Svalbard Science Conference 2025

Book of abstracts

October 2025

This Book of Abstracts presents the contributions to the Svalbard Science Forum Conference on Svalbard 2025:

A Hotspot for Climate Change and International Collaboration.

The conference took place 28-29th October 2025 in Fornebu, Norway.

The collection highlights the latest research addressing the rapid environmental transformations occurring in the Arctic and the importance of shared scientific effort in understanding them. Each abstract included here has undergone a peer-review process, evaluated by at least two independent reviewers to ensure scientific quality and relevance. Together, these works reflect the diversity of, disciplines, and collaborations that make Svalbard a unique arena for advancing climate change research and fostering global cooperation.

The scientific committee was composed of Marie-Anne Blanchet (Norwegian Polar Institute), Chair of the scientific committee, Harald Steen (Norwegian Polar Institute), Gijsbert Breedveld (The University Centre in Svalbard), Arunima Sen (The University Centre in Svalbard), Andrea Spolaor (National Research Council of Italy), Heikki Lihavainen (SIOS - Svalbard Integrated Arctic Earth Observing System), Maaike Weerdesteijn (Association of Polar Early Career Scientists Norway), Tiril Vold Hansen (Nord university), Oskar Andreas Landgren (The Norwegian Meteorological Institute), Oskar Glowacki (Institute of Geophysics, Polish Academy of Sciences), Jon Børre Ørbæk (Svalbard Science Forum/ Research Council of Norway), Lena Cappelen Endresen (Svalbard Science Forum/ Research Council of Norway)

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Main author: Julia Olsen, Faculty of Social Sciences, Nord Universitet, Norway

Full list of author(s): Alexandra Meyer (University of Vienna), Lisbeth Iversen (The Oslo School of Architecture and Design), Ulrich Schildberg (Geografisches Institut Ruhr-Universität Bochum), Ragnhild Holmen Bjørnsen (University of Inland Norway), Grete K. Hovelsrud (Nordland Research Institute), Badu James (Nord University), Tiril V. Hansen (Nord University), Simon Jungblut (University of Bremen), Eystein Markusson (Svalbard Museum), Zdenka Sokolíčková (University of Groningen),

Abstract: Our presentation will provide recommendations for research projects in Svalbard that apply co-creation across fields, sectors, and actors from a transdisciplinary viewpoint. The results derive from a networking project, funded by Svalbard Strategic Grant: “Building transdisciplinary bridges for a sustainable Svalbard and Arctic development.” Considering the rapid changing and challenging situation in climate, society and economy in Svalbard, cooperation across disciplines and between science and society is needed more than ever to generate knowledge for the sustainable development of the archipelago. Such research cooperation between various disciplines and relevant non-academic stakeholders is conceptualized as a transdisciplinary approach. It emphasizes a need for continuous broad and holistic knowledge and relevant data-sharing across sectors to safeguard the foundation for decision-making and development strategies. However, transdisciplinarity can be difficult to navigate, and projects often still follow traditional disciplinary structures. In this presentation, we discuss some challenges for transdisciplinary research by adopting a multivocal methodology. Given the dynamic nature of transdisciplinarity, we present the themes from our discussions, opportunities, and best practices.

COAT: A system for long-term, ecosystem-based monitoring of the Svalbard tundra

Main author: Åshild Ønvik Pedersen, Norwegian Polar Institute

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Abstract: The Arctic Svalbard archipelago is experiencing the fastest temperature increases on Earth. Svalbard's extreme year-to-year and place-to-place variability makes long-term monitoring challenging, yet essential for environmental conservation, management and policymaking. The Climate-Ecological Observatory for Arctic Tundra (COAT) meets these challenges by real time detection, understanding and predictions of climate impacts on tundra ecosystems. The observatory is geographically distributed in Spitsbergen to cover a wide range of climatic gradients and management contexts.

COAT is interdisciplinary and uses an adaptive monitoring approach, guided by a set of hypothesis-driven conceptual 'climate impact path models'. Each of the path models outlines a set of monitoring targets in terms of climate sensitive key species or functional groups in the tundra food web and a priori hypotheses for their key process relations. Climate and environmental management are included as the main drivers of these relations. Seasonal and annual monitoring provides time-series data. In turn, this allows parameterization of statistical versions of the path models in to make causal inferences (estimation and attribution) about climate impacts, management options, as well as forecasts.

Between 2016-2023 substantial resources have been devoted to establishing research infrastructure (e.g., experimental devices, sensor systems and data portal) and model developments. In 2024, COAT Svalbard entered the long-term operational phase and currently represents the terrestrial biosphere core of the Svalbard Integrated Arctic Earth Observing System (SIOS). Together with its low-arctic counterpart on the Norwegian mainland, COAT Svalbard is among the few ecosystem-based observatories in the circumpolar Arctic and quite unique in its approach and objectives. The COAT approach was partly born out of the previous IPY. In the present session we provide suggestions on how COAT can contribute to the next IPY.

Exploring Services, Risk and Observation and Model Improvement with the Polar Coupled Analysis and Prediction for Services (PCAPS) project

Main author: Jørn Kristiansen, Norwegian Meteorological Institute, Development Centre for Weather Forecasting, Norway

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Abstract: The Polar Coupled Analysis and Prediction for Services (PCAPS) Project is a new initiative under the WMO's World Weather Research Programme (WWRP), building on the success of the Polar Prediction Project (2013–2022). Running from 2024 to 2028, with potential extension to coincide with IPY-5, PCAPS is an international, interdisciplinary effort to enhance environmental forecasting services in the Arctic and Antarctic.

The project responds to rapid polar changes and aims to improve the actionability, impact, and fidelity of forecasts through better integration of physical and social sciences, co-production with users, and international collaboration. Emphasis is placed on improving coupled models and addressing key gaps in polar observing systems—such as surface wind, sea ice, visibility, and mixed-phase clouds—through novel approaches including AI and machine learning.

PCAPS recognizes that advancing service delivery requires deeper cooperation between researchers, operational centres, and diverse user groups—including Indigenous communities. Early activities focus on developing transdisciplinary task teams, assessing observing network needs, and improving understanding of key polar processes.

With a clear connection to the goals of the upcoming International Polar Year, PCAPS provides a timely and strategic platform for coordinated efforts to close critical knowledge gaps and foster resilient, inclusive, and informed decision-making across polar regions.

Initial Norwegian planning towards IPY5: Expectations for mobilization and contributions from Svalbard

Main author: Jon Børre Ørbæk, Research Council of Norway

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Abstract: The 5th international polar year (IPY-5) is planned as a decade of actions starting with implementing contributions already in 2026 and with gradual build-up towards the intensive phase in 2032-2033. The Norwegian Government decided already in September 2024 that Norway shall set up a significant and visible contribution to IPY-5, tasking the Norwegian Polar Institute (NPI) and the Research Council of Norway (RCN) to set up an initial planning group to make plans for establishing a national IPY-secretariat and -committee. NPI will lead the committee with RCN hosting the secretariat, both established gradually from 2026.

Svalbard, as a hotspot for Arctic climate and environmental research and international cooperation is expected to provide significant contributions to IPY-5. This will build on the extensive research carried out by scientists from many countries, as well as making use of the advanced research infrastructure and observational programs already in place. As a Norwegian platform for international research and higher education, Norway has high expectations for the international cooperation, emphasizing joint research programs (flagships), joint sharing of data and research infrastructure, open publishing and contribution to international/global observing programs etc. These are best practice solutions that contribute to strengthen the importance of Svalbard in closing major knowledge gaps in global climate and environmental challenges through collaborative efforts.

The presentation will give an update of the national planning process towards IPY-5, present ideas for potential Norwegian contributions and discuss expectations for how the international Svalbard research community best can prepare itself to set up a significant and visible IPY-5 program.

SESS to IPY: Advancing an Integrated Earth System Perspective in Svalbard

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Abstract: The State of Environmental Science in Svalbard (SESS) report collates multidisciplinary research efforts to understand Svalbard's rapidly changing Earth system. Contributions of international research groups bring together diverse aspects of the Earth system in Svalbard and consolidate key environmental data for the Svalbard region. The report identifies knowledge gaps and observational needs essential for tracking environmental change in the region. In doing so, the SESS report serves as a dynamic platform for aligning long-term observations, fostering interdisciplinary collaboration, and encouraging dialogue around innovative scientific approaches. It is published annually by the Svalbard Integrated Arctic Earth Observing System (SIOS).

The aim of the upcoming International Polar Year (IPY) 2032-2033 is to boost the advance and integration of polar science, for instance through expansion and coordination of Earth observing systems. In this context, the SESS report can serve as both a reference for the current state and trends of research in Svalbard and a foundation for future research priorities and joint observing efforts towards understanding changes in environmental processes on a regional and global scale.

This poster explores the SESS report as a starting point for a cohesive and comprehensive Earth system perspective during the upcoming IPY. We present the report's current structure, showcase examples of knowledge integration across disciplines, and illustrate its potential as a valuable tool for scientific coordination during the next IPY and beyond.

Integrating Geodesy into Polar Science: Enhancing Collaboration for the 5th International Polar Year

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Abstract: Geodesy, the science that measures Earth's size, shape, orientation, and gravitational field, provides vital data for monitoring environmental changes in the polar regions. The Norwegian Mapping Authority (NMA) supplies high-quality geodetic data via its Geodetic Earth Observatory in Ny-Ålesund and other infrastructure on Svalbard, supporting both research and societal needs.

The observatory is part of a global network of stations that monitor Earth Orientation Parameters, which are essential for accurate satellite positioning. Without regular updates, satellite position errors can accumulate to 12 meters over 10 days. This impacts navigation, communication, and all GPS-reliant systems, which in turn affects research, infrastructure, and safety in polar and global contexts.

Geodetic data also contribute to interdisciplinary research, e.g.:

• Glaciology: Tracks mass balance, motion, and thickness of ice sheets and glaciers.

• Sea-Level Change: Allows precise monitoring of sea-level rise from melting polar ice.

• Land Uplift: Provides time series of vertical land motion, with secondary effects such as permafrost exposure, erosion, and ecosystem establishment.

• Geodynamics: Supports monitoring of tectonic plate motion and subsurface processes.
Svalbard offers unique potential for advancing these studies, integrating geodetic insight across disciplines.

While global collaboration around geodesy is strong, geopolitical tensions can pose risks. The importance of geodetic infrastructure remains underappreciated by the public, policymakers, and parts of the scientific community. To ensure its protection and maximize the impact of global geodesy in polar research, we call for strengthened international collaboration among geodetic and polar research institutions, especially in view of IPY-5. The collaboration with geodesy will address urgent global challenges and promote sustainable development in the Arctic and Antarctic.

From Local to Global: Modelling Flux Climate Drivers in Svalbard as a Step Towards the Establishment of a Pan-Arctic Observation Network for IPY-5

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Abstract: Terrestrial ecosystems regulate the carbon cycle, and therefore atmospheric CO2 and Earth climate. The Arctic plays a major role in this cycle, due to the large amount of carbon stored in Arctic soil and vegetation. During the Holocene, the tundra has been acting as a carbon sink, but it is not clear if it will turn into a carbon source. Yet, data regarding Arctic CO2 fluxes are scarce due to scattered and non-coordinated observations, and the modelling of their dynamics and fate at global scale is affected by large uncertainties, with difficulties to include it into Earth System Vegetation Models.

Aiming at investigating the tundra soil and vegetation dynamics under climate pressures, CNR established a CO2 fluxes observatory in Ny Ålesund, Svalbard, in 2019, equipped with an Eddy Covariance and flux chambers for measuring Gross Primary Productivity (GPP) and Ecosystem Respiration (ER), and correlating such variables to climate and environmental parameters, vegetation types and functions, and phenology.

Such measurements and modelling activities are scarce and not coordinated at the circum-artic scale. Attempts like the NASA ABoVE experiment need to be upscaled at pan-Arctic scale, sharing methods and protocols at multiple scales, including remote sensing, increasing the number of measurement sites, guaranteeing the acquisition of long term and harmonized datasets.

We are therefore proposing the creation of a coordinated circum-Arctic network of observatories for the next IPY-5, to provide a sound database as a benchmark for models at various scales, linking vegetation composition and phenology to CO2 fluxes and generalizing the CO2 fluxes modelling effort. This will facilitate the identification of

the main variables to be used in general vegetation models and allowing future projections of CO2 fluxes under different climate change scenarios in the Arctic tundra, where Svalbard observatories can play a key role due to the existing infrastructure and expertise.

A research strategy for the pan Arctic Earth System exemplified by weather and biogeochemical cycles

Main author: Øystein Hov, Norwegian Meteorological Institute

Abstract: Extreme Arctic weather events may cause changes in the physical, chemical or biological conditions that determine biogeochemical fluxes (S, N, C, organic species, halogens, Hg and other heavy metals) between the atmosphere and sea-ice, ocean or soil. Such changes can last much longer than the weather event itself and the Arctic earth system can be put on a different long-term trajectory. Examples: Episodic rain on snow or bare surfaces can change the air pollution removal rates, albedo, turbulence and heat transfer in the boundary layer for whole seasons or longer.

Long term, regular observations of a frequency that resolve important controlling processes like synoptic variability are of high value for new discoveries as well as for confirmation of established knowledge and for the provision of data required for reanalysis efforts like ERA5 or MERRA. Reanalysis provide clues for how to develop the observational system further or how to carry out field experiments to reduce uncertainties due to low observational coverage and complexity. A long-term reanalysis contains the probability space for fast events like storms, heavy precipitation, wild fires, methane bursts at sea, “halogen bombs” during the polar sunrise, polar stratospheric ozone depletion events that redirect important physical, dynamical and biogeochemical processes over long time periods (hysteresis).

Long term observations and intermittent research campaigns integrated with operational data assimilation in forecast and reanalysis model calculations and service provision provide a strong framework for research and services. Trusted relationships should be encouraged to grow between the communities of research and practice (operations). Researchers will be drawn into the pool of experience and knowledge that accumulates along with operational services and their use, providing new ideas for research. In the community of practice, learning will take place as opportunities emerge in the community of research. Key words: Digital twin modelling, interoperable earth system observations, FAIR data management and the provision of operational services.

IPY-5 should adopt this framework in its planning.

Monitoring atmospheric and night sky characteristics in Ny-Ålesund research station

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Abstract: The Arctic is highly vulnerable to environmental changes, particularly those resulting from human activities, even though most of these activities are concentrated far from the Polar region. Monitoring the Arctic environment is extremely important and challenging due to extreme weather conditions especially in winter when the polar night lasts 24 hours. The Arctic is an extremely sensitive environment to changes induced by anthropogenic activities, making its monitoring critically important. In 2024, the National Research Council has issued a project (AIRQINO, low cost air quality sensor network in extreme environments) for monitoring the chemical composition of the atmosphere and light pollution in the Ny-Ålesund area by using low cost sensors able to operate in extreme weather conditions. This work aims to present the network of sensors that measure air quality composition, night sky quality and atmosphere transparency, the data management system.

The network is composed by: four low-cost sensors (AIRQino) for monitoring basic meteorological parameters and atmospheric composition (air temperature, relative humidity, particulate matter, and CO2) set along a transect that extends from the Ny-Ålesund port to the Gruvebadet monitoring station; two sky quality meter (SQM) sensors set on the roof of Gruvebadet and next to the Amundsen-Nobile Climate Change Tower (CCT) for measuring night sky brightness and sun-sky-lunar CIMEL CE318-T photometer installed at the AWIPEW Atmosphere Observatory in Ny-Ålesund, for the monitoring of aerosol optical characteristics.

All datasets and their metadata have been collected and are available at the Italian Arctic Data Center (https://iadc.cnr.it/), in accordance with the FAIR principles. Finally, some preliminary results of the analysis of data collected in the first two years of monitoring will be presented, highlighting potential application both for site characterization and other interdisciplinary studies.

Unlocking Arctic Hydrological Dynamics: Bridging Knowledge Gaps for future collaborative strategies

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Abstract: Climate-driven changes in Arctic hydrology are occurring at an unprecedented rate, with profound implications for both local and global ecosystems. Arctic amplification is accelerating the melting of snow cover, glaciers, and permafrost, leading to changes in river discharge and groundwater dynamics. These changes are impacting the water balance and hydrological processes, as well as the dissolution and mobilization of contaminants and microbes.

However, the assessment of these processes in high-latitude regions remains a major challenge due to limited hydro- bio-logical and chemical data. There is an urgent need for a coordinated, interdisciplinary research approach to understand the interactions between surface and subsurface waters and their seasonal dynamics in the context of a warming Arctic. ICEtoFLUX project in the Bayelva river catchment provides a valuable case study to address these knowledge gaps. The study integrates hydrological, geophysical, geochemical, microbiological and isotopic measurements to quantify water and suspended matter fluxes from glaciers to the Kongsfjorden, with a focus on understanding the development of the active layer and the interaction between ground- and stream- water.

Chemical and isotopic results indicate that groundwater flow is spatially and temporally heterogeneous, both quantitatively and from a physico-chemical-isotopic point of view. At the same time these data point out the increasing importance of water flowing in the underground. Geophysical data supported the presence of a deep and well-organised

groundwater flow system in the area. Contaminant distribution indicates mobilization due to seasonal melt.

Our work is an example of how targeted research in Svalbard can contribute to a wider network of Arctic research on water system, fostering international collaboration and knowledge exchange, which is essential to address the challenges posed by climate change in the Arctic and to support the goals of the next IPY-5.

ARCAOS – Advancing Polar Science with a Year-Round Arctic Airborne Observing System

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Abstract: The Arctic is experiencing rapid and complex environmental changes that challenge scientific understanding, operational safety, and sustainable governance. Addressing these challenges requires high-resolution, year-round observations—something satellite and ground-based systems alone cannot provide. We present the concept for the Arctic Airborne Observing System (ARCAOS), a proposed research infrastructure designed to close critical observation gaps in the Arctic. The concept is currently under development, and future funding opportunities are being explored.

ARCAOS makes use of the Dornier DO-228 aircraft operated by Lufttransport AS and based in Longyearbyen, Svalbard. The aircraft supports regular logistics flights between Longyearbyen and Ny-Ålesund (Svalbard), and between Longyearbyen and Station Nord in North Greenland. It is already equipped with a scientific pod and has been used for airborne hyperspectral imaging in research projects. The ARCAOS concept proposes expanding this capability into a mobile, flexible, multi-sensor science platform capable of collecting data during both dedicated campaigns and routine operations.

Planned instrumentation includes hyperspectral imaging systems, synthetic aperture radar (SAR), atmospheric sensors, and systems for deploying drifting buoys. These would enable high-resolution, year-round retrieval of observations that complement satellite and in situ measurements. Crucially, ARCAOS would support calibration and validation of satellite products and monitoring of Essential Climate Variables (ECVs), such as sea ice, snow cover, atmospheric composition, glaciers, and permafrost.

ARCAOS supports Svalbard–Greenland scientific cooperation and aligns with key infrastructures including the Svalbard Integrated Arctic Earth Observing System (SIOS), the Greenland Integrated Observing System (GIOS), and the Aerosol, Clouds and Trace Gases Research Infrastructure (ACTRIS). It is well positioned to contribute to the International Polar Year 2032–2033 (IPY-5) through interdisciplinary research and the delivery of high-impact data and services.

Recommendations for transdisciplinary projects in Svalbard

Main author: Julia Olsen, Nord University

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Abstract: Our presentation will provide recommendations for research projects in Svalbard that apply co-creation across fields, sectors, and actors from a transdisciplinary viewpoint. The results derive from a networking project, funded by Svalbard Strategic Grant: “Building transdisciplinary bridges for a sustainable Svalbard and Arctic development.” Considering the rapid changing and challenging situation in climate, society and economy in Svalbard, cooperation across disciplines and between science and society is needed more than ever to generate knowledge for the sustainable development of the archipelago. Such research cooperation between various disciplines and relevant non-academic stakeholders is conceptualized as a transdisciplinary approach. It emphasizes a need for continuous broad and holistic knowledge and relevant data-sharing across sectors to safeguard the foundation for decision-making and development strategies. However, transdisciplinarity can be difficult to navigate, and projects often still follow traditional disciplinary structures. In this presentation, we discuss some challenges for transdisciplinary research by adopting a multivocal methodology. Given the dynamic nature of transdisciplinarity, we present the themes from our discussions, opportunities, and best practices.

Session Svalbard in an Arctic context

The terrestrial and freshwater invertebrate fauna of Svalbard: an inventory and assessment of species biodiversity.

Main author: Stephen Coulson, The University Centre in Svalbard, Norway

Abstract: The terrestrial and freshwater invertebrate fauna of the Arctic remains poorly documented, with comprehensive species inventories available for only a few locations, such as Greenland's Zackenberg and Disko Island, and Canada's Cambridge Bay. Many regions lack thorough taxonomic assessments due to logistical challenges, limited availability of taxonomic expertise, and insufficient historical research. Yet, understanding biodiversity is crucial for ecological studies and conservation efforts.

This poster summarises Coulson et al. 2024 (Coulson S J, Bartlett J, Boström S, Brittain J, Christoffersen K S, Convey P, de Smet W, Dózsa-Farkas, K, Ekrem T, Fjellberg A, Füreder L, Gillespie M A, Gustafsson D, Gwiazdowicz D J, Kaczmarek Ł, Kolicka M, Laniecki R, Moerman T M, Seniczak S, Seniczak A, Simon J, Stur E, Søli G, Wieczorek K, Zawierucha K, and Zmudczynska-Skarbek K. (2024) On the terrestrial and freshwater invertebrate diversity of the High Arctic archipelago of Svalbard: a revised species inventory and synopsis of the community composition. Arctic Science 10: 799–814).

Svalbard stands out as a region with a relatively detailed invertebrate inventory (Coulson et al. 2014). However, this dataset has not been widely accessible, and taxonomic revisions in recent years necessitate updates. Here, we provide a comprehensive revision of Svalbard’s invertebrate inventory, incorporating new findings and archiving the data in the Global Biodiversity Information Facility (GBIF). This updated resource identifies gaps in molecular data in sequence libraries and highlights species requiring further study.

With over 1,000 recorded species, the Svalbard fauna database serves as a benchmark for Arctic biodiversity research. By critically appraising species records and integrating modern taxonomies, this living document aims to support ongoing research and conservation efforts in the Arctic and beyond.

Paper: https://doi.org/10.1139/as-2024-0017

Dataset: https://www.gbif.org/dataset/443d4938-8d5a-4e2e-a5b8-53fd139bb1d6

Coulson, et al. (2014) Soil Biol. Biochem. 68; 440-470.

Tracking Atlantic cod in a changing Arctic: Telemetry Reveals New Patterns in Isfjorden, Svalbard

Main author: Mathilde Oddekalv, University of Bergen

Abstract: The ongoing Atlantification of the Arctic has increased the inflow of warm, saline Atlantic water into fjords like Isfjorden, Svalbard, enabling boreal species such as Atlantic cod (Gadus morhua) to expand northwards. By using acoustic telemetry, this study investigated the seasonal presence and movement patterns of Atlantic cod in Isfjorden. Atlantic cod primarily followed the distribution of Atlantic Water in Isfjorden, both vertically and horizontally, where the greatest abundance was seen near shore. Both Coastal cod (CC) and Northeast Arctic cod (NEAC) were present in the fjord. Some NEAC left the fjord during the spawning season, and a few individuals returned, suggesting seasonal use of the fjord as a foraging ground. One CC was later caught in Lofoten, approximately 1000 km from the tagging site, challenging the general understanding of CC as a stationary ecotype. These findings underscore the importance of Isfjorden as a habitat and highlight the need for further studies on spawning behaviour and long-distance migration of both NEAC and CC in Arctic fjords like Isfjorden. Such knowledge is important not only for fisheries management, but also for understanding how the ongoing climate changes are reshaping Arctic marine ecosystems.

Two decades of monitoring of landfast sea ice conditions in Inglefieldbukta, Storfjorden, Svalbard

Main author: Dmitry Divine, Norwegian Polar Institute

Full list of author(s): Dmitry V. Divine, Sebastian Gerland, Jan Ijzerman; Norwegian Polar Institute, Norway

Abstract: The decline of winter sea ice cover in the fjords of northern and western Svalbard in the last two decades has been the focus of several studies on effects of climate change on fjord systems. The fjords of eastern Svalbard are not that frequently visited and the climate change effects on fjord ice there are not well known. Monitoring of landfast ice, with a focus on in situ measurements of its physical characteristics, has been performed at Inglefieldbukta in Storfjorden, Svalbard, since 2006. Two light huts serve as infrastructure of this site. One of the huts hosts an automatic weather station (AWS) and a time-lapse camera overlooking the bay. Beyond full season monitoring in the first years, the monitoring consists of one to three visits by scientists between March and May every year for measuring various physical sea ice and snow properties in situ, plus taking samples for later laboratory analyses.

The monitoring shows that the sea ice seasons are in general longer at Storfjorden than at the west coast of Svalbard, that sea ice grows thicker (up to 1 m and even above), and that snow amounts are larger (up to 40-60 cm). Such snow deposition has been observed to lead to negative freeboards and consecutive snow-to-ice transformation. Clear long-term trends are not (yet) visible, but data show substantial interannual variability. We apply a freezing degree days approach constrained by actual dates of the onset of sea ice formation and local meteorological data to model sea ice growth in the bay. Despite a relatively complicated history of sea ice growth on the site inferred from the analysis of sea ice microstructure profiles, it is demonstrated that this simplistic method can adequately model the thickness of sea ice at the end of the ice growth season. We further give an overview on the monitoring results so far, and also discuss linkages of the monitoring to interdisciplinary studies, such as ecosystem research, and environmental management.

Spatial Variability of Fish and Zooplankton Density in Kongsfjorden

Main author: Carina Kraemer, Master's student at UiT - The Arctic University of Norway

Abstract: The Arctic is undergoing rapid environmental shifts, with fjord systems like Kongsfjorden experiencing complex changes in both physical and biological dynamics. Capturing the spatial variability of pelagic organisms—such as fish and zooplankton—is essential for understanding how these ecosystems respond to ongoing change. However, long-term monitoring has mostly relied on fixed observatories, which may not fully reflect the spatial heterogeneity of fjord environments, especially in dynamic glacier-influenced areas.

This study is part of the broader OpKROP project, which aims to optimize the Kongsfjorden Rijpfjorden Observatory Program (KROP) by incorporating mobile platforms and expanding observation capabilities. Specifically, it investigates how representative acoustic measurements from a fixed underwater observatory are for the broader fjord system and explores how spatially distributed acoustic surveys using an unmanned surface vehicle (USV) can complement and enhance long-term monitoring.

Active acoustic data were collected by the USV across multiple stations—including previously inaccessible glacier-proximal areas—during four seasonal field campaigns in January, March, June, and September 2025. These measurements are compared to fixed-point data to assess both horizontal and vertical patterns in fish and zooplankton density. The research addresses three key questions: (1) Are densities observed at the observatory representative of the fjord system? (2) How well do limited spatial stations capture broader ecosystem patterns? (3) Can a USV improve our understanding of pelagic dynamics in challenging environments?

Preliminary results available at the time of the conference will be presented, offering insight into the spatial and seasonal variability of pelagic communities and highlighting the value of combining fixed and mobile platforms for Arctic ecosystem monitoring.

Improving short-term forecasts of sea ice edge and marginal ice zones around Svalbard

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Abstract: Sea ice is a major threat to marine operations around Svalbard, and accurate short-term (1-5 days) forecasts of sea ice edge (SIE) and marginal ice zone (MIZ) are crucial for safe marine operations. In this study, we investigate the effects of assimilating the Advanced Microwave Scanning Radiometer 2 (AMSR2) sea ice concentration (SIC), the Norwegian sea ice chart, and the Operational Sea Surface Temperature and Ice Analysis (OSTIA) sea surface temperature (SST) on the short-term forecasts of SIE and MIZ around Svalbard. The used model system, Barents-LAON, is based on the coupled Regional Ocean Modeling System (ROMS, version 3.7) and the Los Alamos sea ice model (CICE, version 5.1.2), with the Local Analytical Optimal Nudging (LAON) for data assimilation. The effects of the assimilations are evaluated through 7 model experiments, from Free_run to full assimilation of OSTIA SST, AMSR2 SIC and ice chart. The results show that the Free_run of Barents-LAON contains large bias, which significantly overestimates the sea ice extent and underestimates the SST. Assimilation of SST mildly improves the analyses of SIE and MIZ, and additional assimilations of AMSR2 SIC and ice chart both considerably improve the analyses and forecasts. We show that 1-3 days forecasts of SIE and MIZ using assimilations of both SIC and SST outperform the operational forecasts TOPAZ5 and neXtSIM from the Copernicus Marine Environment Monitoring Service (CMEMS), the US Navy GOFS3.1 system, and the Norwegian Meteorological Institute's Barents-2.5km Ensemble Prediction System (Barents-EPS). All the short-term SIE forecasts with assimilations of SIC and SST outperforms the sea ice chart persistence forecasts after the first day. However, all the MIZ forecasts, regardless of using the operational models or the current model experiments, are shown to have lower skills than the sea ice chart persistence. This tends to suggest that some important physical processes may be lacking for the transformation between dense pack ice and MIZ in the present coupled ocean and sea ice models.

Historical meteorological data from Svalbard to better understand today's Arctic warming

Main author: Björn-Martin Sinnhuber, Karlsruhe Institute of Technology, Institute of Meteorology and Climate Research IMKASF, Germany

Abstract: The Svalbard and Barents area is warming faster than any other Arctic region. Understanding this early 21st century warming requires long-term observations to put the current warming into a context of past climate change and variability. We have retrieved and compiled a variety of historical meteorological observations from Svalbard to fill existing gaps in the observational record and to improve our knowledge of the spatial variability across Svalbard. These data include observations from German military weather stations during World War II that were assumed to be lost, early observations in Ny-Ålesund, and multi-year observations from Svalbard's Nordaustlandet that experiences a very different climate compared to West-Spitsbergen. In my presentation I will describe the different data sets, their historical context, and discuss what these data tell us about past climate variability in the context of a rapidly changing Arctic.

Long-Term Observations in Ny-Ålesund: A Key to Understanding Arctic Change

Main author: Christina A. Pedersen, Norwegian Polar Institute

Full list of author(s): Christina A. Pedersen and Ingrid Kjerstad, Norwegian Polar Institute

Abstract: The Arctic plays a crucial role in the global climate system and is currently experiencing rapid and unprecedented changes. Nowhere is this more evident than in Svalbard, where warming is occurring at a rate 4 to 6 times higher than the global average. This makes Svalbard a key region for understanding the processes and feedbacks shaping a warmer world.

Ny-Ålesund Research Station hosts an exceptional concentration of long-term observational series, international research projects, and institutions from over 20 countries. This combination of multidisciplinary science and sustained presence makes Ny-Ålesund one of the most valuable Arctic observatories in the world and makes it possible to monitor, understand and explain Arctic systems and global changes.

Through the coordination efforts of NySMAC (Ny-Ålesund Science Managers Committee) and the four Ny-Ålesund flagship programmes, the research community has worked to map and share the long-term datasets available in Ny-Ålesund. This collective effort aims to inform and inspire broader scientific use of these data in new projects and applications.

This poster presents an overview of the long-term time series collected in Ny-Ålesund, highlighting their scientific relevance and pointing to resources for accessing these datasets. By increasing awareness and promoting collaboration, we can enhance our understanding of environmental change in this critical part of the Arctic.

Variability and decadal trends in the Isfjorden (Svalbard) ocean climate and circulation – An indicator for climate change in the European Arctic

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Abstract: Isfjorden, a broad Arctic fjord in western Spitsbergen, has shown significant hydrographic changes and increased Atlantic Water (AW) inflow over recent decades, changes only recently observed north of Svalbard. Using observations and reanalysis from 1987–2017, we analyse variability and trends in the fjord's climate and circulation. A structural shift occurred in summer 2006, with AW presence moving from the bottom layer to higher in the water column, along with reduced fast ice. This shift links to positive trends in mean sea surface temperature (SST) and volume-weighted temperature (VT) in winter (SSTw/VTw: $0.6 \pm 0.1/0.9 \pm 0.3$ °C $10yr^{-1}$) and summer (SSTs/VTs: 0.6 ± 0.1 °C $10yr^{-1}$). Increasing volume-weighted mean salinity in winter (0.21 ± 0.06 $10yr^{-1}$) and summer (0.06 ± 0.05 $10yr^{-1}$) suggests AW advection as the main driver. Trends in local air temperature, and its significant correlations with sea ice, SST, and VT, indicate strong fjord-atmosphere coupling. Following the 2006 shift, Isfjorden transitioned from an Arctic fjord with Winter Deep and Winter Intermediate convection and sea ice formation to a Winter Open regime dominated by deep thermal convection of AW. AW indexes for both the fjord mouth and inner fjord show consistent wintertime AW influence over the last decade. Alternations between Arctic and Atlantic type water at the mouth reflect the geostrophic balance between the Arctic-dominated

Spitsbergen Polar Current and AW-dominated Spitsbergen Trough Current. High AW impact events allow Atlantic-type water to propagate along isobaths defined by winter convection depths. Loss of sea ice and enhanced AW intrusion onto the shelf cause denser winter shelf waters, positioning warmer AW from the West Spitsbergen Current closer to the surface. These findings highlight Isfjorden's role as an early indicator of climate change in the Arctic Ocean.

Glacier thickness, thermal regime, and human error estimation from radio-echo sounding of 25 Svalbard glaciers

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Abstract: Ground-penetrating radar (GPR)-derived glacier thickness data is essential for future and past modelling of glacier evolution. In addition, information on their current thermal regimes aid in understanding the state and fate of their dynamics. Between 2019 and 2025, we collected GPR data from 22 glaciers throughout Svalbard and we present them here. We autonomously pre-process the data and then use a multi-operator radargram interpretation approach to obtain a consensus and to assess the subjective spread in bed and temperate ice picking. All raw and processed data will be made available for further use by the glaciological community.

Morpho-lithological structure of the contemporary marginal zone of the glacier on Spitsbergen

Main author: Alfred Stach, Department of Geoinformation, Adam Mickiewicz University, Poznań, Poland

The marginal zones of contemporary glaciers are a record of their dynamics. It is shaped in response to fluctuations in the climatically determined mass balance of the glacier. These reactions were very diverse due to local conditions. Knowledge of the marginal zones of contemporary glaciers is also often used to build and validate models of Pleistocene glaciations. An essential stage in research in this field is morphological and lithological mapping. It involves creating an inventory of existing landforms, determining their internal structure and spatial relations. Such mapping is currently based in various proportions on data from direct field studies and interpretation of remote sensing materials, mainly aerial photographs. The possibilities offered by the analysis of multispectral satellite data with high spatial resolution are very rarely used. They provide the possibility of area-based identification of the variability of sediment features, and especially their mineralogical composition. On the other hand, image texture analysis allows for inferences about the nature of the landforms that build the surface. These possibilities were demonstrated in the marginal zone of the Hørbye glacier.

Hørbye is a polythermal glacier with an extensive and internally complex marginal zone. In this study, a rectangular area of approximately 8.3 km2 was analyzed, covering the marginal zone and its immediate surroundings. The source data for the analyses were satellite images from MSI sensors of the Sentinel-2 series satellites and PlanetScope Dove satellites. The methodology used consisted in integrating multispectral data of different resolutions from different sensors and acquired at different times. The obtained results should be considered as preliminary, but they made it possible to identify significant variability within areas previously considered homogeneous, verify the courses of morpho-lithological boundaries and add new data to the discussion on glacier dynamics.

Do persistent organic pollutants (POPs) impact survival of female common eiders breeding in Svalbard and Northern Norway?

