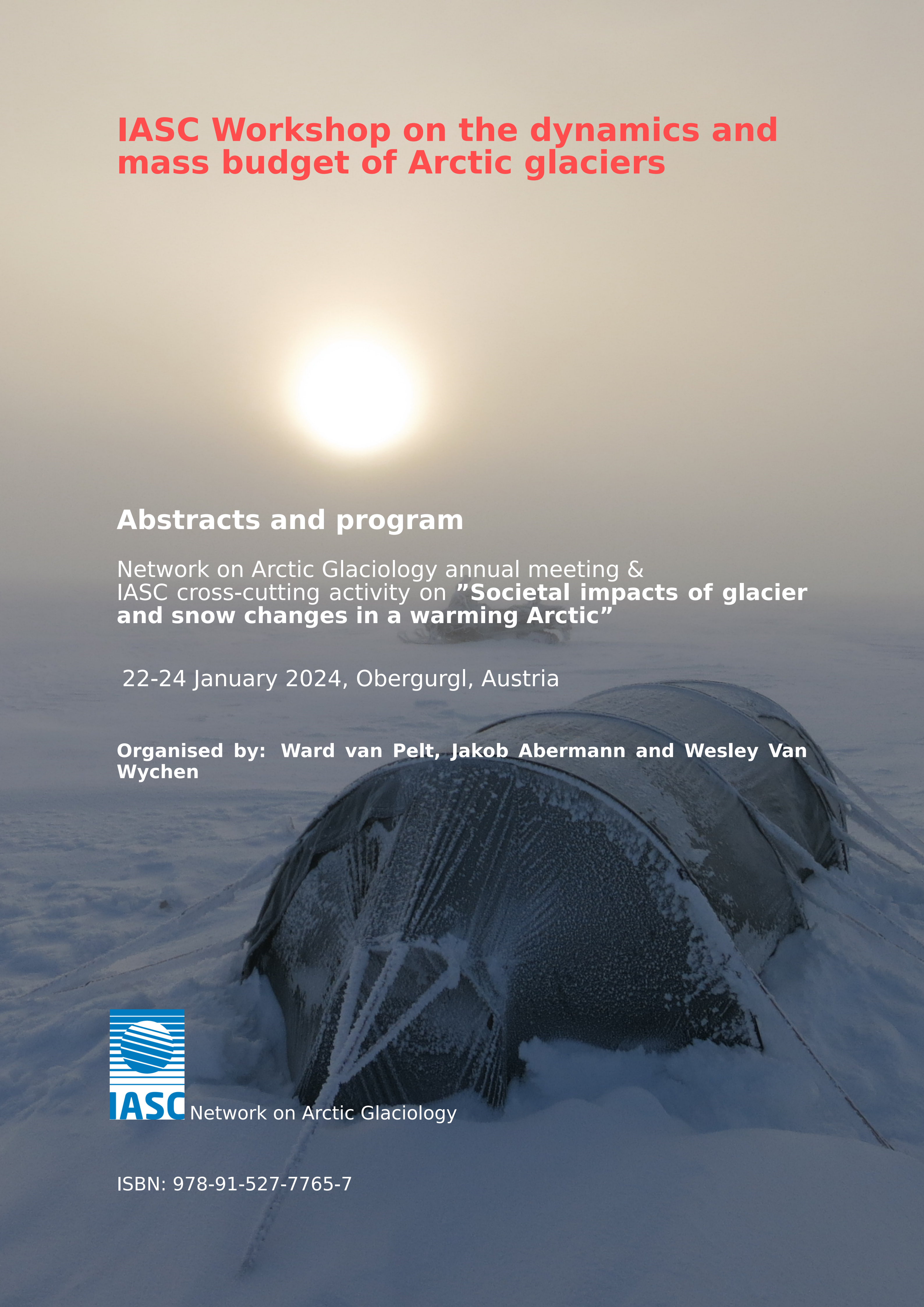

IASC Workshop on the dynamics and mass budget of Arctic glaciers

Abstracts and program

Network on Arctic Glaciology annual meeting &
IASC cross-cutting activity on **"Societal impacts of glacier and snow changes in a warming Arctic"**

22-24 January 2024, Obergurgl, Austria

Organised by: Ward van Pelt, Jakob Abermann and Wesley Van Wychen

Network on Arctic Glaciology

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Participants of the 2024 IASC workshop on Arctic Glaciology in Obergurgl, Austria. (Photo: Shin Sugiyama)

Contents

Preface

The 2024 IASC Workshop on the Dynamics and Mass Budget of Arctic Glaciers & the IASC Network on Arctic Glaciology (NAG) Annual Meeting took place at the University Centre in Obergurgl, Austria, 22-24 January 2024. The workshop hosted a cross-cutting activity on "Societal impacts of glacier and snow cover changes in a warming Arctic" and attracted 48 participants representing 14 countries. We thank the IASC Cryosphere, Atmosphere and Social & Human Working groups for supporting the meeting and cross-cutting activity, which for example allowed for travel support of fifteen early-career scientists and one keynote speaker.

As during previous meetings, the program covered 2.5 days and included six oral presentation sessions (of which two cross-cutting sessions), a poster session + introductions, cross-cutting discussion session, and the NAG open forum. The meeting contained a total of 44 presentations, of which 28 oral presentations and 15 posters. Topics in the general workshop on Arctic glaciology included snow and firn processes, frontal processes, glacier dynamics and glacier mass balance. The cross-cutting activity consisted of two oral presentation sessions, followed by a cross-cutting discussion. Two keynote lectures were given on Impacts of cryosphere change on natural hazards in Alaska (Gabriel Wolken) and Living with or without snow and ice: Changes in the cryosphere affect human activities in the high north (Grete Hovelsrud). Other cross-cutting presentations discussed among others impacts of cryospheric change on Arctic communities, e.g. in Greenland, seasonal snow monitoring and trends and impacts on human activities, glacier tourism, land-slide induced risks, glacier outburst floods, and Arctic sea level change. Engagement of social scientists and glaciologists in the cross-cutting discussion led to vibrant discussions, e.g. on how to generate funding for cross-cutting cryosphere - societal projects, and on science communication and increased involvement of Arctic communities/ indigenous knowledge holders in our research.

During the open forum meeting, it was confirmed that the next IASC NAG meeting is held in Niseko, Japan, on 21-23 January 2025, and more details were provided by local organizer Shin Sugiyama. It was further decided that the 2026 meeting is held in Obergurgl, Austria, in late January. Furthermore, a number of changes were made to the list of national contacts (Regine Hock and Eric Bernard as new national contacts for Norway and France, respectively). Finally, we discussed the future hybrid meeting format, upcoming cross-cutting activities (potentially shifting the focus to Arctic glacier hazards in 2026) and website updates.

Thank so much for your participation and contributions! And I already look forward the next occassion in Japan!

Best regards,
Ward van Pelt

Schedule

The meeting takes place at the University Centre in Obergurgl, Austria, 22 - 24 January, 2024.

Sunday 21 January

19:00 - 20:00	Dinner

Monday 22 January

08:30 - 09:00	Registration: pick up your name badge and copy of program. Please upload your presentations for the morning session.
09:00 - 09:05	Welcome
Session I:	**Snow and firn processes**
Convener:	*Carleen Tijm-Reijmer*
09:05 - 09:20	Using received laser signal intensity to measure snow and ice surface properties automatically - Alexander Prokop
09:20 - 09:35	Subsurface water movement in the percolation zone of the Greenland ice sheet - Regine Hock
09:35 - 09:50	Hydrothermal structure of Elfenbeinbreen, Sabine Land, Svalbard, and the use of gprMax to simulate the hydrothermal structure of polythermal glaciers - Unai Letamendia
09:50 - 10:05	Greenland Ice Sheet Surface Classification from Satellite Optical Remote Sensing - Rasmus Bahbah
10:05 - 10:35	Coffee break
Session II:	**Frontal processes**
Convener:	*Jakob Abermann*
10:35 - 10:50	How to propel a floating iceberg 400 m up into the air - Martin Lüthi
10:50 - 11:05	Observed frontal processes prior to a large calving event at Sermeq Kujalleq in West Greenland - Andrea Kneib-Walter
11:05 - 11:20	Modeling frontal ablation in a global glacier evolution model - Ruitang Yang
11:20 - 11:35	Seasonality in Terminus Ablation Rates for the Glaciers in Kalaallit Nunaat (Greenland) - Aman KC
11:35 - 11:50	LATTICE: Land-terminating ice cliffs in North Greenland: processes, drivers and their relation to regional climate - Marie Schroeder

11:50 - 15:45	Lunch & ski break
15:45 - 16:15	Coffee break
16:15 - 16:45	Poster introductions (1-2 slides and max. 2 minutes per person)
Convener:	*Wesley Van Wychen*
16:45 - 18:30	Poster session
19:00 - 20:00	Dinner

