Norwegian Centre of Excellence

Bjerknes Centre for Climate Research

Annual Report 2005

Centre of Excellence activities

NERSC

Norwegian Centre of Excellence

The ambition of the Bjerknes Centre for Climate Research (BCCR) is to become a leading international centre for climate research in the high latitudes and a key provider of first-rate knowledge on climate change to stakeholders, i.e., policy makers, industry and the general public.

The BCCR is a joint venture between the University of Bergen (UiB), the Institute of Marine Research (IMR) and the Nansen Environmental and Remote Sensing Center (NERSC). The Collaboration was formally established in August 2000 with the aim of creating a Center of Excellence in climate research. The BCCR constitutes the largest climate research group in Norway and provides excellent opportunities to conduct top quality climate research in high-latitudes by virtue of its breadth, research infrastructure and unique extensive data series.

In 2002 the BCCR was awarded the status of national Center of Excellence by the Research Council of Norway.

Editors: Beatriz Balino, Martin Miles and Eystein Jansen
Layout and print: Symbolon forlag AS, www.symbolon.no

Words from the director

In the third year as a CoE, the BCCR followed the research strategy developed in the first year. The research was organised in topical research groups (Research Activities) with specific scientific objectives. Important progress has been achieved in several areas.

■ New evidence was produced on the mechanism behind the northward oceanic heat flux in the north Atlantic/Nordic Seas.

■ The Bergen Climate Model was further developed and run without flux correction. A highlight of these activities was the production of the IPCC AR4 scenario simulations as one of 4 European groups and the only one in the Nordic countries.

■ Palaeoclimate analyses produced key new results, synthesising wintertime precipitation records, records of flooding and on the role of intermediate water variations in the Southern Hemisphere linked with Antarctic climate variations.

■ BCCR has further expanded its activities in carbon-cycle studies with a new emphasis on global carbon-cycle modelling, and the Centre leads a 42-partner European team with the purpose of unravelling how the ocean controls the global CO2-budget. This takes place in the EU Integrated Project Carboocean co-ordinated from the Bjerknes Centre. Several new papers on the marine carbon uptake were produced, providing new insight into how the current atmospheric CO2-increase influences the capacity of ocean uptake.

■ Starting in 2005, the BCCR has been very active in the 4th assessment report of the IPCC, both as Co-ordinating lead author, lead authors and contributing authors, as well as providing scientific input to the report to be due in 2007.

A major result of the activities is the publication of a special AGU monograph on the Nordic Seas. This book, in which almost all chapters are by BCCR staff, sums up the present state of knowledge on the Nordic Seas, and its role in the climate system.

I wish to thank all BCCR staff for their dedication and hard work, our sponsors in the Research Council and elsewhere, and our host and partner institutions for their trust and support.

Prof. Eystein Jansen

Table of contents

Research strategy & organisation

The overall objective of BCCR is to understand and quantify regional climate changes in the context of the global climate system.

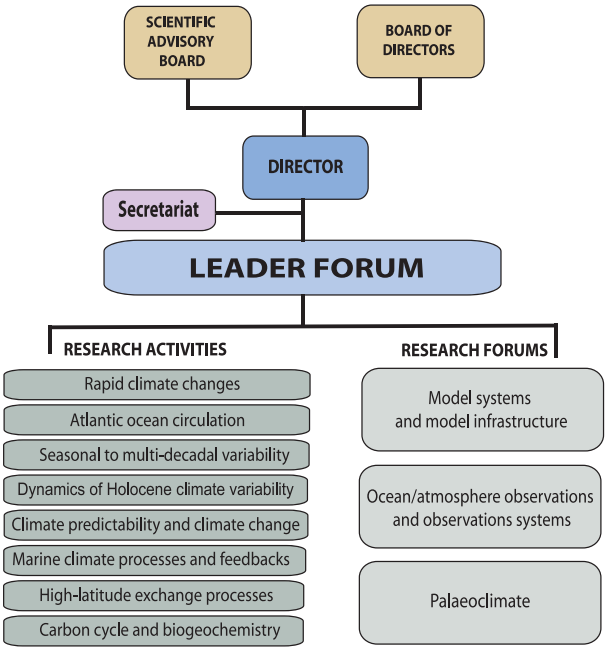
To reach this objective, research at the BCCR is organised into multi-disciplinary Research Activities to provide insight and answers to the following main research themes:

1. **Abrupt climate change:** To understand the causes and likelihood of high-amplitude rapid climate change and assess the possibilities for major climate surprises affecting our region.

2. **Climate variability:** To understand causes of climate variability, both natural and man made, to asses climate trends and the predictability of climate changes in order to deliver high quality scenarios of future climate change

3. **Processes & feedbacks:** To study and understand key processes and feedbacks governing the response and sensitivity to climate forcing

In addition, and following *the* recommendations of the Scientific Advisory Board and in accordance to BCCR´s research strategy, a number of Working Groups (WG) were formed in 2005 in order to deal with prioritized and focused scientific themes with a view to producing high-impact scientific articles. A WG is typically a small group (10 –12 people) with a maximum lifetime of 2 years and which will disband after the publication of the science paper(s).



Board of directors

Tore Nepstad, director, Institute of Marine Research (Chair)
Ola M. Johannessen, director, Nansen Environmental and Remote Sensing Center
Kåre Rommetveit, director general, UiB
Hans Petter Sejrup, dean, Faculty of Mathematics and Natural Sciences, UiB

The director and the leader forum

Prof. **Eystein Jansen**, Professor (Director) Palaeoclimatology, BCCR
Ass. Prof. **Tore Furevik**, Associate Professor (Deputy Director) Climate modelling, UiB
Dr. **Trond Dokken**, Palaeoclimatology, BCCR
Prof. **Helge Drange**, Climate modelling, NERSC
Dr. **Ken Drinkwater**, Fisheries ecology, IMR
Dr. **Tor Eldevik**, Ocean processes & modelling, NERSC
Prof. **Peter Haugan**, Polar oceanography, UiB
Prof. **Christoph Heinze**, Carbon cycle modelling, UiB
Prof. **Truls Johannessen**, Chemical oceanography, UiB
Dr. **Ina Kindem**, Stratospheric physics, BCCR
Prof. **Atle Nesje**, Palaeoclimatology, UiB
Dr. **Kerim H. Nisancioglu**, Palaeoclimatology, BCCR
Dr. **Are Olsen**, Biogeochemistry, UiB
Dr. **Odd Helge Otterå**, Climate modelling, NERSC
Dr. **Asgeir Sorteberg**, Climate modelling, BCCR
Prof. **Svein Sundby**, Ocean climates, IMR

Scientific advisory board

Peter Lemke, Alfred Wegener Institute for Polar and Marine Research, Germany (Chair)
Lennart Bengtsson, Max Plank Institute for Meteorology, Germany
Raymond Bradley, Climate System Research Center, University of Massachusetts, USA
Øystein Hov, Norwegian Meteorological Institute, Norway
Jerry McManus, Woods Hole Oceanographic Institution, USA
Peter Rhines, Dept of Oceanography, University of Washington, Seattle, USA
Rowan Sutton, Centre for Global Atmospheric Modelling, University of Reading, UK
John Walsh, International Arctic Research Center, University of Alaska, Fairbanks, USA
Andrew Watson, School of Environmental Sciences, University of East Anglia, UK

Fieldwork on Norwegian glaciers.

