

International Conference on
Climate Change Research in the Arctic
– Future Challenges

Svalbard, 25 – 27 July 2003
Conference statement by the Science Committee





In addition to a broad European representation from the leading research groups and institutions in the field of Climate Change, accompanied by research representatives from Asia and North-America, there were high-level political representation from Norway, EU and USA.

From the left: The Norwegian Minister for Research and Education, Kristin Clemet, Executive Director Kathie Olsen from the Office of Science and Technology Policy, White House, USA and the EU Commissioner, Philippe Busquin, European Commission.

(Photo: Mona Gravningen Rygh)

Cover photo:

The glacier front (Nordenskiöldbreen in Billefjorden),

The picture was taken during one of the conference field trips.

International Conference on

Climate Change Research in the Arctic – Challenges for Science and Research Policy

Svalbard, 25 – 27 July 2003

**Conference statement and recommendations
by the Science Committee**

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It was an honour to host the International Conference on Climate Change in the Arctic organised on Svalbard this summer. The conference attracted eminent scientists from a variety of scientific fields as well as high level policy makers and resulted in valuable input to our common knowledge base as well as our common understanding of research challenges and the need for policy measures.

I would like to take this opportunity to thank all participants from the different countries, the Research Directorate General of the European Commission, the Research Council of Norway, and the Scientific Committee for their valuable contributions to the conference. The presence of Commissioner Philippe Busquin of the European Commission and Dr. Kathie Olsen, Associate Director at the Office of Science and Technology Policy of the US president, was greatly appreciated.

Svalbard is a unique location geographically and lends itself to scientific studies of great importance to our understanding of the complexity of global nature and of climate processes. Svalbard is under Norwegian sovereignty. Its unique possibilities for research, however, are an international common good. It is Norway's responsibility to provide infrastructure on Svalbard, but it is an international responsibility to seize the opportunities available there.

The scientific committee has drawn up a useful conference statement with recommendations and key questions that I feel will contribute significantly to the planning of future international research co-operation. I trust that many of us will contribute in these research efforts.

Oslo, October 16, 2003

A handwritten signature in black ink, appearing to read 'Kristin Clemet', written in a cursive style.

Kristin Clemet
Minister of Education and Research

Preface

The conference on climate change in the Arctic was organised as a meeting point between scientists and high level science policy makers to address the many pressing issues concerning ongoing and future climate changes in the Arctic. This combination of attendants was very fruitful and led to a broad overview of the knowledge status, the research challenges and a number of research policy measures. This was brought about by a common understanding that climate change in the Arctic is an issue of urgency that deserves broad attention. This document contains the scientific motivation for the conference, a summary of the main scientific issues which were addressed, conclusions which were obtained concerning the research status on climate change in the Arctic, as well as a series of challenges and recommendations for future research and research policy. This document was prepared by the science committee of the meeting, and the science committee is hence responsible for its contents. The document should, nevertheless, reflect the broad consensus that was gained on most issues. We feel, therefore, that the document is a fair representation of the outcome of the meeting and the consensus views of the participants.

Bergen, October 16, 2003

A handwritten signature in black ink, reading "Eystein Jansen". The signature is written in a cursive, flowing style with a large initial 'E'.

Eystein Jansen
Chair of the Science Committee

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Introduction

The Arctic has over the last 2–3 decades experienced more warming than other regions of the world, and the ice cover has decreased in the order of 10% in the same period. Climate models furthermore indicate that anthropogenic global warming will be enhanced in the northern high latitudes due to complex feedback mechanisms in the atmosphere-ocean-ice system. The predicted warming in the Arctic over the next 50 years is in the order of 3–4 °C or more than twice the global average, while the ice cover is predicted to be reduced ~40% during summer and ~10% during winter time over the same period. At the end of this century, the Arctic Ocean is predicted to be “a blue ocean” during summer time. This suggests that the Arctic may be where the most rapid and dramatic changes may take place during the 21st century.

Climate changes in the Arctic also impact climates on a hemispheric and global scale via potential impacts on the ocean circulation, the planetary albedo and associated feedbacks. The Arctic region must therefore receive close attention in terms of: 1) monitoring climate change, 2) conduction of research into the dynamics of climate processes, 3) assessments of the possible large implications of climate change on ecosystems and society. Research installations and infrastructure on *Svalbard* constitute a unique platform for Arctic climate research, which – together with other infrastructures available to the science community – should be used increasingly for this purpose.

