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HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

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Berichte

zur Polar- und Meeresforschung

Reports on Polar and Marine Research

Dynamic Poles and High Mountain Environments

29th International Polar Conference
Rauris, 16–20 September 2024
Austrian Polar Research Institute and
German Society for Polar Research

Edited by

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HELMHOLTZ GEMEINSCHAFT

Die Berichte zur Polar- und Meeresforschung werden vom Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar- und Meeresforschung (AWI) in Bremerhaven, Deutschland, in Fortsetzung der vormaligen Berichte zur Polarforschung herausgegeben. Sie erscheinen in unregelmäßiger Abfolge.

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Titel: Pasterze und Hufeisenbruch in Auflösung
Foto: Christoph Ruhsam, Media Officer, Austrian Polar Research Institute

Cover: Pasterze and Hufeisenbruch in decay
Photo: Christoph Ruhsam, Media Officer, Austrian Polar Research Institute

29th International Polar Conference

Dynamic Poles and High Mountain Environments

Austria, Rauris, September 16 – 20, 2024

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Dear Colleagues, Friends, and Enthusiasts of Polar and High Mountain Research,

We are looking forward to welcoming you to the 29th International Polar Conference, "Dynamic Poles and High Mountain Environments", to be held at the Mesnerhaus in Rauris, Austria, from September 16 – 20, 2024. Rauris is located at the foot of the Sonnblick mountain with its observatory, founded in 1886, and is a center for interdisciplinary climate and environmental research. Co-organized by the German Polar Research Society and the Austrian Polar Research Institute, this conference is a key event for fostering interdisciplinary dialogue and collaboration among researchers and enthusiasts dedicated to exploring and understanding the planet's polar and high mountain environments.

The conference promises a comprehensive program featuring scientific talks, an extensive poster session, and abundant opportunities for intensive discussions. A workshop by the "Association of Polar Early Career Scientists" will kick off the conference, providing an invaluable networking opportunity for participants. We are especially excited about the contributions from early career researchers, who will present their latest findings, and contributing fresh perspectives to our field. Another highlight will be the launch of a new working group within the German Society of Polar Research, dedicated to Polar Politics. Additionally, the conference will host an art exhibition, where artists from various European countries will share their experiences and perspectives on the effects of the Anthropocene on polar regions and high mountains. This blend of science and art underscores the multidisciplinary nature of our field and the broad impacts of our research.

The public evening lecture, "Einblicke in die abenteuerliche Welt der wissenschaftlichen Polarexpeditionen und was wir daraus lernen können", offering valuable insights into the adventurous world of scientific polar expeditions and the lessons they impart.

Our scientific sessions cover a broad spectrum of critical topics, including:

- Atmospheric, Sea-Ice, and Ocean System Dynamics
- Biology and Biogeography in Polar Environments
- Cool Classes – Polar Educators
- History and Future of International Cooperation in Polar Regions
- Integrating Social and Natural Sciences: Collaborative and Inclusive Approaches Beyond Traditional Boundaries
- Mass Balance and Evolution of Glacier Systems in a Changing Climate
- Permafrost in a Warming World: Impacts and Consequences
- Physical Processes of Glaciers and Ice Sheets in their Environment
- Polar Earth Sciences
- Snow as an Interdisciplinary Field of Research (Waalem Polar Cluster)
- The Anthropocene and Climate Change in Polar and Mountain Regions

The conference will conclude with an exciting excursion program, featuring:

- From Sonnblick to the Arctic: A science hike covering topics such as gold mining, climate and glacier history, and research at the Sonnblick observatory.
- Vanishing Ice: An excursion to Austria's largest glacier, the Pasterze, focusing on glacier and climate history and the results of recent interdisciplinary research.
- Kings of the Skies: A guided tour along the Kruml valley, offering explanations on the vulture project funded by the WWF.

We look forward to your active participation in these sessions and discussions, where we aim to deepen our understanding of the dynamic poles and high mountain environments. Your contributions are essential to the success of this conference. We are confident that this meeting will inspire innovative approaches to the scientific challenges we face.

Warm regards,

Cornelia Spiegel
Wolfgang Schöner
Heidemarie Kassens

29th International Polar Conference
Dynamic Poles and High Mountain Environments
16. – 20. September 2024, Mesnerhaus Rauris, Austria

Sunday, 15. September 2024

16:00 – 18:00 APECS (Gemeindeamt)

Monday, 16. September 2024

08:30 – 09:00 Registration, Mesnerhaus

09:00 – 10:30 Opening and Honors

10:30 – 11:00 **Coffee break, Hotel Platzwirt**

Mass balance and evolution of glacier systems in a changing climate

11:00 – 11:15 *Daniel Binder (Institute for Geosciences, Potsdam University) et al.*
Timing and trigger(s) of a periodic Jökulhlaup at Zackenberg, NE-Greenland

11:15 – 11:30 *Alexandra M. Zuhr (University of Tübingen) et al.*
Investigating recent surface mass balance changes in Dronning Maud Land using airborne radar data

11:30 – 11:45 *Yuting Dong (Alfred-Wegener-Institute Helmholtz Center for Polar and Marine Research) et al.*
Geodetic mass balance estimation and future evolution projection of glaciers flowing into Wordie Bay on the West Antarctic Peninsula

11:45 – 12:00 *Jan Erik Arndt (Universidad de Concepción/ Universität für Bodenkultur)*
The decline of a caldera-filling glacier at Volcán Sollipulli, Chile

12:00 – 12:15 *Frank Wilhelms (Alfred-Wegener-Institute Helmholtz Center for Polar and Marine Research) et al.*
Towards the Beyond Epica – Oldest Ice – Little Dome C (beldc) 1.5 ma ice core record

12:15 – 12:30 *Andrea Securo (University of Venice) et al.*
Area, Volume and ELA changes of West Greenland local glaciers and ice caps over the last 35 years

Integrating social and natural sciences: collaborative and inclusive approaches beyond traditional boundaries

12:30 – 12:45	*Andreas Trügler (University of Graz) et al.* Sermilik research station in East Greenland
12:45 – 13:00	*Peter Schweitzer (University of Vienna) et al.* Arctic transport infrastructures and local communities: What works and what doesn't
13:00 – 13:15	*Ria-Maria Adams (University of Vienna/ University of Lapland)* Temporalities of Arctic Tourism in Finnish Lapland: Infrastructural Perspectives
13:15 – 14:30	**Lunch, Hotel Platzwirt**

History and future of international cooperation in polar regions

14:30 – 14:45	*Alexander Jost (Salzburg University)* Conceiving the Arctic in middle period China
14:45 – 15:00	*Erki Tammiksaar (Estonian University of Life Sciences and Universitity Tartu, Abteilung für Geografie, Tartu, Estland), Cornelia Lüdecke (Universität Hamburg)* From a frozen ocean to a continent - about the discovery of Antarctica
15:00 – 15:15	*Ursula Rack (Gateway Antarctica, University of Canterbury, New Zealand)* History from the freezer: historical maps and satellite imagery compared
15:15 – 15:30	*Barbara Schennerlein (Independent researcher)* German polar research in the 1920s as reflected in international relations
15:30 – 15:45	*Evgen Dykyi, Andrii Fedchuk (National Antarctic Scientific Center, Kyiv, Ukraine)* The contribution of Ukraine's key Antarctic infrastructure facilities to international scientific cooperation
15:45 – 16:00	*Gerlis Fugmann (International Arctic Science Committee ASC)* Defining priorities for Arctic research and international cooperation for the next decade: from ICARP IV to IPY 5
16:00 – 16:30	**Coffee break, Hotel Platzwirt**
16:30 – 18:00	**Poster session, Hotel Platzwirt**
18:00	Opening of the Art Exhibition **Welcome reception, Hotel Platzwirt**

Tuesday, 17. September 2024

08:30 – 09:00 Registration, Mesnerhaus

DFG SPP 1158 Antarctic research: report colloquium

09:00 – 09:30 *Stefanie Arndt (Alfred-Wegener-Institute Helmholtz Center for Polar and Marine Research/ Universität Hamburg) et al.*
Implications of inherent snow property variability on the Antarctic Sea ice mass budget

09:30 - 09:45 *Carolin Mehlmann, Saskia Kahl (Otto-von-Guericke Universität Magdeburg) et al.*
A hybrid ice model based on particle and continuum methods

09:45 – 10:00 *Nina Maaß, Stefanie Arndt (Alfred-Wegener-Institute Helmholtz Center for Polar and Marine Research)*
Snow cover evolution on sea ice in the Weddell Sea from autonomous measurements and 1-D model simulations

10:00 – 10:15 *Silvia Henning (TROPOS) et al.*
Antarctic cloud condensation NUCLEI (CCN) and ice nucleating particles (INP) *Neumayer Station III*

10:15 – 10:30 *Ying Ye (Alfred-Wegener-Institute Helmholtz Center for Polar and Marine Research) et al.*
How can we learn from an iron fertilisation experiment about the marine biological carbon pump?

10:30 – 11:00 Coffee break, Hotel Platzwirt

11:00 – 11:30 *Johann Klages (Alfred-Wegener-Institute Helmholtz Center for Polar and Marine Research)*
Evolution of the Antarctic ice sheet since its inception 34 million years ago and using this knowledge for advancing numerical model simulations

11:30 – 11:45 *Daniela Roehnert (University of Bremen) et al.*
Above or below? Delving into the foundations of the Transantarctic Mountains

11:45 – 12:00 *Nina-Marie Lešić (MARUM - Center for Marine Environmental Sciences, University of Bremen) et al.*
Late Pleistocene and Holocene sediments around South Georgia: Archives for climate-induced signals in sub-Antarctica since the last glaciation

12:00 – 12:15 *Clara Henry (Stockholm University) et al.*
The dynamics of Antarctic pinning points

12:15 – 12:30 *Denise Kulhanek (Kiel University) et al.*
Sediment records from the Siple Coast below the Ross Ice Shelf: Update from the first season of the SWAIS-2C project

Permafrost in a warming world: impacts and consequences

12:30 – 12:45 *Jan Beutel (University of Innsbruck) et al.*
The Matterhorn Cryosphere Observatory: Long-term monitoring of steep-bedrock, high-altitude mountain permafrost

12:45 – 13:00 *Susanna Gartler (Universität Wien) et al.*
Local risks from Arctic permafrost thaw – A transdisciplinary, comparative analysis

13:00 – 13:15 *Helena Bergstedt (b.geos) et al.*
High-salinity liquid water as a source of uncertainty in bedfast lake ice mapping

13:15 – 14:30 **Lunch, Hotel Platzwirt**

The Anthropocene and climate change in polar and mountain regions

14:30 – 14:45 *Sandip Tanu Mandal (Mobius Foundation, New Delhi, India / Jawaharlal Nehru University) et al.*
Impacts of climate change on the glaciers of high-altitude cold desert of Lahaul in the western Himalayas, India

14:45 – 15:00 *Mia Hurst (University of St Andrews) et al.*
The ecological impacts of productive polynyas responding to future climate change

15:00 – 15:15 *Gunther Seckmeyer (Leibniz University of Hannover, Institute of meteorology) et al.*
Measuring the sky spectral radiance within seconds in polar and mountainous regions

15:15 - 15:30 *Thorsten Bauersachs (RWTH Aachen University) et al.*
Heterocyte glycolipids: Novel organic proxies to reconstruct climate change in polar regions

Integrating social and natural sciences: collaborative and inclusive approaches beyond traditional boundaries

15:30 – 15:45 *Albert van Wijngaarden (University of Cambridge)*
Lessons from the interpolar conference (September 2023) about commonalities between social and legal science issues in the arctic and third pole regions

15:45 – 16:00 *Vera Solovyeva (Arctic Studies Center, George Mason University) et al.*
Challenges in developing decolonial research methods. Modeling the sustainable indigenous community in the Sakha Republic (Russia)

16:00 – 16:30 **Coffee break, Hotel Platzwirt**

16:30 – 16:45 *Thierry Rodon (Université Laval) et al.*
Arctic people double exposure: energy transition and climate change

16:45 – 17:00 *Olga Povoroznyuk (University of Vienna) et al.*
Arctic coastal communities: infrastructure for a sustainable future?

17:00 – 17:15 *Jerbelle Elomina (BOKU University) et al.*
Economic development and socio-cultural impacts in the European Arctic: perspectives and comparative insights with Alpine regions

Snow as an interdisciplinary field of research (Waalem Polar Cluster)

17:15 – 17:30 *Svetlana Stuefer (University of Alaska Fairbanks, College of Engineering and Mines) et al.*
Overview of NASA SNOWEX Alaska field campaigns in 2022-2023

17:30 – 17:45 *Helene Hoffmann (University of Tübingen) et al.*
The Cryosity Project - Artistical preservation of snow crystals and glacier ice samples

17:45 – 18:00 *Birgit Sattler (University of Innsbruck/ Austrian Polar Research Institute) et al.*
The Waalem Polar Cluster (the future lack of) snow and how to deal with it – or not

18:00 – 19:00 **Side meeting A, Gemeindeamt Rauris**

19:00 Klemens Weisleitner (University of Innsbruck): Einblicke in die abenteuerliche Welt der wissenschaftlichen Polarexpeditionen und was wir daraus lernen können, Schulzentrum Rauris

Wednesday, 18. September 2024

08:30 – 09:00 Registration, Mesnerhaus

Atmospheric, sea-ice and ocean system dynamics

09:00 – 09:15 Jens Hölemann *(Alfred-Wegener-Institute Helmholtz Center for Polar and Marine Research) et al.*
Water mass transformation in the northern Barents and Kara Seas: Is the system changing?

09:15 – 09:30 *Felix Müller (Deutsches Geodätisches Forschungsinstitut der Technischen Universität München) et al.*
Improving the representation of the Arctic Sea level, ocean currents and tides using multi-mission satellite altimetry

09:30 – 09:45 *Maria Osińska (University of Gdańsk)*
Impact of westerly winds on Antarctic Bay circulation, glacial water spreading and formation of feeding hotspots

09:45 – 10:00 *Marcel Nicolaus (Alfred-Wegener-Institute Helmholtz Center for Polar and Marine Research) et al.*
Characteristics and composition of sea ice in the Central Arctic Ocean

10:00 – 10:15 *Océane Hames (WSL Institute for Snow and Avalanche Research SLF) et al.*
Numerically predicting drifting snow deposition around icebergs, polar buildings and solar power plants

10:15 – 10:30 *Karl Kortum (German Aerospace Center DLR e.V.) et al.*
Towards Pan-Arctic Sea ice freeboard maps at 100 m resolution

10:30 – 11:00 Coffee break, Hotel Platzwirt

DFG SPP 1158 Antarctic research: Report colloquium

11:00 – 11:30 *Rolf Gradinger (UiT The Arctic University of Norway)*
Arctic and Antarctic marine ecosystem – responses to environmental change

11:30 – 11:45 *Helena Herr (Universität Hamburg)*
SPP1158 project: Recovery status and ecology of fin whales at the Western Antarctic Peninsula

11:45 – 12:00 *Heike Link (University of Rostock) et al.*
Role of meio- and macrofauna in benthic ecosystem functioning: testing effects of different ice cover regimes

12:00 – 12:15 *Doris Ilicic (Leibniz-Institute für Gewässerökologie und Binnenfischerei IGB) et al.*
Exploring the unseen: chytrid fungi in Arctic and Antarctic microphytobenthic communities

12:15 – 12:30 *Judith Piontek (Leibniz Institute for Baltic Sea Research Warnemünde) et al.*
Bacterial transformations of dimethylsulfoniopropionate in the Weddell Sea

Atmospheric, sea-ice and ocean system dynamics

12:30 – 12:45 *Renato R. Colucci (Institute of Polar Sciences - National Research Council of Italy) et al.*
The impact of an atmospheric river triggers debris and slush flows on Disko Island, West Greenland

12:45 – 13:00 *Florina Schalamon (University of Graz) et al*.
Exploring the influence of large-scale atmospheric patterns on Greenland air temperature: a century-long analysis focused on warming periods

13:00 – 13:15 *Günther Heinemann (University of Trier, Germany)*
A case study of a wintertime low-level jet associated with a downslope wind event at the Tiksi observatory (Laptev Sea, Siberia) using the regional climate model CCLM

13:15 – 14:30 **Lunch, Hotel Platzwirt**

14:30 – 14:45 *Doyeon Kim, Patrick C. Taylor (NASA Langley Research Center, Hampton, Virginia)*
What factors explain the current Arctic Albedo and its future change?

14:45 – 15:00 *Tereza Uhlíková (Finnish Meteorological Institute, Helsinki, Finland/ Institute for Atmospheric and Earth System Research, University of Helsinki, Finland) et al.*
Effects of Arctic sea-ice concentration on turbulent and radiative surface fluxes in four atmospheric reanalyses

Polar Earth Sciences

15:00 - 15:15 *Frank Lamy (Alfred-Wegener-Institute Helmholtz Center for Polar and Marine Research), Gisela Winckler (Lamont-Doherty Earth Observatory, Columbia University)*
Five million years of Antarctic circumpolar current strength variability

15:15 – 15:30 *Bernhard Diekmann (Alfred-Wegener-Institute Helmholtz Center for Polar and Marine Research) et al.*
Natural Heritage af Lake Wiyashakimi, Subarctic Canada

15:30 – 15:45 *Mirko Scheinert (Technische Universität Dresden) et al.*
The surveying of Gaussberg, East Antarctica

15:45 – 16:00 *Karsten Gohl (Alfred-Wegener-Institute Helmholtz Center for Polar and Marine Research) et al.*
Past dynamics of the West Antarctic Ice Sheet from marine seismic data and drill records: What have we learned?

16:00 – 16:30 **Coffee break, Hotel Platzwirt**

Cool Classes – Polar Educators

16:30 – 16:45 *Rainer Lehmann, Franziska Warringsholz (Europa-Universität Flensburg)*
Coole Klassen in Antarktika (CIA)

16:45 – 17:00 *Kamilla Oliver (Independent scholar)*
Greenlandic immersion

17:00 – 18:00 **DGP General meeting**

18:00 – 19:00 **Side meeting B, Gemeindeamt Rauris**

19:00 **Conference dinner, Hotel Platzwirt**

Thursday, 19. September 2024

08:30 – 09:00 Registration, Mesnerhaus

Polar Earth Sciences

09:00 – 09:15 *Kenichi Matsuoka (Norwegian Polar Institute) et al.*
Quantarctica 4 - Looking beyond our own disciplines with an updated version of the interdisciplinary mapping tool for Antarctic research

09:15 – 09:30 *Frank Lisker (Universität Bremen) et al.*
Meander intrusion in the Mountaineer Range: Local igneous pulse with global climate impact

09:30 – 09:45 *Cornelia Spiegel (Institut für Geowissenschaften, Universität Bremen) et al.*
Past landscape evolution and tectonics of West Antarctica

09:45 – 10:00 *Katrin Meier (University of Bremen) et al.*
The Eurekan Orogeny and the De Geer fracture zone from the North Greenland perspective

10:00 – 10:15 *Andreas Läufer (Bundesanstalt für Geowissenschaften und Rohstoffe) et al.*
Trust the thrust? Ross-orogenic versus post-Ross tectonics in northern Victoria Land, Transantarctic Mountains

10:15 – 10:30 *Antonia Ruppel (Bundesanstalt für Geowissenschaften und Rohstoffe) et al.*
A glance beneath Antarctica's glaciers - what can we learn from potential field data about the Transantarctic Mountains?

10:30 – 11:00 Coffee break, Hotel Platzwirt

Biology and biogeography in polar environments

11:00 – 11:15 *Luisa Federwisch (Alfred-Wegener-Institute Helmholtz Center for Polar and Marine Research) et al.*
Microbial abundance, richness and community composition in Antarctic deep-water sponges are related to host histology

11:15 – 11:30 *Miao Fan (Alfred-Wegener-Institute Helmholtz Center for Polar and Marine Research) et al.*
3D Photogrammetry and ROV acoustic data for ultra-high resolution benthic habitat mapping in Powell Basin

11:30 – 11:45 *Friederike Weith (University of Rostock) et al.*
Polychaete community distribution: The challenge of identifying functional and taxonomic patterns using bioregionalization approaches

11:45 – 12:00 *Ulf Karsten (University of Rostock, Institute of Biological Sciences)*
Dark survival mechanisms in polar benthic diatoms

12:00 – 12:15 *Cora Hörstmann (Alfred-Wegener-Institute Helmholtz Center for Polar and Marine Research) et al.*
Picoplankton connectivity pattern indicates increasing dominance of Prokaryotes in warmer Arctic Fjords

12:15 – 12:30 *Fritz Hertel (Umweltbundesamt) et al*.
First ASPA initiated by Germany protects the largest Adélie penguin population of the Antarctic Peninsula

12:30 – 12:45 *Marie-Charlott Rümmler (ThINK – Thuringian Institute of Sustainability and Climate Protection GmbH, Jena, Germany) et al.*
Survey of a snow petrel nesting site to inform designation of an Antarctic specially protected area

Physical processes of glaciers and ice sheets in their environment

12:45 – 13:00 *Sarah Elise Sapper (University of Copenhagen) et al.*
Methane emissions from the meltwater of the Greenland ice sheet and mountain glaciers – occurences, temporal dynamics and how to measure them

13:00 – 13:15 *Kornelia Wójcik-Długoborska (Institute of Biochemistry and Biophysics Polish Academy of Sciences) et al.*
A 10-years satellite study of glacial meltwater plumes in the South Shetland Islands

13:15 – 14:30 **Lunch, Hotel Platzwirt**

14:30 – 14:45 *Lea Hartl (University of Alaska Fairbanks) et al.*
Air- and spaceborne remote sensing reveals glacier runoff driven sediment plumes in Kachemak Bay, Alaska

14:45 – 15:00 *Helmut Rott (ENVEO IT) et al.*
Response of Antarctic Peninsula outlet glaciers to changes in atmospheric and oceanic forcing

15:00 – 15:15 *Sindhu Ramanath Tarekere (German Aerospace Center DLR) et al.*
Investigation of tidal grounding line migration using SAR line-of-sight offset time series

15:15 – 15:30 *Johanna Kerch (Geoscience Centre, University of Göttingen) et al.*
Variability of crystal-preferred orientation in high-resolution data from EGRIP ice core

15:30 – 15:45 *Sonja Berg (University of Cologne) et al.*
East Antarctic ice sheet instabilities – field work in un-glaciated coastal areas during the RV Polarstern voyages EASI 1 - 3

15:45 – 16:00 **Closing Ceremony**

16:00 – 16:30 **Coffee break, Hotel Platzwirt**

16:30 – 18:00 **Poster session, Hotel Platzwirt**

18:00 – 19:00 **Side meeting C, Gemeindeamt Rauris**

Friday, 20. September 2024

Excursions

- From Sonnblick to the Arctic: A science hike covering topics such as gold mining, climate and glacier history, and research at the Sonnblick observatory.

- Vanishing Ice: An excursion to Austria's largest glacier, the Pasterze, focusing on glacier and climate history and the results of recent interdisciplinary research.

- Kings of the Skies: A guided tour along the Kruml valley, offering explanations on the vulture project funded by the WWF.

Contents

ICING ON THE FOREFIELD OF A LAND-TERMINATING OUTLET GLACIER IN WEST GREENLAND

Jakob Abermann[1], Andreas Trügler[1], Harald Zandler[1], Kerstin Rasmussen[1], Florina Schalamon[1], Sebastian Scher[1], Wolfgang Schöner[1]

[1]Department of Geography and Regional Sciences, University of Graz, Graz, Austria

In this contribution, we share observations of a braided river plain adjacent to the little ice age moraine of a land-terminating outlet glacier in West Greenland at around 71°N. Two spring visits in a row (2023 and 2024) made us opportunistic witnesses of a considerable plain with refrozen water; during April 2024 we observed liquid surface water at air temperatures below -10°C. We report on observations of extent, genesis and decay of the ice plain and hypothesize on drivers leading to it. Based on time-lapse and high-resolution satellite imagery we observe build-up of the ice plain during core winter until spring and decay throughout the melting season. We find that long after the adjacent glacier and ice-free surroundings are snow-free, the icing plain still is in place. Furthermore, we estimate extent and thickness of the ice cover based on satellite imagery and UAV photogrammetry and plan to compare spring and summer conditions applying DEM differencing. We use automated weather station data near the ice plain to determine atmospheric conditions for surface meltwater generation. We discuss other potential water sources related to groundwater aquifers in porous ground moraine material. Assessing the volume of the generated ice plain, we determine the amount of energy needed to melt it entirely based on surface energy exchange considerations. We attempt to contextualize a buffering component of melting the ice two times (once during generation of freshwater that is at disposal for freezing and once for removing it during the melting season) and consider conditions that make such a meltwater icing plain formation favourable. We discuss research avenues based on isotope analysis of the ice that may be able to highlight meltwater origin. Based on qualitative assessment of satellite imagery we assess catchments nearby that have the potential of icing generation.

Integrating Social and Natural Sciences: Collaborative and Inclusive Approaches Beyond Traditional Boundaries

TEMPORALITIES OF ARCTIC TOURISM IN FINNISH LAPLAND: INFRASTRUCTURAL PERSPECTIVES

Ria-Maria Adams[1] [1]University of Vienna/ University of Lapland

Tourism infrastructures in the Fennoscandian Arctic tend to cater to the imaginations of tourists rather than engaging in sustainable practices co-created with local communities. This trend is exemplified by the promotion of the mythical figure of Santa Claus, now a tangible presence in Finnish Lapland. Additionally, activities such as northern lights tours, Arctic engagement proposals and weddings, husky and reindeer safaris, and the popularity of “igloo” hotels are visible in Fennoscandian Arctic destinations, accompanied by a steady increase in flights to Europe’s Arctic. Infrastructure is continually being developed to meet the needs of tourists and to accommodate the increasing influx of visitors. However, this growth in tourism brings with it challenges and consequences, as highlighted by this presentation, which is based on a long-term ethnographic study within the framework of the InfraNorth project, focusing on transport infrastructures.

The promotion of Arctic destinations increasingly resembles what has been termed by Herva et al. 2020 as the “Disneyfication of the Arctic”, impacting local communities and their way of life. These tourism practices reflect the temporal dynamics of an era where the significance of social media and self-presentation has become paramount. By examining the temporalities of Arctic tourism in Finnish Lapland through the lens of infrastructure, it becomes evident that certain aspects of the tourism industry are fragile, leading to adverse consequences for local communities and residents amidst the rapid growth.

Integrating Social and Natural Sciences: Collaborative and Inclusive Approaches Beyond Traditional Boundaries

ACCUMULATION OF TRACE ELEMENTS AND POLYCYCLIC AROMATIC HYDROCARBONS IN SOILS OF EAST ANTARCTICA

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Although Antarctica is considered as one of the most pristine areas on Earth, increased anthropogenic forcing (scientific operations, functioning of the numerous scientific stations, logistics, tourism activities) raised numerous environmental risks in recent decades. Anthropogenic impact may cause various disturbance of the environment including soil (i.e., soil profile heterogeneity, mechanical disturbance, soil compaction, appearance of artificial components, involvement of various contaminants). Soil is one of the most important components to investigate in regard of trace metals and polycyclic aromatic hydrocarbon pollution since it can accumulate and bond these organic and inorganic pollutants. Moreover, soils play a significant role in processes of accumulation, mobilization, redistribution of chemical elements within landscapes, and ecosystems. The purpose of this work was to analyse the accumulation of various potential contaminants (eight trace elements and polycyclic aromatic hydrocarbons) in soils across different landscapes of East Antarctica ice-free areas (Larsemann Hills, Pravda coast and Bunger Hills). Various human activities have been found to be responsible for increase of metal levels in studied Antarctic environments. We also revealed a specific role of ornithogenic factor and moss cover for distribution of contaminants. Ornithogenic soils were characterized by higher rates of accumulation of some trace metals and metalloids (especially zinc and copper) compared with other investigated “pristine” sites without significantly visible traces of guano inputs. In general term, obtained geoaccumulation index for trace elements in all samples were under or slightly above the 0 level, indicating low to moderate pollution of the studied soils. Our study revealed the predominance of light molecular weight PAHs (fluorene and acenaphthylene) in studied soils. Results of our study are not completely in agreement with the idea of a practically uncontaminated Antarctic ecosystem which was previously reported for Eastern Antarctica ice-free areas (Gasparon and Matschullat, 2006). Results of principal component analysis revealed the necessity for further detailed research on interactions of trace metals with soil organic matter for better understanding of their biogeochemistry in the Antarctic environment. Although most of contaminated sites were found in anthropogenically affected areas, accumulation of some elements in guano-derived and moss materials were associated with higher values for soil pollution indices in natural soils, as well. High contents of organic matter in ornithogenic habitats could increase trace metal mobility, environmental risks for surrounding terrestrial environments should be considered.

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Atmospheric, sea-ice, and ocean system dynamics

LEARNING FROM LOCAL SNOW PROPERTIES FOR LARGE-SCALE ANTARCTIC ICE PACK VOLUME: THE SNOWFLAKE PROJECT

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Snow depth on sea ice is an essential climate variable, as it dominates the energy and momentum exchanges across the atmosphere-ice-ocean interfaces and actively contributes to the sea ice mass balance. Antarctic sea ice is characterized by a year-round snow cover preventing/delaying surface melt in summer, and amplifying sea ice growth through extensive snow-to-ice conversion processes. The lack of knowledge on both snow depth and its complex seasonal stratigraphy causes substantial uncertainties in large-scale data products from satellite remote sensing. Also, the accurate representation of small-scale snowpack processes in numerical climate models remains a major challenge, leading to critical uncertainties in estimates of the Antarctic sea ice energy and mass budgets.

This poster presents the new Young Investigator Group SNOWflake project that will test the hypothesis that seasonal variations in snowpack properties on Antarctic sea ice are sensitive indicators of changing atmospheric forcing, as they could trigger snow-albedo feedbacks that accelerate sea ice melting and retreat. Climate warming may reverse the contribution of widespread snow-to-ice conversion processes to a positive Antarctic sea ice mass balance, and lead to increased surface melting, as currently prevalent for Arctic sea ice - with potential feedbacks for Earths' climate. However, those feedbacks are not yet thoroughly investigated.

Addressing this key gap, SNOWflake will describe the temporal evolution of seasonal processes and properties of the Antarctic sea ice snowpack across all relevant spatial scales. The resulting

improved snow parameterization will be linked to satellite remote sensing measurements in order to develop a novel and more accurate Antarctic sea ice thickness data product. Finally, the improved snow process formulations will be introduced into climate models to achieve an enhanced atmospheric sensitivity, and thus reduced uncertainties in sea ice forecasts and predictions for the Southern Ocean. These advances will then allow us to understand implications for the occurrence of characteristic Arctic snow processes, such as melt pond formation, on Antarctic sea ice, and vice versa, in order to draw appropriate conclusions on snow as an indicator and modulator of climate warming in the polar regions.

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IMPLICATIONS OF INHERENT SNOW PROPERTY VARIABILITY ON THE ANTARCTIC SEA ICE MASS BUDGET

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Snow cover on Antarctic sea ice plays a critical role in influencing the sea ice mass and energy budgets through intricate physical processes. This study presents in-situ observations of snowpack properties collected during multiple expeditions to the Weddell Sea since the 1990s, highlighting significant seasonal and regional variations.

It is therefore essential to distinguish between snow covers on seasonal and perennial sea ice: Perennial snowpacks exhibit high mean bulk densities in late summer and autumn due to compacted wind slabs and thaw-freeze clusters, contrasting with lower densities in winter caused by depth hoar crystal formation. Conversely, on seasonal sea ice, bulk densities surpassing 400 kg m^{-3} are observed in summer but drop below 300 kg m^{-3} in winter due to thaw-freeze processes and the related transition from the high-density snow layers to ice at the snow/ice interface.

Furthermore, the analysis of 10 years of autonomous snow observations in the Weddell Sea indicates that the highest snow accumulation rates (8 to 10 cm per month) occur from May to October, with snow ice formation contributing to one third of the snowpack, predominantly in perennial sea ice regions. These regional variations in snow bulk density and snow-to-ice conversion processes significantly affect heat conductivity, influence thermodynamic ice growth, and contribute to uncertainties in large-scale sea ice mass budgets derived from satellites and numerical models.

Mass balance and evolution of glacier systems in a changing climate

THE DECLINE OF A CALDERA-FILLING GLACIER AT VOLCÁN SOLLIPULLI, CHILE

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Volcán Sollipulli, located at about 39° S in the Chilean Andes, is one of only few sites worldwide where a caldera is filled by glacier ice. After retreat of its last glacier tongues, today the glacier is located entirely within the caldera (diameter of about 4 km), with a nearly constant surface elevation of about 2100 m. Ground-penetrating radar data from 2013 suggest a maximum ice thickness of approximately 750 m, making it the deepest measured body of ice in Chile north of the Patagonian Ice Fields, thus harboring a vast amount of freshwater. Glaciers in the southern Andes are generally undergoing fast retreat in recent decades which results in reduced freshwater storage, contribution to sea-level rise, and to formation of glacial lakes, implying the risk of glacial lake outburst floods (GLOFs). For the glacier on Sollipulli, however, no detailed glaciological study has been conducted, despite its unique geometry, size and location.

We used remote sensing data and field measurements to reveal the mass balance evolution of Sollipulli glacier in the last decades. While the glacier was already losing mass in the 2000 – 2015 period, our results show a nearly two-fold increase in melt rates since then, resulting in more than 60-m glacier thinning during the 21st century. This increasing melt coincides with observations of late summer snow absence on the entire glacier, which indicates that the equilibrium line altitude has risen above the maximum glacier surface altitude. We discuss the future fate of the caldera-filling glacier with a focus on its special geometry, including implications for downstream freshwater supply and the hazard potential in the form of GLOFs at newly forming lakes.

Permafrost in a warming world: impacts and consequences

UTILITY OF LAND SURFACE CHARACTERIZATION WITH SATELLITE DATA ACROSS THE ARCTIC FOR ERC Q-ARCTIC

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The Q-ARCTIC project funded by European Research Council (ERC) follows a synergetic approach by combining remote sensing and local-scale observations with modeling on scales from a few meters to hundreds of kilometers. The primary objective of Q-ARCTIC is to close the gap between process scales and the much coarser grid resolution of Earth System Models (ESMs), with a particular focus on the net effect of disturbance processes and associated changes in hydrology on the pan-Arctic scale.

Remote sensing allows for identification of wetness gradients through e.g. fusion of multispectral and synthetic aperture radar (SAR) data (Bartsch et al. 2023a). SAR can be also used to characterize variations in topography, seasonal and long-term which can be associated with permafrost properties (Bartsch et al. 2023b). Both approaches are utilized supporting Q-Arctic goals. Recent achievements will be presented and discussed.

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The Anthropocene and climate change in polar and mountain regions

HETEROCYTE GLYCOLIPIDS: NOVEL ORGANIC PROXIES TO RECONSTRUCT CLIMATE CHANGE IN POLAR REGIONS

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To evaluate the magnitude and velocity of climate change in polar regions, robust temperature proxies that allow high-resolution temperature reconstructions with low residual error are required. A novel organic temperature proxy, which allows reconstructing continental climate change, is the heterocyte diol index of 26 carbon atoms (HDI26; Bauersachs et al., 2014). This proxy is based on the relative abundance of the two heterocyte glycolipids HG26 diol and HG26 keto-ol, synthesized by N2-fixing heterocytous cyanobacteria, which are ubiquitously distributed in freshwater environments from tropical to polar regions. Both components have been shown to vary systematically with growth temperature and in lacustrine sediments, the HDI26 shows a strong linear correlation with surface water temperature (Bauersachs et al., 2021). As such, the HDI26 provides the exciting opportunity to extract climate information from lacustrine sequences. In polar regions, however, the proxy has been little tested yet.

Here, we investigated, for the first time, the distribution of heterocyte glycolipids in Antarctic freshwater environments and evaluated their potential as novel temperature proxies for reconstructing continental climate change in polar regions. Ponds and lakes, located on the McMurdo Ice Shelf and in East Antarctica, were characterized by well-developed microbial mats dominated by heterocytous cyanobacteria. In accordance with this observation, all microbial mats and their underlying surface sediments contained high concentrations of HGs ranging in chain length from 26 to 32 carbon atoms. Among these, HG26 diols and HG26 keto-ols, were most abundant and the relative abundance of both components showed a significant correlation with surface water temperatures measured during the season of highest productivity. Preliminary HG analyses of a lacustrine sediment sequence from East Antarctica suggest that surface water temperatures of the lake have increased by 1.5 °C compared to pre-industrial values. Together these observations suggest that the HDI26 may be well suited for reconstructing Antarctic continental climate change and extending the repertoire of proxies applicable to polar regions. Moreover, the presence of HGs in 90 Ma old sediments of the Amundsen Sea, West Antarctica (Klages et al., 2020), indicates that the HDI26 not only allows investigating climate change of the Anthropocene but also during other critical time intervals of Antarctica's climate history.

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Atmospheric, sea-ice, and ocean system dynamics

ATLANTIFICATION IN THE SVALBARD AND FRAM STRAIT REGIONS AND ITS IMPACT ON DEEP-SEA PROPERTIES: A VIEW FROM COMBINED IN SITU AND SATELLITE DATA

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The Arctic environment is undergoing profound change under the influence of rising air and ocean temperatures, which are strongly influenced by the climatic processes known as Atlantification. This term refers to the increasing influence of the Atlantic Ocean on the Arctic region, which has intensified in recent decades. Atlantification not only affects the delicate balance of Arctic flora and fauna, but also has far-reaching implications for global climate patterns and geopolitics. As scientists, we know that the only way to observe climate change is to record sufficiently long time series of data, despite the efforts and difficulties this goal requires. Here we combine satellite and in-situ data to investigate both long-term, seasonal, and short-term variations, including meteorological conditions and sea ice concentration trends. We present 10 years (from June 2014 to June 2024) of oceanographic mooring data collected in the southeastern Fram Strat at site S1 (76°N, 14°E), which is moored along the 1000-m isobath above the continental slope on the southwestern edge of the Svalbard archipelago. There, the main branch of the West Spitsbergen Current transports Atlantic water (in the upper layer) and deep water from the Norwegian Sea (below 900 m depth) polewards into the Arctic Ocean. Oceanographic mooring S1, part of the Svalbard Integrated Arctic Earth Observing System (SIOS) Marine Infrastructure Network, is strategically located at a point where water of Atlantic origin meets water from the Storfjorden (Spitsbergen's largest fjord) and shelf polar water flowing off the West Spitsbergen continental shelf. The mooring data in combination with current and historical vertical profiles of temperature and salinity derived from oceanographic cruises, autonomous platforms (Argo floats), and satellite data, show that Atlantification increased after '2000 and that the period 2014-2021 was characterized by a strong Atlantic signal and limited potential production of dense water in the fjords. Furthermore, interannual variability in ice rafted debris and zooplankton data from the mooring's sediment trap provide additional information on the sea ice signal and Atlantification. Indeed, a gradual decline in winter sea ice cover (satellite data) has been observed in the S1 area and neighbouring fjords over the last decade. The only exception is the winter of 2020 (and to a lesser extent the following winters), when sea ice extent appears to have returned to pre-2013 levels and there were faint signs of cascading dense shelf water at 1000 m depth, likely originating from the Storfjorden polynya.