Research activities

	Leader (deputy leader)
Rapid climate changes: causal connections	T. Dokken (K. Nisancioglu)
Seasonal to multi-decadal variability	T. Furevik (I. Kindem)
Dynamics of Holocene climate variability	A. Nesje (O. H. Otterå)
Climate predictability and future climate change	A. Sorteberg (S. Sundby)
Marine climate processes and feedbacks	T. Eldevik (P. Haugan)
Carbon cycle and biogeochemistry	C. Heinze (A. Olsen)

Research forums

	Co-leaders
Model systems and model infrastructure	Mats Bentsen, NERSC Paul Budgell, IMR
Ocean/atmosphere observations and observation systems	Henrik Søiland, IMR Richard Bellerby, BCCR
Palaeoclimate	Ulysses Ninnemann, UiB Øyvind Lie, BCCR

The BCCR approach

The approach of the BCCR is to combine cutting-edge research with first-rate education and outreach activities.

The BCCR is working to:

- Facilitate top research in key areas in order to establish the BCCR among the leading international climate research centres
- Become a visible contributor to national and international research programs and assessments, such as the World Climate Research Programme (WRCP), the International Geosphere–Biosphere Programme (IGBP) and the Intergovernmental Panel on Climate Change (IPCC).
- Become the primary national centre of competence on climate change for education, policy makers, the media and the general public.

Assessment

The BCCR is subject to annual critical assessments of its scientific advancement and the timely fulfilment of its objectives by the Scientific Advisory Board, an external panel of acknowledged climate scientists. As in previous years, the key evaluating criteria are:

- High quality papers in peer-review, leading international journals addressing the objectives of the research Activities
- Multi-authorship across disciplinary boundaries within the BCCR
- Memberships in scientific steering committees of national and international programs and activities
- Media exposure and public outreach
- Interaction with stakeholders (governmental bodies, decision and policy makers, enterprises, NGOs, etc.)

Gender issues

In 2005, following last year's doctoral dissertation defences by several female PhD students who are now in postdoc positions at BCCR, the fraction of female postdocs reached 36%. The current development fits the BCCR´s promotion and incentive plans to increase the number of female scientists at the leader and senior levels.

Summary of accomplishments

During its third year as a CoE, the BCCR´s new functional research groups, the Research Activities, started working based on the research strategy implemented the previous year.

In addition, a number of short-term Working Groups were formed in order to carry out prioritized and focused scientific themes with a view to producing high-impact scientific articles.

Eighteen new research projects were launched with BCCR participation as coordinator or partner, funded by a variety of agencies, such as the EU's 6th framework, Research Council of Norway, joint UK/Norway/Dutch RAPID programme, Worldwide University Network (WUN), COMER foundation, Meltzer foundation and National Oceanic and Atmospheric Administration (NOAA).

In 2005, Bjerknes scientists continued to make key contributions to the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report (4AR). Profs Eystein Jansen and Christoph Heinze are coordinating lead author and lead author, respectively, and a number of Bjerknes scientists participate as contributing authors. In addition, the Bergen Climate Model group – one of four European climate modelling groups and the only one from the Nordic countries providing model scenarios using the IPCC 4AR protocols – produced a total of 1600 years of simulations of climate developments. The last working meeting of the IPCC WG 1 will be hosted by the BCCR in Bergen, from 25 June to 1 July 2006, to prepare the final draft of the 4AR.

The BCCR was very active in fostering new institutional cooperation as well as strengthening already existing liaisons during 2005. At the national level, the BCCR and the Norwegian Meteorological Institute (Met.no) in Oslo formalized a comprehensive cooperation in climate research entitled Norsk Klimasenter (Norwegian Climate Centre). The agreement was officially announced in connection with the visit of former Minister of Environment, Knut Hareide, to the University of Bergen on May 9, 2005. On the international plan, BCCR was invited to organise and contribute to two meetings under the auspices of the Norwegian Embassy in Washington DC, aimed at strengthening cooperation with the USA and Canada, on topics ranging from the fundamentals of climate research, policy development and climate related health issues. The meetings gathered politicians, the scientific community, as well as representatives from non-governmental agencies and the industry.

In 2005 the following BCCR affiliated scientists were distinguished with prizes and honours: Prof. Jan Mangerud was awarded the Brøgger Prize awarded by the Norwegian Geological Union; Prof. H. John B. Birks was honoured with a one-day special session at the University College London and Prof. Ola M. Johannessen won the Descartes Prize on Research awarded by the European Commission.

The membership of the Scientific Advisory Board of BCCR changed and expanded in order to ensure the appropriate evaluation of the range of the Centre´s disciplines and research activities. Three members rotated off while three additional members were appointed in order to bring to the Board expertise on polar dynamical meteorology and oceanography, marine and terrestrial palaeoclimatology, and climate dynamics.

Communication and outreach activities were strengthened. A communication officer was hired and the Bjerknes web site was revamped in order to turn it into the main communication channel of BCCR activities to policy makers, journalists, educators and the general public. In 2005, the Centre´s scientific production consisted of 62 scientific articles in the international peer review literature (with two papers in Science), one review book on the Nordic Seas and 6 chapters in books, and more than 300 presentations at national and international science meetings. Outreach activities included popular articles and lectures, and considerable coverage in the mass media (newspapers, TV and radio).

Selected contributions

BCCR scientists are indicated in bold

Scientific research papers

- Hátún, H., **A.-B. Sandø, H. Drange**, B. Hansen and H. Valdimarsson (2005). "Influence of the Atlantic subpolar gyre on the thermohaline circulation." *Science* 309: 1841–1844.
- **Johannessen, O. M.**, K. Khvorostovsky, **M.W. Miles** and L. P. Bobylev (2005). "Recent ice sheet growth in the interior of Greenland." *Science* 310: 1013–1016.
- Smol, J., Wolfe, A., **H.J.B. Birks** and 23 co-authors (2005). "Climate-driven regime shifts in the biological communities of arctic lakes". *Proc. National Academy of Sciences/pnas.0500245102:* 1–6.
- **Sorteberg, A., T. Furevik, H. Drange** and **N.-G. Kvamstø** (2005). "Effects of simulated natural variability on Arctic temperature projections." *Geophysical Research Letters* 32(18): L18708, 10.1029/2005GL023404.
- **Østerhus, S.**, W. R. Turrell, S. Jónsson and B. Hansen (2005). "Measured volume, heat, and salt fluxes from the Atlantic to the Arctic Mediterranean." *Geophysical Research Letters* 23: L07603, doi: 10.1029/2004GL022188.

Scientific book

- **Drange, H., T. Dokken, T. Furevik**, R. Gerdes, and W. Berger. Eds., The Nordic Seas: An Integrated Perspective. *AGU Monograph 158, American Geophysical Union, Washington DC, 366 pp, 2005.*

Other

- *Science Express*, which promotes selected forthcoming publications, and highlights as "Bigger in the Middle" in "*This Week in Science", Science* 11 November 2005. Promotion of the article of **Johannessen, O. M.**, K. Khvorostovsky, **M.W. Miles** and L. P. Bobylev (2005). "Recent ice sheet growth in the interior of Greenland." *Science* 310: 1013–1016.

