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The Norwegian Scientific Academy for Polar Research
Norges Vitenskapsakademi for Polarforskning

Report from the symposia

Security and Preparedness in the Changing North
–
Research perspectives

Held at

Royal Swedish Academy of Sciences, Stockholm, 8-9 November 2022

and

The Norwegian Academy of Science and Letters, Oslo, 23-24 March 2023

These symposia were inspired by the IPCC report *The Ocean and Cryosphere in a Changing Climate*. They were initially conceived at a meeting in 2018 between the Geoscience class of the Royal Swedish Academy of Sciences and the Norwegian Scientific Academy for Polar Research. It was decided to hold one symposium in Stockholm and one in Oslo, concentrating on the following five themes.

Conditions for livelihoods, health, and ecosystems
Northern and Arctic regions experience more rapid warming than the global average, with impacts threatening livelihoods, health, and ecosystems, for example by thawing permafrost, melting glaciers, increased frequency of extreme events, such as storms, floods and wildfires. Effect cascades imply that, for instance, permafrost thaw can change the abundance and distribution of animals and plants, disturb or entirely shift ecosystems (such as terrestrial ecosystems to thermokarst wetlands/ lakes, and vice versa), and ultimately impact food and water security, infrastructure, and livelihoods. It can further release, not only carbon, but also dangerous pathogens currently trapped in the frozen ground, while also changing the pathways (distances and timings) of waterborne transport and spreading of these pathogens, as well as of other pollutants and nutrients. Changes in temperature and hydrological patterns, and their combinations can also affect health conditions by shifting the geographical range, prevalence, and/or severity of climate-sensitive infectious diseases. This session presents research perspectives on the range of shifts and risks threatening livelihoods, health, and ecosystems in the changing north, and possible mitigation-adaptation solutions, measures and actions.

Forecasting the changing ice, ocean and weather conditions
Climate change leads to increased activity in the North, but the "high-impact weather" common in these areas is hazardous to marine operations and industrial development. There is an urgent need to advance capacity for the delivery of reliable and accurate Arctic weather forecasts and warnings for the benefit of maritime operations, business and society. To that end, the WMO's World Weather Research Programme (WWRP) has instigated the "Polar Prediction Project" to promote cooperative international research enabling development of improved weather and environmental prediction services for the polar regions, on time scales from hours to seasonal. The North has unique prediction challenges: observation gaps (e.g. improve the use of satellite data over sea ice and snow and in cloudy conditions) as well as specific model uncertainties due to physics parameterisations and limitations in resolution (e.g. mixed-phase clouds and stable boundary layers, the complex interplay in the sea-ice characteristics, the turbulent upper ocean; specific high-impact weather situations like polar lows and so on. There is also evidence that weather and climate of the mid-latitudes are affected by what happens in the Arctic and vica versa. In this session we wish to highlight advances made in the use of existing and new observation systems; in our understanding and model representation of the key processes and phenomena, in our understanding of the predictability of the coupled atmosphere-cryosphere-ocean system; and in the development of high-resolution Earth System models for ice, ocean and weather forecasting.

Impacts of climate change - effects and actions
Climate change in the Arctic impacts large areas of the globe, including the Nordic countries, and society needs to respond to these changes through mitigation to cut emissions, adaptation and transformation to a low-emission society. One critical effect of increasing temperature in the long-term is sea level rise, a condition that already some coastal communities adapt to by building protection against critical coastal erosion. Current sea level rise is minor compared to what is projected for the coming 50-100 years. Another projected and on-going change is increasing precipitation over Scandinavia, which will change water flow conditions over land as well as waterborne particulate and dissolved matter to the coast. This effect is amplified in northern regions with permafrost thaw, exposing organic matter to weathering and mineralization. Increased freshwater supply to the coastal ocean impacts stratification, which together with changes in waterborne material supply affect the coastal ecosystems. The ocean has stored more than 90% of the total energy caused by anthropogenic global warming, which is reflected in northward migration of different biological species into Nordic waters. This implies changing regional patterns of sustainable resources, potentially moving across borders with large socio-economic effects. In this session, the state of art of known climate-driven changes and their effects are presented, together with actions needed to address the societal consequences.

Access to infrastructure and data for Arctic research
A large part of the Arctic region is environmentally harsh and geographically remote, i.e. located far away from populated areas. Gathering of direct field observations from the Arctic region is critical for numerous research projects and monitoring programs. Field observations may, for example, complement and ground-truth measurements from space. This requires access to research platforms and instruments that are specifically designed to sustain the Polar environment. Platforms may range from heavy research icebreakers and air crafts to field stations, all equipped with instruments capable of sustaining the harsh environment. To date, only a few research-equipped icebreakers exist that are able of reaching the heaviest sea-ice covered parts of the Arctic Ocean, and vast land areas are without installed field stations. The Norwegian University Centre in Svalbard (UNIS) together with the research station in Ny-Ålesund are examples of well-developed infrastructures on Svalbard, which also may serve as logistical starting points of expeditions into the adjacent territories, including the Arctic Ocean. Accessible field stations for the international community to do research on Greenland also exist, but are less equipped. The limited availability of infrastructure for data collection in the Arctic region emphasizes the importance of international collaboration around existing resources. While collaboration and exchange of data within Arctic research community has increased substantially since the end of the cold war, the geopolitical change for the worse over the last decade has halted the progression. In a time when we witness an accelerated rate of environmental change in the Arctic in particular, a backwards progression regarding international collaboration and data sharing across national borders is worrying. This session aims to discuss available infrastructure and access to data for research in the Arctic region. Are there specific identifiable geographical regions where this is particularly difficult? If so, for logistical or geopolitical reasons? What can be done to improve the situation and make optimal use of existing resources? This session also welcomes presentations on new technology that may facilitate data collection in the Arctic environment.