Polar Earth Sciences

EAST ANTARCTIC ICE SHEET INSTABILITIES – FIELD WORK IN UN-GLACIATED COASTAL AREAS DURING THE R/V POLARSTERN VOYAGES EASI 1 – 3

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Un-glaciated terrestrial oases in East Antarctica are unique sites to obtain records on past ice sheet extent, local deglaciation histories and to study the subsequent environmental and climatic history of different catchments of the East Antarctic ice sheet (e.g., Berg et al. 2020, White et al. 2022).

A series of three R/V "Polarstern" expeditions was carried out by the initiative "East Antarctic Ice Sheet Instabilities" (EASI 1-3) in 2022 and 2023/24 that successfully collected oceanographic, geological, geophysical and geodetic field data and samples from different sectors of the Southern Ocean and the East Antarctic coastline. The aim of the programme is to integrate terrestrial, near-shore and open marine observations to study the history of the East Antarctic Ice Sheet, its interaction with changes in Southern Ocean circulation and the thresholds and triggering mechanisms for its instabilities on different spatial and temporal scales. As part of the expeditions, geological and morphological work was carried out in the Thala Hills (Enderby Land), Vestfold Hills (eastern Prydz Bay) and Bunger Hills (Wilkes Land) in order to address open questions about the Late Quaternary ice retreat history of the respective areas. The focus of the geological sampling campaigns was on sediment coring on lakes and marine inlets for paleoenvironmental and paleoclimatic reconstructions. This work was complemented by collections of glacial erratics, surveying of raised beaches and weathering studies that will provide new information on the timing and patterns of ice sheet retreat in the three regions. We will provide a brief overview of the completed field work, as well as report on initial results and planned analyses.

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HOLOCENE ENVIRONMENTAL CONDITIONS IN THE COASTAL OCEAN OFF EAST ANTARCTICA – EVIDENCE FROM THE PALEO-DIET OF SNOW PETRELS

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Reconstructions of past environmental conditions in the coastal ocean off East Antarctica are crucial to better understand mechanisms of ocean - ice interaction as well as biogeochemical processes. Records from marine sediments indicate changes in nutrient cycling and sea-ice during the Holocene. However, regional differences are not well resolved due to the scarcity of available records. A novel approach is to infer past environmental conditions in the coastal ocean in Antarctica by using fossil stomach oil deposits of snow petrels (Pagodroma nivea) (Antarctic mumiyo) (e.g. Berg et al. 2019, 2023). Here we present preliminary results from two currently funded DFG projects (BE4764/6 and BE4764/8). We apply a multiproxy approach, combining radiocarbon dating, lipid (fatty acids) and isotope (δ13C and δ15N) analyses to track past changes in snow petrel diet, which can be linked to environmental conditions in the foraging range of the birds, such as sea-ice variability, polynya activity and primary production (McClymont et al. 2022). The investigated sample material originates from four unglaciated sites from Mac Robertson Land to Wilkes Land. The spatial distribution of these sites will provide information on regional patterns of Holocene sea-ice changes and shifts in oceanographic conditions in the coastal zone along a large sector of the East Antarctic coastline. In addition to the regional studies on stomach oil deposits, these findings will be related to ice sheet and marine environmental reconstructions in order to better understand interactions between ice and ocean under changing climatic conditions.

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Permafrost in a warming world: impacts and consequences

HIGH-SALINITY LIQUID WATER AS A SOURCE OF UNCERTAINTY IN BEDFAST LAKE ICE MAPPING

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Arctic permafrost landscapes are characterized by numerous shallow lakes which play an important role in the Arctic ecosystem as crucial areas of wildlife habitat and drivers of landscape change. Understanding the depth of shallow Arctic lakes is crucial for monitoring climate change, managing resources, and predicting ecological and biogeochemical processes in these ubiquitous landscape features. Previous assessments estimate that more than 50% of the lakes on the Arctic Coastal Plain (ACP) in northern Alaska develop bedfast ice, with ice freezing to the bottom of the lakebed during the winter. Synthetic Aperture Radar (SAR) imagery has previously been used to distinguish between bedfast and floating ice lakes on a regional and circumpolar scale, creating a possibility to quantify different winter ice conditions on a large spatial scale and monitor annual differences on a lake-to-lake basis. However, high salinity liquid water present below ice has been found to be a source of uncertainty in bedfast lake ice mapping efforts, leading to misclassification of floating lake ice as bedfast lake ice. Moderate-to-high-salinity water can be caused by ocean water intrusions through storm surges for near coastal lakes, through hydrologic connectivity with the ocean, as a result of evaporative enrichment, as well as through the thaw of saline permafrost soils that are a relic of past high sea level stands. As ice forms throughout the winter, salts in the water are excluded which increases the salinity of water remaining below the ice. To further investigate the possible magnitude of errors introduced into bedfast lake ice data sets, an extensive field campaign was conducted in May 2024 sampling more than 100 individual lakes along an 800 km snowmachine expedition on the ACP. Lakes were sampled for depth, ice thickness, and conductivity of the water remaining below the ice. Here we compare field measurements collected between 01 and 10 May 2024 to Sentinel-1 SAR data, acquired on 02 May and 05 May 2024, to benchmark SAR backscatter values for lakes with floating ice, bedfast ice and those lakes with saline water remaining below the ice. In addition, we aim to better understand the relationship in salinity and SAR backscatter to propose solutions to the uncertainty caused by residual moderate-to-high saline water in large-scale lake ice mapping efforts. Identification of the misclassification of floating ice lakes as bedfast ice lakes due to the presence of brackish to saline water below the ice has implications for permafrost thaw, ecosystems, the potential presence of extremophiles, and winter overland travel route planning and safety.

Permafrost in a warming world: impacts and consequences

THE MATTERHORN CRYOSPHERE OBSERVATORY – LONG-TERM MONITORING OF STEEP-BEDROCK, HIGH-ALTITUDE MOUNTAIN PERMAFROST

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High-altitude mountain areas are very susceptible to the climate evolution at all scales. However, little is known about this extreme end member characterized by steep topographies and remoteness. Therefore in-situ observations are scarce and often limited in their temporal and spatial coverage as well as their fidelity. Over the past two decades teams from Italy as well as Switzerland have concentrated multiple interdisciplinary research efforts at and on the slopes of the Matterhorn. This cross-border laboratory today covers a full altitude transect from the valley floor to the summit at 4478 m asl as well as from south to north with a dense network of permanent in-situ observation locations. In addition, several research campaigns have been historically undertaken and add to this unique footprint of observation data as well as insight.

Primary data observed are ground-surface temperature as well as permafrost active layer depth, meteorological parameters, surface kinematics using crackmeters as well as GNSS, resistivity, optical imaging, seismic signals as well as personal observations through a regional observer network. In this presentation, we will summarize the activities over the past two decades and discuss insights, key findings as well as data availability.

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Physical processes of glaciers and ice sheets in their environment

TIMING AND TRIGGER(S) OF A PERIODIC JÖKULHLAUP AT ZACKENBERG, NE-GREENLAND

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Since 2005 quasi-annual jökulhlaups, or glacial lake outburst floods, are registered at the Zackenberg research station (74°28′N, 20°34′W), NE-Greenland. The jökulhlaups typically happen during the sommer months, but were also observed during winter and spring. The Zackenberg jökulhlaups feature rapid-rising discharge curves with maximum discharges of 120 to 380 m³/s. The total duration of a jökulhlaup event is typically 12-24 hours. The source is a lake dammed by an outlet glacier of the A.P. Olsen ice cap (APO) about 35 km inland of the research station.

Besides Zackenberg environmental monitoring data, we analysed APO weather station data and water depths of the ice-dammed lake. We found that environmental parameters quantifying snow-free conditions in the Zackenberg area were generally correlated with the timing of the jökulhlaups. However, only the correlation between the jökulhlaup timing and the onset of ice melt at the lowest APO weather station was significant. The mean difference between APO ice melt start and jökulhlaup timing was 36 ± 7 days. Our results led us to hypothesise that the APO jökulhlaups are initiated once an efficient, channelised subglacial drainage system extends to the vicinity of the ice dam.

Jökulhlaups from ice-dammed lakes may be initiated by expanding existing conduits or by the flotation of the ice dam when the lake level reaches a threshold of around nine tenth of the ice dam height. For the APO jökulhlaups, we favor initiation by conduit expansion through melt feedback over ice dam flotation. This is based on the following observations: (I) A rather wide range of initial water depths were observed, ranging from 30 m (2013) to 47 m (2019), which corresponded to a volume range of 6.5 to 16.6x10^6 m³. (II) The drainage water levels increased between 2013 and 2019, while the downwasting of the ice dam has been documented through regular photos since 2008. (III) In 2018, despite a higher water level (35 m) and larger volume (9x10^6 m³) than in 2013 and 2022, there was no jökulhlaup and the ice-dammed lake remained filled until summer 2019. Therefore, we concluded that there is no distinct water level threshold that solely triggers the APO jökulhlaup through ice dam flotation.

However, the 2019 LAPO outburst was the earliest on record (6 July) with the highest water level (47 m) and thus the largest volume (16.6×10^6 m³). The 2019 jökulhlaup corresponded to the second earliest onset of APO ice melt (13 June) after the third least snowy winter on record and a rather warm summer. The second earliest jökulhlaup was recorded in 2013 (4 June) after the earliest APO ice melt start following the least snowy winter on record and an average summer. We attribute this asymmetry of jökulhlaup outburst and onset of APO ice melt to the largest lake volume on record in 2019. We propose that the high 2019 lake water level caused sufficient ice dam flotation leading to an elevated water pressure gradient to earlier establish a connection with a subglacial conduit and initiate the outburst. Consequently, we concluded that the dominant trigger is the expansion of a pre-existing conduit, but that the lake water level and thus ice dam flotation does play a minor, but supporting role.

Permafrost in a warming world: impacts and consequences

INDUSTRIAL ECHOES: THE IMPACTS OF DRILLING MUD SUMPS AND HIGHWAY BORROW PITS ON ARCTIC FRESHWATER ECOSYSTEMS

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Rapid warming in Arctic Canada poses additional threats to industrially affected regions like the Mackenzie Delta in the Northwest Territories, where oil and gas drilling and highway construction have been prevalent. Recent permafrost degradation is jeopardizing the structural integrity of drilling mud sumps, designed to permanently contain drilling fluids (Langer et al. 2023). As a result, new ponding has been observed directly on the drilling mud sumps, however, they have yet to studied. Similarly, borrow pits excavated for materials to construct the Inuvik-Tuktoyaktuk highway have also encountered ponding. This prompts inquiries into the formation of new ponds due to industrial activities and raises concerns about their ongoing evolution and impact on the surrounding landscape. Previous studies have demonstrated that some lakes and ponds in close proximity have undergone chemical and ecological shifts directly correlated with the compromise of mud sumps (Thienpont et al. 2013; 2015), which will be expanded upon in this study using biogeochemical indicators in sediment records. Water samples, surface sediments, and sediment cores collected during summer 2024 offer insights into the present-day and baseline conditions of freshwater ecosystems surrounding drilling mud sumps. Samples from ponds situated directly on drilling mud sumps and within borrow pits will establish a comprehensive timeline of the biogeochemical evolution of these nascent systems, shedding light on how they may continue to evolve. Diatom and Cladocera assemblages, along with analyses of organic matter and biomarkers in sediments, will reveal the interacting effects of warming and legacy contaminants. Paired with modern water samples, this will offer a comprehensive overview of the evolving freshwater conditions along the Inuvik-Tuktoyaktuk Highway. This region is heavily utilized by Indigenous communities, making it crucial to understand landscape shifts to guide long-term monitoring and management. By using a combined paleolimnological and limnological approach, we can determine reference conditions and ultimately reveal the rate, magnitude, and trajectory of contemporary changes.

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Biology and biogeography in polar environments

LICHEN GROWTH FORM EFFECTS ON ROCK WEATHERING IN THE WESTERN ANTARCTIC PENINSULA

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The enhancement of rock weathering by lichens is well-documented in literature (Chen et al, 2000). As pioneering organisms, lichens are one of the first to colonize newly exposed substrate such as recently deglaciated terrain. In the poles and high mountain areas, rock weathering by lichens is an important component of biogeochemical cycling. For sites with accurate deglaciation data, the biological and chemical action of crustose lichen species on rock weathering has been well-observed (McCarroll and Viles, 1995; Matthews and Owen, 2008). This allowed rate of weathering to be quantified, but only in areas of known deglaciation.

Weathering activity of other lichen growth forms such as fruticose and foliose lichens are less known despite being major components of polar and alpine regions. In the lichen-dominated ecosystems of Antarctica there are over 200 documented lichen species (Peat et al, 2007) but these are unlikely to contribute equally to rock weathering. In February 2022, we recorded how different lichen growth forms affect the hardness of rock substrate, a proxy for weathering (McCarroll and Viles, 1995) using an N-type Schmidt Hammer. Crustose lichens affected rock hardness with the average hardness of lichen-encrusted rock averaging 11.3% lower than bare rock. Foliose lichens on average reduced substrate hardness by 6.6%, while fruticose lichens either had little weathering effect or even a slightly protective effect on their rock substrate.

In addition, we tested if rock hardness was influenced by lichen presence and not reflecting a preference by lichens to establish on weathered rock. This was done on a dated deglaciation sequence on the Morteratsch glacier forefield, Swiss Alps. The effect of crustose lichens on rock substrate hardness increased with time since exposure, indicating that lichen presence weakens rock hardness. Lichen presence on rock clearly affects rock hardness, and thereby aspects of rock weathering, but this influence differs between different lichen growth forms. Here we showed that foliose lichens, a dominant component of many Antarctic ecosystems, also plays a role in rock weathering with potential impacts on the local release of minerals.

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Atmospheric, sea-ice, and ocean system dynamics

THE IMPACT OF AN ATMOSPHERIC RIVER TRIGGERS DEBRIS AND SLUSH FLOWS ON DISKO ISLAND, WEST GREENLAND

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Debris flows and slush flows are mass movements that can be triggered abruptly by precipitation and snowmelt. They are a well-known contributor to geomorphic changes and potential geohazards in areas such as the subpolar regions. In this study we discuss and analyse a series of mass movements linked to a single event that happened between July 6th and 7th 2023 in Central West Greenland. An atmospheric river led extreme precipitation into Qeqertarsuaq (Disko Island) and surrounding areas, increasing late spring snowmelt runoff significantly and causing hundreds of slush flows and debris flows, which also damaged local infrastructures. We combined remote sensing observations (Sentinel-2 and drone-based) before and after the event to map the larger mass movements. We then used the environmental monitoring dataset available in the area (Greenland Ecosystem Monitoring Disko) and climate reanalysis (Copernicus Arctic Regional Reanalysis) data to assess the synoptic pattern at the base of the event. We found almost 200 significant slush flows and debris flows only in Disko Island. During the 18-hours-event cumulative precipitation peaked 100 mm being generally above 80 mm in several portions of the island (mainly in the Southwest) where most events occurred. An increase in moisture transport through atmospheric rivers in a warming Arctic, has already been seen as a further contributor to abrupt glacial melting. We show here how such events can trigger potential hazards to local communities, making necessary to increase our knowledge about past events and future hazards in remote and less monitored areas, such as Greenland.

Polar Earth Sciences

BRIDGING ON- AND OFFSHORE STRUCTURES AT THE PACIFIC COAST OF NORTH VICTORIA LAND, ANTARCTICA: THE BGR-PNRA GANOVEX-BOOST PROJECT

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The joint BGR-PNRA project GANOVEX-BOOST (German Antarctic North Victoria Land Expedition- Bridging Onshore-Offshore Structures at the Pacific Coast of North Victoria Land, Antarctica: an integrated approach) involved an amphibian-style approach towards a new morphotectonic model to correlate on- and offshore structures and geomorphological features to link Cenozoic geodynamic processes and ice sheet evolution. Geological fieldwork in the Rennick/Lillie glaciers area of NVL and a parallel high-resolution aeromagnetic survey flown over the lower Rennick Glacier, northern Bowers Mountains and western Lillie Glacier up to the Pacific coast were subject of the first phase of the project during the BGR-led land-based GANOVEX XIV-BOOST campaign (2021-22). Two subsequent PNRA-led phases (2023 and 2024) acquired new offshore geophysical data onboard the OGS R/V Laura Bassi (multichannel seismics and sub-bottom profiles, bathymetry, magnetics, coring) over an about 5000 km² large area crossing the continental shelf and the present grounding zone of the ice sheet off the Pennell coast. The northern shelf sector of the survey area exhibits an outer concave form of its break and slope and is incised by several gullies. In contrast, a step-shaped geometry with a WNW linear trend characterizes the southern sector. The continental shelf consists of a thin, horizontally layered succession over crystalline basement, dissected by two U-shaped, several km wide glacial troughs. Seaward prograding sediments on the slope are truncated by a regional unconformity on the shelf (RSU-1). Three distinct seaward prograding wedges are present in the upper part of the slope in the NW sector, but missing in the S sector. On shelf and continental rise, NW-trending fault-bounded basement highs are associated with growth strata that point to a tentative Oligocene age of tectonic activity. An approximately 20 km long drift deposit-covered basement ridge at a depth of 2500 m is bordered by faults that indicate recent tectonic activity and may have reactivated inherited structures separating tectonic blocks related to Australian-Antarctic rifting. Particularly, the unconformity recorded at the top of the growth strata may be related to the onset of fast seafloor spreading between Antarctica and Australia. Two broad elongated, NNW-trending volcanic zones consisting of individual volcanoes and small volcanic ridges composed of coalescent bodies coincide in their trend with the direction of the main tectonic lineaments onshore NVL. Several volcanoes show clear evidence of recent activity, and fluid-related structures channel through the surrounding sedimentary strata. The volcanism correlates well with airborne magnetic data and may represent the NNW-ward prolongation of the Mid-Miocene to Quaternary Hallett volcanics forming the Adare Peninsula, or they may be alternatively linked to post-spreading volcanism of the Adare Basin of Pliocene to Recent age.

History and future of international cooperation in polar regions

CHARACTERIZING BASAL CONDITIONS OF THE ICE SHEET IN EAST ANTARCTICA THROUGH AIRBORNE SURVEY

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Poor knowledge on basal conditions leads directly to “deep uncertainty” in evaluating and predicting the instability of the Antarctic Ice Sheet (AIS), which could cause catastrophic rising of sea level (IPCC, 2021). However, geophysical data insufficiency and deficiency in Antarctica seriously hinders our understanding of basal conditions and ice sheet dynamics.

Since 2015, an international project of ICECAP/PEL has been launched to survey the PEL through the Chinese airborne platform of Snow Eagle 601(Cui et al., 2018; 2020a). With airborne geophysical data collected in seven austral seasons: 1) ice thickness and bedrock elevation is derived from ice penetrating radar measurement, and bedrock topography was well revealed by an interpolated DEM with 500m spatial resolution in PEL(Cui et al., 2020b); 2) a large subglacial lake in PEL was confirmed, but its size is smaller than the previously result inferred by surface features from remote sensing data (Jamieson et al., 2016); 3) after preliminary analysis of its geometry, and thickness of overlying ice, lake water and sediment, with the location of ~100 km away from Chinese Taishan Station, China has initiated a project to drill into the lake with both clean hot-water and hot-melting drilling technologies in the next several years (Li et al., 2021; Yan et al., 2022; Zhou et al., 2024); 4) we also utilize RES data to extract grounding points of the Amery Ice Shelf by identifying significant echo reflection changes between ice-bed and ice-seawater interfaces, and comparison between our radar-derived positions with remote sensing grounding line positions shows good consistence(in preparation); 5) China successfully surveyed the large data-sparse regions of ice sheet margin between Zhongshan Station and Princess Elisabeth Antarctica in last season, making very important contribution to an international project of Dronning Maud Land and Enderby Land (DML/EL) RINGS, which is the first international project endorsed by SCAR RINGS Action Group (Matsuoka et al., 2022). Here, on behalf of ICECAP members and PRIC aviation group, I will give a review of the progress and future plans of Chinese airborne survey in Antarctica.

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History and future of international cooperation in polar regions

THE 1897-99 *BELGICA* EXPEDITION THAT FIRST OVERWINTERED IN ANTARCTIC WATERS; A TALE OF EXTRAORDINARY SCIENTIFIC ACHIEVEMENTS AND OF HUMAN ENDURANCE

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Some 120 years ago Belgium funded an international expedition that departed Antwerp in August 1897. At that time, it was still unknown as to whether Antarctica was a continent and the location of the south magnetic pole was unchartered. The original aim of the Belgica expedition was to overwinter at Cape Adare in Victorialand on the edge of Antarctica. But this did not happen; instead, the voyage first led to the chartering of the deep Drake Passage and eventually the discovery of many new islands bordering the Antarctic Peninsula and a new Passageway (the de Gerlache Strait) frequented today by many tourist ships. There, the expeditioners collected a huge amount of scientific data while also mapping all the islands. Eventually, the vessel continued its voyage westward towards the Bellinghausen Sea where it eventually became trapped in ice for 13 months. The ship drifted in the sea ice for close to 2,000 km. After much duress, the expeditioners, who had lost two companions, successfully returned to Belgium. All the expeditioners gained international fame during the rest of their career.

Prior to reaching Drake Passage, the expedition carried out much scientific investigation in the vicinity of the Beagle Channel at the southern tip of South America, that included geological, glaciological, biological [fauna and flora], anthropological data collecting. Later on, during the expedition, investigations were broadened and included meteorological, oceanographic, geophysical and ice formation studies that were of great importance to science at the time. This amounted to some Many of these investigations continued while the vessel was trapped in sea ice during which time the expeditioners experienced significant illnesses and deprivation, while also fearing drowning from the possible crushing by movements in the sea ice and some large icebergs.

The numerous scientific reports resulting from the expedition make up to 3767 pages that have been published after the expedition! **Most results have long been ignored** but are resurfacing and being used as they are now available on the internet. Some of the oceanographic and meteorological investigations nowadays are a very important baseline since knowledge that the Antarctic Peninsula is one of the places on the globe facing the largest changes and challenges due to global warming.

The presentation will rely on many archives, some of which are listed in De Deckker (2018).

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Polar Earth Sciences

NATURAL HERITAGE OF LAKE WÎYÂSHÂKIMÎ, SUBARCTIC CANADA

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This report documents a new initiative of Canadian-German research collaboration and highlights the conduction and preliminary scientific results of limnogeological field work in the sub-Arctic of northeastern Canada. In summer 2023 and spring 2024, two research expeditions took place at Lake Wiyâshâkimî (56.2°N, 74.4°W) organized by the Alfred Wegener Institute (AWI, Germany) in collaboration with the Centre d'Études Nordiques (CEN, Université Laval, Québec, Canada). The indigenous name Lake Wiyâshâkimî refers to the purity of the body of water. Known as "Lac á l'Eau Claire" in Québec French and "Clearwater Lake" in English, the crater lake is located just over 100 kilometres east of Hudson Bay. In summer 2023, the field team (HM, BD, BB, PA) conducted preliminary limnological and geophysical research in the lake system by boat, and lacustrine sedimentary sequences were identified for later deep coring." In April 2024, the field team (BD, DS, CZ, BB, OS, EL) retrieved sediment cores from the ice surface, by using a piston coring system.

The study area is located on the Canadian Shield, where Precambrian crystalline rocks reach ages as old as 2.8 billion years. Two meteorite impacts formed the double crater structure of Lake Wiyâshâkimî, once 450 million years ago (late Ordovician) and again 285 million years ago (early Permian) (Schmieder et al. 2015). In the Pleistocene, the study area repeatedly was overrun by the Laurentide Ice Sheet. The last ice disappeared in the Holocene, some 7000 years ago (KRG 2007). Traces of glacial activity are indicated by erratic boulders, abraded crests, moraines and meltwater deposits (eskers). The postglacial landscape is characterized by boreal coniferous forest, periglacial structures, and peat bogs (KRG 2007).

CTD-profiling confirmed the freshwater nature of the lake system. The shallow seismic survey exhibited a scoured bottom of the lake. In many places it is free of sediment and in places only covered by a thin veneer of postglacial mud. Sediment coring concentrated on thicker pockets of preserved sediments in the western lake basin. In 120 m water depth, we penetrated through an 8 m thick sequence of deglacial meltwater deposits and postglacial lacustrine muds. These two lithologies were also encountered in a 2.9 m long section off the northern shore at 12 m water depth. The lake muds consist of reddish minerogenic silty clay, including low amounts of organic matter and abundant frustules of fresh-water diatoms. The material is promising for ongoing palaeolimnological studies.

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Mass balance and evolution of glacier systems in a changing climate

GEODETIC MASS BALANCE ESTIMATION AND FUTURE EVOLUTION PROJECTION OF GLACIERS FLOWING INTO WORDIE BAY ON THE WEST ANTARCTIC PENINSULA

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The Antarctic Peninsula (AP) is at present one of the most rapidly warming regions on Earth. AP is a narrow marginal part of the Antarctic continent extending into the sea and climate change has a direct and immediate effect on it. Analyzing the causes of the mass loss mechanism of the outlet glaciers on the west coast of the Antarctic Peninsula is crucial to understand the interaction mechanism of the ocean, glaciers and atmosphere in the Bellingshausen Sea or further north. It is also an important step towards improving coupled models of the Antarctic Peninsula Ice Sheet and predicting its future state and contribution to sea-level rise.

The Graham Land of AP has complex and undulating terrain conditions. There are many outlet glaciers with small basin areas, showing heterogeneous dynamic changes and mass loss characteristics. Therefore, higher spatial resolution is required for data acquisition, especially to obtain temporal surface DEMs for mass balance calculation. The bistatic TanDEM-X mission acquires interferometric data with area coverage and has the advantage of fine resolved spatial observations. However, InSAR data requires the use of external data for absolute phase calibration (usually existing prior DEM products or TanDEM InSAR DEMs with different baselines), and is also subject to problems of image geometric distortion and radar wave penetration into ice and snow. The altimetry data including Cryosat-2 and ICESat-2, has the advantages of high absolute elevation accuracy and short revisit period. As the data coverage becomes more and more dense, the spatial resolution of the acquired altimetry data is also constantly improving.

In this study, we will combine bistatic TanDEM-X InSAR DEM data and altimetry data to better estimate the surface elevation changes and geodetic mass balance of typical outlet glaciers in western AP. This will also help us evaluate the characteristics of glacier surface elevation changes estimated based on TanDEM-X InSAR DEM data and altimetry data. We will try to further analyze the mechanisms of mass loss of these glaciers by analyzing surface velocity, ocean and atmospheric data, etc.

Mass balance and evolution of glacier systems in a changing climate

GLACIER RETREAT IN SØR-SPITSBERGEN NATIONALPARK FROM 1990 TO 2020

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The modern polar environment is very sensitive to the global rise of the air temperature. Svalbard, located in the European Arctic, is among the regions with fastest climate warming noted after the end of the Little Ice Age (LIA). Climate change influences the entire environment of the archipelago, including components of the cryosphere such as glaciers. Covering more than a half of its area glaciers are currently responding to warming by losing mass at an accelerated pace (Geymann et al. 2022). This work presents changes in the geometry of glaciers of Sør-Spitsbergen nationalpark, located in the southern part of Spitsbergen, the biggest island of the Svalbard archipelago, over the period from 1990 to 2020.

A baseline dataset for glacier delineation used in this investigation consisted of digital imagery such as aerial photographs for the years 1990 and 2010/2011 from the Norwegian Polar Institute (NPI), one Landsat 5 TM scene acquired in the summer of 1990, and Planet Imagery from the year 2020/2021. Glacier elevation differences were obtained from subtracting digital elevation models (DEMs) derived from different sources. For the years 1990 and 2010/2011 DEMs from NPI, at the resolution of 20 m and 5 m respectively, were used in the study (NPI, 2014). Glaciers elevations in the years 2020 and 2021 were obtained from high-resolution Arctic DEM (Porter et al. 2018). Using available datasets changes in glacier extent and thickness have been assessed in the following periods: 1990-2010, 2010/2011- 2020/2021, and 1990-2020.

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Polar Earth Sciences

DEVELOPMENT OF AUTONOMOUS GNSS STATIONS FOR POLAR REGIONS

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The operation of autonomous measurement stations in the polar regions is an important tool to gather in-situ observations of a variety of processes. The continuous recording over a long time, especially under the polar environment, demands ingenious solutions to solve problems like independent power supply and data transfer.

For six years now, our working group has been operating permanent autonomous Global Navigation Satellite Systems (GNSS) stations in polar regions. Three stations are located in west and northeast Greenland, two stations in western Dronning Maud Land, Antarctica. During the recent Polarstern cruise PS141 a further new GNSS station could be established at Gaussberg, East Antarctica. For the design and set-up of this station latest technological developments were taken into consideration such that an optimal performance can be envisaged. In contrast to the aforementioned stations, which regularly transmit status messages but no observational data, the new station at Gaussberg is enforced to transfer also the data recorded by the GNSS receiver.

In this presentation we will discuss the evolution of the technology applied for our stations and the experiences made. Specific solutions for the power supply and the data transfer using satellite communication will be discussed. Furthermore, we will present first results, especially evaluating the GNSS data recorded at the new Gaussberg station. Thus, the benefit will be emphasized to facilitate a complete data transmission by autonomously operating measurement stations in the polar regions.

Integrating Social and Natural Sciences: Collaborative and Inclusive Approaches Beyond Traditional Boundaries

ECONOMIC DEVELOPMENT AND SOCIO-CULTURAL IMPACTS IN THE EUROPEAN ARCTIC: PERSPECTIVES AND COMPARATIVE INSIGHTS WITH ALPINE REGIONS

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The European Arctic region is experiencing increased activity across various economic activities such as fish farming, forestry, mining, tourism, and indigenous activities like reindeer herding and hunting. While these industries play a crucial role in utilizing the region's natural resources, there are concerns about the fragility of Arctic ecosystems and the potential socio-cultural impacts on local and indigenous communities with distinct livelihoods (Glomsrød et al 2021; Suopajärvi et al 2022). This study **asks how local stakeholders and citizens perceive the development of existing and new economic activities in the European Arctic and Alpine countries.** We employed a mixed method approach, including literature review, expert interviews, Q-method and collected data in 7 locations, or so called "hubs" in European Artic and 2 in Alpine region, between which we conducted comparative analysis. The study identified a range of local perspectives that centred around four main aspects: economic growth, social inclusion, environmental sustainability, and cultural conservation. By comparing the Arctic and Alpine hubs, the study found that while industries undoubtedly bolster economic development, they also pose challenges to social inclusion, environmental sustainability, and cultural conservation. The local subjective perspectives on development provided a nuanced picture of local realities that challenges current indexes of development. Finally, the results highlight the need for tailored approaches to development that account for the unique socio-cultural contexts of each area. Therefore, we suggest promoting integrative development focused on sustainability, adopting adaptive locally-fitted management practices, fostering inclusive growth, investing in sustainable infrastructure, promoting environmental stewardship, and leveraging local knowledge and science.

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Biology and biogeography in polar environments

3D PHOTOGRAMMETRY AND ROV ACOUSTIC DATA FOR ULTRA-HIGH RESOLUTION BENTHIC HABITAT MAPPING IN POWELL BASIN

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The Powell Basin serves as a conduit for the flow of water masses between the Weddell Sea and the South Atlantic Ocean and is recognized as a biodiversity hotspot within the Southern Ocean. It is located in one of the fastest warming regions of the world (King, 2014, Veit et al., 2018). However, the impact of climate change on its ecosystem is far from known, lacking a detailed ecosystem base description. In this study, we present a comprehensive approach that integrates ship-based multibeam and ROV sidescan data and 3D photogrammetry data collected from the northwesterly flank of the Powell Basin. By integrating these diverse datasets, we were able to produce predicted benthic habitat maps at centimeter-scale resolution, revealing the fine-grained complexity of seafloor features and communities. Ship-based multibeam captured the general geomorphological landforms of the region, whereas the ROV-based microbathymetry data helped identify the different types of fine-scale submarine landforms of the flanks of Powell Basin. This revealed four distinct geomorphical units: cliff, sand ripples, small rocky outcrops, flat bottom. To further study this area, ROV images and video data were collected and analyzed using a defined Structure from Motion (SfM) workflow, producing millimeter-resolution 2D and 3D models. Object-Based Image Analysis (OBIA), applied on orthomosaics, allowed us to obtain a fine classification of main benthic communities covering a total area of 900m2. Spongia lamella species tend to inhabit the small rocky outcrops. The correlation coefficient between the size of Spongia lamella and the rocky outcrops inhabited was also analyzed. These ultra-high resolution maps provide unprecedented insights into the distribution and composition of the investigated benthic ecosystem supporting a recognized aim for Antarctic marine conservation in this important area. The detailed habitat information can inform efforts to protect vulnerable marine species and habitats, and serve as a base for monitoring environmental changes in this sensitive region in the future. This method showcases the power of combining cutting-edge marine survey technologies for comprehensive seafloor habitat mapping in deep, inaccessible ocean environments.

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History and future of international cooperation in polar regions

THE CONTRIBUTION OF UKRAINE'S KEY ANTARCTIC INFRASTRUCTURE FACILITIES TO INTERNATIONAL SCIENTIFIC COOPERATION

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The polar regions play a key role in the Earth's system. Therefore, a robust world-class research infrastructure is critical in enabling scientists to explore and understand these extreme environments. This research provides an overview of the scientific potential and contribution to international scientific cooperation of Ukraine's key Antarctic infrastructure facilities – year-round Vernadsky station and the ice-capable research vessel Noosfera. It is argued that Ukraine has played a role in shaping policies on creating an international network of polar infrastructures by sharing research facilities and contributing data and insights to global discussions related to climate change adaptation, and environmental protection in the polar regions. In particular, it is highlighted that Vernadsky Station (former British Faraday Station before 1996) is an important reference point for long-term monitoring of the impact of climate change on the Antarctic ecosystems because of its exceptional location on the west coast of the Antarctic Peninsula. Moreover, the well-equipped and multi-purpose geophysical observatory at the station makes it possible to study processes in various layers of the Earth – from the tectonosphere to the geospace. It consistently observes the meteorological processes, magnetic field, ionosphere, ozone layer, and seismic observations and shares one of the longest continuous series data with international monitoring systems and global databases (WMO, IAEA, IHO, INTERMAGNET, Global Seismographic Network, respectively). In addition, Vernadsky station is important for biological research, first of all, to study the origin and biodiversity of terrestrial and marine ecosystems of the Antarctic, their adaptive variability, and forecasting ecosystem transformations under the influence of climate change. Simultaneously, the ice-capable RV Noosfera (former British RRS James Clark Ross before 2021) – a flagship of the Ukrainian research fleet – is available year-round for national and international research activities, offering a platform for world-class biological, oceanographic, and geophysical research in the polar regions and beyond.

Despite the Russian full-scale military aggression and the imposed martial law, Ukraine systematically and consistently integrates into the European research area. Thus, in April 2022 the National Antarctic Scientific Center became a member of the European Polar Board and participates in the EU funded the Horizon Europe framework program collaborative projects, which aims to facilitate sharing the international polar infrastructures. The Vernadsky Station, operating as an Antarctic science and logistic hub, is expected to play a pivotal role in facilitating collaborative research with other parties (including countries that currently do not have their infrastructure in Antarctica but seek to carry out research activities), while RV Noosfera will be serving as a mobile platform for international maritime research, to contribute significantly to globally impactful multi-nationally co-ordinated research and long-term standardized scientific monitoring to better understand and preserve the polar environment as a unique and crucially important area for the Earth System.

Biology and biogeography in polar environments

MICROBIAL ABUNDANCE, RICHNESS AND COMMUNITY COMPOSITION IN ANTARCTIC DEEP-WATER SPONGES ARE RELATED TO HOST HISTOLOGY

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Sponges are important ecosystem engineers that live in close association with microbial symbionts. Despite the abundance and high biomass of sponges in many regions of the Antarctic shelf, the microbial communities hosted in their tissues have only gained attention in recent years. Most studies so far have focused on shallow-water demosponges, resulting in a very limited knowledge on the microbiomes of Antarctic deep-water sponges and especially glass sponges. Therefore, we have combined molecular and microscopical methods to investigate the microbial abundance, richness, specificity and community composition in several species of Antarctic deep-water demosponges and glass sponges, and to relate the findings to sponge histology and ultrastructure. Sponges, bottom water and sediment were collected at depths of 300-850 m in the eastern and western Weddell Sea. Samples were analyzed by 16S rRNA gene amplicon sequencing and a subset of sponges was investigated microscopically. All sponges were characterized by low microbial abundances. However, sponges with a denser tissue hosted a higher abundance and diversity of microbes. This relation has previously only been described in temperate and tropical sponges. Both the number of microbial cells hosted in the tissue as well as the richness in microbial phyla and amplicon sequence variants (ASVs) were considerably lower in the glass sponges than in the demosponges. Furthermore, the microbial communities differed significantly between glass sponges, demosponges and ambient seawater. While the demosponges shared abundant ASVs with the seawater microbial community, the glass sponges hosted a higher proportion of specific ASVs than demosponges and environmental samples. Several bacterial phyla present in demosponges and seawater were very rare or absent in the glass sponges. Based on a clustering dendrogram, the microbial community composition seems to reflect differences in sponge histology, as well. Our study provides a starting point for further investigations on the so far understudied microbiomes of Antarctic deep-water sponges.

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EAST ANTARCTIC ICE SHEET INSTABILITY IN THE VESTFOLD HILLS, PRYDZ BAY REGION, ANTARCTICA – HISTORY AND CONTROL

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Geological fieldwork was carried out during the 2023/2024 austral summer in the Vestfold Hills, an ice-free area of 413 km^2 in Princess Elizabeth Land at the eastern margin of Antarctica´s Prydz Bay. Fieldwork was conducted during the R.V "Polarstern" expedition PS140, which was initiated by the international initiative East Antarctic Ice Sheet Instabilities (EASI). During a three week stay, complete sedimentary records were recovered from Watts Lake and from three sites that form a 10 km long N-S transect in Ellis Fjord, southern Vestfold Hills. Based on the multi-disciplinary analysis of the sample and data sets obtained, supported by organic and inorganic deposits on land as well as geodetic field data, the glacial history of the Vestfold Hills shall be reconstructed in unprecedented spatial and temporal detail. The reconstructions shall shed light on the ice retreat and possible readvances since the Last Glacial Maximum (LGM), as well as the controversial extent of the ice coverage during the LGM and possible ice-free settings prior to the LGM. Additionally, the forcing mechanisms for the reconstructed glacial history shall for the first time be investigated systematically, evaluating the factors that influence the ice mass balance via calving as well as subaereal and subaquatic melting. This on the one hand concerns the postglacial variations in local temperature and relative sea level, whose reconstructions shall be improved by the new sediment records. On the other hand, it concerns the history of sea-ice coverage and ocean currents on the adjacent continental shelf, which will be reconstructed by other EASI projects. Lastly, it concerns potential impacts by the glaciological and morphological characteristics of the oasis, which shall be evaluated by comparisons with the respective characteristics and individual climatic and environmental histories in other East Antarctic oases. The presentation will provide an overview about the sample material recovered and deeper insights into initial results and the perspectives of their complex analyses.