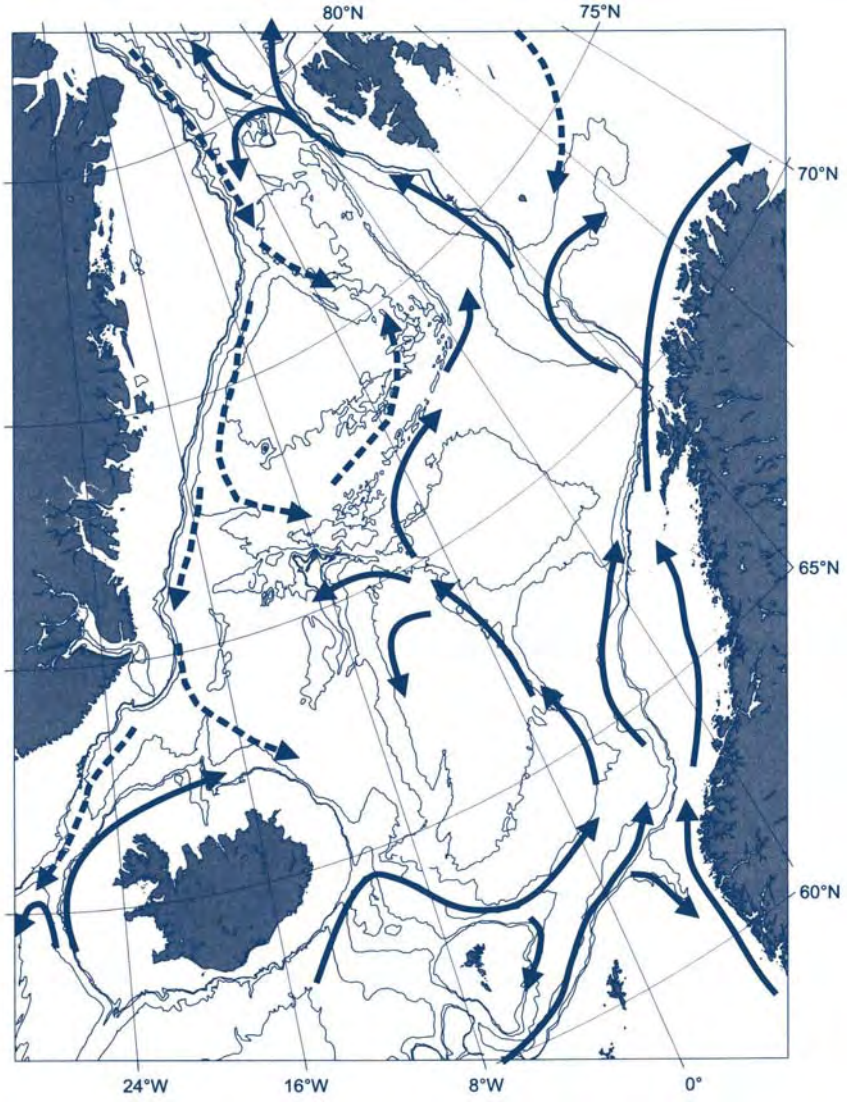
New Book - The Nordic Seas: An Integrated Perspective

*Edited by **Helge Drange, Trond Dokken, Tore Furevik**, Rüdiger Gerdes, and Wolfgang Berger. AGU Monograph 158, American Geo-physical Union, Washington DC, 366 pp, 2005*

This book is the outcome of a concerted effort by the Bjerknes Centre to summarize the state-of-the-art on the role of the Nordic Seas in the climate system. It was initiated as a key aspect of our initial Centre of Excellence activities, and also to commemorate Vilhelm Bjerknes´ decisive work using scientific principles to decipher the weather and climate of the region.

The motivation for producing the monograph is two-fold. On the one hand, climate sciences have been advancing rapidly during the last 20 years due to advancements in methodology and societal concerns about climate change. An updated account of the progress on understanding the climate system in the region is therefore of special urgency. In that respect, this monograph marks the beginning of an era driven by a truly interdisciplinary effort where classical oceanography, meteorology, palaeoclimatology, biogeochemistry, and numerical modelling are bridged to obtain knowledge that would not be possible based on those disciplines alone. On the other hand, this monograph involves historical continuity: sustaining the tradition of compiling available knowledge about the Nordic Seas climate system, the earliest records of which date as far back as the early 13th century.

The Nordic Seas realm, located between polar and extratropical climate regimes, is expected to be particularly sensitive to global warming. In this regard, *The Nordic Seas: An Integrated Perspective* provides a comprehensive and multidisciplinary description of the past and present climate states of the area, the growing realization of the importance of the Nordic Seas in the global climate system, and consideration of how the local climate may respond to global warming. Although the monograph does not address how climate changes may impact societies and resources in the region, it will nevertheless provide essential background knowledge for such an assessment. The present compilation will be of particular importance for policy makers and governmental bodies to ensure scientifically based knowledge for assessing issues related to human induced global and regional climate change, and for conducting optimal timing and scaling of mitigation and adaptation strategies. Most of the papers are authored by BCCR's own staff.



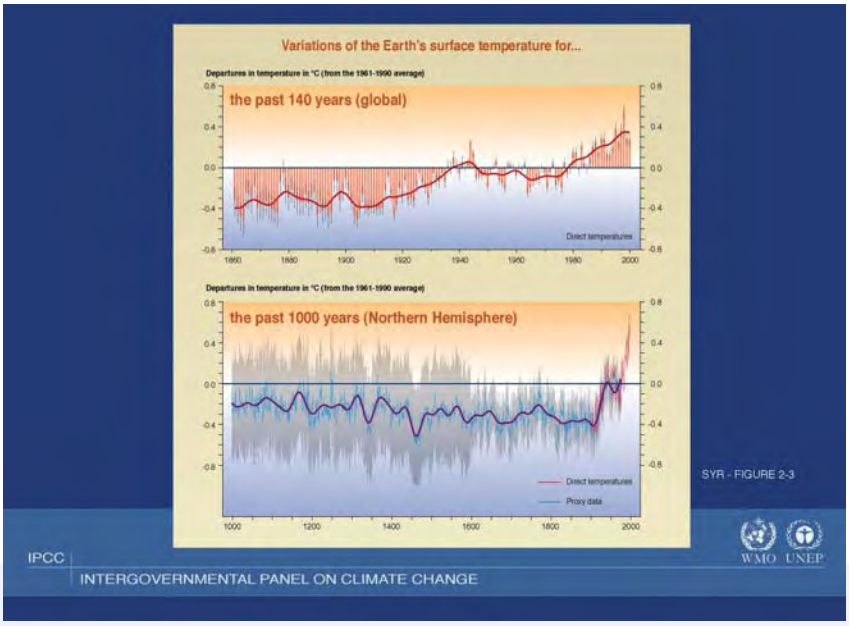
Schematic of the upper-layer circulation in the Nordic Seas. Solid lines are warm Atlantic Water and broken lines are cold Arctic and Polar Waters. From the *Nordic Seas* book contribution by J. Blindheim and S. Østerhus.

- **Scientist involved:**
  Helge Drange (NERSC/BCCR), Trond Dokken (BCCR), Tore Furevik (UiB/BCCR) as Editors. Numerous other Bjerknes scientists and other staff have authored and otherwise contributed to the papers contained in the monograph.

