51st International ARCTIC WORKSHOP
Svalbard Science Centre, 2022

Oral Presentation Abstracts

Title: The struggle for age control

Presenting Author (keynote): Alexanderson, Helena.[1]

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Abstract:
Chronology is a key part in any research that aims to reconstruct the past; it provides timing of different events, rates of change, possibility of correlating between different records and establishing cause and effect. Depending on the age range, subject field and available material, different methods can be used to establish a chronological framework. In Arctic Quaternary geological research there are several dating methods that are commonly used, for example radiocarbon, luminescence, and cosmogenic exposure dating, each with their own specific benefits and limitations.

In some cases, sampling is easy, analyses quick and nice results are produced, making it relatively uncomplicated to construct a chronology. In other cases, dating can be a struggle: samples are hard to get, analyses are not going as planned, or results are not straightforward to interpret. Though the latter are time-consuming, costly and frustrating there are some benefits: you learn much more about the method you are using, you may get information about your site and material that you otherwise would not have gained, and you get a reason for going back and do more fieldwork.

In this talk, I will present recent and ongoing work to improve chronological frameworks for the glaciation history of northern Svalbard and of northern Fennoscandia, respectively. In addition to showing final(?) results, I will also share the discussions and choices that led us there: sampling strategies, analytical decisions, interpretations, and limitations.

Title: Formation of the Bustarfell drumlin field, NE-Iceland: Integrating sedimentological and GPR data

Presenting Author: Aradóttir, Nína.[1]

Co-authors: Benediktsson, Ívar Örn[1], Ingólfsson, Ólafur [1], Sturkell, Erik [2], Brynjólfsson, Skafti [3], Farnsworth, Wesley R.[4]

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Abstract:
Recently mapped drumlins and other streamlined subglacial bedforms (SSBs) in NE-Iceland reveal cross-cutting flow sets of palaeo-ice streams that were active during and following the Last Glacial Maximum (LGM). The Bustarfell drumlin field is located within the Vopnafjörður-Jökuldalsheiði flow set in NE-Iceland and consists of 77 drumlins. The internal architecture of two drumlins was investigated using sedimentological analysis and ground penetrating radar (GPR with 50 and 100 MHz antennas), to illuminate processes that contribute to drumlin formation, the glacial history and ice dynamics in NE-Iceland. The drumlins studied were found to be composed of subglacial traction till, with interbedded glaciofluvial sediments, showing signs of deformation. On the stoss side of one of the drumlins, two till units were identified, separated by a thick unit of deformed glaciofluvial sand and gravel layers. The core of glaciofluvial material suggests that the drumlin formation is best explained by the sticky spot hypothesis where well-drained patches in the subglacial bed retarded the ice flow locally through increased basal drag and encourage till deposition. Furthermore, our GPR data indicates that a combination of erosional and depositional processes are responsible for drumlin formation. The stratigraphy and formation of the Bustarfell drumlins suggest that the glaciofluvial sediments were deposited proglacially during deglaciation, possibly in the Bølling-Allerød interstadial, and that the drumlins were formed during a subsequent readvance during the Younger Dryas (YD). The sedimentological and GPR data are complimentary and integrating these data is considered a useful approach to investigate the internal architecture and formation of subglacial bedforms. However, the need for integrating GPR data with stratigraphical work and testing of different GPR parameters is highlighted.

Title: Elucidating changing climatic gradients across Late Quaternary Svalbard: inferences from Ringgåsvatnet and Erdmannflya

Presenting Author: Buckby, Joseph M.[1]

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Abstract:

The overarching aim of the project is to contextualise glacier activity across a transect of the Svalbard Archipelago to reconstruct and infer the past climatic and atmosphere-ocean interaction during the Late Quaternary. Palaeoclimates will be reconstructed along a highly sensitive transect ranging from the northeast at Nordaustlandet, to southwest central Spitsbergen determining temperature and precipitation gradients as well as identifying shifts in the positioning and coalescing of the polar air and ocean masses. This will be elucidated through a multi-proxy investigation including Quaternary geomorphology, sea-level histories, proxies, and geochrononologies from lacustrine sediment records and terrestrial surface exposure dating. The lakes Ringgåsvatnet and Straumsjøen form part of a transect of cores that seek to elucidate the evolution of palaeoclimatic gradients across Svalbard during the Holocene. Ringgåsvatnet is situated above 80ºN on Nordaustlandet, northeast Svalbard Archipelago. Sediment cores were retrieved in 2017 and have undergone of analysis and interpretation of the glacial, sea-level and palaeoclimate story contained within. The cores record the post-glacial emergence of Ringgåsvatnet and the surrounding terrain, with initial isolation of the basin dated to the Early Holocene based on AMS ^{14}C radiocarbon dates on terrestrial macrofossils and foraminifera supported by other chronological approaches (^{210}Pb, PSV). There appears to be no distinct/extensive period of no glaciogenic input into Ringgåsvatnet during the Holocene, suggesting that Ahlmannfonna remained throughout and did not disappear, although it may have remained in a heavily reduced state during the Holocene Climatic Optimum/mid-Holocene. Straumsjøen, located on the Erdmannflya peninsula, western Isfjorden, provides a high resolution Late Holocene sedimentation history and evidence of late Holocene climatic conditions for the Isfjorden. CT images reveal frequent stratigraphic variability which possibly indicate annual or multi-year sedimentation cycles/events. An initial ^{210}Pb chronology is to be derived. Furthermore, there is the potential for the Straumsjøen core record to capture aeolian activity with the area receiving episodic winter delivery of fine iron oxide-rich sediments from Ekmannfjorden and Dicksonfjorden (>50 km away).