Tuesday 23 January

Session III:	**Cross-cutting session (part I)**
Convener:	*Lea Hartl*
09:00 - 09:20	[Keynote] Impacts of cryosphere change on natural hazards in Alaska - Gabriel Wolken
09:20 - 09:35	Planned relocation due to landslide-triggered tsunami risk in recently deglaciated areas - Stephanie Matti
09:35 - 09:50	Adaptive Practices in Glacier Tourism: A Case Study of Small- and Middle-Scale Operators in Vatnajökull National Park, Iceland - Johannes Welling
09:50 - 10:05	Impacts of the changing cryosphere on an Inuit community in East Greenland and challenges in communication between scientists and community members - Sophie Elixhauser
10:05 - 10:35	Coffee break
Session IV:	**Cross-cutting session (part II)**
Convener:	*Elke Schlager*
10:35 - 10:55	[Keynote] Living with or without snow and ice: Changes in the cryosphere affect human activities in the high north - Grete Hovelsrud
10:55 - 11:10	Snow cover evolution at Qasigiannguit glacier, West Greenland - Kirsty Langley
11:10 - 11:25	Changes in coastal environments and their impact on society in Qaanaaq, northwestern Greenland - Shin Sugiyama
11:25 - 12:00	Cross-cutting discussion - led by *Gabriel Wolken*
12:00 - 16:15	Lunch & ski break
Session V:	**Glacier dynamics**
Convener:	*Owen Nowitsky*

16:15 - 16:30	Drivers of melt-induced ice speed-up events on Hansbreen, Svalbard - Małgorzata Błaszczyk
16:30 - 16:45	Distribution and characteristics of glacier surges across the St. Elias Mountains, Yukon-Alaska - Luke Copland
16:45 - 17:00	Modeling the dynamic response of polythermal valley glaciers to climate change on a regional scale - Matt Nolan
17:00 - 17:10	Short break
17:10 - 18:30	IASC Network on Arctic Glaciology – Open forum meeting
19:00 - 20:00	Dinner

Wednesday 24 January

Session V:	**Glacier dynamics (cont'd)**
Convener:	*Owen Nowitsky*
09:00 - 09:15	Thickness inversion for all glaciers in Svalbard - Thomas Frank
09:15 - 09:30	What remains of LIA glacier extent? Recent morphometric evolution of 2 high-Arctic ice-cored slopes in the context of a glacier retreat - Eric Bernard
Session VI:	**Glacier mass balance**
Convener:	*Marie Schroeder*
09:30 - 09:45	Pan Arctic glacier runoff and calving time series - Jonathan Bamber
09:45 - 10:00	Recent changes in geometry and mass of the Grise Fiord Glacier, NU - Dave Burgess
10:00 - 10:15	Surface energy balance closure over snow and ice from in-situ measurements in the ablation zone of the Greenland ice sheet - Carleen Tijm-Reijmer
10:15 - 10:50	Coffee break
10:50 - 11:05	Glaciers and climate change in West Greenland – Wegener, his impact and heritage - Jakob Abermann
11:05 - 11:20	Greenland ice sheet melt-elevation feedback at automatic weather station sites and beyond - Jason Box
11:20 - 11:35	Feasibility of statistical and machine learning methods for discovering large-scale drivers of local melt rates - Sebastian Scher
11:35 - 11:50	Novel developments in automated mass balance measurements - Andreas Ahlstrøm
11:50 - 12:00	Final words followed by lunch / skiing / side events / early departure
19:00 - 20:00	Dinner

Posters

- Dynamic changes in glacial landforms: Analysis of the evolution of the glacier forefield terrain based on data from different years - Adrian Szalkowski
- *Investigating rates of sedimentation and oceanic melt at a major tidewater outlet glacier in South Greenland - Andreas Vieli
- *Assessing future changes in Greenland runoff using machine learning and climate models - Elke Schlager
- Advancing knowledge of glacier dynamic instabilities in the Canadian Arctic: insights from recent analyses and directions for future research - Benoît Lauzon
- Reanalysis of the Surface Mass Balance of Mittivakkat Glacier (Southeast Greenland) synthesizing different data sources - Christoph Posch
- *Future sea level changes around Iceland: contribution from the Ice sheets, Icelandic glaciers and land uplift - Guðfinna Aðalgeirsdóttir
- Glacier retreat in Sørkapp Land, Spitsbergen, from 1961 to 2020 - Justyna Dudek
- Recent Dynamics of Yelverton Glacier, Northern Ellesmere Island, Nunavut - Kristie Shannon
- *Snow observations in Alaska: The need for continued in situ monitoring - Lea Hartl
- Studying frontal ablation of tidewater glaciers in Hornsund fjord, Svalbard: a multi-sensor approach - Oskar Glowacki
- Identifying Glacial Pulsing characteristics in the Canadian Arctic - Owen Nowitsky
- Influence of sea-ice variability on the surface mass balance of Freya Glacier, Northeast Greenland - Sonika Shahi
- Research on a vanishing object - Svenja Holste
- *Snow modelling for the Sami reindeer herders in northern Sweden - Ward van Pelt
- *Glacier Lake Outburst Floods in the Canadian Arctic - Wesley Van Wychen

* Contribution to the cross-cutting activity on "Societal impacts of glacier and snow cover changes in a warming Arctic environment"

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*ECRs or keynote speakers receiving travel support

Minutes of the IASC-NAG open forum meeting

Chair: Ward van Pelt
Minutes: Kristie Shannon
Invited to attend: all participants of the workshop.

Agenda

1. Recent developments
2. IASC Network on Arctic Glaciology
3. Chair, vice-chair and national contacts
4. Upcoming meetings
5. Hybrid solutions
6. Cross-cutting activity
7. Website & promotion

Recent developments

Ward van Pelt presents an overview of activities of the Network on Arctic Glaciology since the last meeting in January 2023. Developments included website updates & reporting to IASC (Feb 2023), IASC funding decision (Apr 2023), first meeting announcement (May 2023), meeting preparations, search for keynotes (Jun-Aug 2023), registration & abstract submission (Sep-Nov 2023), final meeting preparations, application to IASC for next cross-cutting activity (Dec 2023 -Jan 2024).

IASC Network on Arctic Glaciology

An overview is given of the general aims and objectives of the IASC Network on Arctic Glaciology, and its history. Main objectives of the annual meetings are to 1) present and discuss new research, 2) coordinate fieldwork, 3) discuss future project ideas and collaboration, 4) networking.

Chair, vice-chair and national contacts

The chair (Ward van Pelt) and vice-chair (Wesley Van Wychen) indicated interest in continuing with their role and this was supported by the participants. Both are likely to step down though after the Japan meeting. Suggestions for replacements are welcomed. Ward indicated potential availability as vice-chair in 2025 to help with the transition to a new chair. The list of national contacts was then discussed and a few suggestions for changes emerged. Confirmed are new national contacts for Norway (Regine Hock, replacing Jon Ove Hagen) and France (Eric Bernard, replacing Florian Tolle). Brice Noël will be asked as new national contact for Belgium (currently no contact).

Upcoming meetings

The 2025 meeting will be held in Niseko, Japan, on 21-23 January. This was already confirmed at the previous meeting and local organizer Shin Sugiyama gave an introduction about the Japan meeting. Travel to Niseko is most convenient via Tokyo and Sapporo by plane and from Sapporo to Niseko by bus. The meeting venue will be the Hilton Hotel. The deadline for registration will likely be late October.

Based on a vote a preliminary decision was taken to have the 2026 meeting in Obergurgl, from 26 to 28 January (Monday - Wednesday). We would have 24-27 double rooms at the University Center (in 2024 we used 30 rooms). An alternative would be to have the meeting in Switzerland, but only if a price-wise comparable alternative would be found (Martin Lüthi will contact some potential venues).

Will Kochtitzky has indicated interest in organizing the 2027 meeting in Maine, USA. This will be discussed further at the next meeting in Japan. Luke Copland also indicated interest in organizing the meeting in Canada sometime in the future, but preferably after 2027.

Hybrid solutions

Several hybrid meeting solutions were presented for future meetings and as in previous discussions the preference is still for the 'hybrid-medium' variant, which implies a physical meeting with live-streamed presentations. This is the same format as during the current meeting. To open up for more online attendants, we will advertise the livestream on the Cryolist a few days before the meeting. Whether or not to also record presentations will be discussed further before the Japan meeting.

Cross-cutting activity

It is discussed that a proposal for funding of a cross-cutting activity was submitted to IASC in January 2024. Topic: "Impacts of the changing land-based cryosphere on Arctic society". IASC working groups involved: Atmosphere, Cryosphere, Social & Human, and Terrestrial. The activity will be presented to IASC WG members on February 7 and a decision will likely follow in April after the Arctic Science Summit Week. The activity will look into societal impacts of Arctic glacier retreat (e.g. sea level rise & coastal communities, glacier outburst floods, water resources, and glacier tourism) seasonal snow trends (e.g. rain-on-snow events, extreme precipitation, hydropower potential, snow cover duration & mobility and avalanches), and permafrost changes (e.g. landslides, coastal erosion, GHG release, ecosystem & mobility changes). Requested funding: €12500. Early-career scientists will be engaged in the planning, execution and reporting of the meeting.

In a discussion on future cross-cutting activities an idea was raised by Regine Hock to focus on "Glacier hazards" in an attempt to involve many (if not all) IASC WGs, but still with a direct connection to glaciological research. There was an overall positive reply to this suggestion. Another idea is to revisit previous cross-cutting themes. It was further mentioned that cross-cutting activities may be more effective and may attract more participants when the same WGs are involved several years in a row.

Engaging scientists from the different disciplines in the cross-cutting activity will be a challenge that will require effort from the entire network. Any suggestions on whom to best involve and approach are welcomed and can be shared with the chair.