- **Reference:**
  Drange, H., T. Dokken, T. Furevik, R.Gerdes, and W. Berger. Eds., *The Nordic Seas: An Integrated Perspective. AGU Monograph 158, American Geophysical Union, Washington DC, 366 pp, 2005.*

BCCR's Contribution to the IPCC 4th Assessment Report

The Bjerknes Centre contributions to the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report (4AR) continued throughout 2005. Prof. Eystein Jansen is coordinating lead author of Chapter 6 on "Palaeoclimates", and Prof. Christoph Heinze is lead author of Chapter 7 on "Couplings Between Changes in the Climate System and Biogeochemistry".



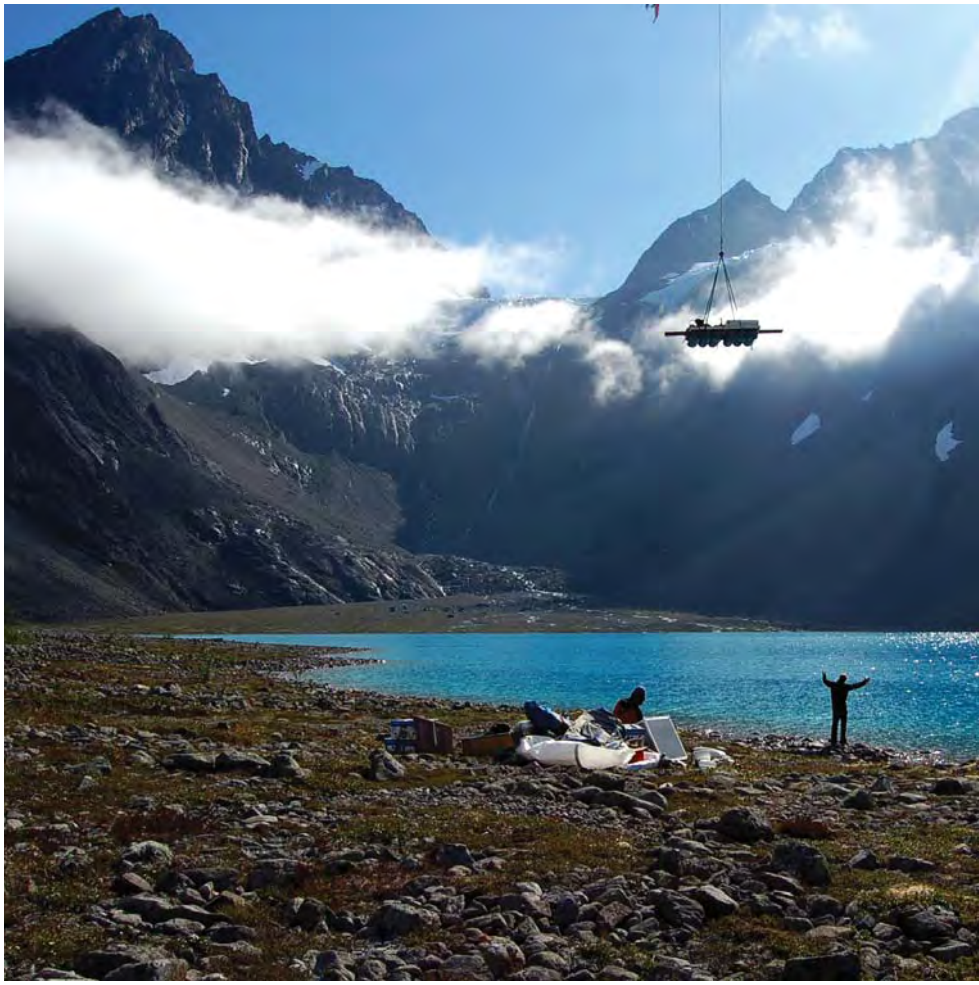
In addition, a number of Bjerknes scientists participate as contributing authors. BCCR is one of four European modelling groups, and the first from the Nordic countries, to provide a full set of climate scenarios to the report using the IPCC 4AR protocols. This was carried out with the Bergen Climate Model and included a total of 1600 years of different simulations on climate developments between 1850 and 2100, in addition to a set of idealized climate simulations. The runs have been carried out thanks to the support of the Norwegian High Performance Computing Programme (NOTUR) and the Bergen Center for Computational Science. These activities have produced about 40 terabytes of modelling fields, all accessible from IPCC´s database and the BCCR.

The IPCC has accepted the invitation of Prof. Jansen, on behalf of the BCCR, to host the final WG1 Lead Authors meeting at the Solstrand Hotel in Bergen, from 25 June to 1 July 2006, to finalize the last draft of the report. This is the most crucial phase of the process because the panel must respond, in writing, to each comment to its second draft following an expert and governmental review. After the first draft was subjected to an expert review, the panel received 22.000 comments to the report. Thus it is a very detailed work that shall be carried out during the meeting. In addition, the "Summary for Policymakers" will also be prepared in Bergen, a key chapter which will be read by governments worldwide, and the "Technical Summary" which is a popular version of the report. The final publication of the IPCC 4AR will occur in February 2007.

Scientists involved:
Christoph Heinze (BCCR)
Eystein Jansen (BCCR)
Øyvind Paasche (BCCR)

Palaeo reconstructions: Past variability in the North Atlantic and Arctic regions

An extraordinary number of new research articles by Bjerknes Centre scientists published in 2005 provide new insights into past variability of climates in the North Atlantic and Arctic regions.



In BCCR's palaeoclimate group has produced in impressive number of publications in 2005, including many on palaeo reconstruction using terrestrial proxy data, most often acquired in the field by the BCCR scientists themselves. These include temporal and spatial climate and environmental development from high-resolution, continuous reconstructions of Lateglacial and Holocene glacier, temperature, and precipitation variations reconstructed by a multi-proxy approach on lake sediments in different regions in Norway and the Arctic.

Among the many findings, detailed studies in Lyngen (photos right) in Troms, northern Norway, have provided a unique opportunity to describe the dynamics of local glaciers during the Lateglacial and Holocene, i.e. 20,000 to 10 000 years before present. It is shown that periods with extreme frequencies of icebergs in the North Atlantic (also called Heinrich events) lead to periods with reduced temperature and considerable reduction in precipitation along the north-west border of the Fennoscandia ice sheet.