Mass balance and evolution of glacier systems in a changing climate

SAR SIGNAL PENETRATION DEPTH CORRECTION IN TANDEM-X DEM DIFFERENCING FOR MEASURING GLACIER ELEVATION CHANGE

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Single-pass interferometric SAR satellite configurations offer unique opportunities for observing dynamic features of ice masses. Currently the cross-track interferometry constellation of TanDEM-X mission has produced interferometric DEMs globally since 2011 and has offered opportunities for regular monitoring surface elevation of glaciers all over the world. In the present contribution we want to address one of the main issues encountered when mapping the topographic changes with multitemporal TanDEM-X InSAR DEMs over glaciers, the SAR signal penetration. We will give examples and illustrate open questions for InSAR DEM data acquisition when targeting height change rate calculation for mountain and outlet glaciers at large scale with particular emphasis on the X-band (9.65 GHz frequency, 3 cm wavelength) signal.

Radar signal penetration in ice and snow causes the scattering phase center to be located below the actual surface, introducing an elevation bias in the InSAR DEMs. We attempt to assess the bias on examples of DEM differences obtained from DEMs in different seasons and propose a correction which can be included in the operational environment of the Integrated TanDEM-X Processor (ITP) (Rossi et al, 2012). Hence, we investigate the influence of the acquisition date on the surface and volume change rates. When selecting the DEM pairs to derive the surface elevation change stronger biases due to the penetration can appear when winter and summer data are combined, even if other criteria for a high-quality DEM difference like the SAR acquisition geometries are fulfilled.

In order to optimize the use of TanDEM-X for surface elevations over snow and ice a penetration correction layer is proposed which could be implemented in ITP. The SAR signal penetration can be approximated based on the volume decorrelation contribution and the height of ambiguity (given by the geometry of the two satellites' position) (Dall, 2007). The volumetric coherence in turn can be derived from the total coherence product generated during InSAR processing assuming the signal-to-noise ratio (SNR) is known. The sensitivity of the volume decorrelation on the values of SNR will be discussed (Rizzoli 2022).

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GEOMAGNETIC FIELD AND OCEANOGRAPHIC RECONSTRUCTIONS FROM A SEDIMENT CORE IN THE ROSS SEA (ANTARCTICA).

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The stability of the Antarctic Ice Sheet (AIS) is currently under threat from Southern Ocean warming[1,2,3] and increased advection of warm water beneath the ice shelves[4]. Our ability to predict its behaviour is limited, because parameters such as critical ocean temperature that trigger ice volume loss need further investigation. Reconstructing past climatic and oceanic events archived from geological records can provide that crucial missing information. Our objective is to investigate the ice-ocean interaction evolution in the Ross Sea through time by targeting past warm intervals and periods of ice sheet retreat.

Here we present a new paleomagnetic and organic geochemical record from core ANTA02-PT39[5], which is located in the centre of the Ross Embayment (Antarctica). The successions comprises diatom bearing mud and ooze in the upper 90 cm, homogeneous mud between 90 cm and 420 cm with thin gravel-bearing sandy intervals (160 to 216 cm and 370 to 400 cm) and finally a clast poor diamicton from 420 cm to the base of the core at 780 cm.

Continuous paleomagnetic u-channel and organic geochemical samples were collected in September 2023 at the Italian National Antarctic Museum. Paleomagnetic analyses were conducted at the Otago Paleomagnetic Research Facility on a 2G Enterprises DC 760.5 pass-through superconducting rock magnetometer where u-channels were demagnetised in Alternating Field (AF) to 100 mT and data were analysed using PuffinPlot software. Overall sediments contain a well behaved steeply inclined normal polarity magnetisation which is between 100% and 80% demagnetised by the 100mT step with Natural Remanent Magnetisation (NRM) varying between 0.04 and 0.0001 A/m. Organic geochemical analysis will focus on Long Chain Diols (LCD) as a sea surface paleothermometer and Highly Branched Isoprenoids (HBIs) as a sea ice proxy.

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History and future of international cooperation in polar regions

DEFINING PRIORITIES FOR ARCTIC RESEARCH AND INTERNATIONAL COOPERATION FOR THE NEXT DECADE: FROM ICARP IV TO IPY 5

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International cooperation and coordination of priorities are vital for research in the Arctic to understand and effectively respond to the climate crisis and other changes in the Arctic. From 2022 to 2026, the International Arctic Science Committee (IASC) in cooperation with many partners worldwide, is organising the decadal Arctic research planning process International Conference on Arctic Research Planning (ICARP) for the fourth time. ICARP IV is a community-wide undertaking and brings together Arctic researchers, Indigenous Peoples, policy makers, residents and stakeholders from all countries engaged in Arctic research to considers the most urgent knowledge gaps and research priorities for the next decade, to explore avenues to address and implement these research needs, and to identify opportunities to enhance synergies that might exist across existing research plans, or where there is potential for formalising new alliances and collaborative partnerships. The summative event of the ICARP IV process will the the ICARP IV Summit during the Arctic Science Summit Week 2025 in Boulder, Colorado, USA (20 – 28 March 2025). The outcomes of the ICARP IV process will provide the foundation for developing the Arctic research goals for the 5th International Polar Year (IPY) 2032-33. This presentation will highlight the progress of the ICARP IV process as well as the key steps in the planning process and visions for the 5th IPY.

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Permafrost in a warming world: impacts and consequences

LOCAL RISKS FROM ARCTIC PERMAFROST THAW – A TRANSDISCIPLINARY, COMPARATIVE ANALYSIS

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Permafrost thaw poses significant risks to Arctic environments and livelihoods, impacting societies, cultures, health, ecosystems, and economies (see e.g., Doloisio and Vanderlinden 2020, Ramage et al. 2022). However, existing studies lack comprehensive frameworks for understanding such impacts on coupled socio-ecological systems from a transdisciplinary perspective. To address this gap, we introduce a holistic, comparative, and transdisciplinary risk analysis based on multidirectional knowledge exchanges and thematic network analysis (Attride-Stirling 2001). Local stakeholders and scientists' perceptions shape our understanding of risks that we holistically define as dynamic socio-natural phenomena involving physical processes related to permafrost thaw, ensuing key hazards, and societal consequences. Consolidating findings from four regions (Longyearbyen, Svalbard, Norway; Avannaata Municipality, Greenland; Beaufort Sea region and Mackenzie River Delta, Canada; Bulunskiy District, Sakha Republic, Russia), we identify five key hazards of permafrost thaw: infrastructure failure, disruption of mobility and supplies, decreased water quality, challenges for food security, and exposure to diseases and contaminants. The novelty of this study resides in the comparative approach spanning different environmental and societal contexts, and transdisciplinary synthesis considering various risk perceptions. We present the main local risks from permafrost thaw faced by diverse Arctic communities, seen through the lenses of multiple scientific disciplines and local experts. Developing such an understanding is vital for informed policy-making and adaptation efforts.

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The Anthropocene and climate change in polar and mountain regions

ANTHROPOGENIC INFLUENCE ON ANTIBIOTIC RESISTANCE IN CRYOSPHERIC BACTERIA: A COMPARATIVE STUDY ACROSS ALPINE REGIONS

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The growing concern of antibiotic resistance is exacerbated by anthropogenic activities, influencing the prevalence of multidrug-resistant (MDR) bacteria even in cryospheric environments. Our study investigated this phenomenon by examining antibiotic resistance in snow, ice, and water samples from glacial and other alpine regions with differing levels of human activity. Utilizing publicly available heatmaps from Strava and CORINE Land Cover (CLC) data, we categorized sampling sites into low, medium, and high anthropogenic impact zones.

Samples were systematically collected from these zones, revealing significant variations in resistance patterns. Antibiotic resistance among bacterial isolates was markedly higher in regions with high anthropogenic influence. Specifically, the number of resistant isolates in highly impacted areas was on average 18.5% and 29.8% higher than those in medium and low impact regions, respectively. This trend was consistent across all sample types, including glaciers, seasonal snow, and freshwater ecosystems. Glacier samples under strong anthropogenic influence exhibited a comparable number of bacterial isolates with reduced susceptibility to antibiotics as those found in clinical settings and hospital effluents. “Industrialized” glaciers showed up to 40% more MDR bacteria than relatively remote glacial areas.

Across all samples, MDR within cryospheric bacteria exceeded 50%, indicating limited effectiveness of the eight antibiotics tested, with only 17.8% of isolates being susceptible to all antimicrobials. Among these antibiotics, ampicillin and trimethoprim were the least effective, while linezolid and gentamicin demonstrated the highest success in inhibiting bacterial growth.

Overall, these findings underscore the significant impact of human activities on antibiotic resistance, even in cryospheric regions. However, the reduced susceptibility to antimicrobials of some bacteria in low-impact areas suggests that parts of the resistances found are intrinsic. The reduced effectiveness of synthetic antibiotics in all sampling sites acts as an indicator of acquired resistance, and although lower in remote regions, long-range transport plays a potential role. Melting waters that can potentially transport resistant bacteria and their respective antibiotic resistance genes into downstream areas highlight the necessity of addressing the topic in these environments. The natural environment remains somewhat of a black box in our understanding of antibiotic resistance and needs to be better understood to effectively tackle this worldwide phenomenon.

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EVIDENCE FOR EUREKAN DEFORMATION WITHIN AND AROUND THE YERMAK PLATEAU, ARCTIC OCEAN

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The Yermak Plateau is a submarine plateau that lies to the north of Svalbard. Strong magnetic anomalies over its northeastern part led early interpretations of an origin by volcanic processes in an oceanic setting, during the formation of the SW Eurasia Basin and the Fram Strait between Svalbard and Greenland. However, subsequent geophysical research delivered evidence that at least the southern and northwestern parts of the plateau might be underlain by extended continental crust. This implies that plate reconstructions for times before the opening of the Eurasia Basin should account for these continental fragments. Up until now, the true northward extent of this microcontinent and neighbouring parts of Svalbard, and their late Cretaceous and Paleogene relative locations, have been incompletely known.

Moreover, during the late Cretaceous and Paleogene, large areas along the Northern Canadian and North Greenland continental margins, as well as the West Svalbard and Southwest Barents Sea continental margins were affected by compressional and strike-slip deformation that culminated in at least two discrete phases together referred to as the Eurekan orogeny, which dates from 53 to 34 Ma. Considering that the continental fragments of Yermak Plateau were located to the north of Greenland or even north of the Canadian Arctic Islands, it is conceivable that the Eurekan deformation might have also left traces within or around the present-day Yermak Plateau.

Here we report on evidence from seismic reflection data from the Sophia Basin, which separates the Yermak Plateau from Svalbard. Evidence for compressional and transpressional features beneath a Neogene-Quaternary sedimentary cover can be correlated to the two Eurekan deformation phases. Reconstructing the Yermak Plateau towards the North Greenland margin by closing the Neogene-Quaternary Lena Trough spreading system based on aeromagnetic data, we also found further evidence for continuity of geological structures between North Greenland and the northwestern Yermak Plateau.

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PAST DYNAMICS OF THE WEST ANTARCTIC ICE SHEET FROM MARINE SEISMIC DATA AND DRILL RECORDS: WHAT HAVE WE LEARNED?

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The attention on the current enormous ice mass loss of the West Antarctic Ice Sheet (WAIS) leads to questions about its behavior in the geological past, in particular during past warm periods. The compilation of the growing network of seismic lines linked to relevant ocean drilling sites (e.g., from IODP Expedition 379 in the Amundsen Sea) enables analyses of the temporal and spatial evolution of the WAIS in the southern Pacific sector from early expansion to the continental shelves in the Oligocene-Miocene to variations in its dynamic behavior up to the Pliocene/Pleistocene. This includes significant warm periods with major grounded ice retreat events in the mid-Miocene and middle-late Pliocene. Our analyses, however, indicate that expansion and retreat of the various main ice-stream outflow systems from the Bellingshausen Sea sector to the Amundsen Sea and farther to the eastern Ross Sea region occurred less synchronously as previously assumed. The regional ocean circulation patterns, that were prevalent at a given time period, seem to have major control on long-term (over multiple glacial cycles) expansion and retreat phases. We show recent seismic data analyses and paleo-circulation reconstructions, and try to synthesize our observations into a consistent model for past WAIS dynamics over long-term periods.

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ARCTIC AND ANTARCTIC MARINE ECOSYSTEM – RESPONSES TO ENVIRONMENTAL CHANGE

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A multitude of environmental changes are co-occurring at different spatial and temporal scales in Polar seas. While it is understood that these changes do have impacts on the marine systems in the Arctic and Antarctic, data and detailed knowledge across trophic levels and habitats are incomplete, sporadic or even missing.

The presentation will highlight examples of observed changes in e.g. ice regime, river and glacial run off and highlight how the biological system has responded. While we principally understand that we are in a period of change, poor spatial and temporal resolution in biological data have many changes undocumented, hampering the efforts to build reasonable scenarios of the future Arctic and Antarctic. Snapshots will be presented from the Arctic and Antarctic, highlighting observed biological responses but also outline the challenges to get a solid understanding of ecosystem responses, leading to better predictions, ecosystem models and the sustainable use of polar seas.

Permafrost in a warming world: impacts and consequences

SHALLOW THAW LAKE MONITORING WITH SATELLITE DATA

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Permafrost thaw lakes frequently are partly very shallow, specifically along the rims. Such shallow lakes/parts of lakes are often freezing to the ground in winter across the Arctic. This allows their identification with satellite data, specifically synthetic aperture radar. An initial inventory using ENVISAT ASAR was established by Bartsch et al. (2017). It was found that the proportion of ground-fast ice increases with increasing soil organic carbon content in the proximity of the lakes. A new 10m landscape unit map which includes a shallow water/macrophytes unit was recently released (Bartsch et al. 2023). It is based on fusion of multispectral (Sentinel-2) and SAR data (Sentinel-1). The aim of this study was to compare the different approaches for characterizing rims of thaw lakes.

The existing datasets have been compared, but they represent different periods. New retrievals based on Sentinel-1 have been therefore made. Several regions have been selected for analysis: the Teshekpuk Lake region on the Alaskan North Slope, the Tuktoyaktuk Coastal Plains in the Canadian Northwest Territories, and the Yamal Peninsula in northwest Siberia. The percentage of ground-fast lake ice has been determined through a marker-based watershed segmentation (Pointner et al. 2019). A comparison to the original inventory (Bartsch et al. 2017) has been made to determine change in ground-fast ice quantity. The lake sections which freeze to the ground have been compared to the shallow water/macrophytes unit of the landscape unit map derived by Bartsch et al. (2023) to ascertain how the presence of macrophytes in midsummer coincides with areas affected by ground-fast ice in late winter.

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Physical processes of glaciers and ice sheets in their environment

EVOLUTION OF GROUNDING-LINE RETREAT ALONG THE MAC. ROBERTSON SHELF (EAST ANTARCTICA) OVER THE PAST 30,000 YEARS: CREATING RELIABLE SPATIOTEMPORAL BENCHMARKS FOR VALIDATING ICE-SHEET SIMULATIONS

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The future behaviour of the Antarctic Ice-Sheet is considered as one of the largest unknowns in global climate predictions. Dramatic and accelerating ice loss has been observed over the past few decades for numerous of its drainage basins (Smith et al. 2020, The IMBIE Team 2018). However, those records only reflect a short moment of limited informative value when considering the length of a full cycle of ice-sheet build-up and retreat. This emphasizes the strong need for reliable long-term data of mass balance change in time and space, particularly for sectors along the East Antarctic margin that play key roles in supplying the world's oceans with bottom waters (Ohshima et al., 2013). We present newly acquired geophysical and geological datasets from the previously insufficiently studied East Antarctic Mac. Robertson Shelf (Leventer et al. 2006, Mackintosh et al., 2011). Combined analyses of sedimentological proxies, sediment echography and bathymetry will allow for creating a four-dimensional framework of mass-balance variations over the past ~30,000 years. These unique data provide valuable spatiotemporal records for benchmarking paleo-ice sheet models and thus contribute to improve simulations of those changes for the coming decades and centuries. Furthermore, they advance our understanding of past variability in the formation of Antarctic Bottom Water that originates in the nearby Cape Darnley polynya today.

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Snow as an interdisciplinary field of research (Waalem Polar Cluster)

DATA ASSIMILATION AND MODELING TO IMPROVE ALASKA SNOW WATER EQUIVALENT ASSESSMENTS

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Measuring snow water equivalent (SWE) across the globe is imperative for improved assessment of the seasonal snowpack as part of the greater water cycle. Yet the accuracy of SWE measurements is dependent on relevant observation networks, which are particularly sparse in Boreal and Arctic regions of Alaska due to extreme topographic gradients and the state's vast spatial extent. Across most of Alaska, snowfall and the subsequent snowpack and snowmelt serve as the primary water resource for surrounding biological, ecological, and societal cycles in Alaska. Regions north of 64N are those which have especially evolved around a relatively short growing season but are highly vulnerable to warming-induced seasonal snowpack changes. As such, with a long-term goal of creating accurate and reliable SWE maps for the entire state, SnowModel has been employed to capture current and historical spatially distributed SWE in northern Boreal forest and Arctic regions of Alaska. SnowModel is used to leverage existing atmospheric forcing datasets from NASA's MERRA-2 reanalysis and the University of Alaska Fairbanks (UAF); and SWE measurements collected by UAF, Cold Regions Research and Engineering Laboratory (CRREL), USDA SNOTEL, UAF LTER networks, and by the recently completed NASA SnowEx Alaska 2022-2023 field campaigns. Here we present differences in Boreal forest and Arctic SWE simulations forced with available atmospheric datasets and advancements of snow modeling capabilities with data assimilation. This work contributes to larger SWE uncertainty analyses in Boreal and Arctic environments that lay the foundation for NASA's Terrestrial Hydrology Program snow-focused observing system simulation experiment.

Atmospheric, sea-ice, and ocean system dynamics

NUMERICALLY PREDICTING DRIFTING SNOW DEPOSITION AROUND ICEBERGS, POLAR BUILDINGS AND SOLAR POWER PLANTS

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Snow is ubiquitous in polar and alpine regions, where negative temperatures are observed almost all year round. Snow is as a very dynamic component of the Earth system through its strong modification of both atmospheric and surface processes. Aeolian snow transport typically stems from the trilateral interaction between snow, wind and ground surface: snow gets eroded by the wind and the terrain surface conditions and topography rule where (and how) it gets redistributed. Aeolian snow transport is of major importance in polar and mountain regions as it strongly influences the height distribution, micro-structure and mass balance of snow (Mott et al., 2018). In Antarctica, the large-scale katabatic winds relocate the snow over an extremely large terrain from the inner plateau to the coast, forming wind sculptured snowdrifts of various shapes and extents (Amory et al., 2017; Sommer et al., 2018). Antarctic research facilities can be particularly affected by snow accumulation if they constitute the only obstacles over vast, flat areas. In this case, the building design becomes crucial and can be optimized using numerical simulations.

Modelling snowdrifts involves representing their governing processes within a numerical framework. However, knowledge on their formation is currently limited. We present snowBedFoam, a snow transport model implemented in the fluid dynamics software OpenFOAM (Hames et al., 2021). Using Euler-Lagrange simulations, the influence of factors such as snow properties, building design and wind forcing could be evaluated using *Neumayer Station III* as a test site (Hames et al., 2024). The model was further applied to simulate drifting snow deposition around icebergs and photovoltaic power plants. Recent model developments include the evolution of snowdrifts over time by introducing a quasi-dynamical mesh, which adapts to the snow distribution prediction over time. We compare the snow distribution results modelled around *Neumayer III* with both the “static” and “dynamic” approaches, and discuss the pros and cons of both methods. Overall, our work aims to better understand snowdrift formation and improve snowdrift modelling around man-made structures (buildings) or natural ones (icebergs, sea ice). The methodology serves many engineering applications from building design to solar panel placements.

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Physical processes of glaciers and ice sheets in their environment

AIR- AND SPACEBORNE REMOTE SENSING REVEALS GLACIER RUNOFF DRIVEN SEDIMENT PLUMES IN KACHEMAK BAY, ALASKA

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Freshwater and sediment input from glacierized catchments has wide-ranging impacts on marine ecosystems. Turbid glacial runoff affects habitat characteristics and, hence, species distribution in coastal waters. In the Gulf of Alaska, glacier runoff contributes almost half of the annual freshwater input. Under ongoing climate warming and glacier recession, the timing and amount of glacial runoff is expected to change. Combining different types of observational and modelling data can provide an improved overview of how glacier melt and downstream processes are connected, especially in data sparse regions.

We present a case study employing a multi-sensor approach to map plumes of sediment-laden glacial runoff in Kachemak Bay, a glacierized estuarine fjord in the Gulf of Alaska. Comparing the spectral characteristics of turbid glacial water with water uninfluenced by glacial freshwater allows us to generate a high resolution reference map of a glacial plume based on airborne imaging spectroscopy. We then map turbid glacial plumes in Kachemak Bay using a homogenized, Rayleigh corrected time series of Landsat and Sentinel-2 data. We assess plume variability throughout the glacier melt season and contextualise the seasonality of plume extent with modelled glacier runoff from the glacierized catchments draining into the Bay. Complementing prior, point scale studies, our results show that plume extent generally follows the seasonal pattern of glacier runoff for individual catchments as well as at the scale of the Bay. Plume sizes typically decrease with decreasing glacier runoff in September and October but large plumes covering up to half the Bay can still occur late in the melt season. Most of the glacial sediment transported into the Bay likely settles out of the surface layer close to the river input points, while surface layer turbidity often spreads across much of the Bay.

In the future, tracking the seasonal onset of turbid freshwater plumes and turbidity distribution in Kachemak Bay in satellite data could help detect changes in timing or magnitude of sediment fluxes and complement in situ studies of changing habitats and water quality. Airborne imaging spectroscopy can fill information gaps in regions where in situ measurements are challenging to obtain, augmenting the greater spatial coverage of space-borne sensors with high resolution calibration and validation data.

Atmospheric, sea-ice, and ocean system dynamics

A CASE STUDY OF A WINTERTIME LOW-LEVEL JET ASSOCIATED WITH A DOWNSLOPE WIND EVENT AT THE TIKSI OBSERVATORY (LAPTEV SEA, SIBERIA) USING THE REGIONAL CLIMATE MODEL CCLM

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Low-level jets (LLJs) are important features in the Arctic atmospheric boundary layer (ABL). The forecast of LLJs in polar regions can be important for logistic operations, particularly for aircrafts, since LLJs are associated with strong wind shear and turbulence at low levels. Several mechanisms were found for the formation of LLJs, such as baroclinicity, inertial oscillations or topographic forcing. In the present paper, we investigate an LLJ event during winter 2014/15, which was observed at the Tiksi observatory (71.586°N, 128.918°E, 7 m asl) in the Laptev Sea region. Besides the routine synoptic observations data from a meteorological tower, and a SODAR (Sound Detection And Ranging) were available. The SODAR yields vertical profiles of the wind speed, wind direction and the turbulence characteristics with a vertical resolution of 10m and a temporal resolution of 20min (height range 30-550m). In addition to the measurements, simulations were performed using the regional climate model COSMO-CLM (CCLM) with 5 km resolution. CCLM was run with nesting in ERA5 data in a forecast mode, and the ABL measurements were used for comparison for an LLJ occurring from 31 Dec. 2014 to 1 January 2015.

The CCLM simulations agree well with near-surface and SODAR observations and represent the LLJ development very well. The simulations show that the LLJ at Tiksi is part of a downslope wind event, and LLJ structures are present for a large region. The flow is preconditioned by a barrier wind and channeling in the Lena valley in the initial phase, but the synoptic forcing by a low over the Laptev Sea is dominant in the mature and dissipation phase of the LLJ. High turbulence intensity occurred in the mature phase of the LLJ, which seemed to be associated with wave breaking. Downslope wind events are likely the reason for most LLJs at Tiksi.

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ANTARCTIC CLOUD CONDENSATION NUCLEI (CCN) AND ICE NUCLEATING PARTICLES (INP) *NEUMAYER STATION III*

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The earth's climate is undergoing changes at rates that are unprecedented in thousands, if not hundreds of thousands of years. The polar regions are experiencing the fastest warming on the planet. The polar regions exert a strong global impact on climate conditions, which in turn affect lives and livelihoods across the world. Despite the progress polar climate research has made, there are still poorly understood processes, one of which is the aerosol – cloud – climate interaction. This process is still not able to be modelled with satisfying accuracy. Modelling clouds and their interactions with the climate system is one of the most challenging aspects of climate research, particularly in polar regions. This is due to the difficulty of obtaining high-quality data. Therefore, the availability of high-quality measurements is of great importance for understanding processes and for driving and/or evaluating atmospheric models.

Starting with December 2019, TROPOS continuously performs in-situ Cloud Condensation Nuclei (CCN) and Ice Nucleating Particles (INP) measurements at *Neumayer Station III* (NM III, 70° 40′ S, 8° 16′ W), which is located at the Atka Bay on the Ekström Ice Shelf to improve the data base and thereby the knowledge of the locally important particle formation processes for either one. In 2023, the TROPOS OCEANET-Atmosphere container was installed at the station, providing, among others, lidar-derived aerosol / CCN profiles. These will be analysed in order to establish a link between ground and column data.

The data to be presented will include information on CCN number concentrations, hygroscopicity, INP freezing spectra, and other relevant meteorological data (e.g., back trajectories) and chemical composition of the prevailing aerosol particles. This will facilitate the identification of sources of INP and CCN over the full annual cycle.

The outcome of this project will be a more profound comprehension of the processes that prevail in the CCN and INP populations in high latitudes.

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THE DYNAMICS OF ANTARCTIC PINNING POINTS

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Accurate projections of the Antarctic Ice Sheet depend on precise modelling of ice flow in coastal regions. In particular, it is important to explicitly resolve pinning points which form in ice shelves where the otherwise floating ice comes into contact with the seabed. Pinning points regulate the flow of ice towards the open ocean by modifying the ice-shelf force balance through buttressing, influencing continental grounding line dynamics and the ice sheet mass balance. Despite their significance, pinning points are routinely modelled using ice-flow approximations that neglect key components of the stress balance and are therefore typically under-represented in continental-scale ice-sheet models. Furthermore, larger pinning points, known as ice rises, are particularly important scientifically as they store information about past flow regimes and exhibit similar flow regimes to ice sheets but on a smaller spatial scale, providing valuable insights into Antarctic Ice Sheet dynamics.

Using the full Stokes model Elmer/Ice, we address several questions related to Antarctic pinning points. Our findings show that idealised pinning points respond with hysteresis to sea level variation, suggesting that model initialisation should ideally consider the dynamic history. Moving to real-world geometries, we present the first three-dimensional simulations with a Stokes model of the stratigraphy of an ice rise, making comparisons with radar observations. Lastly, we predict the anisotropic ice fabric of an ice rise, providing a framework for model-observation comparisons and showing that parameter choices from previous studies result in significantly differing ice fabric types.

Our model results showcase the complexity of the role pinning points have in coastal Antarctic ice-flow dynamics and provide improved modelling frameworks for comparison with geophysical observations.

Atmospheric, sea-ice, and ocean system dynamics

ANTARCTIC COASTAL POLYNYAS: LOCALIZED HOTSPOTS OF OCEAN–SEA ICE–ATMOSPHERE INTERACTIONS

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Coastal (latent heat) polynyas are regions of extremely strong ocean–atmosphere heat, moisture and momentum exchange, often with wind speed and surface turbulent heat flux exceeding 30 m/s and 1000 W/m2, respectively, and air temperature below −20°C. Consequently, polynyas play a very important role in shaping the local and regional weather, are crucial for sea ice production ('ice factories') and for the associated formation of dense water masses. The ocean mixed layer (OML) during polynya events is highly turbulent, with turbulent dissipation due to wind shear, waves and convective mixing. Crystals of frazil ice forming in those very dynamic conditions are transported throughout the OML along irregular, three-dimensional trajectories. The manifestation of those processes at the surface are characteristic elongated strips with high frazil concentration – so called frazil streaks – forming in convergence zones of the Langmuir circulation (Bradtke and Herman, 2023). The presence of frazil streaks and open water areas between them leads to high spatial variability of OML and, crucially, sea surface properties. This affects the momentum flux from the atmosphere and the evolution of wind waves. Wave breaking is suppressed, and short waves are dissipated by frazil/grease ice (Ackley et al., 2022). Therefore, the whole spectral energy balance is modified (Herman and Bradtke, 2024), with feedbacks on freezing processes and ocean heat loss to the atmosphere.

In this paper, based on satellite data and numerical modelling, we discuss selected aspects of dynamic processes and interactions in one of the most widely studied Antarctic coastal polynyas, the Terra Nova Bay Polynya (TNBP). We also discuss consequences of those processes for the effectiveness of TNBP 'ice factory'.

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SPP 1158 PROJECT: RECOVERY STATUS AND ECOLOGY OF FIN WHALES AT THE ANTARCTIC PENINSULA

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The project 'Recovery Status and Ecology of fin whales at the Antarctic Peninsula' investigates the population status and identity, feeding ecology and migratory behaviour of Southern Hemisphere fin whales at feeding grounds around the South Shetland and South Orkney Islands.

Southern Hemisphere fin whales were brought to near extinction by 20th century commercial whaling. After decades of absence, recently, a return of large fin whale feeding aggregations to historical whaling grounds in the Antarctic was confirmed as part of this project, indicating progressing population recovery. Since then, we have revisited the feeding grounds during a dedicated fin whale research voyage with *RV Maria S. Merian* in 2023. We (1) conducted a fin whale abundance survey concurrently to a macrozooplankton survey to investigate predator-prey relationships, (2) deployed satellite transmitters on fin whales to track their short- and long-term movements, (3) collected biopsy and faecal samples for investigations of feeding ecology and genetic analyses, (4) recorded fin whale acoustics using sound traps, and (5) collected aerial video footage for behavioural analyses.

Here, I present the current status of the project and first results on group feeding behaviour, individual movements on the feeding grounds, and fin whale distribution across feeding grounds in relationship to krill and krill fishery effort distribution.

Biology and biogeography in polar environments

FIRST ASPA INITIATED BY GERMANY PROTECTS THE LARGEST ADÉLIE PENGUIN POPULATION OF THE ANTARCTIC PENINSULA

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Following the Protocol on Environmental Protection to the Antarctic Treaty, protected areas in the Antarctic can be designated to shelter outstanding environmental, scientific, historic, aesthetic or wilderness values or ongoing or planned scientific research. Currently, 76 areas are designated as Antarctic Specially Protected Areas (ASPAs), prioritising conservation.

The ASPA Danger Islands is the most recent addition to this list. It was designated in 2024 and is the first to be the result of a German initiative together with the USA as a co-proponent. ASPA Danger Islands, an archipelago at the tip of the Antarctic Peninsula, consists of seven islands with a total area of 4.48 km². The reasons for its designation as a protected area are manifold and range from the conservation of environmental to scientific to aesthetic values. The area is characterised by its outstanding biodiversity, with the Adelie penguin playing the leading role among the at least ten seabird species that breed there. With more than 750.000 breeding pairs, it is home to more than half of the population of this species in the entire Antarctic Peninsula. This population is also subject of scientific interest. For example, it is not yet understood why the huge Adelie penguin colonies of the Danger Islands are situated so far north compared to other Adelie penguin colonies of similar sizes and why colonies in this region appear to have flourished in recent years. To answer this and other questions, a monitoring of the local bird population of the Area is envisaged. Further studies on the penguin foraging areas should complete first insights given by recent studies of a multinational researcher team. The overall aim of the new conservation status is to protect the outstanding terrestrial wildlife from disruptive influences, while at the same time ensuring further scientific exploration of the Area.

Mass balance and evolution of glacier systems in a changing climate

ICE ELEVATION CHANGES AT SWISS CAMP (GREENLAND) – A 30-YEAR OBSERVATION SERIES

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Since 1991, a long-term project at Swiss Camp (Stober) in West Greenland has been investigating changes in ice elevation, flow velocity, and ice deformation using GNSS ground measurements. The existing data comes from 12 campaigns conducted between 1991 and 2014. As part of the “Spurensuche” project (Korth, Hitziger), additional measurements were carried out in 2015, 2021 and 2024, extending the data series to more than 30 years.

The results show a significant decrease in ice elevation by a total of approximately 20 metres, which represents 1.7% of the ice thickness at this location. Prior to 2014, a markedly accelerated decline in elevation was observed, which continued between 2014 and 2021 but at a slower rate. These changes correlate with summer air temperatures, which rose until 2012 and then remained at a slightly lower level, as well as a slightly increased albedo after 2012.

The measured local elevation changes are consistent with large-scale findings across Greenland, as determined by data from the GRACE satellite mission. This long-term project provides unique insights into the dynamics of the Greenland Ice Sheet and its response to climatic changes.

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Snow as an interdisciplinary field of research (Waalem Polar Cluster)

THE CRYOSITY PROJECT – ARTISTICAL PRESERVATION OF SNOW CRYSTALS AND GLACIER ICE SAMPLES

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Snow crystals are among the most delicate and aesthetically beautiful things in nature. Their geometrically unique features have inspired photographers and scientists for more than two centuries. However, being made of frozen water, their beauty is usually ephemeral and can usually only be captured in pictures. In this project, we present a system to permanently preserve the highly detailed imprints of snow and ice crystals using special kinds of glue and a custom-built cooling device. The resolution of the imprints is high enough to reveal the inner structure of the sometimes sub-millimetre sized features. We collected more than 100 snow crystals from Antarctica and the Arctic so far, including both winters. Additionally we also found a way to preserve imprints of larger snow and glacier ice samples. These snow crystals and ice features are showcased in artistical objects. The objects not only highlight the delicate beauty of the ice, but also refer to the fragility and delicate balance of the environments they originate from. This is supported by the integration of other materials that have been in use in the polar regions, for example discarded parts of scientific and technical equipment. We consider the artistic presentation as a pathway not only to communicate the fascination of our scientific work, but also to bring people closer to the uncomfortable truths of climate change.

DFG SPP 1158 Antarctic Research: Report Colloquium

INVESTIGATING PAST CLIMATE VARIABILITY USING AN ICE CORE FROM SKYTRAIN ICE RISE (WEST-ANTARCTICA) – A SPOTLIGHT ON ABRUPT CHANGES IN THE EARLY HOLOCENE

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West-Antarctica is one of the globally most sensitive regions to climate change. An even partial collapse of the West Antarctic Ice Sheet (WAIS) could contribute substantially to future sea level rise. Here, we use an ice core record from Skytrain Ice Rise spanning the last 130 kyr before present (1950 CE) to investigate past climate changes in this important region to support future predictions. Ice core $\delta^{18}O$, Total Air Content (TAC) and sodium provide evidence of abrupt and substantial ice loss and ice sheet retreat in the early Holocene between 8.2 and 7.3 kyr before present (Grieman et al., 2024). These fast changes in ice cover led to local changes in climate characteristics and dynamics documented in changing variability parameters of the $\delta^{18}O$ and sodium signal before and after the shift. Here we present the first results of these climate variability investigations. The variability analysis based on the decadal to centennial scale based of the ice core data is supported by three short ice core depth intervals (40-80cm) of high-resolution impurity analysis (Sodium, Magnesium, Aluminium) via Laser-Ablation Inductively Coupled Plasma – Mass Spectrometry (LA-ICP-MS). These high-resolution data enable segmentary analysis of changes on annual or even sub-annual time scales and provide a deeper understanding of the climatic processes in this important Antarctic region.

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Atmospheric, sea-ice, and ocean system dynamics

WATER MASS TRANSFORMATION IN THE NORTHERN BARENTS AND KARA SEAS: IS THE SYSTEM CHANGING?

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Warm and salty Atlantic water (AW) flows through the Fram Strait and the Barents Sea (BS) into the Arctic Ocean (AO), where it releases heat into the atmosphere, thus increasing the density of inflowing water masses. This transformation of the water mass has an effect on the thermohaline structure of the AO and the sea ice cover. Ultimately, the return flow of the altered AW reaches the Nordic Seas (Greenland, Norway, and Iceland Seas) via the western side of the Fram Strait, where the denser portion of the AW exits the Polar Ocean and contributes to the overflow waters that flow southwards over the Greenland-Scotland Ridge as an important component of the Atlantic Meridional Overturning Circulation.

Unlike in the Fram Strait, almost all of the AW heat is released into the atmosphere in the BS. Cooling the AW inflow in conjunction with brine rejection during sea-ice formation produces denser water masses that then sink to greater depths in the AO. Recently, it has been reported that cooling efficiency in the BS has decreased, with possible implications on ocean circulation in the adjacent ocean basins. Therefore, the AW reaching the northern BS has become warmer (Skagseth et al., 2020). However, results from a model study (Shu et al., 2021) indicate that overall cooling efficiency has not really decreased. While the cooling capacity decreased in the southern BS, it increased in the northern BS and Kara Seas (KS).

In a study based on oceanographic observations, Arctic Ocean physics reanalysis and satellite data, we want to clarify whether the denser water flowing from the deep St. Anna Trough (Kara Sea) into the adjacent basin of the AO has changed significantly in recent decades and which physical processes occurring in the northern BS and KS control the temperature and salinity variability of the outflow. In this respect, the data from the Russian-German-Swiss expedition “Arctic Century 21” represents a significant step towards a better understanding of these complex physical processes (dataset: Makhotin et al., 2022)

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Biology and biogeography in polar environments

PICOPLANKTON CONNECTIVITY PATTERN INDICATES INCREASING DOMINANCE OF PROKARYOTES IN WARMER ARCTIC FJORDS

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Climate change is opening the Arctic to increasing human impact and profound ecosystem changes. These pristine ecosystems are some of the most productive high-latitude systems and are sustained by a diverse microbial community at the base of the marine food web. In our study, we show that Arctic fjords become more prokaryotic in the picoplankton (0.2–3 µm) with increasing water temperatures (Hörstmann et al. 2024). Across 21 fjords, we found that Arctic fjords had proportionally more trophically diverse (autotrophic, mixotrophic, and heterotrophic) picoeukaryotes, while subarctic and temperate fjords had relatively more diverse prokaryotic trophic groups. Modeled oceanographic connectivity between fjords suggested that transport alone would create a smooth gradient in beta diversity mainly following the North Atlantic Current and East Greenland Current. Deviations from this suggest that picoeukaryotes had some strong regional patterns in beta diversity that reduced the effect of oceanographic connectivity, while prokaryotes were mainly stopped in their dispersal if strong temperature differences between sites were present. Fjords located in high Arctic regions also generally had very low prokaryotic alpha diversity. Ultimately, increased warming of Arctic fjords could induce a fundamental shift from more eukaryotic- to prokaryotic-dominated communities, particularly within the heterotrophic functional group, with profound implications for Arctic productivity patterns.