This situation, with a number of urgent scientific questions, constitutes the timely backdrop for the conference which was hosted by the *Norwegian Ministry of Education and Research* in close cooperation with *the Research Council of Norway*. It was organised in dialogue with the Research Directorate General of the *European Commission*.

The objectives of the conference were to:

Summarise the status of research on climate change in the Arctic

Identify the main research challenges for the future

Provide input to future research policy and research initiatives

Present Svalbard as an Arctic research platform

Several ongoing and planned research initiatives as well as policy documents underpin the conference.

Science syntheses

- The ongoing Arctic Climate Impact Assessment (ACIA) process initiated by the Arctic Council
- The third assessment of the IPCC (Intergovernmental Panel on Climate Change), as well as the initiation of the fourth assessment
- AMAP – the Arctic Monitoring and Assessment program

Research activities

- National and bilateral projects and programmes, e.g. the UK/Norway Rapid/NOClim joint efforts, the German MARCO-POLI-Programme, the ASOF programme and the US SEARCH programme
- Integration and intensification of Polar Research in Europe under the auspices of the European Polar Board and other international research organisations
- A number of activities funded through the 5th Framework Programme of the European Union, and planned activities for the 6th Framework Programme

Policy documents

The recently published Second Northern Dimension Action Plan (2004–06) of the European Commission (COM 343), which specifically calls for scientific research in the Northern Dimension area, with a focus on climate change and the economic, social and environmental impacts caused by climate variability and change.

The key science questions and challenges

The Arctic dimension

The Arctic is an important part of the global climate system through oceanic, terrestrial and atmospheric processes that impact hemispheric and global climates, through processes and feedbacks which can trigger rapid climate change and "climate surprises" and changes to its storage capacity of greenhouse gases. The region ventilates the world's deep ocean and the sea ice and snow covers are important for the planetary albedo. Both ocean and land areas contain large reservoirs of greenhouse gases. Climatically induced changes to the stability of these constituents and exchange with the atmosphere contain possibilities for significant feedbacks to climate change.

An important aspect of this situation is that the Arctic region currently is the region in the world which is experiencing the fastest warming. Numerical models predict that this is going to continue at high speed. These changes will significantly impact ecosystems and societies, and may create conditions that have not prevailed for millions of years.

Climate processes of the Arctic

a) The meridional overturning circulation in the Atlantic ocean whereby dense waters formed in the circum-Arctic descend to great depths, provide a mechanism that is partly responsible for the excess heat from the ocean which gives mild climates over NW Europe and the Eurasian sub-Arctic. The circulation is dependant on a fine balance of salt and temperature in the surface waters of the sub-Arctic which may be jeopardised by increased freshwater supply. The effect may be a drastic reduction of northward heat transport, and a "climatic surprise" which, with the knowledge available from similar climate shifts in the past, is likely to be rapid and dramatic. Potential triggering mechanisms lie in melting of sea ice, sea ice exports out of the Arctic, diminishing Greenland ice cap, and increased rain and snowfall over the regions which drain towards the Arctic. It is essential for predictions of climate change over large areas in the high latitudes that the likelihood for such events can be established with confidence.

Key questions:

- Is the Arctic capable of causing rapid climate change?
- What will be the effects of ongoing and future changes to the ocean circulation?

These questions can only be properly addressed by combined studies of past changes, extensive studies of the central processes, and an improved ability to represent this aspect of the climate system in models.

- b) The ongoing changes in Arctic Climate are characterised by a trend in the NAO/AO¹⁾ patterns towards a positive phase characterized by increased westerlies, increased precipitation and stronger advection of warm ocean water to the region. The last decades have seen a large shift in a number of key factors of Arctic climate, with higher temperature, shifts in the axis of the transpolar drift, and increased permafrost temperatures.

Key questions:

- What drives the NAO/AO¹⁾ variability?
- What are the underlying critical interactions between ocean, ice and atmosphere?
- What are the long-term effects of a shift towards the positive mode of the NAO/AO¹⁾?
- Are the ongoing changes signalling a more permanent shift?

- c) The Arctic is characterised by high reflectivity due to ice and snow cover and cloudiness, which strongly influence the global energy balance. Many of the processes are specific for the Arctic. Yet there are major unknowns in our understanding of the key radiative processes involved, and how they may change in the future.

