial variations in sea surface temperature, air temperature, provenance and terrestrial residence times of terrigenous organic matter in Beringia

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During the last glacial termination atmospheric carbon dioxide (CO2atm) rose about 100 ppm and atmospheric radiocarbon activity (Δ14C) concurrently dropped by about ca. 400 ‰. Global warming likely triggered large-scale thawing of permafrost soils in the northern hemisphere resulting in release of 14C-depleted carbon which may have contributed to the changes in CO2atm and Δ14C1. However, the timing and duration of the thawing as well as regional differences regarding these points are poorly understood. In order to unravel the evolution of permafrost decomposition and its role within the glacial-interglacial climate change a profound understanding of the deglacial carbon-turnover and temperature development in subarctic and arctic regions are of great importance.
Working with two sediment cores from the continental margin off Kamchatka Peninsula, western Bering Sea (WBS, site SO201-2-114KL) & Northwest Pacific (NW Pacific, site SO201-2-12KL, compare Fig. 1) we establish Glacial to Holocene records in sea surface temperature (SST) and mean air tem-

perature (MAT) using the TEXL86 (SST) and CBT/MBT (MAT) temperature proxies that are based on marine and terrigenous biomarkers (Glycerol dialkyl glycerol tetraethers). The hydrogen isotopic composition (δD) of plant-wax derived lipid biomarkers (long-chain n-alkanes and long-chain n-fatty acids) is another tool for reconstructing air temperature but can also provide information of the provenance of terrigenous organic matter (OM). The radiocarbon activity of the lipid biomarkers is applied to reconstruct changes in terrestrial residence times of terrigenous OM.

Our records in SST and CBT/MBT-based MAT are interpreted as summer temperatures. From the Bølling/Allerød interstadial (B/A) to the present they show temperature fluctuations similar to Greenland ice core records including a warming at the onset of the B/A and a cooling during the Younger Dryas (YD) followed by a warming into the Preboreal (PB) suggesting an atmospheric coupling between N-Atlantic and N-Pacific, East Siberian/Kamchatka temperature development. However, during Heinrich Stadial 1 (HS1) where WBS SST and Kamchatka MAT cool down synchronously with Greenland temperatures, the NW-Pacific SST rises gradually and seems to be decoupled from the N-Atlantic. Since the gradual warming trend and the subsequent synchronization with Greenland ice core data during B/A is known from SST records from the Gulf of Alaska2 (GOA) surface conditions in the NW Pacific likely are controlled by the Alaskan Stream overprinting the atmospheric effect and the influence of the East Kamchatka Current. Asynchronous development of our TEXL86 record and the GOA records during the Holocene indicate that the AS weakenes over the deglaciation. For the time-span of the Last Glacial Maximum to the onset of the B/A interstadial, the CBT/MBT temperature proxy may be seasonally biased as it produces improbably high summer temperatures that level Holocene conditions.

In contrast to the CBT/MBT-based temperatures the δD of n-fatty acids does not show clear stadial-interstadial fluctuations and remains on a stable level during the deglaciation instead. During the Holocene, δD increases progressively, which may have resulted from a gradual warming trend. Comparing the radiocarbon activity of the n-fatty acids to the Δ14C-signature of the atmosphere at the time of deposition the dimension of the terrestrial residence time prior to the deposition (ΔΔ14C) can be estimated. High ΔΔ14C values during deglaciation indicate that the plat-wax biomarkers are strongly pre-aged which may bias the δD-temperature record. Gradually decreasing ΔΔ14C imply declining terrestrial residence times from late glacial to late Holocene and argue for major changes in the relative contribution of weakly and strongly pre-aged OM. Possible sources for strongly pre-aged OM include permafrost decomposition and the congruent mobilization of 14C-depleted carbon but also the erosion of basal tills from the North-American or Kamchatka ice sheets that bear OM dating back to times prior to the glaciation.

The n-C25/n-C25+n-C27 ratio, an indicator for the relative contribution of sphagnum spp.3, is on a stable level over most parts of the deglaciation indicating a constant composition of the vegetation and/or a constant carbon source. Between 16.5-14.6 kaBP the record shows a sharp excursions towards higher values congruent with a sharp increase in the δD of n-alkanes that is not evident in the δD of n-fatty acids. Coevally, lowered CPI-values (carbon preference index) point to a major contribution of fossil carbon at that time. Thus, our sites may be subject to a change in the carbon source. It coincides with melting events of the N-American ice sheets4 which may indicate that large amounts of OM from eastern Beringia accumulated in the WBS/NW Pacific during HS1.

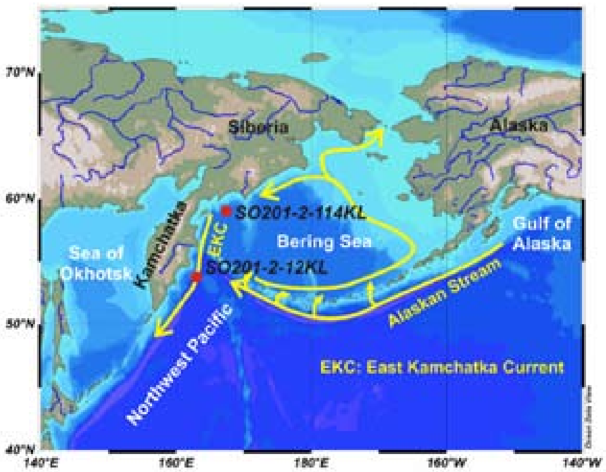

Fig. 1: Location of permafrost sites covered in this study (yellow dots, COL-sites) and sites of previous research (green dots) in the foothill region of northern Alaska.

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Permafrost history and environmental change at the margin of Beringia and the Laurentide Ice sheet, Tuktoyaktuk Coastlands, western Arctic Canada

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The Tuktoyaktuk Coastlands of Canada's Northwest Territories preserve an important record of Late Pleistocene geological history across the margins ofsome major ice age environments in the western Arctic. They are located near the eastern margin of the unglaciated sub-continent of Beringia, near the northwest margin of the Laurentide Ice Sheet, and at the mouth of North America's largest river that flows into the Arctic Ocean, the Mackenzie River. As a result, the Late Pleistocene sedimentary sequences of the Tuktoyaktuk Coastlands include windblown sediments typical of Beringia, glacial deposits and glaciotectonic structures associated with the Laurentide Ice Sheet, and pre-glacial and post-glacial fluvial deposits, including gravels attributed to catastrophic flooding. The sediments are preserved frozen within permafrost, and contain abundant ground ice, the interpretation of which permits reconstruction of permafrost history.

Optical stimulated luminescence (OSL) dating of sand provides a valuable method of investigating the ice age geology of the Tuktoyaktuk Coastlands. OSL dating of quartz sand grainsobtained from stratigraphic sections around the coast of northern Richards Island, Hadwen Island and Summer Island constrains the timing of geological events there. Landscape development is traced from the deposition of river sands of the Kidluit Formation between 76 and 34 ka and through windblown sands deposited in larges dunes and sandsheets of the Kittigazuit Formation between 26 and 12.9 ka. Glaciation during the Toker Point Stade interrupted aeolian activity at about 16.5ka, consistent with Mackay and S.R. Dallimore's(1992) suggestion that glacier ice advanced to Tuktoyaktuk sometime between 17 and 15 cal. ka., based on radiocarbon dating of massive ice. Catastrophic meltwater flooding near the end the ice age curtailed widespread aeolian activity, causedmajor erosion of the terrain and may have contributed to abrupt climate cooling during the Younger Dryas Stadial.

Postglacial environments of Nettilling Lake basin (Baffin Island, Canada) inferred by the geochemical and biological proxies

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Although signs of recent climate change are more compelling in circumpolar regions, we have limited knowledge of Arctic climates and environments and their past variability. In order to better understand and anticipate the extent and nature of future changes in the Arctic, it is necessary to increase our capacity to model past environmental changes. Instrumental monitoring using high technology in circumpolar regions has been implemented only over recent decades. Hence, to extend the climate record in time, we use a multi-proxy paleolimnological approach to study three sedimentary records (Ni4-7, 54 cm; Ni2-B, 82 cm; Ni-MP, 104 cm) preserved in Nettilling Lake, the largest lake in the Canadian Arctic Archipelago. The main objective is to reconstruct the postglacial environmental history of the Nettilling Lake watershed using geochemical and biological proxies.

Nettilling Lake, Baffin Island, has a surface area of 5500 km2 and a maximum depth of 65 m. Its basin has undergone postglacial marine invasion, ca. 7600 BP, following the last deglaciation due to isostatic subsidence exerted by the Laurentide Ice

Sheet. The glacio-isostatic uplift of the region resulted in the establishment of a freshwater lake ca. 5300 B.P. Biostratigraphic and geochemical analyses were completed on three sediment cores, from western, eastern and southern part of the Lake. The sediment records clearly document the marine-lacustrine transition through shifts in paleosalinity inferred from the chemistry of the cores, the oxygen isotope composition ($\delta^{18}O_{diatom}$) of biogenic silica and the composition of fossil diatom.

Our radiocarbon dates refine regional glacio-isostatic rebound (1m/100yrs) and 2000 yrs duration of the postglacial marine phase in the Lake's basin.

Post-glacial marine regression and the associated changes in paleosalinity are reflected in the sediment cores sedimentology and geochemistry analyzed using a Multi Sensor Core Logger and a microfluorescence scanner. Shifts in Ca/kcps, Si/Ti and Ti/kcps profiles indicate paleoproductivity and sedimentary changes. High S/kcps ratios indicate strong anoxic conditions in the lower water column during the saline to freshwater transition. Downcore variations in $\delta^{18}O_{diatom}$ values show a marine-lacustrine transition. The samples from the marine-brackish zone show a higher isotopic composition (27.5‰) than the samples from the lacustrine section (21.7‰). The transition zone can be distinguished by values between these extremes, too (23.4‰). This likely reflects changes in the water source, from more isotopically enriched marine water in the past to more depleted and cold lacustrine water.