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The Anthropocene and climate change in polar and mountain regions

THE ECOLOGICAL IMPACTS OF PRODUCTIVE POLYNYAS RESPONDING TO FUTURE CLIMATE CHANGE

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Climate change is expected to impact polar regions at an increasingly rapid rate, with rising temperatures contributing to the extensive loss of sea ice (Stuecker et al. 2018; Convey & Peck 2019). Consequently, the extent and distribution of vital polar marine ecosystems, such as Antarctic polynyas, are expected to change drastically. Polynyas are large persistent areas of open water within otherwise consistent regions of sea ice cover, representing areas of high primary productivity and biological activity (Maqueda et al. 2004). As a result, polynyas support a wide range of marine life, from primary producers such as phytoplankton, to top trophic predators, including elephant seals (Arrigo & van Dijken 2003; Arce et al. 2021). Despite their ecological significance, little research has focused on how the future extent and distribution of polynyas will alter with climate change, and the resultant ecosystem-wide impacts this might have (Mohrmann et al. 2021). Therefore, this study aims to model how productive Antarctic polynyas in the Amundsen Sea will respond to climate change projections and highlight the potential ecological consequences. As there are many different geographical, physical, and biological attributes used to define polynyas, it is often challenging to detect them within climate models. Therefore, this study first determines a methodology of how to identify productive polynyas within modelling. By utilising climate models from the Coupled Model Intercomparison Project, this methodology is then used to compare the future distribution and size of polynyas in the Amundsen Sea under climate change projections, to that of the present day. Preliminary findings show that primary productivity of the Amundsen Sea becomes less concentrated under future climate change, as sea ice concentration, and thus polynyas, diminish. The predictive maps of polynyas which this study will produce will benefit marine managers, as it will enable them to anticipate ecological change and develop adaptive strategies which could mitigate negative impacts on marine life.

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Mass balance and evolution of glacier systems in a changing climate

ACCUMULATION BY AVALANCHES AS SIGNIFICANT CONTRIBUTOR TO THE MASS BALANCE OF A HIGH ARCTIC MOUNTAIN GLACIER

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Greenland´s peripheral glaciers are losing mass at an accelerated rate and are contributing significantly to sea-level rise, but only a few direct observations are available. Here, we use the unique combination of high-resolution remote sensing data and direct mass balance observations to separate and quantify the contribution of a singular avalanche event to the mass balance of Freya Glacier (74.38° N, 20.82° W), a small (5.5 km², 2021) mountain glacier in Northeast Greenland. Elevation changes calculated from repeated photogrammetric surveys on 11th - 18th August 2013 and on 28th - 31st July 2021 range from -11 m to 18 m, with a glacier-wide mean of 1.56 + 0.10 m (1.34 + 0.21 m w.e.). Somewhat surprisingly, the geodetic mass balance over the full period of 8 years (2013/14 - 2020/21) is positive, (0.74 + 0.22 m w.e.). A main imprint of the near decadal mass balance stems from the exceptional (2.5 standard deviations above average) winter mass balance of 2017/18 with 1.85 + 0.05 m w.e., when in addition to above average precipitation, snow avalanches affected more than one third of the glacier surface and contributed at least 0.31 m w.e. (17%) to the total winter mass balance of 2017/18. While snow of the 2018 avalanches is still visible on the glacier surface in summer 2021, we observed also avalanche in 2012 and 2016, but to a much lesser extent. Due to a gap in valid point observations caused by high accumulation rates and the COVID-19 pandemic the recently reported glacier-wide annual mass balance are rather crude estimates and show a negative bias in respect to the geodetic mass balance, which demands a thorough reanalysis of the glaciological time series. Finally, we speculate that the projected future warming increases the likelihood of extreme snowfall events for individual years and thus, may increase the contribution of snow avalanches to the mass balance of mountain glaciers in NE Greenland.

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DFG SPP 1158 Antarctic Research: Report Colloquium

EXPLORING THE UNSEEN: CHYTRID FUNGI IN ARCTIC AND ANTARCTIC MICROPHYTOBENTHIC COMMUNITIES

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Fungal parasites have been recognized as critical and abundant components of every ecosystem. They have the potential to regulate host populations, mediate interspecific competition between hosts and other species, and thus affect biodiversity and food web structure. However, parasite diversity is still poorly known, particularly for fungal parasites in aquatic ecosystems, and only rough estimates exist on total species diversity and abundance. A few recent studies in polar regions indicate that parasitic species, in particular of the early fungal lineages, are highly abundant in both Antarctic and Arctic aquatic ecosystems, yet their diversity and ecological roles are still poorly understood. Therefore, we aimed to address these gaps and investigate the relevance of fungal parasites for microphytobenthic communities, which form the basis of coastal food webs and are key components for trophic interactions in polar ecosystems. In our study, we describe fungal diversity and identify host-parasite interactions in marine, brackish and freshwater benthic habitats of Kongsfjorden (Svalbard) and Potter Cove (King George Island, Antarctic Peninsula) using high-throughput sequencing and microscopy. We show that fungal parasitic taxa are present in these habitats in high abundances, whereby their correlations with benthic diatoms indicate potential parasitic interactions. Moreover, we show that salinity is a major driver of fungal diversity and community composition and thus emphasize the need for further research, considering the effects of increased inputs of glacial meltwater caused by increasingly severe climate warming.

Physical processes of glaciers and ice sheets in their environment

CHANGE IN PHYSICAL PROPERTIES ACROSS THE NEGIS SHEAR MARGIN

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The East Greenland Ice-core Project and associated research programmes succeeded in acquiring extensive data for studying the dynamics of the North-East Greenland Ice Stream, a crucial element in Greenland's ongoing ice mass loss. Alongside the main ice core, EGRIP, several shallow cores from locations near the shear margin of NEGIS southeast of the EGRIP drill site were drilled. The cores S5 (drilled in 2021), ExS5-1 and ExS5-2 (drilled in 2022) are located along a line crossing the shear margin along an apparent streamline of the currently observed velocity at the site, approximately 4 km apart. Each core extends to 100 m depth. The position of the first core was determined to be at the lowest point of the dip in elevation observed across the shear margin. At this position the shear strain rate determined from the surface velocity is approaching a plateau. The strain rate further increases towards ExS5-1, and the drops again towards ExS5-2, which is located within the ice stream main trunk.

We obtained physical properties data from the cores, that is, crystal-preferred orientation and bulk density. We present the evolution of crystal anisotropy in the top 100 m across the shear margin. Our observations include a cross-girdle CPO, previously found in the EGRIP ice core at a depth of around 200 m, in shallow depths. Consistent with accelerated densification at the location of ExS5-1, we find that the crystal anisotropy evolves more rapidly, resulting in a strong horizontal single maximum CPO occurring 10 to 15 m higher than in ExS5-2.

For ExS5-1, within the highest shear strain rate zone, the density of 850 kg/m3 is reached in a depth of 45 m already, while for the core in the ice stream main trunk this density is reached in 60m depth. Thus our results confirm that the high strain rate not only influences the evolution of crystal orientation fabrics but also densification.

Biology and biogeography in polar environments

BENTOOLSMAPS – FROM BIODIVERSITY TO ECOSYSTEM FUNCTIONS: SEAFLOOR TOOLS FOR INTEGRATIVE MANAGEMENT OF MARINE PROTECTED AREAS

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A healthy hydrosphere with a rich biodiversity and functioning ecosystem ensures oxygen and food. Smaller benthic organisms are known to respond to fluctuation in sea-ice cover and benthic food regimes (Säring et al. 2022, Veit-Köhler et al. 2018) but particularly knowledge of their role for ecosystem services as carbon storage and cycling is still lacking. For example, meiofauna communities and ecosystem services have rarely been considered in the planning of Marine Protected Areas. The Southern Ocean is facing increasing pressure from climate change effects. International efforts such as the Southern Ocean Action Plan (UN Decade 2021–2030) aim to manage and protect this unique ecosystem. The Weddell (WS) has been the focus of German Antarctic research for 40 years and an MPA initiative has been underway since 2013 (Teschke et al. 2021). The fairly good database and the established stakeholder network make the WS an excellent case study for integrating seabed knowledge (Jerosch et al. 2015) into conservation and management measures. This is relevant for other marine regions under the Antarctic Treaty System and future High Seas Treaty areas. We aim to

1. provide a detailed description of sediment-inhabiting meio- and macrofauna,
2. include modern approaches for accelerated and in-depth analyses,
3. quantify and map ecosystem functions and services, and
4. integrate the knowledge into MPA planning and conservation of shelf and slope habitats under different climate change stressors.

Led by the University of Rostock, partners from four institutions (URO, AWI, SaM, HIFMB) will create this baseline knowledge from field experiments in the WS , integrate the findings, create spatial models and transfer the knowledge to stakeholders, including CCAMLR, the Biodiversity of the Blue Ocean Cluster and the public. *BEnToolsMaPs* will combine knowledge on the structure and function of Southern Ocean seafloor systems, facilitating decision-making on sustainable management of carbon storage and biodiversity ecosystem services.

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History and future of international cooperation in polar regions

CONCEIVING THE ARCTIC IN MIDDLE PERIOD CHINA

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Political and military control of the steppe borders to the north have been of so great concern of Chinese History since antiquity, that geographical zones beyond the steppe belt have largely been removed from the focus of scholarly attention. The rôle of these was subject to multiple changes over time. These changes had a direct impact on the Chinese perceptions of the Forests, the sub-arctic and arctic environments of the North and related aspects of cosmology. More than during any other pre-modern period, under the Mongol Yuan dynasty (1279-1368), territories beyond the steppe were controlled from and linked to China proper. In this talk it will be discussed, to which extent the changing permeability of the steppe belt during the Middle Period, here defined as the long stretch between the decline of Xiongnu influence in the 3rd century A.D. and the rise of Russian control over Siberia in the 17th century, influenced Chinese understanding of the North and lead to the questioning of legendary and speculative narratives of the past.

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A RECENT INCREASE OF ICE-SURFACE ELEVATION IN CENTRAL EAST ANTARCTICA

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In recent years, increased precipitation has caused the East Antarctic Ice Sheet (EAIS) to gain mass, partially offsetting sea level contributions from accelerated West Antarctic Ice Sheet mass loss. This mass gain was primarily observed for the margins of the EAIS where precipitation amounts are largest. Here we ask the questions: Are there detectable mass gains in the interior of the EAIS, such as the Lake Vostok region where mean annual precipitation is as low as 20 mm water equivalent? Can a related small increase in ice volume be observed by satellite altimetry despite known uncertainties resulting from time-variable penetration of radar signals into the snowpack, which may be large in relation to the small signal expected? With the launch of the ICESat-2 laser altimetry mission in late 2018, elevation measurements of unprecedented accuracy are now available. In this study, we analyse measurements from ICESat-2 and CryoSat-2, a radar altimetry mission launched in late 2010, over selected areas such as Lake Vostok, which is representative for the central EAIS. We use results from ICESat-2 to validate different radar altimetry analysis methods that aim to minimise errors related to radar penetration. These methods include different algorithms to retrack the radar return waveform and different versions of empirical corrections based on the relationship between apparent variations of elevation and variations of waveform parameters. ICESat-2 results reveal an increase of 2.2 ± 0.2 cm yr^{-1} in surface elevation of the ice sheet above Lake Vostok from September 2019 to December 2023. Over the same period, elevation rates from CryoSat-2 are in the range from 0.1 to 1.3 cm yr^{-1} depending on the analysis method applied. We find that only new retracking algorithms and/or improved empirical corrections are able to detect the increase in elevation change tracked by ICESat-2.

Biology and biogeography in polar environments

DARK SURVIVAL MECHANISMS IN POLAR BENTHIC DIATOMS

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The polar regions represent an extreme habitat for phototrophic algae due to long periods of darkness caused by the polar night. Benthic diatoms, which dominate microphytobenthic communities in coastal soft bottom regions, can survive this dark period, but the underlying physiological, biochemical and cell biological mechanisms are not well understood. Over the last decade numerous benthic diatom strains from Arctic Svalbard and Antarctic Peninsula were isolated and established as clonal cultures, and used for controlled dark incubation experiments mimicking the polar night along with other polar conditions. The data indicate an array of response patterns, such as, for example, a reduced basic metabolism, utilisation of stored energy products, chloroplast shrinkage/degradation etc. Dark exposure for 10 months dramatically reduced the chloroplast ultrastructure, thylakoid stacking, and led to a higher proportion of cells with compromised membranes compared to light-adapted cells. However, photosynthetic oxygen production was readily measurable after such a long dark period indicating that the main adaptive strategy in polar benthic diatoms is the maintenance of a functional photosynthetic apparatus that guarantees rapid recovery after re-irradiation.

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Physical processes of glaciers and ice sheets in their environment

VARIABILITY OF CRYSTAL-PREFERRED ORIENTATION IN HIGH-RESOLUTION DATA FROM EGRIP ICE CORE

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The North-East Greenland Ice Stream (NEGIS) is a major contributor to ice loss experienced by the Greenland Ice Sheet. However, our current understanding of the mechanics of this highly dynamic feature, compared to the surrounding slowly deforming ice sheet, is inadequate, despite the significance for enhancing ice flow models and attaining more accurate sea-level rise projections. Between 2016 and 2023, the East Greenland Ice-core Project drilled the first deep ice core in such a fast-flowing regime (surface velocity of around 55 m a-1 (Hvidberg et al., 2020)) at the onset of NEGIS, reaching bedrock at approximately 2670 m (https://eastgrip.org/Bedrock). Data collected from the ice core have provided the crystal-preferred orientation (CPO). This data set contains more than 1000 vertical thin sections prepared from 220 continuous ice segments of 55 cm length. The first major analysis of the data (Stoll et al., in preparation), considering one data point per thin section, reports an exceptionally fast development of anisotropy with depth and a prevalence of girdle CPO combined with a horizontal maximum of varying strength, as a result of significant along-flow extension and vertical shear. Moreover, the unprecedented amount of CPO data from a single deep ice core allows for the exploration of decimetre- and centimetre-scale CPO variability, providing a reference for comparison with other ice core parameters, such as dust load, to study the respective influence of impurities and physical properties. Additionally, this extensive data can be valuable for understanding the effects of sampling, which must be considered to estimate uncertainty in CPO data.

We share our preliminary results from the CPO computation using variable vertical resolution, that is, varying the vertical depth interval contributing to each data point, and benchmark this against standard data analysis. We assess the strength of horizontal layering by computing CPO from randomly sampled grains within an interval. This approach contributes to our methodology toolkit for using CPO for the study of crystal anisotropy in glacier ice.

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Atmospheric, sea-ice, and ocean system dynamics

CONTAMINATION PROFILE OF PFAS IN THE KONGSFJORDEN, SVALBARD, NORWEGIAN ARCTIC

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Per- and polyfluorinated chemicals (PFASs) are a group of emerging contaminants with highly toxic effects, and they are widely distributed in the global ocean network, including the Arctic ocean. Limited studies have been conducted on their presence in the sedimentary environment of polar regions. This study assessed the concentration and distribution of different PFAS in the Kongs fjords of the Svalbard archipelago in Norway.

This study measured the concentration of different PFAS compounds in the surface and bottom water and sedimentary environment. Samples were collected from the ten different stations in Kongsford. The ΣPFOA observed for Kongsfjorden was 0.68 ng/g. The concentration of various PFASs was lower in water samples. The data indicated that the influence of glacier melting, anthropogenic activities on the inner fjord and the open ocean on the outer fjord system. In the midst of climate change scenarios more studies have to be conducted to understand the fate and transport of PFASs in the marine environment.

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Atmospheric, sea-ice, and ocean system dynamics

WHAT FACTORS EXPLAIN THE CURRENT ARCTIC ALBEDO AND ITS FUTURE CHANGE?

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In recent decades, the Arctic has experienced rapid sea ice loss and an accelerating positive surface albedo feedback, thereby significantly altering the Arctic surface radiation budget. The projections from the Coupled Model Intercomparison Project (CMIP6) climate models indicate a consistent trend of decreasing Arctic surface albedo, despite a significant inter-model spread. Using CMIP6 models and Clouds and the Earth's Radiant Energy System (CERES) satellite observations, this study investigates the factors contributing to the inter-model spread and projected changes in Arctic surface albedo by developing a decomposition method to separate the contributions from sea ice albedo, sea ice concentration, and ice region to the total surface albedo change. Analyzing the Atmospheric Model Intercomparison Project (AMIP) within CMIP6 with prescribed sea ice concentration, we find a substantial inter-model spread in Arctic surface albedo attributed to differences in land snow cover and sea ice albedo. Particularly, a strong seasonality is found in the surface albedo over the ocean, with the ice region term predominantly contributing to the spread across the Barents, Kara, and Greenland seas during early summer. In late summer, sea ice albedo and sea ice concentration terms, especially in the Central Arctic and Chukchi Sea, became more influential in explaining inter-model spread in present-day surface albedo. Applying the decomposition to projections shows that models projecting a larger decrease in sea ice concentration and ice region area, especially in Central Arctic show more pronounced reductions in surface albedo. However, models fail to capture the yearly fluctuations in the ice albedo term as in the CERES data. The surface albedo decomposition presented in this study provides valuable insights into the factors contributing to the spread and changes in Arctic surface albedo and hence to the sea ice albedo feedback and associated Arctic climate change.

Physical processes of glaciers and ice sheets in their environment

NEW INSIGHTS INTO PAST EAST ANTARCTIC MARGIN ICE SHEET BEHAVIOR FROM COMBINED GEOPHYSICAL AND GEOLOGICAL DATA COLLECTED DURING RV POLARSTERN EXPEDITIONS PS140 AND PS141 (EASI-2 & -3)

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Compared to its inherently unstable West Antarctic companion, the East Antarctic Ice Sheet (EAIS) as the largest ice mass on Earth was long considered to be relatively robust to external oceanic and/or atmospheric forcing. Recent studies, however, have revealed that ice masses in its marine-based portions such as the Wilkes and Aurora Subglacial Basins, which hold a potential sea-level equivalent of about 20 meters, may react just as sensitively. Currently, many outlet glaciers that connect into these deep hinterland basins are subject to significant ice flow acceleration and grounding-line retreat, hence may hint at potentially substantial ice losses in coming decades and centuries. Since those observations only cover a relatively short time period of several decades, it remains largely unconstrained how the modern rapid changes in those sectors compare to ice sheet dynamics since the ice sheet's last maximum extent some 20,000 years ago. Here, we report on first results from newly acquired multibeam bathymetry, sediment echosounder and *in-situ* sediment core data from the Davis and Mawson Sea continental shelves, revealing major palaeo-ice stream troughs, grounding-line stabilization features, and extensive meltwater drainage systems. These new combined data will allow crucial spatiotemporal benchmarks to be established for characterizing past ice sheet dynamics for these vulnerable EAIS portions. This, in turn, will enable the development of a four-dimensional framework for testing and validating ice sheet models that ultimately aim at predicting EAIS's future response more reliably.

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KEYNOTE: EVOLUTION OF THE ANTARCTIC ICE SHEET SINCE ITS INCEPTION 34 MILLION YEARS AGO AND USING THIS KNOWLEDGE FOR ADVANCING NUMERICAL MODEL SIMULATIONS

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The Antarctic Ice Sheet (AIS) is thought to diminish considerably over coming decades and centuries – largely because warm deep waters increasingly reach its ice margins with many hinterland ice sheet portions grounded way below modern sea level, together leading to accelerating and irreversible retreat. So, are we currently witnessing the fate of an ice sheet associated with severe consequences for global coastal communities? Finding better answers to this question requires robust multi-proxy continental data evidence from times that were warmer and CO_2-richer than today. Such sediment records, however, are rare and challenging to obtain, and associated continental drilling campaigns only feasible within large multinational consortiums. Some extensive Antarctic field campaigns, however, were recently realized, are about to be accomplished, or at planning stage. This presentation will introduce these campaigns and highlight how their results combined with novel coupled modeling techniques will eventually allow for significant new insights into AIS' long-term evolution and, with this, for better predicting its behavior to conditions anticipated for the foreseeable future.

Polar Earth Sciences

EVIDENCE FOR EUREKAN DEFORMATION WITHIN AND AROUND THE MORRIS JESUP PLATEAU, ARCTIC OCEAN

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The Morris Jesup Plateau is located offshore North Greenland and includes the Morris Jesup Rise in the west and the Morris Jesup Spur in the east. The Yermak Plateau north of Svalbard represents the conjugate margin of the Morris Jesup Plateau. Both margins are separated by the southernmost part of the Eurasia Basin with the Gakkel Ridge. The wider Eurasia Basin started to open in Paleocene-Eocene times. At those times, Greenland moved northwards due to active spreading both in the NE Atlantic and the Labrador Sea. This northward motion of Greenland resulted in the Eurekan compressional deformation between Greenland and Svalbard and limited or strongly influenced the opening of the Eurasia Basin towards the southwest. Only with the cessation of the Eurekan deformation in late Eocene times, the spreading system of the Eurasia Basin advanced southwards and finally separated the Yermak and Morris Jesup plateaus.

While Eurekan deformation is well documented onshore across the West Spitsbergen Fold-and-Thrust Belt and complex thrust and strike-slip zones in North and NE Greenland, only little is known about how these compressional/transpressional structures continue offshore across the North Greenland continental margin towards the Morris Jesup Plateau. Furthermore, the extent to which the Morris Jesup Plateau was affected by extension prior to its separation from the Yermak Plateau in the early Oligocene is poorly resolved. Answering these questions is essential to determine where the Morris Jesup and Yermak plateaus were situated along the North American margin in the late Mesozoic and earliest Cenozoic. Was the opening of the Eurasia Basin compensated by deformation within the plateaus, or did strike-slip movements reactivate the ancient Paleozoic Canadian Arctic transform system? Are there any indications for initial subduction to the North of Greenland as previously proposed on base of potential field data?

Here we report on the first multichannel seismic survey along with magnetic data of the southern Morris Jesup Plateau. The seismic data image transpressional and transtensional deformation likely associated with the two Eurekan deformation episodes, the transition to passive margin evolution as well as glacial sedimentation. We compare the results with two seismic lines of the northern Morris Jesup Plateau, which allow to discuss structural variations along the Morris Jesup Spur.

Polar Earth Sciences

IS THE YERMAK PLATEAU A CONTINENTAL FRAGMENT FROM NORTH AMERICA?

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The Yermak Plateau (YP) north of Svalbard is a prominent bathymetric feature in the Eurasia Basin of the Arctic Ocean, forming the northwesternmost margin of the Eurasian plate. Seismic data indicate that the YP comprises continental basement, however, little is known about its geology.

Rock fragments, which were previously recovered by dredges and corers from basement highs of the northeastern and southwestern YP, are dominantly of magmatic origin. New petrographic, geochemical, Sr–Nd isotopic, and Ar–Ar geochronological data combined with available literature data, and comparison with volcanic and sedimentary rocks from onshore and offshore areas adjacent to the YP indicate that the northeastern YP and the southwestern YP are different regarding their geological evolution (Estrada et al. 2024).

The southwestern YP comprises an alkaline basaltic suite for which an Ar–Ar biotite age of 51 Ma was previously reported (Riefstahl et al. 2013). The suite was formed in a continental extensional regime offshore northern Svalbard. Associated sedimentary rocks (sandstone, several limestones) show petrographic similarity with rocks of the Devonian Old Red Sandstone on Svalbard.

From the northeastern YP, in contrast, we recovered mildly alkaline basaltic rocks with mid-Cretaceous Ar–Ar ages (102±3 and 98±3 Ma). The rocks show certain geochemical characteristics (partial enrichments of P, Ba and Eu), which overlap with similar-aged Cretaceous basaltic rocks from northern Ellesmere Island of Canada and North Greenland. We suggest that the northeastern YP is a continental fragment derived from the North American plate, which was separated from the conjugate Morris Jesup Rise and juxtaposed to the geologically distinct southwestern YP by the propagation of the Gakkel Ridge spreading center since the early Oligocene.

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Atmospheric, sea-ice, and ocean system dynamics

COMPARISON OF HIGH RESOLVED NUMERICAL MODEL SIMULATIONS WITH AIRCRAFT MEASUREMENTS FOR GAP FLOWS IN NARES STRAIT – GREENLAND

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The steep topography along Nares Strait, located between Ellesmere Island and northern Greenland, leads to intense, southward low-level winds. In the small part of Smith Sound gap flows form, which also influence the largest and most productive polynya of the Arctic, the North Water Polynya.

We use the non-hydrostatic COMSO-CLM regional climate model (CCLM) to study the wind formation process and the atmosphere-ocean-sea/ice interaction for the period of the aircraft-based experiment IKAPOS in June 2010. These measured data are used to evaluate CCLM simulations with 14km, 5km and 1km horizontal resolution.

All three resolutions resolve the small channel and represent the stable boundary conditions realistically. The highest winds of around 14m/s are present in the exit region of Smith Sound for June 2010. A statistical comparison with 234 flight profiles for potential temperature and wind speed shows small biases and correlations higher than 0.84. Inversion and jet heights as well as low-level jet maximum speed vary slightly between the model resolution but are close to the measured data. The comparison of available vertical cross-sections shows high agreement between model and aircraft data. There is an improvement in the simulation for the structure of the boundary layer and the intensity of the near surface winds between the 14km and 5km resolution.

The barrier of Smith Sound partly blocks the stably stratified upstream flow, which is then channelled and forced through the gap. Maximum winds occur at gap exit region due to gravity waves generated by the barrier and the resulting downward flow within the gap. The benefit of model simulations in comparison to measured data is that the temporal development of the gap flows and the associated lee waves in the exit region of the gap can be studied. The calculated Froude Mountain number (Frm) for the gap flows match to the idealized cases of gap flows classified in Markowski and Richardson (2010).

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Atmospheric, sea-ice, and ocean system dynamics

TOWARDS PAN-ARCTIC SEA ICE FREEBOARD MAPS AT 100 M RESOLUTION

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Sea ice topography observations can be used to derive ice-atmosphere coupling, monitor thermodynamic as well as dynamic ice formation events and melting. Directly measuring the sea ice height above water (freeboard) at pan-Arctic scale can only be achieved with spaceborne altimeters, like ICESat-2 and CryoSat-2. These instruments have excellent vertical resolution and medium to high resolution along track, but only extremely sparse coverage in the across track direction – measuring along a thin line directly underneath the satellite orbit (or six lines in the case of ICESat-2, with three strong and three weak beams). Thus, high resolution topography maps across spatial dimensions cannot be captured by altimeters alone.

In (Kortum et al. 2024) we have shown, that sparse measurements made by ICESat-2 can be extrapolated to Sentinel-1 C-band SAR scenes, using the radar backscatter as a proxy. In a further step one can use this technology to retrieve freeboard maps. The deep network at the core of this technique is trained using a range of unsupervised and supervised techniques, which allows to train from the very limited spatiotemporal SAR and altimeter overlap. The network learns to perform a sorting of the SAR pixels according to their freeboard. Once the sorting is complete, one can map an altimetry-measured freeboard distribution to the sorted pixels via their respective cumulative distribution functions. As colocation is no longer necessary here, this can be performed even with larger time gaps between the satellite measurements. The resulting freeboard maps at Sentinel-1 coverage admit uncertainties between 11 and 6 cm at resolutions of 100 m to 800 m respectively. Such maps with freeboard estimates can be created for all Sentinel-1 acquisition with overlapping ICESat-2 data within the last day(s) and by this pan-Arctic sea ice freeboard maps can be aggregated at approximately a frequency of 3 days. Due to the sensors used, the marginal ice zone and summer sea ice are problematic to resolve and our initial study focusses on acquisitions in October and November.

Monitoring Arctic sea ice topography at these resolutions and coverage could be a valuable source of data for the scientific Arctic community as well as other polar stakeholders in the future. For example, more accurate ridge spacing distributions can be obtained and thus better air-sea ice drag coefficient estimates are possible.

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UNDERSTANDING PAST EAST ANTARCTIC ICE SHEET DYNAMICS FROM SEISMIC REFLECTION DATA IN THE DAVIS AND MAWSON SEA SECTORS

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The East Antarctic Ice Sheet (EAIS) has long been assumed to remain relatively stable. This theory has, however, been challenged by recent increased ice mass loss and improved subglacial topography data. Reconstruction of past glacial dynamics can improve understanding of current and future ice sheet behavior with relevance to sea-level changes.

Glacial-marine sediments deposited on the continental shelf and rise contain records of past ice sheet expansion and retreat periods, which have occurred since the onset of Southern Hemisphere glaciations. We use deep penetrating seismic reflection data collected by RV Polarstern during Expedition PS141 in early 2024 in conjunction with previously existing data to construct a seismic stratigraphic assessment of the continental shelf and rise in the Davis and Mawson Sea sectors in front of the Shackleton Ice Shelf with its Denman Glacier, as well as the Vanderford Glacier to the east. Results of preliminary data processing reveal preglacial sedimentary strata and glacially transported sequences on the shelf and slope, which will be linked to scientific drill records from the northern Mawson Sea, Prydz Bay and offshore Wilkes Land for age control via long-distance correlation. These seismic reflection data allow the analysis of glacial and preglacial sedimentation processes on a previously unmapped part of the East Antarctic continental shelf. This, in turn, will allow dominant phases of early Oligocene to Pleistocene ice sheet development of the EAIS in these sectors to be deciphered.

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SEDIMENT RECORDS FROM THE SIPLE COAST BELOW THE ROSS ICE SHELF: UPDATE FROM THE FIRST SEASON OF THE SWAIS-2C PROJECT

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The Sensitivity of the West Antarctic Ice Sheet to 2°C (SWAIS 2C) project is a new international drilling project that aims to collect key sediment records from below the Ross Ice Shelf along the Siple Coast, eastern Ross Sea, to address questions of West Antarctic Ice Sheet (WAIS) stability during past intervals of warmer-than-present climate (e.g., super-interglacials, mid-Pliocene Warm Period, and Miocene Climate Optimum). This project is supported by 10 countries (New Zealand, United States, United Kingdom, Germany, Australia, Republic of Korea, Japan, Italy, Spain, Netherlands), as well as the International Continental Scientific Drilling Program (ICDP). During the first drilling season (2023–2024), we successfully hot-water drilled a hole through ~577 m of the Ross Ice Shelf at Kamb Ice Stream (KIS) Site 3 (82.6285°S, 156.3046°W). We collected 8 gravity cores between 3 and 76 cm in length, as well as four hammer cores with recovery between 0 cm and 1.92 m. We also deployed four CTD instruments in the ~54 m ocean cavity between the base of the ice shelf and the seafloor to measure conductivity, temperature, and pressure, as well as two GoPro video cameras to capture images of the base of the ice shelf and the seafloor. At the end of the season, we deployed an oceanographic mooring with two CTD instruments and two current meters to record a time series of conditions within the open water cavity at KIS-3. We collected X-ray and computed tomography (CT) images, as well as physical property data (gamma ray attenuation bulk density, magnetic susceptibility, P-wave velocity, and electrical resistivity) using a Geotek multisensor core logger (MSCL) for all cores. Three cores were split in April 2024 at the Otago Repository for Core Analysis (ORCA) in Dunedin, New Zealand, with the split-core

surface imaged using a Geotek Boxscan, which also collected color spectrophotometry, point magnetic susceptibility, and X-ray fluorescence data. These data sets, together with visual core descriptions, indicate that the sediment consists of muddy to sandy clast-poor to clast-rich diamict with varying proportions of diatoms. Sampling for research by the SWAIS 2C science team will occur in August–September 2024, prior to the start of the next SWAIS 2C field season in late 2024, when team members will return to KIS-3 to core to ~200 m below the seafloor.

Atmospheric, sea-ice, and ocean system dynamics

MODELING OF PATTERN FORMATION DURING BRINE CHANNEL FORMATION

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During the ice formation in the Arctic Ocean, small liquid-saline channels remain, which are colonised by various small microorganisms. The size of the ice domains separating regions of concentrated sea water depends on salinity and temperature and corresponds to the size of sea ice platelets obtained from a morphological stability theory for the solidification of salt water. We consider a pattern formation on the bases of the theory of phase transitions using the Landau-Ginzburg free energy. Instead of a reaction-diffusion kinetics with the formation of morphological Turing structures1 or the BCM-model2 a modified thermodynamic approaches are considered. These are characterised by a total differential according to Schwarz's theorem. We modify the original Kobayashi's phase field model3 by including freezing point depression due to salt in order to describe the phase boundary of the fine network and cavities filled with brine which are formed during the freezing process in sea ice. A modified Cahn-Hilliard like model4,5 allows deeper supercooling temperatures than the modified Kobayashi approach and is therefore better suited for coupling to larger scales which can be realised by the extend Theory of Porous Media (eTPM)6. A linear stability analysis selects the parameter range that enables formation of structures. Initially, the diffusion parameter is time-dependent because of the changing porosity and tends towards a constant value at equilibrium.

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Atmospheric, sea-ice, and ocean system dynamics

FIVE MILLION YEARS OF ANTARCTIC CIRCUMPOLAR CURRENT STRENGTH VARIABILITY

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Our community's understanding of Earth's long-term climate evolution suffers a bias towards the Northern Hemisphere, where the majority of Plio-Pleistocene climate records have been developed. Although more recent efforts by the International Ocean Discovery Program (IODP) have sought to increase the number of long-term sedimentary records from the Southern Hemisphere, there remains an enormous gap in paleoclimate data from the South Pacific, representing the largest surface area and volume fraction of the Southern Ocean and therefore holding the largest capacity for carbon storage in the deep ocean.

The Antarctic Circumpolar Current (ACC) represents the world's largest ocean current system and impacts global ocean circulation, climate, and Antarctic ice sheet stability. Today, ACC dynamics are controlled by atmospheric forcing, oceanic density gradients, and eddy activity4. While paleoceanographic reconstructions exhibit regional heterogeneity in ACC position and strength over Pleistocene glacial-interglacial cycles, the long-term evolution of the ACC is poorly known.

Here, we document changes in ACC strength from sediment cores in the Pacific Southern Ocean. We find no linear long-term trend in ACC flow since 5.3 million years ago (Ma), in contrast to global cooling and increasing global ice-volume. Instead, we observe a reversal on a million-year time scale, from increasing ACC strength during Pliocene global cooling to a subsequent decrease with further early Pleistocene cooling. This shift in the ACC regime coincided with a Southern Ocean reconfiguration that altered the sensitivity of the ACC to atmospheric and oceanic forcings.

We find ACC strength changes to be closely linked to 400,000-year eccentricity cycles, likely originating from modulation of precessional changes in the South Pacific jet stream linked to tropical Pacific temperature variability. A persistent link between weaker ACC flow, equatorward shifted opal deposition, and reduced atmospheric CO2 during glacial periods first emerged during the Mid-Pleistocene Transition. The strongest ACC flow occurred during warmer-than-present intervals of the Plio-Pleistocene, providing evidence of potentially increasing ACC flow with future climate warming.

Polar Earth Sciences

TRUST THE THRUST? ROSS-OROGENIC VERSUS POST-ROSS TECTONICS IN NORTHERN VICTORIA LAND, TRANSANTARCTIC MOUNTAINS

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NE- to E- and opposite-directed thrusting in the northern Victoria Land (NVL) basement have been traditionally attributed to the Ediacaran-early Paleozoic Ross Orogeny. This is certainly true where combined indicators like basement-cover relations, deformation, metamorphism and geochronology prove the Ross-orogenic activity (e.g., Wilson-Exiles thrust system, Lanterman Fault, Millen Shear Zone). New Ar-Ar mica ages of ca. 467-451 Ma from (i) Roberts Butte, Boggs Valley, Lichen Hills (Wilson Thrust), (ii) Pothole (Exiles Thrust) and (iii) Last Chance Ridge (Lanterman Fault) add to existing data and support a late-Ross age. Recent studies at the eastern boundary fault of the Cenozoic Rennick Graben indicate multiple ductile to brittle reactivation of damage zones and syntectonic hydrothermal fluid-rock interactions in the epidote-prehnite stability field within Ross-age granitoids (NW Lanterman Range). The hydrothermal epidote-prehnite veins are linked to W-directed thrusts and cogenetic WNW-ESE to NW-SE striking sinistral and NE-SW dextral faults, which predate brittle normal faults of the Rennick Graben and thus Cenozoic reactivation. Along-strike to the N (Mt. Gow, Carryer Glacier), W-directed epidote-prehnite bearing semi-brittle thrusts are overprinted by brittle deformation including normal faults of the Rennick Graben and E-directed reverse faults. Their Ross age is challenged by observations in Jurassic volcanics not far W of these locations in the Rennick Glacier (Litell Rocks, Sickle Nunatak, “Cobb Nunatak” group), again with syntectonic epidote-prehnite hydrothermal vein mineralization and tectonic breccias linked to E- and W-directed reverse faults and cogenetic WNW-ESE to NW-SE sinistral and NE-SW dextral faults and rare E-W striking normal faults. These faults fit geometries and mineralizations observed in the NW Lanterman Range and at Mt. Gow. Brittle reactivation by younger faults with (i) Rennick-parallel normal faults and (ii) conjugate NNW-SSE to NW-SE dextral and NE-SW sinistral faults associated with around NE-SW directed thrusting and folding in restraining bends, is documented in all units at several locations and linked to Cenozoic tectonics defining the present structural architecture of NVL. U-Pb LA-ICP-MS geochronology of epidote-prehnite syntectonic veins gave ages of (i) 109±16 Ma (NW Lanterman Range) and (ii) 79±10 Ma, 90±23 Ma, and 77±11 Ma (Litell Rocks). These dates together with overprinting criteria indicate a Cretaceous age of tectonism. Comparable faults occur also at other locations (e.g., Edisto Inlet/Admiralty Granite, Mario-Zucchelli-Station/Ross basement). Due to the similarities of these thrusts in basement rocks and Jurassic volcanics, we question simple interpretations of thrusts in the NVL basement with Ross-like kinematics and low-T mineralogy as *a priori* Ross-orogenic structures. A more comprehensive multi-methodological approach and re-evaluation of the structural evolution of NVL are needed.