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Remote marine areas of the Arctic have become a sink for pollutants like Persistent Organic Pollutants (POPs), transported long distances from southern latitudes. This presence of contaminants is creating pressure on Arctic organisms. As such, Svalbard´s wildlife has been monitored for decades to follow temporal trends of pollutants, in addition to better understanding the effects of pollutants on Arctic wildlife.

Seabirds are a key group of Arctic animals that are particularly sensitive to the pollutants' toxicity via effects on behavior, demography and long-term population viability. Understanding how pollutants affect population viability is essential to protect Arctic wildlife but has been an understudied topic in marine ecology.

Two populations of female common eider (Somateria mollissima) have been monitored in Kongsfjorden (Svalbard) and Grindøya (Troms) since 2007 and 1984, respectively. Concentrations of POPs have been analyzed in eiders blood samples, between 2007 and 2009 for Kongsfjorden and from 2005 to 2009 for Grindøya. Previous studies found higher concentrations of HCB (Hexachlorobenzene) for common eiders breeding in Kongsfjorden, while it is the concentrations of PCB (polychlorinated bipheyls) that are the highest for the common eiders breeding in Grindøya. Additionally, the adult survival is higher Kongsfjorden compared to Grindøya common eiders. However, the interaction between those different concentrations of POPs and the adult survival of those two populations have not been studied yet.

Here, we will investigate whether POPs may affect adult survival of female common eiders breeding both in Kongsfjorden and Grindøya. If the POP levels are sufficiently high to induce health effects, we predict that higher concentrations of POPs will negatively affect adult survival.

Wind as a Key Element of the Arctic Energy Transition

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Abstract: Wind is a defining element of the Arctic weather due to its overall abundance, yet energy production is still mostly based on fossil fuels, propelling the fast warming and changing climate. The role of wind in the context of the energy transition in this region is diverse. Wind energy can be an alternative, relatively cheap local energy source, as demonstrated in the North American Arctic. At the same time, a windy climate poses challenges to renewable energy infrastructure through icing, snow drift and extreme wind loads. In Svalbard, where the energy transition is fully ongoing in Longyearbyen, the complex terrain makes the understanding of wind even more complicated due to the combination of large fjords, steep mountains and deep valleys, which interact with the radiative budget of a very long polar night and day, large storms and intensive polar lows. The resulting wind patterns are very local and different from other places, and Svalbard's wind climate can therefore be considered unique even within the Arctic. Some highlights of local wind investigations will be presented, illustrating that some of the local wind characteristics are beneficial for renewable energy, while others are unfavourable. This positions Svalbard as a place where intensive wind research helps understanding conditions locally, while contributing to the overall question how to efficiently adapt renewable energy technology for the whole Arctic.

Monitoring Svalbard's Changing Cryosphere: Insights from Superconducting Gravimetry (2000-2024)

Main author: Ove Christian Dahl Omang, Geodetic Institute, Norwegian Mapping Authority, Norway

Abstract: Continuous monitoring of Svalbard's sensitive cryosphere is crucial in a warming Arctic. We present findings from a Superconducting Gravimeter (SG) located in Ny-Ålesund, Svalbard, operating since 2000, providing high-precision measurements of local gravity variations indicative of mass changes. While the SG time series exhibits a long-term trend due to Glacial Isostatic Adjustment (GIA), significant short-term variability is dominated by hydrological processes, including changes in snow cover, ice masses, and particularly the annual melting season. Our analysis focuses on melt season dynamics from 2000 to 2024. We demonstrate the SG's sensitivity to melt onset, validated against QuikSCAT satellite data (2000-2008). Over the observation period, we identify a significant trend towards earlier melt onset, advancing by approximately 10 days over the last two decades. Concurrently, the duration of the melting season has markedly increased at a rate of ~2.5 days per year, extending from roughly 70 days in 2000 to ~115 days in 2024. These ground-based gravimetric observations provide critical, continuous data on the accelerating cryospheric response to climate change in Svalbard.

Sea ice - cloud feedback in the northern Barents Sea area

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Abstract: Sea ice loss is the primary driver of Arctic amplification, but other factors, such as changes in cloud cover, also contribute to the region's energy imbalance. Clouds affect the surface radiation budget in two opposing ways: they reflect incoming shortwave radiation - cooling the surface - and absorb outgoing longwave radiation - warming it. While clouds tend to have a net cooling effect globally, they are seen to be related to surface warming in the Arctic. The role of clouds is not yet fully understood in the northern Barents Sea area, where the ongoing retreat of the sea ice causes larger areas of open ocean. One hypothesis is that in spring, summer, and autumn, cloud cover acts to increase albedo, thereby dampening the warming effect and the Arctic amplification caused by a missing sea ice cover. Conversely, during the polar night in winter, cloud cover may enhance insulation by trapping longwave radiation rather than blocking sunlight, hence potentially increasing the warming effect. In this contribution, we study the connection between the changing sea ice, air temperature, and cloudiness in the northern Barents Sea area. We examine available state-of-the-art data reanalysis (ERA5 and CARRA) and satellite-derived cloud and sea ice products to test if our hypotheses are consistent with observations. The consistency between the representation of the relevant parameters in the different data sets are also discussed. The study includes a canonical-correlation analysis (CCA) to explore links between sea ice extent and cloud cover. At least one distinct regime shift was detected and will be discussed.

POLARIN Data Hub: Advancing International Collaboration and Open Science through a Federated Polar Data Infrastructure

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Abstract: POLARIN is an international network of polar research infrastructures and services designed to tackle the scientific challenges of the Arctic and Antarctic regions. It comprises a wide array of high-quality research infrastructures (RIs) both in- and outside the Svalbard region, including research stations, vessels, icebreakers, observatories, and data repositories for ice and sediment cores. By offering integrated and challenge-driven access to these resources, POLARIN supports interdisciplinary research on complex polar processes.

The project provides a unique opportunity to study Svalbard in a pan-Arctic context, because it streamlines access to data from RIs that previously were challenging to access. With the development of the POLARIN Data Hub, the project strives to make data collected using the infrastructures during the project lifetime openly available in a unified, semantically consistent manner. The hub has been built on experience gained from the development of other existing discovery metadata brokering approaches available within the consortium (SIOS, INTERACT), other European projects (Arctic PASSION, ENVRI-FAIR, EOSC) and within the broader polar data management community (SAON/IASC ADC, POLDER, WMO Global Cryosphere Watch).

The hub is built on a state-of-the-art distributed data infrastructure, which allows for streaming data directly from the authoritative source and simplifies end-to-end (meta-)data traceability. The hub supports both interactive web-based discovery and machine-readable interfaces, and it aims to provide researchers with AI-based querying functionality and data processing tools that allow for collaborative, efficient, and online data discovery and handling.

The presentation will showcase how the POLARIN Data Hub bridges fragmented data ecosystems and how POLARIN's approach to data management makes polar research data more findable, accessible, interoperable, and reusable, to facilitate innovative pan-Arctic and Antarctic research.

Shifts in Microbial Communities and Ecological Networks in a Warming Arctic Fjord

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Abstract: Microbial communities, particularly bacteria and archaea, play essential roles in Arctic marine ecosystems, driving elemental cycling and supporting food webs. While physical changes are well documented, microbial responses remain less understood. Kongsfjorden, a glaciated fjord in Svalbard, is undergoing rapid Atlantification, marked by glacier retreat, rising temperatures, and decreasing sea ice. As part of the Kongsfjorden seasonal pelagic monitoring program, we observed distinct microbial shifts under contrasting spring conditions. Microbial community dynamics in Kongsfjorden were analysed during 2019 and 2020, to assess the effects of climate-driven environmental changes. The year 2019 was warmer, with minimal sea ice and higher nutrient concentrations, while 2020 was colder and more ice-covered. Beta-diversity analyses revealed greater variation within years than across depths. Communities in 2019 were more diverse and variable, with higher cyanobacterial abundance, whereas 2020 communities were more uniform, dominated by Bacteroidota and Crenarchaeota. Network analysis showed stronger and more vertically consistent microbial interactions in 2019, while in 2020, surface-level connections were reduced but overall modularity increased. To build on these findings, we will incorporate data from 2021 to 2024, allowing for a more comprehensive temporal analysis of microbial community responses to ongoing Atlantification. Future analyses will also include protists, enabling the investigation of cross-domain interactions and co-occurrence networks between prokaryotic and eukaryotic taxa. This study highlights the role of environmental variability, particularly temperature and ice cover, in shaping microbial diversity and interactions. Our results indicate warmer conditions foster more dynamic communities, while colder conditions promote stability. These findings advance our understanding of microbial dynamics in a rapidly changing Arctic environment.

Linking Temperature and Precipitation: Observational Evidence from Ny Ålesund, Svalbard

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Abstract: Understanding the response of extreme precipitation to warming is critical for assessing future hydrological risks in the Arctic. This study investigates the Clausius-Clapeyron (C-C) scaling behavior of precipitation extremes in Ny Ålesund, Svalbard, using both daily and high-resolution 5-minute observational data. The C-C relationship, which theoretically predicts a ~7% increase in precipitation per 1°C rise in temperature, serves as the framework for this analysis. Observations indicate that precipitation extremes generally follow the theoretical C-C rate (~7%/°C) up to approximately 3°C, particularly for liquid-phase events. However, a breakdown in scaling is observed at higher temperatures, likely due to limitations in moisture availability and changes in atmospheric dynamics. Sub-daily analyses further highlight enhanced sensitivity during short-duration events and emphasize the importance of rain-on-snow and mixed-phase processes near the melting point.

ERA5 reanalysis data reveal a significant increase in convective precipitation over western Svalbard, particularly along the West Spitsbergen Current, with the strongest trends occurring during the cold season. This suggests a shift toward a more thermodynamically driven precipitation regime. Synoptic pattern classification using self-organizing maps (SOMs) identifies that warm rain and warm snow extremes are often associated with strong southerly flows and low-pressure anomalies over the Greenland and Barents Seas. Future projections based on the CNRM-CM6-1 model (total precipitation) and the MIROC6 model (separating rain and snow) under CMIP6 SSP scenarios do not indicate a consistent emergence of super Clausius-Clapeyron (C-C) scaling. Snow extremes exhibit negative or minimal scaling, particularly near the melting point, while rain extremes largely adhere to the theoretical C-C rate. These findings suggest that future precipitation extremes in Svalbard will be shaped by a combination of thermodynamic amplification, moisture limitations, and evolving synoptic dynamics, with significant implications for hydrology, permafrost stability, and ecosystem resilience in the High Arctic.

Exploring Arctic Kinorhynch Diversity through Molecular and Ecological Integration: Insights from Spitsbergen Fjords

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Abstract: Understanding how historical events and present-day connectivity shape species distributions remains a fundamental question in Arctic marine ecology. These patterns are especially critical in the light of climate-driven changes affecting the region’s biodiversity. One meiofaunal group that remains understudied in this context is Kinorhyncha—microscopic invertebrates known as "mud dragons." Despite their global presence in marine sediments, their diversity and population structure in the Arctic are poorly known. The DRAGONnest project addresses this gap by integrating ecological research with molecular analyses to assess kinorhynch diversity across key Arctic locations, including Disko Island (West Greenland), the Barents Sea, and fjords of West Spitsbergen.

Until recently, Arctic kinorhynchs were studied almost exclusively using morphology, which led to assumptions of narrow species distributions. New findings suggest broader ranges, prompting the need for molecular confirmation. By combining morphological insights with genetic markers, the DRAGONnest project aims to evaluate species boundaries, genetic differentiation, and the environmental factors influencing kinorhynch assemblages.

During 2024 fieldwork in Spitsbergen fjords, kinorhynchs from the families Echinoderidae and Pycnophyidae were collected for combined taxonomic and molecular study. Preliminary results point to regional variation in community composition and highlight the role of sediment structure—particularly particle size heterogeneity—as a key factor influencing local diversity. In contrast, trophic variables appeared to have a negligible effect on species turnover, suggesting limited importance of dietary specialization in these systems. Initial molecular analyses further suggest that some haplotypes occur across distant regions, raising questions about dispersal capacity and challenging prior views of regional isolation.

This study is one of the first to combine morphology and genetics for Arctic kinorhynchs and contributes valuable data to global biodiversity assessments. DRAGONnest

provides new insights into the resilience, connectivity, and evolutionary potential of Arctic meiofauna.

Assessing sunlight radiative transfer process through different snowpacks: an experimental approach

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Abstract: Snowpack in polar and high-altitude alpine regions plays a vital role in Earth's climate dynamics, largely due to its albedo which significantly influences local temperature and radiative energy balance. While freshly fallen snow reflects most incoming solar radiation, its albedo may diminish over time due to metamorphism and contamination by nano- and micro-particles, thus accelerating melting. In addition, several chemical and biological processes that occur in snow are supported or triggered by sunlight. In this context, the understanding of light penetration through snow layers is of utmost importance, particularly in fast-warming regions like the Arctic. Currently, the comprehension of sunlight in the snowpack primarily relies on computational models based on Radiative Transfer Equation or simulations tailored to specific snow structures. These models often depend on many variables and involve simplifying assumptions that may limit their accuracy. Therefore, this issue is best addressed following a thorough experimental approach. To this end, we developed a novel ad-hoc probe has been developed, enabling high-resolution measurements of sunlight flux in three spectral regions at different depths without disrupting the snowpack structure. This probe has shown effectiveness under diverse illumination conditions and snow characteristics, offering insights that challenge existing models and improve understanding of light-snow interactions. Our findings show that the depth to which light penetrates is significantly influenced by the unique characteristics of the snowpack. In some cases, measurements show specific features that are hard to model, opening the need for more insights into the radiative transfer process in some peculiar conditions. In future research, this approach could be expanded to include

complementary information from spectral albedo measurements, introducing an additional constraint from independent measurements of the same snowpack.

Optical characterisation of particulate matter deposited in the Arctic snowpack

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Abstract: In the context of climate change, there is a need to refine the understanding and quantification of the impact of particulate matter, primarily originating from long-range dust transport and emissions from mid-latitude regions, on the Arctic snowpack. The presence of these impurities has been shown to contribute to a decrease in surface reflectivity over time, thereby accelerating melting. However, the magnitude of these effects remains a subject of considerable scientific interest, since complete understanding of radiative transfer processes between the atmosphere and the cryosphere is still limited by the incomplete knowledge of the interaction between nano- and micro-metric particles and visible and near-infrared light.

A fundamental contribution in this respect can come from optical methods. We rely on Single Particle Extinction and Scattering (SPES) method, which enables a model-independent, calibration-free, multi-parametric analysis on melted snow samples. Based on the far-field self-reference interference between the zero-angle field scattered by a nano- or microparticle passing through a focused laser beam and the more intense field transmitted through the sample, it allows the independent and simultaneous retrieval of two optical parameters of each particle: the extinction cross-section and the polarizability.

We discuss the preliminary results from two measurement campaigns carried out in April 2024 in the proximity of Ny Ålesund (Midtre-Lovenbreen and Austre Brøggerbreen). Snow samples were collected with a depth resolution of 10 cm and subsequently analysed with the SPES instrument within a collaboration with the paleoclimate and glaciology group of the EuroCold Laboratory (University of Milano-Bicocca, Italy). A layer-by-layer stratigraphic and morphological characterisation of the sites under study is also presented.

On the motion of the magnetic pole

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Abstract: Over the past 30 years, the Earth's northern magnetic dip pole has moved approximately 1500 kilometers and continues to drift by several tens of kilometers annually. In addition to this secular shift of the pole, there has also been a reduction in the Earth's magnetic dipole moment over the last decades. An international research initiative, led by scientists at UNIS, has compiled long-term magnetic field records and decades of auroral observations from satellites and Arctic observatories to explore and understand what these changes mean for Svalbard and the Arctic. Changes in the geomagnetic field impact both technology and nature. Magnetic orientation is still widely used for navigation, and the changing magnetic orientation means that local maps as well as aeronautical and maritime charts maps will have to be updated more frequently. Natural phenomena, such as the aurora, are also being influenced. While auroral activity is largely governed by solar activity and space weather effects, long-term observations show a subtle but measurable shift in the auroral oval linked to the changing magnetic field. Looking ahead, further displacement of the auroral ovals and continued weakening of the geomagnetic field could expose mid-latitude regions to increased space weather risks—areas that are currently less impacted and thus less prepared. Likewise, the reduced effect of magnetic protection could lead to higher exposure from space radiation in polar regions.

Changes in Arctic mixed-phase clouds with global warming – insights from case studies and perturbed climate simulations

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Abstract: Clouds have an important influence on Arctic climate through their interaction with radiation. They can consist of liquid water, ice or a mixture of both. The partition between ice and liquid water is expected to change in the course of the ongoing rapid warming in the Arctic. We use a numerical weather prediction model to study how Arctic clouds may change in the future with a special emphasis on the role of different ice production processes in clouds. These processes include interactions with aerosols as well as so-called secondary ice production processes where more ice crystals are formed from existing ice particles. We use a mixed-phase cloud case observed from Ny-Ålesund, Svalbard, in November 2019 and cloud in-situ measurements from aircraft performed over the ocean between Northern Norway and Svalbard in March 2021 to validate our simulations against observations at present-day conditions. We then use the same model to study the cloud properties in a perturbed climate. We find that changes in cloud phase and thereby also in cloud radiative effect are highly related to the efficiency of different secondary ice production processes. This is due to the dependence of these processes on ambient cloud temperature.

Evaluating regional model biases in the European Arctic using paired stable water isotope observations

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Abstract: Svalbard is located within the major entry pathway of relatively warm, mid-latitude air masses into the polar region. The stable water isotope composition in atmospheric water vapour and precipitation is a sensitive indicator of the accumulated condensation history of air masses on their way into the Arctic. The progressive loss of heavy isotopes with precipitation results in the well-known latitude gradient of stable isotopes in precipitation. Here we evaluate how well a simulation with the isotope-enabled regional model COSMO-iso driven by ECHAM6 nudged to ERA5 reanalyses represents the increasing depletion with higher latitude measurement location. We thereby make use of a data set of time-resolved precipitation and vapour isotope measurements collected during February and March 2020 at Ny-Ålesund, Longyearbyen, Tromsø, Andøya, Bergen, and Finse, all located along the European entry pathway for mid-latitude air masses into the Arctic. Results show that the time variations are well represented at all three measurements sites. While the sub-Arctic and the mid-latitude sites show a small low-bias in the simulated isotope depletion for

δ18O and δD in precipitation, the indicator for non-equilibrium fractionation d-excess shows a high bias of more than 10 permil. Comparison with measurements taken on Svalbard during the ISLAS campaign show a substantial increase in scatter with no consistent bias for δ18O and δD, whereas the d-excess has a consistent low bias. Vapour measurements confirm the results the from precipitation comparison. An investigation of the thermodynamic environment within and below clouds from in-situ and remote sensing observations points to an important role of the saturation adjustment in the microphysics scheme that prevents highly ice super-saturated environments in clouds that are conducive to low values of the d-excess. The operational model AROME-Arctic allows for more wide-spread regions of ice super-saturation, but does currently not include water isotopes. We conclude that paired precipitation-vapour water isotope measurements are a valuable diagnostic for model evaluation for mixed-phase cloud microphysics in the Arctic.

LIQUIDICE - SIOS Success Story

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Abstract: The LIQUIDICE project, funded by the Horizon Europe Programme, aims to address the critical impacts of climate change on inland ice, snow cover, and permafrost, and their subsequent effects on water resources and society in vulnerable regions. This four-year initiative involves 18 partners and focuses on five key supersites: the Monte Rosa Glacier System in the Italian Alps, the Jostedalsbreen Glacier System in Norway, the Ilulissat and Kangerlussuaq Ice Sheet catchments in Greenland, the Austre Brøggerbreen, Werenskioldbreen, and Fuglebekken catchments in Svalbard, and the Ladakh Region and major river basins in the Indian Himalayas.

The primary objectives of LIQUIDICE are to reassess the past and future century-plus of climate-induced changes in these regions, develop harmonized data from satellite Earth Observation and ground stations, improve ice sheet and glacier models with Earth System Models, and inform water resource, hydropower, and socio-economic strategies through transparent communication of results and uncertainties.

Key outcomes expected from the project include the creation of FAIR-principled multi-decade data catalogues, refined assessments of glacier and ice sheet freshwater fluxes, new hydrological simulations for High Mountain Asia, and integrated socio-economic risk and adaptation assessments. By enhancing our understanding of the interplay between climate change and cryospheric processes, LIQUIDICE aims to provide accurate predictions that support effective water resource management and socio-economic planning in the face of global climate change.

New coastal landscapes emerging from the retreat of marine-terminating glaciers in the twenty-first century

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Abstract: Accelerated climate warming has caused the majority of marine-terminating glaciers in the Northern Hemisphere to retreat substantially during the twenty-first century. While glacier retreat and changes in mass balance are widely studied on a global scale, the impacts of deglaciation on adjacent coastal geomorphology are often overlooked and therefore poorly understood. The proglacial zones of marine-terminating glaciers across the Northern Hemisphere has been exposed by glacial retreat in an accelerated rate between 2000 and 2020. From the total of 2,466 ± 0.8 km (123 km a−1) of new coastline only ca 8% of the total length was identified in Svalbard. However, Svalbard has a great potential for detailed study as it hosts surprisingly diverse coastal landscape, climate and bedrock geology. It is also one of the most important clusters of surging glaciers. Combination of these factors makes Svalbard a perfect natural laboratory to study development of new coastal areas. These young paraglacial coastlines are highly dynamic, exhibiting high sediment fluxes and rapidly evolving landforms. Retreating glaciers and associated newly exposed coastline can have important impacts on local ecosystems and Arctic communities.

A FAIR-compliant individual-level morpho-functional trait database of marine swimmers and sinkers from the Mooring Dirigibile Italia (MDI) in Kongsfjorden

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Abstract: The Arctic is undergoing profound environmental transformation due to Atlantification, characterized by ocean warming, freshening, and sea-ice retreat. These changes are reshaping ecosystem dynamics and biodiversity, especially in vulnerable regions like Kongsfjorden, a high-latitude fjord in the Svalbard archipelago. Despite the central ecological role of zooplankton in Arctic marine food webs, there remains a significant lack of findable, accessible, interoperable, and reusable (FAIR) biodiversity and functional traits data. This gap limits our ability to understand and predict the impacts of climate change on both zooplankton diversity and functional dynamics within Arctic ecosystems. Here we present a FAIR-compliant, individual-level morpho-functional trait database compiled from an 8-year (2014–2022) time series of zooplankton samples collected via sediment traps deployed on the Mooring Dirigibile Italia (MDI) in Kongsfjorden. The MDI mooring provides continuous, year-round biological and physical oceanographic observations, facilitating the investigation of seasonal and interannual variability in zooplankton communities of swimmers and sinkers. Zooplankton samples were analyzed to obtain abundance, biomass, and individual level morphological measurements, complemented by metadata on life stage, sex, and categorical functional traits such as feeding strategies and reproductive modes. This comprehensive and FAIR dataset offers a valuable resource for investigating zooplankton diversity, size structure, and inter- and intraspecific variability, including during the underexplored Arctic winter. It strengthens our capacity to model community function, assess ecological processes, and track biodiversity responses in a rapidly warming Arctic. By ensuring data transparency and accessibility through adherence to FAIR principles, this database supports ongoing Open science research and contributes to conservation strategies in the Arctic.

Deep-time paleoclimate scientific drilling in Svalbard – introducing the SvalCLIME project

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Abstract: Svalbard offers a nearly continuous Phanerozoic (538.8 million years ago [Ma] to the present) geological succession that records several environmental perturbations of global relevance. Integration of excellent outcrop exposures with subsurface data from fully cored boreholes is a powerful tool to understand how the Earth System evolved in the deep geological past.

The SvalCLIME project aims to drill and fully core the Permian to Oligocene interval on Spitsbergen to decipher the deep-time local, regional, and global paleoclimatic evolution recorded in the strata. SvalCLIME comprises two proposals, both currently under consideration by the International Continental Scientific Drilling Programme (ICDP).

The first proposal, SvalCLIME-P2P (Permian to Paleogene), is a full drilling proposal that seeks to conduct systematic coring of Svalbard's nearly continuous Permian to

Paleogene (~251–34 Ma) succession. Svalbard hosts a high-fidelity, mid- to high-paleolatitude sedimentary record that will provide essential insights into global climate dynamics across this interval, especially the impact of past hyperthermal events. Drilling a high-resolution paleoclimate archive will allow for the investigation of environmental and biotic responses to large-scale igneous activity and other climate perturbations at local, regional, and global scales. This will help improve our understanding of paleolatitudinal gradients in climatic responses to global warming and how these have varied in magnitude across Earth's past.

The second proposal, SvalCLIME-H2C (Hot to Cold), is to host a workshop to develop a full proposal to collect drill core records from Svalbard across the Eocene–Oligocene Transition to test the hypothesis that the opening of Fram Strait played a major role in the establishment of global thermohaline circulation and cooling of Earth's climate.

In this presentation we present the SvalCLIME proposals and encourage involvement of the broader Svalbard scientific community.

Session Managing risks in a changing Arctic

Linking microbial and oceanographic data to study microbial resistance to antibiotics and spread under climate change scenarios in Svalbard's Kongsfjorden

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Abstract: The Svalbard archipelago is warming rapidly. As a result, both sea and land ice are retreating. Atlantification (i.e. an increasing influence of Atlantic Water in the Arctic regions) and global warming contribute to the ice melting and consequently can mobilise and release dormant but viable microorganisms entrapped in the glaciers and permafrost for thousands of years. The fate of these biological components is not yet fully known, as their dispersal and persistence after release and accumulation in the terrestrial and marine environment depend on many factors, including their adaptation to the hydrological conditions and physical processes to which they are exposed in the release environment. This study aims to explore the microbial diversity and the presence of antibiotic-resistance genes (ARGs) in cryosystems and correlate them with different water masses (Atlantic waters, polar waters, meltwater, etc.) to gain insight into their potential spread and resilience in a climate change scenario. To investigate the presence of potential pathogens and antibiotic-resistant microorganisms and genes in glaciers and water masses of the fjord, field activities were conducted in April 2025 to collect oceanographic and biological data in the Kongsfjord and two glaciers facing the fjord (Midtre Lovenbreen and Kongsvegen). Vertical conductivity-temperature-depth (CTD) measurements were carried out along the zonal transect in Kongsfjorden, seawater samples were collected at 4 stations, while snow and ice cores were taken at two sites in the Midtre Lovenbreen glacier and one site in Kongsvegen. Here we present preliminary results from the field activities carried out with the support of the SIOS (Svalbard Integrated Arctic Earth Observing System) Infrastructure Access Programme and the Norwegian Research Council as part of the Arctic Field Grant Programme.

Adaptation and strategies for risk reduction and rescue operations in a changing Arctic

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Abstract: Climate change is affecting the environment of Arctic increasing the objective dangers. These changes require adaptation in risk mitigation and response strategies in case of accidents. The Arctic regions and Svalbard Islands don't allow for mistakes during an excursion or a scientific measurement campaign. All of this has implications for how professional guides and safety personnel approach trips. Lack of statistics on accidents and near misses in Svalbard activities makes it difficult to address the challenges related to climate change. Furthermore, a system that allows an exchange of information between people who move in the environment and who can exchange strategies and opinions, could be of great interest. For these reasons, a working group has been created within the International Commission for Alpine Rescue (ICAR) to collect, process and share experiences of accidents, near misses and rescues related to climate change. Within the working group, the various episodes will be examined based on exposure (e.g. changes in snowpack, glacial retreat), adaptation (strategies implemented to solve the problem), and sensitivity (e.g. changes to routes, changes in urban planning of risk). Developing this system in a context such as Svalbard and the entire Arctic, where the effects of these changes are more intense and impactful, could be useful for adaptation.

Bridging Trust Gaps: Local and National Dynamics in Climate-related Risk Communication in Arctic Communities

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Abstract: This paper explores the complex dynamics between local and national authorities in the context of risk communication within Arctic communities, with a particular focus on Longyearbyen, Svalbard. Drawing on interview data, the study explores residents' perceptions of and trust in communications about climate-related risks, such as avalanches and permafrost thaw. The findings reveal that local authorities are generally regarded as more trustworthy, whereas national authorities are met with considerable scepticism. This trust gap appears to stem from a perceived disconnect between national policymakers and the lived experiences of Arctic residents, resulting in conflicting messages and challenges to effective long-term climate risk management. The study highlights that trust in local authorities is strengthened by familiarity, transparency, and deep-rooted local knowledge, while national policies are often perceived as inflexible and insufficiently attuned to the specific Arctic context. The study argues for the development of a more integrated and context-sensitive communication strategy to bridge the gap between local and national governance. By doing so, it emphasizes the critical need for collaborative approaches to enhance community resilience amid escalating climate-related threats. This research contributes to broader understandings of how trust influences the success of risk communication in remote and vulnerable regions.

Polar Climate and Cultural Heritage: results of the PCCH-Arctic project

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Abstract: Arctic cultural heritage holds immense value for indigenous and local populations, as well as for people in temperate regions as it reflects human interactions with this harsh and fragile region. These cultural heritage sites are irreplaceable sources of historical information, offering insights into the social, religious, and economic aspects of our ancestors' lives. Furthermore, they represent an asset for sustainable development in the Arctic region. The preservation of cultural heritage is particularly important on Svalbard, a region without indigenous inhabitants but with a history of human presence dating back to the early 1600s.

The PCCH-Arctic project focuses on the communities and cultural heritage of Longyearbyen and Ny-Ålesund. Both localities started out as coal mining communities and have numerous cultural heritage objects from this period. The project results contribute to the knowledge base for managing built environments of cultural heritage in the Arctic. The project results encompass recommendations for management of built cultural heritage in Polar climate, high-resolution climate projections, permafrost modelling, sociological aspects (such as regulation, conservation, valorization), as well as geotechnical aspects (such as assessing natural hazards and employing probabilistic geotechnical modelling). Further, these results are utilized to providing input to management procedures for preservation of several case study objects of cultural heritage in Longyearbyen and Ny-Ålesund.

The CryoGrid community model – Simulating the impacts of climate change on snow, glaciers and permafrost

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Abstract: The CryoGrid community model is a modular toolbox designed for process-based simulations of the terrestrial cryosphere. Within the model framework, model forcing from both present-day reanalysis data sets and future projections with Earth System Models can be downscaled and bias-corrected with in-situ observations, which makes CryoGrid an excellent tool for realistic projections of climate change impacts. The model configuration can be customized for a wide variety of application scenarios, in particular simulations of permafrost temperatures and glacier mass balance both at the point and regional scales. The submodels for glaciers and for permafrost use the same formulations for land-atmosphere coupling and the winter snow cover, so that consistent simulations in glacierized catchments can be performed within a single model framework.

We present an overview over recent CryoGrid applications on Svalbard, such as spatially distributed simulations of various cryospheric variables, simulations of saline permafrost, ingestion of remote sensing observations through data assimilation and machine learning, as well as simulations of the ground thermal regime below and around man-made structures. Finally, we highlight the challenges of developing and maintaining a community model for cryosphere applications and discuss directions for future development.

Systematic Risk Identification in the Energy Mix of Longyearbyen: The Role of Community Involvement

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Abstract: Longyearbyen (LYR) is currently fully dependent on imported diesel for electricity and heating. As part of a conceptual-phase energy transition, alternative fuels import is considered to the energy mix. This transition has created tensions between the locals and decision-makers. Hence, this study examines socio-technical systems for energy risk identification by first evaluating the current risk governance model in LYR, then assessing how community participation can be better integrated to elicit valuable input to the technical risk identification process.

Handling systemic risks requires a holistic approach to risk identification, with hazard identification as a key step. The study focuses on risk identification as part of risk assessment, embedded in risk appraisal and broader risk governance. The aim is to explore how inclusive governance can support context-sensitive risk identification while acknowledging limits of knowledge and uncertainty.

The fit of six concepts for inclusive risk governance in LYR are presented and examined through interviews with energy infrastructure experts, LYR residents, and scholars at The University Centre in Svalbard. The study explores how community input can be combined with technical methods to integrate local knowledge into formal risk processes.

A thematic analysis of interviews and supporting materials shows that Arctic community engagement is essential for effective hazard identification. Findings reveal a gap in risk understanding and trust between experts and the public. A suitable inclusive risk governance model can facilitate experts by clarifying community roles and the way of communicating risks and opportunities of the transition. This integration can uncover hidden risks and reduce uncertainty in the future energy system. Community insights can enhance traditional tools like the Hazard and Operability Study (HAZOP), contributing to a more holistic assessment.

Native, colonising, and invasive salmonids in the Isfjorden ecosystem, Svalbard

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Abstract: A climate-induced regime shift in the north Atlantic Ocean has altered the Atlantic water input to western Svalbard, creating Atlantification of major fjords including Isfjorden. Isfjorden is historically home to one anadromous fish, the Arctic charr but since 2006, Atlantic salmon have been increasingly observed in Isfjorden, migrating from European rivers. This increase happened simultaneously with an increasing presence of invasive pink salmon (native to the Pacific Ocean) in this Arctic ecosystem. The Svalbard fjord thus holds a unique possibility for studying the marine habitat use and range expansion of three salmonids at the northern range edge. We tagged native Arctic charr, colonising Atlantic salmon, and invasive pink salmon in Isfjorden, Svalbard with acoustic transmitters and deployed an array of acoustic receivers in the fjord. Fish movements were analysed to contrast behaviour and habitat selection. Comparison of the three species will help understand how the oceanographic changes in the Arctic are influencing biological responses and the future of these polar ecosystems as biodiversity increases.

Thawing Arctic permafrost, emerging risks: managing critical infrastructure, cultural heritage, and mountain slopes under climate change

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Abstract: The ThawingLYR research project addresses the urgent need for a comprehensive knowledge base to support sustainable management of critical infrastructure, cultural heritage, and mountain slopes in Longyearbyen, Svalbard – an area under severe pressure due to climate change. Significant challenges are due to amplified climate change and the resulting warming and thawing of permafrost. To map, observe, model, manage, and synthesize data related to this in vulnerable areas of Longyearbyen, our trans-disciplinary and interdisciplinary approach integrates methodologies from social and political science, geoscience, data science, and geotechnics, and includes local expert knowledge from local authorities, the local museum, businesses, and inhabitants. The project's primary outcome will be a fully integrated climate and permafrost response system. This online platform will provide direct access to real-time data on permafrost temperatures, active layer water content, meteorological observations, ground ice distribution, and remote sensing-derived terrain movement maps. Furthermore, it will incorporate high resolution meteorological and geotechnical models and explore the integration of novel passive seismics for active layer monitoring. The project also investigates local exposure and sensitivity to

and best management practices for permafrost-related risks in order to develop tailored adaptation strategies. By synthesizing findings and building upon previous research and collaborating closely with several other projects in the Arctic addressing thawing permafrost ThawingLYR will deliver an optimized online climate change and permafrost response system empowering Longyearbyen and other Arctic communities in their resilience efforts. Such a tool is particularly important when adapting the society both on the long-term for planning area usage, but also for short-term preparedness situation use.

Fragmented Management of Permafrost Thawing Risks, but a National and more holistic Policy on Avalanches and Landslides Risk Management

Main author: Elisabeth Angell, NORCE, Health & Social Sciences, Norway

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Abstract: In Norway, Longyearbyen on Svalbard is the largest settlement located on permafrost. All infrastructure has been constructed and adapted to a permafrost climate. Due to rising temperatures, the active layer is expected to deepen. This may lead to subsidence that can damage buildings and other infrastructure. It also increases the occurrence and magnitude of mass wasting processes. Several serious landslides have already occurred.