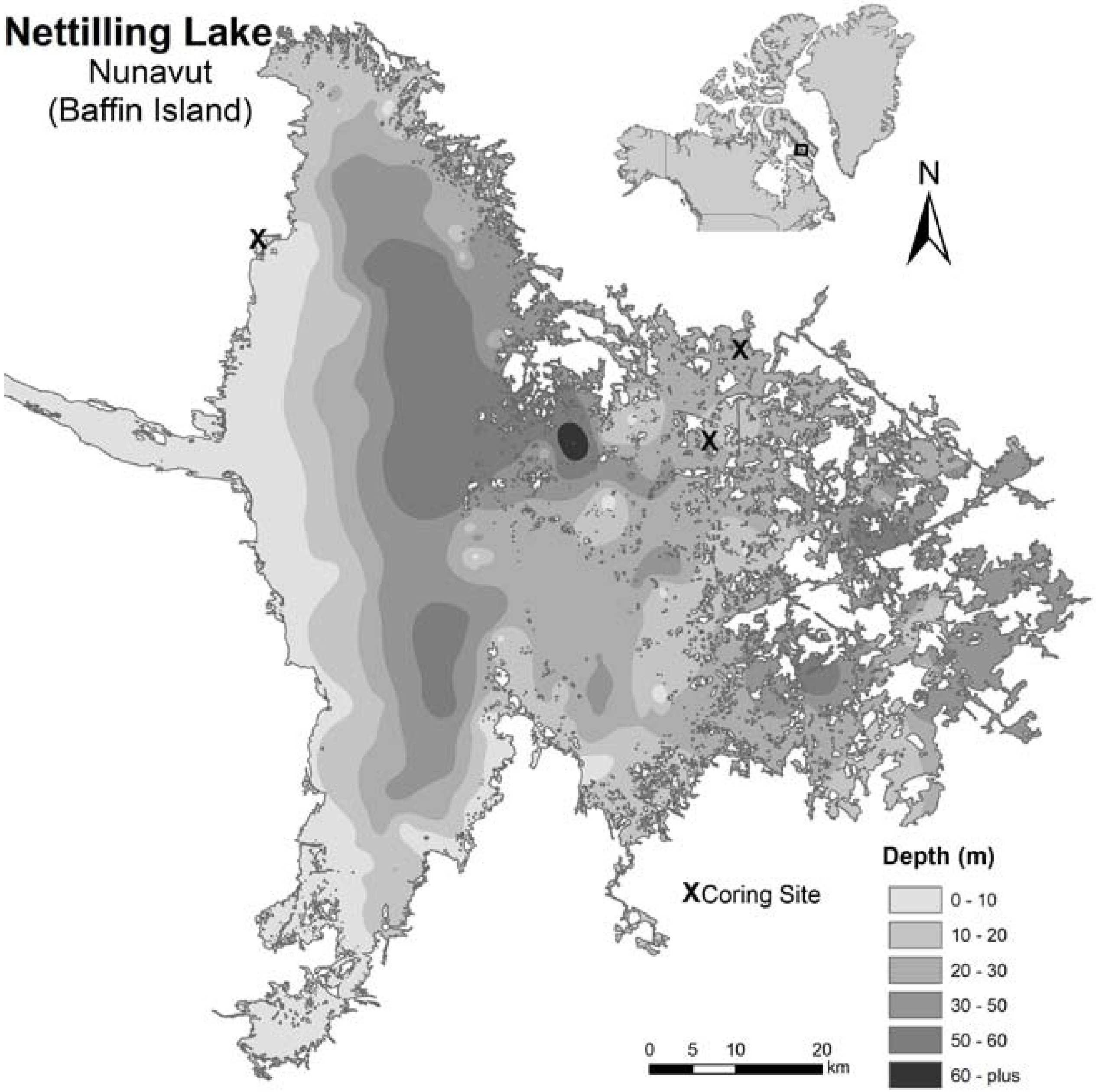
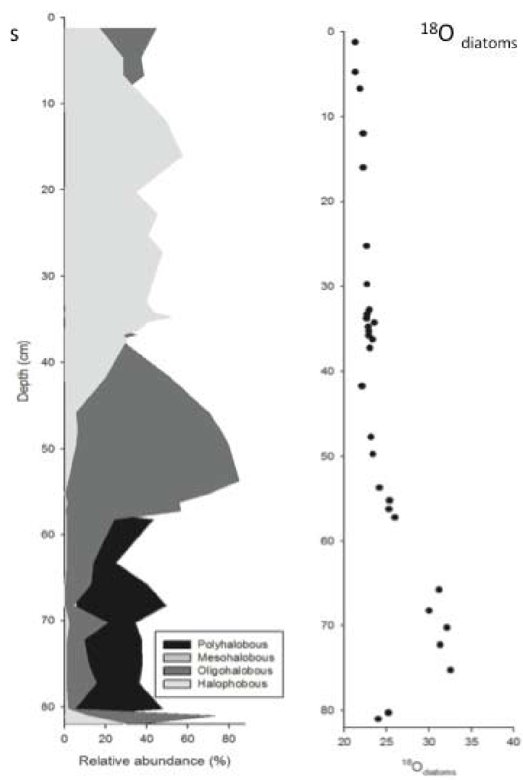


Fig. 1: Bathymetry map of Nettilling Lake with coring sites.



The diatom assemblage reflects the same transition. The marine-brackish zone contains polyhalobous-mesohalobous benthic species (e.g. Trachyneis aspera, Gomphonemopsis aestuarii, G. pseudexigua,Cocconeis scutellum) which have a salinity preference between 35‰ to 5‰, indicating a shallow, littoral environment. The transition zone is characterized by a sharp rise of alkaliphilous freshwater benthic taxa (e.g. Staurosirelle pinnata, Staurosira construens, Staurosira brevistriata). The diatom flora of the upper zone is characterized by halophobous planktonic and benthic species (e.g. Cylotella rossii, Cyclotella pseudostelligera, Tabelaria floculosa, Encyonema silesiacum, Nitzschia perminuta).

Fig. 2: Diatom distribution throughout the core and preliminary $\delta^{18}O_{diatom}$ results

Tentative age model of marine glacial landforms and related glaciations on the East Siberian and Chukchi margins

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As a relatively new discovery in the western Arctic Ocean,glacial landforms were presented and interpreted asa complex pattern of Pleistocene glaciationsalong the continental margin of the East Siberian and the Chukchi borderland1,2. These landforms include moraines, drumlinized features,glacigenic debris flows, till wedges, mega-scale glacial lineations (MSGL), and iceberg plough marks.Orientations of some of the landforms suggest the presence of former ice sheets on the Chukchi Borderland and the East Siberian shelf. In seismic and sub-bottom profiles there is evidence that glaciations have occurred repeatedly possibly during the Pleistocene. However, the chronology of most of these western Arctic Ocean glacial periods remained undetermined.

Here we present a tentative age model for some of the younger glacial events by correlation of sediment cores with glacial landforms as seen in sub-bottom profiles and swath bathymetry. The database was obtained during RV „Polarstern“ cruise ARK-XIII/3 (2008), RV “Araon” cruises ARA03B (2012), which investigated an area between the Chukchi Borderland and the East Siberian Sea between 165°W and 170°E.The stratigraphic correlation of sediment cores is based on physical properties (wet-bulk density and magnetic susceptibility), lithology and color. The chronology of the area has been proposed by Stein et al.3for a core from the Chukchi Abyssal Plain (PS72/340-5) and includes brown layers B1 to B9, which are dated and/or interpreted as marine isotope stages MIS 1 to MIS 7. Amongst other stratigraphic features these brown layers are used as marker horizons for lateral core correlation.

Our tentative age model suggests that the youngest and shallowest (480 m below present water level; mbpwl) grounding of an ice sheet on the Chukchi Borderland is younger than B2 (interpreted as Last Glacial Maximum; LGM). There is no clear evidence for a LGM glaciation along the East Siberian margin because intensive post LGM (Younger Dryas4) iceberg scouring occurred above 350 mbpsl. On the slopes of the East Siberian Sea two northerly directed ice advancesoccurred, both of which are older and younger than B2 and B3, respectively. The younger advance grounded to about 700 m present water depth along the continental slope and the older to 900 m and 1100 m on theArlis Plateau and the East Siberian continental margin, respectively. We interpret these advances as Middle Weichselian-glaciations on the Beringian shelf (MIS 4 to 3). Two older glaciations can be dated as Early Weichselian (MIS 5b to 5d), of which the younger event is older and younger than B3 and B4, respectively. These glaciations can be traced by glacial wedges, MSGL in up to 1200 mbpsl and subglacialdiamicton along the East Siberian margin, the Arlis Plateau, and the Mendeleev Ridge. On a seamount of the Mendeleev Ridge, at 77°36'N and 800 to 900 mbpsl, streamlined lineations suggest an ice source on the East Siberian Shelf. The related diamicton on top of the seamount is older than B3 and interpreted as relict of a MIS-5a grounded ice shelf. There are at least three glaciation visible in acoustic images from the East Siberian continental margin, which are older than MIS-5a and probably predate the Weichselian. The corespresented here did not penetrate these events and the ages remain speculative until longer cores become available.

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Deglaciation of the Svalbard-Barents Sea Ice Sheet in the northern Barents Sea, east of Svalbard

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The Barents Sea was glaciated several times during the Quaternary. The seafloor imprint from the build-up and disintegration of large ice masses has been used by numerous authors attempting to reconstruct the extent, dynamics and processes of the former ice sheets covering the Svalbard-Barents Sea area. Despiteconsiderableincrease in research activity over the past decade, the lack of geological and geophysical data frommany parts of the Barents Sea is hampering the reconstruction of the paleo-Svalbard-Barents Sea Ice Sheets(SBIS) with the resolution that is needed for ice sheet and climate models to adequatelycapture their dynamics.In this presentation we present new high-resolution acoustic (multibeam bathymetry and subbottom profiling) and sediment core data that provide new insights into the dynamics of the Late Weichselian SBIS in the Norwegian sector of the northern Barents Sea, north and east of Svalbard.

Sediment core data from the upper continental slope north of Nordaustlandet suggest that the SBIS was at the shelf edge at c. 22-21cal y BP. High-resolution bathymetric data revealed submarine glacial landforms (glacial lineations, Grounding Zone Wedges (GZW), marginal moraine ridges and subglacial crevasse-fill ridges) that indicate stepwise retreat of the ice sheet margin in the glacial troughs north of Nordaustlandet and east of Edgeøya. The glacial lineations and troughs east and south of Kvitøya, east of Edgeøya and south of Nordaustlandet imply generally easterly ice-flow directions. The assemblage of small, arcuate moraine ridges suggests extensional flow of relatively thin, grounded ice in the deeper, axial part of the glacial troughnortheast of Kong Karls Land. Orientation of small lineations and recessional moraines locally on the trough flanksand on slopes around local elevations implies the presence of local ice caps on the shallow banks and islands after the somewhat earlier deglaciationof glacial troughs in eastern Svalbard.Sediment core data suggests that the glacial trough east of Kvitøya became ice free c. 17.6 calky BP whereas the large trough north of Kong Karls Land was deglaciated at least 12-14, possibly as early as 16calky BP (Kristensen et al., 2012). Significant variations in sediment character and occasional reversed ages imply local ice margin re-advances and iceberg activity during the deglaciation of the Barents Sea.

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The appearance of pollen on the archipelago Franz-Josef Land of the Arctic Ocean

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We present and compare results of our pollen investigations at the archipelago Franz-Josef Land and Kola Peninsula.

The archipelago Franz-Josef Land (80°40′ N, 54°50′E) includes 192 islands. In frame of complex expedition of the Russian Arctic National Park in 2012 year few islands (Jackson, Hooker, Greely, Alexandra Land, Yeva-Liv, Appolonov, Georg land, Kane, Bell) were studied. They have a common type of polar deserts landscapes. The ice-free marine terraces rise to 35 m high. Lichens, mosses and grasses cover less than 60% of surface. Vegetation complex of archipelago includes 57 species of vascular plants (Poaceae, Juncaceae, Caryophyllaceae, Brassicaceae, Saxifragaceae are more spread). They usually grow up in little caves of relief, hollows or borders of permafrost where the fine-grained sediments accumulations are. The considerable part of island is free from vegetation cover. Slide-slopes and solifluction are spread, usually around the ice-cap.

Due to geographical remoteness, there is a lack of pollen data from the Franz-Josef Land. We received first surface samples. Subrecent spectra of Franz-Josef Land archipelago include pollen of Saxifragaceae, Poaceae, Juncaceae. Spores are rare; usually they are of bad safety. Pollen of trees is presented by Pinus and Betula; grains are damaged. All pollen grains of trees were transported. This results correlates with spectra from other Arctic islands (Kalugina et al., 1979; Anisimov, Moskalenko, 2006) whereas trees and shrubs are more spread.