Polar Earth Sciences

THE ARCHITECTURE OF GONDWANA UNDER GONDWANA: THE "BASEMENT" OF BGR'S ANTARCTIC STATION IN NORTHERN VICTORIA LAND

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The geology around BGR's Gondwana Station at Terra Nova Bay in northern Victoria Land (NVL) comprises late Ediacaran to early Paleozoic (Ross-orogenic) high-grade metamorphic and plutonic rocks and Neogene glacial marine deposits. There are no mid-Paleozoic to pre-glaciation magmatic and sedimentary units preserved, which occur in other regions of NVL.

Basement lithologies consist of: (i) Biotite-quartz migmatite gneisses with granulite relicts, tight folds and zones of partial melting with large blocky feldspars; (ii) biotite-chlorite schists with strong slaty cleavage and rarely preserved folds; (iii) rare biotite schist with garnet; (iv) m-wide, foliation-parallel WNW-ESE (semi-)ductile dextral-transpressional shear zones with sigmoidal calc-silicate blocks of internal lower-strain and synkinematic felsic hornblende-rich pegmatite melts with blocky feldspar crystals at their margins, likely related to fluid-driven reactions with the surrounding migmatite; (v) blocky quartz pegmatites, which crosscut the shear zones of (iv); (vi) late-stage fine- to medium-grained felsic in-situ melts and dykes containing Cr-rich mica (fuchsite).

Lithologies and structures (i) to (vi) are related to the Ross Orogeny, based on geochronology and regional comparison. All rocks, including late-stage granitoids, and foliation/shear zones are reactivated by WNW-ESE to NW-SE semi-brittle left-lateral shear zones of most likely post-Ross orogenic age.

The sequence of deformation is tentatively:

(i) Main foliation Sn+1 with in-situ melt injections and isoclinal intrafolial folding; (ii) asymmetrical folding of Sn+1 into a new foliation Sn+2 with SC-type fabrics; (iii) open steeply SSW plunging, highly flattened non-cylindrical folds; (iv) NW-SE to WNW-ESE striking, Sn+1-parallel, (semi-) ductile dextral-transpressional discrete shear zones with sigmoidal, SC-type fabrics, which off-set granitoid dykes but are in turn cross-cut by quartz-rich felsic veins. (i) to (vi) are related to the Ross Orogeny.

(v) Post-Ross and (based on regional comparison) likely late Mesozoic to early Paleogene WNW-ESE to NW-SE high-strain semi-brittle left-lateral shearing; (vi) Neogene brittle thrusts and co-genetic dextral to dextral-oblique faults with pseudotachylites (Ar-Ar dated at c. 34 Ma).

The structural architecture at Gondwana Station documents that the NVL basement is affected by repeated reactivation and polyphase deformation. While the present structural architecture, for instance, is characterized by NW-SE trending brittle dextral strike-slip tectonics, similar fault trends and kinematics were apparently already active during the Ross Orogeny and later. The

data show that kinematics of shear and fault zones switched repeatedly from dextral to sinistral or from extension to thrusting and vice versa during the Phanerozoic. Therefore, geodynamic analyses must be done with care and by using multimethodological approaches to decipher NVL's complicated structural history.

Cool Classes - Polar Educators

COOLE KLASSEN IN ANTARKTIKA (CIA)

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Junge Menschen sind unsere Zukunft. Ihnen sollte die bestmögliche Bildung ermöglicht werden, um die anstehenden Herausforderungen bewerten und meistern zu können. Das 21. Jahrhundert wird weiterhin von zahlreichen Umwandlungen und Veränderungen geprägt sein, die sich sehr stark in unserer Umwelt zeigen werden. Insbesondere wird der Klimawandel Auswirkungen auf den Naturraum, aber auch die Gesellschaft haben. Umso wichtiger ist ein fundiertes Hintergrundwissen zu diesen Veränderungen und den daraus entstehenden Folgen. Diese zeigen sich bereits jetzt insbesondere in den Polargebieten. Der Arbeitskreis Polarlehrer der Deutschen Gesellschaft für Polarforschung (DGP) möchte daher mit einem neuen Projekt *Coole Klassen in Antarktika (CIA)* in Zusammenarbeit mit dem Umweltbundesamt, der Europa-Universität Flensburg und der Association of Polar Early Career Scientists (APECS) aktuelle Forschungsfragen, -methoden und -ergebnisse in schülergerechtes Arbeitsmaterial transferieren und online für Lehrkräfte kostenfrei auf der Webseite der DGP bereitstellen, sodass sie bundesweit und global abrufbar sind.

Dabei werden die Bereiche der Geographie/Geowissenschaften, Biologie, Physik und Chemie thematisiert. Ergänzend zum Unterrichtsmaterial soll es Online-Fortbildungen für Lehrkräfte geben. Begleitend wird das Projekt durch Öffentlichkeitsarbeit in Presse und sozialen Medien großräumig bekannt gemacht. Mit der Öffentlichkeitsarbeit soll die Politik auf das Projekt und den Arbeitskreis aufmerksam gemacht werden mit dem Ziel der Sensibilisierung, um notwendige Änderungen in den Fachanforderungen und Curricula zu bewirken.

Mit Beispielen aus dem neuen Projekt CIA werden Möglichkeiten der Kooperation zwischen der Polarwissenschaft und dem Arbeitskreis gezeigt, um wissenschaftliche Erkenntnisse an die junge Generation zu tragen.

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DFG SPP 1158 Antarctic Research: Report Colloquium

LATE PLEISTOCENE AND HOLOCENE SEDIMENTS AROUND SOUTH GEORGIA: ARCHIVES FOR CLIMATE-INDUCED SIGNALS IN SUB-ANTARCTICA SINCE THE LAST GLACIATION

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South Georgia, an island in the Atlantic sector of sub-Antarctica and south of the Polar Front, lies between the fronts of the wind-driven Antarctic Circumpolar Current (ACC) system. This unique position, including the far distance from continents, makes South Georgia a climatically sensitive region, where climate changes can be recorded earlier than on the more thermally isolated Antarctic continent, south of the ACC. Due to a scarcity of marine-geological studies on the continental shelf of South Georgia, especially on the southern side of the island, the extent and timing of the Local Last Glacial Maximum have not been unravelled in detail until recently. In order to validate ice sheet and climate models, however, it is important to investigate the glacial history on both sides of the island. For this purpose, high-resolution bathymetry data, sediment echosounder profiles and sediment cores from the King Haakon Trough System and the Drygalski Fjord System were investigated (Lešić et al., 2022, 2024; Lešić, 2023; Streuff et al., in press). In King Haakon Trough, glacial landforms and subglacial till sequences reveal past ice extents to the shelf edge, at least one of which was likely related to the last glacial (Streuff et al., in press). This is supported by findings in the Drygalski Fjord System, where the radiocarbon-dated sediments from outer Drygalski Trough suggest an extensive ice cap before 30 ka BP (Lešić et al. 2022). This finding indicates an early and extensive Local Last Glacial Maximum. The results obtained from the sedimentary records in both cross-shelf troughs also cover the subsequent deglaciation, which continued with the retreat of the ice edge from the mid-shelf in Drygalski Fjord System around 17.5 ka BP. Further, the records suggest that both shelf areas were free of glacial ice during and after the Antarctic Cold Reversal, therefore being exposed to shelf currents at least throughout the Holocene (Lešić et al. 2022, 2024, Lešić, 2023). Thus, the combined data sets from both troughs serve as a record of the glacial history and sedimentary processes on the southern South Georgia shelf since at least 17.5 ka BP.

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Biology and biogeography in polar environments

WEDDELL SEA OBSERVATORY OF BIODIVERSITY AND ECOSYSTEM CHANGE (WOBEC)

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The Weddell Sea plays an important role in global climate regulation and constitutes a potential sanctuary for unique Antarctic species. In recent years, there is increasing evidence of accelerating climate change all around Antarctica, prompting the need for sustained monitoring to assess the current state and how ecosystems will change under progressing sea-ice decline, ocean warming and ocean acidification (Gutt et al 2022). Since no systematic ecosystem monitoring exists in the eastern Weddell Sea, scientists of 11 institutes from 8 countries join forces together with stakeholders from economy, conservation and society to design a monitoring framework for a Weddell Sea Observatory of Biodiversity and Ecosystem Change (WOBEC). We target the following objectives:

1. Make the baseline biodiversity and ecosystem knowledge of the Eastern Weddell Sea globally accessible to the public.
2. Co-design a WOBEC monitoring framework with stakeholders ensuring strong legitimacy, high societal relevance and potential application in the WSMPA process.

3. Develop and apply a multiscale monitoring strategy that integrates established methods with advanced technology.

WOBEC builds on a comprehensive co-design process with stakeholders to develop a monitoring framework considering the latest state of scientific knowledge and societal demands, which will unfold in a series of stakeholder-science workshops. To provide the necessary knowledge base, we will inventory historic, recent and new ecosystem data and make them available through publicly accessible data portals, e.g. OBIS and EMODnet. Furthermore, we will assess and apply available technologies for their suitability for long-term monitoring across spatial and temporal scales, including autonomous observatories, Earth Observation and traditional ship-based methods during the PS152 expedition on *RV Polarstern* to the Eastern Weddell Sea in 2026. Finally, we will analyse ecological data to generate scientific products, such as statistical models and maps, facilitating an iterative process to inform and refine the co-design process of the WOBEC monitoring framework. WOBEC will yield publicly available scientific data from the past 5 decades to the present, a societal relevant monitoring framework for future continuation, including a data management plan and standard operating procedures for the sampling of Essential Variables (EVs). Development in close collaboration with the Convention for the Conservation of Antarctic Marine Living Resources will support the Weddell Sea Marine Protected Area (WSMPA) planning to ensure the future protection of its biological treasures (Jones et al 2022). Involving other stakeholders from economy and conservation, and further monitoring initiatives in the Southern Ocean and beyond will ensure a wide dissemination of results from science to stakeholders and policy makers.

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DFG SPP 1158 Antarctic Research: Report Colloquium

ROLE OF MEIO- AND MACROFAUNA IN BENTHIC ECOSYSTEM FUNCTIONING: TESTING EFFECTS OF DIFFERENT ICE COVER REGIMES

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It is largely unknown if and how sea-ice cover changes in the Southern Ocean influence the processes at the seafloor, the benthic functions. For a comprehensive understanding of ecosystem functioning, we investigated the composition and role of different ecosystem components (i.e. faunal community groups) for seafloor processes under changing and stable ice-cover regimes. As a novelty, we included both the macrofaunal and meiofaunal (<500µm) size classes of endobenthic organisms simultaneously, and studied their complementary role for food uptake and benthic boundary fluxes (ammonium, nitrate, phosphate, silicic acid, oxygen).

We analysed data from sediment and environemental samples taken during 3 expeditions on *RV Polarstern* (PS81, PS96, PS118; 2013 – 2019) in the Weddell Sea and in the vicinity of the Antarctic Peninsula. The sampled area includes sites with reduced, variable and lasting sea-ice cover regimes.

Apart from discovering new species (Säring et al. 2022a), we could show that meiofauna communities vary more distinctly with sea-ice cover regimes compared to macrofauna, with the highest abundance found in regions with variable ice cover (Säring et al. 2022b). Pulse-chase experiments could show a fast uptake of algal material, particularly in copepods. Moreover, the community composition of meiofauna can better explain variability in benthic boundary fluxes than that of macrofauna. However, our current knowledge of endofaunal distribution is insufficient for species or community distribution modelling and therefore for predicting shifts with sea-ice changes. Our results indicate the importance of meiofauna and endofaunal distribution patterns for evaluating the response of benthic ecosystems to sea-ice changes.

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Polar Earth Sciences

MEANDER INTRUSION IN THE MOUNTAINEER RANGE: LOCAL IGNEOUS PULSE WITH GLOBAL CLIMATE IMPACT

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The Transantarctic Mountains (TAM) are an extensive, up to 4.5 km high continental rift escarpment that subdivides Antarctica into the East Antarctic cratonic and the West Antarctic terrane assemblages. Various climate evolution studies suggest that the initial Antarctic ice sheet did nucleate there and spread subsequently onto the continent but location, timing, and cause of this initial glaciation are controversially debated.

Key problem of many early glaciation models is that they explicitly or implicitly rely on a traditional concept of a homogeneous TAM topography throughout the Cenozoic, and the glacial nuclei were placed preferably on the highest peaks of the present mountain chain. However, geological and thermochronological evidence suggests that the region hosted a Mesozoic low-standing terrestrial basin from which the TAM evolved only since the Late Eocene (Lisker & Läufer, 2013). New thermochronological data recognize the highest thickness of sedimentary basin infill in the vicinity of the Mountaineer Range at the transition from stable Precambrian basement to early Paleozoic volcanic and turbidite terranes, underlain by anomalously hot mantle and intruded by Late Eocene–Oligocene igneous rocks. The emplacement of these Meander Intrusives triggered fast uplift followed by immediate erosion of more than 4 km of clastic overburden and similarly deep incision of the granite and gneiss basement beneath.

Kilometre-scale plateau uplift combined with chemical weathering of vast volumes of clastic sediments and acidic igneous rocks under temperate climate conditions resulted in substantial atmospheric CO2 depletion and may have contributed to climatic cooling and local ice cap formation. New climate-ice sheet modelling verified by shallow-marine drilling data from the Amundsen Sea Embayment off the West Antarctic margin supports the Mountaineer Range as a prominent ice sheet nucleus and further concludes a highly asymmetric initial Antarctic glaciation during peak Early Oligocene Glacial Maximum (~33.7–33.2 Ma).

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Polar Earth Sciences

DIFFERENCES IN WEST ANTARCTIC ICE SHEET DYNAMICS IN THE PLIOCENE RELEVANT TO PRESENT AND FUTURE SEA LEVEL CHANGES

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The West Antarctic Ice Sheet (WAIS) is currently losing mass at an alarming rate, raising concerns about its contribution to global sea-level rise. Analyses using geological and geophysical data, coupled with model simulations, have indicated that the WAIS experienced partial or total collapse during extremely warm periods in the past, particularly during the Pliocene epoch (5.3-2.6 million years ago). Notably, recent studies focusing on the Pliocene epoch reveal that the WAIS retreat is far from synchronous along the Pacific margin of West Antarctica and that the various ice drainage regions acted with different sensitivities to oceanic forcing over time and space. A long period of ice sheet retreat in the Amundsen Sea of West Antarctica from 4.2 to 3.2 million years ago has been identified and named the “Pliocene Amundsen Sea Warm Period” (PAWP). This does not correspond with the globally observed “Mid-Pliocene Warm Period” and the “Pliocene Climatic Optimum”, as is also observed in analyses from the Ross Sea and Antarctic Peninsula. A quantification of these variations along the Pacific margin of West Antarctica linked to ice-sheet model simulations is expected to reveal conditions for temporal and spatial ice-mass balance effects on sea level changes.

This project aims to test the hypothesis that the WAIS dynamics have reacted regionally differently, depending on variations in Southern Ocean circulation with warm deep-water shelf incursions, and these regional variations have had different effects on sea-level change contributions. To test this hypothesis, a wealth of geophysical (mainly seismic) and geological data (DSDP, ODP, and IODP drill records) from the Southern Pacific off West Antarctica are integrated to cover most of the glacially controlled sediment transport, deposition, and erosion processes throughout the Pliocene. Seismic as well as core-record characteristics are combined to develop a unified and detailed seismic stratigraphy of the Pliocene warm periods. Temporal and spatial regional differences in the stratigraphic units that represent signals in ice sheet dynamics and processes will be quantified. Additionally, by examining past ocean-bottom and deep-water conditions through the study of contourite deposits, we will infer the conditions that influenced oceanic forcing. The findings from these analyses will be compared with paleo-ice sheet models for continent-wide scenarios with variations in regional ice-sheet advance and retreat patterns, aiming to provide robust estimates of the WAIS’s contributions to sea-level changes over time.

Atmospheric, sea-ice, and ocean system dynamics

DIFFERENT IMPACTS OF SNOW ON ARCTIC AND ANTARCTIC SEA ICE MASS BALANCE

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Sea ice in the Arctic and Antarctic has very different characteristics. While summer sea ice is snow free and dominated by melt ponds in the Arctic, it is snow-covered throughout the year in the Antarctic. The snow cover is on average thicker and the role of snow for the sea ice mass and energy balance is more complex in the Antarctic. The formation of meteoric ice from snow occurs through the formation of 'snow ice' (mostly in winter and spring) and 'superimposed ice' (mostly in summer) in both hemispheres but is much more pronounced in the Antarctic. However, quantitative estimations are still sparse, and the lack of knowledge about internal snow processes leads to substantial uncertainties in sea ice remote sensing products and climate studies.

Here, we analyse snow accumulation as measured with autonomous 'Snow Buoy' platforms since 2013. We present results from 57 Snow Buoys in the Arctic Ocean and 36 in the Weddell Sea (Antarctica). In order to quantitatively estimate the contribution of meteoric ice to the snow pack, we simulate the temporal evolution of the snow and sea ice column with the 1-D snow cover model SNOWPACK. The model is initialised with snow and ice thickness and forced with the measured snow surface height and meteorological reanalysis data along the buoy track.

We find that snow ice occurs in 8% of the Arctic and 62% of the Antarctic data points. For the buoys with snow ice formation, the mean maximum thickness is 9.7 ± 11.7cm in the Arctic and 28.8 ± 24.2cm in the Antarctic. Superimposed ice occurs in 15% of the Arctic and 51% of the Antarctic datapoints. However, when it forms, the maximum thicknesses are very similar: 7.1 ± 6.0cm on Arctic and 7.6 ± 3.1 cm on Antarctic sea ice.

In order to quantify the role of snow on the sea ice mass balance, we additionally performed the SNOWPACK simulations along the buoy trajectories for snow-free conditions, for a constant very thin snow cover (5 cm) and for different precipitation rates (50% and 150% of the snow accumulation as measured by the buoys). We find that total sea ice thickness (including meteoric ice) is higher for the no/thin snow cover cases as compared to the buoy-observed snow accumulation and its modifications (50% and 150%). These are important findings also regarding potential future changes in precipitation patterns in polar regions, as they are suggested to occur due to climate change.

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SNOW COVER EVOLUTION ON SEA ICE IN THE WEDDELL SEA FROM AUTONOMOUS MEASUREMENTS AND 1-D MODEL SIMULATIONS

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Antarctic sea ice is characterized by a year-round relatively thick snow cover as compared to Arctic sea ice. Snow acts as an insulator for the sea ice underneath, hampering both melting of ice under warm conditions and growing of ice under freezing conditions. Additionally, snow on Antarctic sea ice is frequently flooded with sea water and subsequently forms snow ice. Another frequently occurring phenomenon on Antarctic sea ice is the internal melting and re-freezing of snow above sea water level, which results in superimposed ice formation. Thus, snow is an important factor in the energy and mass budget of Antarctic sea ice, and the lack of knowledge about snow leads to substantial uncertainties in sea ice remote sensing products and climate studies.

In this study, we examine 35 autonomously operating snow observation platforms (‘Snow Buoys’) that have been deployed in the Weddell Sea since 2013. They float with the sea ice and measure the height of the snow surface in reference to the snow-ice interface at the time of deployment. As parts of the accumulated snow turn into meteoric ice (snow ice and superimposed ice), the height measured by the Snow Buoy is generally not equal to the snow thickness. In order to understand what processes lead to the measured snow height, we simulate the temporal evolution of the snow and ice column using the 1-D snow cover model SNOWPACK. The model is initialised with snow and ice thickness as measured during buoy deployment and driven with meteorological reanalysis data along the buoy track. By comparing buoy-observed and simulated snow heights for different model configurations, we can learn how SNOWPACK, which was originally derived for alpine regions, can be best applied to Antarctic sea ice environments, specifically the Weddell Sea.

We find that SNOWPACK driven with ERA5 reanalysis precipitation overestimates snow height as compared to the observations. In contrast, when we allow for snow removal using a wind-speed dependent snow drift model, snow height is underestimated. When we constrain snow removal with the available open water areas (’sinks’) around the buoy position, simulated and observed snow heights agree much better. We obtain the best agreement when using a snow drift model developed for Antarctic land applications instead of using the default snow drift models in SNOWPACK developed for alpine regions. In addition, using a simple approach describing ocean heat flux as a function of longitude and season performs better than using a constant value for ocean heat flux.

Using the best model settings, we can upscale our results on snow and the processes therein from the Snow Buoys’ point measurements to regional scales and, for example, estimate the fraction of snow that has turned into meteoric ice for the whole Weddell Sea.

The Anthropocene and climate change in polar and mountain regions

IMPACTS OF CLIMATE CHANGE ON THE GLACIERS OF HIGH-ALTITUDE COLD DESERT OF LAHAUL IN THE WESTERN HIMALAYAS, INDIA

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The Hindu Kush Himalayan (HKH) region is home to the loftiest mountain ranges spanning over 42 lakh km2 on the planet having the largest volume of ice and snow outside the polar regions. These 'Water Towers' are the source of major river systems in Asia, providing water for more than a billion people. Nestled in the remote and rugged part of the Western Himalayas, Lahaul Valley is witnessing significant changes in its glaciers. Considered a high-altitude cold desert, the Lahaul is home to some of the largest glaciers in the entire region. With very little rainfall during the Indian Summer Monsoon months, the people of Lahaul rely heavily on glaciers and snowmelt for its domestic and agricultural water needs. This study presents a detailed inventory and spatio-temporal changes in the glacier in the last half a century (1971-2023). The results show a significant loss of ice in the observation period. Climate change is behind the loss of ice, revealed by analysis of climatic data. It is observed from the data that there is an overall increasing trend in Annual and wintertime temperatures over the study area. Also, the rapid growth of two ice-contact pro-glacial lakes in the study area after 2000 increases the risk of GLOF (Glacial Lake Outburst Flood). A warmer climate is further expected to cause an acceleration in glacier ice loss. The melting ice has implications for the people living in the region and downstream.

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QUANTARCTICA 4 – LOOKING BEYOND OUR OWN DISCIPLINES WITH AN UPDATED VERSION OF THE INTERDISCIPLINARY MAPPING TOOL FOR ANTARCTIC RESEARCH

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Quantarctica is a comprehensive data package developed under the lead of the Norwegian Polar Institute for use with QGIS, an open source GIS software, and will soon be available as a new updated version, Quantarctica4. It provides a wide range of Antarctic geospatial data suitable for research and teaching purposes. The package includes high-resolution satellite images, topographic maps and various scientific datasets covering geophysical, geological, glaciological and climatological aspects of Antarctica. It also includes administrative boundaries, including protected areas, and logistical information such as research station locations.

Quantarctica datasets are freely available for download and are provided in standard GIS formats, preferably as Esri shapefile and GeoTIFF, making them accessible and easy to use. The package is highly customizable, allowing users to add their own data to suit specific research needs. Supported by a community acting as theme editors and developers, the Norwegian Polar Institute offers workshops, most recently at the SCAR Open Science Conference (Chile), and documentation to help users to effectively utilize the package. We will present the latest update with new datasets and improvements.

Overall, Quantarctica4 is a valuable resource for anyone involved in Antarctic research or education, providing a comprehensive and easy-to-use collection of geospatial data.

History and future of international cooperation in polar regions

‘MICRO-METAMORPHOSEN DES POLAREISES’ 150 YEARS AFTER WEYPRECHT: FROM MOSAIC TO THE EUROPEAN SYNCHROTRON RADIATION FACILITY

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Sea ice plays, as we know today, a key role in the Arctic and global climate system. Karl Weyprecht was one of the first scientists who dedicated a book to Arctic Sea ice and its metamorphosis, based on observations during the 1872-1874 Austrian-Hungarian North-Pole Expedition (Weyprecht, 1879; Moseley, 1879). Weyprecht’s text covered topics like high salinity and unfrozen brine in young sea ice, seasonal changes in snow and sea ice properties, the formation of cracks, pressure ridges and leads, as well the water circulation in the ice-covered Arctic Ocean in relation to global climate. He understood that progression in polar research essentially depended on international collaboration and proposed a circumpolar network of Arctic stations taking regular measurements of weather and ice conditions. Based on Weyprecht’s ideas and proposals the First International Polar Year (1882-1883) was initiated. Tragically, Weyprecht was unable to participate – he died in 1881 from tuberculosis.

150 years after Weyprecht’s Northpole expedition we look back to 4 International Polar Years and the recent MOSAiC expedition (2019-2020) during which unique sea ice information and sea ice cores have been collected (Nicolaus et al., 2022). Very recently, a group of international scientists has scanned a set of these sea ice cores by means of the most powerful 3D micro-CT microscope in the world – the BM18 beamline at the European Synchrotron Radiation Facility (Espuny, 2024). The analysis of this unique (~100 TB, corresponding to 1 Million thin sections) dataset of sea ice microstructure, relevant for several sea ice topics (physics, engineering, remote sensing, biology), has just started. In this talk I will present first images and impressions of the microstructure metamorphosis of sea ice during MOSAiC as seen by 3D X-ray tomography.

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Permafrost in a warming world: impacts and consequences

EFFECTS OF PERMAFROST THAW ON N-CYCLE PROCESSES IN A THERMOKARST SYSTEM

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The Arctic warms about four times faster than the global average, leading to increased permafrost thaw. When ice-rich permafrost thaws, thermokarst formation alters microbial decomposition of soil organic matter, including nitrogen (N) pathways. Our work explores the changes in N-cycling in thermokarst landscapes, by incubation of soils with 15N stable isotope tracing to assess organic N depolymerization, N-mineralization and nitrification rates over time.

Permafrost soils from the Yukon coast (Canadian Arctic) from 3 different depths in the active layer and the upper permafrost, in two phases of thermokarst development were investigated. We performed a 15N tracing experiment, by incubating soils with a 15N-protein for 9 days and estimated 15N in dissolved organic N (DON), microbial N (Nmic) and nitrate as well as ammonium.

Our results show changing N-cycle processes with depth, in compliance with literature, as well as with progress of thermokarst stages. Generally active layer microbial N uptake was favoured over N mineralization, while the contrary was the case in permafrost layers. This pattern might be connected to a microbial N-limitation in the upper soil layers leading to increased microbial N demand. In permafrost layers microbes are strongly energy and carbon limited and thus rather excrete inorganic N (ammonification) that they don't need, while keeping the organic C.

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A HYBRID ICE MODEL BASED ON PARTICLE AND CONTIUUM METHODS

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Ice mélange, a composite of sea ice and icebergs, can have a major influence on sea-ice-ocean interactions. Ice mélange, is currently not represented in climate models, as numerically efficient realizations do not exist. This motivates the development of a prototypical dynamic hybrid ice-mélange model that is presented in this talk. In the approach, icebergs are included as particles and sea ice is treated as a continuum.

In the first part of the talk the ice mélange model is derived. To formulate ice mélange as a joined continuum, we integrate particle properties into the sea-ice continuum. Thus, icebergs are viewed as thick, compact pieces of sea ice. The ice mélange formulation is derived based on the viscous-plastic sea-ice rheology, which is currently the most commonly used material law for sea ice in climate models. Starting from the continuum mechanical formulation, we modify the rheology such that icebergs are held together by a modified tensile strength in the material law [1].

The second part of the talk discusses the numerical discretization of the model. Here, the focus is on a particle in cell scheme that is used to couple the continuum and particle method. Due to the particle approach, we do not need highly resolved spatial meshes to represent the typical size of icebergs in the ice mélange (<300 m). Instead, icebergs can be tracked on a sub-grid level while the typical resolution of the sea-ice model can be maintained (>10km).

The talk closes with a discussion of idealized test cases. These setups demonstrate that the proposed changes in the material law allow for a realistic representation of icebergs within the viscous-plastic sea-ice rheology. Overall, the suggested extension of the viscous-plastic sea-ice model is a promising path towards the integration of ice mélange into climate models.

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THE EUREKAN OROGENY AND THE DE GEER FRACTURE ZONE FROM THE NORTH GREENLAND PERSPECTIVE

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The Eurekan Belt is an intraplate orogen that extends for nearly 2000 kilometres across the Arctic Realm and is closely associated with large-scale transform faults. The Eurekan Orogeny affected the northern rims of North Greenland and Eurasia. After orogenic movements ceased, the Eurekan Belt became dissected between these two land masses, which led to the formation of the East Greenland and Barents Shelf passive margins and finally to the opening of the Arctic-North Atlantic gateway. Resulting geological structures are complex and difficult to correlate between the affected areas, complicating the reconstruction of processes controlling the evolution of the Eurekan Belt. For better understanding the processes related to the formation of the Eurekan Belt in particular, and to the formation of intraplate orogens in general, we studied its thermotectonic evolution.

For this, we applied apatite fission-track and (U-Th-Sm)/He thermochronology on samples from North Greenland, a key area in the development of the Eurekan orogen. Additionally, we analysed samples from the Barents margin, and hence from both sides of the Arctic-North Atlantic gateway.

Thermal histories modelled from the thermochronological data and the stratigraphic and structural geological context suggest that the De Geer Fracture Zone – a large transform fault system of the North Atlantic - played a major role in the development of the Eurekan Belt and the subsequent formation of the Barents and Greenland margins. Heat transfer along the fault segments caused thermal anomalies during various stages of orogenic evolution, and, by weakening the crust, contributed to the final break up. Crustal blocks in of the fault system show differential exhumation and burial even in the post-Eurekan phase and were possibly transported and displaced for hundreds of kilometres along the faults.

Our results underline the general importance of continental transform faults for the development of transform margins.

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THE TECTONOMORPHIC EVOLUTION OF THE BELLINGSHAUSEN SEA SECTOR OF WEST ANTARCTICA

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The Bellingshausen Sea sector is largely covered by the West Antarctic Ice Sheet and hosts deep troughs that are interpreted as branches of the West Antarctic Rift System. Except from few nunataks, the West Antarctic Rift System of the Bellingshausen Sea sector is covered by thick ice, impeding direct geological investigations. Rift-related structures presumably control the course of ice streams. The glacially eroded troughs, in turn, provide pathways for warm oceanic deep water causing basal melting of the overlying ice.

During Polarstern cruise PS134 we collected rock samples from onshore nunataks and clastic sediments from glacial outlets. The clastic sediments originated from rocks under the ice sheet. We will perform petrographic analyses and apatite and zircon U/Pb, fission track and (U-Th)/He radiometric dating, in order to characterize the source area hidden beneath the ice and to investigate the thermotectonic evolution of the Bellingshausen sector.

Our data will provide information on the timing of activity, mode, and kinematic relationship of the rift branches of the West Antarctic Rift System in the Bellingshausen Sea sector, as compared to the adjacent Amundsen Sea sector. Furthermore, the newly acquired data will allow to refine the paleotopographic models of West Antarctica, providing boundary conditions for understanding and modelling the onset of West Antarctic glaciation. We will combine the new data and published thermochronological data from other parts of West Antarctica and the Transantarctic Mountains with offshore seismic and sedimentological data to visualize onshore and offshore denudation and burial over time. These data will contribute to better understand source-sink relationships, drainage patterns and the regional long-term landscape evolution. First results will be presented.

Biology and biogeography in polar environments

COMPREHENSION OF PLANKTON DIVERSITY AND BIOGEOCHEMICAL PROCESSES IN THE POLAR ECOSYSTEM CLIMATE CHANGE SCENARIO

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The global environmental changes due to natural and anthropogenic impacts are challenging the structure and functioning of the ocean food web ecosystem. The composite processes interacting within the physical, chemical, and biological environment at different spatio-temporal scales and their influence on the ocean ecosystem processes are yet to be explored. A long-term trend on phytoplankton biomass (in terms of Chlorophyll-a concentrations; Chl-a), phytoplankton compositions and the processes that regulate the variability is required for understanding the ocean ecosystem. The present research investigated decadal trends of phytoplankton compositions and biogeochemical variables over the Global Ocean (GO), Southern Ocean (SO), and the Arctic Ocean (AO) using ocean color remote sensing and assimilated data from the National Aeronautics and Space Administration (NASA) Ocean biogeochemical model. The consequences revealed the dominance of diatoms (larger cell) throughout the SO and AO; however, the coccolithophores dominate in the remaining part of the GO. Analysis of nutrients indicated that nitrate is not a limiting for the variability of phytoplankton biomass in the SO and AO. The low nitrate concentration influenced in the rest of the GO. The photosynthetically available radiation (PAR) is limiting the phytoplankton biomass and compositions in the SO and AO. Although the SO is known as the high nutrient low chlorophyll (HNLC) region of the GO, the low iron concentration along with the PAR co-limits the growth of phytoplankton biomass. Trend analysis displayed an increase in Chl-a and diatoms in the SO and AO. In contrast, it declined significantly in the other regions of the GO, in response to the consistent increase in sea surface temperature. The results indicated that, shifting of phytoplankton community from regional to global scale have a greater implication for climate change and marine food web ecosystem.

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History and future of international cooperation in polar regions

THAWING ARCTING, FREEZING RELATIONS? ENERGY DYNAMICS BETWEEN RUSSIA AND JAPAN

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While the world's attention is currently focused on pressing global issues such as the Russian invasion of Ukraine, the Nagorno-Karabakh conflict with its Armenian crisis, and the Israel-Hamas war, it's crucial to recognize the rising economic, ecological, and energy-related geopolitical significance of the Arctic region, as it is offering new strategic export opportunities for Russian oil and gas producers. Current research lacks comprehensive insight into the contemporary dynamics between Japan and Russia, particularly those that are rooted in Japan's historical and geopolitical aspirations in East Asia. This gap is especially noticeable in the energy sector, where new collaboration patterns have emerged. This contribution aims to investigate the impact of the Ukrainian conflict and consequential shifts in the global order on energy cooperation in East Asia, with a focus on Japan's role. Based on the following assumption made by the Japanese Arctic Geopolitics expert Fujio Ohnishi that "the participation of non-Arctic states will gradually develop in the direction of bilateral relations rather than multilateral ones, and shift from environment protection-oriented cooperation to a business-oriented one", it is assumed that now more than ever Russia is looking for options of improving its policy to concentrate eastward for its energy cooperation plans. Japan and Russia intersect in the Arctic through economic collaboration, particularly in resource extraction. Both nations share an interest in Arctic energy development, exemplified by Japan's pursuit of access to Russia's Arctic resources, notably through joint Liquefied Natural Gas (LNG) ventures like the Yamal LNG and Arctic LNG 2 projects. The overall PhD research, which this contribution will be based on, is adopting a regional focus on areas adjacent to the Russian coast, investigates the transformative effects of the war on energy collaboration and identifies potential avenues for sustained dialogue beyond the Arctic Council. The primary research question explores how the war in Ukraine has affected energy cooperation in the Arctic, with an adhered hypothesis suggesting a transformative impact despite temporary disruptions. The dissertation uses a dual-methodology approach, employing discourse analysis and International Relations frameworks to examine Japan and Russia's strategic interests in the Arctic, especially in the Northern Sea Route. Empirical evidence is drawn from statements, articles, and expert interviews with Japanese and Russian inter alia policymakers and industry experts, redirecting the narrative from pessimistic views of Northeast Asian regionalism to spotlight a more dynamic contemporary reality.

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Atmospheric, sea-ice, and ocean system dynamics

NITROUS OXIDE DISTRIBUTION IN THE ARCTIC SIBERIAN SHELVES OF THE NORTH KARA SEA DURING SUMMER 2021

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Previous studies report an accumulation of nitrous oxide (N_2O) on the shallow continental shelves of the western Arctic Ocean. We sampled full-depth profiles of sea water samples for N_2O measurements in the eastern arctic shelves, in the North Kara Sea, collected during summer 2021. The results show a strong scatter between each N_2O profiles, but an overall pattern shows an accumulation of N_2O in the shelf bottom waters with a strong correlation to N* ($p < 0.001$). N_2O enrichment is more pronounced in areas where the water's residence time on the shelf is longer. These observations point towards a production at depth, linked to benthic denitrification, that is intensified on the shelves. However, in surface waters, physical processes – i.e. temperature and air-sea exchange – emerge as the main controlling factor on N_2O concentrations. We observe low saturations of 80% at the surface of the open ocean stations that receive under-ice water influx. This is likely due to cooling and a limitation of air-sea exchange by the presence of sea ice cover, during the water masses transport from the Fram Strait to the Kara Sea. River supply does not exert a discernable influence on N_2O concentrations in the studied area. This study reveals the potential of the Arctic Siberian shelves for the uptake of atmospheric N_2O during summer.

Atmospheric, sea-ice, and ocean system dynamics

IMPROVING THE REPRESENTATION OF THE ARCTIC SEA LEVEL, OCEAN CURRENTS, AND TIDES USING MULTI-MISSION SATELLITE ALTIMETRY

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The Arctic Ocean is highly sensitive to climate change. Its effects can be seen in reduced sea ice cover, rising sea levels and changes in ocean circulation. Satellite altimetry has been providing accurate observations of these changes for about 30 years by continuously improving the determination of sea surface height (SSH) in the ice-covered ocean. In this contribution we present three examples of how satellite altimetry can contribute to a better understanding of the physical processes taking place in the Arctic Ocean.

The presence of sea ice requires special classification and retracking algorithms (e.g. Passaro et al., 2018) that allow distinguishing between water and ice observations, as well as providing reliable ranges between the satellite and the sea surface. Here we show how satellite altimetry data can be used to detect open water based on an automatic radar waveform classification (Müller et al., 2023).

Besides the computation of accurate SSH, the monitoring of ocean tides by altimeter satellites is of great interest to generate improved tidal corrections for sea level determination, but also to better assess the effects of tides on circulation. Therefore, a concerted effort to produce an in-situ ocean tide validation dataset, ArcTiCA (Hart-Davis et al 2024), as well as recent results of the extension of the empirical ocean tide model, EOT, to the Arctic Ocean are presented.

Finally, a high-resolution long-term dataset of altimetry-derived dynamic ocean topography (DOT) and geostrophic currents is created with the use of the aforementioned algorithms for SSH determination in the sea-ice-covered ocean. The dataset is used to study the mesoscale and interannual variability of the Chukchi and Beaufort Seas in 2013—2023. The reversals of the northward flow in the Bering Strait under the influence of anomalously strong northerly storms are investigated. The area of the Beaufort Gyre has decreased from 2013 to 2023, which is tightly linked to the low sea level pressure in the Beaufort High and could potentially mean the release of freshwater into the Arctic Basin (Pisareva et al., 2024).

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Physical processes of glaciers and ice sheets in their environment

USING UAV AND SATELLITE REMOTE SENSING DATA TO MAP THE TOPOGRAPHY OF A CONTINENTAL OASIS IN QUEEN MAUD LAND

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For the effective management and monitoring of protected areas, highly accurate topographic maps are essential. They serve as a crucial basis for the localisation of the protected values, as well as for various monitoring and research activities. This importance also extends to Antarctic regions. While traditional land surveying methods are precise, they can be time-consuming. However, the use of unmanned aerial vehicles (UAVs) now allows us to collect high-resolution topographic data, even in remote or challenging locations where operating stations are not available. We employed two types of UAVs to capture high resolution imagery of the Otto-von-Gruber-Gebirge, a high mountain inland oasis in Queen Maud Land, which is proposed to be designated as an Antarctic Specially Protected Area (ASPA). The area is dominated by glacial and periglacial landforms. The survey took place in December 2022. High-precision orthomosaic and digital surface models were produced. We used PPK (post-processed kinematics) to accurately determine the UAV base station position (+/- 2 cm) with Trimble Business Center and Trimble RTK Post Processing Service. However, the UAV data did not cover the entire area of interest. To address this, we combined satellite imagery from Worldview-2 and Sentinel-2 with the Reference Elevation Model of Antarctica (REMA). Information on the character of the relief and the distribution of topographic features has been derived from the resulting composite data set. We introduce the completed topographic map and discuss issues related to the integration of datasets with different scales of precision, temporal and spatial differentiation, and the use of naming conventions for geographic features.