Svalbard is governed under the Svalbard Treaty and falls under Norwegian jurisdiction. Longyearbyen is currently undergoing significant structural transformation. Norwegian authorities aim to develop tourism, education, and research to replace the long-standing coal mining industry that is now phasing out. Notably, they do not intend to increase the settlement's population. A key feature of the community is its transience; residents typically stay for about five years.

Document analysis and interviews with local and national authorities reveal strong state governance, where different agencies manage narrowly defined responsibilities. For example, Statsbygg and Store Norske Kullkompani own most housing, heritage authorities oversee cultural sites, and AVINOR operates the airport. However, there is no overarching national politics to prevent or manage the consequences of permafrost thawing. Each agency primarily focuses on damage to its own assets. Consequently, the management approach is highly fragmented. What is lacking is a more holistic and coordinated strategy to address permafrost thaw challenges and mitigate related risks. In contrast, avalanches and landslide risk is governed by significantly more systematic and holistic national politics. In recent years, extensive avalanche protection measures have been implemented in Longyearbyen. The Norwegian Water Resources and Energy Directorate (NVE) is designated as the national avalanche and landslide authority, so that the associated risk is managed in a more holistic manner.

Integrating InSAR and ground observations to interpret permafrost-related hazards in Longyearbyen, Svalbard

Main author: Leydier Matthieu, Department of Arctic Geophysics, The University Centre in Svalbard (UNIS), Svalbard, Norway

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Abstract: Longyearbyen is located in a narrow Arctic valley surrounded by steep mountain slopes and underlain by permafrost, making it highly vulnerable to climate-driven geohazards. Ongoing climate warming has led to deeper active layer thaw and a prolonged unfrozen season, increasing the risk related to slope instabilities (landslides) and thaw subsidence.

This study uses spaceborne Interferometric Synthetic Aperture Radar (InSAR) to detect seasonal surface displacements with millimeter-centimeter accuracy. The technique is limited to summer months when snow does not cover the ground. However, thaw subsidence and slope movements mostly occur in summer and autumn when the ground surface is unfrozen, making this a suitable technique for geohazard assessment in Longyearbyen.

We compare InSAR-derived displacement patterns with geomorphology and ground ice contents in the Longyearbyen valley to investigate areas with high movement rates. Ongoing work integrates these patterns with local ground and meteorological observations from boreholes and weather stations, enabling a multi-source approach to explore drivers of surface displacements in flat terrain and on slopes.

This research contributes to the Fram Centre PermaRICH project in synergy with the RCN ThawingLYR project. It supports broader efforts to enhance geohazard preparedness and strengthen climate resilience in Arctic communities.

A geospatial tool to support Cumulative Risk Management of the Svalbard Archipelago

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Abstract: While Svalbard is a well-recognised hotspot for climate change and long-range pollution it has also been increasingly exposed to human activities such as tourism and shipping.

However, an effort to synthesise knowledge on the occurrence and intensity of current pressures on the archipelago, and further develop it into spatially explicit Integrated Risk Assessment to inform Cumulative Risk Management, is still lacking.

Here we present an interactive geospatial tool to map current and potential future (2030, 2050, 2100) cumulative impacts and risk of multiple pressures, including endogenic (tourism, underwater noise and shipping) and exogenic ones (climate change, ocean acidification and long-range transport pollution), on the Svalbard ecosystem.

The geospatial tool consists of several modules including:

• a metadatabase documenting empirical and model-generated data and methods used;

• an interactive digital atlas visualising the current and potential future impact and risk of pressures on different ecosystem components;

• an interactive mapping tool visualising the current and potential future cumulative impact and risk of combinations of pressures to support decision-making in environmental management and policy making

This tool will assist in identifying and prioritising cumulative risk and management actions based on multiple criteria, while also enabling the exploration of future scenarios under varying policy and climate conditions.

Evaluating Multi-Model Performance in Simulating Ground Temperature Dynamics in SW Spitsbergen, Svalbard

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Abstract: This study focuses on understanding ground thermal conditions to evaluate permafrost stability and hydrological responses in the High Arctic, specifically within the Fuglebekken catchment in the Hornsund region of Svalbard. We compare ground temperature simulations from the GEOtop 3.0 and CryoGRID 2.0 models, which differ in their complexity of representing heat and moisture transport, snow dynamics, and surface energy balance. The models were tested against borehole temperature data collected up to 12 meters deep. High-resolution UAV-based digital elevation models, meteorological data, and soil properties served as the input. Model performance during both calibration and validation was assessed using the Kling-Gupta Efficiency (KGE) sum from layers with temperature data. The initial results from GEOtop demonstrate how surface energy exchanges, snow cover, and soil properties interact to affect subsurface temperatures. A comparison with CryoGRID revealed similar ground temperature patterns, though GEOtop offered a more detailed representation of subsurface processes due to its adaptable soil parameterization. The findings emphasize the importance of accurately representing snow insulation, soil thermal and hydraulic properties, and surface energy fluxes for reliable ground temperature predictions. This model comparison is useful for selecting and enhancing models used in permafrost studies and Arctic climate change assessments.

Time-varying uplift in Svalbard – an effect of glacial changes

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Abstract: Arctic areas are heavily affected by climate change. The temperature is increasing, the permafrost is melting, the sea ice is disappearing, and the glaciers are retreating. The elastic response of the changes in the glacier affects the earth crust. On Svalbard the uplift can reach several centimetres pr year.

The geodetic observatory in Ny-Ålesund is a key station in the global geodetic network. It is the northern most fundamental station, containing all the main geodetic techniques and important for the realization of the International Terrestrial Reference Frame (ITRF). However, its stability has been questioned. The observatory experience variations in the uplift on seasonal, inter-annual, decadal and longer time-scales. The uplift has increased from below 6 mm/yr in the 1990 to more than 12 mm/yr today. This has challenged the realization and stability of global and regional reference frames.

We have modelled the elastic response of glacier changes based on various glaciological sources. These results will be presented. We will in particular compare the elastic uplift with geodetic time-series from Ny-Ålesund and other GNSS in Svalbard and discuss how this could effect reference frames and Earth observation.

Tracking a thawing Arctic: Expanding permafrost observations on Svalbard

Main author: Julia Lutz, Norwegian Meteorological Institute

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Abstract: The Norwegian Meteorological Institute's web portal for cryospheric information, cryo.met.no, offers real-time insights into permafrost temperatures on Svalbard, enhancing our capacity to monitor and respond to climate-driven environmental changes. Built on MET Norway's infrastructure, it integrates observational data into a robust operational system with automated quality control, archiving, and distribution via the Frost API. This enables near-instantaneous visualisation and analysis of permafrost conditions.

In recent years, new operational permafrost stations, co-located with automatic weather stations, have been established further inland and in remote areas of Svalbard. These efforts are part of projects like SIOS (https://sios-svalbard.org/), COAT (www.coat.no/en/), and BarentsCryoClim. Each station is equipped with high-precision ground temperature sensors and a full scale weather station with extended measurement programme, allowing for a comprehensive view of local climate dynamics. Several new stations from external stations holders have recently been added to the station network, with plans for further expansion. This growing network enables the study of spatial variability in permafrost on Svalbard, including coastal-inland and east-west gradients, highlighting the complex regional patterns in permafrost response to climate change. The exceptionally warm summer of 2024 led to record active layer thicknesses and notable rises in permafrost temperatures, underscoring the pace of change.

The portal now generates ten continuously updated products, providing researchers, policymakers, and stakeholders with timely, actionable data. Updated daily, these real-time products offer faster insights than ever before and may support future early warning systems. This enhances both scientific understanding and informed decision-making in the Arctic.

Hectometric weather modelling of extreme precipitation events in Svalbard: A case study of the 2016 landslide events

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Abstract: Ongoing and projected changes in Svalbard include rising air temperatures, increased precipitation, and more frequent extreme weather events with heavy rainfall. In autumn 2016, Longyearbyen experienced two major rainfall events that triggered landslides and caused infrastructure damage. Aiming to improve local forecasts relevant for landslide risk assessment in Longyearbyen and the surrounding area, we evaluate the added benefit of hectometric weather simulations. The two extreme precipitation events serve as test cases.

We conduct hectometric-scale weather simulations using a modified version of the HARMONIE-AROME model system, which in its operational configuration is used by the Norwegian Meteorological Institute for weather forecasting in Svalbard. Increasing model resolution allows for better representation of high-resolution atmospheric processes, such as orographic lifting and local convection, which influence the spatial variability and intensity of precipitation in the complex terrain around Longyearbyen. Observations from automatic weather stations, borehole temperature records, and local precipitation measurements are used for model verification.

Preliminary results suggest that higher-resolution simulations capture sharper precipitation gradients and higher peak intensities compared to coarser-scale models. To assess the sensitivity of the high-resolution simulations to the large-scale flow provided by the host model, additional time-lagged boundary experiments are planned. These experiments will help to evaluate how slight changes in large-scale forcing affects precipitation patterns. Further evaluations of the spatial structure and contributing physical processes are underway.

This study contributes to a broader understanding of ground instability risks in Svalbard under a changing climate, and the outcomes will support the development of integrated weather-landslide early response systems in Svalbard, as part of the RCN-funded ThawingLYR project.

Layer by Layer: Vegetation's Role in Active Layer Insulation in Svalbard Tundra

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Abstract: Tundra ecosystems across the Arctic are being drastically reshaped by climate warming, with substantial consequences for ecosystem functioning. The rate and direction in which ecosystems change is influenced by the interactions between permafrost and vegetation. While it is known that Low Arctic shrubby vegetation can affect permafrost thaw by slowing down winter cooling and summer warming, it is unknown if the same mechanisms and associated plant-traits apply for sparse High-Arctic vegetation, which is dominated by bryophytes and graminoids. Across twelve tundra sites distributed throughout the High-Arctic Archipelago of Svalbard, we investigated the role of different vegetation types in insulating permafrost. At each site, we established three plots representing key vegetation types: (i) vascular plant-dominated, (ii) bryophyte-dominated, and (iii) mixed communities. The aim was to investigate how vascular and bryophyte properties contribute to the insulation of the active layer over the season.

Bryophyte cover was significantly associated with shallower thaw depths and lower mean summer surface temperatures compared to vascular vegetation dominated by graminoids and shrubs. Soil temperature variation at 5 cm depth was primarily linked to the thickness of bryophyte and organic layers, with greater thickness leading to cooler soils. This implies that permafrost insulation mediated by High-Arctic vegetation is strongest in bryophyte-dominated communities with thicker organic surface layers. Based on our observations, ongoing vegetation shifts that reduce bryophyte abundance and organic layer thickness may be detrimental to permafrost insulation. The present findings represent an important advancement in understanding how vegetation mediates active layer insulation in natural High Arctic tundra ecosystems.

Soil moisture content estimations from autonomous electrical resistivity tomography monitoring to improve slope stability modelling in Longyeardalen

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Abstract: Quantifying the soil moisture content in the active layer above permafrost in sloping terrain is critical for understanding slope stability and potential for active layer detachment slides. Current climate warming is leading to increased precipitation, melting of ground ice at the top of the permafrost, and a longer thawing season in Svalbard. These factors together increase the risk of active layer detachment slides that may impact infrastructure in Longyearbyen. Soil moisture is typically monitored at single points using in-situ water content sensors that require excavations for the installation of the sensors at different depths in the ground. This invasive method can disturb the sensitive Arctic environment and alter measurements, and is restricted to the active layer. Automated Electrical Resistivity Tomography monitoring is a novel technique that can be used to indirectly monitor the soil moisture content in the subsurface (both in the active layer and permafrost) with minimal disturbance. It monitors the subsurface electrical resistivity, which can be inverted to soil moisture content. An Automated Electrical Resistivity Tomography line, which runs surveys twice a day in the winter season and four times a day in the thawing season, was installed adjacent to Vannledningsdalen in Longyearbyen in November 2024. To convert the resistivity results to soil moisture, sensors were installed in the active layer at different depths at two locations along the line and a best fit was derived using Archie's law. The soil moisture derived from the Electrical Resistivity Tomography profile can then be used to improve slope stability models, increasing the understanding of active layer detachments slides and debris flow risk at any given time, and in turn increasing resilience to these geohazards in Longyearbyen.

Interannual surface displacement trends in the permafrost landscape of western Svalbard

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Abstract: Permafrost is sensitive to ongoing climate change, making it important to monitor due to its role in the global carbon cycle, its influence on ecosystem stability, and the integrity of Arctic infrastructure. Monitoring surface subsidence and heave over multiple years can provide valuable insights into how the ground responds to climatic changes, with long-term subsidence being an indicator for ground ice loss and related permafrost degradation.

This study presents early results from satellite radar observations using Interferometric Synthetic Aperture Radar (InSAR) to detect interannual surface displacement trends from 2018 to 2023 in western Svalbard. The study focuses on areas around Ny-Ålesund and Longyearbyen, which are underlain by continuous permafrost and have experienced substantial warming in recent decades. Sentinel-1 images acquired between consecutive snow-free seasons from 2018 to 2023 were processed with a Small Baseline Subset (SBAS) algorithm to track long-term vertical ground movements across the landscape, highlighting changes that are otherwise difficult to detect through field measurements alone.

Our preliminary results reveal widespread subtle patterns of long-term surface subsidence and heave. Most lowland areas show gradual vertical changes in the mm-cm/year range, while larger movement rates are detected on some landforms such as pingos and ice-cored moraines. Initial comparisons with field measurements suggest that long-term subsidence is more commonly observed in areas with an ice-rich uppermost permafrost.

We will discuss the potential of satellite-based monitoring to detect slow, long-term dynamics in permafrost landscapes related to ground ice conditions and permafrost thaw. The work contributes to our understanding of surface displacements and ground ice dynamics under ongoing climate change in Svalbard.

Developing a Permafrost & Climate Change Response System

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Abstract: Longyearbyen, situated in a narrow valley surrounded by steep mountain slopes and built on permafrost, is undergoing strong climatic warming. With rising air temperatures, the permafrost active layer thickness increases and stays unfrozen longer into the autumn. Climatic warming and thawing permafrost in Longyearbyen have two major consequences: (1) damage of the town's infrastructure and cultural heritage and (2) an increase of landslide risk due to mountain slope instability.

Longyearbyen has minimal space to expand due to limited safe space between the mountain slopes and the river that impose hazards such as avalanches, landslides, and flooding. To efficiently use available space, to maintain current infrastructure, and to understand the increasingly dynamic landscape, we need to monitor, model and predict natural changes and hazards in Longyeardalen. Therefore, we build the online Permafrost & Climate Change Response System, providing valuable resources for researchers, educators, the municipality, infrastructure owners, and inhabitants.

Ground- and satellite-based observations, and landslide and weather modelling output will feed into the Response System. The ground-based instruments consist of thermistors strings in boreholes measuring permafrost and active layer temperature with depth, soil moisture sensors, weather stations, passive seismic stations, and time-lapse cameras for deformation monitoring. These instruments are equipped with telemetric devices that send data real-time over the mobile network. The landslide model requires a digital elevation model, ground characteristics, such as ground ice content, thermal properties, and grain size of the sediment obtained from borehole cores, and high-resolution weather simulations that resolve the steep topography around Longyearbyen. These weather simulations are validated with meteorological data from weather stations in and around town. Deformation maps from interferometric synthetic aperture radar (InSAR) are correlated to landforms in the valley to identify areas of concern in the wetter summer and autumn periods and to ground and meteorological conditions for more robust landslide prediction.

ID77- Hectometric weather modelling of extreme precipitation events in Svalbard: A case study of the 2016 landslide events

Main author: Teresa Remes, Development Centre for Weather Forecasting, Norwegian Meteorological Institute, Norway

Full list of author(s): Teresa Remes (1), Marvin Kähnert (1), Marius O. Jonassen (2), Sibylle Krause (3,2), Morten Køltzow (1), Kerstin Ebell (3)

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3 University of Cologne, Germany

Abstract: Ongoing and projected changes in Svalbard include rising air temperatures, increased precipitation, and more frequent extreme weather events with heavy rainfall. In autumn 2016, Longyearbyen experienced two major rainfall events that triggered landslides and caused infrastructure damage. Aiming to improve local forecasts relevant for landslide risk assessment in Longyearbyen and the surrounding area, we evaluate the added benefit of hectometric weather simulations. The two extreme precipitation events serve as test cases.

We conduct hectometric-scale weather simulations using a modified version of the HARMONIE-AROME model system, which in its operational configuration is used by the Norwegian Meteorological Institute for weather forecasting in Svalbard. Increasing model resolution allows for better representation of high-resolution atmospheric processes, such as orographic lifting and local convection, which influence the spatial variability and intensity of precipitation in the complex terrain around Longyearbyen. Observations from automatic weather stations, borehole temperature records, and local precipitation measurements are used for model verification.

Preliminary results suggest that higher-resolution simulations capture sharper precipitation gradients and higher peak intensities compared to coarser-scale models. To assess the sensitivity of the high-resolution simulations to the large-scale flow provided by the host model, additional time-lagged boundary experiments are planned. These experiments will help to evaluate how slight changes in large-scale forcing affects precipitation patterns. Further evaluations of the spatial structure and contributing physical processes are underway.

This study contributes to a broader understanding of ground instability risks in Svalbard under a changing climate, and the outcomes will support the development of integrated weather-landslide early response systems in Svalbard, as part of the RCN-funded ThawingLYR project.

Data assimilation of inter-annual ground subsidence into a permafrost model

Main author: Clarissa Willmes, Department of Geosciences, University of Oslo, Norway

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Abstract: Increases in permafrost temperatures are observed globally and models predict this increase to continue with climate change, imposing economic, societal and environmental consequences. For well-informed future projections of permafrost evolution, accurate representations of current ground states are needed, but the models typically suffer from the spatial and temporal sparsity of in-situ measurements. The permafrost ground ice content is one of the most important variables determining ground subsidence and landscape development upon permafrost thaw. Quantifying and monitoring surface subsidence has long been a challenge, but novel remote sensing using the InSAR technique can now quantify the surface subsidence signal over several years. In particular, the InSAR Svalbard project has recently compiled the first prototype maps of multi-annual surface subsidence around Ny-Ålesund, which show a clear subsidence signal of several centimeters in the last years in some areas, while other areas have remained stable. In this study, we combine the CryoGrid community model with inter-annual ground subsidence observations in a data assimilation scheme to constrain the ground ice content of the uppermost permafrost layers. We investigate the suitability of this data assimilation scheme to infer subsurface parameters by applying it to a set of well-studied and monitored permafrost sites. We present a dedicated validation data set comprising permafrost properties from promising field sites with largely varying permafrost conditions on Brøgger Peninsula, Svalbard.

Session New technologies and methods: how can they benefit polar science?

Glaciers from above and below: applying the observational pyramid in Svalbard

Main author: Richard Hann, NTNU UAV Icing Lab, Norwegian University of Science and Technology, Norway

Abstract: The observational pyramid is a multi-tiered framework designed to integrate diverse data sources across spatial and temporal scales in a wide range of research applications. By combining satellite imagery, ground-based surveys, aerial drones, and underwater drones, this approach enables a comprehensive understanding of glacier dynamics, facilitating cross-validation between different observation levels. The pyramid's strength lies in its ability to bridge large-scale remote sensing data with high-resolution field measurements, enhancing our ability to monitor and predict changes in glacier behavior, including surging events.

In this study, we apply the observational pyramid to two surging glaciers in Svalbard: Borebreen and Fridtjovbreen. At Borebreen, we employ a combination of high-resolution satellite imagery to track large-scale ice movement, uncrewed aerial vehicle (UAV) surveys for detailed surface mapping, and ground-based observations to measure ice velocity, thickness, and deformation. Additionally, underwater exploration using remote-operated vehicles (ROVs) and autonomous underwater vehicles (AUVs) provides key insights into subglacial hydrology and meltwater dynamics, while uncrewed surface vehicles (USVs) contribute marine-surface measurements to complement the broader dataset.

At Fridtjovbreen, we extend this approach to investigate the interaction between subglacial hydrology and methane emissions. Aerial and submarine drones have been deployed to map the glacier front, identify subglacial meltwater channels, and analyze their connection to methane release from the glacier bed. This multi-method approach allows for a detailed examination of how glacial meltwater pathways influence greenhouse gas fluxes in the Arctic environment.

By integrating these diverse observation techniques, the observational pyramid enhances our understanding of surging glacier behavior, providing critical insights into ice-ocean interactions, subglacial hydrology, and climate-driven glacier dynamics. This methodology not only improves our ability to study individual glacier systems but also offers a scalable framework for broader Arctic and cryospheric research.

Long-term ecological research in short postgraduate courses: a multi-year student collaboration in UNIS course Arctic Winter Ecology

Main author: Stephen Coulson, The University Centre in Svalbard, Svalbard, Norway

Abstract: UNIS provides field-based education in Svalbard, with postgraduate courses running intensive 5–6-week modules. This short timeframe typically limits student project work to studies that yield usable data within 2–3 weeks. As a result, long-term ecological studies, such as assessing winter survival in soil microarthropod faunas, might seem unfeasible. However, can these courses still collect and archive high-quality data from long-term experiments?

This poster presents a method where students in bachelor and postgraduate courses collaboratively conduct a multi-year experiment to measure overwintering survival of soil microarthropods. The AB-329/-829 Arctic Winter Ecology course, taught each spring, includes an ongoing project assessing the response of the soil microarthropod fauna to environmental stressors across the full 9-month winter period.

The system operates across multiple student cohorts:

1. In Year I (autumn), bachelor students begin the new cycle and establish the experiment.

2. In Year II (spring), AB-329/-829 students maintain and manipulate environmental conditions (e.g., controlled icing or snow depth). These samples will be examined by AB-329/-829 in Year III.

3. In Year III (spring), AB-329/-829 students analyze samples prepared in Year I and manipulated in Year II while manipulating samples for AB-329/-829 Year IV.

4. AB-329/-829 students in Year II analyse samples from the previous cycle from prior to Year I.

This structure enables continuous, multi-season experiments while engaging students in both data collection and analysis.

Key outcomes include:

• Full-winter experiments producing valuable data and unexpected findings.

• Strong student engagement through contributions to future cohorts.

• High-quality publishable and archived data: two papers published, with more in progress.

This approach demonstrates how short postgraduate courses can support long-term ecological research while enhancing student learning and scientific contributions.

A digital twin of Svalbard's cryosphere (SvalbardDT)

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Abstract: In this contribution, we will update on the development of a Digital Twin Component (DTC) of Svalbard's cryosphere (SvalbardDT) as part of the European Space Agency's (ESAs) Digital Twin of the Earth (DTE). We will construct a new DTC of the ice and snow of Svalbard's cryosphere in the 21st Century through an automated data management system to ingest, harmonise, and analyse data products. Earth Observation (EO) data products describing glacier dynamics, snow cover, and sea ice variability combined with atmospheric reanalysis data will be ingested into our DTC. These data products are multi-modal i.e. they are collected at different resolutions, scales and time/spatial periods. Therefore, the DTC will fine-tune a deep learning foundational model to ingest the relevant data products and harmonise them into a 4D data cube describing the data set variable, x-dimension, y-dimension, and its changes over time. Our aim is to generate weekly to monthly data cubes describing ~15 parameters. With spatially modelled data cubes, we will next initiate a feedback loop to train the DTC using multi-modal learning. SvalbardDT will focus on the application of two case studies. Firstly, we will study the impacts of extreme weather events on Svalbard's cryosphere, such as Rain on Snow and Ice, by analysing 'emergent behaviour' from the AI models that may elucidate new understanding of these physical processes. The second use case will focus on developing the DTC as a tool for optimising marine and terrestrial navigation across Svalbard and associated waters in response to changing snow and ice conditions. These 'use cases' have been developed using feedback from stakeholder engagement meetings. The development of a DTC that can map the current state of the cryosphere and analyse the physical processes interconnecting the different sub-systems has profound implications for marine and terrestrial decision-making as well as our understanding of the fundamental physical processes that govern Svalbard's cryosphere. We will present the architectural design of our DTC, the data products used, and the first results of the AI models used to harmonise these multi-modal data sets.

IceView – Operational mapping of landfast sea ice around Svalbard

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Abstract: Landfast sea ice (LSI) is critical for understanding coastal environments, including biological habitats, heat exchange processes, travel and navigation conditions, and environmental change and impacts. Despite its significance, a continuous mapping effort or pan-Arctic dataset of LSI has been lacking due to historically sparse satellite data and the difficulty in distinguishing LSI from temporarily stationary pack ice.

The ongoing project IceView, funded by the Svalbard Integrated Arctic Observing System (SIOS) and the ESA Arctic PhiLab, aims to test a new method to develop and providing access to a ten-year LSI dataset for the coast of Svalbard. The goal of the project is to evaluate the approach and the potential relevance of continuing monitoring as a potential SIOS core variable for Svalbard or for extending the monitoring to other regions in the Arctic. The dataset will be developed using an automatic workflow and processing chain created within the project, utilizing Synthetic Aperture Radar Interferometry (InSAR) from Sentinel-1 satellites.

The InSAR technique is sensitive to ice and ground surface movements and will enable mapping of areas that are landfast but also how responsive ice in different regions is to external forcing conditions, which can help track regional ice stability over time. The resulting LSI maps will be incorporated into operational routines by the Norwegian Ice Service to help map ice conditions for Svalbard. The algorithms will also be tested on larger geographical regions to investigate the potential for pan-Arctic ice mapping.

On the value of being there: What ethnography can add to studies of Arctic (geo)politics

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Abstract: When talking and reading about the Arctic, one often encounters two starkly contrasting perspectives on the nature of the region's political affairs. On the one hand, the narrative of "Arctic exceptionalism" portrays the Arctic as a "peaceful, unique region of mutually beneficial cooperation and a low probability of conflict." On the other, the future of the Arctic is viewed as an "arena for political competition and rivalry" in which "global warming has given birth to a new scramble for territory and resources". Yet, there is more to Arctic politics than simplistic dichotomies or popularized geopolitical analyses. To fully explore these nuances warrants a greater appreciation of the diversity of methods available for social scientists. In this article, we explore the apparent neglect of ethnographic data in this context and argue not only for expanding the use of ethnographic data, but also for making the use of such data more explicit, recognised and reflexive. To this end, we find it is crucially important to articulate the particular strengths of ethnographic methodology in relation to the study of arctic politics. Drawing on our own research on political processes in Svalbard, Norway, we therefore illustrate the essential role ethnographic data can play in making sense of what is going on in Arctic (geo)politics.

MET-AICE: an operational data-driven sea ice prediction system for the European Arctic

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Abstract: There is an increasing need for reliable short-term sea ice forecasts that can support maritime operations in polar regions. While numerous studies have shown the potential of machine learning for sea ice forecasting, there are currently only a few operational data-driven sea ice prediction systems. Here, we introduce MET-AICE, a prediction system providing sea ice concentration forecasts for the next 10 days in the European Arctic. To our knowledge, it is the first operational data-driven prediction system designed for short-term sea ice forecasting. MET-AICE has been trained to predict sea ice concentration observations from the Advanced Microwave Scanning Radiometer 2 (AMSR2) at 5 km resolution. After one year of operation, we show that MET-AICE considerably outperforms persistence of AMSR2 observations (root mean square error about 31 % lower on average) and forecasts from the Barents-2.5km physically-based model (root mean square error about 50 % lower on average).

Improving Our Understanding of Processes at The Base of Glaciers: A New and Improved Multi-Sensor Ploughmeter

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Abstract: Understanding subglacial processes is crucial for predicting future sea-level rise, but in situ measurements remain challenging due to difficult accessibility and harsh conditions. Current subglacial measurement technologies have seen little advancement since the 1990s. To address these challenges, we introduce a new multi-sensor ploughmeter to gather detailed measurements at the glacier base.

Our instrument can measure ploughing stress, water pressure, and pore pressure to explore their interrelationships, investigate ice-bed coupling and assess the influence of surface meltwater on sliding. Additionally, it includes a differential pressure sensor for studying sediment weakening through clast ploughing [1] and an electrical conductivity sensor to differentiate water sources and understand the connectivity of the subglacial hydrological system. Recognising the limitations of previous analogue ploughmeters [2], our design incorporates an inertial measurement unit (IMU) providing instrument attitude to separate physical and instrument-induced responses better, thus enhancing data interpretation.

In this poster presentation, we will outline the design, testing, and calibration procedures required for the autonomous operation of the ploughmeter in extreme conditions. Our multi-sensor approach represents an advancement in subglacial measurement technology, offering the potential to gain new insights into the coupling of ice and the bed and subglacial hydrology.

[1] Rousselot, M., & Fischer, U. H. (2005). Evidence for excess pore-water pressure generated in subglacial sediment: Implications for clast ploughing. Geophysical Research Letters, 32(11). https://doi.org/10.1029/2005GL022642
[2] Fischer, U. H., & Clarke, G. K. C. (1994). Ploughing of subglacial sediment. Journal of Glaciology, 40(134). https://doi.org/10.1017/S0022143000003853

Non-target screening as a new tool to better understand climate and environmental pollution

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Abstract: While more than 100,000 different organic compounds exist, only a few dozen are commonly targeted in environmental studies, limiting our understanding of key climate and environmental processes. Today, thanks to the development of highly sensitive high-resolution mass spectrometers and non-target screening workflows, it is possible to achieve a broader and more comprehensive characterization of environmental samples by identifying thousands of different compounds.

Here, we present two pioneering approaches and preliminary results leveraging non-target screening analysis of snow samples for two distinct objectives: (1) developing new proxies for the reconstruction of marine productivity, and (2) achieving an holistic characterization of environmental pollution by identifying a broader set of organic contaminants.

The results open up promising avenues for the chemical characterization of the Svalbard and Arctic cryosphere, from long-term reconstructions of marine productivity to enhanced monitoring of organic pollution, as well as the study of long-range transport mechanisms from lower latitudes to the Arctic.

Finally, the integration of these techniques in Svalbard holds strong potential for strategic interdisciplinary collaborations with research institutions based in Ny-Ålesund, particularly those involved in marine ecology, snow, and atmospheric research, paving the way for future partnerships and scientific advancements.

InSAR Svalbard Ground Motion Service: Pilot Products and Development Plan

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Abstract: Since 2018, InSAR Norway (https://insar.ngu.no), the Norwegian Ground Motion Service (GMS), has provided Sentinel-1 InSAR displacement maps and time series for mainland Norway. At a European level, the European Ground Motion Service (EGMS) maps ground displacement across Copernicus member states. However, Svalbard remains uncovered by both services. Its distinct environmental conditions — short snow-free seasons, continuous permafrost, nonlinear displacements, and patchy coherent areas due to glaciers and fjords—require tailored InSAR processing strategies.

In addition, the user needs differ from the mainland. A dedicated InSAR Svalbard GMS will serve the needs of management agencies and local stakeholders in charge of hazard monitoring and land-use planning, as well as researchers in e.g. permafrost, glaciology, and polar science.

The InSAR Svalbard Development Project (2023–2025), funded by the Norwegian Space Agency and NGU, lays the foundation for an operational GMS in Svalbard (www.ngu.no/en/geological-mapping/insar-svalbard). In 2023, user needs and product development plan were summarized in an open-access report (https://hdl.handle.net/11250/3125660). The identified needs have guided the design of the products and visualisation tools. In 2024, pilot products were generated in three areas in Svalbard (Longyearbyen, Ny-Ålesund, Svea).

Two product types were produced:

1. Seasonal time series during snow-free periods, capturing thaw subsidence, frost heave, and slope creep.

2. Interannual time series between snow-free periods, documenting long-term permafrost changes in flat areas.

In fall 2024, products were shared with a user group through a web portal. Feedback from a following user workshop and survey guided 2025 refinements. Automation of the processing chain is underway to support future scaling. A first public release is planned for late 2025.

This contribution presents the products, their uses and limitations, illustrates the web portal functionalities, and outlines future development plans for an operational InSAR Svalbard GMS.

Long-term Analysis of Vertically Resolved Cloud Observations at Ny-Ålesund (Svalbard) using Self-Supervised Deep Learning

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Abstract: Climate change is particularly evident in the Arctic, where warming between 1979 and 2021 was almost four times faster than the global average (Rantanen et al., 2022). However, this temperature increase is not uniform across the region. For example, the Svalbard archipelago, situated in the warmest part of the Arctic, has experienced the most significant warming (Dahlke and Maturilli, 2017). Understanding the role of clouds in the rapidly changing Arctic climate system, along with the underlying processes, remains a major challenge. While detailed cloud observations are crucial, only a few Arctic locations with continuous, high-resolution vertical cloud measurements exist. One of these sites is the German-French Arctic Research Base AWIPEV, located at the Ny-Ålesund Research Station in Svalbard. Here, a 94 GHz cloud radar has been operational since 2016 as part of the Transregional Collaborative Research Centre TR172 on Arctic Amplification (AC)³ (http://www.ac3-tr.de; Wendisch et al., 2023). Combined with existing remote sensing tools such as ceilometers and microwave radiometers, this setup enables continuous monitoring of clouds with high temporal and vertical resolution. This presentation will showcase key findings from these multi-year cloud radar observations. A novel approach to efficiently characterize the long-term observations of diverse cloud systems over Ny-Ålesund is applied by using a self-supervised deep learning framework. This machine learning approach has been recently applied to satellite images of trade-wind cumulus clouds to describe their organizational variability (Chatterjee et al., 2024). For Ny-Ålesund, the method has been adapted to time-height images of cloud radar measurements. During training, it captures the non-linear, orthogonal aspects of the clouds' vertical and temporal structure over Ny-Ålesund and extracts the essential low-dimensional features. The extracted cloud features will be combined with additional measurements, e.g., cloud water amount, thermodynamics,

radiation, and precipitation observations. In this way, we will gain valuable insights into cloud evolution and its dependency on the environmental conditions.

FAIR Open Virtual Research Enrnviroments: A new tool to store, share, analyse data from the **all-year round CO2 fluxes multi-instrumental observatory in the High Arctic Tundra**

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Abstract: Arctic amplification will bring rapid changes in the tundra carbon cycle, possibly transforming the tundra from a carbon sink into a carbon source. Monitoring the all-year-long CO2 cycle is a challenge, due to the remoteness, the winter weather conditions and the lack of infrastructures. Nevertheless, all-year data are extremely precious, to fill the data gaps due to the lack of data on winter emissions (the “great unknown” of the Arctic carbon cycle according to Susan Natali, 2019), and the scattered collection of data that is possible to collect during the short summer, making it difficult to provide an all-year round accurate tundra carbon budget. We made the most of the opportunities offered by the new Virtual Research Environments (VRE) in the framework of the Next Generation EU Project “ITINERIS” and the CNR Data Centers (IADC) to build an integrated, multi-instrument, all-year round observatory of CO2 fluxes, consisting in an array of instruments that measure CO2 fluxes at different scales, as portable flux chambers, Eddy Covariance and an array of below and above ground CO2 sensors aimed to measure winter CO2 fluxes from the snowpack, particularly aimed to intercept wind gusts generated emissions, when the Eddy Covariance fails due to the absence of vertical turbulence, all complemented by meteorological stations.
All data are integrated and made available following the FAIR principles through a web portal available through the Italian Arctic Data Centre, SIOS, the Svalbard Integrated Observing System and a CNR Virtual Research Environment (VRE). We aim to create an open virtual laboratory for modelling arctic CO2 fluxes at multiple scales and to serve as seed for a pan-arctic network of similar observatories, possibly including other observation platforms as airborne remote-sensing (either from drones or satellites).