The aim of our researches was the correlation between surface samples from continent and Franz Josef Land archipelago. Pollen grains may be transported for great distances. We dispose 20 surface samples from Sredniy and Rybachiy Peninsulas (69°44’ N, 32°30’ E; Kola Peninsula, Murmansk region) which is the most advanced to north in European Russia. Vegetation type of this region is southern tundra. Betula fruticosa and Betula nana cover more than 40% of surface. Ericaceae, Poaceae and Cyperaceae are dominating. Bogs are spread in relief diminutions, meanwhile terraces are covered by typical tundra vegetation with xerophytes. In spectra pollen of Betula and Betula nana are dominate, Pinus and Alnus are presents, but it makes less than 5% of trees. According to geographical position Kola Peninsula may be the region wherefrom pollen is introduced to Franz-Josef Land archipelago. We found a few common species in spectra of these regions. There exist different ways of introduction of pollen grains. Due to analysis of baric systems and circulation type of the region we tried to predict wherefrom pollen is infused by air to Franz-Josef land archipelago.

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Glacimarine sediment facies and morphology of the Disko Bugt Trough Mouth Fan, West Greenland

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The Disko Bugt Trough Mouth Fan is a major submarine sediment fan located along the central west Greenland continental margin offshore of Disko Trough. The location of the fan at the mouth of a prominent cross-shelf trough indicates that is a product of repeated glacigenic sediment delivery from former ice sheet outlets of the Greenland Ice Sheet, including an ancestral Jakobshavn Isbrae, which expanded to the shelf edge during successive glacial cycles. This study focuses on the uppermost part of the fan and analyses multibeam swath bathymetry and sub-bottom profiler records, supplemented by vibrocores up to 6 m in length. The swath bathymetry data show that the surface of the fan is prominently channelled with channels extending downlslope from a series of shelf-edge incising gullies. Sub-bottom profiles from across and down-fan show that the fan sediments are acoustically stratified. Although glacigenic debris flows were recovered in sediment cores from the upper slope they are absent in cores elsewhere on the fan. Rather glacimarine lithofacies in the Disko Fan are dominated by turbidites, hemipelagic sediments and IRD. The channelled surface of the fan implies erosion at the base of dense, sediment-laden turbidity currents related to the delivery of meltwater and sediment from ice grounded at the shelf edge. Such a morphology is unusual as is the dominance of turbidites and hemipelagic sediments. Although glacigenic debris flows are often regarded as the basic building blocks of trough mouth fans the Disko Fan is a type of turbidity-current dominated fan perhaps related to the control of slope gradient. More widely the large fans formed along the west Greenland margin contrast with the Baffin Island margin to the east which is characterised by a short shelf and relatively poorly developed fans. The well-developed trough mouth fans along the Greenland margin are likely a product of ice streams that extended across a wide continental shelf from large ice sheet drainage basins. These results highlight the variability in fan morphology and mechanisms of sediment delivery on high-latitude trough mouth fans and show that the classic Polar North Atlantic model of glacigenic debris flow dominated fans is but one of a number of styles for such large-scale, glacimarine sedimentary depocentres.

Ice-wedge record of Arctic winter temperatures over the past two millennia – long-term and recent warming in the Siberian Laptev Sea region

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The Arctic currently experiences a pronounced and likely unprecedented warming. This highly dynamic response on changes in climate forcing and the global impact of the Arctic water, carbon and energy balance make the Arctic a key region to study past, recent and future climate change on different spatial, temporal and seasonal scales.

Recent proxy-based Arctic and Northern Hemisphere temperature reconstructions show a long-term cooling trend over the past millennia that has been reversed by the ongoing Arctic warming (e.g. PAGES 2k Consortium, 2013, Marcott et al., 2013). This cooling is mainly related to the decrease in summer insolation. Climate models on the other hand show no significant change or even a slight warming. The resulting model-proxy mismatch might be caused by a seasonal (i.e. summer) bias of most reconstructions that are based mainly on summer-temperature proxies. Hence, there is a strong need for past winter climate information. Moreover, the Russian Arctic is largely underrepresented in recent Arctic-wide proxy compilations (PAGES 2k Consortium, 2013; Sundqvist et al., 2014). Ice wedges may help to fill these seasonal and spatial gaps (Meyer et al., 2015).

Polygonal ice wedges are a widespread feature in the Arctic coastal permafrost lowlands. They are formed by the periodic repetition of wintertime frost cracking and subsequent crack filling in spring mostly by melt water of winter snow. Hence, the isotopic composition of wedge ice is indicative of past climate conditions during this extended winter season. δ18O of ice is interpreted as proxy for local winter air temperatures. Radiocarbon dating of organic remains in ice-wedge samples enables one to generate stacked records in an up to centennial resolution as well chronologies for single ice wedges in even higher temporal resolution.

Here we present ice-wedge records from a thermokarst depression at the Oyogos Yar coast (72.7°N, 143.5°E) in the Northeast Siberian Arctic (Opel et al., 2011) that cover the past two millennia. We discuss the chronological approaches as well as the paleoclimatic findings. The co-isotopic relationship of wedge ice is close to the Global Meteoric Water Line pointing to no significant isotopic changes during ice-wedge formation and, therefore, to a good suitability for paleoclimate studies.

Our ice wedge data show a distinct long-term warming trend (δ18O: from about -26‰ to about -24‰) over the past two millennia detectable in a stacked record and time series based on single ice wedge profiles This trend culminates in an unprecedented rise over the last decades reflecting the ongoing Arctic warming and reaching the absolutely highest δ18O values (-21‰) found in Late Quaternary ice wedges in the study region. These findings may be related to the increases in winter insolation as well as in greenhouse gas forcing over this period and support recent results from Holocene ice wedges in the Lena River Delta (Meyer et al., 2015). However, this temperature pattern is in contradiction to most other Arctic reconstructions that, in turn, represent rather summer temperatures. This underlines the seasonally different orbital forcing trends.

Our ice-wedge record adds therefore unique and substantial climate information for understanding the seasonal patterns of Late Holocene Arctic paleoclimate and might help bridging the gap between proxy records and climate models.

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Past environmental variability in the eastern Fram Strait from the early deglaciation to the early Holocene reconstructed from benthic microfossils and IRD records

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The climate-induced environmental variability in the eastern Fram Strait over the early deglacial – early Holocene time interval has been reconstructed based on benthic microfossil and IRD data from core MSM5/5-723-2 (79°09.66 N, 5°20.27 E). The core is located on the western continental slope of Spitsbergen at 1359 m water depth directly beneath the pathway of Atlantic Water and in close vicinity to margin of the Weichselian ice sheet and the modern winter sea-ice margin. It has a sound AMS14C-based chronology for the Holocene section back to 10351 cal.ka at 371.5 cm, whereas the underlying almost 6 m thick sediment sequence has 3 datings and lacks reliable age control because of an age reversal in the middle.

IRD in the fraction >500 microns was counted continuously in 1 cm thick slices from the core top down to 677 cm. The taxonomic composition of benthic foraminifers and ostracods was analyzed in the core interval 200-677 cm with 10 cm resolution. A preliminary stratigraphic subdivision of the studied core section (200-677 cm) and time-slice reconstructions of past environmental changes during the early Holocene and deglacial times are based on the correlation of the obtained results with existing regional data (Rasmussen et al., 2007; Ślubowska-Woldengen et al., 2008; Jessen et al., 2010; Aagaard-Sørensen et al., 2014 among others).

IRD input was high though variable during the deglacial part of the record with peaks at 435-445 cm, 460-500 cm, 540-570 cm and 650-677 cm provisionally correlated with cold periods, i.e., Pre-Boreal Oscillation, Younger Dryas, Older Dryas and Heinrich 1 events, respectively. The pronounced IRD minimum at 570-650 cm is correlated with the regional meltwater spike during the early Bølling interstadial centered around 14.4 ka (Jessen et al. 2010). Based on IRD evidence the AMS14C dating of 14,863 yrs BP at 651.5 cm is assumed to be reliable, in contrast to the likely reversed dating at 571.5 cm (17,689 yrs BP).

The variability in the composition of benthic microfossil assemblages and the application of a cluster analysis reveals 4 characteristic benthic assemblages replacing each other upcore within the studied section.

1) The interval 480-677 cm refers to the major part of deglaciation prior to the mid-Younger Dryas. The low-diversity and poorly preserved deglacial foraminiferal assemblage is dominated by Cassidulina neoteretis that reaches up to 90% of the population. Its maximum spikes correlate with intervals of enhanced IRD input, likely associated with a meltwater-induced stratification and a strong subsurface inflow of Atlantic Water, in antiphase with peaks of other common Arctic species as Islandiella norcrossi/helenae and Cassidulina reniforme.

2) Transitional assemblages at 415-480 cm, corresponding in time to the Younger Dryas-Holocene transition, are dominated by species characteristic for Arctic shelf and upper continental slope environments (C. reniforme, Elphidium clavatum., Stainforthia feylingi, Melonis barleeanus, I. norcrossi/helenae, Nonion labradoricum, Polycope spp.) with cold, turbid and stratified waters, chilled Atlantic Water in the subsurface level, high accumulation rates, extensive sea-ice cover and seasonal pulses of productivity largely related to sea-ice algae blooms.

3) Interglacial, taxonomically diverse and rich assemblages at 250-415 cm, corresponding to the early Holocene thermal optimum (c. 8.2-10.5 ka), are dominated by deep-water epibenthic species Cibicidoides wuellerstorfi, Oridorsalis umbonatus and phytodetritus species Epistominella exigua, together with the Arctic species C. reniforme among foraminifers and Krithe sp. and Argilloecia sp. among ostracods. These assemblages characterize conditions of warm surface waters with high productivity due to the appearance of Atlantic Water at the surface and a diminished or absent sea ice cover. The observed faunal change manifests the establishment

of a modern-like circulation with possible indications to deep-water formation in the Nordic Seas.

4) Interglacial assemblages corresponding to the time interval of c. 7-8.2 ka (200-250 cm) indicate a cooling trend and increasing sea-ice abundance as manifested by the re-appearance of C. neoteretis and a considerable reduction in the representation of Epistominella exigua. The presence of Buccella frigida gives evidence for a denser sea-ice cover, though less severe than in deglacial times.

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Numerically modelling the growth and collapse of the Barents Sea ice sheet

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Geophysical data collected from the Barents and Kara seas during the last decade have significantly advanced our understanding of a number of important process dynamics related to marine-based glaciation of this domain, particularly so for the pattern and timing of retreat during the Late Weichselian. Notable empirically based insights include major ice-divide migrations, early ice-sheet thinning, asynchronous and rapid flow switching, and also highly non-linear rates of ice-stream retreat. Using a 3D thermomechanical ice-sheet model, we present results from a suite of transient numerical experiments, tuned against glacial isostatic adjustment model output, to explore the internal and external drivers that underpin such behaviour. Crucial to the build-up and deglaciation of the Barents Sea Ice Sheet is its sensitivity to non-linear feedbacks associated with the spatially heterogeneous climatic and oceanographic forcings that affect the domain. However, during periods of widespread glaciation, phases of internal thermomechanical switching act to stabilise the ice sheet through repeated cycles of ice streaming, reproducing elements of the geological palimpsest observed today. Improved process understanding related to the retreat of this marine-based ice sheet is not only crucial for providing insights into the destabilisation of present-day ice-sheets, but also for helping interpret analogous empirical data found in neighbouring palaeo ice-sheet domains.