Biology and biogeography in polar environments

HOPE FOR THE EMPEROR PENGUIN? ARE THERE REFUGIA WHEN THE FAST ICE VANISHES?

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Like many species, emperor penguins are affected by climate change. Most colonies of this species use land-fast sea ice as breeding habitat. The at least in some regions of Antarctica decreasing fast ice, earlier break-ups, or increased instability put breeding success and colony persistence at risk. Recent studies have shown that 80 % of emperor penguin colonies are threatened by extinction under a business-as-usual greenhouse gas emission scenario. For some colonies one option to encounter this threat seems to be the use of the adjacent ice shelf as alternative breeding habitat. Despite the suspected disadvantage of this habitat, like wind exposition and longer distances to the open sea, some colonies for instance at Atka Iceport or Astrid Ice Tongue are already known for this behaviour. In those colonies, the ice shelf may serve as a climate change refugium, possibly reducing the predicted colony losses.

In the presented study, we examined how many of the Emperor Penguin colonies already use the ice shelf as breeding habitat and how they did since 2013. We used Sentinel and Landsat satellite imagery to manually inspect known locations of Emperor Penguin breeding sites for guano stains on the ice shelf.

The Anthropocene and climate change in polar and mountain regions

THE HIGH-ALTITUDE HUMAN FOOTPRINT: ATMOSPHERIC MICROPLASTIC DEPOSITION AT 3106 METRES AT SONNBLICK OBSERVATORY

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After almost 100 years of plastic production, the pollution with plastics became a global crisis. In this context microplastics (MPs), plastic particles, less than 5 mm gained worldwide attention. The plastic pollution originates from litter, abrasion from everyday products and primary microplastics, which fragment due to environmental factors such as UV radiation and mechanical abrasion. Significant amounts of MPs were already detected in remote areas like polar regions or high mountains without direct human impact. These findings underline the importance of atmospheric MP transport.

However, even the importance of the atmosphere for MP dispersal, the detailed transport and deposition processes of MPs in the atmosphere are still only barely understood.

This study provides new insights into atmospheric MP deposition at 3106 metres altitude in the core zone of the nationalpark Hohe Tauern in the Austrian Alps. An ISO-certified sampler was used to collect the total monthly deposition at the Geosphere Sonnblick Observatory from spring 2021 to spring 2023. We will analyse deposited MP concentration, morphology, size distribution and polymer types to investigate potential seasonal dynamics. To trace the air mass movements, that might have transported the MPs into the high mountains, we will use the application tropolink (doi 10.1029/2023GH000885) which is based on the HYSPLIT atmospheric transport and dispersion model. Tropolink is able to find potential networks of atmospheric highways that connect distant locations by air mass movements. Air masses crossing urban areas are expected to transport higher concentration of MPs compared to air masses coming from less populated regions.

As plastic production volumes continue to increase, plastic pollution is also expected to increase, calling for a better understanding of transport- and deposition of atmospheric MPs into remote environments.

Biology and biogeography in polar environments

SOME DATA ABOUT LIFE CYCLE AND GROTH OF BOECKELLA POPPEI FROM LAKES OF EIGHT ISLAND, WILHELM ARCHIPELAGO

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The crustacean Boeckella poppei (Mrazek, 1901) (Calanoida: Centropagidae) is one of the main species of freshwater zooplankton of the Maritime Antarctic (Nabokin et. al., 2023).

To understand the mechanism and distribution pathways in terms of adaptation of this widespread species to Antarctic conditions, knowledge of the parameters of its life cycle is necessary.

The size of B. poppei is known to vary from population to population (Weller, 1977; Pociecha & Dumont, 2007), perhaps due to the differences in latitude and the related environmental factors. We studied the animal's life cycle, growth rate, and developmental features in two lakes on Eight Island, Wilhelm Archipelago (65º13.550'S 64º12.600'W, 1st lake and 65º13.530'S 64º 12.601'W, 2nd lake). The samples were collected in the season 2023–2024 every two weeks.

Only nauplia were present in the first sample (December) from the 1st lake. Both lakes contained only adults in the last two samples (March). The density was lowest in January (0.46 / L). It peaked in March, at the end of the season, at 1.52 / L. The size varied from 0.33 mm (nauplia) to 2.41 mm (adult females). The males were smaller and somewhat less abundant (≈1:1,14), which agrees with the literature. The development to adulthood took around two months, slightly less than reported by Pociecha and Dumont (2007), perhaps adapted to a shorter hydroperiod.

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Physical processes of glaciers and ice sheets in their environment

CONSTRAINING THE ONSET OF FUTURE IRREVERSIBLE RETREAT OF THWAITES GLACIER, ANTARCTICA, THROUGH IDEALIZED MODEL SIMULATIONS

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The Antarctic Ice Sheet is susceptible to instability-driven ice loss triggered by ocean-induced melting at its grounding lines (Joughin and Alley 2011). When engaged in such a retreat, ice loss – and consequentially sea-level rise – can potentially not be reversed over multi-millennial time scales. What determines the future onset of irreversible grounding line retreat at Thwaites Glacier, one of (West) Antarctica's widest and at the same time most vulnerable glaciers? By comparing different ice-sheet trajectories modelled with the ice-sheet model PISM after strong pulses in ocean-induced melting, we delineate reversible and irreversible grounding line positions in those parts of West Antarctica that might already be primed to long-term collapse under sustained present-day climate conditions (Reese et al., 2023). We find that irreversible ice loss in Antarctica is preventable, but the time window for avoiding this ice loss, by reversing today's global warming trend, drastically shrinks with the magnitude of the additional forcing, i.e. when overshooting critical thresholds of ice loss.

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History and future of international cooperation in polar regions

HOW WILL THE GLACIOLOGY RESEARCH COMMUNITY LOOK LIKE IN 2073? A TIME CAPSULE FROM THE 2023 KARTHAUS SUMMER SCHOOL

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Despite the increased awareness towards Equality, Diversity, and Inclusion (EDI), the glaciological community still experiences and perpetuates numerous examples of inappropriate and discriminatory behavior, adding to the systemic inequalities embedded in the scientific community. What are the EDI challenges we currently face within the glaciological research community? How can we overcome them? Where do we want our research community to be in fifty years? These questions were used as a starting point for a first-of-its-kind workshop at the 2023 Karthaus Summer School on Ice Sheets and Glaciers in the Climate System. Drawing on the outcomes of that workshop, in this paper we discuss the answers and challenges to addressing these questions, in the form of both actionable steps forward and imaginative visions of the future. We identified common threads from their responses and distill them into collective visions for the future built on actionable steps towards change. Having consulted additional literature, while formulating suggestions for improvement, stating our own commitment, and highlighting existing initiatives, contributions to this “time capsule” exercise were sorted into three main challenges we want and need to face: making glaciology more accessible, equitable, and responsible.

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Atmospheric, sea ice, and ocean system dynamics

CHARACTERISTICS AND COMPOSITION OF SEA ICE IN THE CENTRAL ARCTIC OCEAN

Marcel Nicolaus and the MOSAiC snow and sea ice team

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Arctic sea ice has decreased in extent and thickness during all seasons. The ice cover changed to a younger and more seasonal ice pack with different physical properties. However, it is still challenging to characterize sea ice and snow properties and processes during all seasons in relation to feedbacks with the atmosphere and the ocean. As a result, numerical simulations and forecasts as well as satellite data retrieval algorithms still have large uncertainties.

During the Multidisciplinary drifting Observatory for the Study of Arctic Climate, MOSAiC, sea ice and snow properties were observed over a full annual cycle in 2019/2020. In this presentation, we will summarize and review the sea ice and snow conditions over the annual cycle based on MOSAiC results. We will present mean properties of key parameters ranging from the lowest atmosphere, through snow and sea ice, into the upper ocean. The results indicate that the contrasts of different sea ice types in the Arctic Ocean diminish from autumn to spring. New sea ice types, pressure ridges and snow distributions need to be considered more explicitly when describing and modelling atmosphere-ice-ocean interactions. This will help to improve our understanding of the coupled Arctic system and lead to improved forecasts.

Atmospheric, sea-ice, and ocean system dynamics

TARA POLAR STATION

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Fifteen years after its first 500-day drift in the Arctic, the Tara Ocean Foundation is launching a new scientific platform – Tara Polar Station (TPS) – in the heart of the Arctic Ocean. This mission aims to strengthen international research on this environment, to better understand the impact of the accelerated climate change on biodiversity and adaptive abilities of endemic species. TPS is designed to be locked in ice and drift with the ice pack in 12 to 18 months missions in the coming 20 years. This unique program has scientific, technical and human challenges to study the Central Arctic Ocean over the next decades. The scientific objectives are to

- better understand the impact of climate change in the Arctic and on the rest of the planet
- improve knowledge of biodiversity on Earth by exploring regions currently inaccessible today
- analyze the consequences of melting sea ice and pollution on these unique and fragile ecosystems
- discover new molecules/species/processes with new potential applications

The very interdisciplinary observational program on board merges specific measurements and observations for targeted studies on individual sentinels with long-term measurements to quantify ongoing changes, trends, and variability of the coupled system.

In this presentation, we will present the platform together with the scientific program and the implementation of the drift program. We aim to inform the community and reach out for further collaboration.

Polar Earth Sciences

A SEDIMENTARY RECORD FROM BELOW THE CENTRAL ROSS ICE SHELF OF HOLOCENE ICE SHEET GROUNDING ZONE RETREAT AND OCEAN CIRCULATION CHANGE

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In 2017 the Ross Ice Shelf Programme drilled three holes through the centre of the Ross Ice Shelf (RIS) at a site known as HWD-2 (Hot Water Drill Site 2, Lat -80.65° Long 174.46°). Some of the key objectives were to understand better the ocean processes within the ice shelf cavity while also reconstructing the West Antarctic Ice Sheet (WAIS) grounding line retreat since the Last Glacial Maximum (LGM) from sea floor sediment cores. Work carried out at HWD-2 included installation of an ocean observatory (mooring) and seismometers, direct ocean water sampling and measurements, microbiological sampling, and recovery of sediment cores from the sea-floor. Here we look forward to future hot water drilling opportunities on the Ross Ice Shelf and present results from sediment cores recovered from HWD-2 including paleomagnetic and magnetic fabric data.

A total of 10 sediment cores were recovered c.740 m below sea surface (c. 780 below the top of the ice self) with lengths of between 40 and 65 cm using a gravity corer. The 10 cores consist of a thin upper interval (5-10cm) of clast rich mud followed by c. 50cm of clast poor mud culminating in a basal, over-consolidated diamicton which was deposited beneath the grounded WAIS.

Paleomagnetic data indicate a step magnetisation has been preserved and that some degree of magnetic inclination shallowing has occurred. Magnetic fabric data contain a basal glacial sheer and ocean current fabric with evidence for sediments having undergone compression after deposition suggesting the ice shelf grounding zone may have readvanced over the site after initially retreating.

Integrating Social and Natural Sciences: Collaborative and Inclusive Approaches Beyond Traditional Boundaries

GREENLANDIC IMMERSION

Kamilla Oliver Independent scholar

This contribution recounts the author's experiences gathered during a year stay in Tiniteqilaaq, East Greenland.

Tiniteqilaaq is a traditional fishing and hunting settlement which about 80 inhabitants call home. It is considered remote even by Greenlandic standards. It lies about 30 km into the majestic Sermilik icefjord, on the Greenlandic mainland in beautiful surroundings. Local living conditions are rather Spartan compared to what one is used to in a so-called 'civilized' world.

The author is a middle-age Polish/German woman, former scientist, taking up a teaching job in the settlement. Not knowing the language and despite the obvious difficulties she avails herself of anything and everything that comes along, trying to learn and understand the local i.e. the Inuit way of life and differentiate romanticism from reality. A personal account will be given of what it means to live and work on a settlement in a different culture with a limited means of communication. Discussed topics focus on education and educational projects, such as building sledges with pupils and building a kayak. Local perspective on hunting, development of tourism, environmental changes in face of the changing weather and climate and how they affect the human society, will be mentioned.

Atmospheric, sea-ice, and ocean system dynamics

IMPACT OF WESTERLY WINDS ON ANTARCTIC BAY CIRCULATION, GLACIAL WATER SPREADING AND FORMATION OF FEEDING HOTSPOTS

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A four-year hydrographic measurement campaign was conducted in Admiralty Bay (AB), South Shetland Islands. Based on its conclusions, a 3D hydrodynamical model of AB has been created using the Delft3D program. It revealed that the circulation pattern in AB consists of two clockwise circulation cells, and an inflow current transports ocean waters into the bay along its western boundary. Consequently, glacial water introduced to AB through marine-terminating glaciers is transported out to the ocean along its eastern edge, in a thin surface layer. By comparing the model and measurement results, it was estimated that the annual volume of glacial water added to AB is between 0.434 and 0.632 Gt per year. During summer the influx of glacial water is more than 10 times higher than during winter. AB hydrodynamics are always primarily driven by oceanic forcing; however, it has been demonstrated that in inner inlets, the large input of glacial water can alter the local circulation pattern.

In AB westerly winds are dominant, acting perpendicularly to the main axis of the bay. Its impact on glacial water spreading has been examined. These western winds have been shown to produce upwelling in regions of observed penguin and whale feeding hotspots. Lagrangian particle tracer modeling has been used to calculate the particle transport pathways and residence time in AB in order to study this process. Finally, by combining results from glacial influx analysis, hydrodynamical models, measurements, and considering local biochemistry, bathymetry, and wind patterns, the necessary conditions for creating feeding hotspots in AB have been found.

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Integrating Social and Natural Sciences: Collaborative and Inclusive Approaches Beyond Traditional Boundaries

STRIKING A BALANCE: CENTERING INDIGENOUS VOICES & ADDRESSING POSITIONALITY IN TRANSFORMATION FRAMEWORKS

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Transformation in this time of complex change demands not only a new way of thinking about our relationships with each other and with our natural surroundings, but also calls for a framework within which to pursue our collaborative visions for the future. The question, then, becomes more a matter of how to move forward with centering Indigenous knowledges and perspectives in shaping concepts of sustainability with an interdisciplinary approach that is grounded in reality and sparked by our imagination.

The essence of grassroots activism manifests as a bottom-up approach to hold space for voices that have historically been lost in the margins of conversations involving the future of their communities. This emergent phenomenon has the potential to catalyze change and yet, for one reason or another, grassroots efforts do not often withstand the test of time. It has been suggested that, in order to scale up these efforts, there is a need for increased structure designed to maximize sustainability that does not come at the expense of the essence of these efforts (Wolf et al., 2021).

Within this context, we will narrow our focus to explore the development of an educational framework that is designed to center Indigenous worldviews while addressing the question of positionality. As one of many non-Indigenous researchers in the broader academic community, my question is one of how to position myself in relation to Arctic Indigenous communities as we work toward this idea of transformation. In this sense, it is essential to start with “the right relations” (Gram-Hanssen et al., 2022) to ensure that we are not perpetuating the history of colonization in academic research or contributing to research fatigue in these communities.

We will take a deeper look at the application of grassroots efforts within an educational framework that has been built around the concept of partnership to center Indigenous voices within and beyond the academic community. My goal here is to offer an analysis of current educational and organizational partnerships as a model in moving forward to center Indigenous voices while addressing positionality and decolonization from the ground up.

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Atmospheric, sea-ice, and ocean system dynamics

A COUPLED MULTI3 (SCALE, PHASE, FIELD) FRAMEWORK TO MODEL SMALL SCALE PROCESSES IN ANTARCTIC SEA ICE

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The Antarctic sea ice, which undergoes annual freezing and melting, plays a significant role in the global climate cycle. Since satellite observations in the Antarctic region began, 2023 saw a historically unprecedented decrease in the extent of sea ice. Further ocean warming and future environmental conditions in the Southern Ocean will influence the extent and amount of ice in the Marginal Ice Zones (MIZ), the BioGeoChemical cycles, and their interconnected relationships. The so-called pancake floes are a composition of a porous sea ice matrix with interstitial brine, nutrients, and biological communities inside the pores. The ice formation and salinity are both dependent on the ambient temperature. To realistically model these multi-phasic and multi-component coupled processes, the extended Theory of Porous Media (eTPM) [1] is used to develop high-fidelity models capable of simulating the different seasonal variations in the region. All critical variables like salinity, ice volume fraction, and temperature, among others, are considered and have their equations of state. The phase transition phenomenon is approached through a micro-macro linking scheme. A Phase- field solidification model [2] coupled with salinity is used to model the microscale freezing processes and up-scaled to the macroscale eTPM model. The evolution equations for the phase field model are derived following Landau-Ginzburg order parameter gradient dynamics and mass conservation of salt. This allows for modeling the salt trapped inside the pores. For the biological part, a BioGeoChemical model for sea ice [3] is set up to simulate the algal species present in the sea ice matrix. Processes like photosynthesis and loss of algae, dependent on sunlight, temperature, nutrients, and salinity are derived through an ODE-PDE coupling with the eTPM model. Academic simulations and results are presented as validation for the mathematical model.

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Biology and biogeography in polar environments

USING AERIAL IMAGERY FROM DRONES AND AIRCRAFT TO DETERMINE THE POPULATION AT SIX EMPEROR PENGUIN (*APTENODYTES FORSTERI*) COLONIES

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Emperor penguin (Aptenodytes forsteri) colonies are found along the entire coastline of the Antarctic continent (Fretwell et al. 2012). The remoteness of these colonies makes it difficult to obtain accurate population data. Climate change is threatening these penguins by reducing their sea ice breeding habitat (Jenouvrier et al. 2021). Accurate population data are therefore crucial for assessing any changes. We conducted aerial surveys from drones and aircraft to assess the number of breeding pairs at six emperor penguin colonies along the coast of the Weddell Sea and Queen Maud Land. These aerial surveys took place during the 2019/20, 2022/23 and 2023/24 seasons, specifically during the crèche and fledging phases. The flights were performed with the Polar-5 and 6 aircraft from the Alfred Wegener Institute (AWI) and with a DJI Phantom 4 Pro quadcopter. Using sub-decimetre aerial imagery from these flights, we were able to identify individual birds and, under certain conditions, differentiate between adults and chicks. In particular, our results provide the first population data on breeding pairs for these colonies in decades. In addition, our study examines variations in the detectability of individual penguins in relation to the timing of data collection, weather conditions and spatial resolution of the aerial images. As a result, we demonstrate that imagery from drones and aircraft is a valuable tool for estimating breeding pair numbers in Emperor penguin colonies.

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History and future of international cooperation in polar regions

VERGLEICHENDES WEG-ZEIT-DIAGRAMM DER SÜDPOL-EXPEDITIONEN VON ROBERT FALCON SCOTT UND ROALD AMUNDSEN IN DEN JAHREN 1911 UND 1912

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Über den „Wettlauf“ von Scott und Amundsen zum Südpol sind zahlreiche Publikationen erschienen (Huntford 1979). Bis auf Gorbunov (2015) zeigt jedoch keine dieser Arbeiten eine graphische Darstellung, um die zeitlichen Abläufe und Fortschritte dieser beiden Expeditionen ablesen und direkt miteinander vergleichen zu können.

In dem vorliegenden Weg-Zeit-Diagramm, das auf einen Entwurf von Kurt Wegener für die Grönlandexpedition seines Bruders Alfred 1930-31 zurückgeht (Wegener 1932), sind die Abläufe der Expeditionen von Amundsen und Scott anhand der vergangenen Zeit und des zurückgelegten Weges dargestellt (Amundsen 2001, Scott 2001). Je steiler dabei die Kurven sind, umso schneller bewegen sich die Gruppen. Ein horizontaler Verlauf der Kurven zeigt an, dass die Expeditionen an einer Stelle verharren.

Der Vergleich dieser Expeditionskurven zeigt die Unterschiede bereits bei den Vorbereitungen beider Pol-Expeditionen vor der Überwinterung 1911. Das Depot III der Norweger (82° Süd) war 3,5 Breitengrade südlich der Bay of Whales angelegt und noch 8 Breitengrade vom Südpol entfernt, während das One Ton Depot der Briten (79°30‘ Süd), nur 2 Breitengrade südlich von Cape Evans gelegen, noch 10,5 Breitengrade vom Südpol entfernt war.

Die Kurven zeigen den Nachteil der nördlicheren Ausgangslage der Briten und ihres späteren Aufbruchs. Als Scott die Breite des Startpunkts der Norweger auf etwa 78°30‘ erreichte, war Amundsen bereits 20 Tage unterwegs. Es ist jedoch erstaunlich, dass bei dem weiteren Vormarsch zum Südpol beide Kurven ein relativ ähnliches Gefälle zeigen. Scott war zu Fuß nur unwesentlich langsamer als Amundsen mit seinen Hundeschlitten. Trotzdem erhöhte sich der Zeitraum zwischen beiden Gruppen bei Ankunft am Südpol auf 33 Tage. Auf dem Rückweg wurde Scott aufgrund der knappen Verpflegungslage und der Erfrierungen immer langsamer. Als er mit seinen Begleitern das letzte Camp auf etwa 79°45‘ erreichte, hatten die Norweger diese geographische Breite bereits zwei Monate vorher passiert. Das Diagramm unterstreicht, welche Auswirkung Scotts Fehlplanung in der Depotlegung auf dem Rückweg hatte.

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Polar Earth Sciences

ANTIPHASE GLACIAL OCEAN SUBSURFACE WARMING AND THE ANTARCTIC BOTTOM WATER FORMATION OFF EAST ANTARCTICA

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Results from numerical modelling, observations, and reconstructions from sedimentary archives indicate that the poleward transport of warm Circumpolar Deep Water (CDW) onto the Antarctic continental margin plays a crucial role in both the future destabilization of the Antarctic ice sheet and the significant ice losses since the last ice age. Recently, enhanced freshening of Antarctic Bottom Water (AABW) has been linked to increased melting of the Antarctic Ice Sheet. However, past changes in AABW formation remain a topic of controversial discussion, and current understanding is correspondingly limited. These processes contribute to sea level rise and have triggered rearrangements in global overturning circulation. We provides, for the first time, a comprehensive library of the main carbonate proxies on planktic and benthic foraminifera unique sedimentary archives in the immediate vicinity of the East Antarctic ice shelf spanning the last 80,000 years. Using Mg/Ca ratio paired with clumped isotope temperature reconstructions combined with oxygen and isotope (d18O) results on planktic foraminifera *Neogloboquadrina pachyderma* (sin) we identify subsurface warmings and high salinity conditions associated to the upwelling of CDW during the last glacial period. Our results represent the southernmost paleotemperature records currently available. The CDW upwelling occurs in the context of the offshore glacial Weddell Polynya, which has been ascribed to regional atmosphere-ice-ocean interactions and a long-term variability in Atlantic Meridional Overturning Circulation (AMOC). Our temperature proxies reveal that glacial subsurface warmings occurred in antiphase with the Antarctic air temperature. Furthermore, we present the difference of radiocarbon 14C ages between planktic *N. pachyderma* (sin) and benthic *Cibicidoides wuellerstorfi* (sl.) species (B-P 14C age). It is important to note that there are no 14C dating records available south of 60°S. The B-P 14C age offset reveals that the AABW formation was highly associated to the offshore glacial Weddell Polynya, which was particularly strong during the Last Glacial Maximum (LGM). Our novel findings indicate enhanced AABW formation during Heinrich Stadial (HS) 3, HS2, LGM, and HS1.

DFG SPP 1158 Antarctic Research: Report Colloquium

BACTERIAL TRANSFORMATIONS OF DIMETHYLSULFONIOPROPIONATE IN THE WEDDELL SEA

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Dimethylsulfide (DMS) is a climate-relevant trace gas that acts as a precursor of cloud condensation nuclei in the atmosphere. It is produced in the surface ocean by the bacterial degradation of phytoplankton-derived dimethylsulfoniopropionate (DMSP). The Southern Ocean is considered a region of significant sea-to-air fluxes of DMS, in particular in regions close to the Antarctic continent and in the zone of seasonal sea ice melting. Nevertheless, our understanding of DMSP cycling is largely derived from studies conducted at low- and mid-latitudes, while the knowledge on polar oceans is still very limited. A better understanding of microbial communities and their genetic capabilities that control pathways of DMSP transformations is of high importance to unravel the environmental control of biologically driven DMS fluxes. While global-scale implications of marine DMSP cycling had been recognized for more than 30 years, only recently developed "omics" techniques identified genes involved in the bacterial DMSP metabolism and provided insight into their phylogenetic distribution. We will present results on the taxonomic composition and the metabolic potential of DMSP-degrading bacterial communities in coastal polynyas of the southern Weddell Sea and in coastal waters of the Antarctic Peninsula. Metagenomic and -transcriptomic data were used to analyse the inventory of DMSP-processing genes in the communities and in metagenome-assembled genomes, i.e. bioinformatically reconstructed genomes. In addition, the potential of different taxa to contribute to the DMSP cycling in the Antarctic communities was quantified using digital droplet PCR. Our analyses revealed taxonomically diverse DMSP-cycling bacterial communities with an unexpectedly high potential for DMSP demethylation in Gammaproteobacteria. In addition to microbiological data, we will show results on sea-air gas fluxes of different climate-active gases like methane and nitrous oxide, which depend on the surface concentrations but also on meteorological forcing, and the accumulation of surface-active substances in the sea-surface microlayer. Results will be discussed in comparison to low- and mid-latitude marine systems and in the context of bacterially mediated linkages to biological processes and biogeochemical cycles in the Weddell Sea. Our results will contribute to the understanding of trace gas dynamics in the Southern Ocean and their relevance for the global climate.

Mass balance and evolution of glacier systems in a changing climate

REANALYSIS OF THE SURFACE MASS BALANCE OF MITTIVAKKAT GLETSJER (SOUTHEAST GREENLAND): SYNTHESIZING DATA SOURCES

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The contribution of Arctic glaciers and ice caps (GICs) to sea level rise in the last decades was similar to that of the Greenland Ice Sheet, however, their mass loss per unit area was larger (Box et al. 2018; Meredith et al. 2019; Wolken et al. 2020). Between 2006 and 2015, mass changes were largest for GICs in Greenland when compared to other regions in the Arctic (Meredith et al. 2019). Mittivakkat Gletsjer (Southeast Greenland) has the longest surface mass balance (SMB) record from field-based observations (since 1995/1996) for peripheral Greenland and is significantly out of balance with the current climate (Mernild et al. 2011; 2013). In this study, we synthesize glaciological SMB from the ablation stake record (WGMS 2024), modelled SMB from the 1 km-downscaled Regional Atmospheric and Climate Model (RACMO) 2.3p2 (Noël et al. 2019), and geodetic mass balance (MB) estimated from volume changes from the digital elevation models (DEMs) AERODEM (Korsgaard et al. 2016), ArcticDEM (Porter et al. 2018), and PléiadesDEM (Berthier et al. 2024). RACMO is forced by meteorological (reanalysis) data and estimates SMB from multi-layer snow cover simulations and albedo scheme covering the period 1958-2022 (Noël et al. 2019). The DEMs are photogrammetrically derived products from aerial or satellite imagery and were acquired in 1981, 2013, and 2023, respectively. The modelled output correlates well with the glaciological SMB ($R2 = 0.74$; $p < 0.01$) but underestimates the glacier-wide mass loss by 47 % in the overlapping period (1996-2022). Therefore, we calibrate the modelled SMB with the glaciological record. The calibrated model output for 1996-2022 (1.06 ± 0.46 m w.e. yr-1) agrees with the glaciological record (-1.06 ± 0.16 m w.e. yr-1) in the same period. The modelled SMB indicates a change from an almost balanced state for 1959-1992 (0.47 ± 0.46 m w.e. yr-1) to a negative mass balance regime for 1993-2022 (-1.14 ± 0.46 m w.e. yr-1). When comparing those two periods, the modelled output shows that most months experienced a reduction in SMB with highest decreases in summer (Jun-Aug). Furthermore, the equilibrium line altitude increased from ~350 to ~850 m a.s.l between 1959-1992 and 1993-2022, with a SMB decrease in each of the 11 altitude sections between 300-950 m a.s.l. The geodetic MB yields estimates of -0.79 ± 0.37 m w.e. yr-1 for 1982-2013 (modelled SMB: -0.55 ± 0.46 m w.e. yr-1) and -0.97 ± 0.21m w.e. yr-1 for 2014-2023 (modelled SMB: -1.19 ± 0.46 m w.e. yr-1; glaciological SMB: -1.20 ± 0.16 m w.e. yr-1). Differences in the mass loss estimates might be related to challenges in synthesizing results of different mass balance methods such as spatial coverage, density assumptions, data quality, scaling, spatial extrapolation, an englacial and subglacial processes. The change to a more negative regime in early 1990s is discussed in the context of climate indices (i.e., Kaplan et al. 1998; Enfield et al. 2001; Hanna et al. 2016) and are in line with modelled and ablation stake SMB being negative in 24 out of 27 years

between 1996 and 2022. The three years with a slightly positive balance can be associated with unusually high winter precipitation (Mernild et al. 2011). As a next step, we aim to include volume changes from previous ground-penetrating radar (GPR) studies in 1994 (Knudsen and Hasholt 1999) and 2012 (Yde et al. 2014) and from a recent GPR survey (2023) in the comparison of the mass balance records.

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Integrating Social and Natural Sciences: Collaborative and Inclusive Approaches Beyond Traditional Boundaries

ARCTIC COASTAL COMMUNITIES: INFRASTRUCTURE FOR A SUSTAINABLE FUTURE?

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In recent decades, the Arctic has been attracting global attention both as an epicenter of climate change and a hotspot of resource extraction and infrastructural development. Global environmental change processes, large-scale development projects and, more recently, militarization and securitization, reconfigure the lives of Arctic Indigenous and local residents. While decisions about the futures of Arctic communities are often made by outside stakeholders and politicians, local visions and needs often remain neglected.

My research draws on ethnographies of infrastructural development in two Arctic coastal communities - Nome, Alaska, and Kirkenes, Norway. It examines the social, cultural, and environmental implications of large-scale infrastructural projects and explores local concepts of sustainability. I employ an array of approaches from the anthropology of infrastructure and future, including interview-based ethnographic fieldwork, discourse analysis, and scenario building in order to address my research questions – *What are the promises and threats of infrastructure projects for Arctic communities in transition? And how do Indigenous and local residents envision futures of their communities in the context of climate change, resource extraction and geopolitical tensions?*

Biology and biogeography in polar environments

SPRINGTAILS FROM THE WILHELM ARCHIPELAGO (2023–2024)

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Springtails (Collembola) are a vital component of the soil fauna. They help shape habitat characteristics both above- and below-ground (Bardgett & Van der Putten, 2014). In Antarctica, springtails are one of the main terrestrial invertebrate groups present and, at regional scale, their diversity and distribution are reasonably well-described (Baird, et al., 2019). However, given current global warming trends, along with other direct anthropogenic influences acting synergistically, significant changes are possible in the distributions of native species. Furthermore, a number of non-native springtail species are also already present in the Antarctic, especially at locations in the South Shetland Islands (Hughes et al., 2015). The distributions of these may also expand, while there is a risk of further non-native species arriving (Greenslade et al., 2012; Hughes et al., 2020). Here, we examined soil samples collected in the Wilhelm Archipelago (western Antarctic Peninsula) in the 2023–2024 austral summer. We recorded three species, *Cryptopygus antarcticus* Willem, 1901, *Friesea antarctica* (Willem, 1901) and *Folsomotoma octooculata* (Willem, 1901), all species that are indigenous to this region. Further surveys describing in more detail and tracking shifts in native and potentially future non-native springtail ranges will provide data documenting the impacts of the multiple environmental change drivers acting in this region and support efforts to predict changes in the functioning of the continent's terrestrial ecosystems.

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Mass balance and evolution of glacier systems in a changing climate

LARGE-SCALE AND HIGH-RESOLUTION FRONTAL ABLATION ESTIMATES IN THE ARCTIC THROUGH A MACHINE LEARNING APPROACH

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Frontal ablation is an important component of tidewater glacier mass loss, yet high temporal resolution estimates remain elusive due to difficulty in reliably capturing terminus position changes with satellite imagery. Recent development in automatically delineating glacier fronts with machine learning-based radar image segmentation has opened an opportunity to calculate frontal ablation over fine timescales. By segmenting Sentinel-1 synthetic aperture radar image sequences, using a deep learning-based terminus segmentation algorithm, we aim to quantify seasonal and annual frontal ablation for tidewater glaciers throughout the Arctic. The derived frontal ablation information is valuable to climate and glacier models, which could benefit from high-resolution reference data, resulting in improved calibrations and parameterizations. Svalbard, an Arctic region characterized by variable glacier and fjord geometries, will serve as a methodological test site before expanding the scope to the Canadian Arctic, Russian Arctic, Greenland periphery, and Alaska, or ~1400 marine-terminating glaciers in the Northern Hemisphere. Currently, workflow pipelines are developing for the pre- and post-processing of Sentinel-1 radar images, the creation of regional training data to assist the segmentation algorithm, and the generation of monthly ice flux calculations, with early results for Svalbard expected this summer.

Future project efforts will focus on quantifying total mass budget for all glaciers in the study by integrating frontal changes, ice discharge calculations from ice thickness and surface velocity products, and climatic mass balance data. To identify and evaluate external drivers of glacier change, the frontal ablation and mass balance estimates will be combined with modeled and observational atmospheric, oceanic, and sea ice data. Through multivariate statistical analyses between these Earth system datasets and mass budget components, we look to provide an improved understanding of dynamic tidewater glacier processes, their spatio-temporal variability, and the influence of glacier geometry on observed changes across the Arctic.

History and future of international cooperation in polar regions

HISTORY FROM THE FREEZER: HISTORICAL MAPS AND SATELLITE IMAGERY COMPARED

Ursula Rack

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A few years ago, a photo exhibition organised by Gateway Antarctica at the University of Canterbury, has revealed that visitors were more attracted to the images of ice and snow than other motives. Following this exhibition, many questions were asked about the history of early Antarctic exploration, the motivation of scientists, how findings were made, and the legacy of these findings.

Paintings, photos, and descriptions of ice are available from early explorers who studied the ice. Many of them were geologists such as Otto Nordenskjöld, leader of the Swedish Antarctic Expedition in 1901–1903. The scientific reports and narrative give a great insight into the diversity in observation techniques. Many observations were made on sledge parties. Otto Nordenskjöld, even shaped the name ‘ice shelf’ based on his observations. The maps and the reports are very valuable today to compare the historical material with modern data sets to reconstruct the changes over the decades and possible predictions for the future.

This paper shows the exploration of Antarctic snow and ice from a historical angle and focuses on the Swedish expedition, especially on its maps and modern satellite images. These are compared for analyses about the changes of the Larsen Ice Shelf to understand the mechanisms of climate change.

Physical processes of glaciers and ice sheets in their environment

INVESTIGATION OF TIDAL GROUNDING LINE MIGRATION USING SAR LINE-OF-SIGHT OFFSET TIME SERIES

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The abundance of satellite-based SAR, laser and radar altimetry observations have enabled temporally and spatially extensive mappings of Antarctic grounding lines. However, the grounding lines derived from tidal methods include the additional ephemeral shift in position induced by the tidal flexure of ice shelves. Previous works have demonstrated that grounding lines migrate a few hundred metres to several kilometres heterogeneously and out-of-phase with ocean tides (Milillo et al. 2019), implying that the tidal component does not diminish in an interannual time series. Changes in the grounding line position over the period of several years provide insights into the stability and dynamics of ice sheets (Schoof 2007), and thereby also impact the assessment of their evolution and contribution to sea level rise.

We aim to quantify grounding line migration and model ice shelf flexure at tidal timescales. We employ a times series from 2019 - 2021 of line-of-sight (LOS) offsets from 6-day repeat cycle Sentinel-1 acquisitions over Larsen C Ice Shelf (LCIS) and Thwaites Glacier. The datasets were generated using the differential range offset tracking method which is outlined in Nagler et al. 2015. Following the methodology of Wallis et al. 2024, we computed Pearson's correlation between LOS offsets and contemporaneous differential tide levels derived from the CATS2008 tide model (Howard et al. 2019). Preliminary results show a strong correlation for LCIS and no significant correlation for Thwaites. We attribute this to the large tidal range in the Weddell Sea and surmise that the rapid acceleration of the Thwaites glacier tongue likely dominates the tidal signal in LOS. We analysed the offsets of pixels along multiple ice flow lines of LCIS. Despite the same differential tide level, we observed different profile curves for the same flow line. We will fit to each profile a one-dimensional elastic beam model (Vaughan 1995), estimate the respective grounding line positions by performing a least squares inversion and discuss their migration patterns in the purview of rising and falling tide state and tide level.

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Polar Earth Sciences

SPELEOTHEM TRACE ELEMENT IN A GREENLANDIC CAVE

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The Earth's climate is undergoing significant changes, primarily due to anthropogenic greenhouse gas emissions, resulting in observable changes in the atmosphere, biosphere, ocean, and cryosphere (IPCC, 2022). Human activities, such as greenhouse gas emissions and unsustainable practices, are exacerbating global warming, with the Arctic region experiencing accelerated warming known as Arctic amplification (Davy et al., 2023). This phenomenon causes ice to retreat and melt, contributing to global sea level rise, habitat loss, shifts in species distribution, and changes in food availability (Anisimov et al., 2007; Meredith et al., 2019).

Understanding past periods characterized by glacial and interglacial cycles driven by Milankovitch cycles provides context for current climate changes. The Quaternary, which was colder than previous geologic periods, was followed by the warmer Miocene, during which significant climate changes occurred, including the mid-Miocene climatic optimum (Scotese et al., 2021) and the late Miocene cooling (Tanner et al., 2020). In the Miocene, CO2 concentrations are similar to today and in the near future, and the geographic location is similar to today. Therefore, the Miocene is a good analogy for studying our near future (Haywood et al., 2011; Bouchet et al., 2023).