Fibre-optic sensing for environmental monitoring at Hornsund: results of the first land-based DAS deployment in Svalbard

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Abstract: Environmental seismology focuses on studying ground motion and changes in shallow subsurface properties using passive seismic recordings. Within this field, cryoseismology examines glacial and permafrost processes—areas traditionally difficult to monitor. The SIOS-funded FROST project explored the application of fibre-optic sensing, specifically Distributed Acoustic Sensing (DAS), for cryoseismological research in Svalbard, a region experiencing rapid warming and hosting long-term seismic and environmental monitoring infrastructure. Compared to conventional geophones, DAS provided significantly higher spatial resolution, though issues like large data volume and lower signal-to-noise ratio remain. The project achieved a milestone by conducting the first land-based DAS deployment in Svalbard, installing 9 km of fibre-optic cable and 44 geophones across tundra and Hansbreen glacier in Hornsund in autumn 2023 and spring 2024. Despite harsh Arctic conditions and logistical challenges—including cable damage from Arctic foxes, snow burial, and delayed site access due to sea ice—valuable DAS data were acquired in both autumn 2023 and spring 2024. These data captured seismic signals related to icequakes, drifting icebergs, and glacier calving. Furthermore, we analysed the continuous ambient seismic noise measured with DAS, both on tundra and on the glacier, to investigate the feasibility of time-lapse monitoring of the near surface, particularly the active permafrost layer dynamics. Such dynamics are already being observed at the permanent seismometer array at Hornsund. This pilot study demonstrated the feasibility of long-term, high-density DAS monitoring within the Svalbard observing system. The experience gained in deploying and maintaining the fibre-optic system under extreme Arctic conditions is valuable for future DAS campaigns.

Svalbard Integrated Arctic Earth Observing System (SIOS) Remote Sensing Service

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Abstract: Svalbard Integrated Arctic Earth Observing System (SIOS) is a consortium of 29 research institutions from 10 countries with research infrastructure in Svalbard. SIOS builds on the collective observational capacity and research infrastructure to develop and maintain an observing system focused on processes in – and interactions between – the atmosphere, cryosphere, hydrosphere, geosphere and biosphere. Remote Sensing is an important component of the observing system, allowing study of the entire archipelago even in bad weather or during polar night. Remote sensing also has the potential to offset some of the environmental footprint of research activities. The purpose of the SIOS Remote Sensing Service (RSS) is to be the focal point of a network of remote sensing data producers, users and other stakeholders, bridging the gap between the space agencies and the Svalbard science community. The SIOS RSS works to ensure that researchers have access to appropriate data to effectively conduct their research, provides training to the next generation of remote sensing specialists, and promotes Svalbard as an Earth Observation satellite calibration/validation supersite.

We present some of the tools and resources the SIOS RSS makes available to the Svalbard science community including Copernicus Sentinel-related tools, the Svalbard satellite database, the remote sensing discussion forum, materials from previous remote sensing training courses, and access to high performance computing resources and remote sensing software packages in Longyearbyen. We introduce a Product Inventory register allowing dataset producers to increase the visibility of their products derived from remote sensing. We also solicit feedback on community need for remote sensing data, geospatial products, training, and support for calibration/validation activities via an online User Requirement survey, allowing the Svalbard science community to help shape the SIOS RSS to better serve its needs.

The Arctic Data Centre: from data to information

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Abstract: The Arctic Data Centre (ADC) is a service provided by the Norwegian Meteorological Institute and gives access to FAIR data through FAIR services and includes information from distributed data repositories. Dedicated efforts have been put on developing interfaces that lower the barrier for scientists to search, access, integrate and reuse data from different sources, by following consolidated community standards. Services have been developed to give quick access to data visualization as well as machine-to-machine interfaces to allow programmatic searches throughout the catalogue. The technical solutions used to support ADC are modular, cost-efficient and allow for easy integration of data across communities through interoperability and compliance with international standards.

The ADC is both an aggregator, harvesting data from external data repositories, and a data repository, providing support and publication services to users. The team supports data providers to publish data that can be used in an inter- and multidisciplinary perspective, which is needed to approach complex scientific challenges, promoting and supporting data-driven research about the earth system, climate and environmental change. The ADC, as a partner data center, feeds into the SIOS Data Management System and contributes to the SIOS unified data catalogue as well as the SAON Data Portal and WMO Global Cryosphere Watch.

The Svalbard Marginal Ice Zone Campaigns 2024/2025 - distributed networks of wave, sea-ice drift, and temperature observations

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Abstract: The coupling of weather, sea-ice, ocean, and wave forecasting systems has been a long-standing research focus aimed at advancing Arctic forecasting systems. In 2024 and 2025, we deployed large networks of buoys north of the Svalbard Archipelago in the Marginal Ice Zone to observe and better understand the complex interplay between the atmosphere, waves, and sea ice in the Marginal Ice Zone (MIZ). The observed variables include air and surface temperature, sea-ice drift, and wave energy spectra. The large network of buoys allows for a representative comparison between in situ observations and gridded model data, and we initiated a Model Intercomparison Study with about 20 different model setups, employing various coupling approaches and complexities, provided by ten international modelling and forecasting centers. We will give a detailed overview of the results of the campaign in 2024, where the coupled weather, sea-ice, and wave system was very dynamic in that region. The beginning of the campaign was characterized by strong northerly winds with temperatures around -20°C, leading to a compact sea-ice cover north of Svalbard. A subsequent shift to easterly winds led to a gradual break-up of the sea ice and the formation of polynyas north of Spitsbergen. In the second period, after all the buoys were deployed, the weather changed to southerly winds, accompanied by air temperatures about 20 degrees higher, and waves from the Atlantic with significant wave heights of up to 5 meters. This shift in the weather towards southerly warm air and larger waves resulted in a well-defined and northward-shifted sea-ice edge.

CATAIN: Exploring Fine-Resolution Dynamics of Newly Settled Invertebrates Using a Prototype Camera

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Abstract: Settlement dynamics and post-settlement mortality of sessile invertebrates is a black box in marine benthic ecology. Most studies capture recruitment (i.e., survival of an individual until the researcher returns) rather than the in-situ growth and survival of newly settled sessile invertebrates. Quantification of settlement in situ is labor-intensive and nearly impossible in remote habitats, meaning nearly every settlement study takes place in highly populated and accessible habitats. In an effort to alleviate this shortcoming, we have developed a prototype camera, CATAIN (CAmera To Analyze INvertebrates), which can be deployed in-situ for months at a time, giving us a never before possible fine resolution glimpse into this important bottleneck. CATAIN captures settlement, growth, and post-settlement morality in sessile invertebrates remotely at daily intervals. A 2019 review by Molis et. al. stated that “for most of the benthic species in Kongsfjorden it is neither clear when, how often, and on which spatial scales settlement happens, nor what kind of post-settlement processes affect recruitment success.” Now we do. We have deployed CATAIN in Kongsfjorden, Svalbard for nearly two years. Beyond tracking seasonality of settlement of myriad hard bottom taxa, we found relationships between environmental factors and the settlement timing of barnacles. We also documented incredibly high rates of post settlement mortality, especially for barnacles. These findings suggest settlement is a larger bottleneck than previously assumed for seafloor communities in the Arctic, significantly contributing to recruitment success. Further, we find that the adherence to accepted paradigms seems to be species and region specific. These exploratory studies show the capabilities of CATAIN as a promising research tool in the remote Arctic and illuminate previously unknown early life-history characteristics of common sub-tidal benthic invertebrates in this difficult to study and rapidly changing environment.

Snow map services for estimating seasonal snow conditions over Svalbard in real-time

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Abstract: Seasonal snow cover is a dominating, seasonal land cover feature in Svalbard for more than 7–8 months of the year. Up-to-date and forecasted snow conditions, including rain-on-snow events and snow melt rates, are crucial information for protecting life and infrastructure (e.g. avalanche forecasting), planning of transportation and tourism, as well as for scientific purposes (e.g. hydrology, ecology, meteorology). However, the operational observation of snow amounts across Svalbard is hampered by the sparsity of measurement stations. Furthermore, the operational station network has a geographical bias towards low elevations, challenging a representative view of the highly variable snow depth in Svalbard's rugged topography and windy winter conditions.

Daily updated maps of simulated snow conditions in Svalbard (at 1 x 1 km resolution) have been operationally produced by the Norwegian Water Resources and Energy Directorate (NVE) since 2020. These snow maps, simulated by the seNorge snow model and weather data from the Arome Arctic model, are publicly available via the SeNorge.no website. Using an energy-balance approach, the University of Oslo provided alternative cryospheric grid-data maps (2.5 km resolution) for seasonal snow and glacier mass balance, based on the CARRA re-analysis for the period 1991-2024 and using operational weather forecasts from Arome Arctic for real-time updating. We present the first results from a comparison between these two high-resolution snow mapping products for Svalbard. We also present results from recent field campaigns assessing the representativity of a few automated snow depth measurement stations on Svalbard. These analyses are based on 1 x 1 km snow depth surveys around the station sites during February-March 2023 and 2025.

Satellite data for Svalbard - the Norwegian National Ground Segment

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Abstract: This presentation showcases how the Norwegian Ground Segment (NBS) is delivering long-term access to Copernicus satellite data for Norway, Svalbard, the Norwegian and Greenland Seas and much of the Barents Sea. We present the system's architecture, data holdings, usage trends, and future developments.

Operated by the Norwegian Meteorological Institute for the Norwegian Space Agency, the NBS provides streamlined access to Sentinel-1, -2, -3 and -5P data via the satellittdata.no portal. Data covering an area surrounding Svalbard are also made available via the SIOS data access portal. Users can access data in both original SAFE/SEN3 format and CF-NetCDF, visualise data on the fly using the Web Mapping Service (WMS). Data can be efficiently streamed, subsetted, and integrated into workflows via a THREDDS Data Server supporting OPeNDAP and direct download.

The archive spans from the launch data of each platform (dating back to 2014 for Sentinel-1A) to the present, ensuring multi-decadal Earth observation coverage. Maintaining such a comprehensive historical archive is critical for understanding environmental change in the Arctic and surrounding regions, supporting a variety of applications including, but not limited to, sea-ice monitoring, land cover mapping, sea surface temperature mapping and atmospheric composition and dynamics.

Future Sentinel missions—including Sentinel-6 and other upcoming Copernicus missions—will be included as they become available.

The Isfjorden Weather and Ocean Observing System (IWOOS): Bridging Observational Gaps in a Key Arctic Region

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Abstract: The Isfjorden Weather and Ocean Observing System (IWOOS) has been developed to address critical observational gaps in atmosphere–ocean data within Isfjorden, central Svalbard—an area of high relevance for Arctic climate change research. IWOOS integrates multiple observational platforms, including cost-efficient ocean moorings equipped with sensors that monitor surface waves and subsurface ocean properties. Complementary atmospheric data are collected using various platforms, including vessels operating in the fjord that are instrumented for meteorological observations. This multi-platform approach enables high-resolution, continuous monitoring in regions often undersampled by conventional observing systems. A primary objective of IWOOS is to provide high-quality in situ data for the validation and calibration of satellite remote sensing products, thereby improving their accuracy in the challenging Arctic environment. Additionally, the system supports detailed studies of atmosphere–ocean interactions and contributes to long-term climate monitoring efforts. Real-time data transmission, enabled via 4G and Iridium satellite communication, also provides up-to-date weather and sea-state information to enhance safety for operations in Arctic waters. Preliminary results will be presented to demonstrate the system’s performance and its potential contributions to Arctic environmental research.

Electromagnetic emission in ice bending failure tests

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Abstract: Detection of acoustic and electromagnetic emission is used for structural health monitoring of materials and structures (Sharma et al, J. Mater. Sci., 2021). Acoustic emission in ice caused by crack nucleation is in the range of 100-200 kHz (Lishman et al, Cold Reg. Sci. Techn., 2021). Energy and number of acoustic hits depending on fracture types are used to describe ice failure process. Lengths of p-waves with frequencies 100-200 kHz are shorter 4 cm. Waves of such short lengths are detected on relatively short distances from locations of cracks nucleation, so they are useless for remote observations of ice. Electromagnetic emission is caused by spontaneous charge separation at the crack edges during initiation and subsequent charge removal under the action of electric current caused by the difference in electrical potential at the crack edges. Pulses of electromagnetic emission were measured in tests on ice compression and indentation conducted with small specimens (Thiel, Cold Reg. Sci. Techn.,1992; Fifolt et al, Phil. Mag., 1993; Shibkov et al, Phys. Prop. of Crystals, 2005; Tanurcov&Marchenko, IAHR Ice Symp, 2022). It was noted that pulses of acoustic and electromagnetic emissions are synchronous. A set of tests with fixed ends beams was conducted in cold laboratory of UNIS in 2023-2024 (Marchenko et al, IAHR Ice Symp, 2022). During these tests, the ice is destroyed under a specific combination of bending and compressive stresses, which is also typical for the loads that destroy floating ice. Acoustic sensor PK 15I and electromagnetic antenna were connected to the oscilloscope during the tests, and the trigger was synchronized with the acoustic sensor. At the initial stages of beam deformation, synchronous acoustic and electromagnetic signals were recorded in all tests. After the formation of large cracks, only acoustic signals were recorded. The frequency of electromagnetic signals in the range of several MHz makes it possible to use electromagnetic emission for remote observations of the stress-strain state and destruction of ice. At the same time, the very low power of electromagnetic emission affects requirements for the antenna and range.

A new approach for measuring solar radiation and its application for solar energy production at high latitudes

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Abstract: Solar energy at high latitudes is gaining interest as a key component in the energy transition for Longyearbyen and other Arctic communities. However, the lack of accurate data on solar potential hinders the confident development of solar projects.

At UNIS, we have developed a novel instrument called GLOB, which consists of pyranometers (solar light sensors) that measure solar radiation in 26 different directions, covering a full 360° view. This design eliminates the need for mechanical actions that could fail in the harsh Arctic climate. The goal of this innovative approach is to estimate solar irradiance with high precision, surpassing the accuracy of models that contain large uncertainties at high latitudes. This will provide reliable estimates of yearly solar energy production for Longyearbyen.

With the data gathered by GLOB, we developed an algorithm finding the best estimation of beam and diffuse solar irradiance. This allows us to confidently determine the global irradiance across 360° of azimuth and all angles of inclination. Additionally, using a neural network-based approach, we can replicate the 360° global irradiance estimates with fewer pyranometers at different locations.

To validate our estimation of beam and diffuse irradiance, we deployed GLOB in Ny-Ålesund this year, alongside high-quality irradiance instruments from the BSRN network. This deployment was made possible thanks to the Arctic Field Grant.

This research not only aids in solar energy planning for the industrial sector but also holds promise for solar energy forecasting. This can help anticipate energy penetration in isolated grids like Longyearbyen's, ensuring a more stable and predictable energy supply.

How did R2D2 land in Adventdalen? Story of the multi-directional solar panel rig.

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Abstract: UNIS recently initiated research to enhance our understanding of renewable energy in high-latitude regions. As part of the "renewable energy group" at the Arctic Technology department, we constructed a rig equipped with solar panels that measure the solar energy produced on nine different faces: North, East, West, and South, with tilts of 90°, 45°, and 0°. R2D2 was born and deployed in Adventdalen, near Longyearbyen, in April 2024.

Since its deployment, the energy produced by R2D2 has been dissipated through resistors and recorded. We aim to understand how the Arctic's distinct solar regime, which is marked by low sun angles and strong seasonal variations, and its cold, snowy climate affects solar production. This experiment offers important insights into solar production in the Arctic and serves as a demonstration of how to build a solar panel rig that can function as a measurement unit.

Sampling Strategies in Data-Scarce Regions: An Adaptive, Quantum-Inspired Approach

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Abstract: This paper integrates principles from Svalbard Integrated Arctic Earth Observing System (SIOS) prioritization documents and recent The State of Environmental Science in Svalbard Report (SESS) findings with a quantum-inspired, adaptive sampling framework tailored for Arctic environments. Recognizing the urgent need to detect, attribute, and respond to rapid, multi-system environmental changes—particularly in data-scarce, rapidly shifting regions such as Svalbard—this approach balances classical sampling methods with insights from Quantum Decision Theory (QDT) and Earth System Science (ESS) priorities. Maintaining multiple “superposed” sampling designs and iterating based on real-time data enables researchers to capture both broad representativity and fine-scale signals of change across interconnected subsystems. This method aligns with evolving strategies promoting interdisciplinary integration, supersite development, and scaling observations from Svalbard to the broader Arctic. Ultimately, it aims to build a responsive, resilient sampling protocol capable of detecting tipping points before they become irreversible, while minimizing environmental impact and supporting long-term modeling efforts.

Assessment of Snow Depth in Fugleberget Catchment, Hornsund, Svalbard Using Terrestrial Laser Scanning

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Abstract: The accurate assessment of snow depth in polar regions is crucial for understanding hydrological processes and predicting water availability. This study focuses on the use of Terrestrial Laser Scanning (TLS) to measure snow depth in the coastal unglaciated Fuglebekken catchment, located in Hornsund, Svalbard. Consecutive TLS scans were conducted during the snowmelt period in May and June 2024, utilizing the Riegl VZ-6000, which provided high-resolution spatial data on snow depth variations. The TLS data were complemented by in situ measurements of snow depth and Snow Water Equivalent (SWE), as well as satellite imagery to capture the extent of snow cover. The integration of these diverse datasets allowed for a comprehensive analysis of snow dynamics in the study area. Initial results indicate significant spatial variability in snow depth, influenced by topography and microclimatic conditions. The TLS scans revealed detailed patterns of snow accumulation and ablation, which were compared with the in situ measurements. Satellite imagery provided a broader context for understanding regional changes in snow cover. This study demonstrates the effectiveness of the TLS in capturing fine-scale variations in snow depth and highlights the importance of combining multiple data sources for robust snow assessments. The findings contribute to the improvement of hydrological modelling and water resource management in polar environments.

Drone-based flux estimations of greenhouse gas emissions from rivers in periglacial environments

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Supervisor: Norbert Pirk, Department of Geosciences, Section of Physical geography and Hydrology, University of Oslo, Norway

Co-supervisor: Gabrielle Emma Kleber, Department of Geosciences, The Arctic University of Norway (UiT Tromsø), Norway

Abstract: Periglacial environments in Arctic settings feature complex systems of groundwater springs and in parts glacial-fed rivers that have recently been found to emit large amounts of strong greenhouse gasses like methane (Kleber et al., 2023). The flux rates and mechanisms behind these emissions are however still largely unknown and disputed (Strock et al., 2024). Observations of these methane emissions and models of the underlying mechanisms are therefore critical for understanding these environments and their effect on the regional and global climate system.

We investigate different water bodies on Spitsbergen through observations of surface layer methane concentrations using drone-based point measurements as well as path-averaged concentrations along variable path geometries. We compare methane emission estimates from Lagrangian stochastic particle models (Wolz et al., 2022) as well as Bayesian inverse modelling (van Hove et al., 2025). Preliminary results indicate that this observing system is capable to localize methane hotspots and quantify their emission strength.

A comprehensive snow observing system to monitor the seasonal evolution of the snowpack and the impacts of warm spells in Ny-Ålesund

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Abstract: Due to amplified Arctic warming, Svalbard has warmed four times faster than the global average, leading to more frequent winter warm spells and associated rain-on-snow (ROS) events. These events significantly alter snowpack properties, glacier mass balance, ecosystems, and infrastructure, necessitating improved understanding of their impacts on seasonal snow cover as their frequency and intensity are projected to increase. While numerical models and remote sensing assess spatial impacts on the cryosphere, detailed ground-based measurements are essential to bridge the multi-scale gap. To this end, a comprehensive snow observing system was installed in late 2020 in Ny-Ålesund (West Svalbard), providing continuous, high-resolution data on snow depth, SWE, albedo, temperature, and liquid water content. The data collected over these years accurately show the seasonal evolution of the snowpack, from its formation in late autumn to its melting in summer. At the same time, they also highlight the rapid increases in snowpack temperature and wetness during RoSs events, offering crucial insights into snowpack dynamics. Here, we present the instrumental setup, the data collected and potential strategies for local communities to prevent the consequences of RoS events.

Quantitative and fast snowpack stratigraphy: the Snow Light Optical ProbE (SLOPE)

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Abstract: The snowpack is a mixture of ice crystals, liquid water, water vapor, air, and various other compounds and particles. The structure, composition and chemical-physical characteristics are in continuous evolution due to many factors. To understand the metamorphic processes and to evaluate the avalanche danger a stratigraphic study of the snowpack is usually carried out. Each layer is characterized by a series of parameters like the shape and size of the grains, the hardness and water content. Characterizing the stratigraphy of the snowpack is time-consuming, exposes the operator to the dangers of the arctic environment, and the results are often influenced by the knowledge and skills of the operator him/herself.

In order to meet the need of rapid and quantitative analyses of the characteristics of inhomogeneous solids, we developed the Snow Light Optical ProbE (SLOPE), a device providing quantitative measurements of the snowpack profile. This system is based on the illumination of the snow with a light source and the simultaneous measurement of the backscattered light through a photodetector. One of the aims of the probe is to become an easy and fast method to provide the information about the optical properties of the snow, that can be related to the typology of snow grains. The probe has been custom-made, assembled at the Optical Laboratory of the University of Milan, validated at the European Cold Laboratory Facilities (EuroCold Lab) of the University of Milano – Bicocca and preliminary tested in a number of alpine environments characterized by different types of snow.

We believe that SLOPE could be very important for analyses of the arctic snow, allowing correlations across multiple sites, speeding up operations and reducing the operator exposure to risk in polar environments.

Svalbard at the Forefront of Global Change: The Role of Marine Robotics in Polar Observations

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Abstract: Svalbard is a critical region for studying the impacts of global environmental change, yet observational data remain sparse due to the constraints of conventional monitoring methods. Emerging technologies, particularly marine robotic platforms, are transforming our capacity to collect high-resolution, spatially distributed oceanographic and environmental data in these remote and challenging environments. This study emphasizes the value of robotic systems in enabling sustained, low-impact data acquisition in polar marine settings.

The dataset compiled through these robotic deployments includes measurements of hydrographic properties, pollutant concentrations, and biogeophysical parameters at the land-ocean interface, particularly in fjord and estuarine systems. These observations provide key insights into freshwater discharge, pollutant transport, stratification processes, microbiological modifications and other key parameters supporting the interpretation and validation of satellite-derived products. In addition, in-situ data contribute to the characterization of local environmental variability and to the assessment of anthropogenic pressures on fragile Arctic ecosystems.

The work focusing on datasets from recent robotic deployments–specifically during two recent missions, RELOAD (2022) quantifying heavy metals in meltwater from tidewater glaciers in Hornsund Fjord, and ARIVE (2023, SIOS Access) examinting pollutant runoff into Adventfjorden– also highlights the role of data management practices aligned with FAIR (Findable, Accessible, Interoperable, Reusable) principles, ensuring that these unique datasets remain accessible and actionable for future research and long-term environmental monitoring. Overall, the study demonstrates the growing importance of data-centric, robotic-enabled oceanographic missions in advancing our understanding of polar marine systems.

Innovative Marine Robotic Platforms for High-Resolution Monitoring of Arctic Fjords

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Abstract: The Arctic region is undergoing rapid transformations due to climate change, with tidewater glaciers playing a key role in freshwater and sediment input into fjords. Understanding the dynamics and consequences of these processes is often hindered by the difficulty of accessing the hazardous glacier-ocean interface, where traditional manned vessels cannot operate safely. In this context, lightweight, modular, and reconfigurable unmanned marine vehicles such as SWAMP and PROTEUS offer a transformative approach to polar science.

PROTEUS is a portable and transformable UMV able to operate as a surface, semi-submersible and underwater vehicle. SWAMP, is a flexible, lightweight ASV studied for extremely shallow waters and harsh environments. Their modular design allows adaptation to specific scientific goals, including plume detection, surface and subsurface sampling, and hydrographic column profiling.

This work presents the technological advancements and field applications of these robotic platforms during campaigns conducted in Ny-Ålesund (2015, 2017, 2018), Hornsund (2022), and Adventfjorden (2023), focusing on high-resolution sampling and monitoring of freshwater plumes and environmental parameters near glacier fronts. These vehicles enable close-range operations in dynamic and dangerous environments, allowing for the collection of physical-chemical profiles, water samples for contaminant analysis, and cooperative observations with UAVs for integrated air-water monitoring.

The ability to autonomously reach areas influenced by subglacial discharge and perform 3D environmental mapping opens new avenues for environmental assessment and long-term ecosystem monitoring. These campaigns demonstrate how portable and reconfigurable autonomous marine robots contribute to polar science by overcoming logistical and safety constraints, improving spatial-temporal data resolution, and supporting global efforts for climate change observation and mitigation.

Metal oxides heterojunctions for the detection of the ultraviolet radiation through the snowpack

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Abstract: The increasing warming of the Planet is having its major consequences on the Arctic region. In addition to affect local ecosystems, the rapid changes in cryosphere properties have global-scale implication on climate. The interaction of the solar radiation with the snowpack is the primary driver of these changes. Light propagation into the snow contributes to the snowmelt, which in turn causes a reduction in the snow cover albedo and its associated feedback effect. Furthermore, ultraviolet radiation (UV) has been shown to be responsible for the photolysis of solids compounds deposited into the snow; consequently, some gaseous pollutants are emitted into the atmosphere. A complete understanding of these phenomena requires a deep investigation of the radiative transfer process through the snow. Our purpose is to measure the intensity of the solar radiation at different depths into the snowpack, associating the intensity profile with the measured snow properties. We focus on the UV, which can penetrate more than ten centimetres into the snowpack, about twice the penetration depth of the visible light. Since the UV flux from the Sun is a small fraction of the total solar irradiance and a great fraction of it is absorbed by the Earth atmosphere, a high efficiency sensor with a large collection area is needed. Similarly, transparency to visible light to minimise the impact on the system is another important requirement. Metal oxides heterojunctions resulted to be suitable for this application. In view of the development of an ad hoc UV photodetector, we propose a TiO_2-NiO UV-sensor realised with sol-gel methods. The deposition procedure and the electrical characterisation of the first prototypes are presented; current-voltage profiles under dark conditions are reported, as well as the photocurrent produced under UV illumination at different wavelengths. The electrical measurements are accompanied by the optical characterisation of the samples.

Radiative properties of free carbon aggregates and their impact on snow albedo

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Abstract: Despite their comparatively short atmospheric lifetime, black carbon aggregates are volatile and abundant enough to be found in a variety of environments far from their sources[1]. In addition to influencing the local thermal and radiative balance while suspended in the atmosphere, they are among the main drivers of cryospheric degradation. This contribution is particularly relevant in climate-sensitive areas such as the Arctic and mid-latitude glaciers[2].

More broadly, their effectiveness in interacting with solar radiation accounts for the substantial impact of carbonaceous aerosols on climate. This is due to both their composition and shape: the former enables absorption across a broad spectrum, while the latter enhances their internal electromagnetic response. A large body of research has investigated the growth, transport, structure, and composition of these particles. However, many studies of their microphysical properties—including optical parameters—rely on destructive, indirect, or model-dependent measurements[3].

We employ a non-destructive optical technique that can be used in situ and allows us to measure several optical parameters at once, on a particle-by-particle basis. As the results are model-independent, we can examine the validity of commonly made assumptions[4]. Both field measurements and laboratory tests show that aggregate particles exhibit exceptional scattering and absorption efficiencies relative to their mass. A strong connection is observed between the morphology of carbon-based aerosols and their radiative properties. After quantifying these, we discuss the effect of the interaction of carbon aggregates with snow, particularly their impact on snow albedo.

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[4] L Cremonesi (2020) Aerosol Sci Technol 54.4: 353-366

Probing the polar atmosphere with uncrewed aerial vehicles (UAVs)

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Abstract: Observations of the upper-air meteorological state, or of surface characteristics in the Arctic are scarce, and are typically limited to few sites with stationary instrumentation or to satellite retrievals. Such observations typically cannot resolve the full spatial and temporal scales of related processes in the Arctic climate system: for example the evolution of the vertical thermodynamical structure of the boundary layer or related spatial gradients due to small-scale heterogeneities in the surface characteristics.

With the advent of specialized, user-friendly and affordable uncrewed aerial vehicles (UAVs), and the ongoing miniaturization of state-of-the-art atmospheric sensors, such systems are becoming increasingly popular platforms for polar research, as they bridge the gap between stationary and aircraft/satellite observations. UAVs can be used to target the lower atmosphere with lower personnel and financial investment compared to conventional aircraft, and can be operated in rough terrain or in regions, that would otherwise be hard to sample.

We present insights from four drone campaigns in the Arctic, including northern Finland, Ny-Ålesund/Svalbard, and from an icebreaker campaign in the Central Arctic sea ice, including both fixed-wing and multicopter UAVs for measurements for atmospheric structure. We also highlight future plans for UAV-borne measurements of atmospheric radiation and skin temperature, and its application in the Svalbard region.

Measurements of Arctic ultrafine aerosol particles during melting season 2024 using UAV and tethered balloon

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Abstract: Ultrafine particles (UFPs) play an important but still poorly understood role in the changing Arctic climate system. To improve that understanding, a field campaign was carried out during the 2024 melting season at the research site Ny-Ålesund, Svalbard. The campaign used the tethered-balloon system BELUGA and the research drone ALADINA, both equipped with comparable instruments to measure the number concentration of aerosol particles smaller than 20 nm as well as the number size distribution above 150 nm.

Between May 19 and June 7, 2024, a total of 43 BELUGA profiles and 40 ALADINA flights with 136 profiles were conducted. The combination of vertical and horizontal profiling from both platforms provided a three-dimensional picture of the spatial distribution and variability of UFPs in connection to meteorological parameters and local conditions within the lowest 1.5 km of the atmosphere.

The results show that UFP presence varies strongly depending on local atmospheric conditions. On some days, UFPs were observed mainly at higher altitudes, while on others they were found near the surface or in association with cloud layers. Selected case studies illustrate this variability: on 22 May, high UFP concentrations were measured near the surface in the morning and evening, with a noticeable interruption in between in connection to a change in the prevailing wind direction.

On 24 May, particularly high UFP concentrations exceeding 10,000 cm^{-3} were observed, along with pronounced temporal and spatial variability in the horizontal distribution over just a few hundred meters—likely influenced by orographic features and shifting wind regimes. On 29 May, UFP were detected between cloud layers, suggesting that particle formation might have been influenced by mixing processes.

To build a more comprehensive picture of the ambient conditions driving new particle formation in the Arctic boundary layer, ground-based data from nearby stations will also be incorporated. This study provides valuable insights into the mechanisms driving UFP formation and transport in the rapidly changing Arctic environment, offering an important contribution to regional climate research.

Svalbard Radar Snow Penetration Experiment

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Abstract: We will present the results of a two-part fieldwork campaign on Svalbard targeting quantification of K-band radar penetration into snow. Radar penetration is one of the most important knowledge gaps for the snow on sea ice thickness measurement of the future CRISTAL satellite, of which the data provided by this project will contribute to a better understanding. The fieldwork is aimed at characterizing conditions where the penetration is ambiguous, or more precisely, where the measured range between the radar and snow surface corresponds to somewhere within the snow layer, and not in the snow-air or snow-ice interfaces.

Results from the fieldwork campaign are divided between measurements from dry snow at Kjell Henriksen Observatory (KHO) on Breinosa close to Longyearbyen, and snow on the Hansbreen glacier and lake Revvatnet in Hornsund, in the vicinity of the Polish research station. For the former, results presented contain a longer time series between the months of March and May, where changes in penetration over time can be observed and compared with meteorological data from the Breinosa weather station. For the latter, the main results consist of measurement runs at regular intervals either up the glacier or on the lake, with information about the location of main stratigraphic layers within the snowpack. In the data collected on Hansbreen glacier, we can distinguish ice lenses up to 80cm below the air-snow interface, corresponding to rain events during past winter, demonstrating significant radar penetration into snow.

This work is funded by an Arctic Field Grant "Svalbard Radar Snow Penetration Experiment – SValpen" from the Norwegian Research Council.

Observing Marine-Terminating Glaciers: A Combined Aerial and Underwater Methodology

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Abstract: The impact of climate change on the Arctic is increasingly evident, as glaciers experience higher-frequency surges and melting events, leading to dynamic structural changes and the irreversible transformation of the surrounding landscape. While aerial surveys using satellites and drones have advanced our understanding of glacier dynamics, the submerged portions of marine-terminating glaciers remain largely unexplored.

This project addresses this critical gap by mapping sections of the submerged front of a marine-terminating glacier as it enters the ocean. Using a Remotely Operated Vehicle (ROV) in coordination with an Unmanned Aerial Vehicle (UAV), we created a comprehensive view of the glacier's structure both above and below the waterline. Fieldwork was conducted at Fridtjovbreen, a recently surging marine-terminating glacier located in Van Mijenfjorden, Svalbard. To maximise optical data quality, operations were scheduled during the winter months, taking advantage of reduced turbidity caused by minimal runoff. To our knowledge, this represents the first optical survey of a marine-terminating glacier in Svalbard.

We successfully surveyed two glacier sites optically and collected hydrographic data at one using a CTD sensor mounted to the ROV. In this work, we discuss the robotic setup, operational challenges of conducting Arctic fieldwork, and our glaciological and biological findings. This research not only provides a critical snapshot of the current state of Arctic glaciers but also introduces a novel methodology for surveying these complex environments, offering new insights into the dynamics of glacial surges and their interactions with marine ecosystems.

Initial EarthCARE Aerosol Observations in the Arctic

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Abstract: The Earth Cloud, Aerosol and Radiation Explorer (EarthCARE) mission was launched on 28 May 2024. Its objective is to enhance our understanding of cloud-aerosol-radiation interactions and the Earth's radiative budget using observations from three optical instruments—the ATmospheric LIDar (ATLID), a Multi-Spectral Imager (MSI), and a Broad Band Radiometer (BBR)—from ESA, along with the Cloud Profiling Radar (CPR) from JAXA. The satellite flies at a relatively low altitude of 393 km with an equatorial revisit time of 25 days. ATLID has a 30 m footprint, and the MSI swath is 150 km wide. The first Level 2 data have now been made publicly available.

Here, we present an analysis of the initial aerosol observations obtained in the Arctic. We utilize information from the “C” frames of ATLID and MSI, which cover the area north of the Arctic Circle. We show statistical results for layer-based optical thickness and aerosol extinction profiles across various aerosol types obtained from the ATLID target classification, including dust, smoke, continental pollution, and sea salt. Aerosols observed in the area around Svalbard are compared with those in other parts of the Arctic.

A Ground-Based Technique for Virga Detection over Ny-Ålesund, Svalbard

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Abstract: Virga, a phenomenon where precipitation evaporates/sublimation before reaching the surface due to dry air. Virga plays a critical role in shaping the Arctic's energy balance, hydrology, and climate. Virga remains poorly understood due to limited observations, especially in polar regions. Conventional satellites such as CloudSat provide valuable insights but struggle to accurately capture near-surface precipitation due to blind zones, leading to significant uncertainties in precipitation estimation. To address this gap, this study proposes an improved ground-based method for detecting virga using the Micro Rain Radar (MRR). This technique uses a season and height dependent reflectivity (Ze) and fall velocity (W) thresholds to identify virga. The outcomes are future validated with surface disdrometer data to ensure observational accuracy. This tool is tested with the field observation in Ny-Ålesund which is a climatically sensitive Arctic site and among the fast warming regions of the world. The outcome indicates that 29–35% of precipitation is virga which fails to reach the ground. The evaporation/sublimation layers occur closer to the ground during the cold season. Virga was frequently observed before surface precipitation events, suggesting that pre-precipitation virga is dominant in the Arctic. This new tool aims to bridge observational gaps between ground and satellite platforms, and helps to better calibrate satellite-derived precipitation products. This method contributes significantly to advancing polar meteorology and refining climate models in high-latitude environments.