Title: Uncovering the long-term impact of sea ice on Arctic species: using the past to predict the future

Presenting Author: Dance, Maria[1,2]

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Abstract:

Sea ice is a key habitat, corridor, or barrier for many living things in the Arctic. Yet the consequences of a seasonally ice-free Arctic are poorly understood, in part because of uncertainties about how biota responded to past changes.

We aimed to address this by tracking how sea ice variability affected Arctic mammals during the Holocene (11,700 years ago - present).

We used published genetic data from marine and terrestrial mammals to model their postglacial histories and the timing of key population events. We combined these estimates with modeled paleo sea ice extent to infer the role of sea ice variability in shaping the ecology and evolution of Arctic species.

We find complex species-specific responses to changing sea ice conditions. This panarctic overview of long-term sea ice impacts, spanning marine and terrestrial systems, improves our understanding of the ecological and evolutionary consequences of a seasonally ice-free Arctic.

Title: Quantification of proglacial landscape change based on examples from central Spitsbergen, Svalbard

Presenting Author: Ewertowski, Marek W.[1]

Co-authors: Tomczyk, A.M.[1], Evans, D.J.A.[2], Roberts, D.H.[2], Ewertowski W.[1], Pleskot, K.[1]

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Abstract:
Widespread ice marginal recession in Svalbard has resulted in the exposure of extensive glacier forelands containing a wide range of glacial landforms, many of which continue to evolve well after deglaciation because of their significant ice cores. The objective of this study was to quantify and compare recent (post-LIA) dynamics of proglacial areas of different glaciers located around Petuniabukta (Central Spitsbergen) based on remote sensing and field-based data. The most important results include (1) Quantification of short-term (annual and weekly) dynamics of ice-cored moraines in front of Ebbabreen and Ragnarbreen. We demonstrated that the short-term dynamic of volume changes in the active part of ice-cored moraines was substantial, with lowering even up to 1.8 m a^{-1}; (2) Quantification of decadal landscape changes in front of Hørbyebreen and Ragnarbreen. In case of Ragnarbreen the glacier snout showed a 135 million m^3 decrease in volume; whereas the moraines, despite being ice-cored, were transformed at a much lower magnitude, reaching 5 million m^3 of volume loss during the period 1961–2009. For Hørbyebreen the total net volume of change over the 1961-2009 period from the glacier snout and foreland was about -215 million m^3; whereas volume loss from that part of the latero-frontal moraine, which was already exposed in 1960 equalled to 1.8 million m^3 for the period 1960-2009; (3) Exploration of linkage between the former glacier thermal regime and the associated volumes of debris in englacial and supraglacial positions and description of the two resultant landscape domains and their potential of preservations: (a) subglacial surfaces related to the inner, temperate ice zone, characterised by former limited englacial and supraglacial debris; and (b) outer complex of moraine-mounds and arcuate latero-frontal ice-cored moraine related to the former cold-based snout and large concentrations of supraglacial debris.

Research funding: National Science Centre, Poland, Grant Number 2019/35/B/ST10/03928

Title: Extreme wind directionality at Bjørnøya, Svalbard

Presenting Author: Henkies, Matthias[1,2]

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Abstract:
Estimations of extreme winds are vital for the design of large structures like wind turbines, since both extreme loads and fatigue increase non-linearly with wind speed. In conservative approaches it is often assumed that these extreme winds can occur from any direction, which has been disproved for certain locations earlier. This study extends the research to a far-offshore Arctic climate at the isolated island Bjørnøya (Svalbard).

This is done through a statistical approach using Gumbel distributions to estimate directional return periods for extreme winds. The analysis uses 30 yearly maxima of 6-hourly, 10-min average wind speed data covering the period 1991 – 2020 and is done separately for each direction sector and both for the reanalysis ERA-5 (at 100 m above ground) and a weather station on Bjørnøya (at 10 m above ground).

The estimated directional 50-year return period wind speeds from the reanalysis (weather station) vary between 26 and 29 m/s (22 and 27 m/s). The directions with the highest 50-yearly wind speeds are different from the most frequent wind directions whose speeds exceed the 99th percentile. This is due to different extreme wind speed variabilities in each sector, visible with this statistical approach. However, a large part of the estimated differences is not significant.

The results imply that the directionality of extreme winds is not important on Bjørnøya. Their investigation seems more relevant in more complex terrain.

Title: Relative sea-level change during the Common Era in Norway: new data from intertidal basins and salt marshes

Presenting Author: Holthuis, Max[1]

Co-authors: Nixon, F.C[1], Kylander, M.E.[2], van der Bilt, W.[3], Martin, J.[1], Lakeman, T.[4]

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Abstract:

This study aims to close the gap between palaeo and instrumental relative sea level (RSL) data by generating late Holocene sea-level index points (SLIPs) from low-elevation and intertidal basins in southwestern and northern Norway. Most RSL curves in Norway have been constrained using SLIPs from isolation basins. Many of these imply slow, steady RSL fall to modern sea level during the late Holocene. We lack however SLIPs younger than ca. 2000 years. The few curves with one or two SLIPs younger than 2000 years BP hint at accelerated rates of sea-level fall during this period. Tide gauge records from southwestern and northern Norway however indicate that RSL may have been rising since they were installed (ca. 100 years ago). Geochemical analyses of the sediment cores from southwestern Norway suggest that marine influence has been increasing during recent centuries, possibly due to rates of eustatic sea level rise overtaking residual glacio-isostatic adjustment (ca. 1-2 mm yr-1), related to former ice-sheet loading. Anecdotal evidence from local residents of Egersund, with family histories and records of past storm levels going back to the 1800s, confirms recent RSL rise, particularly during September storms. Indeed, discrete storm layers consisting of shell fragments in one salt marsh protected by a sheltered intertidal basin, may be overprinting subtle trends in RSL rise in the last centuries. Interim results of multi-proxy analyses of multiple cores from four salt marshes and protected, intertidal basins with bedrock sills will be presented from the southwestern corner of Norway, in addition to expected results from fieldwork in northern Norway, carried out in June 2022.

Title: Identifying risk species to Scandinavia – a horizon scanning study

Presenting Author: Ivison, Katy[1]

Co-authors: Dawson, W.[1], Speed, J.[2]

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Abstract:
There is increasing number of non-native plants becoming introduced to Norway due to both climate change and an increase in human activity. Preventing further introductions is of the utmost importance in managing plant invasions, and it is therefore key to understand which plants, not currently invasive to Norway, may become so in the future. To identify such species, we carried out a horizon scanning study to determine which species may become introduced to Norway and which of these may become invasive using a series of factors including climatic suitability, economic use and known ecological impacts. This resulted in a 'high risk' group of 284 species, all invasive somewhere in the world and with the potential to harm their invaded ecosystems. Of these, we carried out species distribution models to determine the potential distribution of these species within the wider Scandinavia region. Species distributions were predicted across the southern range of Scandinavia under current climate conditions. Under climate change, the climatically suitable ranges expanded and shifted to higher latitudes, and more species were predicted to occur within the Arctic circle. In addition, we identified 'hotspot' areas suitable to a very high number of species around Oslo in Norway and the coastal regions of Sweden, Denmark and Finland. These results have huge implications for Arctic ecosystems, particularly in the future where introduced species may move further north from lower latitude regions. It also highlights the importance of carrying out horizon scanning studies to identify risk species before they become a threat.

Title: Ice-shelf sediment facies

Presenting Author (keynote): Jennings, Anne E.[1]

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Abstract:
An Arctic ice shelf sediment facies has been described using sediment cores collected from Petermann Fjord, NW Greenland, including samples collected beneath the modern ice tongue. The modern facies is laminated and lacks coarse clasts (IRD) due to release of basal debris by strong basal melting at the grounding zone driven by buoyant subglacial meltwater plumes and entrained Atlantic Water. The turbid meltwater plumes rise to the surface and deposit fine, laminated sediments (plumites) widely beneath the ice tongue and beyond the calving front. Proximal to the grounding zone (15 km in this case) strongly laminated sediments comprising turbidites and plumites, aslo lacking IRD, are deposited in the deep inner basin. In recent years, multiple studies around northern Greenland and in the Canadian Arctic have documented similar facies attributed to past ice-shelf influenced environments. This talk presents the lithofacies characteristics and processes involved in forming the modern ice shelf facies, contrasts these fine-grained, laminated facies with facies from the opposite extreme of marine terminating glaciers with calving margins that produce glaciomarine diamicton units, and applies the concepts to paleo marine records.

Title: Coastal change in Svalbard – filling a knowledge gap in Arctic response to climate change

Presenting Author: Jensen, Maria A.[1]

Co-authors: Hagen, R[1, 2] , Missana, A.[1], Ottem, M.J.D.[1,2], Rubensdotter, L[1,3.], Skinner, L.R.[1,4], Garestier, F.[5] , Besset, M.[6]

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Abstract:
The coastline of the Svalbard archipelago is highly dynamic with known consequences for erosion of modern infrastructure as well as cultural heritage. Focus from natural and local management has mostly been on coastal erosion, but our work also documents lateral movement and progradation on the order of up to tens of meters per year, which has implications for sediment and nutrient transport to the fjords, wetland dynamics and vegetation. Until recently large-scale geomorphological mapping of the coastal environment in Svalbard was lacking and studies carried out were typically site-specific or focused on a particular depositional system making it difficult to compare trends with regional and pan-Arctic patterns.

Here we present the results of a decade of site-studies in a range of inner fjord environments combined with large-scale remote sensing based mapping of coastal geomorphology, mapping of coastal processes and responses and tool development for quantification of horizontal change. Under the DynaCoast project, we mapped the geomorphology of the coastal zone of Isfjorden from the shoreline to 500 m inland. A key result from the DynaCoast map is that most segments of the Svalbard coastline are dominated by a combination of physical processes with particular morphological results. Change in for example glacier front locations, sea ice presence and duration, run off, and wave action create specific morphological signatures and can be traced in the landscape. Here we present the first map of coastal process classifications for the Svalbard archipelago and discuss the implications for predicting sensitivity to change or planning mitigation strategies.

Quantification of horizontal change in real time is approached through use of satellite imagery and compared to historic records through use of digital elevation models with potential to study transects across Svalbard or regional trends.