Greenland ice cores do not provide access to the Miocene, and other Arctic terrestrial archives do not go back far enough (e.g., Lake El'Gygygtyn) (Brigham-Grette et al., 2013). The use of cave deposits, or speleothems, can fill this knowledge gap about warm climates in the High Arctic, providing us with more accurate information about a much warmer and wetter time than today. Speleothems provide high-resolution local climate data through their growth patterns and isotopic composition (Fairchild and Baker, 2012). The study of speleothems can fill the gap in our knowledge of warm climates in high Arctic regions, expand the terrestrial paleo-dataset, and provide us with more accurate information about a much warmer and wetter time than today (Moseley et al., 2020; Honiat et al., 2023). A multi-proxy approach, combining speleothem data with other proxies, improves climate models in the development of adaptation strategies for future climate scenarios. Depending on the growth conditions, trace elements (e.g. Mg, Sr, Ba) are incorporated into the lamellae, which contain valuable climatic information. Trace elements can record interesting features, pronounced peaks or anomalies and their causes (Bögli, 1978; Audra et al., 2015).

The aim of this research is to compare different methods to study the variability of trace elements in Greenland speleothems. The presentation of preliminary results will provide insights into the variability of soil and water dynamics in the High Arctic during the late Miocene.

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Mass balance and evolution of glacier systems in a changing climate

A MULTI-MODEL APPROACH FOR MORE REALISTIC SIMULATIONS OF THE GREENLAND ICE SHEET DURING THE LAST GLACIAL CYCLE

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Realistic simulations of the evolution of large ice sheets under various climate conditions are crucial to estimate future ice sheet (in)stability and melt. Here, I focus on the Greenland ice sheet and its evolution under the climate of the last glacial cycle. I present a coupled model approach using three models: an ice sheet model (Yelmo), performing the simulation of the ice sheet, a surface mass and energy balance model (BESSI), providing the mass balance input to the ice sheet model, and a tracer model (ELSA), tracking the (depth-dependent) age of the ice.

The surface mass and energy balance model BESSI simulates all surface and internal fluxes of heat and mass explicitly, providing a much more realistic mass balance than the commonly used positive-dregree-day approach, while still being computationally efficient. The englacial layer tracer ELSA models the evolution of isochrones in the ice sheet over the course of the simulation. Together with reconstructed isochrones from radiostratigraphy data, the simulated isochrones can be used to evaluate the simulation results.

The goal is to achieve a realistic simulation of the last glacial cycle, using ELSA as a tuning tool to guide the parameterization of both the ice sheet and mass balance model. All three models are open source and available on git for the ice sheet modeling community to use.

Atmospheric, sea-ice, and ocean system dynamics

ORBITAL CONTROL OF THE PATAGONIAN ICE SHEET

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The Patagonian ice sheet (PIS) played a dynamic role by amplifying, pacing, and driving local to global climate changes, participating in sea level changes, albedo effect, and sediment production (Clark, Alley, and Pollard 1999). The geographic maximum extent of the ice sheet is mainly determined through continental ice-derived sedimentary sequences on land such as radionuclide-dated moraines. Unfortunately, older glaciations are often eroded by more recent glacial advances, resulting in an incomplete picture of past glaciations. In this study, we use a composite record at Site U1542 on the Chilean margin (54°S) to investigate the forces that drive and shape the PIS. Ice-rafted debris and terrigenous accumulation rates, together with terrestrial biomarkers are applied to reconstruct the history of the PIS over the past 790, 000 years. This study presents the first detailed, continuous reconstruction of the PIS at an orbital timescale. The timing of terrestrial sediment deposition aligns notably with the extent of Patagonian moraines, and mirrors dust records from Antarctic ice cores and deep-ocean sediment cores from the South Atlantic. This implies a close connection between PIS and global climate dynamics, emphasizing its role in the global carbon budget. Our record highlights the crucial role of sea temperature in controlling PIS growth. Additionally, the sediment discharge to the Chilean margin is controlled by sea level stands.

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Biology and biogeography in polar environments

MICROBIAL SYMBIONTS IN ARCTIC SPECIMENS OF *LAFOEA DUMOSA*

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Despite the harsh conditions, the Arctic Ocean harbours a diverse array of marine organisms. Among these, Cnidarians host an impressive number of microbes and are engaged in different kinds of relationships, such as epibiosis or strict symbioses (mutualism or parasitism) (Bosch et al., 2011; Kimes et al., 2013). Microbial symbionts of Cnidaria play important biological and ecological roles (Leal et al., 2014; McFall-Ngai et al., 2013). Among Cnidaria, Hydrozoans (which are colonial, gelatinous animals) form close associations with bacteria which can provide essential nutrients, aid in digestion, and protection against pathogens. Studies on several hydroid species carried out by electron microscopy and cultivation approaches have revealed epibiotic phototrophic microorganisms (Gorelova et al., 2009). Understanding the diversity and function of microbial communities associated with hydrozoans in the Arctic has significant implications for our understanding of marine ecosystems. Understanding how these changes affect the symbiotic relationships between hydrozoans and their bacterial symbionts is essential for predicting the resilience of Arctic marine ecosystems in the face of ongoing environmental stressors. This study aimed to explore the diversity of bacterial communities associated with specimen of *Lafoea dumosa* collected in the Arctic region (Isfjorden, West Spitsbergen). Next generation sequencing techniques was employed to elucidate the taxonomical composition of bacterial communities, showing a predominance of *Proteobacteria*, *Bacteroidota*, *Actinobacteriota*, *Verucomicrobiota* and *Plancomycetota*. At genus level, *Brevundimonas*, *Arenicella* and *Aeromonas* members were the most abundant on the total community. The study provides an intriguing contribute to the current knowledge on hydrozoan microbiomes in the Arctic region.

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Integrating social and natural sciences: collaborative and inclusive approaches beyond tradinational boundaries

ARCTIC PEOPLE DOUBLE EXPOSURE: ENERGY TRANSITION AND CLIMATE CHANGE

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In this paper, we analyze the response of northern and arctic jurisdictions to the need for so-called critical minerals, which are seen as key to the energy transition, creating a double exposure for Arctic People: Climate change and the demand for critical minerals. The warming of the Arctic has been well documented (Jansen et al. 2020), as well as its impact on Arctic people (Nuttall 2007). The demand for critical minerals is not limited to the Arctic. However, due to the lack of social acceptability of mineral extraction in more populated southern regions, there is increased pressure to open mines in the North and the Arctic. Multiple projects are emerging in the Arctic, and most Arctic jurisdictions have adopted strategies or policies to facilitate the approval process (Alaska/US, Denmark/Greenland, Norway and Canada) and are considered in Sweden and Finland.

The concept of green colonialism (Normann 2021) and greenwashing (de Freitas Netto 2020) helps us to analyze the new wave of extractive activities in the Arctic, as most critical mineral policies and strategies are developed in the South without adequate input from Arctic peoples. Additionally, poorly designed projects that will negatively impact Arctic peoples' livelihoods are being justified under the guise of the energy transition. Examples from Sweden, Norway, and Canada are used to identify these processes. These include green metals in Kiruna, the Nussir Mine in Norway, and the Torngat rare earth project on the Quebec-Labrador border in Canada.

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DFG SPP 1158 Antarctic Research: Report Colloquium

ABOVE OR BELOW? DELVING INTO THE FOUNDATIONS OF THE TRANSANTARCTIC MOUNTAINS

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The bulk of the Transantarctic Mountains (TAM) is characterised by expansive elevated plateaus with a widely uniform architecture, comprising levelled Paleozoic basement overlain by a Permotriassic-Jurassic cover of sedimentary and volcanic units. A contrasting landscape of alpine crests and narrow serrated ridges is only exposed in northern Victoria Land at the Pacific terminus of the TAM. There, the Mountaineer Range constitutes the transition between both morphologies, featuring basement rocks pervaded by shallow Cenozoic intrusions. The corresponding coastal relief is significantly more pronounced than surrounding plateaus, with stronger segmentation and conic peaks such as Mt. Murchison, reaching 3500 m in elevation.

We conducted thermochronological analyses to delineate uplift, exhumation history and long-term landscape evolution in the coastal Mountaineer Range. Apatite fission-track and (U-Th-Sm)/He ages from 10 samples of Mt. Murchison range from 27-33 Ma and 19-31 Ma, respectively. They generally increase with elevation, while the temporal offset between the two systems varies from <2 to ~11 Ma. Thermal history modelling implies an episode of rapid exhumation in the early Oligocene at ~33 Ma, followed by subsequent differential and polyphase cooling of the individual samples at variable rates.

Modelled cooling histories depict landscape evolution at different scales. Initial regional denudation in response to the inversion of a Mesozoic sedimentary basin preceded rift-front backstepping and valley incision. Early Oligocene exhumation rates exceeding 4 km/Ma require substantial uplift and rapid downwearing of poorly consolidated basin infill. The timing of this major exhumation episode correlates with a recorded phase of igneous activity between ~34 and ~25 Ma in the Mt. Murchison area, suggesting that thermal support played a key role in addition to tectonics and isostatic effects. After initial removal of an unconsolidated cover, crustal cooling advanced differentially through local erosion relative to topographic level and distance from the coast. Accelerated exhumation during the Miocene climate optimum between ~18 and ~15 Ma may indicate climate control on relief formation prior to late Miocene deterioration and final transition into icehouse conditions.

Our findings identify the coastal Mountaineer Range as the locus of greatest erosional thickness recorded in the TAM, with a total estimated overburden of >5 km prior to uplift and post-Eocene erosion. Despite its present-day high-relief topography, the erosional level of Mt. Murchison is stratigraphically below adjacent plateaus. In the deepest valleys, exhumation

totals up to ≥ 9 km. This conclusion implies that substantial topographic relief was established in the vicinity of the Mountaineer Range at the Eocene-Oligocene transition, likely marking an initial phase of uplift that laid the foundation for the TAM.

Physical processes of glaciers and ice sheets in their environment

IMPACT OF ENSO ON MASS CHANGES IN THE ANTARCTIC PENINSULA: A GRACE GRAVITY ANALYSIS

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Antarctic ice-mass balance is key to project sea-level changes, to assess future shifts in the global water cycle and ocean circulation, and to predict the fate of the White Continent. The surface mass balance is an essential component of the total ice-mass balance, with intense variations on time scales of months to decades. The surface mass balance varies spatially over Antarctica as a consequence of a complex interplay between accumulation, transport and ablation. These processes respond to patterns and changes of the atmospheric and oceanic circulations which may extend far beyond Antarctica. Identifying and understanding climatic teleconnections helps to improve the accuracy of ice-mass balance estimates for Antarctica and individual regions.

Compared to the Antarctic Ice Sheet covering East and West Antarctica, the Antarctic Peninsula poses particular challenges for the quantification of the surface-mass balance based on regional climate models. The topography, finely structured by mountain ranges, bays and islands, fragments the ice into many individual glaciers and small drainage basins. The exposed position makes the peninsula region especially sensitive to the ocean and the atmosphere, including changes in the extrapolar circulation. During the last decades, the mass balance and dynamics of the glaciers in the Antarctic Peninsula have been affected by the break-up of ice shelves.

El Niño and La Niña are two phases of the El Niño-Southern Oscillation (ENSO) climate phenomenon. The temporal variation of a great number of hydrometeorological variables have been correlated successfully with El Niño-Southern Oscillation (ENSO) indices, in many regions of the globe. The coupling between ocean and atmosphere that causes Niño/Niña effects impacts sensibly large-scale moisture transport and precipitation patterns. At the same time, it affects also, via air temperature, cloud-constrained radiation and the wind field, regional ablation conditions.

Here we use GRACE and GRACE Follow-On level-2 satellite gravimetry data, available since April 2002 with monthly resolution, to investigate whether surface mass density variations throughout the Peninsula region (61-76°S, 55-80°W, except areas corresponding to ocean or ice shelves) correlate with an ENSO index. The establishment of a teleconnection between the

regional mass balance and the interaction of the atmosphere with the tropical Pacific Ocean would help to improve not only mass balance estimates derived from regional climate models, but also operational wheather and sea ice forecast crucial for logistic operations in Antarctica.

Mass balance and evolution of glacier systems in a changing climate

RESPONSE OF ANTARCTIC PENINSULA OUTLET GLACIERS TO CHANGES IN ATMOSPHERIC AND OCEANIC FORCING

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Outlet glaciers of the Antarctic Peninsula have been subject to flow acceleration and retreat in response to enhanced regional warming during the last decades, causing major loss of grounded ice. This presentation deals with the behaviour of glaciers along the Weddell Coast of the Antarctic Peninsula, discharging into the Larsen A and Larsen B embayments and into the Larsen C ice shelf, focusing on the last decade. 10-year time series of ice flow velocities have been derived from Sentinel-1 SAR images, augmented by velocity retrievals using TerraSAR-X and TanDEM-X images. The ice export across flux gates at the calving front, respectively near the grounding line, was derived using ice thickness data from various sources. For glaciers of the Larsen A and B embayments mass balance estimates were also obtained by differencing topographic data of the TanDEM-X mission.

A general mass deficit and retreat of glaciers is observed, but individual glaciers show different behaviour, depending first of all on the presence of a buttressing ice shelf. Glaciers discharging into the Larsen C ice shelf show very little change in velocity during the Sentinel-1 period. This was different for glaciers calving into the Larsen A and B embayments. They were subject to large variations in frontal position, velocity and mass balance since 2010. Up to 2012 the pre-frontal sea ice cleared away in during the summers. As of winter 2012, a permanent sea ice cover formed that grew in thickness and extent. During the fast ice period the losses of grounded glacier ice dropped significantly versus previous years, but the mass balance stayed negative.

In the Larsen A embayment the fast ice broke up in summer 2016/17 and the bay was ice-free during every summer since then. In Larsen B the fast ice persisted in parts of the embayment up to January 2022 when it fractured and drifted away rapidly. During the years of fast ice the glaciers slowed down and floating ice tongues formed that pushed forward beyond the 2011 glacier front position. The maximum frontal advance, 12 km, was observed for Hektoria Glacier. After break-up of the fast ice, the glacier flow accelerated, and the floating tongues fractured rapidly. The glacier fronts retreated inland of the 2011 location, reaching in 2023 locations that have not been ice-free before and retreating further in 2024. This caused increased loss of grounded ice mass. In the presentation we will show examples on the evolution of glacier flow and mass fluxes for outlet glaciers in different sections of the study area and discuss impacts of variations in atmospheric and oceanic forcings.

The Anthropocene and climate change in polar and mountain regions

POLAR REGIONS AND HIGH MOUNTAINS IN THE ANTHROPOCENE

Christoph Ruhsam[1] and co-artists[2]

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The aim of the art exhibition is to invite artists from various European countries to present their experiences and perspectives on the effects of the Anthropocene on the polar regions and high mountains. A variety of techniques like photography, video installations, oil paintings, textiles and 3D models are encouraged.

Mankind has been shaping its environment for millennia in order to wrest its livelihood from nature. The perception of nature has changed in our civilization history from one that threatens life to one that subordinates and destroys. In the Anthropocene, we experience polar regions and high mountains as one of the few remaining large-scale regions of pristine nature, but increasingly also as a gathering place for civilizational plastic waste and industrial exploitation of resources, with impacts local ecosystems, indigenous communities and fuels a positive feedback loop.

The exhibition artists have felt connected to those places for decades and aim to stimulate also a metaphysical connection. Since time immemorial, landscape has been shaped by cryogenesis with forces such as wind, water, ice, and snow. The observers' eyes shall be sharpened for the fragility of the Arctic and ears opened for a tribute to the beauty of frozen landscapes, commemorating also the discovery of Franz-Josef-Land by the Austro-Hungarian polar explorers Julius Payer and Carl Weyprecht exactly 150 years ago. In a sense, the art works make the imperishable in the ephemeral visible, adding a spiritual dimension to the scientific commitment of the polar conference 2024. Thus, the step from physics to metaphysics becomes smaller and leads to more awareness of the universality of life. Nature does not need to be given an economic value defined by humans in order to have a right to exist. Moments of absolute closeness to nature and the feeling of oneness with nature can bring us closer to the truth than natural science alone would be able to do. Then there is only the Now and undivided devotion to it. "Melt the ice in your hearts. Start smiling and praying so that our children may see many, many more springs across the land!" calls the Greenlandic shaman Angaangaq to the world.

Confirmed contributing artists (alphabetically by first name)

Camille Dedenise (France) – https://dedenise.com/

Christoph Ruhsam (Austria) – www.pure-landscapes.net

Fridolin Walcher (Swizzerland) – www.walcherbild.ch

Gloria Rech (Italy) - https://www.gloriarech.art

Helene Hoffmann (Germany) – https://www.uni-tuebingen.de/climatology

Klemens Weisleitner and Birgit Sattler (Austria) – http://www.whiteframe-photo.com

Biology and biogeography in polar environments

SURVEY OF A SNOW PETREL NESTING SITE TO INFORM DESIGNATION OF AN ANTARCTIC SPECIALLY PROTECTED AREA

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Despite the sensitivity of ecosystems in extreme conditions, only 0.029% of the Antarctic continent is currently granted special protection as Antarctic Specially Protected Area (ASPA). Additionally, protected areas are unevenly distributed and unrepresentative of the biodiversity of Antarctica. The Antarctic Treaty Consultative Parties are thus striving to establish a more coherent network of protected areas. In this context, the Otto-von-Gruber-Gebirge, a high mountain inland oasis, was identified as an area highly worthy of protection due to its unique ecosystem, including one of the largest snow petrel breeding sites, and relative pristine nature. However, in the process of designation, an update of knowledge, particularly of the population status of snow petrel in the area, was recognized to be needed. This study (Rümmler et al. 2024) was aimed at estimating a population census of snow petrel breeding pairs in the Lake Untersee catchment, an important subarea of the potentially protected area. Investigations were severely limited by the remoteness and harsh conditions of the area, enabling only a short fieldwork period with limited resources. Additionally, the obscured breeding of snow petrels below large boulders and the large area of potential breeding made it impossible to manually count the whole population. Thus, a combination of remote sensing (drone imagery) and traditional methods (ground-based mapping) and an extrapolation based on habitat suitability was applied. The methods of obtaining breeding pair numbers and the results of the survey will be presented.

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Polar Earth Sciences

A GLANCE BENEATH ANTARCTICA'S GLACIERS – WHAT CAN WE LEARN FROM POTENTIAL FIELD DATA ABOUT THE TRANSANTARCTIC MOUNTAINS?

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The Transantarctic Mountains, with their present highly glaciated topography, were formed in the boundary region between East and West Antarctica. They represent a major extensional mountain belt that confines the East Antarctic Ice Sheet in its hinterland and blocks the lateral flow of ice towards the Ross Sea. However, the region has experienced extensive magmatic activity over considerable timescales in Earth's history, with regional variations in magnitude and extent that are likely to be reflected in the potential field data.

Distinct magmatic events occurred during the Late Neoproterozoic to Early Palaeozoic and Middle Palaeozoic, associated with prolonged convergence along the Palaeo-Pacific active continental margin during the Ross Orogeny. Further mafic shallow intrusive and extrusive magmatism followed during the Jurassic, associated with the breakup of Gondwana. The most recent Cenozoic plutonic and volcanic activity associated with continental rifting and uplift of the Transantarctic Mountains occurs in an area characterised by increased geothermal heat flow, as indicated by Curie depth estimates. Together with tomographic interpretations, this suggests a thermal anomaly beneath the Transantarctic Mountains that has influenced magmatic activity.

Using airborne magnetic data for 3D inversion in combination with geological field observations and ground susceptibility measurements, we present a high-resolution 3D crustal model and transfer the results from the initial key area into adjacent regions of interest to create a subsurface model of the western Ross Sea margin. The regional model is based on joint inversion of magnetic and gravity data using "Variation of Information" algorithm incorporated in the academic software JIF3D. Field observations serve to validate the modelled results and allow the differentiation of magnetic source bodies, their assignment to individual tectonic events with magmatic activities, as well as the assignment of possible deformation sequences along major fault zones. For instance, our model reveals a much more extensive subsurface extent of the only sparsely exposed Eocene-Oligocene rifting-related Meander Intrusives and the spatial and genetic relationship between the respective bimodal plutonism and the more recent mafic volcanism and may provide crucial information for predicting the future stability of the Antarctic Ice Sheet.

Physical processes of glaciers and ice sheets in their environment

METHANE EMISSIONS FROM THE MELTWATER OF THE GREENLAND ICE SHEET AND MOUNTAIN GLACIERS – OCCURENCES, TEMPORAL DYNAMICS AND HOW TO MEASURE THEM

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Recent studies have uncovered a potential, yet previously overlooked, climate feedback mechanism: the release of subglacially produced methane (CH_4) into the atmosphere during glacier and ice sheet melt [(1-3)]. While most research has focused on the Greenland Ice Sheet (GrIS), smaller mountain glaciers have been understudied, leaving gaps in our understanding of the spatial distribution of subglacial CH_4 emissions in glaciated mountain regions. Additional knowledge gaps pertain to seasonal emission patterns and their controlling factors due to the challenges in conducting long-term measurements necessary for estimating total emissions and understanding the contribution of this recently discovered CH_4 source to the global carbon budget.

To bridge these gaps, we undertook expeditions to mountain glaciers in Canada, Norway, and the Alps, searching for dissolved CH_4 (dCH_4) in subglacial meltwater. We analysed discrete samples collected at glacier portals for CH_4 and CO_2 concentrations, stable isotopes of these gases, and hydrochemistry. To gain insights into the processes governing subglacial CH_4 production and release, we conducted extensive measurement campaigns at Isunnguata Sermia, an outlet glacier of the GrIS and a known source of subglacial CH_4, using custom-made dCH_4 sensor prototypes.

Results from the last three years of our research into subglacial CH_4 emissions from the GrIS and mountain glaciers show that subglacial CH_4 emissions are found to exist in mountain glaciers in Canada [(4)] and, at lower concentrations, also at some glaciers in the Alps, but not in the studied meltwater outlets in Norway. Process studies at the margin of the GrIS reveal that

several interconnected processes influence observed patterns of dCH_4 concentrations, which vary on both diurnal and seasonal scales. These processes include changes in the connectivity of subglacial meltwater channels to sediment pockets where CH_4 is produced and the mixing with fluctuating volumes of CH4-free supraglacial meltwater routed through englacial conduits.

These recent insights highlight the broader distribution of subglacial CH4 emissions than initially perceived. Process studies from the GrIS underscore the necessity of continuous monitoring to obtain realistic estimates of subglacial CH4 emissions. This monitoring is pivotal for scaling up findings and precisely evaluating the climate implications of these emissions.

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Snow as an interdisciplinary field of research (Waalem Polar Cluster)

THE WAALEM POLAR CLUSTER: (THE FUTURE LACK OF) SNOW AND HOW TO DEAL WITH IT – OR NOT

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The immense pressure of climate change is resulting in vast cryospheric changes, such as melting of snow and ice, permafrost degradation, sea ice reduction and changed snow fall patterns on the three poles (IPCC AR6, 2023). The striking speed of polar climate change is already igniting a chain of implications for global climate, ecosystems, and human communities. We have already exceeded some tipping points such as the Greenland ice sheet or sea ice collapse where consequences of unforeseen degree are the result.

Hydrologically, snow is a precipitation storage, energetically, it is key to increase the albedo and hence to slow down melt processes in polar and alpine areas since it acts as a natural umbrella against solar radiation. This is valid for sea ice, ice sheets, glaciers and global snow packs. The past has revealed a series of years with extremely low precipitation resulting in dramatic losses of ice, also due to the lack of snow cover. The consequences are substantial for the amount of drinking water, water for irrigation, hydropower for human beings but also responsible for habitat and biodiversity loss. Globally, millions of people are affected by the decrease of glacial meltwater supply, especially in areas such as High Mountain Asia and the Andes, respectively.

Additionally, by the ongoing melt we lose not just resources, and ecosystem service but also cultural identification. The loss of resources is also based on the biotechnological potential for future application of genes, proteins, etc. originating of specifically adapted microbial communities. On the contrary, we also have to deal with unforeseen loads of anthropogenically induced pollutants being released by melt which will be accumulated in food webs. Moreover, biological threats which have been securely harbored in ice and snow can be revitalized by melting processes and can hence be introduced in our systems leading to unprecedent consequences for human health.

Within the Waalem Polar Cluster we are seeking and critically discussing interventions in context with slowing down glacial melt of mountain glaciers. Additionally, we are assessing the biotechnological potential of the melting cryosphere in context with medical applications. Since

we are actually dealing with a vanishing system, we propose to preserve cryospheric microbes of various cryospheric ecosystems – including emblematic regions.

By this presentation we intend to seek for new concepts, ethical considerations and potential transdisciplinary partners.

Cool Classes - Polar Educators

PLASTIC.ALPS: INPUT AND IMPACT OF MICROPLASTICS ON SENSITIVE HIGH ALPINE ECOSYSTEMS

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In the past few years, the awareness about microplastics (MP) in the environment has evolved extremely fast. The topic is omnipresent when media report about enormous amounts of plastics in the sea. However, microplastic pollution did not make a halt in front of seemingly inaccessible areas such as high alpine areas. Sources thereof are manifold and can locally be attributed to skiing tourism, construction activities in high altitudes and the connected gastronomy. Additionally, there are also long-range sources from where particles by airborne transport are manifested in ice and snow. In glacial skiing areas those emissions add on by the local usage of geotextiles in order to reduce albedo. Large areas covered by geotextiles are emission sources for polypropylene fibers which remain in high altitudes and can have an impact on the cryobiota. MP particles are also connected with additives which alter soils, waters and the communities living therein. This fact requires a shift in the overall awareness towards this issue which should result in a sustainable change of behaviour in our plastic consumption. It is the goal in this project to produce a broader understanding of the extent and quality of plastics pollution, especially in high altitude areas. Together with schools we conduct excursions to Tyrolean glaciers to investigate the current plastics contamination. Additional data have been gathered with a Citizen Science contribution via a littering app (Dreckspotz). With the next generation we investigated via workshops at the University of Innsbruck the impact of MP on living organisms such as microorganisms and aquatic invertebrates. Our goal is to achieve new measures together with stakeholders (such as the cable car lobby, Austrian Alpine Club, Naturfreunde) and politicians in the sense of sustainable handling of sensitive ecosystems such as high alpine regions. The next generation should be in the position to move the general awareness to their benefit of their future.

Integrating social and natural sciences: collaborative and inclusive approaches beyond tradinational boundaries

BEYOND HOT AIR: CONVERSATIONS AROUND CRITICAL RAW MATERIALS SUPPLY FOR THE 'GREEN' TRANSITION

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This paper introduces to the concept of *hot air* in discussions around critical raw materials (CRM) and energy transition related to the Arctic. It highlights the colonial contexts of Arctic Indigenous communities, which are nowadays again exposed to a rush and a race for resources on their homelands and traditional territories. This phenomenon is called *green colonialism* or *green extractivism*.

Beyond Hot Air is a conversation. It is an international, multi-stakeholder initiative that explores the complex landscape of CRM supply for the 'green' transition. Combating climate change requires that all of us around the globe step out of our comfort zones – especially when it comes to the mining of CRM in our own backyards.

Through constructive and collaborative conversations, we focus on the feasibility of mining for the energy transition. We seek to expose the dissonance and absurdities in current debates and challenge the mining status quo.

The Beyond Hot Air conversation project brings together diverse people who are involved in – and affected by – the supply and consumption of critical raw materials, and related multi-disciplinary research. We need to come together and think creatively about how we can mine and use critical raw minerals more fairly.

Through listening, sharing and mutual learning from stories, people who are not necessarily on the same page can gain a better understanding of what is at stake. Beyond Hot Air is a collaborative, decolonial, inter-disciplinary research and knowledge-building project, involving people from diverse backgrounds and all pockets of society: consumers, mining-affected communities of local and Indigenous peoples, companies, investors, regulators, civil society, politicians, scientists, and activists.

Integrating social and natural sciences: collaborative and inclusive approaches beyond tradinational boundaries

COLD REALITIES: QUANTIFIYING AND SOLVING WOMEN'S CHALLENGES IN POLAR FIELD RESEARCH

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Remote fieldwork is a crucial component of polar research within both the physical and social sciences. Increasing recognition has been given to the fact that the inherent logistical, physical, psychological, and interpersonal challenges of polar fieldwork are not experienced equally across the polar research community, with women often disproportionately affected. Although the demographics of polar researchers have been evolving, significant barriers to equal participation persist.

To better understand these challenges, we conducted an anonymous survey targeting women involved in polar research. The results reveal that 79% of respondents reported encountering negative experiences during fieldwork. The most prevalent and impactful issues identified were related to field team dynamics and communication, sexism, rest, and weather conditions. Additionally, respondents highlighted other critical concerns including fieldwork preparation, unrealistic work expectations, harassment, and lack of personal space and privacy.

These findings underscore the need for targeted interventions to address the unique challenges faced by women in polar fieldwork. Based on the survey results, we propose strategic measures to remove barriers and enhance the fieldwork experiences of women. These strategies encompass both individual and organizational levels, addressing the pre, during, and post fieldwork phases.

Although this study focuses on the experiences of women, it aims to contribute to the broader discourse on challenges faced by minorities in polar research, advocating for an equitable research environment.

Atmospheric, sea-ice, and ocean system dynamics

EXPLORING THE INFLUENCE OF LARGE-SCALE ATMOSPHERIC PATTERNS ON GREENLAND AIR TEMPERATURE: A CENTURY-LONG ANALYSIS FOCUSED ON WARMING PERIODS

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Large-Scale atmospheric patterns (LSPs) affect local weather by advection of air masses with varying variables, e.g. air temperature (AT), and influencing wind direction at a given location, in this study in front of Qaamarujup sermia, West Greenland. This work conducts a century-long analysis, employing a self-organizing map (SOM) technique to find the prevailing LSPs over Greenland based on reanalysis 20CRv3 of the geopotential height of 500hPa. SOM uses an artificial neural network to reduce dimensionality by defining clusters of the input data.

The analysis focuses on two distinct warming periods (WPs), 1922-1932 (during the ETCWP) and 1993-2007 (recent Arctic warming), which were determined using observations and reanalysis data and correspond with earlier studies, e.g., Box et al. (2009), Bokuchava and Semenov (2021), and Hegerl et al. (2018). These two periods show a rise in AT anomalies across entire Greenland. Among the discovered LSPs are LSP with dominant cyclones centred west of Greenland, alongside so-called atmospheric rivers (AR) with warm and moist air advection from the south. The most frequent LSP in spring, summer and autumn, has a gradient of geopotential height from north to south, resulting in zonal airflow. In winter the LSP indicating AR occur more often. The seasonal frequency distribution of the LSPs in WPs and 1900 – 2015 and the annual distribution are significantly different.

To explore the influence of LSPs on AT, we evaluate whether similar LSPs are responsible for similar deviations. The average AT anomaly per LSP varies between the WPs and between 1900-2015, as well as per season. LSPs with air advection from the south are distinct warm patterns throughout the year, but LSPs with north-westerly, westerly, and south-easterly flow can be cold or warm patterns depending on the season. Furthermore, the impact of LSP composition on WPs will be analysed by examining the association between LSP frequency and expected AT anomaly based on the matching AT anomaly per LSP in a reference period weighed against LSP occurrence.

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Polar Earth Sciences

THE REPROCESSING OF ANTARCTIC-WIDE GNSS OBSERVATIONS AID THE INVESTIGATION OF GLACIAL-ISOSTATIC ADJUSTMENT

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For almost three decades, geodetic GNSS measurements have been used to infer bedrock displacement in Antarctica. However, until now Antarctic-wide studies have only been able to make use of a limited number of GNSS stations and have also been limited in time. Within the SCAR-endorsed project GIANT-REGAIN (Geodynamics In ANTarctica based on REprocessing GNSS DAta INitiative), for the first time geodetic GNSS data have been compiled for as many Antarctic bedrock stations as possible, covering the period from 1995 to 2021. The recordings include permanent and episodic observations at more than 280 sites. In order to provide a consistent and reliable analysis of these data, four processing centres have joined forces to reprocess the data. We will report on the background and the most important issues of the reprocessing. We will discuss the resulting coordinate time series in terms of their reliability and uncertainty. These coordinate time series will allow to investigate the Antarctic bedrock displacement pattern in much more detail than before. This includes the response of the solid Earth on short time scales due to a weak upper mantle or the variability of the Antarctic ice sheet in the Holocene which may lead to present-day subsidence.

Polar Earth Sciences

THE SURVEYING OF GAUSSBERG, EAST ANTARCTICA

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During the first German South Polar Expedition 1901–1903, under the leadership of Erich von Drygalski, a “black mountain” was detected at the East Antarctic coast close to 90°East (Drygalski 1904). Later called Gaussberg, this isolated nunatak with an elevation of 370 m a.sl. represents a special type of volcano, subglacially erupted about 56,000 years B.P. Lamproite, a rare ultrapotassic magmatic rock, dominates the geology of this extraordinary mountain (Smellie and Collerson 2021). Two times, in austral fall and spring 1902, Drygalski carried out a surveying in order to determine horizontal and vertical displacements of the ice surface in the vicinity of Gaussberg.

Now, 122 years later, for the second time a group of German scientists, together with an Australian geologist, visited Gaussberg. They took part in the scientific cruise PS141 of R/V “Polarstern”, which was the third cruise of the multidisciplinary project “East Antarctic Ice Sheet Instability” (EASI). For three weeks, from the end of February to mid-March 2024, the group were based in a field camp at the north-western side of Gaussberg. The program comprised geodetic measurements to repeat the surveying of Drygalski in1902, UAV- and helicopter-based imagery to infer a high-resolution digital elevation model by photogrammetric methods, glacier imagery by time-laps cameras as well as geologic-volcanological samplings.

In this presentation we will report on the fieldwork at Gaussberg as well as on the first results.

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History and future of international cooperation in polar regions

GERMAN POLAR RESEARCH IN THE 1920S AS REFLECTED IN INTERNATIONAL RELATIONS

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This general topic will be examined using the preparation activities of two polar projects with international significance that originated in Germany - the Aeroarctic Society and the German group of the 2nd International Polar Year.

The decade at the beginning of the 20th century was characterized in all spheres of life by the Treaty of Versailles. Germany was subject to severe restrictions, particularly in the economic and military fields, but German scientists were also largely banned from the international stage. During this time, exactly 100 years ago, in October 1924, Germany succeeded in founding the international society Aeroarctic. Its aim was to explore unknown polar regions by airship. Fridtjof Nansen was appointed president for life.

The contribution highlights the cooperation models, but also the potential for conflict between those involved in science, business and politics at national and international level. On the basis of the archive material analysed, it can be concluded that, despite the sometimes chaotic preparations, the planned expedition was made possible precisely by the specific complex social situation in the first half of the 1920s and the enforced dependencies between science, politics and business.

The preparation of the German group for the 2nd International Polar Year, some of whose members were also members of Aeroarctic, was quite the opposite. Despite serious preparation and cooperation with the international groups, the German group's participation failed. Paradoxically, one reason for this was the improved political situation for Germany at the end of the 1920s.

Integrating social and natural sciences: collaborative and inclusive approaches beyond tradinational boundaries

ARCTIC TRANSPORT INFRASTRUCTURES AND LOCAL COMMUNITIES: WHAT WORKS AND WHAT DOESN'T

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Recent developments in the Arctic – from increased resource extraction to militarization, tourism and shipping – necessitate the construction or upgrading of transport infrastructures in this relatively remote, inaccessible and scarcely-populated part of the world. While these large-scale infrastructures are mostly sponsored by outside interests, they can have profound impacts on local residents. The ERC-sponsored project "Building Arctic Futures: Transport Infrastructures and Sustainable Northern Communities" (InfraNorth) focuses on how residents of the Arctic, both indigenous and non-indigenous, engage with these infrastructures, and examines the intended and unintended consequences these projects have on their lives. The challenge is to understand whether existing and planned transport infrastructures will support permanent human habitation and sustainable communities in the Arctic, or whether they will drive people away and strengthen a trend of substituting permanent with temporary residents. Toward that end, we are currently conducting ethnographic case studies in Alaska, Canada, Greenland, the Faroe Islands, Norway, Sweden and Finland. This presentation is a first attempt to go beyond these case studies and to try to draw preliminary conclusions on a pan-Arctic level. The intersecting lines of comparison will relate to types of transport infrastructures, regional specificities, as well as patterns of economic and political control.

The Anthropocene and climate change in polar and mountain regions

MEASURING THE SKY SPECTRAL RADIANCE WITHIN SECONDS IN POLAR AND MOUNTAINOUS REGIONS

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Snow strongly influences radiation quantities like spectral irradiance and spectral radiance. The latter depends on time, wavelength, incident angle, azimuth angle, height and geographic location as well as polarization. According to our measurement the albedo of snow in Antartica can reach 100%, so that nearly all incoming radiation is reflected back in the visible and UV range. This extremely high reflectance alters the spatial distribution of spectral radiance significantly. We found for example that the zenith radiance in Antarctica near the horizon can be up 16 times higher than at the zenith in the red part of the spectrum. Since the albedo is altered by higher temperatures, climate change can affect the spectral radiance significantly and leads to further climate forcing long before the snow surfaces actually melt.

For the measurement of the spectral radiance traditional techniques and instruments are too slow to capture the rapid changes mainly caused by varying cloudiness. A newly developed advanced multidirectional spectroradiometer (AMUDIS) is capable of measuring spectral radiance from the UV to NIR with more than 100 directions within a second. Since turning of the input optics would change its sensitivity new methods for the calibration and characterization of instrument AMUDIS have been developed and tested.

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Mass balance and evolution of glacier systems in a changing climate

AREA, VOLUME AND ELA CHANGES OF WEST GREENLAND LOCAL GLACIERS AND ICE CAPS OVER THE LAST 35 YEARS

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The behaviour of mountain glaciers on decadal time scales is a useful indicator for assessing climate change. Although less monitored and studied than the ice sheet, local glaciers and ice caps (GICs) along the coast of Greenland are significant contributors to meltwater runoff and sea level rise. This study analyses the cumulative area, ice mass and ELA changes occurred in 4100 GICs in West Greenland from 1985 to 2020, using remotely sensed data and including smaller glaciers in the calculations. GICs involved in the study decreased in area by almost 15%, which is equal to -1774 ± 201 km^2. Their surface elevation decreased on average by 20.6 ± 2.9 m. The Equilibrium Line Altitude (ELA) shows a median regional rise of 150 m since the 1980's with marked local variability and higher median rise in the northern areas of this study. Strong regional gradients in ELA of individual GICs are found, both towards the ice sheet and in areas where local orography affects precipitation. The observed high spatial variability of changes suggests that more monitoring on sub-regional level is needed to reduce uncertainty regarding the future of GICs. This study on West Greenland Local Glaciers and Ice Caps underscores their diverse nature in terms of glacier type, size, aspect, and hypsometry. Measurements show high variability in the net changes from 1985, including area and volume shrinkage, alongside an elevation rise of ELAs. We observe a nearly 15% reduction in overall glaciated area, accompanied by a mass balance rate of -0.5 m w.e. yr-1 (-5.6 ± 0.7 Gt yr-1), aligning with observed rates in the Arctic.