Geopolitics (Governance), security and defence
Climate change is one significant driver of the increasing interest in Arctic, by non- Arctic nations. The retreating sea ice increases the accessibility to shipping routes and resources and may lead to critical and irreversible tipping points, both in the environment and in geopolitics. The geopolitical and societal situation in the Arctic increases steadily in complexity and unpredictability as the global community strives for larger shares in the future exploitation of the region's resources. Research on geopolitics in the Arctic have in recent years addressed the relationship between the superpowers in the region, the balance between conflict and cooperation and the growing involvement of new actors in the north, in particular EU and China, but also other Asian powerful nations. What draws their attention is the potential for Arctic shipping, energy and mineral resources, and possibly for strategic purposes. The Arctic has a history of having strategic importance for the operators in the region, especially after the 2nd World War and during the cold war period. Only a decade ago the Arctic was not considered to be an area of geopolitical tension requiring military presence. There are indications that this changing, as the military interest in the region is growing again. It is significant that non-icebreaking ships in the near future may be able to sail across the North Pole. Svalbard and Longyearbyen are located in an area of strategic importance for commercial and military purposes. Science and tourism are replacing coal mining as the main economic activities in Svalbard. This raises interesting questions about the role of science on the Arctic geopolitical arena, and how we ensure that data collection for scientific purposes not is by hampered geopolitics. Even though there is no formal joint authority for the Arctic, many of the issues are in effect regulated by various international agreements and by numerous bilateral agreements with concomitant authorities. The growing interest in the Arctic, for multiple reasons raises questions whether and how we are prepared to meet the mounting challenges through the current international cooperation, conventions and treaties.

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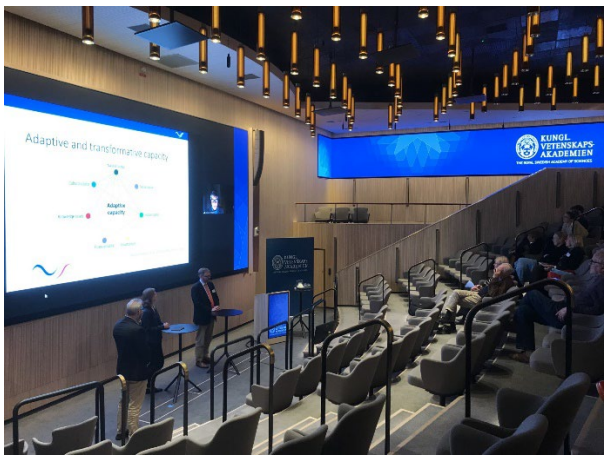

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Marius O. Jonassen, The University Centre in Svalbard, Longyearbyen, Norway
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Session 1: Access to infrastructure and data for Arctic research

Polar marine research infrastructure -a bridge for international collaboration.

Katarina Gårdfeldt, Polar Research Secretariat, Luleå, Sweden

Research in the Arctic is becoming increasingly important to understand climate change and its consequences. The rapid transformations due to climate change that polar regions are currently undergoing are causing consequences to ecosystems, societies, possibilities for economic activities and the whole global climate system. Multiple compilation reports have correspondingly underlined the need for increased international coordination of polar research and infrastructure. Swedish Polar Research Secretariat (SPRS) that operates one of the few heavy ice breakers in Europe, IB Oden, is an active participant in several international initiatives. SPRS has developed a new multi-disciplinary process for polar research planning -the Polar research Process. In short, the Polar Research Process aims to increase international

access to polar research vessels, diminish overlap in international research efforts, and increase knowledge of the systems behind the changing global environment by fulfilling data gaps and observations from both polar regions. The process couples them with a wider multidisciplinary theme that connects maritime polar infrastructure and research to core questions in other disciplines such as humanities, social, terrestrial, atmospheric and technical sciences. Through this kind of multidisciplinary cooperation and coordination can polar research infrastructure contribute to both increased disciplinary understanding and techno-scientific as well as social innovation that is necessary for the development of resilient, sustainable and just societies of the future. The Swedish government has in 2020 released its Strategy for the Arctic Region as well as the Innovation and Research Bill which outlines the direction of Sweden's research policy over the next four years, and in both these documents climate and polar research are identified as critical for Sweden's position as a leading research nation. The Arctic strategy calls for the SPRS to investigate the possibilities for access to a heavy, polar-grade climate-neutral research vessel that can be used all year round, as a replacement for Oden in a near future.

Making access to terrestrial infrastructures and data in the Arctic

Margareta Johansson, Lund University, Sweden

INTERACT is a network of 68 terrestrial research stations in all Arctic countries apart from Russia (where collaboration is currently on hold with 21 additional research stations). INTERACT seeks to build capacity for identifying, understanding, predicting and responding to diverse environmental changes throughout the wide environmental and land-use envelopes of the Arctic. Together, the stations in INTERACT annually host 15 000 scientists from around the world who work on projects within a wide range of fields both within natural and social sciences. The INTERACT stations also host and facilitate many international research and monitoring networks and aid training by hosting summer schools.

INTERACT offers Transnational Access to 39 research stations. It provides opportuni- ties to researchers to work in the field free of charge through its physical transnational programme. The remote access part allows scientists to get research carried out by station staff (an environmentally friendly way to do research) and the virtual access provide real data sets through the INTERACT data portal https://dataportal.eu-inter- act.org/

INTERACT constantly seeks to improve the infrastructure. The Station Managers' Forum has developed a range of best practices book to reduce emissions at the stations, to improve safety etc. The books can be downloaded from the INTERACT web site: https://eu-interact.org/publication/

In the current phase of INTERACT, the project focus on six societal challenges in the Arctic through its joint research activities; increasing extreme weather events, trans- port and communication, making data widely available using Artificial Intelligence, improving education and awareness, documenting and reducing pollution and finally, working on increasing benefits and reducing impacts from developing Arctic tourism.

30 years of Arctic monitoring and assessment cooperation; hurdles to access geographical areas and data.

Lars Otto Reiersen, University of Tromsø, Norway

Arctic Monitoring and Assessment Programme (AMAP) was established by the eight Arctic states (Canada, Finland, Iceland, Kingdom of Denmark, Norway, Russia, and the USA) in June 1991 as part of the Arctic Environmental Protection Strategy (AEPS), today the Arctic Council. AMAP got the task to monitor and assess levels, trends, and effects due to pollutants (persistent organics, heavy metals, radionuclides), climate change and combined effects of these on Arctic ecosystems and humans. To produce such scientific assessments, AMAP had to get access to data from the circumpolar area. A strategy for the work, including a strict QA/QC programme was developed for collection of new data and use of already stored data. Several hundred scientists have been involved in this work and produced more than 35 scientific assessments.

Since the beginning of this Arctic work in the early 1990-ties, a significant challenge has been to access data from the eight Arctic countries and from observing countries to the AEPS/AC. To improve the accessibility to data and geographical areas there are three major hurdles that exist: at national, institute and scientist levels. To improve accessibility, these hurdles have to be reduced/removed.

During the Russian chairmanship of the AC (2007-2009), AMAP in cooperation with IASC, succeed to get this topic on the agenda for the Ministers of Foreign Affairs and at the AC ministerial meeting in Nuuk (2011) it was agreed to

establish SAON (Sustaining Arctic Observing System). Since 2016, the Arctic Science Ministers (ASM) has had this problem on their agenda. The presentation will present the hurdles, initiatives to remove them and calling for proposals on how best to improve the situation.