Reference

Bakke, J., **S. O. Dahl** and **A. Nesje**, 2005. Lateglacial and early Holocene palaeoclimatic reconstruction based on glacier fluctuations and equilibrium-line altitudes at northern Folgefonna, Hardanger, western Norway. *Journal of Quaternary Science* 20: 179–198

Bakke, J., **S. O. Dahl**, **Ø. Paasche**, **R.** Løvlie and **A. Nesje**, 2005. Glacier fluctuations, equilibrium-line altitudes and palaeoclimate in Lyngen, northern Norway, during the Lateglacial and Holocene. *The Holocene* 15: 518–540

Bakke, J., **Ø. Lie**, **A. Nesje**, **S. O. Dahl** and **Ø. Paasche**, 2005. Utilizing physical sediment variability in glacier-fed lakes for continuous glacier reconstructions during the Holocene, northern Folgefonna, western Norway. *The Holocene* 15: 161–176

Bjune, A. E., 2005. Holocene vegetation history and tree-line changes on a north-south transect crossing major climate gradients in south Norway - evidence from pollen and plant macrofossils in lake sediments. *Review of Palaeobotany and Palynology* 133: 249–275

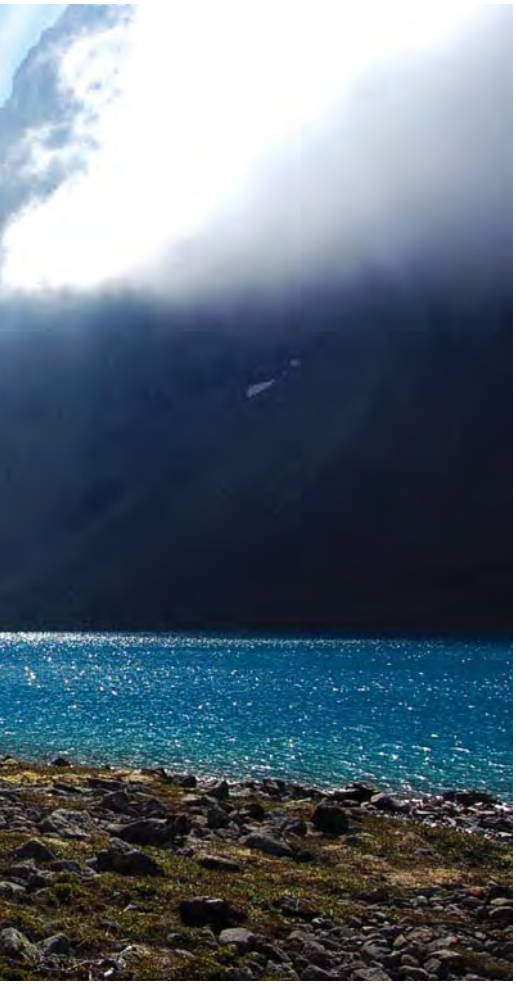
Bjune, A. E., **J. Bakke**, **A. Nesje** and **H. J. B. Birks**, 2005. Holocene mean July temperature and winter precipitation in western Norway inferred from palynological and glaciological lake-sediment proxies. *The Holocene* 15: 177–189

Dalton, C., **H. J. B. Birks**, S. J. Brooks, N. G. Cameron, R. P. Evershed, S. M. Peglar, J.A. Scott and R. Thompson, 2005. A multi-proxy study of lake development in response to catchment changes during the Holocene at Lochnagar, North-east Scotland. *Palaeogeography, Palaeoclimatology, Palaeoecology* 221: 175–201

Heinrichs, M. L., S. M. Peglar, C. Bigler and **H. J. B. Birks**, 2005. A multi-proxy palaeoecological study of Alanen Laanijärvi, a boreal-forest lake in Swedish Lapland. Boreas 34: 192–2006

Matthews, J. A., Berrisford, M. S., Quentin Dresser, P., **A. Nesje**, **S.O. Dahl**, **A.E. Bjune**, **J. Bakke**, **H. J. B. Birks**, **Ø. Lie**, L. Dumayne-Peatyand C. Barnett, 2005. Holocene glacier history of Bjørnbreen and climatic reconstruction in central Jotunheimen, Norway, based on proximal glaciofluvial stream-bank mires. *Quaternary Science Reviews* 24: 67–90

Logistics of remote fieldwork – preparing to core lake sediments in Lyngen, northern Norway. Photos Reidar Løvlie & Jostein Bakke



Miller, G. H., A. P. Wolfe, J. P. Briner, P. E. Sauer and **A. Nesje**. 2005. Holocene glaciation and climate evolution of Baffin Island, Arctic Canada. *Quaternary Science Reviews* 24: 1703–1721

Nesje, A., E. Jansen, H. J. B. Birks, A. E. Bjune, J. Bakke, C. Andersson, S. O. Dahl, D. Klitgaard Kristensen, S.-E. Lauritzen, **Ø. Lie, B. Risebrobakken and J.-I. Svendsen**, 2005. The Nordic Seas: An Overview. Holocene climate variability in the northern North Atlantic region: A review of terrestrial and marine evidence. In: Drange, H., Dokken, T., Furevik, T. Gerdes, R. and Berger, W. (eds.): *The Nordic Seas: An Integrated Perspective. AGU Monograph 158, American Geophysical Union, Washington, DC:* 289–322

Solovieva, N., V. J. Jones, L. Nazarova, S. J. Brooks, **H. J. B. Birks,** J.-A. Grytnes, P. G. Appleby, T. Kauppila, B. Kondratenok, I. Renberg and V. Ponomarev, 2005: Paleolimnological evidence for recent climate change in lakes from the northern Urals, arctic Russia. *Journal of Paleolimnology* 33: 463–482

Smol, J., A. Wolfe, **H. J. B. Birks** and 23 co-authors, 2005. Climate-driven regime shifts in the biological communities of arctic lakes. *Proc. National Academy of Sciences/pnas.0500245102:* 1–6

Velle, G., S. J. Brooks, **H. J. B. Birks** and E. Willassen, 2005. Chironomids as a tool for inferring Holocene climate: an assment based on six sites in southern Scandinavia. *Quaternary Science Reviews* 24: 1429–1462

Velle, G., J. Larsen, W. Eide, S. M. Peglar and **H. J. B. Birks**, 2005. Holocene environmental history and climate of Råtåsjøen, a low alpine lake in central Norway. *Journal of Paleolimnology* 33: 129–153

Scientists involved

Numerous Bjerknes scientists and technicians have contributed to this set of publications (alphabetically): Carin Andersson (BCCR), Jostein Bakke (BCCR), H. John Birks (UiB/BCCR), Anne Bjune (UiB/BCCR), Svein Olaf Dahl (UiB/BCCR), Øyvind Lie (BCCR), Atle Nesje (UiB/BCCR), Øyvind Paasche (BCCR), Bjørg Risebrobakken (BCCR) and Jan-Inge Svendsen (UiB).

Extensive changes in the North Atlantic Ocean unravelled

Large and unexpected changes in the climate of the North Atlantic Ocean, have now been explained by changes in the so-called gyre circulation of the North Atlantic circulation since the mid 1990s.

In the journal Science, a team of scientists from NERSC, BCCR and UiB, together with Færoese and Icelandic colleagues, show that the oceanic waters off Northern Europe are exhibiting record-high temperatures and salinities, and that these extremes relate to the varying contributions of two large gyres of Atlantic Ocean circulation.

The paper describes how measurements of temperature and salinity in the oceans around Norway, the Faroes, Scotland and Iceland were combined with satellite observations and an advanced numerical ocean model to disclose and understand the increases in these parameters, which are unprecedented since regular measurements started in 1948. It is shown that the record highs of temperature and salinity are due to a decade-long reduction in the extension of the cold and fresh waters south of Iceland and Greenland, which allow for an enhanced Gulf Stream transport of warm and saline waters into the Nordic Seas west of the Faroes, along the Norwegian coast, and south of Iceland.