Mass balance and evolution of glacier systems in a changing climate

THREE DECADES OF GLACIER CHANGES ALONG THE NORTHERN ANTARCTIC PENINSULA

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Some of the highest specific mass change rates in Antarctica are reported for the Antarctic Peninsula. However, the existing estimates for the northern Antarctic Peninsula (<70°S) are either spatially limited or are affected by considerable uncertainties. Within this study, the first assessment of the geodetic mass balance throughout the ice sheet of the northern Antarctic Peninsula is carried out employing bi-static SAR data from the TanDEM-X satellite mission. Repeat coverages from austral-winters 2013 and 2017 are employed. An overall coverage of 96.4% of the study area by surface elevation change measurements is revealed. Moreover, the ice discharge to the ocean is revealed from glacier surface velocity fields and ice thickness reconstruction information at more than 300 flux gates. In combination with modeled climatic mass balance information and oceanic reanalysis data, the identification of driving forces is carried out.

Biology and biogeography in polar environments

ENDOSYMBIOTIC BACTERIA ENIGMA IN ANTARCTIC INVERTEBRATES

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Interactions between a host organism and its associated microbiota, including symbiotic bacteria, play crucial roles in host adaptation to changing environmental conditions. In

recent years, there has been considerable warming of the climate in the Antarctic Peninsula region, creating novel conditions which may drive adaptive changes, in which potentially symbiotic bacteria could play a role. One of the most extensively studied symbiotic bacteria in invertebrates is the Alphaproteobacteria *Wolbachia pipientis* Hertig and Wolbach, 1924. However, there is currently no knowledge of the prevalence of this endosymbiont in Antarctic terrestrial invertebrates. We investigated the existence of evidence for the occurrence of Wolbacia in each of the major taxonomic groups of Antarctic terrestrial invertebrates (Acari, Collembola, Diptera, Rotifera, Nematoda, Tardigrada). We conclude that, at present, no reports or molecular evidence exist for the presence of *Wolbachia* in these invertebrate groups in Antarctica even though representatives of the same groups, and sometimes closely related species do host the bacteria at lower latitudes. We suggest opportunities for more targeted future research to confirm its presence or absence in this region.

Physical processes of glaciers and ice sheets in their environment

SULPHURIC ACID WEATHERING IN MOUNTAIN GLACIERS POSES CHALLENGE TO NET-ZERO CARBON TARGETS

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To achieve net-zero emissions, large-scale CO_2 drawdown is crucial. Enhanced silicate and carbonate mineral weathering in mountain basins – a promising CO_2 removal strategy, faces a challenge from our research. While this process is well-established as a CO_2 sink, we reveal the counter balancing effect of sulfur-bearing mineral weathering (e.g., FeS2) acting as a CO_2 source in mountain glaciers. We explore glacier datasets (n=900) across nine-different mountain ranges and estimate the contributions of various weathering processes towards the CO_2 balance. Our findings highlight significant regional variations driven by precipitation. High precipitation (>1000 mm) promotes silicate weathering, likely acting as a CO_2 sink – as traditionally believed. Conversely, drier regions (<500 mm) and those with sulfur-rich bedrock experience a stronger influence of sulfuric acid production from pyrite oxidation, acting as a CO_2 source. These findings emphasize the need to consider both lithology (rock type) and precipitation, as they shape the dominant weathering processes and CO_2 source-sink dynamics in mountain glaciers. Considering silicate weathering for net-zero CO_2 drawdown strategies is insufficient. Present study highlights the importance of understanding these variations while targeting CO_2 drawdown strategies, refining climate models, and even identify alternative mitigation strategies for drier regions where weathering acts as a CO_2 source.

Biology and biogeography in polar environments

SPECTRAL VEGETATION CHANGES IN COASTAL GREENLAND DRIVEN BY BIOCLIMATIC FACTORS

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The terrestrial Greenland ecosystem (ice-free area) has been undergoing significant changes, affecting coastal regions and biodiversity. Changes in air temperature and precipitation have modified snowpack conditions and duration during the cold season, likely exposing vegetation to frost in the spring and drought events in the summer. As a result, vegetation is rapidly adapting, altering ecosystem interactions and functioning, and potentially endangering delicate fauna.

In this study, we integrate high-resolution Arctic reanalysis and remotely-sensed spectral vegetation data between 1991 and 2023 in order to investigate relevant bioclimatic drivers for ecological and phenological processes of tundra ecosystems related to thermal growing season, plant heat stress, and frost indicators. Based on the combined influence of bioclimatic drivers, we assess their interaction with spectral greenness across coastal Greenland, aiming to identify areas experiencing rapid bioclimatic changes. Additionally, we explore these bioclimatic changes as a function of certain physiographic features, in order to better comprehend potential coastal, latitudinal or altitudinal dependence.

We report similar bioclimatic indicators driving greenness change across ecoregions in Greenland, being the thermal growing season the most important indicator. While the early onset of the thermal growing season is the second most relevant bioclimatic indicator for the high arctic ecoregions, the decrease in the accumulated snow water equivalent is the second most relevant bioclimatic indicator for the low arctic ecoregions. The spatio-temporal patterns in spectral greenness change are highly heterogeneous, but strongly depend on topography and soil water availability. Our results suggest that the soil water availability in the high arctic generally is supplied from permafrost thawing, while in the low arctic is originated from snowmelt. These bioclimatic changes, among others, have led to spectral vegetation retreats in coastal areas and expansion towards inland areas.

Integrating social and natural sciences: collaborative and inclusive approaches beyond tradinational boundaries

CHALLENGES IN DEVELOPING DECOLONIAL RESEARCH METHODS. MODELING THE SUSTAINABLE INDIGENOUS COMMUNITY IN THE SAKHA REPUBLIC (RUSSIA)

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In 2021-2022, a multidisciplinary STEM team of Indigenous researchers and activists from the Sakha Republic (Yakutia) residing in and outside of the Republic, with the expertise in their STEM-related fields and Indigenous lifestyle, planned to model a Sustainable Indigenous Settlement (MSIS) in a vulnerable Indigenous community, the village of Khara Tumul, in the Oymyakon ulus. The model of an environmentally friendly settlement was based on ideas and thoughts about sustainable development, which indigenous people shared with the author in 2015-2016, during her Ph.D. fieldwork. The project respected the values of the Sakha culture and heritage and it remained flexible enough to adapt to newly developing circumstances, due to climate change. Our team hoped that the project could create a foundation for international collaboration among Indigenous people, Indigenous culture specialists, and academic scholars for their transdisciplinary research, and successful climate change adaptation and sustainable development. It would have provided a valuable toolbox for developing decolonial research methods, building resilient communities in Arctic regions of the Russian Federation, and polar countries, under the rapidly changing climate conditions. Our methodology focused on Indigenous knowledge, enhanced relationships and ties between the home place and the people. It promoted environmental stewardship, encouraged culturally relevant education, and preserved Indigenous language, ecology, and healing knowledge. Unfortunately, everything abruptly ended, due to the Russian invasion of Ukraine in 2022.

Polar Earth Sciences

PAST LANDSCAPE EVOLUTION AND TECTONICS OF WEST ANTARCTICA

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The evolution of the West Antarctic plate is strongly linked to its glacial history. West Antarctic topography, shaped by the tectonic development of the West Antarctic Rift System, determined when large-scale glaciation occurred. The topography is also the main reason why the West Antarctic ice sheet reacts particularly vulnerable to modern ocean warming. Deeply incised cross-shelf troughs provide pathways for warm ocean water to melt the glaciers from below. In this study, we present radiometric ages, isotope analyses, trace element mineral chemistry, and petrographic data from drill cores obtained from the Amundsen Sea Embayment in West Antarctica's Pacific sector. These data provide information about landscape evolution, tectonic development, and topography of the geological past.

Our results show that at some time between 44 and 34 million years ago, i.e., shortly before permanent glaciation started, West Antarctica was a vast and flat coastal plain, dominated by a braided river system. This river system transported debris ca. 1500 km from the young and rising Transantarctic Mountains across the whole of West Antarctica to the Amundsen Sea, where it formed a swampy delta with vegetated river banks. At the same time, a branch of the West Antarctic Rift System was active and connected the continental interior with the Amundsen Sea. This topographic low presumably contained the river system. Our data also suggest a second period of rift activity ~13 million years ago, incising a 300 to 200 million years old magmatic arc, which was already buried beneath the ice at that time. This rifting period presumably marks the time when deep troughs of the West Antarctic Rift System developed, which were repeatedly eroded by glacial advances creating the deep West Antarctic cross-shelf ice stream troughs that makes the West Antarctic Ice Sheet vulnerable to ocean-forced retreat today.

Physical processes of glaciers and ice sheets in their environment

DO NORWEGIAN GLACIERS RELEASE METHANE?

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Recent studies suggest a potential positive climate feedback mechanism: the release of subglacial methane (CH_4) to the atmosphere with meltwater. While most of the research has focused on subglacial CH_4 release from beneath the Greenland Ice Sheet (GrIS), mountain glaciers have been largely neglected, leaving a significant gap in our understanding of the spatial distribution of these emissions. Emerging evidence from glaciers in Alaska, Canada, China, and Iceland suggests that CH_4 release occurs from glaciers beyond the Greenland Ice Sheet. In this study, we examine the potential of outlet glaciers of the Jostedalsbreen and Midtdalsbreen in central Norway to release subglacial CH_4. Our findings suggest that the Norwegian glaciers do not represent a CH_4 source to the atmosphere, unlike documented glaciers in GrIS, Canada, Alaska, China and Iceland. We discuss our results together with elemental geochemistry of the meltwater and stable isotopes of the elevated dissolved CO_2 (^{13}C-CO_2). Our results enhance our understanding of the subglacial CH_4 emissions and foster discussions on carbon cycling beneath glaciers.

DFG SPP 1158 Antarctic Research: Report Colloquium

GLACIAL HISTORY OF THE KING HAAKON TROUGH SYSTEM, SUB-ANTARCTIC SOUTH GEORGIA

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The sub-Antarctic island of South Georgia is positioned in the Southern Ocean, amidst the core belt of the Southern Westerlies and the main fronts of the Antarctic Circumpolar Current, and is therefore particularly susceptible to climate change. Accordingly, marine-geological records recovered from the island's continental shelf offer unique potential for the reconstruction of past ice sheet dynamics and climate history in the periphery of the Antarctic continent. Here, we present a new suite of glacial landforms, identified from bathymetry data, supplemented with sedimentary sequences observed on sub-bottom profiles, in an effort to further elucidate South Georgia's Quaternary glacial history. Specifically, the aim is to reconstruct the pre-Holocene glacial history of the King Haakon Trough System on the southwestern South Georgia continental shelf (Streuff et al., in press). Numerous landforms common for phases of ice advance and retreat are interpreted to derive from two expansive trunk glaciers during peak glaciation. Progressively elongated linear bedforms indicate increased ice flow velocity and a soft sediment substrate towards the shelf edge, while a grounding-zone wedge at the shelf edge marks the position of maximum ice extent during peak glaciation. Clusters of recessional moraines and three large morainal banks, on the other hand, show two phases of step-wise retreat, interrupted either by smaller re-advances, or by longer still-stands in ice margin recession. Stacked till sequences within the sub-bottom profiles of the mid- and outer shelf imply that the King Haakon Trough System experienced at least three separate ice advances to the shelf edge. The second-to-last till generation appears to be slightly more extensive than the most recent glacial till, and could suggest that South Georgia may have had a similar glacial evolution to other sub-Antarctic islands.

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Snow as an interdisciplinary field of research (Waalem Polar Cluster)

OVERVIEW OF NASA SNOWEX ALASKA FIELD CAMPAIGNS IN 2022–2023

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Snow depth and snow water equivalent (SWE) are used in climate science and several areas of Arctic engineering, including hydrology, transportation, and geotechnical work. Here, we provide an overview of field activities and snow datasets collected during SnowEx campaigns in Northern Alaska in 2022–2023. NASA's SnowEx was initiated by the Terrestrial Hydrology Program in 2017 to study snow remote sensing challenges in different environments in preparation for a future snow mission opportunity. To date, SnowEx campaigns took place in mountain ranges and temperate forests of the Western U.S., in boreal forest and tundra environments in Alaska. A suite of airborne and ground-based validation measurements was collected in fall 2022 and spring 2023 in Northern Alaska at five study sites. Three SnowEx sites were selected in Interior Alaska, a boreal forest environment with discontinuous permafrost and seasonal taiga snowpack. Two SnowEx sites were located in Arctic Alaska, a region dominated by low-stature land cover, tundra snowpack, and continuous permafrost. Largest data collection occurred in March 2023: snow characteristics (microstructure, depth, density, SWE, hardness) were measured at 169 study plots distributed across five SnowEx sites. These ground-based snow measurements were accompanied by two concurrent airborne missions (lidar and SWESARR). When taken together, the SnowEx field campaigns provide snow datasets in support of testing and advancement of remote sensing, modelling, and measurements techniques needed for the development of global SWE products. This presentation focuses on the objectives of the boreal forest and tundra SnowEx campaign and presents an overview of SnowEx March 2023 field activities in Alaska.

History and future of international cooperation in polar regions

FROM A FROZEN OCEAN TO A CONTINENT – ABOUT THE DISCOVERY OF ANTARCTICA

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On his second voyage around the world (1772-1775), James Cook was unable to confirm the assumption that Antarctica was a continent, as he had not discovered any land and could not find the origin of large icebergs. As a result, the *terra australis*, which had existed on world maps since the time of Ptolemy, was deleted from the new maps. Only British and American whalers and the Russian expedition under Fabian Gottlieb von Bellingshausen (1819-1821) made land sightings near the southern Polar Circle, but these did not indicate the existence of a continent. The whaler James Weddell also failed to find land at 74°15'S in what was later named the Weddell Sea. Even the search for the magnetic pole in the southern hemisphere by Charles Wilkes, Jules Dumont d'Urville and James Clark Ross in the 1840s could not clarify the question, although large stretches of coastline were roughly mapped and the large floating ice barrier in the later named Ross Sea was discovered, because they were searching solid ground not ice. At that time, it was believed that the salt-free ice in the Arctic came from the large rivers.

Analogous to August Petermann's maps of the Arctic Ocean (1865) and the possible land connection between northern Greenland and Wrangell Island (1868), the Kiel oceanographer Otto Krümmel postulated a land connection between the Wilkes Coast and the Antarctic Peninsula in 1900, while an ocean current assumed by Georg Neumayer led from the Indian Ocean at 90°E towards the South Pole and then, according to Krümmel, turned northwards in the Weddell Sea. Finally, the results of the international meteorological co-operation (1901-1904), in which the German expedition under the leadership of Erich von Drygalski, the British under Robert Falcon Scott and Ernest Shackleton, the Swedish under Otto Nordensjköld and the Scottish under William Speirs Bruce participated, showed that Antarctica is a continent with an average height of 2200 m ± 200 m.

In our presentation, we explain the difficulty of recognizing from the ice observations whether Antarctica is a continent or a frozen ocean in analogy to the Arctic.

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Permafrost in a warming world: impacts and consequences

PAN-ARCTIC ASSESSMENT OF SETTLEMENTS AND INFRASTRUCTURE VULNERABLE TO COASTAL EROSION, SEA-LEVEL RISE, AND PERMAFROST THAW

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We evaluated the vulnerability of Arctic coastal settlements and infrastructure to coastal erosion, sea-level rise (SLR), and permafrost warming. Therefore, we expanded the Arctic Coastal Infrastructure dataset (SACHI) to include road types, airstrips, and artificial water reservoirs (Bartsch et al., 2023). By analysing changes in coastline, Ground Temperature (GT), and Active Layer Thickness (ALT) from 2000 to 2020, along with SLR projections, we identified settlements and infrastructure at risk of permafrost degradation by 2030, 2050, and 2100. Each dataset was validated through comparisons with in-situ data.

Our methodology offers insights into automatically deriving long-term coastline change rates for permafrost coasts (Tanguy et al., 2024), identifying the total number of coastal communities and associated infrastructure potentially endangered by marine and terrestrial changes over short to long-term periods (2030, 2050, 2100). This study provides a consistent assessment coastline retreat along permafrost coastal settlements at a regional scale in the northern hemisphere between 2000 and 2020. Sixty percent of the identified infrastructure is situated on low-lying coastlines (<10 m). Our findings indicate that by 2100, 45% of all Arctic coastal settlements will be exposed to SLR, and 21% to coastal erosion. On average, coastal GT is projected to increase by 0.8°C per decade, and ALT by 6 cm per decade. Based on these trends, GT will shift to positive temperatures at infrastructure extent in 20 years. These environmental changes may trigger ground subsidence in coastal areas and therefore enhancing potential infrastructure flooding and damage. These conservative results underscore the urgent need for adaptation to current and future environmental changes to mitigate the deterioration of living conditions and ensure infrastructure sustainability.

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Mass balance and evolution of glacier systems in a changing climate

LATE 20TH CENTURY GLACIER ELEVATION CHANGES ON POURQUOIS PAS ISLAND, ANTARCTIC PENINSULA FROM HISTORICAL AERIAL PHOTOGRAPHS

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The archives of over 30,000 aerial photographs from the Antarctic Peninsula (AP) acquired since 1940s are the sole direct observations available over the last century to reconstruct past glacier surface elevations. In this study, we explore the photogrammetric survey data from Falkland Islands and Dependencies Aerial Survey Expedition (FIDASE) in 1956/57, Institut für Angewandte Geodäsie (IfAG) in 1989 in Pourquois Pas Island, Antarctic Peninsula. Pourquois Pas Island is situated on western Antarctic Peninsula, 50 km east of Rothera station containing varied terrain types typical of the entire Antarctic Peninsula. We test Historical Strcture from Motion, an automated method to generate digital surface models (DSMs) without manual section of ground control points (GCPs) on the study area. Using a multi-stage coregistration approach with Iterative Closest Point (ICP) method, we aligned the historical DSMs generated, with the reference elevation data from TanDEM-X generated DEM and REMA 32 m mosaic. Despite only having rough orientation parameters available as input to the bundle adjustment, average RMS reprojection error for all models obtained was within 1.5 pixels. Hypsometric analysis over study area show an overall elevation loss trend for entire elevation range with a increasing elevation loss rates in lower areas indicating glacier dynamics playing a keyrole in mostly marine terminating glaciers in the area. However, further investigation is required to quantify the factors effecting the mass loss. Overall, our results affirm the robustness of the workflow to the AP. In future, we aim to extend the study to the archives in the other parts of AP region, supplementing with high-quality reference data.

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Permafrost in a warming world: impacts and consequences

FORMATION OF COMPOSITE WEDGES AT THE BATAGAY PERMAFROST MEGASLUMP

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Composite wedge is one of the wedge structures, forming due to thermal-contraction cracking. However, the further process of infilling the cracks is under discussion. Baulin (1967) supposed that the composite wedges are formed by infilling and further freezing of the melt soil within the open cracks during spring where ice segregation created alternating layers of ice and soil. Their formation was also described as ice segregation process in sediments around an ice wedge which had thawed due to warming effect of seasonal flood and then frozen (Rozenbaum and Maslov 1967; Kaplina 1971). Kunitskiy (1989) attributed their formation to the difference of infilling the open thermal-contraction cracks by melt snow and aeolian sand in different years.

In 2023, the Batagay megaslump outcrop was studied and monoliths of composite wedges were collected to analyze ice morphology by petrography method. The composite wedge consisted of sand veins (2-4 and 5-10 mm wide) with inner vertical micro-lenticular cryostructure and ice veins (2-5 mm and over 10 mm wide) with vertical and horizontal spatial width change. The composite wedges' texture indicates crystals of segregated ice within sand veins. The segregated ice formed in the thermal-construction cracks infilled by thawed sediments. Water separated and migrated to two cold walls (freezing fronts). There was the origin of segregated ice crystals perpendicular (vertically) and near to the freezing fronts. According to Schollick et al. (2016), once an area of segregated ice appeared within the substance, it spread quickly along the freezing front and formed two lenses near the crack's walls. These lenses then grew in thickness due to the water flow towards the ice lens. At the same time or afterwards, new lenses nucleated closer to the center of the crack, in the direction of freezing front. This process has formed micro-lenticular cryostructure as well. Thus, the composite wedges are formed there due to thermal-contraction cracking and a freezing process of thawed sediments with ice segregation within the cracks.

Field expedition in 2023 and further analytical work was supported by Russian Science Foundation project 23-27-00242 (https://rscf.ru/en/project/23-27-00242/) and the state assignment of the Research work Plan of the Melnikov Permafrost Institute, project No. 122011400151-0.

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DFG SPP 1158 "Antarctic Research: Report Colloquium

A GIANT GROUNDING ZONE WEDGE IN VINCENNES BAY (EAST ANTARCTICA) REVEALED BY HIGH-RESOLUTION 2-D SEISMIC REFLECTION DATA

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Numerous recent studies have challenged the previous assumption that the East Antarctic Ice Sheet (EAIS) remains relatively stable in the context of climate change. A prerequisite for modelling the potential response of the EAIS to further global warming is the knowledge of past ice sheet dynamics during glacial and interglacial periods. Glacial morphological structures including glacial troughs, glacial lineations and grounding zone wedges (GZW) can be used for reconstructing past ice sheet dynamics.

We present 230 km of high-resolution 2D multi-channel seismic reflection data from Vincennes Bay in the East Antarctic collected during *RV Polarstern* Expedition PS141 (EASI3) in early 2024. The data highlight the presence of a giant GZW that is up to 260 m high and extends 60 km along the previous ice stream. These proportions mean that, to our knowledge, this GZW is the largest discovered on Antarctic continental shelves to date. The GWZ shows a stacked pattern suggesting that the grounding zone was located at similar locations during different retreats of the ice margin in the past. The morphology of the GZW is highly variable from west to east across the 40 km width of our survey grid. Our data offer unique insights into the multi-phase development of the giant GZW and offers an enhanced understanding of prior ice sheet dynamics in Vincennes Bay as part of the mostly unknown evolution of the EAIS.

Integrating social and natural sciences: collaborative and inclusive approaches beyond tradinational boundaries

SERMILIK RESEARCH STATION IN EAST GREENLAND

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The University of Graz has significantly expanded the Sermilik Research Station (SRS) at Sermilik Fjord on Ammassalik Island, East Greenland. The initial establishment by the University of Copenhagen from the 1970s has now been enhanced and upgraded thanks to a generous private donation, allowing for the growth and modernization of the station.

The SRS is designed to serve as an interdisciplinary scientific hub and pivotal link between academic research and the local community, focusing on the diverse impacts of Arctic climate change. This presentation will provide an overview of the station's infrastructure and outline some of the ongoing [1,2] and planned research activities. The station aims to support scientists and students globally, offering facilities for various disciplines, including inter- and transdisciplinary research. Starting summer 2025, SRS will accommodate up to 25 researchers and will be jointly operated by the universities of Copenhagen and Graz.

Strategically located at the entrance to Sermilik Fjord, near the Mittivakkat glacier delta, the station is about 15 km from Tasiilaq, the largest town in East Greenland with approximately 2,000 residents. SRS is typically accessed by boat from Tasiilaq, which connects to Iceland via Kulusuk Airport.

The region faces significant climate change challenges, such as sea ice loss, altered fish and animal populations, intensified natural hazards, and permafrost degradation. Research carried out at SRS will particularly consider local needs and challenges and aims to build strong relationships with the local community.

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Atmospheric, sea-ice, and ocean system dynamics

EFFECTS OF ARCTIC SEA-ICE CONCENTRATION ON TURBULENT AND RADIATIVE SURFACE FLUXES IN FOUR ATMOSPHERIC REANALYSES

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Interactive processes within the air–ice–ocean system play a key role in the rapid Arctic warming of the lower troposphere and sea-ice decline. These processes are complex and challenging to represent in models; yet, to better understand the local, regional, and hemispherical impacts of Arctic sea-ice decline on the atmosphere, it is crucial to quantify the effects of sea-ice concentration (SIC) on turbulent and radiative surface fluxes in the Arctic. We analyse these effects utilising four global atmospheric reanalyses, ERA5, JRA-55, MERRA-2, and NCEP/CFSR (including both the NCEP Climate Forecast System Reanalysis (CFSR) and the NCEP Climate Forecast System Version 2 (CFSv2)), and evaluate their uncertainties arising from inter-reanalysis differences in SIC and in the sensitivity of the turbulent and radiative surface fluxes to SIC.

The magnitude of the differences in SIC is up to 0.15 but typically around 0.05 in most of the Arctic over all four seasons. Orthogonal-distance-regression analyses indicate that the greatest sensitivity of the latent, the sensible heat flux, and the upward long-wave radiative flux to SIC occurs in the cold season, November to April. For these months, using daily means of data, the average sensitivity is around 40 $W m^{-2}$ for the latent heat flux, over 80 $W m^{-2}$ for the sensible heat flux, and over 100 $W m^{-2}$ for the upward long-wave radiation per +0.1 change in SIC. The differences between reanalyses are as large as 30 $W m^{-2}$ for the latent heat flux and 60 $W m^{-2}$ for the sensible heat flux per +0.1 change in SIC, with the highest sensitivity in the NCEP/CFSR data. The effects of SIC on both upward long-wave and short-wave radiation are similar among all reanalyses.

Comparing the periods 1980–2000 and 2001–2021, we find that the effect of SIC on turbulent surface fluxes and upward long-wave radiative flux at the surface has mostly weakened in all seasons, owing to the increasing surface temperature of sea ice and sea-ice decline. We note that also the sensitivity of upward short-wave radiative flux at the surface to SIC decreased between the two study periods. According to our calculations, around 20 % of the seasonal decadal decrease in upward short-wave radiation is caused by the decrease in downward short-wave radiation at the surface and the rest by the reduction in upward short-wave radiation at the surface, which can be attributed to the sea-ice and its albedo decline.

Integrating social and natural sciences: collaborative and inclusive approaches beyond tradinational boundaries

LESSONS FROM THE INTERPOLAR CONFERENCE (SEPTEMBER 2023) ABOUT COMMONALITIES BETWEEN SOCIAL AND LEGAL SCIENCE ISSUES IN THE ARCTIC AND THIRD POLE REGIONS

Albert van Wijngaarden — Scott Polar Research Institute University of Cambridge, UK

In my contribution I will reflect on some of the main outcomes of the 'First Interpolar Conference', co-organised by the Northern Institute for Environmental and Minority Law (NIEM) of the Arctic Centre, University of Lapland, in collaboration with the International Centre for Integrated Mountain Development (ICIMOD), the UArctic Chair in Arctic Legal Research and Education, and the UArctic Law Thematic Network, and held in Kathmandu, Nepal, in September 2023 (https://www.arcticcentre.org/EN/Inter-Polar-Conference). Given the conference's focus on social and legal studies, I will mainly dwell on some commonalities and differences that came up in those disciplines, but I will also mention ways in which the natural and social sciences came together in many of the contributions. As the conference was organised with the intention to be the first of several exploring these topics, I will also speculate a bit about future possibilities of collaboration and participation.

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https://www.arcticcentre.org/EN/Inter-Polar-Conference and ICIMOD: https://www.icimod.org/arctichkh/

Mass balance and evolution of glacier systems in a changing climate

PATTERNS OF ELEVATION CHANGE IN SOUTHWEST ANTARCTIC PENINSULA ICE SHELVES AND TRIBUTARY GLACIERS

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Over the past decades, the Antarctic Peninsula (AP) ice shelves and glaciers have experienced considerable thinning and retreat due to atmospheric and oceanic warming (Holt and Glaser 2022; Slater, 2021). These changes are estimated to contribute significantly to sea-level rise (Schannwell 2016). The 'Climate Sensitivity of Western Antarctic Peninsula Ice Shelves' (CSAPIS) project examines the recent response of glaciers in the Western AP south of 68° S to changing climatic conditions. Changes in ice surface elevation were computed using laser altimetry data from the Ice, Cloud, and Land Elevation Satellite (ICESat) and its successor, ICESat-2. From 2018 to 2023, we computed the trend in elevation change in meters per year (m/y) using repeat-track analysis for ICESat-2. Furthermore, we conducted a comparison between the measurements obtained from ICESat (2003-2009) and ICESat-2 (2018-2023) at orbit crossover locations of the two satellites. For the major ice shelves—Wordie, Wilkins, George VI, Bach, and Stange – a mean surface lowering of -0.15 m/y ± 0.8 m/y was observed from 2018 to 2023. The most pronounced changes were observed in the Wordie Bay area and the surrounding tributary glaciers. A comparison of ICESat and ICESat-2 crossover data reveals a significant decline in elevation at the Wilkins IS, which can be attributed to the break-up event and subsequent retreat of the Wilkins IS front in 2008 (Sambos 2009).

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Biology and biogeography in polar environments

POLYCHAETE COMMUNITY DISTRIBUTION: THE CHALLENGE OF IDENTIFYING FUNCTIONAL AND TAXONOMIC PATTERNS USING BIOREGIONALIZATION APPROACHES

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The extended Weddell Sea (WS) shelf region, including the Antarctic Peninsula, is increasingly threatened by effects of climate change. In order to establish conservation strategies and forecast the benthic diversity under changing environmental conditions, it is crucial to understand the benthic community composition, distribution and their relationships to abiotic drivers. However, the limited accessibility in such remote areas results in scarce biological data, forcing the use of environmental surrogates, used for defining habitats (Jerosch et al. 2018), to identify infauna distribution. Polychaetes are a dominant faunal group in the WS soft-bottom ecosystems, contributing up to 50% to the total macrobenthic abundance (Säring et al. 2022), with a high functional diversity. However, their distribution patterns, particularly in relation to ecological drivers in the WS are poorly understood.

Here, we describe polychaete communities including their taxonomy and functional identity at the Antarctic Peninsula and the Filchner Trough region related to sea-ice cover and benthic food regimes. We further present the attempt to fit their distribution to bioregionalization based on environmental parameters. We used point data of fauna, sediment (grain size, TOC, TN, pigment content) and of the water column (temperature, salinity, chlorophyll *a*) from three expeditions (PS81, PS96, PS118) with the RV *Polarstern*, ice-cover data (2010–2019) extracted from remote sensing imagery, as well as nine environmental raster data sets (e.g. sea-ice cover, TOC, current speed). We observed 34 polychaete families that were grouped into 14 functional groups based on categories. Using cluster analysis we identified 6 taxonomic and 5 functional community types. Ice-cover variation and TOC were identified as the best suitable environmental parameters explaining the variation of both taxonomic (39%) and functional (45%) community compositions. Although the four bioregions defined by the *k-means* cluster algorithm could not explain the complex distribution patterns of the taxonomic or of the functional communities, we could highlight potentially vulnerable areas across the WS, e.g. the Filchner Trough region with heterogenous community compositions. We assume that the different resolution of input data, and insufficient fauna data density compared to vast survey areas were limiting factors to run reliable models combining biological and physical information. Our findings underscore the relevance of filling spatial gaps of infauna sampling and environmental data to apply advanced models, in order to specify reliable conservation strategies for vulnerable areas.

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Mass balance and evolution of glacier systems in a changing climate

SURFACE ELEVATION CHANGES OF FEDCHENKO GLACIER, PAMIR MOUNTAINS, DERIVED FROM SATELLITE RADAR DATA

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Fedchenko Glacier in Tajikistan is one of the longest glaciers in the world and the largest one in the Pamir Mountains. Starting with a first geodetic survey using terrestrial photogrammetry in 1928, it has a long history of glacier monitoring. By now, satellite data facilitate acquisitions of digital elevation models and allow for a more frequent and consistent glacier monitoring. Here we present glacier elevation changes based on a 12-year-long time series of radar-derived digital elevation models from TanDEM-X data. In combination with the elevation data of the Shuttle Radar Topography Mission flown in 2000, the time series of elevation change rates and resulting geodetic mass balances covers now more than 20 years.

While the glacier showed an elevation decrease on its lower part and increase in its upper reaches during the first decade of the 21st century, the glacier thinned on its whole extent during the TanDEM-X period. The dense time series with repeated acquisitions during the ablation season but also in winter allows for a detailed analysis of short-term elevation changes related to mass balance processes but also of changes in glacier properties affecting radar penetration. A special focus lays on late summer to early fall when the transition from melting to freezing at the glacier surface alters the penetration conditions rapidly.

Additionally, elevation change data of adjacent surge-type glaciers provide a basis for the analysis of their surge behaviour revealed by their specific elevation change patterns.

DFG SPP 1158 Antarctic Research: Report Colloquium

SEA-ICE LEAD DYNAMICS IN THE SOUTHERN OCEAN AND ASSOCIATED FORCINGS

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Understanding sea-ice lead dynamics is crucial for an improved insight into the atmosphere-sea ice-ocean system in the Southern Ocean. We use monthly sea-ice lead frequencies based on satellite thermal imagery with 1 km^2 grid resolution to investigate potential causes for the observed spatial and temporal variabilities of sea-ice leads during wintertime (April-September), 2003-2023, using ERA5 winds and sea level pressure, as well as climate indices El Niño–Southern Oscillation (ENSO) and Southern Annular Mode (SAM). First results provide evidence for correlations between mean monthly lead frequency and monthly wind divergence, as well as monthly sea level pressure across the majority of the circum-Antarctic regions (significant in the Weddell Sea, Ross Sea and Amundsen & Bellingshausen Sea). Furthermore, our investigation evaluates the influence of wintertime ENSO and SAM on sea-ice lead patterns in the Southern Ocean. Results reveal a positive correlation between sea-ice leads and SAM in the Weddell Sea and specific regions of the Ross Sea. A positive correlation is also found between sea-ice leads and ENSO, particularly in the Ross Sea, Western Pacific Ocean, and certain portions of the Indian Ocean.

While the driving mechanisms for these observations are not yet understood in detail, the presented results can contribute to opening new hypotheses on atmospheric forcing and sea-ice interactions. The contribution of atmospheric forcing to regional lead dynamics is complex, and a more profound understanding requires detailed investigations in combination with considerations of ocean processes. This study provides a starting point for further research into detailed relationships between sea-ice leads, atmosphere and ocean, as well as combined processes in the Southern Ocean.

Physical processes of glaciers and ice sheets in their environment

A 10-YEARS SATELLITE STUDY OF GLACIAL MELTWATER PLUMES IN THE SOUTH SHETLAND ISLANDS

Kornelia Wójcik-Długoborska[1], Joanna Plenzler[1], Robert Bialik[1]

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The analysis focused on the 11 main islands of the South Shetland Islands, with a specific emphasis on turbid plumes generated by the runoff of glacial meltwater into surface waters. A total of 142 satellite images from Landsat 8, spanning a 10-year period (2014-2024), were utilized. The algorithm employed for determining the quantity of suspended matter was based on the work of Nechad et al. (2010). Calibration of the algorithm involved remote sensing data and laboratory data collected between 2019 and 2022, including five satellite images and information on suspended particle concentrations in the surface layer of Admiralty Bay on King George Island.

The use of optical satellite remote sensing in polar regions may encounter limitations due to high cloud cover. Nevertheless, spatial and temporal variability of turbid plumes around the South Shetland Islands was identified. Trends in sediment delivery to the surface water layer were determined for individual months from November to March. Mean sediment concentration were correlated with meteorological parameters: air temperature, wind speed, solar radiation.

These findings are crucial for understanding the impact of glacial meltwater runoff on the quality of waters in polar regions. The results can be valuable for environmental monitoring and management, providing insights into environmental changes over time.

DFG SPP 1158 Antarctic Research: Report Colloquium

HOW CAN WE LEARN FROM AN IRON FERTILISATION EXPERIMENT ABOUT THE MARINE BIOLOGICAL CARBON PUMP?

Ying Ye[1], Christine Klaas[1], Martin Losch[1], Silke Thom[1], Christoph Völker[1]

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Phytoplankton blooms induced by natural and artificial iron fertilisation events have been observed in several High-Nutrient-Low-Chlorophyll regions. Changes in carbon export during those events show, however, large discrepancies, which raised questions about the effect of iron fertilisation on the ocean CO_2 sequestration. In this SPP1158 project, we use the observations during EIFEX (European Iron Fertilisation Experiment, Smetacek et al., 2012), the only *in situ* experiment showing a significant increase in carbon export, to improve model description of the role of diatoms in particle sinking. A previous modelling study (Losch et al. 2014) demonstrated deficits of our biogeochemistry model in reproducing the observed carbon export. We started this project with optimizing the new version of the ocean circulation model used in that study to reproduce the physical state during EIFEX, and examining how different parameterisations of particle dynamics affect the modelled carbon export. Some preliminary results will be presented in the report colloquium.

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Mass balance and evolution of glacier systems in a changing climate

INVESTIGATING RECENT SURFACE MASS BALANCE CHANGES IN DRONNING MAUD LAND USING AIRBORNE RADAR DATA

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Anthropogenic warming of atmospheric temperatures leads to a loss of mass in terrestrial ice masses, destabilisation of ice sheets and a rise in the global mean sea level. In contrast to West Antarctica, East Antarctica is currently gaining mass because increased snowfall rates outpace the dynamic loss of ice at the ice sheet margins. This means, that net annual surface mass balance, including processes such as solid and liquid precipitation, wind-driven deposition, sublimation, melting and runoff, is positive. How or if this increase in mass is linked to anthropogenic warming is not yet fully clear and requires more observations to improve our understanding of the atmospheric history during the last centuries.

Here, we present a novel airborne radio echo sounding dataset covering about 220.000 km^2 on the East Antarctic plateau in Dronning Maud Land to provide large-scale information on recent changes of the surface mass balance. The used ultra-wideband radar system is capable to image isochronal near-surface reflection horizons at a range resolution of ~ 30 cm and, thus, holds the potential to reconstruct surface mass balance in low-accumulation regions on the East Antarctic Plateau. Based on density and conductivity data from nearby firn cores, a depth-age chronology for the isochrones is created. We use this information to present spatial and temporal surface mass balance changes and potential future implications for the global mean sea level.

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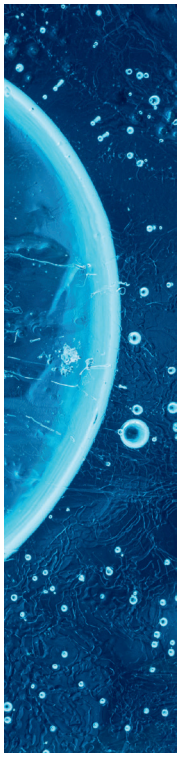

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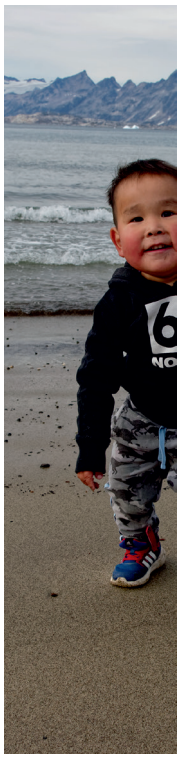

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