Session 2: Forecasting the changing ice, ocean and weather conditions

Developing re-analysis and weather prediction services for the European Arctic

Jørn Kristiansen, Norwegian Meteorological Institute, Oslo, Norway

Numerical weather prediction (NWP) combines physical models and observations to monitor and predict the evolution of the Earth system. In the Arctic, there are specific challenges related to process understanding, modelling and observations. MET Norway has developed and implemented a short-term, high-resolution weather prediction system - AROME Arctic - for the delivery of reliable and accurate weather forecasts and warnings.

Based on AROME Arctic, the Copernicus Arctic Regional Reanalysis (CARRA) combines past observations with NWP models to provide a comprehensive description and consistent time series of the observed climate as it has evolved during recent decades.

AROME Arctic performs relatively well in terms of accuracy. A set of common weaknesses across forecast systems are identified. To advance our understanding and model representation of key processes, the Polar Prediction Project coordinates a process-based model evaluation project based on observations at selected Arctic supersites, including MOSAiC - the largest polar expedition in history.

Impact-based forecasting combines a forecast of a weather or climate hazard and an assessment of possible impacts. Experiments show that the reliability in the weather predictions benefits from better uncertainty estimation at the smaller spatial scales, including the sea ice, snow on sea ice and sea surface temperature.

At present, satellite observations are not used optimally for weather prediction and climate monitoring in the Arctic, particularly in seasons and areas with snow and sea ice. We show the relative impact of different observations on forecast accuracy, disentangling the benefits of observations on local forecast accuracy.

There is a tremendous opportunity and role for physical modeling and data assimilation (including reanalysis) in making observations into usable products, and investments in observing systems must be accompanied by a continued investment in NWP and high performance computing.

Polar prediction: Past, present and future

Thomas Jung, Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany

Following the strong decline of Arctic sea ice in the 2000s associated with the amplification of climate change, in 2011 the World Weather Research Programme (WWRP) of WMO launched a new initiative called the Polar Prediction Project (PPP). PPP along with its flagship activity the Year of Polar Prediction (YOPP) aim to advance predictive capacity in polar regions and beyond on daily to seasonal and longer time scales. They have become two of the most visible international programs in polar research, featuring prominently, for example, in calls for research funding and at the political level (YOPP is one of the key deliverables of the Arctic Science Ministerial). In this presentation, Prof Jung will provide a short motivation for the needs of PPP and YOPP; he will present recent progress with emphasis on observations, modelling and prediction; and he will outline possible ways forward, including a stronger focus on coupled predictions using Earth system models and exploiting the concept of Digital Twins.

From Observations to Search & Rescue in the Arctic

Cecilie Mauritzen, Norwegian Meteorological Institute, Norway

Maritime accidents in the Arctic can be extremely dangerous: potential rescue ships are usually very far away, the weather conditions during rescue operations are likely to be harsh, and the presence of sea ice, even in semi-open waters, can quickly turn a simple situation into chaos. With maritime traffic in the Arctic increasing, every effort must be made to lessen the risk associated with maritime accidents, and, when the accident has occurred, to lessen the inherent risk associated with the rescue operation itself. Key to reducing risk is to improve the precision of, and reach, of information. At the Norwegian Meteorological Institute we support maritime operations in the Arctic with general weather forecasts, special weather, ocean and ice forecasts for special operations, and drift forecasts in the case of rescue support. These services have developed greatly during the past 30 years.

Weather forecasts depend on ground truthing (observations) - if you don't know what the weather is today, no model can tell you what the weather will be tomorrow. In the Arctic, where in situ measurements are few and far between, the main source of observations is satellite remote sensing. In the early phase of Earth observing satellites, the space agencies demanded a high price for their products. But with time it was realized that everyone would benefit from making the data free of charge, not least because of the improved services the weather forecasting centers cold then provide. Today, satellite information from the Copernicus marine services is used as ground truthing for weather forecasts, ice forecasts and ocean current forecasts alike. During years, the horizontal resolution of both data and models have increased greatly, which has further improved the forecasts. Following the Russian helicopter crash outside Barentsburg in 2017, one of the many improvements in preparedness that was instigated by the Norwegian government was to increase the resolution of ocean and ice forecast models around Svalbard to 500 meters and to 2 500 meters in the Barents Sea in general.

As soon as a ship is drifting out of control, oil is accidentally released or a person has fallen overboard, a rescue

operation will focus on search. Also in this phase, the methods have improved greatly: where ten years ago the rescue personnel would be given an uncertain trajectory to search along, and a written briefing, today they will receive formal probability density distributions - from much more precise forecasts - of where the ship/person/oil is likely to be.

Maritime operations in the Arctic will always be dangerous, but the risks are continually lowered thanks to developments in the quality of the data, the models, and in the value chain from observations to a search and rescue operation.

Session 3: Conditions for livelihoods, health, and ecosystems

Climate sensitivity of infectious diseases in the changing north

Georgia Destouni, Stockholm University, Stockholm, Sweden

The Nordic Center of Excellence CLINF engages an international team of scientists for interdisciplinary research that also harnesses traditional knowledge and can support evidence-based policy for meeting the challenges of climate change impacts on Northern societies and the epidemiology of infectious diseases. Based on the CLINF research, this talk focuses on the key question of quantifying the climate- sensitivity of infectious diseases, which is crucial for identifying high- and low-risk areas, and preventing and mitigating major health threats from climate change.

Various studies have reasoned about the potential climate sensitivity of diseases in the Northern/Arctic Region, where climate change is particularly pronounced. The CLINF research has gone further in this effort by developing and applying ways to quantify the climate-sensitivity. To do this, the CLINF team has compiled and synthesized multivariate datasets of disease incidence, along with climate, hydrological, vegetation and other ecological data observed around the region, and combined these with statistical disease models and climate modeling. Disease scenario projections so far have focused on tularemia, as one of the most studied and statistically modeled diseases in high-latitude regions, and one that has caused large epidemics in recent years. Moreover, CLINF has developed data-based disease relationships with climate variables of temperature and hydrological conditions for borreliosis, leptospirosis, tick-borne encephalitis (TBE), Puumala virus infection, and cryptosporidiosis.

These relationships indicate and quantify the climate-sensitivity of the studied infections, and can guide associated prevention and mitigation efforts around the Northern/Arctic region by showing where and to what degree disease threats may increase or decrease under expected forthcoming climate change in the region.