These findings are important because they indicate a reversing of an observed gradual freshening of the North Atlantic and the Nordic Seas since 1960, as a consequence of enhanced precipitation and melting of snow and ice, partially due to global warming. It is noted that this decrease in salinity alone could weaken the Gulf Stream system. The new observations – record-high ocean temperatures and salinity – are ascribed to changes in the circulation of the North Atlantic. They have important implications for the climate in Northern Europe. On the one hand, the high salinity of the water masses will secure that the strength of the Gulf Stream system is maintained in the upcoming decades. On the other hand, the high temperatures will enhance the impacts of global warming on the climate of the Northern Hemisphere.

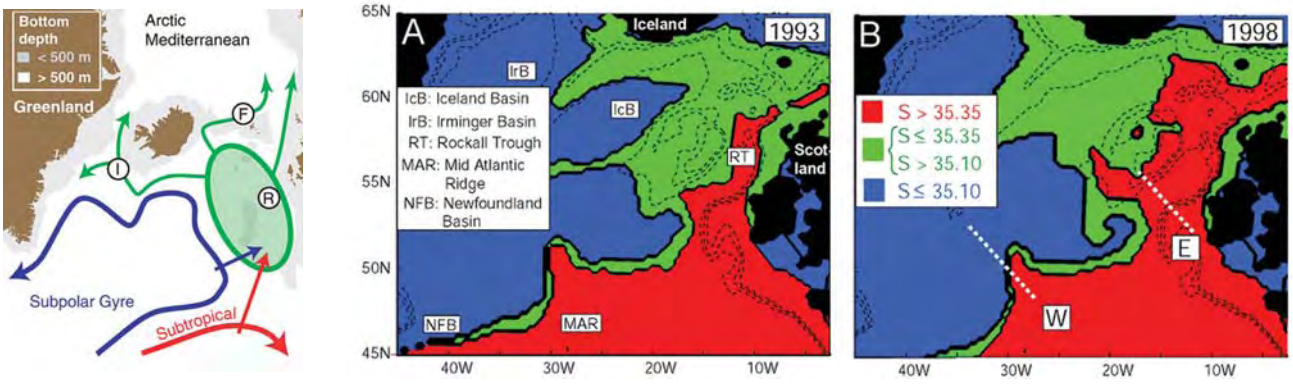
It is unclear whether these changes are due to human influence on the climate system or are simply a consequence of natural variability of the North Atlantic climates system. In order to answer this, it is necessary to combine measurements of parameters of the ocean climate with advanced numerical modelling.

- **Scientists involved**
  Anne-Britt Sandø (NERSC/BCCR), Helge Drange (NERSC/BCCR)

- **Reference**
  H. Hátún, **A.-B. Sandø, H. Drange**, B. Hansen, and H. Valdimarsson, 2005. Influence of the Atlantic Subpolar Gyre on the Thermohaline Circulation. *Science* 309: 1841–1844

Below, left: Schematic of the main features of the surface circulation in the northeastern North Atlantic. The green shaded region shows where the subpolar and the subtropical waters meet, mix, and feed into the Arctic Mediterranean. Hydrographic observations used in the study are from the Rockall Trough (R), Faroe Current (F), and Irminger Current (I).

Below, right: Model-simulated upper-layer spatial distribution of typical subpolar gyre water (blue), subtropical gyre water (red), and a mixture, influenced by both gyres (green), averaged for (A) a low-salinity year 1993 and (B). a high-salinity year 1998.



Marine tracers reveal the role of the Nordic Seas in the global circulation

The global oceanic circulation distributes great amounts of heat over large regions and it is therefore a crucial component of the climate system. When the surface waters of the Gulf Stream extension reach the Nordic Seas, they are cooled down and transformed into heavy and deep-water masses.

The cold and heavy water flows return as a major component of the North Atlantic deep water, and distributed globally in the abyssal depths. In order to understand this process better, scientists injected a tracer in the Greenland Sea (under controlled conditions) in the summer of 1996. The distribution of the tracer was then followed during several years providing scientists with a unique insight into the deep circulation of the Nordic Seas.

Observations and model simulations of this full-scale experiment show that it took two to three years for the deep water of the Greenland Sea to reach the Denmark Strait and the Faroe-Shetland passage towards the North Atlantic in the south, and the Arctic Ocean basin in the north. It has been shown that the spreading routes, velocity and composition of the water masses involved are very much dependent on the large-scale wind circulation in the region.

The tracer experiment and the concomitant research was mainly carried out under the EU-funded projects ESOP (1 and 2) and TRACTOR (with supporting funds from the Norwegian Research Council) both coordinated by the UiB and BCCR.

Scientists involved

Tor Eldevik (NERSC/BCCR, **Anne-Britt Sandø** (NERSC/BCCR), **Tore Furevik** (UiB/BCCR), **Anders Olsson** (UiB/BCCR)

Research projects

TRACTOR (EU), ProClim I and II (RCN)

References

Eldevik, T., F. Straneo, **A. B. Sandø** and **T. Furevik**, 2005. Pathways and export of Greenland Sea water. In: H. Drange, **T. Dokken, T. Furevik**, R. Gerdes, W. Berger (eds) The Nordic Seas: An integrated perspective. *AGU Monograph 158, American Geophysical Union, Washington, DC:* 89–103

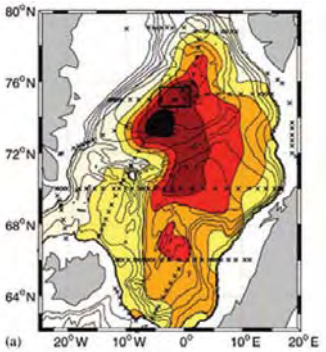
Olsson, K. A., E. Jeansson, L. G. Anderson, B. Hansen, **T. Eldevik**, R. Kristiansen, M.-J. Messias, **T. Johannessen** and A. J. Watson, 2005. Intermediate water from the Greenland Sea in the Faroe Bank Channel: spreading of released sulphur hexafluoride. *Deep-Sea Research I* 52(2): 279–294

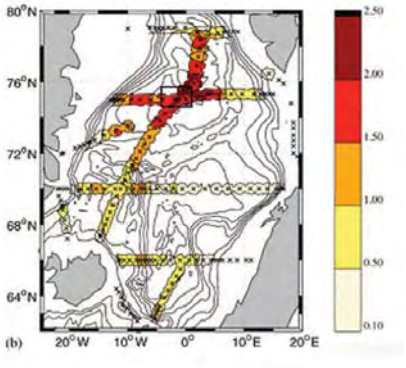
Olsson, K. A., E. Jeansson, T. Tanhua and J.-C. Gascard, 2005. The East Greenland Current studied with CFCs and released sulphur hexafluoride. *Journal of Marine Systems* 55(1–2): 77–95

Tanhua, T., **K. A. Olsson** and E. Jeansson, 2005. Formation of Denmark Strait overflow water and its hydro-chemical composition. *Journal of Marine Systems* 57(3–4): 264–288

Below: Bathymetric map of the Nordic Seas with every 500 m represented by an isoline. The dots mark the locations of the stations sampled during the cruise with R/V Marion Dufresne in 1999. The black rectangle marks the area where 320 kg of SF6 was injected in 1996. Abbreviations: JMCh—Jan Mayen Channel, WIB—West Iceland Basin, FBC—Faroe Bank Channel.