Mid to late Holocene palaeoceanographic evolution of the East Greenland Current based on foraminiferal assemblage data

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The relatively fresh and cold East Greenland Current (EGC) connects the Arctic with the subpolar North Atlantic[1-3]. Its strength and influence on the freshwater balance in the North Atlantic impacts Subpolar gyre (SPG) dynamics and deep convection in the Labrador Sea[4-5]. Enhanced freshwater and sea ice expansion in the subpolar North Atlantic is suggested to modify the northward heat transport in the NAC[6].

However, our knowledge on the palaeoceanographic evolution of the EGC is sparse. Here, we present high-resolution planktonic and benthic foraminifera assemblage data, from a key site that underlies the EGC, Foster Bugt (PS2641, Fig.1). Planktonic and benthic foraminiferal abundance data allow the reconstruction of EGC water mass characteristics (surface) and its underlying Atlantic waters (subsurface) over the last c. 6.3 ka BP. For this purpose we use i) planktonic foraminifera to investigate changes in the cold and fresh Polar Water (PW) surface layer and ii) benthic foraminifera to investigate changes in the subsurface warm and saline Atlantic waters. These reconstructions will provide a high-resolution longer-term Holocene perspective on the palaeoceanographic evolution of the East Greenland shelf.

Our reconstructions reveal distinct centennial to millennial-scale oceanographic variability that relate to climatic changes during the mid to late Holocene (last c. 6 ka BP). The data from Foster Bugt highlight intervals of cooling and freshening of the polar surface EGC waters that accompanies warming in the underlying subsurface Atlantic waters, which receives contribution of return Atlantic Intermediate Water (AIW) and of the Return Atlantic Current (RAC). Mid Holocene thermal optimum-like conditions prevailed until c. 4.5 ka BP. A relatively warm surface PW and strong contribution of subsurface RAC waters, alongside low drift/sea ice occurrence, suggest a relatively weak EGC during this period. Subsequently, from 4.5 to 1.4 ka BP, the surface PW layer freshened and cooled, and the water column became well stratified, indicating a strong EGC. This EGC strengthening is accompanied by increasing subsurface AIW contribution from the Arctic Ocean after c. 4.5 ka BP, which culminated in the time from 2.3 to 1.4 ka BP. Simultaneously to this maximum AIW contribution, distinct warming is also recognized in the NAC[7-8], the Irminger Current[9-10] and the West Greenland Current[11-12]. We relate this enhanced Arctic Ocean AIW contribution to the 'Roman Warm Period'; a warm phase whose origin is still a matter of debate. We suggest that the observed subsurface warming offshore East Greenland, centred at c. 2.0 ka BP, results from the interaction of i) a weakened SPG; ii) increased northward advection of the NAC, and iii) a predominant positive North Atlantic and Arctic Oscillation mode, prevailing during this time.

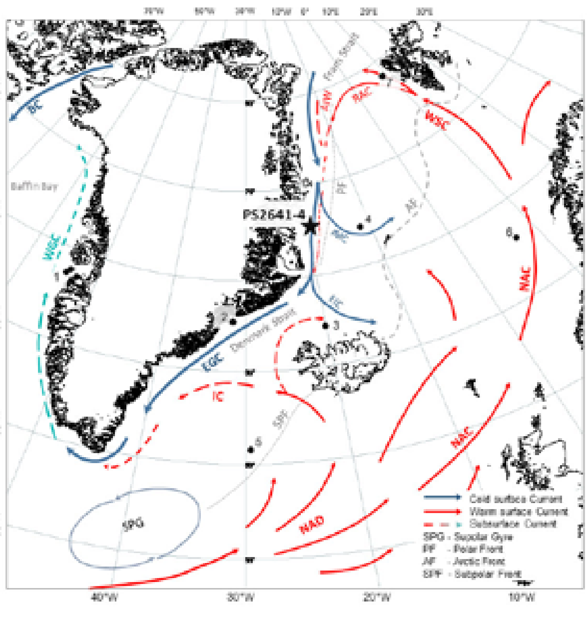

Figure 1. Map of the study area with schematic illustration of the major currents in the North Atlantic region. Abbreviations are as follows: East Greenland Current (EGC), East Icelandic Current (EIC), Jan Mayen Current (JMC), West Greenland Current (WGC), Baffin Current (BC), Irminger Current (IC), North Atlantic Current (NAC), North Atlantic Drift (NAD), West Svalbard Current (WSC), Return Atlantic Current (RAC). Key sites pertinent to this study: 1) West Greenland – MSM343300 and 343310 (Perner et al., 2011, 2013); 2) SE Greenland shelf – MD2322 (Jennings et al., 2011); 3) North Iceland shelf – MD99-2269 (Giraudeau et al., 2004; Moros et al., 2006); 4) Greenland See – PS1878 (Telsiński et al., 2014a); 5) Reykjanes Ridge – DS2P (Moros et al., 2012); 6) Vøring Plateau – MD95-2011 (Risebrobakken et al., 2003); 7) Eastern Fram Strait – MSM5/5-712 (Werner et al., 2013).

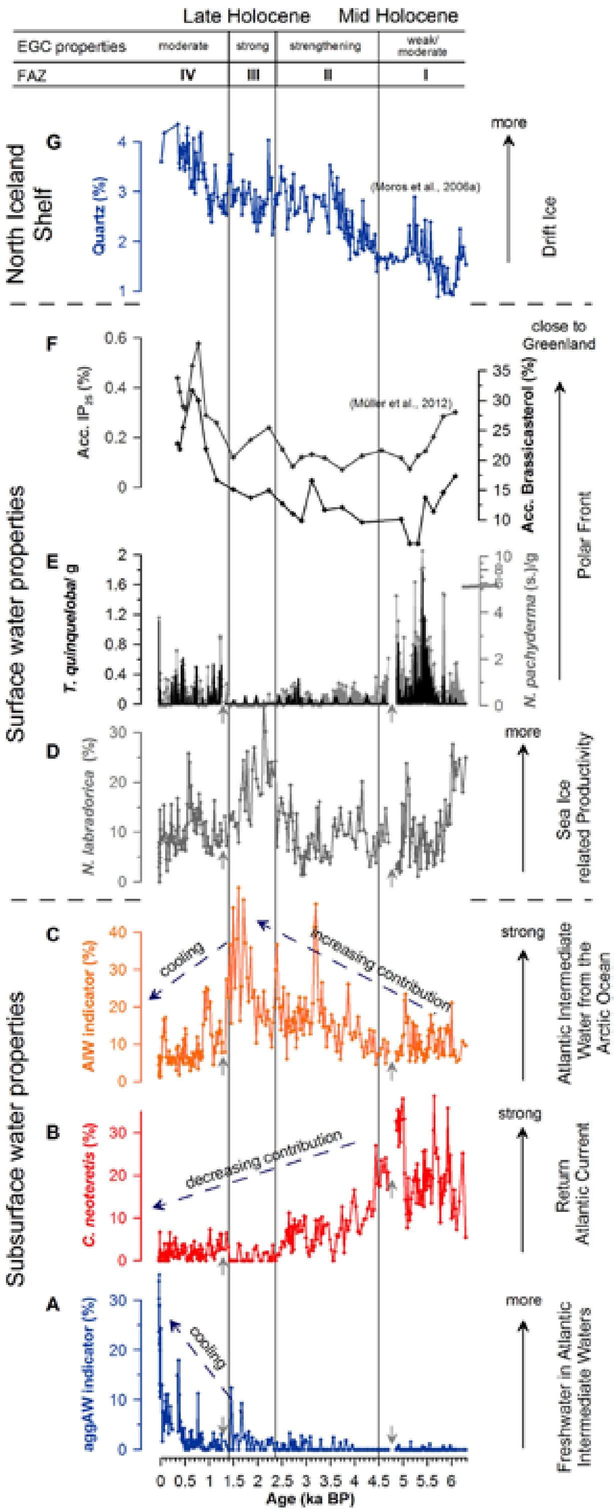

Figure 2. Regional mid to late Holocene (last c. 6.7 ka BP) paleoceanographic changes reconstructed from core PS2641-4GC. A) Abundance (%) of agglutinated AW species; B) Abundance (%) of RAC associated species C. neoteretis; C) Abundance (%) of AIW group; D) Abundance (%) N. labradorica; E) Content of planktonic foraminifera N. pachyderma (s.) and T. quinqueloba; F) Accumulation (%) of IP25 and brassicasterol, phytoplankton marker from this core site, published by Müller et al. (2012); G) Drift ice proxy record (Quartz %) from North Iceland Shelf (MD99-2269, Moros et al., 2006).

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First insights into pre-glacial Pleistocene environments in the Arctic Ocean.

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Most paleoceanographic studies in the Arctic deal with Quaternary deposits characterized by a contrast interlamination of glacial- and interglacial-type sediments. According to the current age model, this stratigraphy generally represents middle to late Pleistocene (~0.7-0.8 Ma), when Northern Hemisphere glaciations were fully developed. These strata are amenable to stratigraphic/paleoceanographic research due to their explicit cyclicity and a relatively good preservation of some fossils, especially those with calcareous skeletons. However, using paleoclimatic records based on this stratigraphy to evaluate modern Arctic change is complicated by the overwhelming imprint of glacial-related processes. Older deposits, formed under lesser glacial impact, have a higher potential for representing the role of sea ice in Arctic environments; on the other hand, going further back in time increases the odds of non-analog paleogeographic conditions. In this perspective, Quaternary deposits formed before the major expansion of circum-Arctic glaciations (pre-glacial Pleistocene) may arguably be the closest paleo-analog for projected near-future Arctic environments. However, developing the stratigraphy and paleoenvironmental proxies for these deposits has been hampered by a lack of explicit lithological changes and a typical absence of fossil remnants.

In a recent paper, Polyak et al. (2013) outlined a provisional stratigraphy and reconstruction of paleoceanographic conditions for a western Arctic Ocean record extending to estimated ~1.5 Ma and containing unusually abundant calcareous microfossils (foraminifers and ostracodes). These data imply a step-wise transition from mostly seasonal to perennial sea ice in the western Arctic, along with an increase in glacial impact on sedimentary environments. We build upon these results to gain further insights into the early Pleistocene Arctic Ocean by augmenting the investigation with a neighbouring sediment core from the Northwind Ridge. Although pre-glacial lithology appears generally monotonous, more in-depth proxy records reveal two cyclicities, expressed notably in manganese content and foraminiferal numbers, which also affect grain-size distribution. The latter, lower-frequency cyclicity was also found in bioturbation patterns, investigated by means of X-ray Computer Tomography (XCT) core scanning. Based on recent studies suggesting a sea-level control on manganese deposition in the Arctic Ocean, we infer that the first type of cyclicity is related to sea-level changes, which followed the obliquity variations prior to glacial Pleistocene. The lower-frequency, biotic (foraminifers and bioturbation) cyclicity may be then related to ~100-ka variations. This variability was possibly modulated via sea-ice extent, as modern Arctic Ocean biological processes are tightly controlled by sea ice, but we cannot exclude other potential factors, such as meltwater pulses. Further research, such as detailed investigation of foraminiferal assemblages and stable isotopes, will aim to elucidate the nature and timing of the cyclic processes involved. In addition, the use of XCT may allow for an export of the developed stratigraphy to cores from other parts of the Arctic Ocean, where early Pleistocene deposits lack fossiliferous material, probably due to dissolution.