Population living on permafrost in the Arctic

Timothy Heleniak, Senior Research Fellow, Nordregio, Stockholm, Sweden

The population and settlement patterns of the Arctic will be affected by many factors in the future including demographic, economic, technological, and importantly climate change. Permafrost thaw is a challenge in many Arctic regions, one that modifies ecosystems and affects infrastructure and livelihoods. To date, there have been no demographic studies of the population on permafrost. We present the first estimates of the number of inhabitants on permafrost in the Arctic Circumpolar Permafrost Region (ACPR) and project changes as a result of permafrost thaw. We combine current and projected populations at settlement level with permafrost extent. Key findings indicate that there are 1162 permafrost settlements in the ACPR, accommodating 5 million inhabitants, of whom 1 million live along a coast.

Climate-driven permafrost projections suggest that by 2050, 42% of the permafrost settlements will become permafrost-free due to thawing. Among the settlements remaining on permafrost, 42% are in high hazard zones, where the consequences of permafrost thaw will be most severe. In total, 3.3 million people in the ACPR live currently in settlements where permafrost will degrade and ultimately disappear by 2050.

Climate sensitive infections and Arctic pastoralism

Grete K. Hovelsrud, Nordland Research Institute, Bodø, Norway

Rising temperatures are causing species to spread into the new geographic areas. Warmer and wetter conditions, and hot, dry, and cold spells both, may enable vector-borne infections to move further north and find new host species. The introduction of new CSIs, especially zoonotic infections, may pose a new risk to both animal and human health. In this study we investigated how climate sensitive infections CSIs, such as Lyme borreliosis, caused by the bacteria Borrelia burgdorferi and spreading through ticks would affect reindeer and herding activities. Through a knowledge coproduction process, we considered the herders' responses to these risks. We quickly learned that CSIs were not yet considered to be a major problem and was overshadowed by adaptation to other pressing challenges such as locked pastures, encroachment, and predators. This caused a methodological conundrum: how do you study an emerging risk that is not yet a major concern for the herders?

We solved this by assessing the broad range of current multiple stressors in reindeer herding (e.g. predators, land encroachment, other diseases) as proxies for understanding the different factors of change that interact with significant cumulative effects. We conclude that while CSIs will require adaptation, exposure to CSIs can also increase because of adaptation to other stressors. Hence, increased acknowledgement of both direct and indirect aspects of the risks surrounding CSIs is important across levels and scale.

Session 4: Impacts of climate change - effects and actions

Effects of sea ice decline on Arctic marine primary producers

Eva Leu, Akvaplan-niva, Norway

Climate warming happens more than three times faster in the Arctic than in the rest of the world. This has strong implications for both the environment and the ecosystems in that region. The accelerating decrease of sea ice affects the marine habitat in several ways – and unialgal cells living in sea ice and water respond strongly. Since they represent the basis of the marine Arctic food web, changes in the occurrence, timing, magnitude and food quality of their blooms link directly to higher trophic levels. More light will be available in a future Arctic Ocean, which is favorable for photosynthesis.

On the other hand, increased stratification will limit the reservoirs of nutrients that are available for primary production in the euphotic zone. Furthermore, sea ice algae have been proven to be much less capable of acclimating/adapting to higher irradiances or ocean acidification compared to their pelagic counterparts. A change in the balance between these two important groups of primary producers potentially leads to major ecosystem shifts, as the fate of the biomass they produce differs. This presentation will give a brief overview of the major changes that are already occurring in Arctic algal blooms and will also put them in a greater ecosystem context.

Permafrost thaw impacts to northern ecosystems and communities

Gustaf Hugelius, Stockholm University, Stockholm, Sweden

The Arctic climate is now warming three times faster than the global average. This warming impacts Arctic terrestrial habitats and communities in many ways.

Accelerated permafrost thaw is already observed and is projected to increase substantially within a few decades. Circa 15 million km2 of the northern hemisphere landmass is underlain by permafrost, including the homes of 5 million people and infrastructure of large strategic importance. Most permafrost is many millennia old, and often contains very large amounts of soil organic matter that has historically been preserved by low temperatures and waterlogged conditions. As the soils warm and thaw, this soil organic matter begins to decompose, producing greenhouse gases.

Depending on the local conditions, thawing permafrost causes increased fluxes of carbon dioxide, in aerated soils, or methane from waterlogged anoxic environments; under certain conditions nitrous oxide can also be released. In areas with large amounts of massive ice in the ground (ice is often >50% of ground volume), the warming causes collapse of the landscape, so called thermokarst, which often causes high fluxes of methane from the post-thaw environment. All these permafrost carbon feedback processes are projected to increase rapidly in the latter half of this century, with combined annual emissions of carbon dioxide equivalents equal to present day emissions of all 28 EU countries. In addition, much of the Arctic infrastructure is at risk; by the year 2050 nearly four million people and 70% of current infrastructure in the permafrost domain are in areas with high potential for thaw of near-surface permafrost. A recent Arctic council report concluded that the only way to prevent broad-scale thaw of permafrost are substantial and rapid reductions of global greenhouse gas emissions.

Multiple hydrometeorological hazards and critical infrastructures

Karina Barquet, Stockholm Environment Institute, Sweden and Magnus Hieronymus, SMHI, Sweden

In this presentation we introduce ongoing work and preliminary results from the HydroHazards project. Impacts from multiple hazards are expected to grow with increased dependency on and vulnerability of Critical Societal Services and Infrastructures. Despite this, risk analyses usually study the likelihood of single events and their impacts but fail to consider the web of connections between them. While the stable welfare society in Sweden and the Nordic countries in general, makes them among the least vulnerable societies in the world, the challenge is whether

existing Disaster Risk Reduction and Climate Adaptation arrangements can react to changes in society, the economy, and the physical environment due to drivers such as climate change or infrastructure development. In HydroHazards, we explore the places in Sweden where multiple hydrometeorological extreme events are more likely to manifest, the impacts and cascading effects from these events upon Critical Societal Services and Infrastructures, and the resulting social vulnerabilities. An example of such hydrometeorological extreme events are snow bands that can form over the northern Baltic Sea and impact on the coastal areas of Sweden and Finland. Snow bands deliver large amounts of snow during short periods of time and cause disruption of traffic and infrastructure. Snow bands form when the Baltic Sea is ice free and the air is cold. These preconditions for snow bands are projected to change during this century. Using an ensemble of regional climate scenarios we show how competing and changing preconditions affect the overall number and seasonal distribution of snow bands during the 21st century. Heavy precipitation and river flooding are among of the multiple hazards investigated in HydroHazards. Both hazards can be driven by atmospheric rivers that deliver large amounts of moisture to the European continent. A robust result from our regional climate ensemble is the increase in frequency and moisture load of atmospheric rivers during the 21st century.