Website promotion

The state of the current website (nag.iasc.info) was briefly discussed. No major changes will be implemented. One suggestion was to update the pictures with newer photos. If anyone has photos of fieldwork or similar that would fit well on the website, please share them with the chair. To reduce the carbon footprint we will make sure to reduce the image file size.

An abstract book will be distributed in February or March. An ISBN will be added.

For meeting promotion it was advised to get in touch with APECS. They can advertise the meeting among young scientists and potentially help with the selection of ECRs that will receive support (in case we receive funding from IASC).

Abstracts

Dynamic changes in glacial landforms: Analysis of the evolution of the glacier forefield terrain based on data from different years

Adrian Szalkowski[1], Maja Potęga[1], Michał, Jarocki[1], Piotr Zagórski[1]

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This poster presents dynamic changes in glacial landforms, with a specific focus on the evolution of the Renard Glacier forefield terrain over a three-year period. Using data collected by a unmanned aerial vehicle (UAV), advanced geospatial technologies to transform the gathered images into detailed orthophotomaps and terrain models. The primary objective is to analyse and compare changes in the glacier forefield terrain over three years. Orthophotomaps generated using iTwin Capture Modeler, Agisoft Metashape Professional, Global Mapper v.23 pl, and ArcGIS Pro 3.2 are crucial tools for visualizing and quantifying these changes. The integration of UAV technology and advanced mapping software allows for a detailed examination of the landscape, providing insights into the dynamic processes shaping the glacial environment. The study focuses on key indicators of glacial landform evolution, exploring variations in moraine deposits and overall topographic transformations. By utilizing data from multiple years, the research aims to discern trends and patterns, shedding light on the dynamic processes in the glacier forefield. Additionally, the comparison of orthophotomaps created from UAV images allows for a comprehensive understanding of how environmental factors contribute to the observed changes. This research not only contributes to the growing knowledge of dynamics of proglacial zone but also emphasizes the importance of integrating UAV technology and advanced cartographic tools in monitoring environmental changes. The results have implications for broader research on the impact of climate change, glacial geomorphology, providing valuable information for sustainable land management in glacial environments.

Using received laser signal intensity to measure snow and ice surface properties automatically

Alexander Prokop[1], Jean-Michel Friedt[2], Eric Bernard[2], Florian Tolle[2]

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[2] Université de Franche-Comté, France

In the context of climate warming it is a common scientific goal to study and monitor surface and volume changes of glaciers and melting dynamics of its snow and ice. Therefore several measurement techniques exist to track permanently ice melting e.g. DGPS stations on glaciers, Smart stake, and snow and ice depth measurements via e.g. ultrasonic depth sensors to create time series of snow and ice loss or gain. None of the existing methods measure if actually liquid water is present and melting occurs, this is later concluded by interpretation of the geometric data. The capability of the laser sensor to do so via the reflectance value, in fact the received signal intensity, we consider as a

big advantage and worth investigating further as a direct measure of snow or ice melt that helps not only to analyze glacier dynamics but is also important e.g. for providing reliable ground truth data for satellite remote sensing. When melting of snow and ice occurs, water changes the reflectance properties as due to absorption of the laser in water, only a portion of the laser is reflected. This allows determining if liquid water is present at the surface measured. We present the data collected in the last 2 melting seasons of the Austre Lovénbreen glacier near Ny Alesund, Svalbard. We show how we classify wet snow and wet ice hours with confidence and are able to compute melting rates. The single point measurement is put into context to area wide LiDAR measurements and melting dynamics of the glacier are analyzed. The data was verified against visual inspections from automatic cameras, data from an automatic weather station both located in the glacier catchment and ice melt was measured in close proximity with a SmartStake station.

Seasonality in Terminus Ablation Rates for the Glaciers in Kalaallit Nunaat (Greenland)

Aman KC[1], Ellyn Enderlin[1], Dominik Fahrner[2], Twila Moon[3], Dustin Carroll[4]

[1] Boise State University, USA
[2] University of Oregon, USA
[3] University of Colorado Boulder, USA
[4] San José State University, USA

Since the 1990s, the Greenland Ice Sheet (GrIS) has undergone accelerated mass loss, with a substantial portion due to the dynamic effects of terminus retreat. Conventional assessments of dynamic mass loss, however often overlook the critical aspect of terminus change, focusing primarily on inland ice flow. In this research, I construct and analyze mass loss due to both temporal variations in ice flow and detachment of ice from the glacier terminus, called terminus ablation, for 55 marine-terminating glaciers in Greenland over a ten-year period from 2013 to 2023. I calculated terminus ablation rates using openly accessible data for terminus positions, surface elevation, bed elevation, and glacier speed so that we could facilitate the extension of the terminus ablation time series when more data become available. Throughout the decade, both terminus ablation and discharge increased in the spring at most glaciers, supporting previous observations of coincident terminus retreat and glacier flow acceleration. However, terminus ablation was more irregular than discharge over seasonal to inter-annual time scales, signifying the presence of sporadic ice fluxes into the oceans that differ from what is estimated through discharge time series. Three common variations in terminus ablation were identified: erratic seasonal cycles, consistent seasonal variations, and large inter-annual fluctuations. On grouping glaciers into regions to examine the regional patterns, larger seasonal oscillations in terminus ablation than discharge were observed. Causal links between terminus ablation and discharge could not be inferred from the datasets due in part to variations in temporal resolution of terminus and discharge observations for each glacier and across all study glaciers. However, the larger magnitude and more sporadic variations in terminus ablation with respect to discharge suggest that studies focused on the impacts of varying freshwater input from Greenland's glaciers into the ocean should use terminus ablation time series to accurately capture temporal variations in freshwater fluxes to the oceans.

Observed frontal processes prior to a large calving event at Sermeq Kujalleq in West Greenland

Andrea Kneib-Walter[1], Guillaume Jouvet[2], Adrien Wehrlé[1], Ana Nap[1], Martin P. Lüthi[1]

[1] University of Zurich, Switzerland
[2] University of Lausanne, Switzerland

Outlet glaciers and ice streams transport ice from the ice sheets to the ocean, where the glaciers lose mass by iceberg calving. Within the framework of the COEBELI project we conducted extensive fieldwork to investigate the complex processes at the ice stream margins and the calving front of Sermeq Kujalleq (SKK, Jakobshavn Isbræ), one of the largest and most dynamic ice streams of the Greenland Ice Sheet. Such processes are essential to understand for projections of the ice sheet evolution but challenging to observe due to the highly dynamic environment. During extensive fieldwork in July 2022 we conducted drone photogrammetry surveys and GPRI measurements at SKK along other field measurements including in-situ GPS, seismometers, and time-lapse imagery. The resulting high-resolution ortho-images, digital elevation models (DEM) and displacement maps enable us to investigate changes in surface topography and ice dynamics. During the observation period several large calving events occurred. Prior to one of this large-scale events an area revealed surface lowering while moving downstream towards the calving front. The rupture of the calving event initiated behind this lowering area. The high temporal and spatial resolution of the drone and GPRI data enables us to investigate the lowering of the area and its influence on the calving process, which gives further insights into potential forcings on calving. Furthermore, we can study crevasse opening, acceleration of the front and weaknesses in the ice and their origin.

Novel developments in automated mass balance measurements

Andreas P. Ahlstrøm[1], Robert S. Fausto[1], Jason E. Box[1], Penelope How[1], Nanna B. Karlsson[1], Baptiste Vandecrux[1], Anja Rutishauser[1], Mads C. Lund[1], William T. Colgan[1], Michele Citterio[1], Anne M. Solgaard[1], Signe H. Larsen[1], Niels J. Korsgaard[1], Kristian K. Kjeldsen[1], Rasmus B. Nielsen[1], Signe B. Andersen[1], Jakob Jakobsen[1], Allan Petersen[1], Christopher L. Shields[1], Alexandra Messerli[2], Kirsty Langley[2], Mai Winstrup[3], Louise S. Sørensen[3], Kenneth D. Mankoff[4], Patrick J. Wright[5]

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The rapid demise of ice sheets and glaciers worldwide has increased the need for mass balance observations at a temporal and spatial resolution, where they can both help us understand the physical processes and also serve as validation or calibration for remote sensing data products or regional climate model output. Here we present the latest developments in measuring crucial components of the surface mass balance at automatic weather stations, including snow water equivalent, snow height in the vicinity of the station, sufficiently accurate transmitted position and elevation of the station, snow compaction and non-stake ice sheet ablation. Immediate access to the observations is key to certain applications, such as numerical weather forecasts. Hence, we also present the complications of providing near real-time data transmission and quality-checking as well as obstacles to a wider distribution on the WMO Global Telecommunication System (GTS).