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Future Priorities for Arctic Research

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The scientific, political and economic interest in the Arctic is rapidly growing and the increasing number of Arctic and Polar research programs requires a better coordination in order to agree on shared objectives and to ensure the best value for funds spent. Consequently, the International Arctic Science Committee (IASC) initiated the planning of a third International Conference on Arctic Research Planning (ICARP III)and invited all interested partner organizations to participate in shaping the future of Arctic research needs.ICARP III is a process to

- identify Arctic science priorities for the next decade;
- to coordinate various Arctic research agendas;
- to inform policy makers, people who live in or near the Arctic and the global community;
- and to build constructive relationships between producers and users of knowledge.

Beginning with a formal launch at the Arctic Science Summit Week (ASSW) 2014 in Finland and culminating in a final conference at the ASSW 2015 in Japan, the ICARP III program included a series of activities, meetings and events during 2014-2015.
The primary outcome of ICARP III is aninventory of reports and recommendations of the various ICARP III activities. Each ICARP III activity reported back to the ICARP III Steering Group who extracted the key messages and findings of the individual activities- and compiled a consensus statement identifying the most important Arctic research needs for the next decade.This overarching ICARP III statement, having the endorsement of all ICARP III partner organizations, has been presented at the main ICARP III conference held during the ASSW 2015 in Japan.
The ICARP III outcome will also be linked to the conclusions of the forward-lookingHorizon Scan conducted by the Scientific Committee on Antarctic Research (SCAR) and it will include contributions to the development of the International Polar Partnership Initiative (IPPI).
The audience of ICARP III includes the international Arctic scientific community (both individual scientists and scientific organizations), funding agencies supporting Arctic research, Arctic policy makers and residents all of which will benefit from a broadly agreed document identifyingthe priorities for forward-looking, collaborative, interdisciplinary Arctic research and observing and providing a roadmap for research priorities and partnerships.
For more information, see http://icarp.iasc.info/.

Early thinning and recession of the Scandinavian Ice Sheet in southernmost Norway - new chronological constraints from cosmogenic ^{10}Be-dates

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The glacial geology of the southernmost coastal areas in Norway was mapped in the 1950s by Bjørn G. Andersen[1]. He was the first in Norway to make systematic use of aerial photographs for geological mapping. Based on observations of moraine ridges, glacial striae and elevated marine terraces, he reconstructed several retreat sub-stages of the Scandinavian Ice Sheet in this part of Norway (covering an area of ca. 10.000 km^2). He assigned ages for the sub-stages based on correlation to what he thought were corresponding, varve-dated moraine ridges in Sweden and also to raised shoreline levels in Denmark. As a result he suggested that the deglaciation of this area started in early Bølling, ca. 14.500 years ago and was complete at the beginning of the Holocene. The marginal moraine furthest inland is almost continuous through the entire area and Andersen correlated this to the huge Younger

Dryas (YD) moraine in the Oslofjord district, known as the Ra. This chronological model has never been confirmed by direct dating, however it is widely used in reconstructions of the Scandinavian Ice Sheet.

We have now tested the reconstruction by re-mapping the whole area and applying ^{10}Be exposure dating of boulders on marginal moraines. The mapping greatly benefited from use of recently acquired airborne LiDAR-data (high resolution laser scanning of the terrain). Digital tools allow us to “remove” all vegetation and create shaded elevation models of the ground in very high detail. In this way we can readily distinguish glacial geomorphic features like moraine ridges from bedrock-dominated terrain. We obtained in total 53 ^{10}Be-ages from boulders and bedrock, and also one ^{10}Be depth profile (five dates) from a coarse-grained glaciofluvial deposit. The age of one of the retreat sub-stages is also supported by radiocarbon dates from a lake record just inside the moraine.

Our study shows that the first stretch of land to become ice-free was the Lista peninsula, where results from a cosmogenic depth profile suggest an age around 19 ka - approximately 4000 years earlier than previously thought. The age complies with recent results from a study at the SW coast of Norway[2] and documents an early break-up of the Norwegian Channel Ice Stream. At the same time, the ice sheet surface slowly lowered and we dated the appearance of coastal nunataks ca. 500 m a.s.l. at around 17 ka. This implies an ice sheet thickness in this region of only 2-300 m. A relatively thin ice sheet during deglaciation in this area, is supported by observations of raised marine deposits and also by a recent isolation basin study which document anomalously weak postglacial crustal uplift rates in this part of Norway[3].

During retreat the ice front halted for a while at fjord thresholds where calving outlet glaciers deposited some terminal and lateral moraines. This was termed the Spangereid sub-stage by Andersen and has been dated by us to about 15 ka. Following the onset of the Bølling warm period, the ice front appears to have retreated rapidly 30-50 km to a position inside the Ra sub-stage. In contrast to the previous reconstruction, our mapping and dating results show that the Ra moraine in this area is in fact a combination of moraines from two glacial advances, the first around 14 ka and the second during the YD. This pattern is also documented from another study ca. 100 km further west in Norway[4]. The older ridges were in some areas overrun by the ice sheet during the YD, leaving only one ridge from which we get a larger scatter in ages (14-11 ka). However, we also targeted a valley where two ridges deposited by steep outlet glaciers are separated by about 5 km. Here, we obtained two clearly different age populations centered at 14 ka and 12 ka, respectively. The ice front must have retreated some distance inland during the Allerød, before readvancing to almost the exact same position in the YD.

To conclude, our study confirms the broad outline of the previous reconstruction of deglaciation for this part of Norway[1], but we show that deglaciation commenced earlier and that the early lowering of the ice sheet surface probably caused strong influence by the underlying topography on ice flow. The early thinning is likely related to the location of this area at the southern end of the main drainage divide of Norway, implying a small source area for ice flowing to this region. Also, the Norwegian Channel Ice Stream probably influenced on ice drainage onshore when it was operative during the LGM. The thin remaining ice sheet wasted rapidly during the Bølling-Allerød Interstadial and the ice front was located far inland already at 14ka. The Ra sub-stage, previously thought to represent the culmination of one major ice sheet advance during the YD, is in fact a combination of moraines spanning more than 2000 years

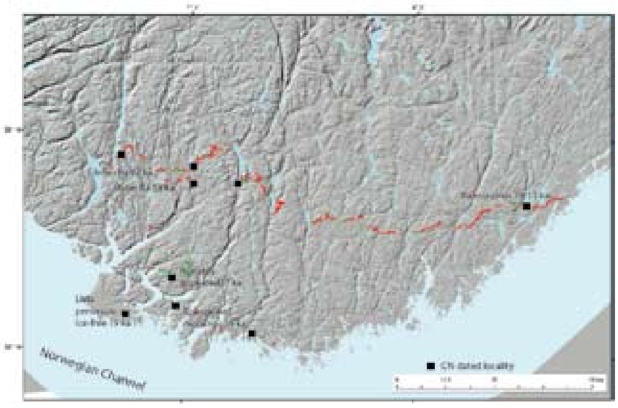

Fig. 1. Overview map with sample sites

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The International Permafrost Association: current initiatives for cryospheric research

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The International Permafrost Association (IPA), founded in 1983, has as its objectives to foster the dissemination of knowledge concerning permafrost and to promote cooperation among persons and national or international organizations engaged in scientific investigation and engineering work on permafrost. The IPA's primary responsibilities are convening International Permafrost Conferences, undertaking special projects such as preparing databases, maps, bibliographies, and glossaries, and coordinating international field programs and networks. Membership is through adhering national or multinational organizations or as individuals in countries where no Adhering Body exists. The IPA is governed by its Executive Committee and a Council consisting of representatives from 26 Adhering Bodies having interests in some aspect of theoretical, basic and applied frozen ground research, including permafrost, seasonal frost, artificial freezing and periglacial phenomena.

This presentation details the IPA core products, achievements and activities as well as current projects in cryospheric research. One of the most important core products is the circumpolar permafrost map. The IPA also fosters and supports the activities of the Global Terrestrial Network on Permafrost (GTN-P) sponsored by the Global Terrestrial Observing System, GTOS, and the Global Climate Observing System, GCOS, whose long-term goal is to obtain a comprehensive view of the spatial structure, trends, and variability of changes in the active layer thickness and permafrost temperature.

A further important initiative of the IPA are the biannually competitively-funded Action Groups which work towards the production of well-defined products over a period of two years. Current IPA Action Groups are working on highly topical and interdisciplinary issues, such as the development of a regional Palaeo-map of Permafrost in Eurasia, the integration of multidisciplinary knowledge about the use of thermokarst and permafrost landscapes, and defining permafrost research priorities - a roadmap for the future. The latter project is a joint effort with the Climate and Cryosphere initiative (CliC) and a contribution to the upcoming International Conference on Arctic Research Planning III (ICARP III). The product stemming from the effort will consist of a journal publication listing permafrost research priorities and putting them into context.

In all of these activities, the IPA emphasizes the involvement of young researchers (especially through the Permafrost Young Researchers Network and APECS) as well as its collaboration with international partner organizations such as IASC, SCAR, CliC, IACS, IUGS and WMO.

Validity of the MIS 2 glacial border in the NW Canadian Arctic based on comparing the on- and offshore clay mineral composition

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The glacial border of the Laurentide ice sheet in the western Canadian Arctic is commonly recognized with Herschel Island in the Beaufort Sea expressing its subaerial northwestern limit. Ice-rich and diamictic deposits build up the island and they are interpreted to result from a push moraine that dumped material in the area. The deposits were likely excavated from the nearby Herschel Basin, a prominent bathymetric depression on the sea floor found in the SE of the island.

We test this glacial interpretation by comparing the clay mineral distribution in the area. Surface samples have been collected on- and offshore, from Herschel Island and the Yukon Coastal lowland, and from the Beaufort Sea shoals with sampling sites placed in- and outside of the supposed ice sheet extension.

Variability of late Holocene ocean and atmosphere circulation in the Labrador Sea and North Atlantic region - or why that which does not fit, fits extra well!

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When describing climate development, one may get the impression that climate evolves with a similar geographical/spatial pattern everywhere. However, there is increasing evidence of an a-synchronous and even opposite pattern in the climate development on a regional scale. These cases are especially interesting, as they are excellent at explaining the mechanisms governing climate change. One such example is the so-called "Little Ice Age" (LIA, ca 1350-1800 CE), which is generally considered as a cold period in Europe, not the least in Denmark. The LIA has often been described as a period of extensive atmospheric and oceanic cooling observed over large parts of the world and that severely impacted human society. In contrast, the preceding climate period, the Medieval Climate Anomaly (MCA, ca. 900-1350 CE), was characterized by relatively warm conditions.

However, a very different picture emerges when studying regional marine-sediment climate record. In particular reconstructed sea-surface and subsurface temperature data off SE and W Greenland[1,2] as well as Eastern Canada[3] indicate exceptionally warm sea-surface and/or subsurface temperatures during the LIA, and colder conditions during the MCA. Off Greenland this pattern is primarily expressed in subsurface waters, while it is seen in the surface waters off E. Canada. Our proxy data include alkenone-based SST reconstructions and other geochemical studies as well as results from foraminiferal, dinoflagellate cyst and diatom studies.

Data from sites located within the North Atlantic Subpolar Gyre region indicate an intensified Subpolar Gyre circulation during the LIA, which was contracted towards the west4. This enhanced the influence of warm water in the eastern North Atlantic. This phenomenon is believed to be linked to an overall strengthening of the negative mode of the North Atlantic Oscillation[1-3], possibly triggered by changes in solar forcing[5,6]. This scenario would also help explain the strong continental cooling during the LIA and the asynchronous buildup of sea ice along

the coast of Greenland[7]. The climate variability of the last millennium thus serves as a strong reminder that climate development is non-linear and significantly more complex than may be assumed when only considering global averages. It thus clearly illustrates the need to also focus our efforts on the regional development of climate and oceanography when predicting future scenarios.