1) The North Atlantic Oscillation (NAO) and Arctic Oscillation (AO) are recurring patterns of climate variability in the Northern Hemisphere. The NAO/AO represents changes in the strength of the westerly winds, and much of the observed variations in climate over Northern Eurasia and in the Arctic are driven by the NAO/AO patterns. In the Eurasian sector of the Arctic there is a strong link between the warmer winters and advection of warm air and water masses into the Arctic.

Predictions and scenarios for the future

Observational evidence shows a 6–10% reduction in Arctic sea ice cover over the past few decades. Similarly, even larger reductions of sea ice thickness have been reported, although with somewhat less confidence. Significant warming is already observed over the Arctic land areas at a rate surpassing any other region in the world. An extrapolation of these trends indicates that the central Arctic will be ice free in summer in the second half of this century. This conclusion is supported by a number of climate model experiments also pointing in the same direction. Thus, the likelihood that we will experience a blue, rather than a white Arctic Ocean, is increasing.

This development raises a series of science issues:

- Are the climatic components of the ongoing changes consistent with anthropogenic forcing only?
- What is the magnitude of the natural climate variability of the Arctic?
- How sure are these predictions, and how unusual are the ongoing changes?
- Were such changes with an Arctic amplification occurring earlier due to natural variations or natural variability, or are they solely forced by anthropogenic causes?
- How will a blue Arctic influence the planetary albedo, weather and storm patterns, modes of variability and distribution of precipitation?
- What are the feedbacks that may influence the course of climate change?
- Will a blue Arctic be opening up a new oceanic sink for atmospheric CO₂, and will the warming trend increase or decrease the sources and sinks for greenhouse gases of the region?
- Will thawing permafrost destabilise methane reservoirs at a rate which is climatically significant?

The consensus view from climate modelling experiments with the IPCC scenarios is that accelerating climate change is projected, both in the moderate and more extreme scenarios with a systematic amplification of changes over the Arctic. The projected changes include, in addition to the reduced sea ice cover, increased precipitation, more extreme events, milder and shorter winters, thawing of permafrost, and changes to the hydrology. It is likely that changes in the extremes will be more important for the impacts than changes in the mean state. Although the trends are consistent between models, regional assessments vary dramatically between models.

Thus we have no real consensus on the magnitude of foreseeable changes on the regional level. There is, however, a large natural variability on annual to multi-decadal time scales which makes it less straightforward to attribute all the observed changes to climate change. Understanding this variability is important for improving the various scenarios for the future development of Arctic climates, and to reduce the high scatter between the different climate models.

Impacts on ecosystems

Since climate change is most pronounced in the Arctic, these changes are likely to induce severe stress on the ecosystems and societies of the region. Changes will influence the cryosphere, including the permafrost, ecosystem functioning and distribution, habitats for wildlife, migration of species, and possibly UV radiation levels.

Current evidence implies that the Arctic is undergoing a series of concurrent changes, which are unprecedented in the light of available observations: fragmentation of habitats, migration of the forest/tundra boundary, changes in animal and plant populations, soil degradation, migrations of species to new areas, and import of new species to the region, reductions in habitats for key species. The populations of widespread species are likely to become reduced. Large long-lived Arctic species tend to be very conservative in their life-history strategies, so even dramatic changes in juvenile survivorship may not easily be detected for considerable periods. At the other side of the size range of organisms, natural variations in population size are generally large and can mask real trends in abundance. Long series are therefore important for monitoring climate induced changes in Arctic animals.

Impacts: Key questions:

- How will terrestrial and marine ecosystems be influenced by a warmer Arctic?
- Will changes be uniform across the Arctic or will there be major regional differences?
- How will changes to the ecosystems and land and sea ice cover feed back on the climate system?
- How stable are the greenhouse gas reservoirs (methane and carbon) when confronted with strong warming?

- Will the soil degradation change the Arctic surface lands from a sink to a source for greenhouse gases?
- How adaptable are the organisms to climate change?
- What will be the effects of competition when/if new species are introduced to the Arctic ecosystem?
- What will be the consequences of altered match/mismatch between predators and prey?

Logistics and technology requirements

The ongoing and projected changes are occurring at a time when the observational network in the region is being reduced or is threatened. In order to solve many of the still remaining scientific questions, key processes must be studied and validated from in situ experiments and observations. It is therefore highly important to establish a pan-Arctic long-term observation, analysis/reanalysis and modelling program, and to immediately stop the deterioration of the observation networks or replace them with new types of observation systems. We need to be able to leave long-term observation series to those who come after us.