Title: Improving past and future relative sea-level constraints for the Norwegian coast

Presenting Author: Lakeman, Thomas R.[1]

Co-authors: Lakeman, T.R.[1], Nixon, F.C.[2], Romundset, A.[1], Simpson, M.J.R..[3], Svendsen, J.I.[4], Vasskog, K.[5], Bondevik, S.[6], Milne, G.[7], Tarasov, L.[8]

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Abstract:

New research aims to improve relative sea-level (RSL) projections for the Norwegian coast. The main objectives are to: i) collect observations of past RSL changes, from the end of the last ice age to the last century, ii) develop a high-quality database of post-glacial sea-level index points (SLIPs), and to iii) improve our understanding of past and future vertical land motion using glacial isostatic adjustment (GIA) modelling. To now, our collection of new empirical data has focussed on three significant, but enigmatic RSL histories that are not adequately reproduced in existing GIA models: very recent stillstands and transgressions documented by historical tide gauge records, rapid transgressions during the early- to mid-Holocene Tapes period, and abrupt transgressions during the latest Pleistocene Younger Dryas chronozone. Ongoing field sampling is focussed on developing high-resolution RSL trends from salt marshes, isolation basins, and raised beaches, using multiple biostratigraphic and geochemical proxies and dating techniques. Results from various localities spanning the Norwegian coast provide robust constraints for the timing and rate of RSL change during the Younger Dryas and Tapes chronozones. Additional results providing new estimates of very recent RSL trends in southwest Norway are presented by Holthuis et al. These new and emerging constraints are being integrated into a post-glacial RSL database that incorporates high-quality data from the entire Norwegian coastline. Over 1000 SLIPs have been assembled from published studies. These existing data were updated using current radiocarbon calibration curves, high-resolution digital elevation models, new field observations, and new quantitative estimates of relevant uncertainties. Ongoing GIA modelling is utilizing the new RSL database, a glaciological model that freely simulates ice sheet changes, as well as geodetic and ice margin chronology constraints, to develop rigorous uncertainty estimates for present and future GIA along the Norwegian coast.

Title: Jan Mayen – Terra incognita coming out of the mist

Presenting Author (keynote): Larsen, Eiliv[1]

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Abstract:
Jan Mayen is a volcanic island located in the Norwegian-Greenland Sea about 500 km east of Greenland. Due to its position between cold and warm surface currents, the island is very sensitive to climatic impacts from shifts of these currents. Jan Mayen is a young island, the oldest rocks are some 560.000 years, and volcanism is still active. The northern part is dominated by the 2277 m high, glacier-covered stratovolcano Beerenberg. The lower-lying middle and southern parts are also dominated by volcanic rocks and sediments. In these areas, glaciogenic material is found in windows between post-glacial lava flows, volcanic domes and pyroclastic deposits. This is why it, until recently, was disputed if the entire island had ever been glaciated. In essence, the Quaternary history of Jan Mayen was unknown when we started working there in 2014. This is a unique and challenging position to be in as we had to build the knowledge base almost from scratch.

Due to volcanic activity, the paleogeography of the island has changed dramatically, and volcanoclastic sediments interchanges with glaciogenic sediments in many ways. Some typical associations will be illustrated by a ca. 500 ka long formational history of a lake basin including its most recent sediment infill history. Following a large effort in mapping and more than 100 dates of different types, we can show that the entire island was glaciated during the LGM. In the Holocene, glaciers in the northern part expanded beyond the LIA limits at least once. Also in the southern parts, glaciers were present in the Holocene. Surprising in this regard, was the finding of a formerly unknown, tephra-covered, climatically dead glacier. Both during the last deglaciation and the retreat following the LIA, volcanic activity played an active part.

Title: Surface freshening in Subpolar North Atlantic due to Arctic Sea Ice is weakening Overturning Circulation

Presenting Author: Madan, Gaurav[1]

Co-authors: Gjermundsen, A.[2], Iversen, S.C.[2,3], LaCasce, J.H.[1]

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Abstract:
The Atlantic Meridional Overturning Circulation (AMOC) regulates the global transport of heat, freshwater, trace gases and nutrients in the Atlantic sector. Published proxy records and modeling studies, reviewed by the IPCC, are consistent with a weakening AMOC in the warming climate. Here, we examine AMOC changes in the quadrupled CO2 experiments conducted under the CMIP6 program. While the forcing is extreme, the abrupt nature of the transition facilitates diagnosing the relevant forcings. The results suggest that AMOC weakens in response to freshwater input in the subpolar gyre, due primarily to sea ice melt. The resulting freshwater flows south along the eastern coast of North America, and then eastward, north of the Gulf Stream. This weakens the density gradient across the North Atlantic Current, decreasing the associated vertical shear and consequently the transport. As such, the inflow to the northern downwelling regions is cut off. This is in contrast with the common perception that freshwater "caps the convection regions", stifling deep water production. Changes in surface temperature have a weaker effect, and there are no consistent changes in local wind forcing among the models. The results thereby indicate that increase in freshwater discharge, primarily from the Labrador Sea, is a precursor to AMOC weakening.

Title: Kapp Ekholm, a yardstick for the glaciation history of Svalbard although we await a more precise chronology

Presenting Author: Mangerud, Jan[1,2]

Co-authors: Svendsen, John Inge[1,2]

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Abstract:
For several reasons, Kapp Ekholm is a key locality for the glaciation history through the last interglacial-glacial cycle on Svalbard (Mangerud and Svendsen, 1992): 1) There are as many as four tills in super-position here, each overlain by a coarsening-upward marine-sediment sequence reflecting glaci-isostatic uplift. 2) The lowermost marine sequence contains the mollusk *Mytilus edulis*, reflecting an ocean climate as warm as today during the Eemian. 3) Kapp Ekholm is located only 14 km outside the large present glacier Nordenskiöldbreen, meaning that the ice sheet over Svalbard must have been small or completely melted away when this site was ice-free. 4) The stratigraphy at Kapp Ekholm shows that the central part of Svalbard was ice-free at least twice during the Weichselian.