Session 5: Geopolitics (Governance), security and defense

A new arctic – from exceptionalism to security dilemma

Niklas Granholm, FOI Swedish Defence Research Agency, Stockholm, Sweden

With the emergence of a new Arctic, challenges abound. To understand the multi-faceted dynamic in the region, several perspectives have to be included. Mono-causal analyses increase the risk of misunderstandings and unsuitable policies. Without a well-grounded analysis of the defence and security situation, the risk is substantial that tensions increase and the risk of incidents or at worst open conflict becomes more likely.

Drivers

The main drivers behind the emergence of a new Arctic in the realm of defence and security are both external to and integral to the region. First, climate change is fundamentally changing the conditions on our planet. In the Arctic, assessments of climate change now indicate a warming about three times as fast as elsewhere. As a result, new geographical conditions will emerge.

Second, the large-scale, fast and relative re-distribution of resources and assets for power and influence on the global level influences power-relationships. Among these geostrategic shifts are the rise of China as an ambitious world power, a weaker European Union and a Russia striving to regain its great-power status. The United States seems more reluctant to underwrite the global order it was instrumental in setting up post-world war two. From this, increasing great power competition, rivalry and weaker multilateral regimes follow. As a result, predictability in the international system is lower. This is in turn already contributing to the naval and military activities and the operational setup in the Arctic region. The increasing ice-melt at sea and on land are influencing naval and military dispositions, both for conventional forces as well as nuclear-strategic deterrence systems.

The combination of these two main factors of influence – climate change and geostrategic change – have clear effects for the trends of defence and security, not least in the Arctic region. The three main actors in the world today, Russia, the United States and China are the state actors with the most influence in the arctic region today. The "big three in the Arctic" will under the rapidly changing circumstances shape much of the security environment in the new Arctic.

The Arctic region does not lack regulation. Several written and unwritten agreements and treaties regulate activities there. However, there are gaps regarding the security and defence sectors. The Arctic Council, the main body for Arctic discussions, is explicitly excluding all discussions on matters of military security. Since 2011, the Arctic Security Forces Roundtable (ASFR) comprising the eight Arctic nations, hold regular discussions on hard security on the highest military levels. Due to the ongoing Russian-led war against Ukraine, Russia does not take part in the ASFR since 2014.

Outcomes and Conclusions

The Arctic was for a long period seen as a region where global geostrategic trends did not really apply. "High North – low tension", was the phrase often used. In recent years, the view of the region has shifted from one described as "Arctic exceptionalism" to describe a region where a clear security dilemma has emerged. A partly different logic thus applies. The new Arctic urgently need discussions on partly new security structure in combination with forms of confidence and security building measures.

Dialogue and transparency in combination with deterrence can contribute to stability. Without a functioning and reasonably stable and predictable security environment in the Arctic, most other activities in the region – science, shipping, economic development and human security – will suffer negative effects.

China Engages the Arctic: a great power in a regime complex

Liselotte Odgaard, Norwegian Institute for Defence Studies, Norway

As global warming accelerates the melting of Arctic ice, opportunities for new transport routes open along with new strategic interests. I discuss how China pursues its interests in the Arctic and, specifically, the degree to which it seeks to work through the existing regime complex with the Arctic Council at the center versus engaging in bilateral cooperation with Arctic states. China's willingness to work through the regime complex or use bilateral cooperation depend on the specific issue area. China relies on global regimes based on the Law of the Sea regarding navigation issues, prefers bilateral cooperation for purposes of extraction of resources such as hydrocarbon reserves, and prioritizes regional Arctic regimes to justify the pursuit of dual-use scientific research. As a great power, China is well-positioned to use institutional complexity to its advantage. China uses existing regimes when it benefits Chinese interests, supplemented by bilateral initiatives as appropriate. Perhaps most importantly, as a great power China is able to reshape regime agendas to better reflect its interests while nurturing an image of looking after the interests of the international community, for example by financing environmental and climate research while at the same time pursuing strategic advantages. As strategic great power competition takes off, this Janus-faced approach to international cooperation is likely to gain ground.

New security concerns in the face of rapid and transformative change

Annika E. Nilsson, Nordland Research Institute, Bodø, Norway

The Arctic has become a bellwether not only for climate change but also for the geopolitical consequences of a changing environment, where military security concerns related to the rapidly declining sea ice have been amplified by deteriorating political relations between Russia and the west. However, the Arctic also faces many other issues with implications for security. This presentation will place the

notion of security into a broader context of the Arctic as a rapidly transforming region, with major uncertainties regarding future development paths. Firstly, it will discuss the implications of the transformation of EU's energy system with the Green Deal, including potential consequences for conflicts over land and resources in the region. Secondly, it will discuss possible implications of ongoing changes for the demography of the region and how demographic trends affect various aspects of human security. Thirdly, it will touch on the increasing need to manage conflicting political goals in ways that are perceived as legitimate by those who are affected.

The presentation is inspired by a synthesis of insights from participatory scenario exercises across the Nordic Arctic. It concludes with a call for approaches for studying Arctic change that consider the dynamics feedbacks between social, environmental, and technological developments, including the how they link processes across spatial scales ranging from the global to the local.

Theme 1: Conditions for livelihoods, health, and ecosystems

Lessons learned from previous epidemics in the Arctic

Peter Sköld, Umeå University, Sweden

This paper intends to bring insight to our understanding of pandemics in a long-term perspective, and what we can learn from them in our ambitions to improve the preparedness for future viruses spread to or from the Arctic. This means that pandemics have to be understood in a broader bio-cultural perspective taking in aspects such as remoteness and immunity, the epidemiologic transition, Indigenous peoples, epidemic pathways, demography, health care organizations, local organization, national policies, communication and information, equality, preventive measures, and population data and projection. Even if the next pandemic will most likely be very different from those we have witnessed during the last four hundred years, and even if we do nothing about the timing the paper concludes that there are learnings from the epidemic past that can guide our preparedness.

People, society and business in the Arctic today and in future

Frode Mellemvik & Andrey Mineev, Nord University, Bodø, Norway

The objective of our work is to investigate Arctic regions through the lenses of a resilience framework. Resilience originates from the Latin word "resilere", meaning "jumping back", "rebounding", or simply to "bounce back". The term was first used scientifically in the mechanical sciences from the end of the 18th century, and then spread to psychology, ecology, and a number of other scientific disciplines such as geography and economics. Since then, the concept of resilience has undergone an essential development, moving from understanding it via the original meaning of "returning to the original state (bounce back), towards an understanding that a different and possibly better state can be achieved through adaption and transformation.