DNA barcoding redefines Svalbard aphid species boundaries

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Abstract: Aphids are among the rarest insect groups in the High Arctic, with only three confirmed resident species on the Svalbard archipelago. One of these, a root-feeding Pemphigus species, has historically been misidentified as Pemphigus groenlandicus due to morphological similarity and the absence of fresh material over several decades, which severely limited taxonomic verification and genetic study. Here, we present an integrative taxonomic reassessment based on field collections and molecular analysis. Our findings reveal that the Svalbard population is not a distinct species but corresponds to the secondary generation of Pemphigus populiglobuli, a North American gall-forming species associated with poplars. Morphometric comparisons with material from Greenland, Iceland, and continental Europe further support synonymizing P. groenlandicus and its subspecies crassicornis with P. populiglobuli. In a related case, molecular markers have also led to the reassignment of the historically misclassified Sitobion (Metobion) calvulum to the genus Macrosiphum, reflecting a more accurate phylogenetic placement. These results underscore the value of molecular tools in resolving cryptic aphid diversity and improving taxonomic resolution in poorly studied Arctic ecosystems.

The Copernicus Arctic Regional ReAnalysis (CARRA): Strength and weaknesses

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Abstract: Reanalysis aims to provide a complete 3-dimensional consistent historical description of the climate system. They are constructed by an optimal combination of numerical models and a range of observations to provide “maps without gaps”. Hence they offer users meteorological consistent data for arbitrary geographical locations where observations may not exist.

Unfortunately, global reanalysis suffers from relatively coarse spatial resolution and is often not able to represent local meteorological and climate details. This is in particular true in regions with complex terrain and coastlines as for example on Svalbard. Regional reanalysis can therefore add value to global reanalysis. The Copernicus Regional ReAnalysis (CARRA) adds value to leading global reanalysis by much more spatial details (values for areas of 2,5 x 2,5 km versus ~ 30x30 km or coarser), a more tailored representation of cold surfaces and processes, and also by a higher usage of local in-situ observations in the generation of the reanalysis.

At present CARRA data is available for two domains (west: Greenland & Iceland, and east: Svalbard, Barents Sea and northern Scandinavia) covering the European Arctic from the Copernicus Climate Change Services (C3S). The period is from 1991 until today with regular updates with a few months delay. In addition, CARRA version 2 is in production and covers a large pan-Arctic domain from 1985 - 2025, and the first years of data is planned to be released in 2025.

The CARRA1 data set has already shown to be useful for many applications and this presentation aims to describe how it is generated, how it adds value compared to the leading global reanalysis ERA5, and discuss strength and weaknesses of how the meteorological and climate conditions are represented for the Svalbard region. This will include both measures of the accuracy compared to observations, but also examples on how climate trends are represented in the reanalysis.

Session Coast and fjords as systems in change

Fjord ice conditions in Hornsund, Svalbard from synthetic aperture radar imagery over 23 seasons

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Abstract: Fjord ice – the combination of sea ice (drift and fast) and glacier ice on fjord waters – has a great impact on energy, heat and light exchange, habitat conditions, coastal processes, boat operation and snowmobile transport. The types of fjord ice respond to climate conditions differently. Higher temperatures result in less fast ice but in more intense calving and, consequently, more glacier ice. In Hornsund, the abundance of drift ice is related to the ice conditions in Storfjorden/Barents Sea, currents and, to a lesser extent, wind. It is, therefore, important to consider all types of fjord ice.

Synthetic aperture radar (SAR) satellite imagery enables detection of ice during the polar night and on cloudy days. The SAR data have been extensively used for automated sea ice detection in the open sea. However, few studies have attempted to map fjord ice. It is partly related to the canonical separation of sea ice and glacier ice mapping efforts and partly to challenges related to fjord environment itself, such as topographic shadowing, the wind tunnel effect, tides and wave breaking over underwater rocks.

Here, we used the full archive of Envisat ASAR, RADARSAT-2 and Sentinel-1 imagery available for Hornsund between Oct 2002 and Jun 2025 to characterize fjord ice conditions over 23 seasons. We applied a segmentation algorithm to create binary ice/open water maps at 50 m resolution. We then split the fjord ice into fast ice, drift ice and glacier ice using a set of calibrated thresholds. The study allows characterizing spatial and temporal (seasonal and interannual) variability in fjord ice conditions.

Eidemlaguna: a portrait of an emerging periglacial ecosystem

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Abstract: This paper presents findings from a 3-year interdisciplinary study of Eidemlaguna, a recently formed lagoon near Eidembukta, Spitsbergen, created by glacial retreat. Research combined bathymetric mapping, hydrological profiling, biogeochemical flux measurements, and biodiversity assessments using both classical (plankton and benthos) and molecular (eDNA) methods.

Eidemlaguna is structurally complex and spatially diverse, comprising semi-isolated basins of varying age—from ~90 to <15 years, with the deepest point (41 m) near the glacier's edge. It exhibits strong stratification, with fresh surface waters overlying cold, saline (up to 28 psu) bottom layers. This creates distinct habitats for both marine and freshwater species. eDNA analyses revealed high spatial variability in biodiversity shaped by lagoon age, salinity gradients, and glacial proximity, with prokaryotic communities supporting key processes such as phototrophy, chemoheterotrophy, and nutrient cycling. Plankton surveys identified ~90 taxa of phyto- and zooplankton influenced by meltwater, tundra runoff, and marine inputs. Benthic studies showed low macrofaunal diversity near glacier fronts, but long-lived marine bivalves in central areas indicate environmental stability and potential refugia.

Biogeochemical measurements revealed spatial variation in CH_4 and N_2O fluxes, with stable zones emitting more methane, and nitrous oxide fluxes shifting between uptake and release. These patterns suggest periglacial lagoons may be emerging greenhouse gas sources.

The EIDEMBUKTA project (RiS-ID 11962) represents the first comprehensive assessment of a high-latitude periglacial lagoon, highlighting its ecological complexity, biogeochemical importance and the urgent need for further research in Svalbard, where similar dynamic lagoon systems are rapidly expanding across the changing coastal landscape.

Late summer precipitation and permafrost degradation in Svalbard increase nitrate flux in an alpine catchment

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Abstract: Svalbard hydrology is rapidly changing with freshwater discharge expected to double by 2100 under current climate models. Increasing solute transport, notably nitrate which is a limiting nutrient in Arctic marine environments, will have profound impacts on fjord ecosystems. Although glacierized catchments have received most attention in the context of land-to-sea nitrate export, we show that their periglacial counterparts may be equally important, especially when underlain by shale bedrock; an appreciable source of geogenic nitrate. Here, we aim to decouple periglacial landscape changes such as deepening active layer by using a source to sink approach: combining a river gauging station with weekly surface water geochemical sampling in the catchment (stable water isotopes, soluble ions, inorganic nutrients, dissolved organic carbon and nitrogen) through the 2023 and 2024 melt seasons. Sources of nitrate are differentiated using δ15N-NO3 and δ18O-NO3 to understand spatial and temporal trends in the system. Early season NO3- displays a strong meteoric signature. Decreasing δ18O-NO3- and high solute loads follow the snowmelt discharge peak, and show that flow paths increasingly acquire more nitrate after travelling through aerobic mineral soils layers that promote net nitrification. As a consequence of warming during summer, these flow paths pass through previously frozen ground, leading to a release of new NO3 derived largely from the geogenic and pedogenic (including permafrost) sources. Peak nitrate yield (max. 0.1 kg day-1 ha-1) therefore occurs following rain events from mid-August onwards, when the active layer reached record depths. The key ingredients for mobilizing the geogenic nitrate can be summed up as follows: (a) N-rich bedrock, (b) high gradient slopes, (c) low biotic demand of inorganic N in the catchment and (d) deep thaw layer to enable flow paths in mineral horizons. Our study shows that the fate of nitrogen in periglacial landscapes is highly dependent on late season dynamics, namely active layer conditions and precipitation patterns.

A decade of summer ice mélange distribution observed by Sentinel-1 and glacier frontal ablation and in Kongs- and Krossfjorden, Svalbard.

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Abstract: The methodology of mapping atmospheric exposure (AtmEx) is applied on the whole decade from 2015 to 2024 of Sentinel-1 summer acquisitions in Extra Wide Swath mode over Kongs- and Krossfjorden on Svalbard. The consistent daily observations during summer, from July to October, allow not only to statistically define a summer glacier front extent of marine-terminating glaciers but reveal also a new application, which is to detect the summer distribution of floating icebergs, bergy bits and growlers (IBGs). These originate from glacier calving during the sea-ice free period and constitute the summer ice mélange in the fjords. Summer glacier extents are defined here by the area where the glacier prevails more than 95% during summer and co-locate well with glacier fronts extracted from end-of-summer Sentinel-2 observations. The yearly summer ice mélange distributions are classified into different percentage ranges of temporal occurrence. The ten years of derived annual ice mélange areas are compared to estimations of summer glacier frontal ablation for the two glaciers Lillehöökbreen and Kronebreen. The comparison showed that there is clear link between the mean summer ice mélange area and the glaciers frontal ablation with a correlation factor R of 0.67 and 0.85 for Lillehöökbreen and Kronebreen, respectively. Frontal ablation includes calving and submarine/subaerial melting at the glacier front and the combination with the estimation of ice mélange could give new insights into the mass loss ratio between calving and melting. The relationship between ice mélange and frontal ablation however is individual for each glacier. As this is the first consistent mapping of the summer ice mélange, further studies and application on other glaciers and fjord systems are needed to explore the full potential and limitation of mapping the ice mélange as a proxy for ice calving intensities.

From marine cold spells to heatwaves: Climatic impacts on a polar shallow-water ecosystem

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Abstract: Global warming affects the Earth system in complex ways, often preventing a functional understanding of the underlying processes. Disentangling these processes

between abiotic drivers and single species or entire communities is, however, essential for an in-depth understanding of climate change impacts on the ecosystem. Using a high-resolution time series on heat waves and cold spells in an Arctic fjord system, we show that for analysing the effects of environmental stressors on biota, AI supported digital data processing based on state-of-the-art observatory technology can provide insights in habitat-community interactions which are not possible with classic expedition-based sampling methods. Furthermore, our study shows that short-term, event-driven anomalies in key ocean variables not only alter a system's hydrography but have the potential to impact the entire community across the trophic chain. We found a significant positive correlation between hydrographic temperature anomalies and biota abundance with high biota abundances linked to 'Atlantic' phases with frequent heat waves and low biota abundances correlated with 'Arctic' phases dominated by cold spells. The study also showed that hydrographic anomalies can not only influence overall biota abundance in an area but also trigger complex shifts in species composition, leading to anomalously high abundances in specific biota groups.

ARK - Arctic marine mammals & their prey in a time of climate change: a Kongsfjorden Case Study

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Abstract: The Arctic is warming at a rate 4 x the global average and the Svalbard Archipelago is a hot spot for warming in a circumpolar context. Atlantification of the marine system in Svalbard is resulting in a mix of Arctic and boreal species, which creates potential for competition. The “ARK project” studied 3 top trophic species-overlaps that have arisen because of climate change in Kongsfjorden (Svalbard): 1) char-pink salmon; 2) polar cod-Atlantic cod and 3) ringed/bearded seals – harbour seals. From a dietary perspective, all 3 groups showed inter-specific overlaps, but also unique aspects of species-specific diets, which are likely to moderate competition. Pianka’s niche overlap for the 2 salmonids was O = 0.59 (a moderate level); both species ate coastal invertebrates, but the char consumed more offshore pelagic fish. Schoener’s D value (= 0.67) suggested high dietary overlap between polar and Atlantic cod, but individual specialization and flexibility in polar cod feeding is likely to reduce impacts of food competition. However, direct consumption of the smaller cod species by the larger presents a serious risk to polar cod. In the case of the new seal-species complex, GPS-tracking suggests high degrees of spatial overlap (50-70%), though fine-scale spatial analyses of diving revealed habitat and behavioural segregation between species. Ringed seals fed close to tidal glacier fronts, while harbour seals fed in shallow, nearshore areas. Bearded seals displayed overlap in area use with both other seals. Fatty acid (FA) and stable isotope analyses of seal blubber and potential prey confirmed a unique feeding niche for ringed seals, but FA-niche overlap between bearded and harbour seals was high (92%). Body condition of animals in all the species’ complexes were good, suggesting that food is not currently a limiting factor. Thus, habitat deterioration is likely to continue to be the most important driver of near-future trends in abundance for most of the Arctic species studied in ARK.

Constraining offshore groundwater flow and porewater freshening mechanisms in Svalbard fjords

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Abstract: Submarine groundwater discharge (SGD) - the flow of groundwater through sediments into the ocean - plays a crucial role in shaping coastal biogeochemical cycles by regulating solute fluxes. In several Svalbard fjords, significant porewater freshening has been observed, with chlorinity values dropping below 400 mM in Tempelfjorden and Hornsund, corresponding with a >28% reduction relative to seawater. Isotopic signatures (δ^2H and $\delta^{18}O$) indicate that the freshened porewater is meteoric in origin. In contrast, brine has been observed in Dicksonfjorden. This points to a highly dynamic and spatially heterogeneous offshore groundwater system. However, the mechanisms driving offshore groundwater emplacement in Svalbard remain poorly understood, limiting our ability to predict solute fluxes into fjords, particularly as hydrogeological conditions evolve with ongoing changes in the cryosphere, precipitation, and sea level. In this study, we use radiocarbon content (^{14}C) of dissolved inorganic carbon (DIC) in marine porewaters to constrain groundwater ages, and thereby infer flow directions and sources. Near Murdoch Hole, large downcore variations in porewater DIC ages may indicate a land-ocean connection with diverse groundwater sources, or the influence of lateral groundwater transport. In central Tempelfjorden, ^{14}C-DIC profiles attest active SGD of older seawater. Meanwhile, three cores from Hornsund reveal the presence of a deeper situated fresh groundwater component, likely glacially injected before ~13 ka when the fjord was fully

glaciated. These findings underscore the spatial complexity and transient nature of sub-fjord groundwater systems in Svalbard.

Increasing ocean acidification observed in Kongsfjorden, Svalbard, over the last decade

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Abstract: The western Spitsbergen fjords are experiencing significant changes due to warming and sea ice loss. However, little is known about the potential changes in the marine chemical environment. Fjord waters exhibit different chemical characteristics depending on water masses, sill depth, marine- and land-terminating glaciers, sea ice cover, and biogeochemical processes. These features and changes impact ocean acidification.

Since 2012, we have studied marine carbonate chemistry, CO2 fluxes, ocean acidification state, and drivers in Kongsfjorden, from transects between the glacier front and the outer shelf. Data from Kongsfjorden transects (e.g., MOSJ, 2012-2022) and NPI pelagic time series (2025-2026) show trends of declining pH and surface aragonite saturation (ΩAr), along with increased pCO2 and ocean acidification. At the inner stations, we observe changes due to freshwater runoff from the glaciers, where rapid glacier retreat has been reported. We present recent findings on increasing ocean acidification in the surface waters of Kongsfjorden and discuss its drivers.

Diversity of prokaryotic communities associated with the sponges Myxilla sp. and Haliclona sp. from the western coast of Spitsbergen Island, Svalbard Archipelago

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Abstract: Marine sponges represent key biological components that harbor complex and diverse microbial communities. These sponge-associated microbiomes play essential roles in nutrient cycling, chemical defense, and host adaptation, particularly in cold, oligotrophic environments such as those surrounding the Svalbard archipelago. Bacterial symbionts are thought to aid host survival in nutrient-poor and cold waters by participating in ammonia oxidation, sulfur metabolism, and the degradation of dissolved organic matter. Moreover, sponge-associated microorganisms may act as bioindicators of environmental change, offering insights into how Arctic benthic systems respond to warming temperatures and increasing human impact. Among Arctic sponges, species within the genera Myxilla and Haliclona are of particular interest due to their widespread distribution and ecological importance. This study reports the taxonomic composition and possible ecological roles of prokaryotic communities associated with Myxilla and Haliclona specimens collected in the Isfjorden, located on the western coast of Spitsbergen Island, Svalbard Archipelago. The results showed different host-microbes interactions between the two sponge species. Myxilla sp. specimens hosted microbial communities predominated by Rhizobiales and Flavobacteriales. Differently, microbial communities associated with Haliclona sp. individuals were mainly represented by Burkholderiales, Paveibaculales, Pseudomonadales, and Flavobacteriales. Both sponge species showed associations with different communities than those living in the surrounding waters and sediments. Understanding the microbial ecology of Arctic sponges is essential for predicting the resilience of polar marine ecosystems. As climate change accelerates, studying these

symbiotic systems provides critical data on biodiversity conservation, ecosystem functioning, and the potential for discovering novel bioactive compounds.

Longyearbyen Lagoon. Monitoring the changes and using as a laboratory

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Abstract: Understanding lagoon behavior is crucial for both scientific research and engineering decisions, especially in delicate Arctic environments. Lagoons are vital to coastal areas, often bolstering infrastructure resilience. Since spring 2019, we have monitored the Longyearbyen lagoon (Spitsbergen), vital for coastal erosion defence and serving as a natural laboratory. The location's well-developed infrastructure and accessible logistics make it an ideal testing site available at any time. It can be used for many natural scientific studies. The lagoon continually changes due to the primary action of waves and tides (maximal tidal range is up to 2 m).

Using methods of aerial and satellite images, laser scanning, and hydrodynamic measurements, we have delineated processes, rates, and mechanisms behind the gravel spit movement. The measurements revealed an accelerating its eastward expansion (propagation), from 8 m in the first year to 86 m in the fourth year of observation.

This can be explained by a combination of the reconstruction of the Longyearbyen riverbed and increased flow because of climate change. Notably, the expansion does not only occur in the summer months: from September 2022 to February 2023, the spit moved by 40 m, and then, by 19 m from February to June 2023. We found that the bed-load transport along the spit coupled with gravel slides are the primary drives of lagoon expansion and growth. We also investigated movements of groundwater table in the spit and changes in gravel contents along the spit, influencing the water saturation of the gravel. Modelling these processes aids in forecasting lagoon system development, crucial.

We estimate the possibility of using the lagoon as a testing site/natural laboratory for scientific and educational purposes, keeping in mind the construction of a natural ice tank for full-scale ice mechanical tests and other experiments. The place could be an excellent testing site due to its developed infrastructure and logistics; it is reachable anytime. In spring 2023 and 2025, a full-scale experiment on ice-bearing capacity was performed with the UNIS Arctic Technology Department course and Msc students.

Do we see a temperature-driven awakening of rock slope instabilities on Svalbard and the Arctic?

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Abstract: Mapping around Isfjorden and its converging fjord arms has revealed large rock slope instabilities and deposits. Two notable rockslides, covering ~2.0 and ~1.1 km2, occur at Forkastningsfjellet and Garmaksla, located 10 km north of Longyearbyen, and 6 km south of Pyramiden, respectively. The onset of the Forkastningsfjell and Garmaksla slides is uncertain. However, rock fall deposits from the back scarp of the Forkastningsfjellet slide suggest an age older than 4.5 ka, while sediments from a pond inside the Garmaksla back scarp indicate an age older than 6 ka. Additionally, two rock avalanche deposits mapped from bathymetric data along the western coastline of Tryghamna fjord predate the Little Ice Age (16th–19th century) based on the overlying sediments. No historic landslide activity was observed at Forkstaningsfjellet until 2016, when a 0.175 million m3 block detached and slid into the fjord. Deformation measurements since then indicate slide velocities of 0.5 to more than 10 cm/yr. In November 2022, a 0.75 million m3 rockslide occurred from the fastest-moving block after a year of acceleration. The back scarp of this slide follows a surface drainage channel, which transformed into a drainage tunnel at least a year before failure. Observations suggest that water and heat along the drainage channel penetrated deep into otherwise frozen ground. Permafrost modelling based on surface temperature data suggests that the basal sliding surface lies in unfrozen ground.

Our research indicates that extremely large rock slope failures occurred in postglacial prehistoric time in and around Isfjorden, and that the frequency and magnitude historic events have increased over the past decade. This trend mirrors observations from Greenland, where similar patterns have been recorded. Whether prehistoric slides were linked to climate variability or regional deglaciation remains uncertain. Addressing this question is critical for improving future rockslide hazard assessments.

Will calcifiers survive rapidly progressing changes in the Svalbard marine system?

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Abstract: Calcifiers are organisms that produce calcareous skeletons. Their skeletal CaCO3 consists of mainly Ca2+ and CO32- but also a range of trace elements. Warming and sea-ice retreat in the Arctic Ocean lead to higher pCO2 values in the surface waters and reduction of CaCO3 saturation state. Undersaturation conditions of CaCO3 in the water may impact calcareous skeletons in many ways e.g. via carbonate dissolution. Yet to what degree these changes are going to influence organisms' survival depends on level of biological versus environmental control of their calcification processes. Organisms with strong biological control will be able to withstand external environmental variations and adapt to changes over time. We analysed mineralogical and chemical content of all major calcifying benthic biota occurring in the Svalbard waters including Bryozoa, Echinodermata, Brachiopoda, Mollusca and Crustacea collected in locations differing in environmental conditions. Altogether 1271 specimens belonging to 165 species were analysed. Mineralogy of skeletons was found to be group-specific e.g. echinoderms were exclusively calcitic while gastropods mostly aragonitic. Species-related differences in concentrations of elements were significant and occurred regardless of environmental differences. This observation implies the dominance of biological processes regulating mineralogical and elemental uptake into the skeleton over mechanisms related to the variability of abiotic environmental conditions.

Guano-derived resources for marine producers in the coastal areas around seabird colonies

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Abstract: Seabirds play a key role in Arctic coastal ecosystems by delivering large amounts of organic matter and nutrients of marine origin, mainly in the form of guano, to the vicinity of their nesting sites. A significant proportion of the ornithogenic nutrients are taken up by terrestrial producers, stimulating the development of exceptionally lush and rich tundra, but the remainder returns to the sea by percolation, leaching and/or run-off from the ground. The nutrients are readily soluble, possibly increasing their short-term bioavailability in coastal waters near seabird colonies and providing a locally important resource for the marine food web. Some amount is dispersed in the water and lost from the area, the greater the waves and the more open the sea. However, the precise role and importance of seabird-derived nutrients in the marine ecosystem is poorly understood.

Here we present the results of studies carried out in the marine coastal zones directly below the bird cliffs at the south-east Bjørnøya and Midterhuken, Bellsund, both compared with nearby reference areas. Along the distance from the cliffs (from 50 to 200 m) and the depth (from the surface down to about 20 m) we followed changes in concentrations of resources for the marine producers (ammonium, nitrate, phosphate, and silicate ions), as well as nitrogen isotope ratio (δ15N) values in suspended particulate organic matter (POM) serving as a proxy for ornithogenic enrichment of pelagic producers. We found that seabird colony inputs affected the nutrient concentrations in seawater although the trends were not always uniform. The observed variability was probably due to the location of the colonies (cliffs exposed to the open sea or the fjord) and the time of sampling (before or after the spring phytoplankton

bloom). Nevertheless, higher δ15N values of POM showed a clear ornithogenic enrichment, which decreased with distance from the bird cliffs.

Nutrient Subsidies and Environmental Heterogeneity Drive Arctic Tundra Vegetation Patterns

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Abstract: High Arctic tundra vegetation is highly sensitive to environmental gradients, including nutrient subsidies from seabird colonies. While guano effects on vegetation below cliffs are recognized, less is known about how plant community composition changes along distance gradients below active colonies, and how seabird-driven influences interact with natural environmental variability.We assessed vascular plant species composition along thirteen transects in Bellsund, Spitsbergen: five in the seabird colony at Gåsberget, Midterhuken, and eight in two separate control areas — five in the Midterhuken Control (MC) site and three in the Tomtvica Control (TC) site. Vegetation data were collected from 1×1 m plots at six distances along each transect (0, 30, 60, 90, 120, and 150 meters from the starting point).

nMDS ordination revealed a primary gradient separating SEABIRD from CONTROL areas, and a secondary gradient between the two control areas (Midterhuken and Tomtvica), highlighting background environmental heterogeneity. Vegetation cover was highest close to the seabird colony and decreased inland. PERMANOVA confirmed significant effects of seabird presence (variance component = 0.1626) and distance (variance component = 0.1149) on plant species composition. A significant interaction (variance component = 0.0739) indicated that compositional changes along transects differed between SEABIRD and CONTROL areas.

SIMPER analysis revealed an average dissimilarity of 81–83% between SEABIRD and CONTROL sites, with species such as Salix reticulata, Polygonum alpina, and Polygonum viviparum contributing most to group separation. Even between the two control sites, substantial differences were found (average dissimilarity = 62%), primarily driven by variation in Polygonum viviparum and Silene acaulis abundance. Our findings emphasize that seabird-driven nutrient enrichment is a major driver of Arctic tundra plant community structure, but also that environmental differences between control sites contribute to vegetation heterogeneity independently of seabird effects.

The coastal and marine ecosystem of Woodfjorden, northern Svalbard.

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Abstract: Svalbard fjords are among the most rapidly changing ecosystems. Due to the accelerating climate change they are experiencing a shift in environmental conditions related to increased inflow of Atlantic water, increasing temperatures, sea ice and glaciers' retreat. In order to understand what are the consequences of these shifts for coastal, fjord and shelf functioning we conducted a complex, multidisciplinary coastal and marine research in Woodfjorden, a fjord located in the northern Spitsbergen, during r/v Oceania (IOPAN) cruise in August 2024. Here we present a synthesis of our findings, offering new insights into the physical and biogeochemical setting of the Woodfjorden ecosystem and their influence on biological communities in shallow coastal areas and across the fjord.

During this study, a wide range of physical and biogeochemical measurements were taken along the fjord axes including temperature, salinity, light penetration, nutrients, pH, alkalinity, pCO2, phytopigments, Dissolved Organic and Inorganic Carbon in the water column, and Total Organic Carbon, sediment grain size, and phytopigments in the sediments. Next, we measured primary production rates (in situ), and assessed zooplankton, and macro- and meiobenthic community structures. In addition, ex-situ experiments were performed to measure sediment respiration rate, and carbon and nutrient fluxes. Littoral zone sampling included shallow waters measurements (temperature, salinity, light penetration) and algal physiology studies. Together, these datasets provide a comprehensive overview of the marine carbon cycle and ecosystem structure in this relatively understudied region of Svalbard

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Processes influencing the discharge and distribution of glacial sediments in Hornsund fjord

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Abstract: The transport of terrestrial material into coastal waters is increasing with the retreat of marine-terminating glaciers. This long-term trend in meltwater and sediment discharge is accompanied by sporadic peaks driven by high air temperatures and precipitation events. The sediment plume can extend 15-20 km from the glacier front, reducing light penetration in large parts of the fjord. However, the presence of a bathymetric sill seems to restrict the export of the uppermost layer by recirculating freshwater and suspended sediments within the inner fjord. In addition, when water exchange over the sill is enabled by favorable winds or tides, the intensified currents, together with the strong horizontal salinity gradient, likely enhance flocculation and the faster deposition of particles out of the water column. Consequently, outside of a sill, the sediment plume has a considerably weaker expression. Here, we describe these processes and how they influence the horizontal and vertical distributions of sediments released from Hansbreen, a tidewater glacier in Hornsund fjord, based on hydrological and sedimentological observations from Hansbukta. Hansbukta is a small inner bay in Hornsund fjord, separated from the main fjord by a 20 m deep bathymetric sill approximately 3 km from the terminus of Hansbreen glacier. Horizontal variability in suspended sediment concentration and deposition are studied using sediment traps, water samples, and turbidity profiles obtained at varying distances from the glacier terminus. Hydrological observations from CTD casts are used to analyze the effect of vertical stratification on sediment transport. These along-fjord cross-sections have been repeatedly measured during the summer season (May-September) over several years, allowing for the study of both seasonal and interannual variability in sedimentation processes.

Distribution and origin of heavy metals in semi-enclosed Brepollen glacial bay (Hornsund, Svalbard)

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Abstract: Svalbard is warming almost four times faster than the rest of our planet, leading to increased melting of glaciers and permafrost, which in turn causes an increase in the supply of meltwater to the marine ecosystem. As a result, fjord waters may currently receive additional important pollution discharge and in consequence can pose treat to the marine ecosystem.

Samples of seawater were collected at 2 glaciers: Hornbreen and Storbreen (Hornsund) in 2022. Meltwater samples at the glacier fronts were collected by ROV while seawater samples at 300m, 500m, 1000m, 5000m distance from the glacier front were collected at different depths using a bathometer. CTD casts were performed to study seawater source. The concentrations of selected heavy metals (Cd, Pb, Cu, Zn, As) and Pb isotopic composition were measured using ICP-MS in diluted and particulate fraction. Heavy metal concentrations were above the natural background concentrations. For example, particulate concentrations of Cd reached 0.6 mg/kg, Hg reached 0.8 mg/kg, while Pb reached 34 mg/kg. The concentrations of studied heavy metals in suspension varied with distance from the glacier, with the highest values directly at the glacier front. Heavy metal concentrations varied also in seawater masses of different provenience. The 206Pb/207Pb ranged from 1.148 to 1.185 suggesting very high importance of anthropogenically derived Pb.

The study was financed by NCN, RELOAD project nr 2020/39/B/ST10/01504.

On the path to reproductive isolation: Cytonuclear incompatibilities between selfing populations of the coastal arctic plant species Cochlearia groenlandica (Brassicaceae)

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Abstract: Our previous research has demonstrated that hybrid sterility barriers have frequently evolved within diploid, circumpolar plant species. To elucidate the genetic mechanisms underlying the rapid evolution of postzygotic reproductive isolation in Arctic plants, we conducted a genetic mapping study on Cochlearia groenlandica (Brassicaceae), using parental populations from coastal areas in Svalbard and Alaska. Through linkage mapping and quantitative trait loci (QTL) analysis, we identified traits linked to reproductive isolation in two large reciprocal mapping populations. Significant trait divergence was observed between populations, with reproductive isolation traits manifesting in one cross direction: approximately 25% of F2 hybrids, where the mother plant originated from Svalbard, exhibited complete floral developmental failure, leading to total reproductive breakdown. In contrast, these traits were not observed in the reciprocal population where the mother plant originated from Alaska. This pattern suggests strong cytonuclear incompatibilities i.e. incompatibilities between nuclear and organelle genomes, as key drivers of reproductive isolation. Our findings underscore the critical role of cytonuclear interactions in establishing reproductive barriers, emphasizing their potential contribution to speciation processes in Arctic plant populations.

Greenhouse gas emission potential of High-Arctic Peatlands in a Changing Climate

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Abstract: High-Arctic peatlands play an important role in the terrestrial carbon cycle, despite their limited extent. These ecosystems can act as significant carbon sinks, sequestering atmospheric carbon and contributing to climate change mitigation. However, their carbon cycle dynamics are complex and likely to change over time. Thawing permafrost could also lead to the release of previously sequestered carbon by promoting microbial activity and enhancing organic matter decomposition. Additionally, drying of the peatlands may trigger a shift in these ecosystems from carbon sinks to carbon sources, highlighting the need to assess their greenhouse gas (GHG) emission potential. We plan to investigate carbon decomposition rates in the peat samples from Stuphallet peatland on the Brøgger Peninsula. We will conduct incubation experiments under both oxic and anoxic conditions, maintaining a constant temperature of 10°C, to measure production of CO2, CH4, NO, and N2O. The samples for incubation experiments are selected across different micro-landscapes, representing a moisture gradient from saturated lowlands to the drier elevated zones of polygonal peatlands close to bird nesting cliffs. Additionally, we plan to examine the role of allochthonous organic matter input from bird nesting excrement on greenhouse gas emission potentials in areas both close and remote from nesting sites of birds. The collected field and laboratory data on carbon mobilization rates from peatlands in Svalbard can improve understanding of the carbon cycle in the Arctic and can be useful in testing soil carbon cycling in Earth System Models.

Seen in Flakes & Drops: Marine Snow, Biogeochemistry, and Plankton at small-scales in Svalbard's Coastal Glacial Waters

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Abstract: Glacier retreat is one among most spectacular effects of progressing climate warming in Svalbard Archipelago, having a substantial impact on physical, biogeochemical and ecological processes occurring in marine ecosystems.

Marine snow are flocs of matter produced in the upper ocean layers, and by sinking they are vehicles of carbon towards sea bottom. They can also carry knowledge about the biophysical state of the pelagic ecosystems and functioning of their food webs, because by knowing the concentrations, appearance and composition of marine snow, one can deduce for example what is the state of primary production bloom, impact of their grazers producing fecal pellets, the input of mineral particles that ballast marine aggregates etc.

In this study we analyzed small scale differences in nutrients, carbon, plankton and marine snow within the waters that are located in the close vicinity to various glaciers in Hornsund, Bellsund and Isfjorden. The study was performed in late summer 2022 & 2023 and in spring 2023. The high-resolution automatic measurements of the Underwater Vision profiler (UVP) were performed to analyze the size spectra, abundance and morphological traits of individual marine aggregates and zooplankton across vertical profiles through the water column.

We observed different biogeochemical water properties depending on the season, which was related to different compositions of plankton and different morphology of individual flakes of marine snow. As expected, water turbidity, chemistry and hydrography had a substantial impact on the composition of pelagic components. The results provide a new interdisciplinary data of physical, biogeochemical and ecological parameters measured together near glaciers at varying states of recession, which is essential knowledge for linking land-ocean interactive effects on marine production, feeding conditions and carbon burial estimations.

Arctic Shoreline Evolution: Case Studies from Northwestern Spitsbergen, Svalbard

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Abstract: The Arctic, being one of the main areas-indicators of climate change, has become the subject of many studies, both in situ, in the High Arctic, but increasingly with the support of remote sensing software and tools. Long-term measurement series on Svalbard are a valuable source of knowledge, extremely heavy logistically, economically, and time-consuming. Remote sensing analysis series seems to be an alternative source in acquiring environmental knowledge. Analysis concern diverse elements of the environment: primarily glaciology, hydrology or geomorphology. The impact of global warming directly affects the activity of glaciers, the rise in the level of the all-ocean and contributes to irreversible changes in the coasts.

Remote sensing and field investigations concerning shoreline evolution were undertaken on Kaffiøyra, a coastal plain located in the northwestern sector of Spitsbergen (Oscar II Land), by the Nicolaus Copernicus University Polar Station. Kaffiøyra covers approximately 24 km of strongly varied coastline: from flat and low-energy to cliff coasts, both active and dead. With its unique location along the Forland Strait, it is an important center for the study of polar coastal change, the impact of deglaciation and hydrological, meteorological or topographical influences. This study employs a range of techniques from the fields of data acquisition and processing, including both remote sensing and photogrammetry. The initial phase of the coastal transformation assessment involved extracting digitized coastline outlines from satellite imagery using semi-automatic, machine learning environments.

The results clearly identify areas of shoreline change, map zones of progradation and erosion. In addition, the combination of remote sensing methods for shoreline extraction, with field measurements, has satisfactorily become a tool for acquiring environmental data.