Investigating rates of sedimentation and oceanic melt at a major tidewater outlet glacier in South Greenland

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Tidewater outlet glaciers of the Greenland ice sheet (GIS) are known to deliver large amounts of ice, freshwater and sediments into the fjords and thereby influence the circulation and functionality of the fjord ecosystem. In the context of the GreenFjord project we combine operationally derived time-series of ice- and freshwater fluxes with insitu measurements at Eqalorutsit Kangillit Sermiat (EKaS), a major tidewater ouitlet glacier of the Greenland ice sheet (GIS) in order to investigate sediment delivery as well as oceanic melt in the fjord. The operational products for ice- and freshwater fluxes are based on remote-sensing and regional climate models (Mankoff et al. 2020a+b) and the insitu observation include CTDs-profiles as well as dating constraints on the fjord sediments. We infer longer-term sedimentation rates of a few cm/year but with large temporal variations through the seasons. The relatively warm subsurface waters of around 4^{o}C at the calving front produce high oceanic melt (several m/day) that substantially contributes to frontal ablation and hence reduces iceberg flux substantially.

Advancing knowledge of glacier dynamic instabilities in the Canadian Arctic: insights from recent analyses and directions for future research

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In recent years, significant progress has been achieved concerning our understanding of glacier dynamic instabilities in the Canadian Arctic. Namely, detailed analyses of a few glaciers undergoing flow instabilities have provided valuable insights into the characteristics, dynamics, and duration of the active phase for surge-type glaciers in this region. Large tidewater glaciers exhibit "classical" surges that initiate at the terminus, lasting approximately two decades, and can reach peak velocities of nearly 5 km a^{-1}. In contrast, land-terminating glaciers experience surges that manifest progressively over much longer periods, often spanning several decades. These events result in less dramatic dynamic changes than those on tidewater glaciers and can result in long, continuous periods of relatively subtle terminus advance. Select tidewater glaciers in the Canadian Arctic also experience pulsing behaviour, characterised by much shorter velocity fluctuations (2-5 years) restricted to where the glaciers are grounded below sea level. Other instabilities, including multiyear accelerations observed on Trinity, Wykeham, Belcher, and Sydkap

glaciers, may suggest a form of retreat instability (e.g., tidewater glacier cycle). Despite these recent advances in research, our understanding of the mechanisms governing glacier surging in the Canadian Arctic remains limited. Further work is needed to refine the total number of glaciers identified as experiencing instabilities in the Canadian Arctic and their characteristics, including geographic distribution, geometry, flow mechanisms, and active phase length. Here, we present a map that summarises the current state of knowledge of unstable glacier flow in the Canadian Arctic, highlighting the location and characteristics of recently studied events. Additionally, we outline forthcoming research efforts as part of a comprehensive analysis of dynamic instabilities in this region over the next few years, with the aim of addressing the identified knowledge gaps.

Surface energy balance closure over snow and ice from in-situ measurements in the ablation zone of the Greenland ice sheet

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Accurately quantifying all the components of the surface energy balance (SEB) is a prerequisite for an accurate estimation of surface melt, and therefore of the surface mass balance over glaciated or snow covered surfaces. We use continuous measurements of both radiative fluxes, turbulent heat fluxes and surface lowering gathered in the ablation zone of the Greenland ice sheet to quantify the SEB closure at seasonal, daily and intra-daily temporal resolution. This study finds that on average, the energy available for surface melt is higher than the observed melt for both snow and ice conditions by about 15 W m2. When no melt is present, the sum of the turbulent heat fluxes and the subsurface conductive flux is larger than than the radiative fluxes. The instrumental uncertainty prevents the SEB closure at sub-daily timescales. These results serve as benchmark for detailed SEB studies over ice and snow, and highlight the need for more accurate long-term SEB observations for the proper interpretation of the surface mass balance of the Greenland ice sheet.

Reanalysis of the Surface Mass Balance of Mittivakkat Glacier (Southeast Greenland) synthesizing different data sources

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Mass changes of glaciers and ice caps (GIC) in the Arctic, are both of great interest in terms of their contribution to sea level rise and as sentinels of climate change. Studies agree that the contribution of Pan-Arctic 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; IPCC, 2019; Wolken et al., 2020). Between 2006 and 2015, mass changes were largest for the GIC in Greenland when compared to others in the Arctic (IPCC, 2019). For peripheral Greenland Mittivakkat Glacier has the longest surface mass balance (SMB) record from field-based observations (since 1995/1996) (Mernild et al., 2013) and is significantly out of balance (Mernild, et al., 2011). Synthesizing ablation stake records (WGMS, 2023), 1 km-downscaled RACMO2.3p2 SMB outputs (Noël et al., 2019) and volume changes from photogrammetrically-derived digital elevation models (Korsgaard et al., 2016; Porter et al., 2018) indicates a change from a balanced regime for 1959-1995 to a negative mass balance regime for 1996-present. The model output suggests a SMB of 33 $\pm$ 625 mm w.e. yr^{-1} for 1959-1995 in contrast to -579 $\pm$ 625 mm w.e. yr^{-1} for 1996-2019. The stake record shows an evolution of SMB of -988 $\pm$ 148 mm w.e. yr^{-1} for 1996-2019 being negative in 22 of the 24 observed years. These numbers are within the magnitude of estimates from Carrivick et al. (2023) suggesting a mass balance of -600 mm w.e. yr^{-1} for peripheral glaciers in Greenland and -930 mm w.e. yr^{-1} for peripheral glaciers in Southeast Greenland for 2000-2019, respectively. The modeled SMB underestimates the mass loss but shows a good fit with the stake record (R2 = 0.49) in the overlapping period. The two years with a slightly positive balance can be associated with unusually high winter precipitation (Mernild et al., 2011). The geodetic records yield SMB estimates of -240 $\pm$ 360 mm w.e. yr^{-1} for 1981-2013 (RACMO: -346 $\pm$ 625 mm w.e. yr^{-1}) and -420 $\pm$ 100 mm w.e. yr^{-1} for 2013-2021 (stake record: -1153 $\pm$ 173 mm w.e. yr^{-1}). These differences highlight the challenge of extrapolating field-based records. The shift to a more negative regime in the mid-1990s is discussed in the context of different drivers such as the Atlantic Multidecadal Oscillation (Enfield et al., 2001), Sea Surface Temperatures (Kaplan et al., 1998) and Greenland Blocking Index (Hanna et al., 2016) and are in line with RACMO and the ablation stake SMB in the observed 24 years between 1996 and 2019. There is a strong relationship (R2 = 0.71) between measured mean summer (JJA) 2 m air temperature (How et al., 2022) and the modelled SMB, which is adjusted to the stake record for 2010-2019.

Recent changes in geometry and mass of the Grise Fiord Glacier, NU

Dave Burgess[1]

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The Grise Fiord glacier is an important contributor to the intermittent stream network surrounding Canada’s most northerly community of Grise Fiord (NU). In this study, annual glacier mass balance surveys conducted by the Geological Survey of Canada since 1998, combined with remote sensing data are used to document changes in geometry and mass of the Grise Fiord Glacier over the past six decades. Between 1960 and 2016 the glacier thinned by an average of 22 meters with maximum thinning of 60 meters near the 2016 terminus. Glacier thinning over this period of time resulted in up-valley retreat of the terminus by 300 metres with total areal shrinkage of 4.5 km^2, or more than two-fold of its 1960 area. Combined thinning and margin retreat resulted in a total of 0.16 km^3 water equivalent mass loss, with 50% occurring in the last 15 years of this study. Accelerated shrinkage of the Grise Fiord Glacier since the early 2000’s is a trend consistent with other

documented evidence of rapid glacier change in the Canadian high Arctic. This study provides baseline information for ongoing research aimed at understanding the fate of intermittent glacier-fed streams in the Grise Fiord watershed.

Assessing future changes in Greenland runoff using machine learning and climate models

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Runoff from Greenland includes components from the ice sheet, local glaciers and non-glaciated land surfaces. Temporal and spatial runoff variability poses potential impacts on infrastructure (such as buildings, bridges, and roads), security of supply (including energy and water), industry, and marine ecosystems. The impacts are particularly significant with ongoing and future warming in the Arctic and knowledge of the runoff is therefore critical both for climate adaptation planning and mitigation efforts within and beyond the Arctic region.

State-of-the-art model simulations show a wide variation in melt and runoff estimates in the near future. While runoff calculations from high-resolution climate models are important to determine future potentials, there is still a limited number of simulations available, and these do not sample the full range of outcomes. Additionally, the availability of observational data to assess these model simulations is restricted.

To investigate the range of present and future runoff from Greenland under different climate scenarios, we will use output from high-resolution regional climate models and in-situ observations of runoff to develop machine learning (ML) tools that can provide estimates of future runoff. These ML-based tools will be applied to different global and regional climate model outputs to produce an ensemble of medium- to long-term projections (2050 to 2150) of runoff under a range of future scenarios, allowing a statistical assessment of the likely range in future runoff.

This poster presents our initial thoughts on the project in terms of data sources and methodological choices.

What remains of LIA glacier extent? Recent morphometric evolution of 2 high-Arctic ice-cored slopes in the context of a glacier retreat

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In the context of glacier retreat and increased precipitations, Arctic glacier basin slopes are subject to stress leading to visible transformations. In this work, sub-surface features of a small Arctic glacier basin slopes are mapped using Ground Penetrating RADAR to assess the past extent of the glacier from buried ice lenses and infer the evolution from their melting.