Hence our approach to Arctic resilience is that it is a result of a combination of a region's socio-economic systems' capacity not only to cope with challenges, but also to adapt and/or transform. This leads to three different responses: 1) Persistence (coping capacities leading to persistence); 2) Adaptability (adaptive capacities leading to incremental adjustments and adaptive changes); 3) Transformation (transformative capacities leading to structural or systemic reconfigurations).

Further, to understand future consequences of decisions and processes taking place in present, we need to understand fundamental trends and uncertainties about the Arctic. In this respect we will present four scenarios which explore the context for international cooperation in the Arctic up to 2035, based on our recent book.

Landscape of colonial memories

Britt Kramvig, UiT The Arctic University of Norway, Tromsø, Norway

In this lecture I will address the conditions for livelihoods, health, and ecosystems as it is embedded in the Sámi traditional knowledges. Within the indigenous worldview, disconnecting health and ecosystems does not really make sense. This becomes evidence within the archive and the practice of the Sámi medical expert Knut Lunde (1867-1937). He himself documented his own practice through medical journals, combining biomedicine, natural medicine and wild herbs. In addition, the letter send to him recognize him as a traditional Sámi healer. A decolonial reading of the archive give glimpses' of a medical practice on the brink of existence by colonial oppression, and legal violation of traditional medical practices. It can be argued that the archive can be read within the context of coloniality that silenced indigenous land-based practices through "forgetting" what was once there. In this presentation I will explore if it is possible to imagine an epistemic decolonial archive practice, that bring the Sámi interconnectedness of land, health and wellbeing together.

Arctic life conditions, environment, nutrition and climate change. The One Health Perspective

Jon Øyvind Odland, NTNU, Trondheim, Norway

The interconnections between environment, human health and animal health have been widely acknowledged. The Arctic environment has a large impact on its residents, for livelihoods, food, transport and cultural identity. However, the importance of different factors and their interactions vary between locations of the Arctic, comprising a variety of community structures, traditions and natural surroundings.

Knowledge is increasing about the significance of local pollutant sources in the Arctic, including sources for plastics and chemicals. These can be related to increased anthropogenic activities, but also to the release of previously accumulated contaminants as a consequence of climate change, e.g. melting ice and thawing permafrost.

The new project Arcsolution aims to develop a One Health approach that improves the understanding of the complexity of Arctic pollution and specifically allows to involve local and indigenous communities in addressing pollution issues in the Arctic. Main pollution sources in a climate change context (local sources, remote sources, remobilization of pollutants within the Arctic, e.g. from permafrost thaw and melting ice) will be assessed, to increase the understanding of impacts of Arctic pollutants on ecosystems and humans, considering ecological, socio-economic and health-associated effects. Solutions to prevent, mitigate and eliminate Arctic pollution will be explored. Resilience and adaptation capacities of ecosystem and human communities will be encouraged, leading to better management tools and strategies for the protection of Arctic environment.

The climate change gives the arctic communities a number of challenges, especially for food security, working conditions, as well as life conditions in general. The presentation will focus on the food security as a part of a One Health approach to the numerous challenges for resilience and adaptation concerning the next generation of the Arctic. Is it possible to develop a "green generation" that will get acceptable life conditions in the Arctic?

Theme 2: Forecasting the changing ice, ocean and weather conditions

Arctic weather forecasting: Experiences and implications for atmospheric observing systems

Michael Tjernström, Stockholm University, Stockholm, Sweden

Weather forecasting is an initial value problem; observations and data assimilation are needed initialize a forecast and having accurate observations therefore lies at the heart of forecasting. This is a major challenge over the Arctic Ocean since there are almost no in-situ observations; only satellites but, on the other hand, there are plenty of those. But high-quality forecasts also require a good forecast model. Arctic modeling problems are often related to the so-called "model physics"; the parametric descriptions of small-scale processes that are not explicitly resolved by models. This includes for example turbulence, clouds and radiation, to name some, all with the potential to modify the vertical structure of the atmosphere. Here problems in the Arctic are also tied to the lack of observations; the detailed process-level observations that forms the platform to develop and test adequate parametrizations. In most current models, these a tuned to mid-latitude or tropical conditions simply because that is where most such observations exist.

This presentation will take its queue from a couple of modeling experiments or evaluations where observations from icebreaker expeditions are used to illustrate the two problems: adequate initial conditions and data assimilation based on existing observations, and systematic model errors caused by problems with the model physics. These cases come from icebreaker expeditions on the Swedish research icebreaker Oden and are therefore limited to summer conditions; there are very few examples from winter because there are even fewer in-situ detailed observations in the dark season, when conditions are harsh and the ice prohibits navigation with most vessels. From these results, a case for how an observational strategy for meteorological observations could be built in the central Arctic, to improve modeling and benefit forecasting on all time scales.

People, society and business in the Arctic today and in future

Jan Fuglestvedt, CICERO, Oslo, Norway, and Vice Chair, Working Group 1, IPCC

In its sixth assessment cycle (AR6) the Intergovernmental Panel on Climate Change (IPCC) has produced three special reports (SRs) and three Working Groups (WG) reports. The three SRs are "Global Warming of 1.5°C", "Climate Change and Land" and "The Ocean and Cryosphere in a Changing Climate". These were followed by the Working Group I report "Climate Change 2021: The Physical Science Basis, the Working Group II report Climate Change 2022: Impacts, Adaptation and Vulnerability and the Working group III report: Climate Change 2022: Mitigation of Climate Change. The final product - Synthesis Report: Climate Change 2023 - is scheduled to be finalized by the 20th of March. The presentation will give an overview of the main findings from IPCCs AR6 reports, starting with a global view followed by a focus on the Arctic region.

New technologies for observing earth - Infrasound arrays as probes for atmospheric and ice dynamics in polar regions

Quentin Brissaud, Johannes Schweitzer & Peter Näsholm NORSAR, Oslo, Norway, Ekaterina Vorobeva, NTNU, Trondheim & NORSAR, Oslo, NorwayMari Dahl Eggen, UiO, Oslo, Norway

Better constraining small- and large-scale atmospheric structures in polar regions as well as the dynamics of the cryosphere is key to provide better weather and climate predictions. However, this problem is challenging due to the absence of in-situ observations. Emerging technologies based on infrasound, a low-frequency sound (< 20 Hz), inaudible to humans, might provide critical insights on both middle atmospheric and ice dynamics. Infrasound can be generated by a variety of man-made and natural sources including glacier calving and ocean waves. Infrasound waveforms contain critical information about both the source characteristics and the atmospheric structures it propagated through. These signals can travel very large distances in the Earth's atmosphere and be recorded at the ground by microbarometers such as NORSAR's IS37 array station in Northern Norway. Listening to the sound traveling at high latitudes can provide a unique understanding of the changing North. In this talk, I will illustrate how polar research can benefit from infrasound monitoring through recent efforts by NORSAR and partners.