The lithostratigraphy at Kapp Ekholm is complicated and many scientists and students have therefor examined the sediment stratigraphy with critical eyes. Our correlation and interpretations from 1992 have nevertheless been largely accepted.

However, there is still uncertainty about precise ages of the units and especially disagreement about the youngest ice-free interval prior to the Last Glacial, which is termed Kapp Ekholm interstadial. Mangerud et al. (1998) found that new OSL dates supported the earlier assumed MIS 3 age, whereas Eccleshall et al. (2016) considered MIS 5a as a more probable age based on their new OSL ages. We nevertheless argue that our original age estimate of MIS 3 is far more likely, mainly based on the amino-acid D/L ratios measured on mollusks. These values are almost impossible to understand if Kapp Ekholm interstadial should be as old as MIS 5a (80 ka) (Mangerud and Svendsen, 1992).

Title: Microplastics in source-to-sink systems in a changing Arctic

Presenting Author: Martin, Jake[1,2]

Co-authors: Consolaro, C.[3], Hjelset, S.[3], Singdahl-Larsen, C.[3], Röhler, L.[3], Martinez-Frances, E.[3], Rødland, E.[3], Nixon, F.C.[1], Noormets, R. [2], Lusher, A.L.[3,4]

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Abstract:
Studies related to high Arctic microplastic pollution have been uncoordinated to date. There has been little follow-up investigation of year-on-year variability, or the treatment of results when different environmental compartments are investigated, even where consistent methodologies and research teams are employed. Freshly exposed paraglacial sediments are being eroded and transported to the fjords and shelf of Svalbard, Norway at an increased rate by mass wasting, glaciofluvial processes, and precipitation events. Sediments transported to the coastal zone are then reworked into coastal landforms, for example, tidal flats, barriers, and spits. The incorporation of microplastics (plastic debris < 5 mm) into such processes and the point at which they enter this source-to-sink system is the focus of this study. Our ongoing investigation of microplastics in Longyeardalen and Adventfjorden includes snow, ice, and glaciofluvial / coastal / distal glaciomarine sediment. End of season snow profiles from the glaciers of Longyearbreen and Larsbreen, which form part of this catchment, were collected in April 2021. Sediment samples from moraine, glacial forefield, Longyearelva river, and Adventfjorden were collected in September of 2020 and 2021. Preliminary results enumerating microplastics within the glacial snowpack at the head of the catchment and within fjord sediment deposits, achieved through visual and spectrographic methods, are presented here.

Title: Deposition patterns of PAHs, PCBs and trace elements in snow on glaciers - Covering a latitudinal gradient from southern Norway (60.54°N) to Svalbard (78.87°N)

Presenting Author: Messinger, A. Nicola[1,2]

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Abstract:
Persistent and volatile compounds have been suggested to be transported from lower latitudes to the artic via long-range atmospheric transport (LRAT). This process is expected to strongly vary depending on the temperature dependency of the volatility of the compounds, and thereby it is also affected by temperature changes with latitude, which leads to global fractionation. The aim of this study is to investigate the deposition patterns of different main and trace elements, PAHs and PCBs in the snow on a latitudinal gradient ranging from southern Norway (60.54°N) to Svalbard (78.87°N) with respect to LRAT. Sampling of snow was selected because it has been suggested to be a suitable matrix to monitor the atmospheric composition. To avoid local contamination of the snow, the samples were taken on remote glaciers. In total 16 glaciers were sampled along the gradient which were analyzed for 62 elements (ICP-MS), the 16 U.S. EPA priority PAHs and seven PCBs (GC-MS). Preliminary results show that the total element concentration is varying from 260 – 12200 µg/L. The highest total element concentration was found on Langfjordsøkelen (70.13°N), which was mainly due to high concentrations of Na, Cl and Br, indicating a marine influence. Furthermore, the concentrations of heavy metals in snow seem to be higher on mainland Norway (4.9 – 59 µg/L) than on Svalbard (1.5 – 4.9 µg/L), while lanthanide concentrations are higher in snow on Svalbard (0.004 – 0.015 µg/L) than on mainland Norway (0.001 – 0.005 µg/L). $\sum_{16}$PAH concentrations in the snow ranges from 14 – 160 ng/L, with the highest concentration found on Austdalsbreen (61.82°N) and lowest on Austré Brøggerbreen (78.87°N). Out of the 7 PCBs only PCB180 was detected in 8 samples (>0.45 ng/L) representing 50% of the studied glaciers. The latitudinal trend of the compounds will be further investigated to study the spatial gradient.