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Early Holocene Atlantic Water advection and ice coverage in the Arctic Gateway

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Water mass exchange between the Arctic and North Atlantic oceans occurs mainly through the Fram Strait which is also the major passage for sea ice export from the Arctic Ocean. Water temperature and the intensity of Atlantic Water advection largely determine the degree of ice coverage. Supported by a maximum of insolation, the Early Holocene was a period of extraordinarily strong advection and relatively high near-surface water temperatures in the eastern Nordic Seas (cf. Risebrobakken et al., 2011, Paleoceanography v. 26).
Radiocarbon-dated records of planktic foraminifer associations and stable carbon and oxygen isotopes allow to recontruct the environmental conditions in the northern and western part of this area. Here we present data from a series of sediment cores of variable temporal resolution (from decades to millennia), reaching from the SW Greenland Sea (73°N) to the Yermak Plateau (81°N). They reveal temporal and spatial differences in the development of the so-called Holocene Thermal Maximum (HTM). In the northern part of the region, the HTM started ca. 11-10.5 ka as indicated by rapidly increasing amounts of subpolar foraminiferal in the sediments. In the eastern Fram Strait and on the Yermak Plateau, our records of (sub) millennial scale resolution show that the maximum influx terminated already 2,000 years later (9-8 ka). Most likely, this development went along with a N-S relocation of the sea ice margin. According to the current stratigraphic model for a core with submillennial-scale resolution from Vesterisbanken seamount (73°N) in the Greenland Sea, the timing was different there. Increasing total amounts of planktic foraminifers in the sediment indicate an early (11-10 ka) reduction in sea ice coverage also in this region. However, evidence from subpolar planktic foraminifers for maximum Atlantic Water advection is younger (9-6 ka) than in the north. Apparently, the site in the SW Greenland Sea was affected by Atlantic Water in the Greenland Gyre that decoupled from the northward flowing Norwegian Atlantic Current/Westspitsbergen Current south of the Fram Strait. Thus, in a suite of events, strong Atlantic Water advection first affected the northeastern sector of the Nordic Seas for ca. 2,000 years. Around 9 ka, the Westspitsbergen Branch weakened somewhat and the Greenland Gyre was strengthened by a westward flow of relatively warm and saline waters. Only in the middle Holocene, when the increasing sea ice production in the Siberian Arctic may have reached conditions comparable to modern, Atlantic Water advection by the Greenland Gyre to the SW Greenland Sea decreased and the current system in this area reached the modern state.

The geomorphological and sedimentary record of the Holocene evolution of Jakobshavn Isbræ in Disko Bay, West Greenland

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A number of fast-flowing outlet glaciers currently drain the Greenland Ice Sheet, providing ice, meltwater and debris to the fjords around Greenland. Because such glaciers strongly influence the ice sheet's mass balance, a number of studies have investigated their evolution and deglacial dynamics since the Last Glacial Maximum (e.g. Young et al., 2011; Jennings et al., 2013; Ó Cofaigh et al., 2013; Roberts et al., 2013; Dowdeswell et al., 2014; Lane et al., 2014). However, their Holocene glacimarine processes and associated geomorphological and sedimentary records are still poorly known.

This study provides a detailed analysis of lithological and geophysical data collected from Disko Bay, a marine embayment in central West Greenland (Fig. 1). Disko Bay is strongly influenced by Jakobshavn Isbræ, Greenland's fastest-flowing outlet glacier, which currently drains ~7% of the ice sheet into the bay. Streamlined glacial landforms, visible on the bathymetry data, record the former flow of an expanded Jakobshavn Isbræ into the bay and across the adjoining continental shelf. The glacier's Holocene sedimentation processes are reconstructed by analysing two transects of vibrocores across the bay, which are correlated with multibeam swath bathymetry data from the area (Fig. 1). The cores comprise a complex set of lithofacies including laminated muds, sharp-based massive and graded sands, IRD-rich massive muds, and massive bioturbated muds. These facies suggest a range of glacimarine sedimentary processes to have occurred in the bay during and following the retreat of Jakobshavn Isbræ, which include suspension settling of fine-grained sediment from turbid meltwater plumes, sediment gravity flows and iceberg rafting. The importance of meltwater-related processes to glacier-

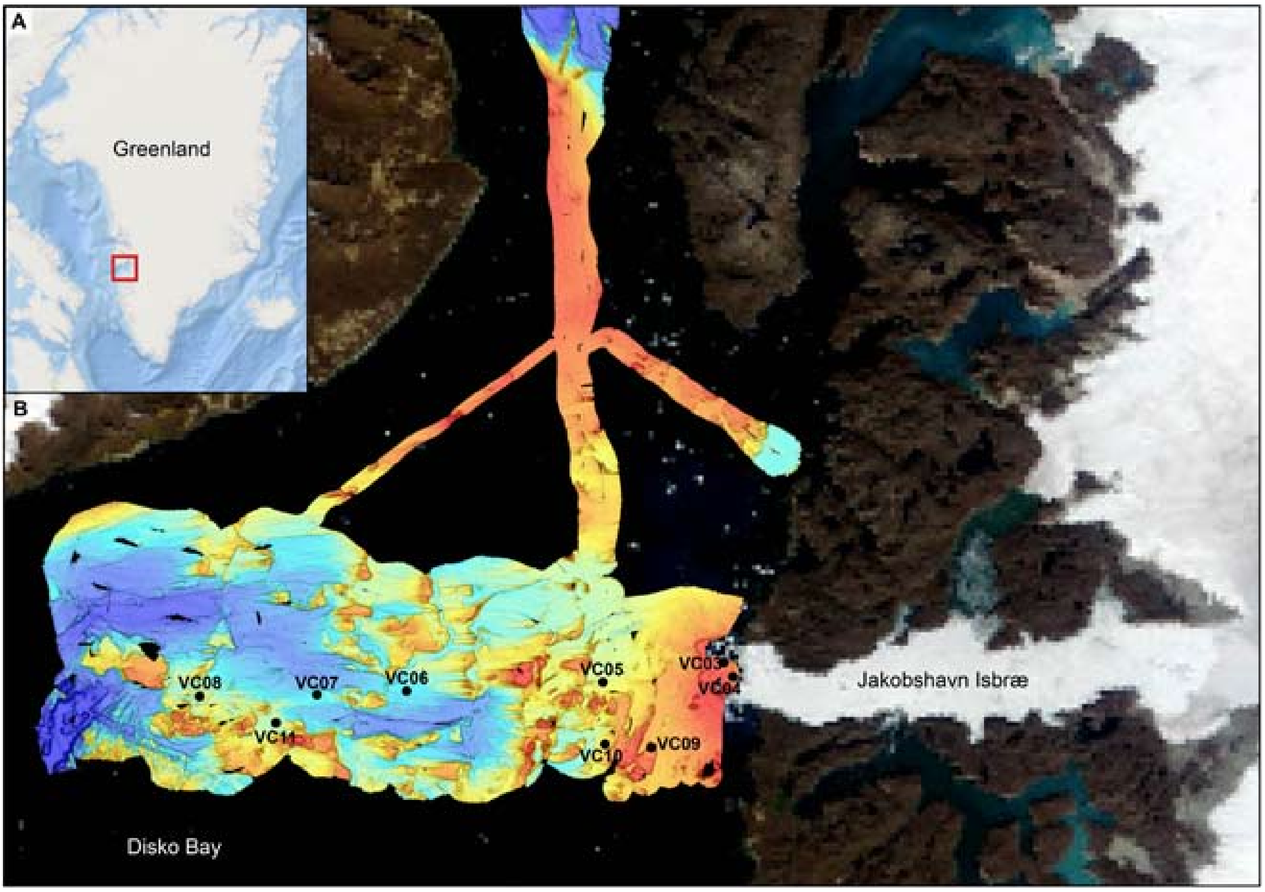

Figure 1: A) Overview map of Greenland with the red rectangle indicating the extent of B; B) Study area showing the available swath bathymetry and core locations. VC=Vibrocore.

controlled sedimentation in West Greenland fjords is emphasised by the abundance of glacimarine muds preserved in the cores.

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Catastrophic events shaping Arctic coasts - impact of tsunamis and ice-berg roll waves on coastal evolution in Greenland

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Most polar regions are sufficiently far from the major plate boundaries to have escaped significant impact by tsunami generated by large earthquakes such as the recent Indian Ocean (2004) and Japanese (2011) events. However, the unstable nature of Arctic landscape in terms of landslides provide potential tsunami sources. Moreover calving glaciers and rolling large icebergs may be potential sources of tsunamis, particularly in the fjords, the shape of which can amplify the size of the wave. Arctic tsunamis have been mostly recorded in fjord systems, which may amplify wave heights due to their constraining topography. For example, a tsunami wave in Lituya Bay (Alaska), reached the highest run−up ever recorded (516 m a.s.l.). Arctic coasts are also affected by far−field events such as famous Storegga tsunami from ca. 8200 years BP. Storegga event is recorded along many of the coastlines of the northern Atlantic, including east Greenland.

In the Disko Bay area (western Greenland) on November 21, 2000 AD, a large landslide took place that caused a tsunami reaching 50 meters above the sea level. The wave destroyed the town Qullissat on the opposite site of the strait, however, material losses were observed in distant places by as far as 150 km from the landslide. The same region is also one of the most threatened by large, often over 5 - meters high incident long waves, which are caused by calving glaciers and icebergs overturning. Most of the icebergs in the area are produced by the fastest ice-stream in the northern hemisphere - the JakobshavnIsbrae.

In this paper we present the selected results of the novel study of the morphological, sedimentological and environmental effects of modern tsunamis caused by landslides and collapsing icebergs in Western Greenland. The project was conducted by Polish-British research team during two expeditions that focused on the documentation of the effects of historical tsunamis, the monitoring of the contemporary processes and the search for traces of past events. Presented results will serve as a guide for further studies of palaeotsunami in Greenland and elsewhere in the Arctic. The results are also of importance for Arctic coastal risk assessment, as almost all the human infrastructure is situated along a narrow coastal strip.

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A new Quaternary sediment sequence from the eastern Mendeleev Ridge: preliminary stratigraphic subdivision based on IRD and microfossil records

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Sediment core KD12-03-10C (79°27,75'N, 171°55,08'W, 2200 m water depth) was retrieved in 2012 during Russian expedition aboard RV "Kapitan Dranitsyn". The 575 cm long sediment sequence was analyzed for IRD (>500 microns), planktic and benthic foraminifers and ostracods (from >125 micron fraction) with 10 cm interval (the uppermost 30 cm were analyzed continuously).

Correlation of the obtained results with previously published evidence (Polyak et al., 2004, 2013; Cronin et al., 2008, 2013, 2014; Adler et al., 2009; Stein et al., 2010; Hanslik, 2011; Poirier et al., 2012) allowed for a preliminary stratigraphic subdivision of the sediment sequence.