Tracing mercury sources in the Arctic marine ecosystem of Kongsfjorden, Svalbard

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Abstract: One of the major challenges limiting the effectiveness of marine pollution prevention is the limited understanding of the sources and exposure pathways of chemicals. The Arctic is a critical hotspot of global change, where the bioavailability and cycling of pollutants in marine food webs are expected to be permanently altered. Insufficient knowledge of changing mercury (Hg) sources and dynamics in the context of a rapidly warming Arctic complicates the assessment of Hg exposure in marine fauna. The novel application of Hg stable isotope analysis (Hg-SIA) holds significant potential to enhance our understanding of the environmental and ecological drivers of Hg sources within ecosystems. This study aims to advance and apply Hg-SIA to identify Hg sources and pathways in a key sentinel bird species, the black-legged kittiwake (Rissa tridactyla), and to assess the potential impact of climate change on Hg pollution. Based on sampling conducted in Kongsfjorden (79°N, 12°E, Svalbard) during spring and summer 2024, we are carrying out comprehensive Hg stable isotope analyses across a broad range of marine ecosystem components, including marine sediments, sea-ice algae, suspended particulate organic matter, zooplankton, benthic invertebrates, various fish species, and blood samples from kittiwakes. Lower trophic-level ecosystem components were collected along a gradient from the Atlantic-influenced mouth of the fjord to the glacially influenced inner fjord, to assess Hg exposure along environmental gradients. While carbon, nitrogen, and sulphur stable isotopes will serve as proxies for the trophic ecology of the kittiwakes, Hg stable isotopes will provide insights into the spatio-temporal sourcing of Hg.

Psychrophilic Bacteria from an Arctic Meltwater Pathway: Potential for Xenobiotic Biodegradation

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Abstract: Cold-adapted bacteria have developed various survival strategies for extreme cold, including membrane stabilization, enhanced biosynthesis, increased production of extracellular polymers, and antifreeze proteins. These traits have sparked growing interest in their potential for low-temperature biotechnological applications, such as bioremediation. As part of the ICEtoFLUX project (PRA2021-0027), four field campaigns were conducted in 2022 and 2023 across spring and summer in the Bayelva catchment (79°N, 12°E; Svalbard Islands). Samples from glacier snowpack, meltwater, Bayelva River, and Kongsfjorden seawater were collected to isolate bacteria capable of growing in the presence of organic pollutants. A total of 107 and 99 isolates from samples of the first and second campaign, respectively, were screened for growth in the presence of pesticides (i.e., DDT and DDE), hydrocarbons (both aliphatic and aromatic), and polychlorobiphenyls (PCBs) as the sole carbon and energy source. Results revealed a 14.8% positivity for PCB oxidation in 2022, compared to 12.5% in 2023. For DDT, positivity reached 31.1% in 2022, while no strains grew in the presence of DDE. Strains capable of growing on petroleum and diesel oil were 17.9 and 20.0%, respectively, in 2022, maintaining similar percentages in 2023. Growth on alkanes (i.e., hexane, octane, dodecane) was more frequent on octane (35.3% of total isolates), followed by hexane (10.0%). In 2022, 13 strains (12.1%) grew in the presence of naphthalene (this percentage was lower in 2023). These findings suggest a possible role played by microbial communities in organic pollutant removal along the meltwater pathway, emphasizing their ecological importance in Arctic environments undergoing rapid climate change. Future analyses will integrate metagenomics to explore microbial functional potential and adaptation mechanisms.

Extensive summer blooms in fjords of West Spitsbergen triggered by run-off from land

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Abstract: Primary production in Svalbard fjords is highly seasonal with the largest fraction of annual primary production traditionally associated with the phytoplankton spring bloom, usually peaking in May. The spring bloom is terminated when winter-accumulated nutrients in surface waters are exhausted and typically followed by a post-bloom period characterized by low phytoplankton biomass. Here we report on extensive phytoplankton blooms in fjords of West Spitsbergen during late-June 2024 occurring four weeks after the peak of the spring bloom and coinciding with the snow freshet period. We focus on bloom development in Kongsfjorden and explore the environmental drivers that triggered this bloom. The bloom developed in the upper 5 – 15 m of the water column with exceptionally high chlorophyll-a concentrations of up to 25 µg L-1. Its species composition was distinctly different from the spring bloom, dominated by diatoms, and almost exclusively dominated by a pelagophyte species new to science. Surface currents, nutrient and chlorophyll-a profiles and satellite images indicate that the bloom developed inside the fjord and was subsequently advected onto the adjacent shelf. Since post-spring bloom nitrate concentrations in fjord surface waters were completely exhausted in the upper 25 m, we hypothesize that this bloom was triggered by land-derived nutrients associated with meltwater run-

off, highlighting terrestrial drivers of marine primary production in fjord ecosystems. Such extensive blooms during early summer are unusual and could possibly be associated with the record melt on Svalbard in summer 2024.

Assessing the roles of geology and glacier thermal regime on subglacial methane release

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Abstract: Rapidly rising air temperatures in the Arctic have cascading effects due to the temperature sensitivity of high latitude environments. Glacier melt and permafrost thaw initiate feedback loops that can lead to increased natural emissions of methane, a powerful greenhouse gas, thus amplifying the warming trend. The anoxic environment of a glacier bed facilitates the microbial production of methane from buried organic carbon. Additionally, thermogenic methane from geologic reservoirs can migrate to the subglacial environment through fractures in the bedrock. Increased meltwater production during glacier retreat may enhance the release of this methane that has accumulated at the glacier bed. While measurements are scarce, methane emissions driven by glacial meltwaters are expected to be widespread and largely undocumented throughout the Arctic. We undertook an extensive field study to establish the pervasiveness of these emissions in glacier catchments on Svalbard and to determine the factors, such as geology and glacier thermal regime, that may govern the magnitude of emissions. Covering a range of geological settings and land-terminating glacier sizes, we measured aqueous methane concentrations and the stable carbon isotopic composition of methane in transects along the lengths of 19 glacial rivers across central Spitsbergen. In addition, we used ground penetrating radar to assess the thermal regime of the glaciers. Our measurements confirm that proglacial rivers are super-saturated with methane across the entire central Spitsbergen region and that the methane is largely of geologic origin. We extrapolate our measurements to roughly estimate a total seasonal methane flux from glacial rivers across Svalbard. Our findings are also used to identify the factors that control the extent of methane

supersaturation in glacier meltwaters, which will help pinpoint other glaciated regions of the world that may be hotspots for methane release.

Drivers of summer protist dynamics in Kongsfjorden: insights from a 12-year time series during peak glacier melt

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Abstract: Changes in glacier types, sea-ice dynamics and hydrographic conditions are reshaping Arctic fjords. These shifts can alter marine protist (unicellular eukaryotes) communities, which are a key component of fjord ecosystem productivity, with cascading effects on higher trophic levels, biogenic matter export, and ultimately on the fjord's role in carbon sequestration and climate regulation.

Kongsfjorden, located on the northwest coast of Spitsbergen, typically receives warm and saline Atlantic Water (AW) especially during late summer but also throughout the year. The frequency and intensity of AW intrusions have changed over the past decades, influencing both the sea-ice cover, hydrography, nutrient concentrations and plankton species composition. For instance, increased winter AW inflow elevates surface nutrient concentrations, potentially promoting earlier pelagic blooms and increase of Atlantic species, while reduced winter convective mixing is associated with delayed plankton development.

Kongsfjorden is also influenced by freshwater discharge from both land-terminating and tidewater glaciers, especially during peak melt periods in summer. Glacial meltwater increases turbidity and reduces light availability near glacier fronts, limiting phytoplankton growth, while upwelled nutrients at tidewater glacier fronts may locally stimulate productivity. Thus, the combined effects of AW advection and glacial inputs on protist dynamics remain poorly understood.

This study addresses this knowledge gap by examining the influence of AW inflow and glacier runoff on marine protist communities. We analyse community composition, abundance, and biomass of protists during late summer (late July to early August) over the period 2011–2022. The dataset includes transect-based oceanographic

observations spanning from the inner fjord (influenced by tidewater glaciers) to the outer fjord (influenced by AW), alongside biogeochemical parameters and hydrographic and atmospheric measurements.

Shale weathering drives flux of geogenic nitrogen from a glaciated catchment: Fagerstadalen, Svalbard

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Abstract: Bioavailable nitrogen (N) limits the productivity of many terrestrial and marine ecosystems, thus restricting the amount of atmospheric CO2 that is naturally sequestered. In the Arctic, summer fjord and coastal surface waters are N-depleted following the phytoplankton spring bloom. On land, the dominant N source is typically atmospheric deposition, but limited studies have suggested that rock-derived N may be an important source that has widely been overlooked. Glaciers are powerful agents of erosion that grind rock into reactive sediment. Glaciers therefore may liberate considerable amounts of rock-bound (geogenic) N which can be delivered to fjords by melt rivers throughout the summer, but this mechanism has not yet been investigated. We monitored the hydrological system of a 30 km2 glacierized catchment on Svalbard (Fagerstadalen, inner Van Mijenfjorden) for a whole melt season (June – September) to investigate the origin, magnitude and seasonal dynamics of terrestrial N fluxes to the fjord. We present a time series of N concentrations and fluxes in meltwater runoff, with nitrate concentrations that frequently exceed previously reported values for other Svalbard rivers. Our riverine nitrate concentrations far exceed snowmelt levels, suggesting a N source beyond atmospheric deposition, and multiple lines of evidence point toward a locally exposed shale rock unit as the dominant source of inorganic N. Our seasonal findings show that dissolved inorganic N fluxes are highest in mid-summer during a heavy rain event which flushes the catchment and leads to doubled nitrate levels in bulk surface runoff, underscoring the importance of summer precipitation events as drivers of N mobilization and export from land to sea. With geologically similar glacierized watersheds across Svalbard and other Arctic regions,

we highlight shale bedrock as an overlooked non-point source of N that may supply nutrients to coastal waters during a time of widespread N limitation.

The effect of future warming on carbon remineralization by iron- and sulfate-reducing bacteria in sediments of Kongsfjorden

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Abstract: Glaciated fjord sediments are biogeochemically active interfaces connecting the cryosphere and terrestrial ecosystems to the ocean. These sediments are hotspots of carbon burial and especially sensitive to climate change. Arctic fjords are warming faster than most regions on Earth, but the consequences for sediment biogeochemistry remain poorly understood. Microbial iron and sulfate reduction are key pathways of anaerobic carbon remineralization in these systems. We conducted anoxic microcosm incubations with sediment from Kongsfjorden, Svalbard (114 m water depth), using RNA-stable isotope probing (RNA-SIP) to identify active microbial populations. Incubations were carried out at 4°C (present-day) and 12°C (projected future), with 13C- or 12C-acetate (500 µM), and in some treatments, ferrihydrite (5 mM) and/or molybdate (20 mM) were added. We tracked Fe and H_2S concentrations, sulfate-reduction rates (SRR; via $^{35}S\text{-}SO_4^{2-}$), and $\delta^{13}C\text{-}CO_2$ in the headspace to monitor acetate utilization.

Acetate stimulated sulfate reduction, increasing SRR up to threefold compared to controls. At 4°C, SRR remained stable, while at 12°C they increased continuously and were ~10-fold higher after 15 days. Ferrihydrite addition stimulated Fe reduction, indicated by declining ascorbate-extractable Fe(III), though only minor Fe(II) accumulation occurred. Combined with low H_2S despite high SRR, this suggests tight coupling between iron and sulfur cycles. RNA-SIP revealed a temperature-driven shift in iron reducers: Arcobacteraceae dominated at 4°C, while Colwelliaceae prevailed at 12°C. Surprisingly, classical sulfate-reducing bacteria showed reduced abundance in heavy RNA fractions, even when SRR increased. These results highlight that warming alters microbial community structure and function, with potential consequences for carbon and redox cycling in Arctic fjord sediments.

Quantification and Characterization of Small Microplastic and Micro-Litter Body Burden in Svalbard Zooplankton Communities: Accumulation and Ecological Implications.

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Abstract: Over the past decades, the Arctic Ocean has undergone rapid changes due to human activities and climate change, highlighting the urgent need to assess how marine communities respond to these stressors. In this study, as part of the EU project ICEBERG, we examine the functional diversity of selected zooplankton taxa in the Krossfjord-Kongsfjord System (KKS) and the eastern Fram Strait (Svalbard Islands), combining ecological assessments with the analysis of ingested small microplastics (SMP) and other microlitter compounds (MLCs). The main goals of this study are to (i) evaluate the distribution and impacts of SMPs and MLCs on zooplankton trophodynamics and (ii) identify bioindicator species for SMPs and MLCs monitoring in Arctic coastal and open water systems during the late spring-early summer period.

Preliminary results revealed high bio- and functional diversity levels across the study area, with taxa exhibiting varied feeding habits and occupying different trophic levels. We analyzed ingested particles in four trapped taxa in KKS (Oikopleura (Vexillaria) vanhoeffeni, Calanus glacialis, Metridia longa and Themisto abyssorum) and the Fram Strait (C. glacialis, M. longa, T. abyssorum and Ostracoda), respectively. Simultaneous quantification and chemical identification of SMPs and MLCs were performed using a Micro-FTIR; the analysis allows the measurement of each particle under study (LOD size 5 µm). The preliminary results indicated the presence of different SMPs (e.g., high and low density polyethylene, polypropylene, tyre-wear particles) and different plastic additives (e.g., vulcanizers, antioxidants); besides, the sizes varied across the analyzed taxa. The data suggest inputs from both local (i.e., research activities and fisheries in Ny-Ålesund) and non-local sources due to long-range transport through

oceanic currents and winds. Ingestion and accumulation patterns were found to be species-specific and related to biometric traits and their feeding behaviours.

Microbial carbon cycling in an Arctic fjord over one full year

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Abstract: Rising Arctic temperatures warrant immediate attention, as they induce environmental changes that could alter microbial carbon cycling. Thermodynamics predict that reaction rates should increase with temperature, but assessing the impact on microbial processes (e.g., enzymatic breakdown, biomass incorporation, and respiration of organic matter) that influence organic vs. inorganic carbon (carbon dioxide) concentrations require rate measurements. These impacts cannot be derived using simple relationships, as microbes have complex emergent properties. However, such measurements are sparse and inconsistent in the Arctic, particularly in the winter, limiting our ability to predict the Arctic's potential as a carbon source or sink in the future. Here we present a year-long, weekly time series in Kongsfjord, Svalbard with coupled experiments to address several questions: How do various microbial processes (e.g., enzyme activities, heterotrophic production, and respiration) change weekly and seasonally over one year, to what is the relative importance of each process in the Kongsfjorden carbon cycle? What are the potential organic matter sources during the polar night, when phototrophic primary production ceases? Which microbial species are the best predictors and potential drivers of the measured processes? The year-long data establishes a weekly-resolved baseline for future comparisons of microbial carbon cycling measurements in Kongsfjorden.

Multi-stage karstification within a rift basin fill, Billefjorden Trough, Svalbard

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Abstract: An extensive deep-time paleokarst system is preserved within the Late Carboniferous basin fill of the Billefjorden Trough in central Spitsbergen. The karst formed due to the local dissolution of evaporites within the mixed siliciclastic-carbonate-evaporite succession. The exceptionally well-exposed outcrops of the narrow half-graben show sediments deposited in an arid to semi-arid warm climate. The basin is bounded by the Billefjorden Fault Zone (BFZ) in the west and cut by a number of mesoscale intra-basinal faults in the east. Here, we investigate the scale, origin, and timing of the formation of the breccias with regard to the active rifting period. We examine the multi-stage paleokarst system within the late syn-rift evaporites of the Minkinfjellet Formation and early post-rift carbonates of the Wordiekammen Formation.

Several karstification pulses developed in reaction to the activity on a series of intra-basinal growth faults. These west-dipping antithetic faults intersect the hanging wall of the BFZ. They facilitated the penetration of meteoric waters into the subsurface. Furthermore, the extent of gypsum dissolution and carbonate brecciation was likely influenced by climate perturbations, local subsidence, and sea-level fluctuations due to glacio-eustatic variations connected to the Late Paleozoic Ice Age. The penecontemporaneous gypsum solution karstification and collapse is preserved as horizontal stratiform breccias within the carbonate beds. They are connected with deeper, vertical breccia pipes formed along the footwall fault blocks of the intrabasinal faults. The breccias thicken towards the west. Two alternative models explain the evolution of the westernmost mega-breccia exposure located in the main basin depocenter adjacent to the BFZ. The breccia can be interpreted as 1) a tectonically-induced architectural feature sourced from the master fault zone by down-slope processes, or 2) a solution-collapse breccia connected to the paleokarst system.

Implications of hydrodynamic processes on the coastal-marine environments in Svalbard

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Abstract: Coastal and fjord environments face increasing pressure from the warming climate as well as socio-economic factors such as outdoor life, nature-based cruise tourism, and commercial fisheries. The resulting consequences for the communities and ecosystem are not well understood and the mitigation of adverse effects requires detailed and holistic knowledge of the environment in order to ensure the future sustainable development of the Arctic coastal communities.

The CoastAdapt project studies hydrodynamic and sedimentological processes in the near-shore coastal zone in Adventfjorden, Svalbard using novel technology developed for acquisition of water motion with very high temporal resolution. The deployed seabed sensors enabled to resolve full spectrum of waves in the shallow-water coastal zone, which is crucial for distinguishing waves and currents of different origins, from ocean swells to propeller wash from ships. We present the collected near-shore hydrodynamic and sedimentological data, and discuss the interaction of coastal and seabed hydrodynamic, sedimentological and morphological processes. Such datasets are rare from the Arctic coastal environments where sea ice and high-energy wave processes are the major drivers of the coastal evolution. The high-resolution data acquired during this project will improve our ability to understand and foresee natural coastal evolution as well as the interactions between changing coastal-marine environment and coastal infrastructure.

Studying spatio-temporal variability of glacier calving in Hornsund Fjord, Svalbard

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Abstract: The Hornsund fjord in Svalbard is undergoing rapid climate-driven transformation, warming over six times faster than the global average. The accelerated atmospheric and oceanic warming has triggered a series of environmental changes, including the retreat of marine-terminating glaciers. The glacier mass loss not only accelerates freshwater input into the fjord system but also contributes directly to the global sea level rise, primarily through surface melting and frontal ablation. However, glacier calving - a key process of frontal ablation, is still poorly understood and not yet fully represented in numerical models. Our study aims to address this gap by studying the temporal and spatial calving variability on marine-terminating glaciers of Hornsund fjord. Preliminary high-frequency time-lapse imagery analysis at Hansbreen has revealed significant calving rate variability both over time and along the glacier terminus. For example, during the 2016 ablation season, calving rates at Hansbreen were lower than 5 d^{-1} near the glacier edges, while rates reached as high as 23 d^{-1} in the central part of the terminus. Therefore, in our study, we further explore similar processes at all marine-terminating glaciers in the Hornsund fjord using satellite imagery. The spatio-temporal analysis of glacier calving will not only help us understand seasonal and interannual variations but may also shed light on potential drivers of glacier calving in Hornsund fjord. 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).

The first high-resolution dataset fort Svalbard coastal landforms and processes - a tool for remote assessment of coastal change

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Abstract: Arctic coastlines are highly dynamic and changing rapidly with warming climate. Observed coastal change includes coastal erosion, coastal build-out, development of new wetlands and exposure of new coasts after ice retreat. Locally coastline change takes place at a rate of up to 10s of meters per year, but variations along shore are large and even small fjords or inlets may experience large variations in change depending on exact location. Lack of baseline data, especially for remote locations, pose challenges for assessment of risk for cultural heritage and impact of costal erosion and wetland generation on ecosystems or carbon and nutrient budgets.

Our recently published dataset “Arctic landforms and processes around the coast of Svalbard” (Blok et al., 2024) is the first high resolution baseline dataset for coastal change in the Svalbard. The dataset encompasses the entire coastline of the archipelago and is based on morphological mapping of landform assemblages. Landform assemblages are linked to dominant physical processes, and the definitions are based on extensive fieldwork on around Svalbard. The coastal landform assemblages are categorized in 13 classes reflecting combinations of wave, tide, fluvial, glacial and gravity processes influencing the morphology and dynamics of the coastline. Mapping has been done in 1:30.000 scale on aerial images combined with satellite imagery. The open-source dataset adds regional high-resolution data to the western Barents Sea sector of the pan-Arctic Coastal Dynamics database (Lantuit et al. 2020). Combining this dataset with field observations of coastal retreat or advance and multispectral satellite images, also opens up possibilities for assessing rates of coastal change in remote regions.

Blok, Carlette N; Missana, Amandine F J M; Rubensdotter, Lena; Jensen, Maria A (2024): Arctic landforms and processes around the coast of Svalbard [dataset]. PANGAEA, https://doi.pangaea.de/10.1594/PANGAEA.973595

Lantuit, Hugues et al. (2020): The ACD Classification of Arctic Coasts [dataset]. PANGAEA, https://doi.org/10.1594/PANGAEA.919573

Towards the borealisation of Isfjorden: Seasonal, interannual and decadal changes in zooplankton biodiversity and community composition

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Abstract: Svalbard is located in the transition zone between warmer Atlantic and colder Arctic waters resulting in a naturally high variability in zooplankton biodiversity and community composition. To determine the rate of borealisation with global warming is therefore challenging and requires long-term time series with high seasonal resolution to establish a reference baseline that enables us to distinguish natural variability from climate change. Isfjorden Marine Observatory Svalbard (IMOS) – a long-term hydrography and plankton time series with seasonal resolution was initiated in 2014 as part of a Norwegian-Russian collaboration and has since been continued by UNIS. We have data dating back to 2001 for the innermost cold station (Billefjord) and to 2006 for the warmer mid and outer parts of Isfjorden. These three stations represent a transition from cold Arctic to warm Atlantic environments across the east-west direction in Isfjorden. Strong seasonal variability in zooplankton communities was found regardless of location but with distinctly different communities in the cold inner versus the warmer mid-and outer parts. Using a combination of morphological identification and molecular methods (DNA metabarcoding) improved the taxonomic resolution and made it possible to determine valid “climate” indicator species for colder, local Arctic water masses versus warmer advective water masses. Our results show interesting seasonal, interannual and decadal trends in zooplankton biodiversity that confirm a gradual borealisation of the zooplankton community in Isfjorden over the last decades, although the community generally resets to Arctic-characteristics during winter. However, in 2024, we observed for the first time a dominance of boreal species year-round suggesting that a “tipping point” had been reached where long dark winters no longer reset the communities to a more truly Arctic one as previously observed. This suggests a strong potential for accelerated borealisation in the coming years.

Same but different: how marine planktonic communities differ between the cold east and warm west coasts of Svalbard despite a large species overlap

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Abstract: Due to the interplay of warm Atlantic and cold Arctic waters, Svalbard is an ideal natural laboratory to study the effects of warming and borealisation on Arctic planktonic communities. While the east coast of Svalbard is dominated by cold Arctic water and seasonally ice-covered, the west coast fjords are in large part influenced by warmer Atlantic water and most are no longer ice-covered in winter. In this study, we capitalized on ships of opportunity – including expedition cruise vessels and the Norwegian coast guard vessel KV Barentshav – to collect marine planktonic microbial eukaryotes and zooplankton as well as associated environmental data in fjords across the Svalbard archipelago. In this way, we compiled over 300 sampling events in the summers (June to September) of 2018-2023, producing a picture of planktonic communities at an unprecedented spatio-temporal scale on Svalbard. Our community DNA metabarcoding data showed that despite oceanographic differences, species composition in cold fjords resembled that of warm fjords. However, the proportion of taxa differed markedly between the two coasts and some rarer taxa were not shared between coasts. Notably, diatom species composition differed strongly between the cold and warm fjords. Zooplankton communities were overall more similar between the two temperature regimes but some meroplanktonic taxa were unique to one regime. As Arctic warming progresses, many fjords currently influenced by Arctic water may shift toward a state resembling today's Atlantic-influenced fjords. These warmer fjords thus provide a glimpse into the future of Arctic marine ecosystems.

A shift in species composition and life cycle length of Calanus in Svalbard waters

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Abstract: The genus Calanus is a key component of sub-Arctic and Arctic marine ecosystems. They graze on algae, biosynthesizing long-chained fatty acids and fatty alcohols, making them lipid-rich and thus an important prey for others. In Svalbard fjords, the Arctic C. glacialis and the smaller boreal C. finmarchicus co-exist and are often used as indicator species for the presence of Arctic or Atlantic water masses. With the accelerated warming of the Arctic, it is predicted that Calanus populations will shift towards shorter generation time and smaller body sizes with less lipids per individual due to increased abundance of C. finmarchicus and a reduction from 2 to 1 year life cycle in C. glacialis.

Both species are very similar in morphology and body size is commonly used to distinguish between these species. This method, however, has been proved to fail particularly in recent years with the change in phenology in body size and life cycle with the warming. Using molecular tools to distinguish between these species is therefore crucial for correct species identification to identify life history adaptations to global warming.

In a yearlong study in Isfjorden and seasonal studies from Kongsfjorden and Billefjorden, we have studied seasonal changes in the Calanus population structure and individual body sizes. For every individual studied the body size was measured and species identified genetically. Our results show a clear dominance of C. finmarchicus in all locations. C. glacialis seems to have shifted towards a shorter life cycle then previously observed. A large portion of developmental stage CIV of C. finmarchicus and CV of C. glacialis is respectively larger and smaller than the previously established size classes used for morphological species identification, resulting in a high degree of misidentification using size only, demonstrating the importance of molecular confirmation to monitor climate change impacts on zooplankton communities in Svalbard.

Biochemistry of Arctic kelp populations is conditioned by local environment

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Abstract: Climate change causes temperature and light to change in Arctic fjords, being the main drivers for ecosystem engineering kelps. Climate projections on temperate kelps are often based on static performance curves, treating species as one homogenous unit. This might lead to mis-extrapolations, as the environmental history might change their susceptibility towards stressors. We assessed the response of eight Saccharina latissima populations towards their in-situ environment along the west coast of Svalbard. Analysing biochemical response variables (pigment composition; antioxidative activity; total carbon and nitrogen content) of sporophytes, we found a distinct clustering of populations, which correlated significantly with their environment. S. latissima responded strongly to changes in run-off induced light availability. High-light availability caused a significant reduction of photosynthetic pigments and a high de-epoxidation state of the photoprotective xanthophyll cycle, indicating high-light stress. Nevertheless, the kelps' total carbon content increased with higher light availabilities. The kelps' total nitrogen content increased with increasing turbidity, reacting to nutrients being washed into the fjord. We found no significant response to temperature (3–7°C), emphasising the importance of light as a driver of high-latitude kelps, and the necessity to include it in climate projections. We found a high site-specific plasticity of Arctic S. latissima sporophytes, and high variation in biochemistry, responding to interacting environmental factors.

Session Climate resilience of Arctic settlements and the footprint of anthropogenic activities

Cultural heritage in a changing climate: The crucial role of snow and building management on ground surface temperatures

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Abstract: Cultural heritage on Svalbard plays a crucial role in preserving historical knowledge, shaping the identity of the local communities, and attracting tourists. Cultural heritage sites are closely linked to the history of coal mining, exemplified by historical buildings in Ny-Ålesund such as the Green Harbour House. However, these structures are threatened by the harsh Arctic climate and changing climatic conditions, and particularly warming permafrost, which endangers their stability.

As part of the PCCH-Arctic project, we analysed two years of ground surface temperature (GST) data collected in the village area of Ny-Ålesund to evaluate how the management of snow and buildings affect the ground thermal regime. Our findings show significant variations in mean annual GST across the village, influenced by snow ploughing, building type, and building wall orientation. Mean annual GST above the thaw threshold of 0°C were found at locations with thick artificial snow deposits during winter, and beneath heated buildings without crawl space ventilation.

Our findings underscore the critical need to understand the interplay between ground temperatures and the management of snow and buildings, which significantly affect local GST variations and consequently the stability of cultural heritage sites.

Adapting to Climate Change: The Role of Cultural Heritage in Arctic Resilience

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Abstract: This presentation examines the critical role of cultural heritage in enhancing the climate resilience of Arctic settlements, with a focus on Svalbard. The rapid degradation of archaeological sites underscores the profound impacts of climate change on cultural heritage and its broader implications for Arctic communities. As climate change accelerates, rising temperatures, thawing permafrost, and increasing coastal erosion pose significant threats to Svalbard's unique cultural landscapes. These changes compromise not only the physical preservation of historical sites but also the intangible cultural connections that define local identity and social cohesion.

Despite growing recognition of these challenges, efforts to mitigate threats to cultural heritage have been limited. Cultural heritage is often deprioritized in favor of tourism, geopolitical interests, and natural science research, to the detriment of the island's international heritage. In Arctic settlements like Svalbard, increasing tourism—vital for local communities—further exacerbates the risks of cultural loss. The erosion of irreplaceable heritage sites affects not only historical knowledge but also the cultural identity and social fabric of the region.

Through a case study of the whalers' burial site at Likneset, this presentation demonstrates how interdisciplinary approaches can contribute to climate resilience strategies. The site's well-preserved burial structures offer a unique opportunity to examine the effects of environmental change on cultural heritage, highlighting its role in fostering social cohesion, identity, and adaptation in the face of climate change.

By integrating archaeological, environmental, and social science methods, this study emphasizes the importance of cultural heritage in Arctic communities' adaptation strategies. Protecting these sites can strengthen the resilience of local populations, safeguard historical knowledge, and ensure that cultural identity endures amidst the challenges of a changing climate.

Wilderness or Witness: Shifting Values and the Governance of Arctic Remains

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Abstract: Cultural heritage in the Arctic, such as the coal cableway station at Hiorthhamn in Svalbard, plays a vital role in interpreting climate impacts and informing adaptation strategies. Within the Horizon Europe project THETIDA, this site is a pilot for developing an integrated digital platform that combines remote sensing, geomorphological mapping, in situ sensors, and 3D modelling to assess multiple risks to coastal heritage. The project employs participatory Living Labs to co-create scenarios, facilitate local engagement, and explore values, perceptions, and governance challenges.

Hiorthhamn exemplifies the layered meanings of Arctic industrial heritage. Once functioning as a coal transport facility, later seen as debris, and now protected as cultural heritage, it illustrates the temporal dynamics of meaning-making in a changing landscape. As Svalbard's identity shifts towards a pristine, tourism-oriented Arctic wilderness, mining remnants are often viewed as incompatible with that imaginary. However, when contextualized with historical narratives of isolation, resilience, and human endeavour, these remnants transform into valued elements of the landscape and memory. This reframing challenges assumptions of "wilderness" and calls for heritage policies that embrace complexity and change.

Looking ahead, two critical pathways for Arctic heritage management emerge: one that prioritizes specific sites for conservation based on value and feasibility, and another that focuses on the systematic monitoring and documentation of climate-driven heritage loss. In both cases, digital tools such as satellite-based geomorphological data, ground temperature sensors, and erosion monitoring become essential for decision-making. These approaches highlight the urgency of integrating cultural heritage into broader Arctic climate adaptation frameworks and ensuring its place in resilient future strategies.

What is the cultural heritage of Longyearbyen in 2040 when more than 50 % of the residential buildings are new?

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Abstract: Longyearbyen is a company town based on coal mining that has developed from 1906 until today. In 2025 the last mine, Gruve 7, will close. Due to climate change the permafrost is thawing and avalanches from the mountain sides are a threat to the community of 2500 inhabitants. The wooden pile foundations that most of the houses stand on, move and rot. Energy prices increase and several calculations conclude that existing buildings must be replaced with new, to reduce energy consumption. Most residential buildings from after the war are not protected, and those that are protected as cultural heritage are at risk of being abandoned, as the cost for upgrade is high.

How much of the existing Longyearbyen do we have to keep, to preserve and develop the DNA of the place?

The work has based on the DIVE method, adjusted in awareness and dialogue with the processes and public discussions in the local community. It's developed together with the Governor in Svalbard, Lokalstyre, Svalbard Museum and Visit Svalbard, financed by Svalbard Environmental Fund.

The result is a knowledge base for the upcoming larger transitions in Longyearbyen. With emphasis to use and develop the colour plan of Longyearbyen and invest in quality in the common spaces. It reflects on the problems in existing processes and points out some of the most important places and buildings for Longyearbyen's identity.

Horizon scanning for alien species and their potential distribution in a warming Arctic: a panarctic and a Svalbard case study of vascular plant species

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Abstract: Increasing human activity and changing climate will increase the arrival, potential for establishment and dispersal of alien species in the Arctic. The lack of biosecurity is thus of concern.

To facilitate the development of biosecurity measures for the Arctic, and for the rapidly warming and highly trafficked archipelago of Svalbard in particular, we carried out data-driven horizon scanning exercises to identify vascular plant species that may present the highest risk to biodiversity for current and future climatic scenarios.

For a panarctic assessment, we compiled a list of relevant, potential alien species using the Global Naturalized Alien Flora database as a species pool, excluding any species already present in the Arctic. We then generated climatic niche models to identify species with a potential climatic niche overlap in the Arctic, and our results highlight hotspot regions for biosecurity measures. For Svalbard, we used data from quantitative ecological risk assessments of 27 established or door-knocker plant species and generated ecological niche models to carry out risk assessments of current and future macroclimate suitability. Results suggest that many Arctic alien plant species have a broader macroclimatic niche than they currently occupy, and that there is a large pool of potential new alien species to the Arctic.

Further horizon scanning across species groups, future standardized monitoring of pathways, and early detection are urgent. It is critical for Arctic research planning to follow up international priority actions to improve the knowledge base for well-informed decision making to prevent and control invasive alien species.

Challenge of emerging organic contaminants in the changing Arctic

Main author: Zhiyong Xie, Helmholtz-Zentrum Hereon, Germany

Abstract: The Arctic is increasingly exposed to contamination from both legacy persistent organic pollutants (POPs) and chemicals of emerging concern (CECs), including per- and polyfluoroalkyl substances (PFAS), pharmaceuticals and personal care products (PPCPs), microplastics, and flame retardants. These contaminants, transported globally via atmospheric and oceanic pathways, now accumulate even the most remote Arctic. Their bioaccumulation poses significant risks to marine life and Indigenous communities relying on traditional food sources. Climate change is exacerbating these threats by altering pollutant distribution and remobilizing historically trapped chemicals. This study examines the sources, transport pathways, and ecological impacts of Arctic contamination. We assess how long-range atmospheric and oceanic transport delivers pollutants to the region, while growing local human activities introduce additional contamination. A critical focus is the climate feedback: warming temperatures release legacy POPs from thawing permafrost, glaciers, and sea ice while simultaneously facilitating the introduction of CECs. Our findings highlight the urgent need to understand these complex interactions to inform justification strategies and protect Arctic ecosystems and communities from increasing emerging chemical threats.

Taking Off The Lid: The changing lightscape of the Arctic Ocean and Barents Sea under sea ice decline

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Abstract: Light is a fundamental driver for marine ecosystems across trophic levels. Nowhere on the planet is the marine lightscape varying more throughout the year than in the Arctic Ocean, but it is also rapidly changing with the retreating and thinning sea ice cover. In addition, the lightscape varies with the cloud cover, lunar phase and the water column concentration of phytoplankton and terrestrial run-off (mainly CDOM), making it challenging to model and observe. Increased light levels will lengthen the phytoplankton growth season, but also force zooplankton to stay at deeper depth for longer periods to avoid predation, which may hamper the energy transfer to visual feeders like pelagic fish. Most Earth System Models used in the Arctic are currently oversimplifying the ecologically relevant optical processes, making it challenging to accurately capture major changes and predict the future state.

Using the irradiance model HEIMDALL in the northern Barents Sea, we have previously shown that the sea ice retreat extends the growth season for phytoplankton by more than a month. Here, we move into the central Arctic Ocean, where terrestrial river run-off from Siberia contributes to substantially higher light attenuation within the Transpolar Drift. We present field measurements from the Arctic Ocean 2022 cruise onboard FF Kronprins Haakon, and model the effects of terrestrial run-off on the lightscape relevant for zooplankton and phytoplankton. We see that higher CDOM levels associated with riverine inputs to the basin have a significant effect on the lightscape, postponing the phytoplankton growth season in spring. Increased run-off will likely augment the ongoing sea ice decline and lead to a highly regionalized Arctic by 2050, with large contrasts between the Amundsen and Nansen Basin and the different shelf areas in terms of light, with wide-ranging consequences for ecological processes in a seasonally ice-free Arctic.