Impacts of cryosphere change on natural hazards in Alaska

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The Arctic is undergoing rapid and intense warming that is leading to unprecedented changes in the cryosphere. As temperatures rise, retreating glaciers, thawing permafrost, and changing snow conditions are affec7ng various aspects of society and the natural environment that have relied on the predictability of climate and frozen environments. In Alaska, many of these changes are causing local- to regional-scale hazards that threaten people, infrastructure, and sustainable resource development. Changes in precipitation type and intensity are influencing snow distribution in much of Alaska, with broad implications for other parts of the cryosphere. As climate warming continues, these changes will alter snowpack conditions and the frequency and magnitude of avalanches, possibly increasing Alaska's vulnerability to avalanche hazard. Glacier mass loss exacerbates slope instabilities, and when coupled with alpine permafrost degradation, it can result in increased potential for very large landslides. Unstable rock slopes in glacierized mountain areas in southeast Alaska have produced landslides that have generated the tallest tsunamis in the world, and despite the remote location, these hazards threaten distant communities, marine traffic, and critical infrastructure. Glacier mass loss also leads to the formation and expansion of glacial lakes, heightening the risk of glacier lake outburst floods (GLOFs). These sudden and massive outbursts of water can result in devastating downstream flooding, affecting communities and infrastructure located in the path of these events. Understanding the interplay between climate-driven glacier, permafrost, and snow cover changes and their implications for hazards is essential for developing adaptive strategies and mitigating potential risks. This presentation will focus on synthesize existing research on cryosphere hazard research in Alaska and drawing connections between the environmental changes and their cascading societal implications. As the effects of climate change continue to unfold, a proactive and holistic understanding of these dynamics is crucial for fostering resilience and sustainable development in the Arctic.

Living with or without snow and ice: Changes in the cryosphere affect human activities in the high north

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The reduced snow cover and increased icing conditions have consequences for reindeer herding in Fenno-scandia, and both retreating glaciers and increased precipitation in Svalbard affect tourism and outdoor activities. Both herders and tourist guides must adapt, and in this keynote, I will provide examples of some of the challenges.

Future sea level changes around Iceland: contribution from the Ice sheets, Icelandic glaciers and land uplift

Guðfinna Aðalgeirsdóttir[1], Berglind Pétursdóttir[1], Sigríður Magnúsdóttir[1], Halldór Björnsson[2]

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Global mean sea level is rising and has risen with a higher rate this past century than earlier centuries for the past three millennia, at least. This increased ocean volume is firstly because of changing ocean density, with thermal expansion playing a key role. Secondly, volume increases because of increasing ocean mass, where mass loss of glaciers and ice sheets have the greatest impact. Sea level changes by increased ocean mass have significant geographical variability because of processes seeking isostatic balance following a redistribution of Earth's surface loads, f.e. changes in Earth's gravitational field, solid Earth deformation and changes in Earth's rotation. These processes are commonly referred to as glacial isostatic adjustment. Because of the proximity to the Greenland ice sheet with its gravitational field deformation, the sea level surrounding Iceland is maintained high. Mass loss of the Greenland ice sheet results in a fall in sea level around Iceland, whereas global mean sea level rises, and conversely mass loss of the Antarctic Ice Sheet results in larger than global mean sea level rise around Iceland. By using the open-source program SELEN (SealEveL EquatioN solver) the sea level change around Iceland is calculated by numerically solving the sea level equation, given a specified mass loss of the Greenland and Antarctic ice sheets, based on the latest IPCC projections, as well as future projections for the Icelandic. To give a projection for future relative sea level (RSL) changes at 14 locations around the coast of Iceland for the years 2100 and 2150 the IPCC projected thermal expansion as well as roughly estimated future land uplift rate, based on current uplift rates, is added.

Glaciers and climate change in West Greenland – Wegener, his impact and heritage

Jakob Abermann[1], Florina Schalamon[1], Sebastian Scher[2], Andreas Trügler[2], Wolfgang Schöner[1], Andreas Aschwanden[3] ,Baptiste Vandecrux[4], Stefan Fauland[5]

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Alfred Wegener's epic last Greenland expedition builds the starting point of several current undertakings steered by Graz University. In the core of it stands the fascination of well-documented and high-quality meteorological and geophysical data from 1929 to 1931, which coincides with the so-called 'Early 20th Century Warm Period'. This gives a chance to compare drivers of snow and ice melt over a century and we show recent monitoring results that can be used to validate reanalysis products (meteorological drivers) and set into perspective satellite imagery (ice conditions, snow line). We find that the end-of-summer snow line during the Wegener expedition years was close to or higher than recent extremely high snow lines (e.g., 2012, 2019). We also find that fjord ice extent in May 1930 was smaller than at the same time in recent years, while it was greater in June 1930 than during average conditions in the satellite era. This sheds light on the

complexity of interpreting short-term data in a climatological context. In this respect, we attempt to use short-term observations to challenge the quality of reanalysis products and to objectively determine comparable conditions regarding climate perturbations and warming periods. Furthermore, we investigate whether the similar rates of warming during the 1930s and the recent decades are caused by the same synoptic conditions or whether the large- and regional-scale drivers have changed. The story of Wegener's last expedition and its relevance for the study of recent human-made climate change bears the potential of narrating climate change in a captivating way. Hence, we conclude with some considerations on how to communicate historical material beyond the scientific community and discuss different perceptions depending on ethnical background, communication medium, age and educational level.

Greenland ice sheet melt-elevation feedback at automatic weather station sites and beyond

Jason Box[1], Andreas Ahlstrøm[1], Baptiste Vandecrux[1]

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Greenland ice sheet thinning from enhanced dynamic flow and surface melting amplifies due to surface lowering into warmer layers of the atmosphere. Here assessed are surface air temperatures, barometric pressure (related to site altitude) and surface mass balance from GC-Net and PROMICE automatic weather station (AWS) sites from the 1990s. The work interrogates airborne and satellite altimetry to evaluate observed surface elevation change at AWS sites over this time period. Emphasizing the ground-truth sites, an observation-based measurement of Greenland ice sheet melt-elevation feedback is presented.

Adaptive Practices in Glacier Tourism: A Case Study of Small- and Middle-Scale Operators in Vatnajökull National Park, Iceland

Johannes Welling[1]

[1] University of Iceland

In the dynamic landscape of Iceland's glacier tourism sector, the increasing impact of glacier recession due to climate change poses a significant challenge. This study analysed empirically the adaptive practices employed by small- and middle-scale glacier tour operators in response to climate change impacts in the Vatnajökull National Park of southeast Iceland. Despite the imminent and ongoing diverse implications of glacier reduction on company operations, the adaptation strategies observed can be characterized as a "wait-see-and-respond re-actively" approach. This research aimed to unravel the underlying factors contributing to the apparent disconnection between the companies' capacity to adapt and the actual adaptation action. By integrating cognitive and institutional factors into the analysis, the study shed light on the anticipatory in-activeness within the glacier tourism sector. The findings emphasize the importance of adopting a multidisciplinary approach to create tools that tackle uncertainties related to future glacial landscapes. These tools should be tailored to relevant spatial and temporal scales, integrating perspectives

and interests from diverse stakeholders. This inclusive approach to planning is crucial for ensuring the sustainability of tourism activities amidst the rapid transformations occurring in glacier landscapes.

Pan Arctic glacier runoff and calving time series

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Here we present a 72 year time series of land ice runoff for the pan-Arctic derived from the regional climate model MAR and statisically downscaled to 1 km resolution at a daily time step. A hydrological routing scheme is also applied to the downscaled runoff to provide meltwater runoff data at coastal outflow points. Meltwater components coming from non glacierized land, bare glacier ice, and glacierized area above the snowline are separated to aid further analyses. The software pipeline is designed to be fully operational so that it can be used to update the time series as soon as the input data are available, so providing a continuous time series for the entire Arctic within the framework of a project aimed to develop a holistic, integrated observing system for the Arctic (www.arctipassion.eu). We are also developing a pan-Arctic calving dynamics data set within the same project. We use a fully automated deep learning approach to generate a new calving front dataset at a high temporal resolution, by harmonizing multiple satellite missions that are available from the 1970s onwards, including optical missions such as Landsat, ASTER and Sentinel-2, and various SAR missions such as ERS-1/2, Envisat, RADARSAT-1, TerraSAR-X and Sentinel-1. We show the interannual and seasonal variability of glacier termini positions by applying this method at scale and investigate the responses of Arctic glaciers to climate change.

Glacier retreat in Sørkapp Land, Spitsbergen, from 1961 to 2020.

Justyna Dudek[1], Michał Pętlicki[2]

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The Arctic is among the regions that have experienced the fastest climate warming recorded in the globe after the Little Ice Age (LIA). As a result of this phenomenon its glaciers are losing mass at an accelerated pace. This work presents an analysis of the changes in the geometry of glaciers located in Sørkapp Land, southern peninsula of Spitsbergen, the biggest island of the Svalbard archipelago, over the period of 1961 to 2020. Dataset used for this investigation consisted of scanned analog and digital photographs for the years 1961, 1990, 2010, captured by Norwegian Polar Institute, two consecutive Landsat 5 TM scenes acquired in the summer of 1990, Planet Imagery from the year 2020, as well as archival maps published by the Polish Academy of Sciences and digital elevation models derived from different sources. Using available datasets changes in glacier extent and thickness have been assessed in the following periods: 1961-1990, 1990-2010, 2010-2020 and 1961-2020.