The major stratigraphic markers recorded so far in the sediments are:
i) seven IRD peaks corresponding to the decay/growth of continental ice sheets in the upper 445 cm; sediments below 445 cm almost devoid of IRD with rare microfossils signify conditions of seasonal sea-ice cover and high productivity prior to the onset of major glaciations;
ii) first occurrence of rare dolomites in the oldest IRD peak (MIS16?) and growing representation of dolomites upcore up to 40-60% in pink layers 1 and 2 at 170-180 (MIS7/8?) and 75-80 (MIS 5d?) cm, respectively;
iii) the oldest peak in the abundance of planktic foraminifers at 240-310 cm dominated by Turborotalita egelida (MIS11) correlative with the peak abundance of diverse benthic foraminifers including agglutinated species Cyclammina sp.;
iiii) faunal changes at 170-190 cm likely corresponding in age to MIS7-9 including disappearance of T. egelida and predominance of Neogloboquadrina pachyderma sin. among planktic foraminifers, appearance of Oridorsalis tener and the presence of indicative species Pullenia bulloides among benthic foraminifers;
iiiii) occurrence of ostracod species Henryhowella asperrima in the limited depth interval 8-26 cm suggesting the age of MIS1-3 for this core interval.

This research was supported by the Russian Foundation for Basic Research (RFBR, project 15-05-08497).

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Timing and frequency of glacigenic debris flows on the Bear Island Fan – implications for the growth and decay of the Barents ice sheet

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It can sometimes be problematic to date and determine the history of ice sheets from cross-shelf deposits alone. The timing of glaciagenic debris flows on deeper-water trough mouth fans provides an alternative method for understanding the growth and decay of Arctic ice streams, especially when ice stream were most likely at the shelf edge. Here we consider the age of large glacigenic debris flows on the Bear Island (Bjørnøyrenna) Fan. This is one of the largest volume sediment accumulations on our planet, and it is also to determine the tempo of sediment deposition on such glacigenic fans for understanding global sediment fluxes. Here we use a new core dataset collected during in July 2014, which complements a smaller number of cores collected previously on the Bear Island (Bjørnøyrenna) Fan.

The age and frequency of glacigenic debris flows has been analysed using a combination of radiocarbon dating, geochemical proxies for regional oxygen isotope stratigraphy curves, and magnetic susceptibility. These new cores are mainly located near the down-slope terminations of the longer runout glaciagenic debris flows.

The last major glaciagenic debris flow present in these cores occurred at 11,000 Cal BP. Of the 37 events in our cores, 15 occur within our radiocarbon dates. The exact timing of these events was estimated between radiocarbon dates using hemipelagic accumulation rates. These 37 events occur in two clusters. The first cluster is centred at 24,000 Cal BP. The second cluster is centred at 36,000 Cal BP. There are also two individual events at 11,000 Cal BP.
The age of events that lie below our radiocarbon dates can be estimated by using a constant hemipelagite accumulation rate. Using this method, two clusters of event occur at 65,000 Cal BP and 82,000 to > 90,000 Cal BP.Ongoing work aims to refine these ages, and investigate changes in the geochemical composition and hence source of material.

This presentation will first outline the record of sedimentation in these new cores, and then compare this record to previously published work on the timing of sedimentation on the Isfjorden, Storfjorden and Bear Island (Bjørnøyrenna) Trough Mouth Fans located further to the north [e.g.[1-2]] . Our aim is to determine when the various ice streams reached the shelf edge, and hence generated glacigenic debris flows on the fans; and the implications for ice sheet behaviour and its controls. The last glacigenic debris flows were emplaced at ~18-20ka on the Isfjorden, Storfjorden and Kveithola trough mouth fans[1-2]. But short episodes of exceptionally rapid deposition of laminated sediment occurred during deglaciation (~14.4-14.7 ka) in more proximal settings on the Storfjorden and Kveithola fans[1], as ice streams retreated. We discuss whether there is any evidence of such events in our cores. More generally, this conference will be a useful venue for discussing future coordinated data collection efforts across the large trough mouth fans in this area.

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The last Northern hemispheric deglaciation: missing ice, data/model challenges, and opportunities

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What do we know and not know about what the LGM ice sheets looked like and their pattern of deglaciation? I will present some summary results from an ongoing Bayesian calibration of the 3D Glacial Systems Model (GSM). This will include both robust characteristics of Eurasian and North American deglaciation as well as the persistent data/model misfits that have vexed me for over a decade. The calibration merges modelling with a diverse and large set of constraint data, including relative sea level (RSL), marine limits, strandline elevations, present day rates of uplift, and geologically-inferred deglacial ice margin chronologies. The calibration generates a posterior probability distribution for the evolution of the ice sheets and related meltwater discharge. Regions and times where the probability distribution is flat point to where future field work can best improve constraints on deglaciation. Perhaps the biggest ongoing issue is an apparent shortfall of at least 10 m eustatic sea-level equivalent when model results are compared against far-field RSL datasets. Such a shortfall is not new. An examination of the evolution of past geophysically-constrained global deglacial ice sheet and ice load reconstructions will reveal a reliance of sticking extra ice where there's no data in order to fit far-field constraints. As new data has arisen, this extra ice load has been sequentially shifted to new regions. I will describe the key observational and physical constraints that limit continental ice volumes in the calibration, and finish with a few ideas of how this shortfall may be resolved.

Development of northern Nordic Seas deep convection during the Holocene – implications from surface and bottom water foraminiferal δ^{13}C records

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The Nordic Seas are an important region of deepwater formation and thus are crucial to understand the overturning circulation of the North Atlantic within the context of glacial-interglacial climate changes. Independent of different water mass properties, planktic carbon isotope records (δ^{13}C) from a number of sediment cores obtained across the northern Nordic Seas show a rather consistent pattern over the course of the Holocene. Data show that carbon isotope values were increasing since the early Holocene. They reached a maximum level between 7 and 6 ka and remained relatively stable thereafter. Ca. 3 ka they rapidly decreased. Benthic carbon isotope records from the north-central Nordic Seas, close to the present-day convection center of the Greenland Sea, reveal a similar trend as the planktic records. Although of lower amplitude, these bottom water data reflect the development of the regional deep convection in this region. A comparison with other proxy records and modelling results supports this presumption. The early to middle Holocene trend apparently reflects the development of deep convection after the last glacial period. The sudden decrease in the convection strength around 3 ka was most probably triggered by a strong solar irradiance minimum which, combined with low insolation, caused an expansion of the sea-ice cover over the convection center and enhanced stratification, thereby strengthening the entire halocline system.

Summer and winter proxy data from Ice Complex features in East Siberia dating back to 200 kyr

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Late Quaternary ice-rich permafrost deposits (Ice Complex) are widespread in the East Siberian Arctic and have analogue formations in Alaska and Canada (1). In particular, the shared characteristics of Ice Complex formations include syngenetic ice wedges (grown synchronic with sediment deposition), fine-grained ice-rich sediments, and a considerable amount of organic material. Such accumulations represent late Quaternary tundra-steppe environments in non-glaciated Beringia. The integration of permafrost-preserved summer (pollen) and winter (stable isotope composition of ice wedges, $\delta^{18}O$, δD, d excess) proxies allows for differing between seasonal trends of past climate and their roles on environmental dynamics.

Exposures at the southern coast of Bol'shoy Lyakhovsky Island of the New Siberian Archipelago (Figure 1) cover among the longest time interval of late Quaternary terrestrial permafrost deposition in East Siberia; from about 200 kyr ago (2) until present.

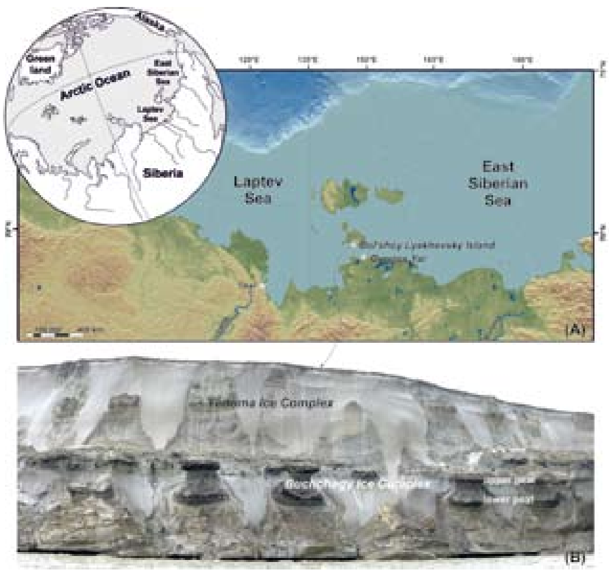

Fig. 1: Study location at the East Siberian Dmitry Laptev Strait (A), and typical lithostratigraphic contact of Yedoma Ice Complex (MIS3) and Buchchagy Ice Complex (MIS5e-b) in coastal exposures of Bol'shoy Lyakhovsky Island (B).

The most prominent Yedoma Ice Complex formed during Marine Isotope Stages 3-2 (MIS3-2) between about >55 and 22 kyr BP. Several sites expose older Ice Complex deposits below the Yedoma Ice Complex (Figure 1), the so-called Buchchagy Ice Complex (3). Peat horizons of Buchchagy Ice Complex yield $^{230}Th/U$ radioisotope disequilibria ages between 130 and 80 kyr (MIS5e-b). The oldest exposed Ice Complex on the Island is named Yukagir Ice Complex (MIS7a) and dated to about 200 kyr by $^{230}Th/U$ (2).

The narrow range of the MIS5 ice-wedge stable isotope data indicates steady moisture sources and cold winter conditions during ice-wedge formation. The mean $\delta^{18}O$ value is with -33 ‰ about 2 ‰ lower than that of the Yedoma interstadial (MIS3) ice wedges and about 1‰ lower than that of the Yukagir (MIS7a) ice wedges (Figure 2). Both suggest colder

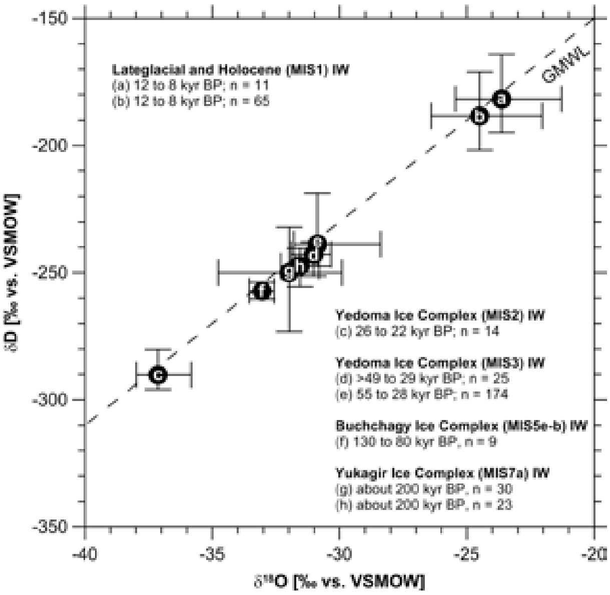

Fig. 2: Cross-plot compilation of stable-water isotope data in several generations of syngenetic ice wedges exposed at the southern coast of Bol'shoy Lyakhovsky Island. Ice-wedge data sources: Lateglacial and Holocene (MIS1) (4, 5); Yedoma Ice Complex (MIS2) (6); Yedoma Ice Complex (MIS3) (5, 7); Buchchagy Ice Complex (MIS5e-b) (unpublished); Yukagir Ice Complex (MIS7a) (5).

winter temperatures during the formation of MIS5 ice wedges. Coldest winter conditions are deduced from Yedoma (MIS2) ice wedges whose mean $\delta^{18}O$ value is about -37 ‰. The slope of 6.9 in a $\delta^{18}O$-δD co-isotope regression of MIS5 data (not shown) and the mean d excess value of 7.17 resemble those of the Yedoma stadial (MIS2) ice wedges and point to similar general atmospheric circulation dynamics but slightly differ for MIS3 and MIS7a data.