Temporal trends of per- and polyfluoroalkyl substances (PFAS) in top predators from Svalbard over two decades

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Abstract: Per- and polyfluoroalkyl substances (PFAS) – widely used industrial chemicals for decades – are ubiquitously present in biota due to their ability for long-range transport, bioaccumulation, and biomagnification. High PFAS concentrations in top predators of remote Arctic ecosystems pose a risk to their health. Long-term monitoring of pollutants in Arctic top predators provides insight into the effectiveness of regulations on the few PFAS that are subject to international regulations and helps detect potential increases in emissions of those still in use. It also enhances our understanding of how climate change influences PFAS exposure.

We updated temporal trends of legacy and currently used PFAS in polar bears and arctic foxes from Svalbard in relation to climate-driven alterations in feeding habits and food availability. The trends covered the period 2000-2022 for adult female polar bear plasma samples (n=302) and 1997-2021 for young Arctic fox liver samples (n=191). Most compounds peaked between 2005 and 2015, while perfluorooctasulfonate (PFOS) declined over the study period. Despite the phase-out of PFOS in the early 2000s, it still constituted ~60% of the ∑PFAS. Currently used short-chained PFAS were mostly below the limit of detection. Overall, PFAS concentrations increased with higher trophic levels (δ15N) and greater intake of marine prey (δ13C), while sea ice extent had less influence. PFAS concentrations corrected for the variation in feeding habits and food availability showed similar trends to the measured concentrations. Although PFAS levels are generally declining in polar bears and Arctic foxes as a response to changes in emissions and regulations, current PFAS concentrations are comparable to those observed in humans with the highest PFAS exposure worldwide and remain thus a concern for their health. Future studies will focus on adverse health effects of PFAS and the potential occurrence of previously unmonitored PFAS.

Microplastics and Microlitter components in fjords of Svalbard Archipelago: seawater and sediment analysis

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Abstract: The present study was part of the PLACEBO (PLasticizers, Additives, miCroplastics in sEawater in SvalBard ArchipealgO, Arctic Fieled Grant) and MICROTRACER (Small MICROplastics (<100 μm) bioindicaToRs in the changing ArctiC EnviRonment, National Program of Research in Arctic, PRA) projects that aimed to identify and simultaneously quantify small microplastics (SMPs) and other microlitter components (MLCs) in the Arctic environment, with a focus on superficial seawater and marine sediment. SMPs are often overlooked, despite are the most abundant in the environment. These smaller particles can be easily transported through atmospheric and marine currents and easily ingested by organisms, bioaccumulating along the trophic webs. During summer 2022, several samples of superficial seawater and sediment were collected along two fjords of the Svalbard Archipelago, the Kongsfjorden and the Krossfjorden. The particles were extracted from the samples by an oleo-extraction and the final filter analyses via Micro-FTIR for characterization and simultaneous quantification.

Some results revealed a difference of MPs and MLCs abundance between the matrices (seawater vs sediment) and between the sampled sites. The highest percentage of particles was found in those points close to glaciers and to the Ny-Ålesund research village, both potential sources of contamination. Most of the particles were smaller than 100 μm, typically with a spheroidal and ellipsoidal shape. The North Atlantic Current, coming from the lower latitudes, can also have an influence on concentration and type of contaminants. Hence, further studies are needed to better understand the role of the local and long-range transport in the Svalbard. Due to analytical and sampling limitations, SMPs have been underestimated; indeed, future studies should consider necessary the study of the smaller particles size.

Power and interests in environmental policy processes: The Svalbard case

Main author: Tiril Vold Hansen, Nordlandsforskning, Bodø, Norway

Abstract: The growing human footprint in remote and ecologically sensitive regions intensifies tensions between environmental protection and development. In the Arctic Archipelago of Svalbard, Norway, rapid climate change and expanding tourism increasingly challenge efforts to preserve wilderness values. While official policy emphasizes conservation, Svalbard has seen substantial growth in tourism, research, and settlement activity—raising critical questions about the governance of protected areas under anthropogenic pressure. This article investigates the contested political process surrounding the Norwegian government's 2021 proposal to tighten environmental regulations in Svalbard. Employing Lukes' three-dimensional view of power, it explores how perceptions of wilderness are constructed and negotiated within environmental policy discourse. The case illustrates how conflicts over regulation often reflect deeper ideological tensions regarding the purpose and ownership of wilderness. Furthermore, the limited transparency and stakeholder participation in the policymaking process provoked criticism, underscoring broader governance challenges in managing complex environmental trade-offs. By analyzing the intersection of power, interests, and wilderness perceptions, this study contributes to a deeper understanding of environmental governance in contested spaces.

Cold-Adapted Bacteria from Arctic Lakes: Potential for Bioremediation of Heavy Metals and Polychlorobiphenyls

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Abstract: Polar regions are increasingly impacted by anthropogenic pollution, notably heavy metals (HMs) and polychlorinated biphenyls (PCBs), which have been detected in Arctic lake ecosystems. Bacteria, at the base of the food web, can absorb or immobilize HMs and degrade organic pollutants like PCBs. This research, as part of the PNRA project MicroPolarS, aimed to isolate and characterize bacterial strains able to degrade PCBs or tolerate HMs at low temperatures. During summer 2021, sediment samples were collected from five lakes surrounding the Ny-Ålesund research village: Solvatnet, Glacier, Knudsenheia, Storvatnet, and Tvillingvatnet. To assess enrichment cultures, 1 g of sediment was inoculated into 75 mL of filter-sterilized lake water, supplemented with selected HM salts (1000 ppm $FeSO_4$, 1000 ppm $CuSO_4$, and 100 ppm $HgCl_2$) or biphenyl (0.1%, wt/vol) at 4°C. This approach led to the isolation of 58 and 46 bacterial strains from HM enrichments and biphenyl enrichment cultures, respectively. Among isolates from HM enrichments, 15 thrived in high iron concentrations (up to 5000 ppm), predominantly affiliated to the genus Pseudomonas within Gammaproteobacteria. Two strains tolerated both copper and mercury, while nine tolerated only mercury. Sequestration rates for six promising strains showed that the overall efficiency ranged 5-15 and 5-12% towards mercury and iron, respectively. Regarding biphenyl-oxidizing bacteria, 24 strains (mainly affiliated to Pseudomonas spp.) grew in the presence of Aroclor 1242 as the sole carbon and energy source, with 18 strains harboring the bphA gene, a key marker for PCB degradation potential. Seven promising strains showed interesting capability in degrading Aroclor 1242, with two strains (i.e., S3D-2 and S3D-5) that resulted particularly efficient. The ability of these indigenous strains to function effectively at low temperatures offers promising avenues for developing eco-friendly strategies to remediate contaminated polar ecosystems.

Our FOOTSTEPS in the tundra

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Abstract: Arctic tundra systems are highly sensitive to direct anthropogenic impacts such as human trampling. Careful planning is necessary during research and recreational activities to identify levels of impact reconcilable with conservation efforts. Even though this is prioritised by the governmental agenda of Svalbard, there is little quantitative data available to make such decisions in an informed manner. In the FOOTSTEPS project, we aim to quantify the sensitivity of various Svalbard ecosystems to human trampling. Specifically, we investigate how human trampling affects vegetation, soil, and carbon balance, and to which extent this is modulated by local environmental factors. Subsequently, we assess whether there are indicators for sensitive areas that can easily be observed in the field. To achieve this, we recycle former research sites to compare pristine and trampled sites, covering a range of trampling intensities and landscape types. For each site, we will measure numerous vegetation and soil properties. As we expect plant groups to differ in susceptibility to trampling and local soil properties to modulate this susceptibility, the findings from this project could inform future activities in arctic tundra ecosystems. This includes tourism and recreation, which could then accurately be directed towards areas with equal scenic quality but lower sensitivity to trampling. Similarly, this could contribute to directing site selection in future research projects, which are often set in pristine and highly sensitive landscapes. Thus, we hope that the FOOTSTEPS project will help to improve decision-making, communication, and understanding during recreational and scientific activities on Svalbard.

Local Arctic Pollution Sources-A circum Arctic perspective

Main author: Geir Gabrielsen, Norwegian Polar Institute

Full list of author(s): Roland Kallenborn (NMBU) & Geir Wing Gabrielsen (NPI)

Abstract: The Arctic region remains one of Earth's last pristine frontiers. However, it is increasingly becoming a sink for various chemical residues. Over the past 50 years, legacy chemicals have been continuously monitored through programs coordinated by the Arctic Monitoring and Assessment Programme (AMAP). Recently, many new chemicals of emerging Arctic concern (CEACs) have been identified and investigated. These substances, including pharmaceuticals, personal care products, poly- and perfluoroalkyl substances (PFAS), industrial chemicals, and microplastics, are either emitted by local sources (domestic, industrial, or military) or transported to the Arctic through complex atmospheric and oceanic pathways from remote sources.

In this presentation, we will explore the latest findings from the recently concluded evaluation of local Arctic pollution sources by AMAP. Svalbard will be specifically addressed and highlighted as a research location. The focus will be on the presence, distribution, and impacts of CEACs in Arctic environments, as well as the methodologies used for their monitoring and assessment under remote and harsh environmental conditions.

We will discuss the possible implications of the ongoing complex research and assessment strategies for risk assessment of CEACs in polar environmental research. The close linkage between modern environmental chemistry, toxicology, fate modelling, monitoring, environmental assessment, and regulation will be highlighted for sustainable pollution regulations in the Arctic. Additionally, potential conflict scenarios between environmental concerns and geopolitical, economic, and strategic interests in the region will be addressed in the planned presentation.

Are we ready for the invasion? – terrestrial aliens on Svalbard.

Main author: Anders Endrestøl, Norwegian Institute for Nature Research

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Abstract: Invasive species are among the greatest threats to global biodiversity with significant ecological and socioeconomic impacts. In the Arctic, increased human activity and climate change are accelerating the introduction and establishment of invasive species.

In 2024 we collected invertebrates and seed banks at 12 sites in Svalbard: seven disturbed sites with current or past animal husbandry, and five undisturbed tundra and bird cliff reference sites. At each site we collected five soil samples and one G-vac sample along a 30 m transect. Invertebrates were extracted with Berlese funnels, and the seed bank was germinated for analysis.

We found more than 275,000 invertebrate individuals and germinated over 4,500 seeds. Most invertebrates were springtails, identified to 43 species, two of which are new aliens to Svalbard. Species composition differed between disturbed and natural sites, with significantly higher diversity in natural areas and most alien species found in disturbed ones. Among a total of 30 plant taxa, we identified 10 alien species. Grasses were dominant, and unlike invertebrates, seed abundance and diversity were highest in disturbed soils.

We hypothesize that alien invertebrates may outcompete native species in disturbed habitats, while the seed bank likely reflects both current and historical plant communities.

Under the Svalbard Treaty (1920), Norway is obliged to protect Svalbard's natural environment. Fulfilling this responsibility requires a comprehensive understanding of the species inventory and how it is affected by human activity. National and international strategies – including Norway's action plan on invasive species, CAFF's Arctic Invasive Alien Species Strategy and Action Plan, and Svalbard's own Action Plan for Invasive Species - highlight the urgent need for mapping, monitoring, and early warning of invasive organisms in the Arctic, underscoring the need to intensify efforts across the Arctic region.

Svalbard amphipods as bioindicators of plastic pollution (MICROTRACER project): simultaneous identification and quantification of microplatics and anthropogenic particles below 100µm particles below 100µm

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Abstract: There is a pressing need to deepen our understanding of plastic load and how microplastics reshape organisms and their environments. Filling this knowledge gap is vital, considering how microplastics (MPs) and other anthropogenic particles, e.g., plastic additives, synthetic fibers, and bioplastics, travel from mid-latitude regions all the way to the poles. Considering global climate change, these seemingly remote areas are now facing significant challenges.

The Microtracer project (PRA 21-005) aims to bridge this gap, with a key goal being the identification of bioindicator organisms that could reveal the extent of plastic pollution. Invertebrates can ingest microplastics and other anthropogenic particles below 100 µm. Examining the plastic load in entire organisms is essential since these organisms serve as prey for a diverse species throughout the food web. Thus, we can better comprehend the threat posed by plastic pollution to the trophic web.

To achieve this, we collected samples from various amphipod species at three sites in Kongsfjorden during the summer. Amphipods, known for their ecological significance, are extensively studied and recognized as environmental bioindicators.

Some of the organisms were used for taxonomic recognition. For microplastic analysis, the organisms were pseudo-digested. After pseudo-digestion, particles were filtered on aluminum oxide filters (0.2 µm, 47 mm), then left to dry in previously decontaminated Petri dishes. All operations were conducted in a plastic-free ISO 7 clean room. The filters were analyzed via Micro-FTIR, performing particles analysis - simultaneous microscopic counting and particle identification. The abundance and

distribution of the particles were found to be different not only among species, but also among the sites. In addition to various plastic polymers, tire wear particles were observed. The results of this study highlighted that Amphipods can be excellent bioindicators of plastic pollution in remote areas.

Arctic Echoes: Reimagining 19th Century Polar Narratives in the Context of Contemporary Climate Science

Main author: Hayley Bowen, Temple University, College of Liberal Arts | Department of English Literature, Philadelphia, Pennsylvania, USA

Abstract: The 19th century saw intense British imperial activity in polar regions, generating a wealth of expedition logs, scientific reports, and popular literature that shaped the public and scholarly discourse of Arctic exploration. These textual records contain valuable but underutilized information about historical ice conditions, wildlife populations, and weather patterns that preceded systematic scientific measurement. Equally important, these narratives reveal problematic imperial frameworks that have shaped how western science approaches the Arctic, particularly in relation to indigenous knowledge systems. My project seeks to establish connections between historical ecological observations through 19th century imperial travel narratives in the Arctic and contemporary Arctic climate science, bridging a gap between environmental humanities and environmental sciences. By providing cultural context for environmental data, my research will focus on uncovering valuable historical baselines from exploration accounts and offer insights into effective communication strategies that connect scientific findings to human experience. My proposed presentation will address the following research questions:

1.How did 19th century exploration narratives document ecological conditions in the Arctic, and how do these historical baselines compare with current scientific observations?

2.In what ways did imperial exploration narratives represent indigenous Arctic peoples, and how have these representations contributed to ongoing forms of erasure?

3.How might historical polar narratives, read alongside contemporary climate science, inform current approaches to Arctic preservation and climate action?

This project creates a dialogue between past and present that presents an opportunity for a crucial humanities intervention in predominantly scientific discussions of climate change, highlighting how cultural narratives shape environmental understanding and policy responses.

Which chemical species are deposited during rain-on-snow events in the Arctic?

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Abstract: Rainfall on an existing snowpack, known as rain-on-snow (ROS), is a significant consequence of climate change, with the potential to disrupt the environment by altering the hydrological cycle and influencing snow albedo. Several ROS events occur in the Arctic, where winters have become progressively warmer and wetter. These events can profoundly impact both the physical landscape and ecosystems of the North. Detecting ROS events is crucial for understanding their characteristics, shifts in frequency and severity, and their wide-ranging effects. Current investigations rely on data from meteorological stations, insights from local and Indigenous knowledge holders, satellite remote sensing, and atmospheric reanalyses. However, the relationships between chemical species deposited during ROS events and snowpack metamorphism remain unclear.

The main aim of the ROSETTA project is to understand how the chemical composition of ROS impacts surface snow. The first step toward achieving this goal is to determine the chemical composition of these wet depositions (especially rain samples, but also snow depositions), to estimate the differences between them.

Wet depositions were collected on the roof of Gruvebadet atmospheric laboratory (GAL, 78°55’03” N, 11°53’39” E, 50 m a.s.l.) located about 1 km far from Ny-Ålesund during the snow season 2023-2024. The samples were collected using a Wet&Dry deposimeter (MTX srl, Italy). Rain (n. 10) and snow samples (n. 18) were analyzed to determine: major ions, methansulphonic acids, carboxylic acids, monosaccharides, alcohol sugars (such as mannitol and arabitol), levoglucosan and its isomers, benzothiazoles, organophosphate flame retardants, trace elements and lead isotopes.

This is the first time that ROS events have been chemically characterized using such a wide range of species, which can help identify potential sources and evaluate their possible impact on snow after deposition.

Human exposure to microplastic and UV stabilisers through Atlantic cod consumption: a focus on Norway

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Abstract: Microplastic (MP) occurrence in food is a rising topic and many matrices are investigated, from crops to animals produced for food. Seafood is an important resource for many countries, but fish fillet is poorly investigated for plastic, and plastic related chemical, pollution. The Atlantic cod (Gadus morhua) is of utmost importance for Norway due to its cultural and economic value. Atlantic cod is the 11th most caught fish worldwide and one third is fished by Norway. MP exposure has been scarcely studied, and their occurrence in edible tissues is unknown. In this study, we quantified MPs and five UV stabilisers (UVS) in 20 cod fillets from the Arctic, southwest of Svalbard. The digestive agent used was KOH and Raman spectroscopy was used for particles' identification. We divided the samples into 2 subsets: ten samples were analysed with a limit of lowest size detection of 50 µm, and the other ten were analysed down to 20-µm and 50 µm, depending on the sample area. MPs were found in 65% of the fillets analysed. Polypropylene was the most common polymer. Only one MP was within the 20-50µm size range. Detected MP sizes ranged between 22 and 1814 µm. MP concentrations ranged from 0 to 1.94 MP/g ww, a similar number to mussels collected along the coast of China (0.9 to 4.6 particles/g ww). Only one congener showed concentrations above LOD (UVS-326), only in four samples. These concentrations were close to the LOD. In a context of food safety, our results mean that an average Norwegian man, woman and 4-year-old weekly ingest 50.2 MPs, 31.2 MPs and 13.6 MPs, respectively, through cod fillet consumption.

Session Svalbard in transformation: from seasonal variability to long-term trends

Systematic assessment of characteristic circulation weather types affecting the Ny-Ålesund column

Main author: Philip Eisenhuth, Alfred Wegener Institute, Physics of the atmosphere, Germany, Potsdam

Abstract: As meteorological conditions in Ny-Ålesund (NYA) are strongly influenced by the prevailing weather regime, such as easterly, cyclonic or anticyclonic influence, we developed a systematic assessment of characteristic circulation weather types (CWT) affecting the Ny-Ålesund column. We achieved this by implementing the Jenkinson-Collison (JC) algorithm for the automated detection of prevailing CWT in the Svalbard region using hourly MSLP reanalysis data (ERA5) and provide a thorough characterisation of the dominant CWT that have influenced NYA over the last 30+ years.

Given the ongoing climate changes in the Svalbard region, an important question to be addressed is to what extent these Arctic amplification (AA)- related trends have been caused by changes in CWT, and what implications this may have for potential future changes in the state of the NYA column. The analysis includes an examination of variability and trends in CWT with respect to frequency of occurrence, intensity and persistence of specific types, respectively. The results are projected onto the relationships between CWT and NYA column parameters, to assess the role of CWT in shaping the multi-year and seasonal evolution of the NYA column properties.

Contrasting conditions of landfast sea ice at the western and eastern coasts of Spitsbergen

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Abstract: During winter and spring, large parts of the coast of the Svalbard archipelago are affected by landfast sea ice, which is sea ice that is directly connected/frozen to the coastline. The duration of seasonal sea ice presence per winter/spring has been reduced many places in the Arctic, including Svalbard, over the last decades. However, conditions in the western and eastern parts of Spitsbergen, the largest of the islands of Svalbard, exhibit interesting contrasts, when it comes to the presence and properties of landfast sea ice. Here, we will illustrate and discuss such contrasting conditions with data from two sea ice monitoring locations of the Norwegian Polar Institute: Kongsfjorden at the western coast of Spitsbergen, and Inglefieldbukta, Storfjorden, at the eastern coast. Landfast sea ice at Kongsfjorden is restricted to the inner parts of the fjord, since waters at the west coast of Spitsbergen are affected by the relatively warm West Spitsbergen Current, bringing Atlantic water to the north. In contrast, Storfjorden at the east coast is only little influenced by advected warm water masses, and the sea ice there lasts longer than in the west, with ice growing thicker. Consequently, also the snow cover in the east is thicker, having implications for the potential of snow-to-ice transformation, for limiting sunlight reaching the sea ice and water below, and for conditions necessary for dens for ringed seals. On smaller spatial scales, specific settings of observation sites in a fjord determine how conditions are locally affected, for example by grounded icebergs, nearby calving glaciers and the specific fjord/coastal hydrographic conditions. The presentation will include comparisons of seasonal and longterm development of ice and snow thickness, as well as ice freeboard, from the two monitoring locations.

How marine life affects clouds and climate: Methane sulphonic acid - a new piece in the puzzle.

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Abstract: New particle formation (NPF) is the primary source of atmospheric aerosol particles and cloud condensation nuclei (CCN) in the summertime Arctic. This process is typically initiated by ion-induced nucleation - i.e. clustering - of sulfuric acid and ammonia molecules over or near open ocean regions, or by iodine oxoacids over sea ice-covered areas. Once formed, these initial 1-2 nanometer clusters grow through condensation to sizes of several tens of nanometers, at which point they can act as CCN, influencing cloud properties and climate.

While methanesulfonic acid (MSA) has been shown to nucleate with sulfuric acid and ammonia under laboratory conditions, in the atmosphere it has previously been shown to contribute only to the condensational growth of particles.

Since spring 2017, we have been conducting real-time measurements at Ny-Ålesund, Svalbard, using a chemical ionization mass spectrometer to monitor sulfuric acid, iodine oxoacid and MSA concentrations alongside cluster size distributions. Instrument upgrades in 2024 enabled us, for the first time, to accurately and systematically determine the chemical composition of freshly formed 1–2 nanometer clusters.

Our observations during the early summer phytoplankton bloom revealed that MSA clusters with sulfuric acid and ammonia, as predicted by earlier laboratory studies. Besides nucleation, MSA promotes also new particle growth - that was already demonstrated in our previous work - and thus likely enhances concentrations of aerosol particles and CCN widely in the Arctic

MSA is formed through the gas-phase oxidation of dimethyl sulfide (DMS), which is emitted by pelagic phytoplankton. Along with sulfuric acid - also largely derived from DMS oxidation - and ammonia from seabird colonies, our observations on the role of MSA in NPF further highlights the remarkable connection between marine life, cloud formation, and climate.

Climate change will affect marine ecosystems and bird colonies responsible on producing the gases necessary for the new particle and CCN formation. Accurate understanding on atmospheric processes help us predicting the future state of the Arctic.

Groundwater Storage and Subsurface Flow Development in a Warming Arctic Catchment

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Abstract: Climate change is rapidly altering the Arctic, with permafrost thawing and changes in active layer thickness (ALT), which in turn significantly affect hydrology. This study investigates the relationship between ALT and catchment responses in the High Arctic Fuglebekken catchment (Spitsbergen), focusing on increased infiltration and groundwater storage. In this study, we combined borehole, piezometer, and surface water observations with HBV model simulations. The results indicated that the slow runoff reservoir showed significant changes, indicating increased subsurface flow. The model parameter KS, related to slow runoff, exhibited temporal peaks during snowmelt and thaw, as well as during high precipitation in September, while the other parameters were more stable. This research provides key aspects of the evolving High Arctic hydrological dynamics due to climate change.

On the tidal forcing of an Arctic coastal polynya - Storfjorden polynya

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Abstract: Svalbard located in the high Arctic harbors a recurring polynya in Storfjorden. A polynya is a region of open water surrounded by ice in a frozen sea, often referred to as "ice factories." The Storfjorden polynya forms when strong northeasterly winds push the ice away from the islands at the northeastern end of the fjord. The channel Freemannsundet, situated between these islands, links Storfjorden to the Barents Sea, and between low and high tide, water flows through the channel. This research aimed to assess the impact of strong tidal currents on the dynamics of the polynya and the formation of sea ice. A novel tidal ice drift model has been integrated into an existing polynya model, revealing that, on average, frazil ice formation increased by 2.7% and salt release by 1.2%. Satellite imagery suggests that strong tides near the channels aid in opening the polynya by breaking up ice near the shoreline, allowing out-fjord winds to carry the ice away. We find that tidal forcing can contribute to the mechanical opening of the Storfjorden polynya within approximately O(1 km) from the coastline. Although small on average, opening of polynyas by tidal forcing is relatively more important in calm wind conditions with increased frazil ice production (4%) and salt release (2%) due to oscillating open water areas along the coast. Our findings suggest that the tidal influence on Arctic coastal polynyas will intensify in tandem with the ongoing thinning of sea ice, attributable to the ongoing Atlantification and Pacification affecting the continental shelf seas surrounding the Arctic Ocean.

Adapting the HBV Model for Permafrost Conditions in the Fuglebekken Catchment, SW Spitsbergen

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Abstract: The HBV hydrological model has demonstrated wide applicability across diverse climatic regions. However, its performance in polar environments, especially in catchments undergoing transition, is limited by insufficient representation of permafrost-related processes. In Arctic and high-latitude settings like Svalbard, the seasonal freezing and thawing of soils and subsurface layers significantly affect infiltration, storage, and runoff generation.This study enhances a lumped and semi-distributed version of the HBV model to better simulate hydrology in permafrost-influenced catchments. Two key cryospheric processes were incorporated: (1) the impermeability of frozen ground during cold periods, inhibiting infiltration, and (2) the freeze-thaw cycle of groundwater, which modulates subsurface flow timing and volume. The adapted model was applied to the unglaciated Fuglebekken catchment in Hornsund, southwest Spitsbergen, a basin characterized by discontinuous permafrost and strong seasonal variability, and currently undergoing hydrological transition due to permafrost degradation.Four model configurations were evaluated: the standard HBV, a version including frozen ground impermeability, a version accounting for freeze-thaw groundwater dynamics, and a combined version with both adaptations. All models were forced using newly calibrated potential evapotranspiration (PET) time series, derived by adjusting the Penman method to local evaporometer data.Model performance was assessed against observed streamflow using the Kling-Gupta Efficiency (KGE). While overall performance was comparable across configurations, the permafrost-adapted models consistently outperformed the standard HBV during years with more challenging hydrological conditions. This emphasizes the importance of integrating cryospheric processes into hydrological models to capture the evolving behavior of Arctic catchments under climate change. Fuglebekken's transition illustrates the broader need for process-based model adaptations to ensure robust hydrological predictions in permafrost-affected regions.

The Tundra Rainfall Experiment; Legacy and Seasonal Effects of Heavy Rainfall Events on Svalbard Ecosystem Functioning

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Abstract: Arctic ecosystems are facing increases in heavy summer rainfall events, and Svalbard is no exception. However, the role of seasonal timing of heavy rainfall events in determining their effects on ecosystem functions, and the legacy impacts of such effects, are poorly understood. We set up an irrigation experiment on several locations on Svalbard, and mimicked a doubling of average summer rainfall at different timings throughout the season (early or late summer). We monitored permafrost thaw, soil temperature, plant growth and phenology proxies and tree-ring growth of key plant species, both during and in the year after irrigation. We found that, contrary to other Arctic ecosystems, experimental heavy rainfall events only had a short-lived effect on permafrost thaw depth on Svalbard, and did not alter soil thermal regimes or end-of-season active layer thickness. Heavy rainfall later in summer delayed the decline in plant productivity ("NDVI") compared to control and early summer rainfall scenarios. We found subtle positive legacy effects of early as well as late summer irrigation on NDVI in the following growing season. Heavy rainfall delayed senescence in Salix polaris, one of the most common species on the archipelago. However, this effect was highly context-dependent, and only evident at sites and moments with low baseline moisture availability (approximately 20% or below). Finally, tree-ring proxies showed similar context-dependent and delayed effects. Only samples from the driest site showed a decline in wood growth compared to sites that had received experimental

heavy rainfall at any moment in summer. This effect only manifested in the year following the experiment, which was the third in a series of anomalously warm summers. Our findings suggest that prolonged drought is a stronger driver of High Arctic vegetation than rainfall events per se. We further observed that ecosystem responses to heavy rainfall were mediated by soil conditions, such as baseline moisture content and moisture retention capacity. The identified legacy effects suggest that previous years' hydrological conditions may still shape ecosystem functioning in later years.

Local and large-scale ocean variability observed from the SIOS Marine Infrastructure network

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Abstract: Atlantification, a phenomenon linked to the increasing influence of Atlantic Water in the Arctic seas and fjords, has a significant impact on the Svalbard archipelago. It is accelerating the loss of sea ice and glaciers, affecting local ecosystems and contributing to global climate change. With the help of the marine infrastructure of SIOS (Svalbard Integrated Arctic Earth Observing System), long-term data on temperature, salinity and biogeochemical properties of seawater have been collected. These data help to understand both local and large-scale seasonal, interannual and decadal variations. Data from marine observatories in different areas of Svalbard, including Hornsund, Isfjorden, Kongsfjorden, and Rijpfjorden, were analysed. The time series includes temperature and salinity measurements with climatological and anomaly analyses to identify Atlantification trends. Temperature and salinity show multi-year cycles and seasonal variations. Atlantification appears to have

become more pronounced from 2012 to 2018, with the influence of Atlantic Water increasing in the fjords and on the continental shelf. Since 2018, a "freshening phase" has been observed, related to freshwater anomalies from the North Atlantic. Atlantification has implications for multiple disciplines and affects the cryosphere, atmosphere, and marine ecosystems. Interdisciplinary collaboration is essential to understand the mechanisms and predict future impacts. The timing and reversibility of Atlantification remain uncertain, although the phenomenon appears to be accelerating with global warming. Several recommendations emerge from the study: (i) maintaining long-term deep-sea observing systems; (ii) promoting systematic temperature and salinity measurements in key regions of Svalbard; (iii) optimising marine infrastructures to monitor Atlantification; (iv) investigating carbon sequestration linked to seasonal zooplankton migration and its impact on nutrient cycling and primary production. This study emphasises the importance of monitoring Atlantification and other marine processes to understand their impact on climate and Arctic ecosystems.

A DECADE OF OCEANOGRAPHIC MOORING DATA OFFSHORE SOUTHWEST OF SVALBARD

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Abstract: The Arctic environment, and the Svalbard archipelago in particular, is undergoing significant changes due to rising air and sea temperatures, largely due to a process known as Atlantification — the increasing influence of Atlantic water on the Arctic Ocean. This phenomenon has intensified in recent decades, disrupting the delicate balance of Arctic ecosystems and has far-reaching implications for the global climate system and geopolitics. Understanding these changes therefore requires the collection of long-term data, despite the challenges involved. In this study, we present a decade (June 2014–July 2024) of in situ ocean measurements collected in the southeastern Fram Strait to investigate long-term, seasonal and short-term variations along with meteorological conditions and sea ice trends. The data originate from oceanographic mooring S1 (76°N, 14°E), located along the 1000-meter isobath, which records the poleward flow of Atlantic water through the West Spitsbergen Current in the upper ocean and the deep water of the Norwegian Sea below 900 m. Mooring S1 is part of the Svalbard Integrated Arctic Earth Observing System (SIOS) Marine Infrastructure Network and is strategically located where Atlantic water interacts with shelf water from Storfjorden and the West Spitsbergen Shelf. The analysis of mooring data in combination with vertical temperature and salinity profiles from research cruises, autonomous platforms (Argo floats) and satellite data shows, from 2014 to 2021, a pronounced Atlantic water signal and a lower potential for the formation of dense water in the nearby fjords. Interannual variations in ice-rafted debris, particulate matter, and zooplankton data from the mooring sediment trap provide further insight into sea ice dynamics and the extent of Atlantification in the study region. Satellite observations confirm a steady decline in winter sea ice cover, except for the winter of 2020 (and to a lesser extent subsequent winters), when sea ice briefly returned to near pre-2013 levels and when weak signs of dense shelf water were observed down to 1000 m depth probably originated from the polynya of Storfjorden.

Changes in Svalbard's nitrogen cycle: seasonal to multi-decadal perspectives based upon studies of riverine biogeochemistry

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Abstract: Work undertaken in Svalbard more than 20 years ago first revealed that glacial runoff exports an excess of nitrate compared to atmospheric inputs to the land surface. This finding was unexpected in a heavily glacierised landscape and now seems critical for understanding the future seaward transport of this important productivity-limiting nutrient. We show that the additional nitrate is derived from the microbial nitrification of ammonium and (less so) organic N derived from: i) atmospheric inputs via snow, firn and glacier ice; and ii) terrestrial substrates associated with organic matter and bedrock ammonium. We argue that climate change impacts have heavily depleted the former, yet are increasing the latter. This problem and its consequences are further explored using long-term observations of inorganic nitrogen concentrations in runoff and natural abundance of 15N and 18O in nitrate collected since the early 1990's. In so doing, we report that:

1. Atmospheric nitrate inputs (either direct or via nitrified atmospheric ammonium) only dominate the seaward flux of nitrate in runoff during the earliest parts of the summer;

2. The influence of the nitrified nitrate generally increases throughout the summer, and can in some cases generate extreme concentrations by the end of the season.

3. Spatial variability in the impact of nitrified nitrate upon runoff fluxes is extremely significant across Svalbard;
4. Deglaciation promotes nitrification, not denitrification – due to the predominance of shallow flow paths through fine sediments with modest or low organic matter.

Current research is trying to establish the impact of tidewater glacier retreat onto land with some urgency, because it is believed that this transition will have the greatest influence upon nitrate availability to near-surface phytoplankton. Our work clearly demonstrates that major changes in the delivery of terrestrial nitrogen need to be considered if we are to properly understand this transition.

Microbial Community Dynamics and interaction with carbon in Kongsfjorden

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Abstract: Global warming is affecting all regions of the world. The Arctic, in particular, is warming at an alarming rate, causing a decline in the sea ice cover, glaciers, and permafrost melting. The declining sea ice cover has led to the expansion of macroalgal beds in the coastal Arctic. Glacier and permafrost melting contribute sediments and terrigenous organic carbon to the Arctic fjord. In addition, the intrusion of warmer Atlantic water and longer melt periods are expected to affect the magnitude and composition of export fluxes of biogenic matter in the high Arctic Fjords such as Kongsfjorden. Although microbes play an important role in the biogeochemical processes, the effects of these climate-change-induced variations on microbial community metabolism and composition are poorly understood. To address this knowledge gap, we have conducted a series of studies over 10 years that evaluate the microbial community dynamics and their responses to various aspects of climate change in Kongsfjorden.

In this talk, we will discuss 1) factors controlling the community composition and assembly mechanism of particle-associated (PA) and free-living (FL) microbes, crucial for particulate organic matter (POM) degradation and carbon flux to deeper depths and 2) the diversity and responses of microbial communities to increased supply of macroalgal-carbon, and 3) glimpse of our year long weekly studies and our plans in Kongsfjorden.

Keywords: Microbial ecology, bacteria, Archaea, Arctic Fjord, macroalgae, particle-attached, free-living

The future of Arctic runoff: simulating Bayelva catchment 1991-2100

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Abstract: The Svalbard archipelago is undergoing increased warming compared to the global mean, which has major implications for freshwater runoff into the oceans from seasonal snow and glaciers. The land surface model CRYOGRID, which includes a coupled energy balance-snow/firn model, is used to quantify the freshwater runoff from glaciers and seasonal snow from 1991 to 2100. For the 1991 to 2024 period, the model is forced by CARRA meteorological fields, which are downscaled to a 100 x 100 m resolution using a lapse-rate correction. From 2024 to 2100, average trends in temperature and precipitation for RCP4.5 and RCP8.5 are adopted from Arctic- CORDEX simulations to continue the simulations into the future.