Title: Reconstructing abrupt sea-ice anomalies east of Greenland using ultra high-resolution paleo and historical archives

Presenting Author: Miles, Martin W.[1,2]

Co-authors: Ogilvie, A.E.J.[2,3], Andersson, C.[1]

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Abstract:
The Great Salinity Anomaly (GSA) of the 1960s–1970s resulted from an abrupt increase in the export of arctic sea ice that was transported southward along the East Greenland Current. The East Iceland Current was transformed into an ice-laden polar current, bringing sea ice to Iceland and polar waters near the Faroe Islands. There are indications of an even larger GSA-like event in the 1880s–1910s, based on fragmentary hydrographic measurements and historical data. However, this has never been properly constrained, nor have earlier occurrences that may be apparent from high-resolution proxy and historical data, except for a "Great Sea-Ice Anomaly" (GSIA) in the 1300s near the onset of the so-called Little Ice Age (LIA). Here we present and investigation of abrupt sea-ice anomalies using ultra high-resolution (annual to decadal) marine and terrestrial archives and historical data. Using indications of Arctic Ocean origin sea ice from marine sediment records, we target periods in the 1300s and around 1600, the late 1600s, around 1800 and the 1880s–1910s. These cases are then examined using annually resolved sea-ice proxy records based on coralline algae, ice cores and historical archives, complemented by data on stable isotopes from shells of the bivalve *Arctica islandica* from Iceland and the Faroe Islands. We find multiple lines of evidence that GSAs/GSIAs of decadal to multidecadal duration are recurrent events during the LIA, which from the regional marine perspective terminated abruptly ca. 1920.

Title: Arctic heat anomalies: Spatial-temporal distribution and effects

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Abstract:

Arctic climate change is amplified and accelerated, and recent high temperature extremes in the region are record-breaking. The impact of Arctic "heat waves" has both environmental and human perspectives. High land temperatures favor wildfires and permafrost thaw, enhance carbon release from soils, and the land disturbances open pathways to afforestation and shrubification of the Arctic. The last decade has witnessed several unprecedented heat waves in the Arctic, notoriously in 2012, 2016, and 2020. Here we produce a spatial-temporal analysis of land surface temperature (LST) data. The LST anomaly maps were made using thermal infrared measurements collected by the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument aboard NASA's Terra satellite. The climatology used for calculating the anomaly spans 2000-2020. Our study demonstrates the increase of Arctic heat wave occurrences during last decade and show some examples of its effects. The 'mindboggling' Arctic heatwave in 2020 was record-breaking, and headlines are full of alarming news. Intense heat also affected several regions in the summer of 2016. The extremely dry and hot weather set in northern Siberia seriously affected local ecosystems, causing severe tundra fires but showing positive anomalies in most northwestern Siberia. The most recent high temperature extremes in the region are record-breaking, with an all-time record high temperature in 2020. The Arctic "thermometer" – Svalbard – shows summer in 2020 is the warmest on record, well above the old summer record from 2015. Heatwaves increase the environment's temperature and exacerbate the difference between temperatures in cities and rural areas. As a result, cities develop additional heat stress on the background of the existing urban heat island effect, for example, extreme urban heat in Nadym (65.5° N, 72.5° E) in Siberia in August 2020. The study is supported by the Belmont Forum project SERUS: Building Socio-Ecological Resilience through Urban Green, Blue and White Space.

Title: Near-surface temperatures and potential for frost weathering in block fields in Svalbard and Norway

Presenting Author: Peter, Maria[1]

Co-authors: Nixon, F.C.[1], Fredin, O.[1], Andersen, J.L.[2], Westermann, S.[3], Etzelmüller, B.[3]

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Abstract:
In Scandinavia, blockfields are found as high elevation, low relief mountain terrain (plateaus) across the Arctic and Subarctic. They remain enigmatic regarding their origin and landscape evolution, internal and surface processes, and glaciological implications. In this study, we present a 1D numerical model that uses near-surface temperatures and snow depths measured between summer 2018 and summer 2020 to calculate frost-cracking intensities (FCI) within the ground column in three different blockfield locations in Norway and Svalbard. Eighty-nine (89) miniature temperature loggers were distributed on Tron Mountain (1650 m a.s.l.) in the Alvdal region, on Gamlemsveten (780 m a.s.l.) near Ålesund in southwestern Norway, and on Platåberget (~460 m a.s.l.) near Longyearbyen, Svalbard. To calculate FCI, a model approach was used, that scales time spent in a frost cracking window (between -3 and -8°C), plus the temperature gradient and water availability with a penalty function for distance to available water.

At Tron and Gamlemsveten blockfields, near-surface temperatures never reached the frost cracking window at approximately 1/3 of the settings, because of insulating snow cover and thus too warm temperatures. Outside the deep snow areas, the time averaged, depth-integrated FCI's showed relatively high values (0.05 to 0.4 [K m]) where the subsurface consists of some boulders and stones in a matrix of fine to medium-fine sediment (sand, silt, gravel). In contrast, very low FCI's (0.003 to 0.02 [k m]) were modelled for a blocky layer with large air-filled pores because of the low water availability. On Platåberget, all sensors reached the frost-cracking window during the annual temperature cycle. FCI values on Platåberget are positive, but extremely low (0.0004 to 0.15 [K m]), as water availability is limited due to permafrost occurrence and as surface and near-surface temperatures remain below the frost-cracking window for 3/4 of the year.

This suggests a landform-preserving mechanism preventing classic blockfields (boulders with air-filled hollows) from disintegration in cold to very cold climates, whereas maritime settings, milder climates and high availabilities of fine interstitial material, place blockfields in the fast lane for frost cracking weathering.