The pollen records of the MIS5 Buchchagy Ice Complex are well comparable to previously studied pollen records from MIS3-2 Yedoma Ice Complex deposits on Bol'shoy Lyakhovsky Island (6, 7, 8). Tundra-steppe vegetation is inferred for all studied periods. In this context, the MIS5e-b pollen record documents harsher summer conditions than during the MIS3 and rather similar conditions during MIS2. Characteristic are lower pollen concentrations and small amounts of re-deposited arboreal tree pollen (Pinaceae, Betula). Brassicaceae reaches high percentages in MIS5e-b spectra after Cyperaceae and Poaceae while Caryophyllaceae occupies the same position in MIS3 spectra. This feature supports the inferred harsher climate during MIS5 because Brassicaceae is more typical today for high Arctic vegetation than Caryophyllaceae. The MIS2 record reveals higher abundances of Artemisia then all other Ice Complex pollen spectra from Bol'shoy Lyakhovsky Island. Artemisia is indicative for dry conditions and hence, we assume a more humid climate during MIS7a, MIS5 and MIS3 than during MIS2.

Late Quaternary terrestrial permafrost is well preserved and accessible in coastal exposures of Bol'shoy Lyakhovsky Island. Paleoenvironmental proxy data unravel at least four generations of Ice Complex deposition ranging from the MIS7a to MIS2. The climatic variability that still allows Ice Complex formation is mirrored by relatively warm and moist (MIS7a, MIS3) or colder and drier (MIS5, MIS2) conditions. Short-term climate variations during MIS5 are however not resolved in the present records since numerical dates of Last Interglacial thermokarst deposits aligned to the MIS5 climatic optimum are still lacking.

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Thermokarst lake history and stable tundra vegetation since the 18th century in a Low Arctic setting, Yukon Territory, Canada

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Climatic change during historic times and their environmental impact are little known for much of the North American Arctic. Instrumental records from the Yukon Coastal Plain have a high uncertainty due to the remoteness of the region and extreme climatic conditions. We present a data set with about decadal temporal resolution reaching back to the mid 1700s. We analyzed a short sediment core from a thermokarst lake on the Yukon Coastal Plain in the Canadian Low Arctic for pollen, $^{210}Pb/^{137}Cs$, AMS ^{14}C, grain size distribution, stable carbon isotopes, and carbon and nitrogen contents. $^{210}Pb/^{137}Cs$ dating results show a chronological age-depth relationship and provide a high temporal resolution for the last 70 years. The AMS ^{14}C dates lie within the same range of each other. They have been interpreted as the result of a fluctuating reservoir effect in an undisturbed setting, as the biogeochemical record shows that the sediment is unmixed. The extrapolated age of the core is 280 years. The pollen record is characterized by high percentages of Betula, Alnus, Ericales, Cyperaceae and Poaceae. Stratigraphically constrained ordination supports two Pollen accumulation zones (PAZ). PAZ1 (AD 1740 – AD 1920) shows stable pollen percentages for most taxa, with some peaks in Ranunculus acris type pollen and a slight increase in Cyperaceae. PAZ2 (1920-2012) shows higher percentages of Alnus pollen, a slight decrease in Cyperaceae and a minor decrease in Artemisia. The other taxa remain stable throughout. We attribute the increase in Alnus pollen since about AD1920 to either an approaching Alnus shrubline or an increase in Alnus within its current distribution range south and east of the study area. The local to subregional vegetation remained relatively stable. Biogeochemical analyses show changes in organic carbon content and carbon to nitrogen ratio that we attribute to local hydrological changes. The lake level seems to have been lower and more variable pre 1920. This could be the result ofgeomorphological change caused by thawing permafrost. The regional climatic warming that took place during the last century[1] is not well represented in the pollen record.
We conclude that the effects of regional climatic warming during the last 100 years on local to subregional vegetation have largely been buffered within the ecosystem. Alnus, a taxon at the limit of its distribution range, and not present in the immediate study area, increases with climatic warming. The effect of thawing permafrost on local hydrology and thermokarst lake development can in part be inferred from the pollen signal in the lake sediment.

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Specificities of sea surface evolution across the last two interglacial cycles in the southwestern Nordic Seas - a comparison

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Reconstructions of past warm intervals provide essential data for future climatic projections. Special attention is given to the role of the circum-arctic regions, because of its direct influence on atmospheric and oceanic evolution beyond the actual polar environment. For example, the northward transfer of Atlantic-derived heat and moisture via Atlantic Meridional Overturning Circulation (AMOC) is highly sensitive to climatic perturbations in the polar North Atlantic (the Nordic Seas), where convective sinking of surface waters defines the functioning of AMOC (Broecker, 1991). This feature played a specific role in regional dissimilarities of the LIG evolution (Rasmussen et al., 2003; Van Nieuwenhove et al., 2011; Bauch et al., 2012) and makes the Nordic Seas a key site for deciphering interglacial surface ocean dynamics.

Here we are focused on reconstruction and comparison of surface circulation patterns across the last two interglacial cycles (MIS5e/LIG/Eemian and MIS1/Holocene). We employed two marine records from the southwestern Nordic Seas (i.e. western Iceland Sea), which remain poorly investigated, due to a scarcity of suitable paleoarchives. The modern surface hydrography here is defined by poleward inflow of Atlantic water and volumetrically equal surface outflow of polar waters, confined to the East Greenland Current (EGC) and controlling, therefore, also the outflow through the main “Arctic Gateway” – the Fram Strait. Records cover deglacial terminations, development of full interglacial conditions and climate deterioration, attributed to the new glacial inception. Methods applied are based on planktic foraminiferal assemblages, IRD counts and stable isotopes (O/C).

High magnitude of deglacial processes during the Saalian termination accounted for a more delayed LIG marine optimum in comparison to an early Holocene Thermal Maximum (HTM) in the Nordic Seas. Restricted occurrence of subtropical species B. megastoma in the Iceland Sea during the late phase of MIS6 evidences for an early advection of subducted Atlantic waters to the site. Thus, meltwater pulses in the eastern Nordic Seas originated from decaying ice sheets, suppressed the propagation of Atlantic water along its modern path, though deflected the flow westwards, what brought warm subsurface conditions in the central Nordic Seas. After the Weichselian glacial peak increased proportions of T. quinqueloba prior to the Bølling-Allerød interstadial suggest a notable AMOC intensification also during the early Weichselian deglaciation (Böhm et al., 2015); the decay of Fennoscandian and Barents ice-sheets provided the freshwater which suppressed the northward propagation of Atlantic water along the Norwegian coast. Thus, early though weak advection of Atlantic water to the central Nordic Seas was counterbalanced by suppressed outflow of polar waters from the Arctic Ocean via EGC. Albeit a generally similar concept was employed for interpretating the B. megastoma occurrence during the penultimate deglaciation, we claim for a principally different development of the water column between the two interglacials, possibly with a much thicker halocline and highly stratified water column during the early LIG. These features are attributed to non-similarities between Saalian and Weichselian ice sheet sizes, their melting histories as well as the interrelation of these processes with differences in orbital forcing.

Planktic foraminiferal assemblages from the Iceland Sea point towards a comparable sea surface temperature (SST) development for both interglacials. But full LIG conditions, which exhibit a two-phase development, had warmest SSTs in the second phase, as inferred from the highest proportions of subpolar species. The HTM was delayed in the Iceland Sea by about 2 kyrs compared to the eastern Nordic Seas, and developed after 9 ka, lasting until about 5 ka. Its regional SST maximum is similar to that of the LIG, indicating the existence of quite comparable peak surface conditions in the southwestern Nordic Seas for this interglacial phase.

For the cooling trend noticed in the western Iceland Sea after 5 ka we hypothesize an increase in polar waters derived from a strengthened EGC due to enhanced outflow from the Arctic Ocean through western Fram Strait. That southwards expansion of polar waters and associated sea ice export, was considerably amplified after Arctic shelf flooding terminated in combination with lowered insolation and a positive albedo feedback (Bauch et al., 2001; Polyak et al., 2011).

In summary, our study supports the notion of the polar amplification of a global climate trend. However, the interglacial comparison also underscores the need to critically reassess reconstructed past ocean/atmosphere circulation patterns, not only in regard to their temporal resolutions, but also to their smaller spatial scales.

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Quantitative micropalaeontological and sedimentary facies analysis of surface samples from the Lomonosov Ridge

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The Arctic Ocean is a mediterranean type basin[1] that is characterized by a restricted exchange of water masses with the world ocean and by the export of large volumes of freshwater[2]. Moreover its seasonal variability of sea ice cover is a prominent indicator[3] and amplifier[4] of climate change.
Sedimentary records are valuable archives on changing and variable environmental processes. Hereby, knowledge on inventories of surface sediments and how they are linked to environmental and sedimentary processes in the modern Arctic Ocean is essential to apply this knowledge to the long-term sedimentary record. In order to interpret sedimentary records properly a comprehensive knowledge and quantification of sedimentary processes in the Arctic Ocean is necessary. These include 1) transport by iceberg and sea-ice, 2) ocean currents, 3) fluvial input, 4) the organic carbon cycle and 5) sediment mass-wasting (including debris flows, slides and turbidity currents)[5].
Albeit each process leaves a characteristic imprint in the sedimentary record it is still difficult to identify the contribution of interacting environmental processes. A dominant factor is the variable preservation potential of biogenic material (organic/calcareous/siliceous) that is connected to 1) the generally low primary production in the Arctic Ocean that is increased only at sea ice margins[6,7], 2) the interaction of biological and chemical processes in the water column and 3) the decay of biogenic material at the sediment-water interface and in the near-surface sediments. In particular O2-rich bottom waters play an important role since these induce decomposition of organic matter, and higher amounts of decaying organic matter leads to a drop in pH and corrosion of calcareous tests[8].
In order to increase the understanding on these interacting biological to chemical processes in the modern Arctic Ocean, thus under known environmental conditions, a comprehensive facies analysis was carried out on surface samples from the Lomonosov Ridge. Samples were collected during the RV Polarstern-Expedition PS87 (ARK-XXVIII/4) in 2014 from the surface centimeter of giant boxcor-

er-sites located at water depths of 731 m to 4187 m. A comprehensive coarse fraction analysis was conducted on the >63 µm size fraction to characterize the sediment compositions. Terrigenous components include quartz, feldspar and opaque minerals and biogenous components benthic foraminifers (calcareous and agglutinated respectively), planktic foraminifers, bioclasts and ostracodes.

Special emphasis was placed on ostracode thanatocoenosis since different ostracode species occur within specific water-masses and thus are useful indicators of bottom water-mass characteristics. Additionally ostracodes may be valuable to reconstruct summer sea ice cover[9-12]. Hereby, of special interest is Acetabulastoma arcticum which is an ecto-parasite on some Gammarus spp. (amphipoda) that lives within the sea ice[13]. Since Acetabulastoma arcticum was found in 94% of samples from locations with at least 75% sea ice concentration during summer and due to the fact that it reproduces from March through September[14] it is a distinctive proxy of summer sea ice concentration[11].

The coarse fraction data (including ostracode indicator species) were combined with spatial proxy-data of sea-ice cover, primary production and bathymetry in order to show correlating patterns.

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