Theme 3: Impacts of climate change - effects and actions

Finding the Threshold for Greenland Ice Sheet Collapse

Kikki F. Kleiven, Nil Irvalı, Ulysses S. Ninnemann, Eirik V. Galaasen & Andreas Born, Univeristy of Bergen, Bergen, Norway, Yair Rosenthal, Rutgers University, New Brunswick, NJ, USA

The Greenland Ice Sheet has been losing mass at an accelerating rate over the recent decades, and if melted completely, it will contribute up to 7.2 m of global sea level rise. Model simulations suggests a warming threshold for an ice-free Greenland to be in the range of 0.8–3.2°C (with a best estimate of 1.6°C), above pre-industrial era. Recently, fears have grown that continued climate change will make the Greenland Ice Sheet (GIS) cross a threshold where long-term melting of the ice sheet is inevitable. Greenland's climate past and present could presage our climate future, hence understanding the past response of the GIS during intervals when conditions were warmer than present will help us to determine how future warming will impact this ice sheet. However not much is known about the duration and magnitude of warming near Greenland in the past and climate records reconstructing past interglacials are sparse and often at low resolution.

However, new paloceanographic reconstructions that takes a closer look at the ice age history of Greenland, finds that during past interglacials, both the magnitude and the duration of warming above a certain threshold is critical for GIS survival. This study uses a coring site on the Eirik sediment drift off southern Greenland to unravel the past. This location is sensitively situated to monitor subpolar climate near and partially over Greenland, fluctuations in GIS extent, and iceberg calving events. It also has the temporal fidelity to detect decadal-millennial climate-ocean variability. The team used calcareous marine microfossil shells to generate multiple temperature proxies reconstructing sea surface temperatures (SSTs) during four interglacial periods, spanning the past 450,000 years. The study found that SSTs were as warm or warmer than at present during all 4 previous interglacials, with mean summer SSTs ranging from 7–11 °C, compared with the modern value of 7.7 °C. The new findings suggest that a near complete melting of the southern GIS ~400,000 years ago occurred under temperatures only slightly warmer than present (~0.5 (±1.6)°C) – within the range of projections for this century. Our results suggest that the duration of warming above a threshold was as important as the magnitude, and, if even modestly warmer conditions were sustained long enough, GIS decline may already be unavoidable. Our geological evidence and new climate model simulations agree with the temperature ranges estimated from previous modeling studies but using an empirical approach (proxy reconstructions) we suggest for the first time that the duration above the lower limit of these ranges (0.8°C) might have been the one that was critical for explaining the near complete deglaciation of the southern GIS in the past.

Using permafrost and meteorological observations to develop a climate change response system in Longyearbyen, Svalbard (PermaMeteoCommunity)

Marius O. Jonassen, Hanne H. Christiansen, Aleksey Shestov, Knut I. L. Tveit & Graham L. Gilbert, The University Centre in Svalbard, Longyearbyen, Norway, Arne Instanes, Instanes AS, Bergen, Norway

The Arctic is warming by a factor close to four times the global mean, and Svalbard is located at a hotspot for this warming. In concert with the higher temperatures, reports show that both experienced and projected future climate change includes increased precipitation and more frequent and intense events with heavy rainfall. In turn, these changes have detrimental impacts on the climate sensitive widespread Arctic permafrost, including increased active-layer thickness and melting of ground ice, resulting in increased risk of landslides. In response to these climate change impacts, the Longyearbyen-based PermaMeteoCommunity project aims to build resilience in Arctic communities by developing a permafrost and meteorological response system that consists of (1) instrumented boreholes for direct observations of ground temperature and pore water pressure in the active layer and top metres of permafrost, (2) a network of meteorological stations, which records key standard parameters such as air temperature and precipitation with high spatial and temporal resolution. Using IoT technology, the observations are to be connected with an open online platform that receives and displays all this data in near real-time. The data can thereby be used for local authorities and decision makers, during operational evaluations and extreme weather events such as large amounts of rain, potentially inducing permafrost-related landslides. The platform will also give access to historical data and the system will be highly relevant for use in research, for education, and in outreach as well as for long-term societal infrastructure monitoring and overall land area planning. Furthermore, work is being done to include more elements in the response system, among others (1) remote sensing data for monitoring of ground movement (2) high-resolution numerical weather simulations to be employed in preparedness situations on an on-demand basis and (3) a machine learning component for enhanced predictions of landslides.

World-wide glacier meltdown - Why should we care?

Regine Hock, University of Oslo, Oslo, Norway

Concurrent with atmospheric warming glaciers around the world are rapidly retreating. Glacier decline has direct consequences for global sea level, river runoff, hazards, and landscape evolution, which in turn can impact human livelihoods, cultural values and ecosystems. For a global mean temperature rise of +2.7°C above pre-industrial, a rise consistent with recent climate pledges from the Conference of Parties (COP), widespread deglaciation is projected in many regions by 2100, especially in Central Europe, Western Canada and USA, and New Zealand. In contrast, in the polar regions projected relative mass losses relative to 2015 are only in the order of a few tenths of percent relative to year 2015. However, due to much larger current ice volume these regions are dominant contributors to sea level rise thus emphasizing the importance of polar glaciers in global environmental change. Global glacier changes are linearly correlated with global mean temperature increase indicating that limiting global warming has a direct effect on future glacier mass changes.

Theme 4: Access to infrastructure and data for Arctic research

The importance of access to capable research icebreakers and international collaboration for central Arctic Ocean research

Martin Jakobsson, Stockholm University, Stockholm, Sweden

The Arctic Ocean environmental conditions are undergoing rapid changes due to climate change, but accessing its most remote and sea-ice infested areas remains a major logistical challenge for scientific research. Although the sea-ice extent has declined by nearly 13 % during the summer minimum in September compared to the average between 1981 and 2010, large areas are still inaccessible without the use of the most powerful icebreakers of which there are a handful. This is, for example, directly reflected in the sparse distribution of bathymetric data in the central Arctic Ocean, particularly north of Greenland and off the Canadian Arctic Archipelago. These areas are some of the least explored of the World's oceans. In addition, the current political situation poses an efficient blockage to answer any scientific questions requiring information from the vast Siberian shelf seas and adjacent continental slope. This unfortunate situation led, for example, to postponement of the IODP (International Discovery Program) ArcOP Expedition #377, scheduled to drill on the Lomonosov Ridge just outside of the Russian continental shelf in 2023, and cancelling of the Eurasian Arctic C4 2023 expedition with Swedish icebreaker Oden. In this talk, I will showcase some examples of successful international collaborations that have utilized heavy research icebreakers to advance our knowledge of the central Arctic Ocean. I will also discuss the current state of access to research icebreakers and highlight the importance of overcoming political barriers to facilitate scientific research in this critical region.