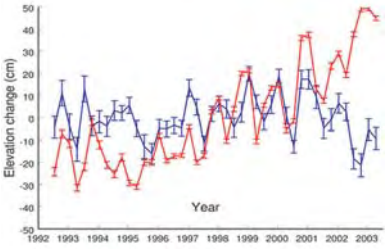
Below and below right: (a) Modelled and (b) observed distributions of released SF6 integrated over the water column 6 years after the tracer release. The observed distribution was obtained subtracting the SF6 estimated to be of atmospheric origin from the total observed. The rectangles in both figures mark the site of the tracer release.



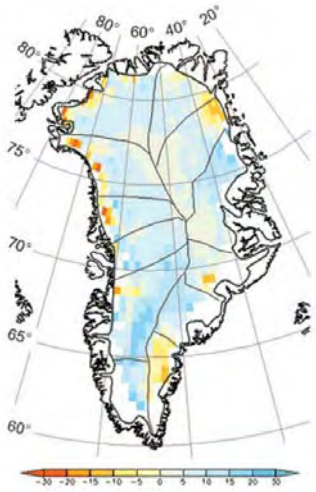


Recent ice sheet growth in the interior of Greenland

Extensive areas of Greenland's ice cap have actually thickened slightly in recent years, in contrast to many highly publicized reports of a widespread melting at the margins.



Interannual variability of spatially averaged Greenland Ice Sheet elevation, shown as anomalies from the 11-year mean, 1992–2003. The data are aggregated into areas >1500m elevation (blue) and <1500m (red), indicating divergent trends since 2000. The vertical bars indicate the errors or uncertainties in the estimates.



Greenland, showing the boundaries (thick line) of the ice sheet and major ice divides (thin lines). The colours indicate ice-sheet elevation change rate (dH/dt) in cm/year, derived from 11 years of satellite altimeter data, 1992 to 2003, excluding some ice-sheet marginal areas (white). The spatially averaged rate is about 5 cm/year when corrected for uplift.

There is still no consensus assessment of the overall mass balance of the Greenland Ice Sheet. There is evidence of melting and thinning in the coastal marginal areas in recent years, as well as indications that large Greenland outlet glaciers can surge, possibly in response to climate. However, much less known are changes that may occur in the vast elevated interior area of the ice sheet.

In the journal Science, an international team of scientists including Ola M. Johannessen (NERSC) and Martin Miles (BCCR) reported finding growth rates in the interior regions of the Greenland Ice Sheet of about 6 cm per year between 1992 and 2003. The study – highlighted in the online Science Express – derived and analysed the longest continuous dataset of satellite altimeter observations of the Ice Sheet elevations by combining tens of millions of data points from European Space Agency (ESA) satellites and NASA. This allowed determination of the spatial patterns of variability in surface elevation and changes over the 11-year period.

The study explained part of the increased precipitation (as snowfall) over the ice sheet to the variability of the North Atlantic Oscillation (NAO) pattern. By establishing a significant correlation between the growth and this large-scale atmospheric circulation, they point out NAO as a wildcard in the mass balance of the Greenland Ice Sheet in a scenario of global warming.

- **Scientists involved**
  Ola. M. Johannessen, NERSC; Martin Miles, BCCR

- **Research Project**
  RAPID Greenland and MACESIZ (RCN)

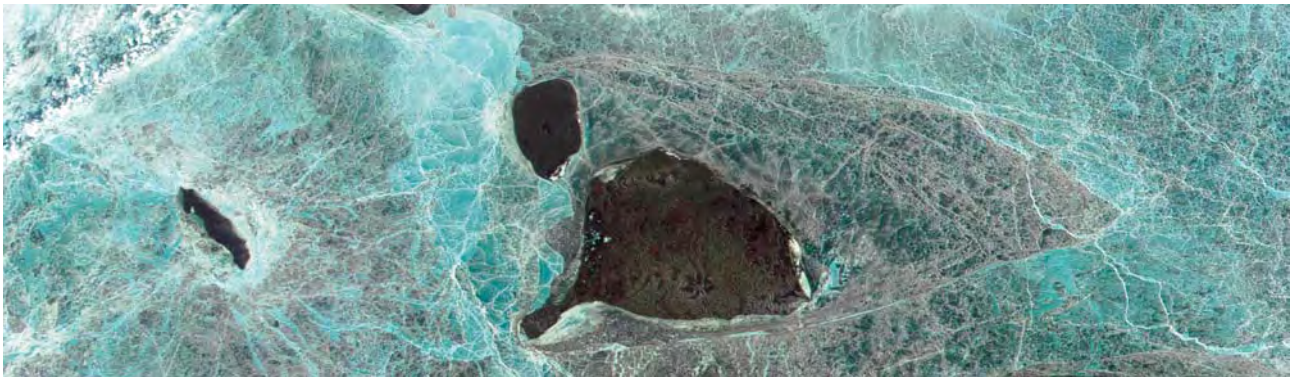
- **Reference**
  Johannessen, O. M., K. Khvorostovsky, **M. W. Miles** and L. P. Bobylev, 2005. Recent ice sheet growth in the interior of Greenland. *Science 310*, 1013–1016.

Greenland highlands photo: Petter Bjorstad, University of Bergen.

Bjerknes International Workshop: The role of sea ice in the global climate system

Bergen, 24-25 May 2005

The goal of the meeting was to discuss various aspects of sea-ice dynamics in response to future climate changes and the role of sea ice in amplifying large-scale climate variability in the past, present and future. Five experts from the University of Washington and Columbia University in the USA and Leibniz-Institute for Ocean Sciences in Germany were invited to give keynote talks and set the tone of the meeting. The workshop addressed the impact of sea ice as an integral part of high-latitude climate system through its influence on heat, moisture and momentum exchange between the atmosphere and ocean as well as its impact on the large-scale horizontal heat and moisture transport both in the ocean and atmosphere. Most modelling results indicate an Arctic amplification of future global warming which will change the large-scale meridional temperature gradient and therefore possibly the poleward heat and moisture transport. Observations and climate models also suggests that the role of sea ice may play an important role in amplifying large scale climate variability in the past, present and future. The workshop was attended by a total of 42 participants. The meeting was sponsored by the Research Council of Norway as part of the support to trans-Atlantic cooperation in climate research. In this regard, specific outcomes of the meeting were: 1) a preliminary agreement for an exchange program for PhD students, and 2) plans for a summer school jointly organised by BCCR and the University of Washington, Seattle (see "New initiatives and collaboration".)



Arctic sea ice and its reflection properties evident in a true-colour satellite image from the Laptev Sea. Image courtesy of the NASA MODIS Land Rapid Response Team.

Meeting the Climate Challenge in the Arctic Region

Washington DC, 9 June 2005

The Royal Norwegian Embassy in Washington DC in cooperation with the Environmental and Energy Study Institute presented this Trans-Atlantic symposium. The goal of the symposium was to consolidate, broaden and strengthen the attention on the emerging and potentially dramatic climate challenges in the northern regions, as a follow-up of the Arctic Climate Impact Assessment (ACIA) and the Reykjavik Declaration of November 2004. The meeting gathered politicians and representatives from research institutions from both the USA and Norway. Representing BCCR was Prof. Helge Drange as invited keynote speaker.