Title: Nuanced responses of seasonal sea ice to a warmer Arctic climate during the Holocene Thermal Maximum

Presenting Author: Pieńkowski, Anna J.[1, 2]

Co-authors: Husum, K.[3], Belt S.T.[4], Ninnemann, U.[5], Köseoğlu D.[5], Divine D.V.[3], Smik L.[4], Knies, J.[6, 7], Hogan K.[8], Noormets R.[2]

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Abstract:
While climate model simulations provide valuable insight into potential future Arctic sea-ice scenarios, marine geological archives offer key information on how sea ice responded to substantial climatic warming in the past, particularly during periods characterized by warmer-than-present conditions. The HTM (Holocene Thermal Maximum), ~10.0-6.0 cal ka BP, was the last major period of warm climate expressed in warmer air and ocean temperatures across the globe. Although a result of orbitally-forced summer insolation, the HTM constitutes a valuable parallel to the greenhouse-gas-driven setting of a current (and near-future) warmer world. At higher latitudes in the Northern hemisphere, the HTM has been proposed as an interval of reduced sea ice and increased Atlantic water inflow, similar to a projected future warmer Arctic Ocean. Two sediment archives elucidate the early Holocene HTM evolution of high Arctic seasonal sea ice in the northern Barents Sea (>80°N), a key area for Atlantic-Arctic Ocean water interaction in a hotspot of current climate warming. HBI (highly-branched) biomarkers (IP_{25}, $IPSO_{25}$, HBI III, HBI IV) unequivocally demonstrate the persistence of spring seasonal sea-ice as high as 55% between 11.7 and 9.1 cal ka BP. Concomitant high $\delta^{18}O$ in benthic foraminifera and elevated phytoplankton biomarker (HBI III, HBI IV) concentrations indicate the influence of warm Atlantic-derived bottom water and peak bioproductivity, respectively. Our results highlight the nuanced and complex cryospheric response to climate warming, showing High Arctic sea ice persisting in a setting of warmer-than-present spring and summer conditions under a concomitant increased inflow of subsurface Atlantic Water. This raises important questions about the fate of Arctic sea ice, oceanography, and ecosystems (including commercially important fisheries) in an increasingly warmer climate driven by anthropogenic factors.

Title: Denudation of a glacierized catchment in accelerated ablation conditions (Svenbereen, central Spitsbergen)

Presenting Author: Rachlewicz, Grzegorz[1]

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Abstract:
Components of denudation balance against the background of hydro-meteorological conditions were monitored between years 2012 and 2018 in the glacierized catchment of Sven glacier (Svenbreen) in the Petuniabukta region in the central part of Spitsbergen. Sven is s a valley glacier of an area 3.82 km^2, at the elevation 200-700 m a.s.l., covering about 42% of its catchment. The coverage diminished by 1/3 in relation to the Little Ice Age maximum ice extent and the average surface elevation change of the ice is reaching in the last two decades -61 cm a^{-1}, almost twice of the amount from the period 1960-1990. Particular years of observations revealed variability of meteorological conditions during the ablation season, in terms of liquid precipitation sum, ranging between 80 and 250 mm, average air temperature from 2.2 to 3.3 deg. C, with a slightly positive trend and glacier melt season length from 76 to 120 days. Combination of these parameters decided about the amount of particulate and dissolved material removed outside the catchment, due to glaciofluvial discharge, in the ratio of about ten to one. The glacierized catchment denudation reaches an average multiannual value of less than 75 t km^{-2} y^{-1}. Concluding, middle size Spitsbergen valley glaciers are reacting to climate changes with significantly negative mass balance, leading to accelerated ablation and areal decrease, although, despite the elongation of ablation season, but due to the ice covers shrinking, the total water and sediments discharge, being responsible for denudation, is decreasing. Long-term monitoring of these processes is absolutely necessary for a reliable assessment of the ongoing changes trend, as the performed seven years period is too short for proper generalizations.

Title: The Svalbox geoscientific portal: from acquisition to sharing digital outcrop models

Presenting Author: Rodes, Nil[1]

Co-authors: Betlem, P.1,[2], Senger, K.[1], Horota, R.[1,3], Van Hazendonk, C.[1,3], Smyrak-Sikora, A.[1], Kuckero, L.[4]

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Abstract:

The Svalbox.no geoscientific portal is primarily a digital model database that acquires, integrates and visualizes digital outcrop models (DOMs) from the Svalbard archipelago. The Svalbox website, www.svalbox.no, provides free access to high-quality DOMs from Svalbard and geospatially integrates them with other geoscientific data such as geological maps, location of subsurface data and photospheres. Further consisting of a Petrel-based multi-physical database, Svalbox represents a major digital research and education tool, including a growing number of thematic stories around the data sets (i.e., Virtual Field Trips).

In summer 2021, the Svalbox team conducted a dedicated data acquisition campaign for DOMs in van Keulen- and van Mijenfjorden in western Spitsbergen. The Czech research sailboat Clione was used for transport and accommodation during the fieldwork. Over 11 days, we acquired > 14 000 drone-based photographs of multiple renowned high-quality outcrops. The DOMs were processed using structure-from-motion processing software. We followed a standardized processing methodology to ensure the reproducibility of the data processing.

The result of the 2021 summer acquisition campaign are 16 high-quality DOMs with a total extent of 45.7 km2. The Akseløya-Storvola transect forms an almost uninterrupted cross-section through western-central Spitsbergen's exposed geology. This section exhibits vertically exposed layers showing the Permian–Triassic boundary in Akseløya, passing eastwards into highly deformed Mesozoic mudstones at Midterhuken that were deformed by the Palaeogene fold-and-thrust belt, and finally the world-class clinoforms of Storvola and Brogniartfjella that developed in a foreland basin. All the models can be visualized on the Svalbox website through Sketchfab. The data relating to each model is uploaded to the Zenodo repository, containing a unique Digital Object Identifier (DOI). Users can freely download both input photographs and processed models.