Snow cover evolution at Qasigiannguit glacier, West Greenland

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We present the results of a study looking at the evolution of snow cover using a number of in-situ methods for Qassinnguit Sermiat, a coastal mountain glacier in Kobbefjord close to Nuuk, W. Greenland. The glacier has been a part of the Greenland Ecosystem Monitoring programme since 2012, allowing the glacier related inputs and outputs to be considered in an ecosystem context.

We gain insights into the snow cover evolution over the melt season which highlight the need to consider the complex spatial evolution of snow/bare-ice ratios, as opposed to a singular snowline, in mountain catchments. In addition, we gain extremely useful insights into our data collection strategies.

In 2022 we experienced an extremely wet summer and autumn in West Greenland, breaking a number of precipitation and discharge records within the Greenland Ecosystem Monitoring data period. Floods destroyed infrastructure in both Kobbefjord, near Nuuk, and Qeqertarsauq, Disko Island. Atmospheric conditions resulted in moisture rich air being transported along the west coast with frequent cyclonic activity leading to the above average levels of precipitation. What impacts this had on the ecosystem and how long lasting, will become evident in the coming years.

Recent Dynamics of Yelverton Glacier, Northern Ellesmere Island, Nunavut

Kristie Shannon[1], Wesley Van Wychen[1]

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Yelverton Glacier is a large, tidewater terminating glacier located on Northern Ellesmere Island in the Canadian High Arctic (CHA). The loss of floating ice extent, such as ice shelves and ice tongues, which fringe Northern Ellesmere Island has been increasingly reported in the CHA due to climate change. For glaciers such as Yelverton, the loss of this floating ice cover may have impacts on the flow speeds of the upstream ice. This work focusses on characterizing the dynamic variations observed on Yelverton Glacier with the objective of characterizing whether ice motion has varied over the last decade. This will be accomplished by applying a specialized offset tracking code that derives glacier motion from SAR data. In this presentation, initial results of glacier motion from offset tracking applied to European Space Agency Sentinel-1 data will be presented for the 2020-2023 period. More broadly, this study will eventually quantify surface elevation changes from differencing of ArcticDEM products, delineate terminus extents to measure change over time, and characterize the glacier's topography using NASA's openly available 3D-tomography data. These analyses combine to produce the most comprehensive investigation of this

glacier to date and will help to better quantify iceberg discharge and understand how glacier motion within the Canadian Arctic is evolving in a warming climate.

Snow observations in Alaska: The need for continued in situ monitoring

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Changing snow cover in the Arctic has widespread environmental and societal impacts. To assess climate driven changes in snow parameters, long observational time series are essential. While modern remote sensing and reanalysis products can help to fill temporal and spatial gaps in data sparse regions, in situ observations remain vital for calibration and validation of gridded data sets and models as well as for climatological trend analysis. We present an overview of the in situ observational data basis of common snow parameters available for Alaska, focussing on long term records and how the number of observations and climatological observing networks have changed over approximately the last century. Considering snow depth as an example, the observational record for Alaska starts around 1900, with a continuous increase in available data until the 1970s, when around 250 snow depth observations were recorded daily throughout the state. The number of active observing stations has since fluctuated. The size of the Alaska SNOTEL network has steadily increased since the 1980s, while other networks had a more variable development with a notable decline in availability of daily observations in the last 15 years, particularly at high latitudes. The discontinuation of long term snow depth and snow fall time series affects our ability to climatologically contextualize recent changes, especially at the scale of individual communities in remote locations. We highlight the need for sustained in situ snow observations in Alaska, as well as for comprehensive homogenization of available data and integration of remote sensing and in situ data sets to address data sparsity.

Distribution and characteristics of glacier surges across the St. Elias Mountains, Yukon-Alaska

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The St. Elias Mountains of Yukon-Alaska contain one of the largest concentrations of surge-type glaciers in the world, yet we still have a limited understanding of their distribution and flow history. Here we present an analysis of long-term (1874-2023) records of rapid glacier velocity events and previous studies to derive characteristics of surge-type glaciers in this region, and to produce an updated inventory of observed surges. A total of 231 glaciers (4.6% of the total) are classified as surge-type, comprising 77% (25,600 km^2) of the total glaciated area. Surge-type glaciers are larger, more centrally located in the mountain range, have more tributaries and are more likely to be marine- or lake-terminating, compared to non surge-type glaciers.

A total of 42 glaciers were observed to have surged a total of 73 times over the period 1985-2023, through either direct measurements or remote sensing observations. For glaciers with observed rapid velocity events, these predominantly fall into two categories: Alaskan-style (hydrologically-triggered) surges with short active (1-4 years) and quiescent (10-40 years) phases, and glacier pulses, which are velocity accelerations that are limited in both magnitude and extent. There is distinct transitional behaviour whereby glaciers accelerate, sometimes for several years to decades prior to undergoing a full surge, as well as a deceleration phase after the peak. A total of 81% of observed surges began in the winter, with the other 19% initiating during the late summer/early fall.

While 'surge' is the most widely used and accepted term to describe the rapid velocity events described in the St. Elias Mountains, this term may be a misnomer: it can be ambiguous, as it can refer to any type of rapid velocity event, despite the wide spectrum of behaviours and mechanisms are observed.

Drivers of melt-induced ice speed-up events on Hansbreen, Svalbard

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Recent advancements in modern surveying techniques, particularly GNSS methods, have rekindled interest in fluctuations in ice flow, especially short-term variations caused by increased runoff. The primary goal of this study is to characterize the spatial and temporal dynamics of surface movement on Hansbreen glacier, Spitsbergen, using high temporal resolution measurements of ablation stakes. Selected stakes were measured every few days, with some being measured daily, from 2006 to 2019. This study presents variations in the number, seasonality, and magnitude of speed-up events. These events are examined in conjunction with surface melt rates and precipitation data collected at the Polish Polar Station in Hornsund. Additionally, we discuss the relevance of speed-up events in relation to average annual and seasonal ice flow velocities.

The Impacts of Climate Change on Youth's Place Attachment. A case study of Tasiilaq, East Greenland

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This article examines the impact of climate change on youth's place attachment, highlighting the pressing need to understand its implications for urban space utilisation in the rapidly changing Arctic. This study employs an expanded place attachment theory, considering the influencing factor of climate change, and adopts a decolonisation of science as well as a community based participatory research approach to investigate the Tasiilaq youth's perspectives on their attachment to public space. The findings highlight that place attachment for the youth is shaped by the fulfillment of functional and emotional needs, encompassing social interaction, physical activity, and reflective purposes. The

study concludes that climate change impacts the place attachment of the youth, albeit in a multifaceted manner, influenced by a complex interplay of factors. The findings reveal both positive and negative effects of climate change on place attachment, which are mediated by the youth's functional and emotional needs and the availability of alternative options.

LATTICE: Land-terminating ice cliffs in North Greenland: processes, drivers and their relation to regional climate

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Land-terminating ice cliffs (LTIC) are relatively rare features, predominantly occurring in cold and dry climatic conditions. Sustaining an angular cliff shape requires a complex interplay of ice flux, melt, sublimation and dry calving. While LTICs are a global occurrence, the reasons for their existence, fluctuation processes, and connection to mass balance and climatological controls remain understudied. In North Greenland, the terrestrial ice margin forms numerous LTICs, but only the Red Rock ice cliff has been researched extensively. Over the last six decades, the observations have revealed periods of advance, retreat and re-advance of the ice cliff accompanied by ice cliff thinning. Here we introduce the LATTICE project. Its primary objective is to understand the processes driving LTIC changes, focusing on the Red Rock ice cliff. Through in-situ monitoring, including weather stations, ablation stakes, and ice temperature measurements, we will analyze the distinct mass balance regimes of both the flat glacier and the vertical cliff face. We also aim to identify the driving processes of the ice cliff movement through investigating ice dynamics. Geodetic mass balance calculations will be used to examine changes in cliff morphology, comparing the data with historical records to reveal multi-decadal changes. Using the observed data and potentially data from additional weather stations, we will subsequently run a mass balance model. With this approach, we aim to unravel the climate sensitivity of the ice cliff and relate its climate signal to large-scale atmosphere-ocean circulations, such as the North Atlantic Oscillation and the Greenland Blocking Index. The overarching goal of the LATTICE project is to enhance our general understanding of LTICs and contribute to the knowledge base regarding the relationship between the atmosphere and cryosphere in North Greenland, which holds relevance for a substantial part of the cold and dry region.

How to propel a floating iceberg 400 m up into the air

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During fieldwork at Greenland fastest glacier (Sermeq Kujalleq in Kangia or Jakobshavn Isbrae) we observed an iceberg shooting some 400 m up before rotating sideways and plunging into the water. Several similar events were captured with time-lapse photography, seismometers and terrestrial radar interferometry. Here, we analyze such events with theoretical considerations and detailed numerical modeling. The process is clearly

buoyancy-driven, but the rates of uplift and the height above the water line allow us to constrain the proportions of the iceberg under water as compared to the visible part. Also, the question how the iceberg can obtain a submerged position priming the up-shooting leads to interesting conclusions with regard to iceberg release through fracturing.

Modeling the dynamic response of polythermal valley glaciers to climate change on a regional scale

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As climate warms in Arctic Alaska, the polythermal glaciers there are getting colder. This eventually causes the basal ice to freeze to the bed and eliminate or reduce sliding there, changing the ice dynamics considerably, as has been observed over the past 20 years. I will present a combined surface mass balance and ice dynamics model that captures all of these dynamics for individual polythermal glaciers on a regional scale, allowing us to assess where and when ice is warm during the lifecycle of these glaciers, as well as many other things.