UN Decade of Ocean Science for Sustainable Development, 2021-2030, as an opportunity to support Arctic Ocean Research

Dr Vladimir Ryabinin, IOC-UNESCO, Paris, France

Achievement of the 2030 Agenda depends on the state of the ocean and is thus ocean-science intensive. In 2016, less than a year after the endorsement of the 2030 Agenda, the 1st World Ocean Assessment concluded that the humankind was missing the time to start managing the ocean sustainably. Since then, steps have been taken to turn the tide. The UN Decade of Ocean Science for Sustainable Development, 2021-2030 (Ocean Decade), coordinated by IOC, was proclaimed in 2017 and has grown into the largest undertaking in ocean research in history. The concept of Sustainable Ocean Planning was coined in the analytical work by the expert community of the High-Level Panel for a Sustainable Ocean Economy. At present 17 (originally 14) countries-members of the Panel, including polar countries of Canada, Norway, and USA, committed to start sustainably managing their Exclusive Economic Zones by 2025. They call on other countries to do the same by 2030. Under the new Kunming-Montreal Global Biodiversity Framework, one target is to have 30% of the ocean area protected by 2030.

The situation in the Arctic Ocean is shaping under the influence of the polar amplification of climate change. “Opening” of the ocean brings with it not only opportunities for economic development but also is profoundly altering environmental conditions, hence calling for ocean science solutions. Long-term experience of the presenter in the international facilitation and coordination of research on the Arctic Ocean and climate shows permanent difficulties in keeping observations and scientific activities sustainable. The role of mechanisms of international cooperation in Arctic Ocean is therefore indispensable. New opportunities for the region may now be associated with the Ocean Decade Arctic Action plan for the Ocean Decade that can add energy, motivation, and strategic direction for ocean observations and research of direct relevance to Arctic sustainability.

Norwegian Space Infrastructure Monitoring in the Arctic

Pål Brekke, Norwegian Space Agency, Oslo, Norway

Norway has become an important space nation in the High North. There has been a strong focus on the use of space as a tool for the government to monitoring the health and human activities in the arctic oceans. Such monitoring can only be done effectively by using satellites. Today a large number of satellites are observing the Arctic using different instruments. The world largest satellite station is located at Svalbard and is the main stations for both US, Canadian, European, and Norwegian satellites.

This gives Norway easy access to large amount of data and we have become a major user of satellite observations. Furthermore, Norway's national micro-satellites have been pioneering in monitoring ship traffic from space. Today we are leading the way in monitoring illegal fishing and oil spills in the High North. We are also pushing for better radio communication and broad band in the Arctic - which is lacking today. Later this year Norway will launch the Arctic Satellite Broadband Mission (ASBM) which provide the first broad band communication capabilities in the Arctic. This will improve the communication for search and rescue as well as and crisis management. In addition, it will provide the Coast Guard and the Armed Forces stable and secure communications for operation in the Norwegian waters. Furthermore, the European satellite navigation system Galileo has greatly improved search and rescue in the Arctic.

Theme 5: Geopolitics (Governance), security and defence

The Arctic as a Geopolitical Playground: Impacts of Strategic Competition on Regional Stability

Katarzyna Zysk, Norwegian Institute for Defence Studies, Oslo, Norway

Arctic stakeholders share a common interest in maintaining the region peaceful, stable, and cooperative, as declared in a range of capstone policy documents. Indeed, numerous security challenges in the region have a transnational character and require therefore international cooperation. Together with the dense web of governance regimens at local, regional and global levels, it contributes to enhance regional stability. Simultaneously, however, the Arctic has become an arena of an intensifying strategic competition between major powers, advancing their national interests, also with coercive means. Notably, Russia's recurring use of force in foreign policy has generated doubts about Moscow's intent regarding the regional status quo, a concern further fuelled by the Russian military build-up in the Arctic over the past 15 years. Despite hopes encapsulated in the idea of "Arctic exceptionalism", the reality has recurrently proven that the region cannot be shielded from the impact of major external dynamics, such as the Russian war in Ukraine. Ripple effects from Moscow's aggressive policies have profoundly reshaped the Arctic security, cooperation, and governance regimes. They have furthered the role of the region as an arena of confrontation between Russia and the West, exacerbated by the spillover from the strategic competition between the United States, China, and Russia. The regional impact of the Russian invasion will continue unfolding over a long period of time. Despite weakening of the Russian conventional forces in Ukraine, however, the Northern Fleet's ability to exercise its core missions in the Arctic, and beyond, has remained intact. Moreover, the importance of the Russian strategic deterrence forces in the Arctic is set to increase. They will continue exerting an impact on regional security and stability, as well as providing tools to advance Russia's interests beyond the region.

Arctic Geopolitics: A three level analysis

Andreas Østhagen, Fritdjof Nansen Institute, Oslo, Norway

The Russian invasion of Ukraine in February 2022 marks a watershed in relations between the West and Russia, including in the Arctic. However, the hope remains that Arctic security relations are sheltered from the War in Ukraine, despite tension creeping northwards through both bellicose statements from Russia, the Finnish and Swedish accession to NATO, and fears of hybrid operations in the North. This presentation takes a look at the different political dynamics when it comes to state, or military, security in the Arctic, and how they have evolved since the beginning of 2022. It leans on a conceptual separation between so-called levels of analysis in international affairs, as well as Norway as a case study when examining the 'national' level, to further develop the way we conceive of Arctic security and geopolitics moving forward. Finally, it showcases how these concerns are not contained to the Arctic, but takes place in a wider Euro-Atlantic maritime domain.

Sweden in the High North, as invitee to NATO – A perspective

Madeleine Lyrvall, Ministry of Foreign Affairs, Stockholm, Sweden

The talk focused on Sweden's role in the High North, particularly as an invitee to NATO. The presentation provided valuable insights into Sweden's perspective on security and preparedness in the rapidly changing Arctic regions, and the implications of its relationship with NATO for the region's stability and cooperation.