The glacier geometry evolution is obtained by coupling CRYOGRID and the physics-constrained machine learning glacier model IGM, to derive associated changes in glacier area and elevation. The effect of elevation changes on mass balance is included through a mass balance gradient.

We find that peak runoff from the catchment likely occurred around 2024 due to intense glacier melt, whereas later, runoff decreases due to retreat of the glacier, rendering a larger part of the catchment without ice, even though continued warming further intensifies melt. According to our simulations by 2100, both Austre and Vestre Brøggerbreen will have disappeared under the RCP 8.5 scenario.

Improved characterisation of rain on snow using integrated multidisciplinary datasets

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Abstract: In Svalbard, continued climate warming is expected to produce a threefold increase in the frequency of winter warming events by 2100 which will have significant impacts on land and glaciers. Wintertime rain-on-snow (ROS) events have considerable ecological impact in Svalbard. Layers of ice may form at the ground-snow interface after a ROS event, which can both damage vegetation and restrict access to forage by reindeer, which may lead to eventual starvation and large die-offs. Changes in the frequency, intensity, duration and spatial distribution of ROS events are therefore important to quantify due to their wide-ranging impacts on the physical environment but also on society, wildlife and ecosystems. Reliable datasets describing the spatial and temporal variations of ROS characteristics are thus crucial. Most studies of ROS have utilised single source datasets compared against limited ground observations for validation. ROS events can be detected using gridded meteorological data, but these datasets are threshold-dependent and can give widely differing results depending on the thresholds applied. ROS impacts, such as snowmelt can be observed at regular intervals using satellite remote sensing methods, but these observations lack the capability to distinguish the cause of snowmelt. In-situ measurements of ground ice provide direct measurements of the ROS impacts on the snowpack but are limited in spatial extent. A lack of integration of ROS data sources across disciplines hinders a more comprehensive understanding of their characteristics and associated impacts on terrestrial ecosystems. This pilot study has carried out a multidisciplinary analysis of ROS characteristics and the spatial heterogeneity of its impacts on the cryosphere across Svalbard by analysing and integrating a diverse set of field, model and remote sensing observations, thus providing a more holistic understanding of ROS and its signatures from atmosphere to cryosphere over the last three decades.

Coexistence in a Changing Arctic: Trait Plasticity and Niche Overlap of Two Calanus Species

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Abstract: The increasing inflow of warm Atlantic Water is transforming Arctic marine ecosystems, promoting the coexistence of resident and advected species, especially in pelagic habitats. We examined two key zooplankton species—Calanus glacialis (Arctic endemic) and C. finmarchicus (boreal)—to explore their morphological variability, spatial distribution, and dietary preferences in the Polar Front region of the Svalbard shelf, spanning Atlantic, Arctic, and transitional waters.

Sampling was conducted during the summers of 2022–2024 in six Svalbard fjords (Hornsund, Isfjorden, Kongsfjorden, Magdalenefjorden, Woodfjorden, and Rijpfjorden) and adjacent open-water stations. Habitat preferences and trophic niche overlap of Calanus species were assessed using high-resolution vertical net sampling and carbon and nitrogen stable isotope analysis. Species identification based on morphology was supported by molecular methods. Individuals selected for further analyses were photographed, and their size, pigmentation, and lipid sac area were quantified at the individual level using machine learning-assisted image analysis.

Our results indicate that, while the horizontal distributions of the two species largely overlap, their vertical distribution patterns differ. In 60% of the samples, one species dominated; 40% showed co-occurrence, suggesting partial niche segregation. Stable isotope analysis further revealed substantial trophic niche differentiation between the species, with isotopic niche characteristics varying between coexistence and non-coexistence cases.

These findings show that potential competition between Calanus species can be moderated by the joint effects of distributional and trophic niche partitioning, and that both processes are key mechanisms facilitating species coexistence. The observed variability in Calanus life-history traits highlights the plasticity of these species and suggests that further adaptive responses may occur as Atlantification progresses.

Downscaled climate scenarios for Svalbard and the Barents Sea region

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Abstract: Important consequences of climate change for society and nature are connected to changes in local temperature and precipitation statistics on Svalbard. To estimate these local changes, we use large-scale output from global climate models, combined with information of how the climate on Svalbard depends on broader Arctic conditions. This process, known as downscaling, translates global climate information into detailed local projections. Downscaling is needed because global climate models are most accurate at large spatial scales and lack the resolution needed for local assessments. However, both the global models and the downscaling techniques may introduce biases or misrepresentations if not applied carefully. To improve reliability, we use a combination of several independent approaches, each with different assumptions, strengths, and weaknesses, in order to produce more robust information. We present robust local climate projections for Svalbard, based on a synthesis from various research projects and downscaling approaches and highlight examples of use in multidisciplinary projects. The projections have been rigorously evaluated against historical observations as well as subjected to various quality tests.

River discharge and water quality observations on Svalbard: a call for data

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Abstract: River runoff and water chemistry have been monitored at numerous locations across Svalbard over recent decades, typically as part of short-term research projects. However, there is a lack of oversight regarding what is monitored, where, and by whom. There is no integrated database; in fact, much of the existing data is not publicly accessible. This fragmentation hinders our ability to know whether findings from individual study catchments are representative of broader pan-Svalbard or pan-Arctic scales, or to understand the varying behaviours of different catchments. Consequently, our capacity to make robust future predictions is compromised. For example, due to the scattered nature of observed river discharge data, most Svalbard-wide hydrology modelling studies rely on data from only two catchments (De Geerelva and Bayelva, long-term monitoring sites with open data maintained by NVE). This is despite significant contrasts in climate, geology, drift and glacial coverage across Svalbard.

Our study aims to address these challenges by: (1) collating existing observed discharge data from across Svalbard into a single open database accompanied by a comprehensive review paper. We anticipate that this consolidated data will serve as a new benchmark for developing and testing hydrology models, with even short and scattered time series being useful for building regional process-based and AI models;

and (2) compiling water chemistry metadata to provide a clearer overview of where and when water chemistry is being measured, with a view towards enhanced harmonization of monitoring efforts across Svalbard in the future.

We have already secured excellent engagement from key institutions researching hydrology on Svalbard, but we invite additional collaborators to join us in this endeavour to enhance our understanding and predictive capabilities relating to river runoff on Svalbard.

Nitrate in Arctic river systems: Insights from a new biogeochemical model applied in Adventelva

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Abstract: Field studies are showing that river runoff in parts of Svalbard has unexpectedly high nitrate concentrations, particularly late in the melt season. This is primarily sourced from nitrification of bedrock-derived nitrogen (N), and is therefore likely to increase in the future as glaciers retreat and permafrost thaws. This nitrate has potential to impact downstream N-limited marine ecosystems, whilst the conversion of nitrate to nitrous oxide in wetlands may present a positive climate feedback. However, difficulties in measuring river discharge in much of Svalbard, together with difficulties in extrapolating point measurements to larger spatial and longer temporal scales, mean that important questions remain regarding the magnitude and fate of this flux at larger spatial scales, and therefore its wider environmental significance. Here, we address these challenges by developing a new, transferable, catchment-scale dynamic nitrogen model. We do this using the Mobius model building system, allowing us to easily tailor the model to our research aims and available data. We then apply the model to simulate nitrate fluxes in Adventdalen. We use the model to quantify how the contributions from atmospheric versus bedrock-derived N vary through the year and to highlight key knowledge and data gaps, to help prioritise future data collection. Future research will involve exploring scenarios of future change, as well as applying the model to a range of contrasting catchments across Svalbard.

Dirty Secrets: Cryoconites Know What Glaciofluvial Sediments Forget

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Abstract: Glacial meltwater transports sediments from supraglacial and subglacial environments to downstream fjords, playing a key role in Arctic biogeochemical cycling. Cryoconite granules, found on glacier surfaces, are known biological hotspots, but their mineralogical and geochemical variability remains poorly studied. We analyzed cryoconites and glaciofluvial sediments from different glaciers in Svalbard with distinct geological settings to assess the roles of local mineralogy and atmospheric deposition in shaping sediment signatures. Overall, cryoconites carry distinct glacier-specific geochemical fingerprints, influenced by both atmospheric inputs and local bedrock. In contrast, glaciofluvial sediments from the same glacial catchments show signs of advanced weathering and geochemical homogenization, as well as the loss of high geochemical resolution. These findings highlight contrasting weathering stages and geochemical sediment signatures across the glacial–proglacial system, and emphasize the importance of integrating multiple matrices to accurately trace geochemical pathways and elemental fluxes to Arctic fjords in a rapidly changing climate.

Impact of climate warming on contaminant and microorganism dynamics in Arctic Environments: Insights from the ICEtoFLUX Project

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Abstract: Climate warming is progressing rapidly in the Arctic, affecting atmospheric and oceanic circulation, cryospheric melt cycles, and hydro-biogeochemical processes. These changes, together with growing human activities, are altering contaminant pathways, fate, and inputs. The ICEtoFLUX project investigated how climate-driven hydrological processes influence the transport, distribution, and transformation of contaminants and microbial communities in Arctic ecosystems. Field campaigns carried out in the Bayelva River catchment (Ny-Ålesund, Svalbard), extending from the Austre- and Vestre-Broggerbreen glaciers through proglacial tundra to Kongsfjorden during spring and summer (April-June–July) of 2022 and 2023. Samples of snow, groundwater, glacial meltwater and seawater were collected and analyzed for legacy (LPs) and current-use pesticides (CUPs), polychlorobiphenyls (PCBs), and microbial biomass. Snow samples confirmed atmospheric deposition as a key input pathway, with PCBs, LPs, and CUPs occurring. Groundwater in July 2022 showed higher contaminant levels than in June, likely due to increased melt. In 2023, LPs remained prevalent, but overall concentrations decreased compared to 2022, suggesting interannual variability in controlling processes. Drainage waters consistently showed higher contaminant loads than snow, highlighting the role of meltwater in pollutant release and downstream transport. The contaminants found in Kongsfjorden reflected the composition of those in the Bayelva River, suggesting that this river, which collects drainage water and flows into the fjord, is a source of these contaminants. Microbial data are being integrated to explore potential links between contaminants and microbial activity or community shifts. These findings underscore the complex interplay between climate-induced hydrological changes, contaminant dynamics, and microbial responses in this environment, reinforcing the importance of long-term, multidisciplinary monitoring efforts.

Assessing the impact of meteorological extreme events on the cryosphere in the Bayelva area (Ny-Ålesund, Svalbard)

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Abstract: The assessment concerning the impact of extreme events on the cryosphere in the arctic region, such as Svalbard islands, is a key knowledge that improve the relationship between meteorological conditions and surface analysis produced by remote sensing techniques. The combination of satellite and ground-based observations is a recommended strategy for the definition of novel metrics aimed at monitoring the impact of winter extreme events on the cryosphere. The performed analysis will present the results obtained considering a 10-years dataset of meteorological observations and multi-source remotely sensed imagery. Sentinel-2, Landsat 8-9 and time-lapse cameras are the data sources considered in combination with in-situ measurements of air temperature, precipitations and wind speed. The detection of hydrological features on the snow cover will be presented as key pattern for assessing the impact of warm and humid events observed during winter time in the Ny-Ålesund study area. Such a feature support the definition of meteorological conditions useful for triggering diffused melting conditions, which contribute to the activation of a water drainage system. Seasonal trends and interannual patterns will be explored considering the evolution of the snow cover during the snow season, in response to event-related conditions that are the major drivers of surface processes.

From pelagic community to species specific vertical migration

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Abstract: Over the past two decades, active acoustics have been developed to investigate the vertical migration of pelagic communities. This method offers high temporal resolution, which is particularly valuable in remote areas such as the Arctic. It has provided new insights into the vertical migration of pelagic communities, including the discovery that these communities remain active during the polar night.

An underwater observatory equipped with active acoustic technology has been deployed in Kongsfjorden for 20 years to monitor the vertical migration of pelagic organisms. This long-term data series is extremely valuable for studying the effects of climate change on these communities. However, the approach has limitations, active acoustics offer poor taxonomic resolution. While we detect multiple vertical migration behavior patterns simultaneously, we cannot attribute these behaviors to specific species or groups, as the technology cannot distinguish between species.

Moreover, our knowledge of species-specific ecology remains limited, preventing us from linking vertical migration patterns to individual species. The aim of this study is to associate swimming behavior with vertical migration patterns, thereby enhancing our understanding of the ecosystem and the potential impacts of climate change on a finer scale.

We monitored the swimming behavior of key Arctic species whose vertical migration is detected by active acoustics, such as Calanus spp., Metridia spp., and krill, in March and June 2025. The behaviors of these species were compared to identify species specific differences. Laboratory-based monitoring was conducted using a locomotor activity monitor, with organisms sampled from Kongsfjorden near the underwater observatory site. The temporal and geographical proximity of the behavioural observations and acoustic monitoring will enable us to relate the two datasets.

The long-term changes in the mass balance of glaciers at Kaffiøyra area, Svalbard, Arctic

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Abstract: The main objective of this study is to assess the temporal variability and spatial distribution of glacier mass balance in the Kaffiøyra region, a coastal lowland on Forlandsundet in northwestern Spitsbergen (Oscar II Land, Svalbard). The analysis focuses on two valley glaciers: Waldemarbreen and Irenebreen. Most of the data come from direct glaciological measurements conducted between 1996 and 2024. Additional insights were obtained through geodetic and remote sensing methods, including satellite imagery. To investigate changes in glacier extent, a detailed analysis of glacier surface area and front recession was performed, starting from their maximum extent at the end of the Little Ice Age (late 19th to early 20th century). The observed retreat and surface area loss are consistent with changes reported for similar Svalbard glaciers. On average, the glaciers in the Kaffiøyra region have lost approximately 50% of their area since the end of the Little Ice Age.

The Kaffiøyra region provides one of the longest continuous glacier mass balance records in Svalbard, making it an important area for monitoring ongoing change of cryosphere. The observed rapid mass loss and glacier retreat in recent decades offer clear evidence of accelerating climate-driven transformations in this part of the Arctic.

Long-term evolution of light-absorbing carbonaceous aerosols in the snow of Svalbard (2018–2025)

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Abstract: Elemental carbon (EC) and selected fractions of organic carbon (OC), key components of atmospheric aerosol, significantly influence the radiative balance in the Arctic through light absorption and snow darkening. Their wavelength-dependent extinction capacity is particularly impactful in polar environments, where even small concentrations can lead to albedo reduction and enhanced snowmelt, thus affecting the regional climate system.

Svalbard represents a strategic observation site due to its proximity to long-range pollution sources from Northern Europe and Russia [Zdanowicz et al., 2021]. Since 2018, we have conducted regular sampling of seasonal surface and bulk snow at Gruvebadet (Ny-Ålesund) and several glacier sites across Spitsbergen, with higher frequency during spring campaigns. EC and OC concentrations were determined using a thermo-optical analyser (EUSAAR-2 protocol). The same samples were analyzed using a dual-wavelength transmissometer (OT21) to measure light absorption at 370 and 880 nm, associated with the concentration of BrC and BC respectively, and correlate with the measured concentrations of OC and EC.

This long-term dataset includes samples collected until 2025, enabling the analysis of interannual trends over a full 8-year period, thus being a key to understanding how Arctic snowpack responds to environmental regulations and climate variability over decadal scales. These results, integrated with atmospheric BC measurements conducted at Gruvebadet, will also provide valuable insights into the transport and deposition dynamics of carbonaceous species on the snowpack.

Assessing Climate–Hydrology Interactions in a Glacier-Fed Arctic Basin Using Data-Driven Models

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Abstract: Arctic freshwater systems are highly sensitive to climate variability, making hydrological modelling a key tool for understanding the effects of ongoing environmental change. In this context, the ICEtoFLUX project investigates the hydrological dynamics of the Bayelva catchment (32 km²), a glacier-fed basin in NW Svalbard. Using a data-driven framework, the study examines how climate variability influences streamflow and identifies the evolving role of groundwater contributions linked to permafrost degradation and active layer deepening.

A multi-seasonal dataset (2022–2024) combining meteorological, hydrological, and piezometric observations was used to develop diagnostic Weighted Multivariate Linear Models (WMLM) and a Mixed Effect Model (MEM) of river water levels. The approach includes cross-correlation and lag analysis to assess the lagged response of discharge to climatic drivers such as temperature, net radiation, and cloud cover. Results show a temporal shift in dominant hydrological controls: from snow and ice melting in early melt seasons to increased subsurface contributions, suggesting enhanced aquifer recharge and discharge under warmer conditions.

Rating curves were used to estimate seasonal water fluxes, showing a steady increase in total discharge over three years. Projections based on IPCC scenarios (SSP1–2.6 to SSP4–8.5) suggest further increases in discharge, with implications for Arctic coastal systems and global freshwater budgets.

The results highlight the value of the Bayelva catchment as a key Arctic observatory for detecting hydrological responses to climate change. The observed transition from a snowmelt-dominated regime to one more influenced by rainfall and groundwater reflects broader hydrological shifts in polar regions. This work demonstrates the effectiveness of data-driven models in capturing complex climate–hydrology interactions and supports the development of future scenario for predicting water resources in polar environments.

Multi-year temperature cycles in Kongsfjorden, Svalbard, with possible causes and implications to the fjord Warming

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Abstract: The present study unravels the multi-year temperature cycles in Kongsfjorden from 2003 to 2018 and associated drivers, using the daily mean Kongsfjorden–Ripfjorden Observatory Program mooring data, ERA5 reanalysis fields, Ny-Ålesund automatic weather station records, and the North Atlantic Oscillation (NAO) index. The fjord has warmed steadily at 0.14 °C yr^{-1} (0.15 °C yr^{-1} for the deseasonalised temperature) over the period, with the most pronounced warming confined below 75 m depth. Superimposed on this trend is a robust quasi-periodic signal that affects the full water column. The water temperature at 75 m, 100 m, and 150 m showed statistically significant peaks at ~ 2.6 yr, 3.6 yr, and 5 yr. Sea-surface temperatures from ERA5 reanalysis averaged over the outer fjord and associated shelf region during the same period as the subsurface mooring temperature suggest that surface and subsurface layers oscillate in phase at 3-5 yr periodicity. Wavelet-coherence reveals that the 2–5 yr cycles emerge from a strong coupling between regional winds and Atlantic Water (AW) inflow. The ERA5 zonal winds exhibit peaks at 2.7, 3.6, 4.4, and 6.4 yr, while meridional winds show 2.3, 3.6, 4.6, and 6.9 yr periodicities that align with, and often precede, the temperature peaks, indicating wind-forced modulation of the West Spitsbergen Current and episodic AW pulses into the fjord. At the basin scale, a 3–4 yr NAO mode coheres with the fjord signal, confirming that clusters of positive-NAO winters enhance AW advection and manifest the fjord warming events. The NAO, through manifestations in the local winds, help AW intrusion and thus drives this cycle. Together, these results quantify coherent 3–5 year temperature cycles in Kongsfjorden, trace their physical drivers from synoptic winds to large-scale atmospheric modes, and show that interannual oscillations partially mask the underlying warming trend. The study advances mechanistic understanding of Atlantification in Kongsfjorden.

Cryosphere monitoring at MET Norway through cryo.met.no

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Abstract: Cryosphere is the collective term for places on Earth with frozen water or permanently frozen ground, like snow, ice, and permafrost. The Norwegian Meteorological Institute (MET Norway) has long experience in monitoring the cryosphere through remote sensing and surface-based automatic and manual observations. Our cryosphere products are gathered on the web portal cryo.met.no.

The portal covers near-real-time monitoring of the terrestrial snow cover and depth, as well as permafrost observations in Svalbard and mainland Norway. In addition, many perspectives on the global and regional sea-ice conditions such as sea-ice concentration, drift, types, surface emissivity and temperature, as well as navigational ice charts, are made available.

This poster will present updated information about the different types of products and climate indicators available on cryo.met.no.

Warming of Svalbard – 25 years of MODIS data

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Abstract: The Arctic, including the Svalbard archipelago, has been warming much faster than the rest of the Earth in recent decades – a phenomenon known as Arctic amplification. Hard data confirming this warming in Svalbard come only from a few sites where measurement series are sufficiently long and complete. Other evidence is indirect – obtained either through mathematical modelling (gridded data from reanalysis and climate models) or by tracking long-term responses to climate change of various environmental components – mainly glaciers. The long measurement series of - meteorological parameters mentioned above have a very limited spatial representativeness. They all come from low-lying sites located on the western coast of Spitsbergen and in the inner fjord zone. Knowledge about changes occurring on other islands of the archipelago, in the mountainous and heavily glaciated interior of Spitsbergen and on its eastern coast comes only from short and often incomplete measurement series and indirect data. In such a situation, a valuable source of data on local and regional variability of warming in Svalbard are satellite recordings of electromagnetic radiation emissions in the thermal infrared range processed to the Land Surface Temperature (LST). Considering the length and uniformity of the measurement series and their frequency and spatial resolution, the best LST data come from the MODIS sensors installed on the Terra and Aqua satellites. They already cover a period of more than 25 years with a spatial resolution of about 1 km and a temporal resolution of 4/day. This study uses the LST version 6.1 “product” databases codenamed MOD11A1 (Terra) and MYD11A1 (Aqua) from March 2000 to February 2025 covering the entire Svalbard archipelago. These data were used to determine local and regional warming variability and to assess the impact of terrain factors on it (landform and land cover, distance from water bodies, etc.).

Temperature and humidity trends from balloon-borne measurements

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Abstract: Weather balloons are used worldwide to collect meteorological data in the vertical atmospheric column by attached radiosondes. At Ny-Ålesund, Svalbard, daily radiosondes are launched since 1993, resulting in a >30 years data series of height-resolved temperature, humidity and wind which allows for climate trend studies in the troposphere and lower stratosphere. From these, a general tropospheric warming is observed over the entire period, with varying strength for the different decades, and varying intensity of the warming signal in the different seasons, respectively. While autumn and winter encounter a significant bottom-amplified warming of the entire troposphere, temperature increase in spring is hardly recognizable. The latter can be attributed to prevailing atmospheric circulation patterns in the month of March, which also lead to a higher incident of marine cold air outbreaks (MCAOs), thus weakening the overall warming trend.

Atmospheric transport events also influence the moisture content of the tropospheric column. Cyclones carry moist air from lower latitudes, and together with moist intrusions and atmospheric rivers are driving the observed wintertime humidity increase. Nonetheless, over climatic time scales, an increase of humidity is observed even when the air originates from the Central Arctic.

Overall, tropospheric temperature and humidity over Svalbard are related to large scale atmospheric circulation, affecting the local ambient conditions by altering clouds, radiation, and precipitation on synoptic time scales, while leading to distinct long-term trends for each season on climatic time scales.

Interannual changes in zooplankton size structure in Svalbard fjords

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Abstract: Distinct traits of arctic zooplankton species in comparison to boreal congener species, such as prolonged life cycles, larger body sizes and higher energy storage capacities are evolutionary adaptations to the extreme seasonality in high latitudes. Climate warming and changes in primary production regimes have been predicted to lead to a shift from larger, lipid-rich Arctic species to boreal species. Furthermore, with warming and changing light climate, long life cycles and large body size with a high proportion of energy reserves may no longer be favourable strategies. Consequently, we can expect changes in such traits, not only due to an increased occurrences of boreal species, but also due to arctic species adapting life history strategies similar to their boreal congener species. Such responses are detectable as changes in the population size structure, timing of reproduction and vertical migration behaviour and can have negative consequences for top predators who rely on energy rich larger prey items. The Kongsfjorden Rijpfjorden Observatory Program (KROP) operates two oceanographic moorings and provides 20 years of biophysical observations from Kongsfjorden and Rijpfjorden, two fjords with contrasting sea ice cover and hydrographic conditions. Over the same time, both fjords have been sampled at least once a year for zooplankton communities. Using this time series data from Svalbard, we document seasonal and interannual variability in zooplankton abundance, population structure and size structure, with particular focus on copepods of the genus Calanus, key species in Arctic ecosystems, to investigate how this variability correlates with changes in sea ice cover and temperature and how the responses differ between the Atlantic and Arctic fjord.

Hydrological Change in Svalbard: From Seasonal Variability to Subsurface-Dominated Systems

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Abstract: The Svalbard archipelago is undergoing a rapid transition from predictable seasonal hydrological cycles to long-term structural changes driven by Arctic amplification. As glaciers retreat, snow cover decreases and permafrost thaws, the hydrological cycle becomes increasingly dominated by extreme events and altered flow regimes. Understanding these changes - from seasonal variability to permanent shifts - is crucial for anticipating the future of Arctic ecosystems and their connection to global climate feedbacks.

In this context, the ICEtoFLUX project in the Bayelva River catchment (Western Svalbard) provides key insights into the evolving hydrological processes of the region. Through the integration of hydrological, geophysical, geochemical, and isotopic data, the study traces water and suspended matter fluxes from glaciers to Kongsfjorden, focusing on the evolution of the active layer and the changing interactions between surface water and groundwater. Results show increasing spatial and temporal heterogeneity in groundwater contributions, with distinct isotopic and chemical signatures linked to seasonal thaw dynamics. Geophysical surveys support the presence of a deep and organized groundwater system that is active well beyond the traditional melt season.

These findings point to a fundamental shift in the Svalbard hydrological system—from one governed by surface-driven, seasonal meltwater pulses to a more complex system shaped by year-round subsurface processes. ICEtoFLUX project is an example how site-specific, multidisciplinary research can shed light on broader Arctic transformations. It also highlights the need for long-term monitoring and international collaboration to understand and respond to the cascading impacts of climate change

in Svalbard and across the Arctic, as well as for resilience solutions in terms of water availability.

Svalbard's 2024 Record Summer: A Window into Future Arctic Glacier Meltdown?

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Abstract: The melting experienced by Arctic glaciers of Svalbard in summer 2024 represents a new record by a substantial margin. Across the entire archipelago, glacier melting corresponded to an anomaly of up to four standard deviations and exceeded any previous observation. The pan-Svalbard mass loss in summer 2024 amounts to ~61.7 Gt and corresponds to 1% of the total ice volume on Svalbard and is comparable to that of the Greenland ice sheet, which occupies an area about 50 times larger. Altogether, Svalbard and other glacier regions surrounding the Barents Sea (Franz-Josef Land, Novaya Zemlya), lost 102.1 Gt of ice in a single year and contributed 0.27 mm (of which 0.16 mm alone are due to Svalbard) to global sea-level, putting the circum-Barents region among the strongest contributors to global sea-level rise in 2024.

Most of the 2024 glacier melt occurred during a six-week period of persistent atmospheric circulation pattern causing record high air temperatures, at a level of extremely low probability under current climate conditions. However, future climate projections suggest that such summer temperatures will become increasingly commonplace by the end of the 21st century, potentially even surpassing those of 2024. Svalbard's summer of 2024 serves thus as a harbinger of future glacier meltdown in the Arctic, offering a glimpse into conditions only a few decades ahead.

Overwintering Strategies in Natural Marine Phytoplkanton Communities in Kongsfjorden, Svalbard

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Abstract: The Year-round Ecosystem Study on Svalbard (YESSS) project aims to characterize seasonal impacts and ecological consequences of climate change in Kongsfjorden, Svalbard. Through a year-long time series of a mid-fjord pelagic station coupled with seasonal experiments, the YESSS project has a special focus on polar night physiology. To investigate this, natural communities of marine phytoplankton were collected from the mid-fjord station at the end of autumn to represent a pre-winter community. The phytoplankton cultures were kept suspended on novel roller tables in 10L darkened bottles for 2 months to simulate polar night. They were then brought back to light in a step-wise fashion. Multiple physiological parameters were measured at different time points including net primary productivity, fast repetition rate fluorometry (FRRF), chlorophyll, particulate organic carbon and nitrogen (POC/N), nutrients, respiration via the Winkler method, eDNA, proteomics, carbonate chemistry, taxonomy through fixed microscopy samples and the FlowCam, and flow cytometry using dyes for viability, cell death, lipid concentration, and mixotrophy. The cultures were monitored regularly using flow cytometry methods and chlorophyll in order to ensure general health and survival throughout the experiment. The goal of this experiment was to examine polar night adaptations in phytoplankton that allow for survival in darkness with a particular interest in mixotrophy and seasonal community composition shifts. Preliminary results will be presented and discussed.

The Role of Light Absorbing Particles in Snow and Ice on Svalbard: A Focus on Dust

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Abstract: Svalbard is warming 5-7 times the global average, resulting in widespread glacier melt. In addition to warming, the deposition of light absorbing particles (LAP) including black carbon from the incomplete combustion of fossil and bio-fuels, mineral dust and light absorbing organics can also contribute to snow and glacier melt by darkening the snow/ice surface and increasing absorption of solar energy. While black carbon has been studied extensively on Svalbard, there is a knowledge gap of mineral dust deposited onto Svalbard snow and glaciers. Numerous recent studies identify the need to study the impacts of high-latitude mineral dust on snow and glaciers, and specifically on Svalbard to assess dust sources, dust deposition, and the contribution of dust to snow darkening and melt. These studies suggest that the extent and emission strength of dust sources are likely increasing due to reduced snow cover and glacier retreat, and there is interest in how dust emissions have changed and will continue to change in the future.

We present LAP results from snow and firn core samples that were collected from eight spatially distributed Svalbard glaciers between 2022-2025. The samples were analyzed for black carbon using a SP2, dust concentrations via gravimetric filtration and ICPMS, dust spectral reflectance using a spectroradiometer, dust composition via SEM-EDS and XRD. Results indicate that dust concentrations vary seasonally with low concentrations during the winter and higher concentrations during the summer-fall, and there are spatial variations in dust concentrations, dust optical properties, and dust composition that are likely associated with variations in local dust sources. Modeled albedo reductions indicate that LAP albedo reductions are dominated by dust, with smaller albedo reductions from black carbon. Changes in dust emissions and dust deposition spatially and temporally in response to a changing climate on Svalbard are also considered.

Biogeochemical scans capture 7000 years of abrupt and extreme winter climate change on Svalbard

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Abstract: Paleoclimate data plays a critical role in constraining the future evolution of climate in the Arctic, our planet's most rapidly warming region. However, most paleo proxies capture past change during the brief summers, when all biological indicators are synthesized, and the availability of liquid water allows sediment transport. As a result, little is known about climate variability in other seasons. This bias is of consequence, because simulations hint at more extensive winter variability. Also, these changes affect regional and global climate by impacting surface albedo, glacier melt, and biodiversity. This work helps close this knowledge gap, by providing a 7000-year long record of abrupt and extreme Arctic winter climate change. For this purpose, we analyzed lake sediments – sensitive recorders of surface change, taken from a high-altitude basin – amplifying the imprint of winter season change, on Svalbard – a High Arctic climate change hotspot. By characterizing variations in geochemistry with X-Ray Fluorescence (XRF), density with Computed Tomography (CT), and anoxia with Hyperspectral Imaging (HI), we provide multiple lines of scanning evidence for the presence of concretions that formed after extreme winters triggered widespread anoxia as permanent lake ice prevented water mixing. These cold spells coincide with large volcanic eruptions, solar radiation minima, and cyclic regional cooling phases. Our findings highlight the potential of imaging techniques to fingerprint the biogeochemical imprint of poorly known but consequential changes in winter climate.

Combination of space observations and in situ measurements to study the Earth's response to climate change in Svalbard

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Abstract: Svalbard has experienced rapid changes in the past decades, with increasing glacier melt, loss of sea ice cover, runoff, erosion, and sediment transport. While glacier mass loss is most visible in the retreat of ice fronts, there is still large uncertainty about glacier mass balance. As glacier retreat has an impact on the transport of sediments to the shoreline, leading to coastal evolution, we question how in-situ glacier measurements, submarine sediment data, and satellite observations can be linked to better understand the geophysical processes. Thanks to their complementary sensitivities and spatio-temporal resolutions, it is possible to separate seasonal variability, current and long-term trends associated with the Little Ice Age (LIA) and Glacial Isostatic Adjustment (GIA).

Computed from daily time series of 3D GNSS coordinates for 2000-2024, crustal deformation exhibits of a weak seasonal component and strong uplift with a mean vertical velocity ranging from 8 to 14 mm/yr. Data from the GRACE and GRACE Follow On space-mission, converted into water equivalent height, clearly show a strong downward trend over the whole Svalbard since 2002. We compared these results with altimetry from CryoSat-2 and ICESat-2 satellites, in-situ snow depth measurements carried out regularly around Ny-Ålesund since 2007, as well as DGPS coastline measurements and the dynamics of deltas and pro-deltas derived from sediment measurements since 2009.

Our analysis consists of interpreting the consistencies and discrepancies between the different types of data and predictive models. We demonstrate the presence of different interannual patterns in all the observations over the last decades. To separate the signal due to the current melting of ice sheets and glaciers from the long-term trends, we compared the observations with GIA models and developed a regional mechanical model of the lithosphere and mantle. To do this, we used realistic values for lithosphere and ice thicknesses at present and at different ice ages.

High Arctic tundra vegetation impacts during a decade of environmental change

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Abstract: Climate and cryosphere characteristics in Svalbard have changed fast during the last decade. Extreme winter weather events, such mild spells with rain that freezes and forms basal ice on the tundra, are widespread and now happen almost annually. Record-high summer temperatures have deepened the thawing of permafrost. Meanwhile, pink-footed geese populations have increased notably over the last couple of decades, and reindeer populations have doubled since the early 1980's. The climatic, cryosphere and biotic changes are all expected to impact different aspects of vegetation. Alongside these impacts, human visitation in the archipelago has increased and raised concerns about the establishment of alien plant species.

We present results from field-based and remotely sensed monitoring of tundra to address questions about the impact of these multi-faceted environmental changes on vegetation. Can we link warmer summers to plant biomass or remotely sensed vegetation indices over the last decade? Do the new winter climate and cryosphere conditions affect tundra greenness? How common are signs of herbivory on the tundra and can we detect herbivory effect in remotely sensed tundra greenness? What is the status for establishment of alien vascular plants in Svalbard and where do we find them?

Dynamic Glacier Response to Rapid Firn Degradation and Enhanced Meltwater Availability in a Low-Elevation Accumulation Area: A Case Study of Slakbreen, Svalbard

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Abstract: Slakbreen, a land-terminating valley glacier in Svalbard, has undergone rapid transformation over the past decade due to sustained atmospheric warming and intensified surface melt. The glacier's firn cover has disappeared, leaving bare ice exposed across its former accumulation zone by late summer and removing the firn's ability to buffer meltwater. As a result, surface meltwater now reaches the glacier bed more efficiently. Increased crevassing is observed alongside firn loss, likely linked to enhanced summer meltwater in the low-lying accumulation area.

In the accumulation area of Slakbreen, the formation and drainage of a supraglacial lake have been documented, followed by the development of a moulin that now channels meltwater directly to the bed-where previously no such drainage existed. DEM differencing reveals distinct mass transfer from the accumulation area toward the glacier margin, with dynamic thinning in the upper glacier and thickening in the central part, despite overall retreat of the glacier tongue.

We combine ArcticDEM differencing, high-resolution airborne LiDAR, ground-penetrating radar, and Sentinel-2 imagery to assess changes in glacier geometry, mass redistribution, and internal structure. Radar profiles confirm the loss of firn stratigraphy and reveal evolving patterns of crevasses, bare ice, and water-filled closed crevasses.

These findings highlight a strong link between increased surface melt, firn degradation, and dynamic glacier response. Slakbreen demonstrates how firn loss in Arctic glaciers can rapidly alter hydrological pathways, basal conditions, and mass transport, resulting in accelerated and sustained mass loss that exceeds the impact of surface melt alone-a process not yet fully represented in regional mass loss projections.