Studying frontal ablation of tidewater glaciers in Hornsund fjord, Svalbard: a multi-sensor approach

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Glacier calving and submarine melting are key processes responsible for mass loss from tidewater glaciers and ice shelves. However, these two mechanisms of frontal ablation are difficult to track and quantify separately. Here, we address this issue through the combination of optical techniques, passive acoustics, and hydrographic measurements. We conducted a field experiment in the summer of 2023 to study frontal processes at three tidewater glaciers terminating in Hornsund fjord, Svalbard: Hansbreen, Paierlbreen, and Muhlbacherbreen. Calving properties estimated from continuous underwater noise recordings are compared with optical observations of glacier termini made with a terrestrial laser scanner and time-lapse cameras. Acoustical data are also combined with measurements of water temperature and salinity to understand potential links between the underwater noise and submarine glacier melting. Moreover, we investigate new possibilities for understanding spatio-temporal variability of glacier calving with the analysis of broadband airborne noise recordings. The results from Hornsund fjord are discussed in a broader context of climate-driven changes in glaciated fjords at high latitudes. [This research has been supported by the National Science Centre, Poland (grant no. 2021/43/D/ST10/00616) and the Ministry of Education and Science, Poland (subsidy for the Institute of Geophysics, Polish Academy of Sciences).]

Identifying Glacial Pulsing characteristics in the Canadian Arctic

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Irregular dynamics of glaciers pose a variety of issues for fully understanding the spectrum of flow behaviours that glacier and experience and the subsequent impacts on sea level rise. A recently identified subset of surge type glaciers in the Canadian Arctic are 'pulsing glaciers', which have some similar characteristics of surge-type glacier, but occur on a shorter time scale, originate near the glacier terminus, and tend to only impact areas of the glacier where the bed lies below sea level. While limited literature exists on pulsing glaciers, the processes and characteristics are not fully understood or described, leading to a gap in glacial knowledge. Three previously identified pulsing glaciers: Dobbin Bay Glacier, Eugenie Glacier, and Parrish Glacier, will be surveyed from 2010-2022. With elevation, terminus extent, ice flow and subglacial topography being used to examine pulsing characteristics. In this presentation, surface elevation change from the differencing of high-resolution (2m) ArcticDEM Strip products are used to quantify the change in glacier height over the 2010 to 2022 period. Preliminary results show that 6 km up from the terminus of Parrish Glacier an elevation gain of almost 30 meters was recorded. Yet even with this elevation increase, Parrish Glacier saw 10 m's of elevation loss in the bottom 2 km of the terminus in the same period. These results align with previous findings; however, will provide a more spatially comprehensive quantification of surface elevation change related to previously identified pulse events. In the future, these results will be combined with dense records of ice motion determined from offset tracking of Synthetic Aperture RADAR imagery as well as measurements of basal topography from NASA's Operation IceBridge Program. Collectively, these results will contribute to our understanding of the behaviour of 'pulse-type' glaciers within the region and help to distinguish 'pulse-like' processes from 'surge-like' processes.

Greenland Ice Sheet Surface Classification from Satellite Optical Remote Sensing

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In recent decades, the Greenland ice sheet has emerged as the largest single regional contributor to global sea level rise due to ice loss. Approximately half of this loss is attributed to surface melting, significantly influenced by surface darkness characterized by albedo, and absorbed solar irradiance. The Greenland ice sheet surface type undergoes seasonal variations, ranging from snow cover to bare ice, with intermediary situations of surface flooding in slush and lakes. Both snow and ice can be darkened by microbiological processes, mineral dust, and even black carbon from wildfires. Satellite optical remote sensing enables the classification of not only bare ice and snow cover but also sub-classes like melted or unmelted snow. Bare ice can be further sub-classified as bright, dark, and even algae rich. In this study, we employ a supervised machine learning algorithm (Support Vector Machine) to create a model that classifies surface types using daily, cloud-free optical data from the Ocean and Land Color Instrument (OLCI) on the EU Copernicus Sentinel-3 satellite. The training data is manually labeled and validated using

EU Copernicus Sentinel-2 satellite Multispectral Instrument (MSI) data. We further estimate the probability of the classified type using Platt scaling and compute the average accuracy of each class and the confusion matrix using a 5-fold cross-validation scheme. We present both the model performance and the time and spatial variation of predicted surface classes, exploring their relation with day-to-day climate variability.

Subsurface water movement in the percolation zone of the Greenland ice sheet

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On the Greenland Ice Sheet meltwater can be retained by refreezing instead of running off. However, recent thick near-surface ice layers in the percolation zone may accelerate ice sheet mass loss favoring direct runoff by preventing melt water percolation. We combine optical and synthetic aperture radar satellite images with data from shallow firn cores to investigate spatio-temporal variations in near/subsurface water movements in the percolation zone in southwest Greenland. We find episodes of rapid river-like subsurface water flow on top thick ice slabs. Water movement is evident tens of kilometers above the upper limit of visible surface rivers or saturated slush fields and persists even after seasonal melting has ceased. Complex flow patterns are directly controlled by subtle kilometer-scale differences in surface slope with lower slope areas forming preferential subsurface pathways of downslope water movement. These flow patterns remain persistent over multiple years. We suggest that surface slope triggers a positive feedback where water preferentially saturates the firn/snow in topographic lows, leading to thicker ice slabs when the water refreezes in fall, accelerating firn/snow saturation the following year. Thus surface slope exerts a key control on both ice slab thickening and expansion as well as runoff patterns from the firn area.

Modeling frontal ablation in a global glacier evolution model

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TBD

Feasibility of statistical and machine learning methods for discovering large-scale drivers of local melt rates

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The question which large-scale atmospheric drivers are responsible for local conditions repeatedly comes up in many fields of climate science. A wide variety of approaches and tools are available for tackling such problems, including recently proposed methods from Explainable Artificial Intelligence (XAI). XAI models rely on training complex machine learning models on a given problem, and then making the predictions of those models understandable. However, the suitability of these novel XAI methods in addressing specific scientific questions remains uncertain. In this work, we investigate which large scale atmospheric drivers determine local melt rates at a glacier outlet in Western Greenland as an opportunity to evaluate a range of statistical and XAI based tools. We use 500hPa geopotential fields from reanalysis to represent large scale circulation, and runoff from the MAR regional climate model as local variable. We qualitatively and quantitatively compare the results from those methods and use prior knowledge and physical intuition to evaluate them. We find that there is reasonable consistency between simple statistical methods and combined methods using established methods of dimensionality reduction techniques (such as empirical orthogonal functions and k-means clustering). The nine XAI techniques that we use, on the other hand, have very high variability, and at least some of them lead to physically implausible results. This, combined with the inherent complexity of those methods, raises fundamental questions on their suitability for uncovering connections between large scale drivers and local conditions.

Changes in coastal environments and their impact on society in Qaanaaq, northwestern Greenland

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Coastal environments around Greenland are rapidly changing under the influence of warming climate. Glaciers are rapidly losing mass and glacial meltwater discharge is affecting ocean environments, resulting in a wide range of influence on marine ecosystems. Thawing permafrost and more frequent heavy rain events destabilize slopes along the coast. These changes in natural environments are serious concerns of Greenlandic societies. Accelerated glacier melting causes floods of outlet streams. Settlements at the foot of a steep terrain are threatened by landslide hazards. Moreover, environmental changes are affecting the traditional way of living in Greenland. For example, dog sledge hunting activities are affected by sea-ice break up events during winter. It is important for researchers to work together with community to understand the mechanisms driving the changes and mitigate their societal impact. To investigate recent changes in coastal environments and their impact on society in Greenland, we have been running a research project in Qaanaaq, northwestern Greenland, under the framework of interdisciplinary Japanese Arctic research projects GRENE (Green Network of Excellence), ArCS (Arctic Challenge for Sustainability) and ArCS II. In this presentation, we introduce the overview of our research activities since 2012 performed with close relationship with the local society in Qaanaaq.

Influence of sea-ice variability on the surface mass balance of Freya Glacier, Northeast Greenland

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Arctic sea ice is known to influence atmospheric conditions in nearby regions. Especially, the rapid decline in the Arctic sea ice cover in the 21st century can have an impact on the mass balance of Greenland's peripheral glaciers. Moreover, regional climate model results suggest that Northeast Greenland is among the most sensitive areas to changing temperatures. Taking these facts into consideration, we investigate the relationship between sea ice concentration and surface mass balance (SMB) of Freya Glacier, a polythermal glacier located in Northeast Greenland, using a combination of automated weather stations, reanalysis, and regional climate model simulations for the period 1990-2020. The singular value decomposition analysis suggests a covariability between sea ice in proximity within the Greenland Sea and the SMB of Freya Glacier. Especially during summer, we hypothesize that a decreasing sea ice cover might have opposite effects on individual components of the SMB of a nearby mountain glacier. While it could increase the temperature and humidity by advection of warm and moist air, it might also lead to more (solid) precipitation in the higher elevation. The advection of moist air might also lead to more cloudiness and fog, which again has opposite effects on the glacier's surface energy balance through shortwave radiation reduction and longwave warming effects. However, the advection of fog towards the glacier depends on the stability of the atmosphere (which depends on the sea ice condition) and the strength of the katabatic wind.