As of May 2022, Svalbox offers 132 DOMs spanning the geologic diversity of Svalbard and is continuously growing with more dedicated campaigns to cover the outcrops from all over the archipelago.

Title: Back in the USSR (A Holocene Arctic climate story starring sea ice, sea level, sediments and Siberia)

Presenting Author (After Dinner Speaker): Spielhagen, Robert F.[1]

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Abstract:
The perennial sea ice cover is the unique feature of the Arctic Ocean. Through the ice-albedo feedback mechanism it controls Arctic climate, but this effect also makes sea ice highly sensitive to global warming. Most of the Arctic sea ice is produced in the "sea ice factories" on the Siberian shelves, from where it drifts across the central Arctic to the Fram Strait. Today it is the major transport agent for clastic sediment particles which are entrained during sea ice formation in offshore polynyas and partly deposited in the deep-sea Arctic during partial summer melting. Modern-type investigations on sea ice sediments started with the first icebreaker expedition to the Arctic interior in 1987, but the source area of the ice was barred to Western scientists. Only in the late 1980s, when the iron curtain lifted, northern Siberia became accessible to non-Soviet researchers. In my presentation I will show how our Arctic group at GEOMAR started sea ice investigations on a small Soviet weather station "in the middle of nowhere" on the New Siberian Islands in 1991. In the following decades, results from sediment cores, obtained along the pathway of Arctic sea ice from the ice source on the Siberian shelves to its exit through Fram Strait, revealed the important role of sea level rise for the Holocene natural variability of Arctic sea ice and climate. In the early Holocene, relatively small areas available for sea ice formation allowed for large seasonally ice-free regions in the eastern Arctic. Flooding of the shelves during postglacial sea level rise increased the "sea ice factories" and the ice export from the Arctic. This development terminated the Holocene Thermal Maximum in the Fram Strait and started a cooling trend. Only when the present-day coastline was reached around 5 ka, pre-industrial conditions were reached.

Title: The sediment accumulation rate in fjords - an underrated climate-sensitive variable

Presenting Author (keynote): Szczuciński, Witold[1]

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Abstract:
The modern Earth Sciences evolve more and more from qualitative to quantitative approaches. The latter is particularly important in the context of significant changes in the magnitude of acting processes during the ongoing warming. One of the critical, quantitative variables is sediment accumulation rate (SAR). However, its applications are often underrated and are most commonly restricted to geochronology. While SAR is also a variable of key importance for benthic ecology, sedimentary source to sink studies, fluxes of bulk sediments, nutrients, and most importantly carbon (carbon burial rate), assessments of erosion intensity, and the transport capacity of various processes (e.g., by meltwater, icebergs, wind). More importantly, the driving controls of SAR: the sediment supply, sedimentation processes, and accommodation space are sensitive to changing climate. Thus SAR is also important as a climate change indicator – sometimes the only one, as qualitative changes may not be noticeable. Moreover, the rapid changes in SAR may also be considered as geohazards (e.g., slope instability, turbidites, landslide-generated tsunamis). In the paper are reviewed examples of opportunities, challenges, and limitations of SAR studies in polar fjords (e.g., Svalbard, Greenland, Antarctica) – known as efficient sediment traps. Among the various methods of Sar assessment, the main focus is given to short-lived radionuclides studies (e.g., ^{210}Pb, ^{137}Cs), the most accurate for tracing the transition from the Little Ice Age towards the modern global warming.

Title: Detailed UAV-based imagery reveals the complex nature of post-depositional modification of debris-flow fan surfaces

Presenting Author: Tomczyk, Aleksandra M.[1]

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Abstract:
In this study, we quantified annual (2015-2019) dynamics of debris-flow-dominated fans located in the central part of Spitsbergen, Svalbard. The dynamics of Arctic fans is important because: (1) it can provide us with a model on how fans will be transformed in other parts of the world, (2) fans in polar environment are often used as analogues for extra-terrestrial landforms; (3) as the climate warms, the number of people living and working in polar areas will increase, so we need to understand how the morphology of fans can change over a short period in the context of potential future human settlements and other activities. We used a time series of very high-resolution UAV-generated images taken in 2015, 2016, 2017, 2018, and 2019 to generate digital elevation models and orthomosaics. The surface morphological changes varied greatly among studied fans, despite their locations in very similar environmental and climatic settings. In general, large portions of fan surfaces were stable over the studied period; however, when the high-magnitude low-frequency processes occurred, the morphological changes were substantial. This response was very diversified over space (i.e., between fans as well as within single fans) and time (i.e., most of the changes occurred over one year, different for each fan, whereas the surface in the remaining years was stable). Our results indicate that the general response of slopes to global climate warming is strongly filtered by local (mainly topographic) factors. We suggest that climate warming will not only make low-frequency, high-magnitude processes more likely in the Arctic, but that those processes will achieve more geomorphological work with the erosion of permafrost. As mass-movement processes transforming fan surfaces will become more widespread and intense, it has clear implications for human activity in polar areas.

Research funding: National Science Centre, Poland, Grant Number 2016/21/B/ST10/01353