A strong increase of activities is foreseen to happen during the International Polar Year (IPY) in 2007, but this must not be at the cost of a general upgrading of the observational systems. There is already a large over-demand on key research platforms such as ice breakers, and there is a general lack of infrastructure to study the many key aspects that occur during wintertime.

An improved infrastructure must involve various types of systems that can be utilised on a shared basis by the nations involved, such as:

- The Svalbard Platform
- Networks of land-based stations
- Ice-breakers/research vessels
- Drifting ice stations
- Development of new in situ sensors and systems for automatic data collection
- Remote sensing systems
- Community climate and earth system models

Adaptation

The projected changes in the Arctic will impose stress on environments as well as societies, in particular the traditional lifestyles of the indigenous peoples of the region. A number of changes will be irreversible.

The changes will require policies for adaptation in terms of management as well as protection of ecosystems, coastal zone management, adapting to a possible breakdown of the permafrost in many regions, and to new health threats for the Arctic human population.

Science policy recommendations – Implications for research policy

Due to the strong likelihood for major climate change and climate impacts in the Arctic, there is a pressing need for improved scientific knowledge which can underpin adaptation and mitigation efforts.

- We need to understand the complex interplay between the natural variability modes characterizing the Arctic climate and the changes originating from human influence on the climate system. We need to be able to describe the nature of the Arctic climate and environments in the future warmer Arctic.
- We need to improve our understanding of the nature and probability of extreme events – ‘triggers’ that can accelerate climate change and the key atmospheric and oceanic processes that can unleash extreme events.
- We need to vastly improve the resolution of climate models in time and space, their ability to reconstruct the mean state, variability and extreme events, particularly their ability to predict precipitation, winds, and the distribution and characteristics of snow and ice.
- We need to obtain a much more profound knowledge of Arctic hydrology, oceanic circulation and processes, the carbon cycle, and greenhouse gas emissions under the future warmer conditions.
- We need to improve the ability of climate and ecosystem models to describe and incorporate processes related to clouds, sea ice, and ocean circulation and significantly improve the quality of marine and biophysical models (meridional overturning circulation, salinity and temperatures,

sea ice primary and secondary production and fish populations), and of terrestrial ecosystem models.

- We need to maintain and expand observation capabilities and monitoring activities to document, detect and understand climate change and their associated impacts.

Requirements

Arctic climate research is expensive and logistically challenging and complex. In order to progress with these issues, a combined effort on a large international scale must be undertaken, as regards in situ field work from ocean, land and sea ice based research platforms:

- describe, understand and quantify the key processes,
- monitoring efforts and observation technology development to provide the necessary time series needed to identify and quantify the changes and their underlying causes, and
- a new generation of numerical model tools incorporating both the physical, chemical and biological elements of the system, as well as the interactions and feedbacks between them.

Specific recommendations

1. There must be a long-term support of international research programmes, and due to urgency and magnitude of changes, a strong focus on the arctic climate.
2. Establish an ERA net and funding under Article 169 of the EU to facilitate collaboration and to prepare the activities of the International Polar Year (IPY). Collaboration between funding agencies is critical.
3. To avoid fragmentation of efforts the multinational collaboration could include joint calls for proposals (+joint evaluation schemes) for common research objectives, supporting multinational teams with support from national bodies.
4. Use the International Polar Year (IPY) in 2007 as a major vehicle for establishing new large scale activities, for promoting Arctic research to recruit new scientists to the field, and for obtaining public awareness of the problems.
5. There is a need to systematically involve industry in the efforts, in terms of providing technologies for research as well as for many of the possible impact and adaptation aspects.
6. Secure long-term support for the research infrastructure and the observational network that underpins the science.

7. Specific investment in key new infrastructure that can be utilised by international consortia of scientists, including infrastructure that allows wintertime observations.
8. Build mechanisms that can ensure joint international use of the Svalbard platform, e.g. by specific funds for drawing together international teams that collaborate and supplement each other.
9. Build mechanisms that allow international access to the research platforms available inside the sea ice, and to the processes determining their use.
10. Emphasise systematic development of Earth System Models capable of simulating the many complex and specific interactions in the Arctic climate system.

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