Impacts of the changing cryosphere on an Inuit community in East Greenland and challenges in communication between scientists and community members

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The rapidly retreating glaciers, less fjord and sea ice, an increase in extreme weather events and several other climatic and environmental changes pose challenges to the residents of the Tasiilaq region in East Greenland, a majority of whom are Inuit, and put a strain on people's improvisation and adaptation capacities. The changing cryosphere impacts upon residents' travel routes and modes of travel, hunting and fishing practices as well as other subsistence activities; it puts extra burden on technological equipment (e.g., motorboats) and leads to a decline in sled dogs, to name just some examples. This presentation draws from my long-term anthropological fieldwork in East Greenland since the mid-2000s and, in particular, from my recent engagement in a transdisciplinary project on how climatic and environmental changes, especially the transition from less snow to more rain, are influencing the quality of life in and around Tasiilaq (Snow2Rain). The project has once and again displayed the difficulties in bringing together natural scientific findings and residents' views of the concept of climate change that is for many rather abstract. In this presentation, I speak about the impacts of the changing cryosphere on the Inuit community, about how residents speak about these changes, and about challenges in communication between scientists and Tasiilaq residents. While many residents clearly experience the impacts of the changing cryosphere, doubts prevail about whether these changes are indeed human-made. These doubts, I argue, have to be understood in the context of different underlying environmental philosophies.

Planned relocation due to landslide-triggered tsunami risk in recently deglaciated areas

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Climate change is contributing to the magnitude, frequency and location of natural hazards, including landslides and landslide-triggered tsunamis. As the costs of protecting against a given risk increase, relocation may become the only feasible option despite the socio-economic, human security and cultural consequences. The relocation of people represents one of the most complex governance challenges generated by climate change. This article contributes to the literature by presenting insights and lessons from two case studies of unprecedented landslide-triggered tsunami risk in recently deglaciated areas that have not previously been described in the relocation literature: the unstable Svínafellsheiði slopes in south-east Iceland, and Karrat and Uummannaq Fjords in north-west Greenland. Our results draw attention to the need for planned relocation to be conducted in-line with international best practices, including those relating to the active involvement of affected people in decision-making, ensuring adequate compensation, and clarifying relocation planning schedules. This has occurred against a backdrop of colonial power dynamics, urbanisation trends, and the rise of tourism in these locations. Based on the findings, we recommend that the role of government pivot from determining risk management and relocation options, to providing a structure to underpin and support community agency.

Research on a vanishing object

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(Geo-)political worldviews of what the Arctic is or what it should be have shaped Arctic science since early times of polar explorations. By combining critical geopolitics and the sociology of science, this dissertation project studies how (western) knowledge is produced in the Arctic. It investigates two main research questions: What are worldviews and role perceptions of permafrost researchers and glaciologists in the Arctic? How is indigenous knowledge perceived from a western scientists' perspective? The focus lies on researchers who work at Canadian, German and Norwegian institutions. Methodologically, a qualitative approach is applied, including literature analysis and semi-structured interviews.

Research on a "vanishing object", as demonstrated here for the field of glaciology, showcases severe human impact on nature. I argue for a sociology of science that contemplates not only scientific, but cultural, ecological, and social loss of natural elements and thus helps to unfold worldviews and to reflect on research methodologies. A cross-cutting topic arises around the role of emotions in glaciology. By exploring how recent

developments are changing the 'doing of science' as such, the poster presents a three folded discussion. First, the focus lies on emotions towards the research object, that is the relationship of a scientist to the glacier. Second, scientists have to deal with negative emotions (feeling of loss, anger, disappointment, frustration, concern) in a rational context. A clear gap between scientific evidence and political action emerges, which leads to questioning the relationship between science, politics and society, and especially the role and responsibility of scientists. Third, a closer look is provided on implications when emotions serve as a bridge to creative forms of science communication – as a solution to showcase the urgency of climate action, when 'pure science' reaches its limit.

Thickness inversion for all glaciers in Svalbard

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Knowledge of the thickness, volume and sub-glacial topography of glaciers is crucial for a range of glaciological, hydrological and societal issues, including, e.g., studies on climate-warming induced glacier retreat and associated sea-level rise. This is not the least true for Svalbard, one of the fastest warming places in the world. Here, we present a new map of ice thickness and sub-glacial topography for every glacier on Svalbard. Using remotely-sensed observations of surface shape, ice velocity, rate of surface elevation change dh/dt and glacier boundaries in combination with a modelled mass balance product, we apply an inverse method that leverages state-of-the-art ice flow models to obtain the shape of the glacier bed. Specifically, we model large glaciers with the ice sheet model PISM at 500 m resolution, while we resolve smaller mountain glaciers at 100 m resolution using the physics-informed deep learning-based ice flow model IGM. Validation against thickness observations shows high statistical agreement, suggesting that the modeled glacier beds are realistic. We discuss sources of uncertainty, differences to previous ice thickness maps of the region and future applications of our results.

Hydrothermal structure of Elfenbeinbreen, Sabine Land, Svalbard, and the use of gprMax to simulate the hydrothermal structure of polythermal glaciers

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Ground-penetrating radar (GPR) is an effective tool to infer the hydrothermal structure of polythermal glaciers. Few GPR surveys have been undertaken in the eastern coast of central Spitsbergen, Svalbard. We carried out extensive radar profiling on Elfenbeinbreen and Sveigbreen, Sabine Land, in spring 2014, and repeated the Sveigbreen profiles in spring 2022. In both cases, a 25MHz GPR was used. The 2014 campaign was focused on ice-thickness retrieval, though the polythermal layering was also captured. The surveying in 2022 was aimed at analysing the evolution of the hydrothermal structure of

Sveigbreen. The results suggested similar decreases of both total ice thickness and temperate ice layer thickness (2-3 m a^{-1}), with the cold ice layer showing little change in thickness, in contrast with the cold ice layer thickness increases observed in western Nordenskiöld Land glaciers such as Fridtjovbreen and Erdmanbreen. We here focus on the hydrothermal structure of Elfenbeinbreen. Its average ice thickness is of 85 $\pm$ 9 m, with a maximum of 285 $\pm$ 7 m. Its upper cold-ice layer, in turn, has a thickness varying between 80 and 250 m, though generally is about 120-150 m. These values are larger than those observed in the neighbouring Sveigbreen, whose cold layer thickness is typically 60-80 m. They are also larger than those found by the authors for glaciers of similar size located in central and western Nordenskiöld Land, and in Wedel Jarlsberg Land. We will also present simulations of hydrothermal structure, and other structural features such as crevasses and englacial channels and water pockets, in the form of synthetic radargrams generated using gprMax software. This will show that gprMax is a useful tool to generate synthetic radargrams to be used to train (together with "real" radargrams) machine-learning algorithms aimed at detecting the cold-to-temperate transition surface (CTS) of polythermal glaciers.

Snow modelling for the Sami reindeer herders in northern Sweden

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Rain-on-snow (ROS) events and the subsequent formation of ice layers in snow packs create challenging conditions for reindeer herding in northern Sweden. In collaboration with the Sami community in the Laevas Sameby we have developed a modeling tool that, forced with regional climate model data, can simulate snow conditions in both forest and non-forest areas. In the work presented here, we use this modelling system to assess long-term (1974-2023) trends of snow depth, density, temperature and water content, and further focus on years with extreme rain-on-snow events. Main findings reveal: 1) strong year-to-year and spatial variations in refrozen mass; 2) an overall positive trend of refrozen mass; 3) increased early-winter rainfall and ROS, and significant snow season shortening; 4) a strong correlation between refrozen mass and rain-on-snow (much less with melt, rainfall, and average winter temperature).

Glacier Lake Outburst Floods in the Canadian Arctic

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GLOFs occur throughout the world, and are particularly well documented in Iceland, the North American Cordillera, the Himalayas, and the Hindo-Kush-Karakoram [1]. Al-

though GLOFs have been identified within the Canadian High Arctic (CHA) [2], they have received negligible research attention [1]. Although GLOFs do not represent a major hazard to either infrastructure or livelihoods in the CHA, as the region is sparsely populated with communities located away from glaciers, understanding the dynamics of GLOFs within the region is of importance for understanding the entire spectrum of glacial processes within the CHA. Furthermore, as the climate warms, there is an expectation that GLOFs will become more prevalent as greater amounts of surface melt water are generated and routed to proglacial lakes [1]. In this work, we leverage high-resolution (2 m) ArcticDEM Strips and TanDEM-X (0.4 arc seconds, 12 m) DEM products to monitor glacier elevation changes indicative of GLOF activity in the CHA over the 2010 to 2022 period. The timestamped DEMs are re-sampled to a common resolution, co-registered using the method of [3], and then differenced which allows us to quantify surface elevation changes associated with GLOF events as well as determine their timing. We use a small, un-named glacier (81°48'08" N, 81°35'47" W) located on Northern Ellesmere Island as our test case. Preliminary results indicate that surface elevations increase gradually over the course of 7-10 years, and surface elevation losses of 40 m over the course of weeks to months suggest that drainage is catastrophic, although our ability to exactly pinpoint the timing of drainage events is hampered by limited data availability.