Workshop on Health and Climate

Bergen, 1 July 2005

This workshop, sponsored by the Wallenberg Foundation and hosted by UiB, gathered experts around the development of a program to establish an international network of researchers to address the spread of infections disease by waterborne pathogens. The promoter of this initiative is Prof. Rita Colwell, former Director of the National Science Foundation. This workshop was a follow up of preliminary talks during the Second Annual Transatlantic Cooperative Research Conference organised by the Norwegian Embassy in Washington DC. Prof. Helge Drange was invited to represent the BCCR to explore the potential involvement of the Bergen Climate Model group in this initiative.

Research and higher education week

■ **Washington DC, 31 October to 3 November 2005**

The Norwegian Research & Technology Forum in the USA and Canada organised the fourth session of this week, where a number of research and education seminars were hosted by the Norwegian Embassy and the Carnegie Institution. In this regard, the BCCR was invited to participate in the following events:

Climate, Oceans and Policies. Challenges for the 21st Century

■ **Washington DC, 1 November 2005**

This session held at the Carnegie Institution, under the auspices of the Third Annual Transatlantic Cooperative Research Conference, was co-organised by the Norwegian Embassy, BCCR, CICERO, and the Research Council of Norway. The conference featured four sessions, each exploring a specific area of the overall topic of climate, oceans, and policy. The main goal of the meeting was to enhance international collaboration in scientific research and policy development on both sides of the Atlantic, under the need to move forward with emission-reduction policies and technological research and deployment, while still working to refine our scientific understanding of the future effects of climate change. Keynote speakers for the opening and closing sessions featured Profs. Eystein Jansen and Ola M. Johannessen, as well as representatives from research institutions, national and intergovernmental institutions and political institutions from both the USA and Norway. Session panellists from BCCR were Trond Dokken, Ken Drinkwater and Tore Furevik. Norway's Minister of Foreign Affairs, Jonas Gahr Støre, opened the conference.

Trans-Atlantic workshop on global infectious diseases, climate, water and health

■ **Washington DC, 1 November 2005**

This workshop was organised under the auspices of the Norwegian Embassy in Washington, DC and the University of Maryland with the goal of launching a discussion among potential participants in the new U.S.-Norway-Sweden collaborative international center focusing on global disease, water, and health. The participants touched on a variety of potentially collaborative projects, including tracking infectious disease worldwide, organizing global disease data into a cohesive database, studying terrestrial and airborne pathogens, use of computer models to simulate future climate changes, as well as reducing poverty and inequality. Participants discussed the linkages among climate, water, and health, and they elaborated on each aspect of the relationship. The BCCR was invited to present the capabilities of the Bergen Climate Model in the study of climate related aspects of diseases, such as the production of climate scenarios for the 21st century for any region of the globe, at high spatial resolution.

Second international conference for Arctic Research Planning (ICARP II)

■ **Copenhangen, 10-12 November 2005**

The goal of ICARP is to prepare Arctic research plans to guide international cooperation over the next 10-15 years. The conference was the culmination of a 24-month planning process involving over 140 scientists to develop draft science plans around thirteen critical research themes identified from the science and Arctic Community at large. From BCCR, Trond Dokken and Helge Drange were invited to contribute to WG6 "Arctic shelf seas" and WG9 "Modeling and Predicting Arctic Weather and Climate" respectively. Tor Gammelsrød and Martin Miles also participated in the WGs at the ICARP II conference.

Bjerknes International Workshop on the Norwegian Coastal Current

■ **Bergen, 21-23 November 2005**

The aim of the workshop at the Institute of Marine Research was to examine various aspects of the Norwegian Coastal Current (NCC) including: the freshwater budget, the fate of freshwater runoff and the exchanges with the offshore waters, the state-of-the-art in modelling the NCC and its role in the climate of the Nordic Seas. A total of 33 participants from 8 institutions from Norway, Poland and the USA attended the workshop.

Norwegian Research Council projects launched in 2005

- Geohazards, Climatic Change, and Extreme Weather Events (GeoEXTREME). Cooperation with Norwegian Geological Survey (NGU). PI: Asgeir Sorteberg, BCCR.
- Impact of changing freshwater flows on the thermohaline circulation and European climate-analysis and modelling of the last deglaciation (ORMEN). Leader: Trond Dokken, BCCR.
- Variations of the Atlantic meridional overturning circulation during rapid climate changes: calibration, modelling and palaeoceanographic observations (VAMOC). Leader: John Inge Svendsen, UiB.
- Understanding the dynamics of the coupled climate system (DYNAMITE). A STREP coordinated by Prof. Helge Drange, NERSC. BCCR is partner. Web site: http//dynamite.nersc.no/
- RAPID (Punctuated disintegration of the NW European Ice Sheet and rapid climate change). Project leaders: Hans Petter Sejrup/Haflidi Haflidason, UiB.
- NESSAS (Norwegian Component of the Ecosystem Studies of Sub-Arctic Seas). Project leader: Ken Drinkwater.

EU projects launched in 2005

- Developing Arctic Modelling and Observing Capabilities for Long-term Environmental Studies (DAMOCLES) - An Integrated Project where BCCR is partner (PI: Peter Haugan). Runs for four years.
- ENSEMBLE-based Predictions of Climate Changes and their Impacts (ENSEMBLES). An Integrated Project where BCCR is partner (PI: Helge Drange). Runs for five years.
- European Network of Excellence for Ocean Ecosystem Analysis (EUROCEANS). BCCR is partner (PI: Christoph Heinze). Runs for four years.
- Marine carbon sources and sinks assessment (CARBOOCEAN). An Integrated Project coordinated by BCCR (Leader: Prof. Christoph Heinze). Runs for 5 years.
- Natural and anthropogenic modifications of the Si cycle along the land-ocean continuum: Worldwide Ecological, Biogeochemical and Socio-economical consequences (Si-WEBS). A research and training network. BCCR is partner (PI: Christoph Heinze). Runs for two years.
- Proxies in Paleoclimatology: Education and Research (PROPER). A Marie Curie Training Network where BCCR is partner (PI: Eystein Jansen). Runs for three years.
- Understanding the dynamics of the coupled climate system (DYNAMITE). A Specific Targeted Research Project where BCCR is partner (Leader: Helge Drange). Runs for four years.
- International Polar Year - Climate of the Arctic and its Role for Europe: IPY-CARE. (PI: Eystein Jansen)

Projects funded by other sources launched in 2005

- Autonomous underway pCO2 sensors for VOS applications. The National Oceanographic and Atmospheric Administration (NOAA). Leader: Richard Bellerby, BCCR
- Development of a web-based tool for modelling marine biogeochemical cycles. The Worldwided University Network. Leader: Christoph Heinze, BCCR/UiB
- High-latitude climate variability and its effects on human settlement and fishery resources as revealed by fossil otoliths. The Meltzer Foundation. PI: Carin A. Dahl, BCCR
- Palaeoclimate in the Southern Ocean. The COMER foundation. Leader: Ulysses Ninnemann, UiB/BCCR

Norwegian Climate Center (NKS)

On May 9, 2005, the BCCR and the Norwegian Meteorological Institute (Met.no) in Oslo formalized a comprehensive cooperation in climate research entitled Norsk Klimasenter (Norwegian Climate Center).
The agreement was announced in connection with the visit of the former Minister of Environment, Knut Hareide, to the University of Bergen. The goals of the NKS are to be the primary provider of independent knowledge on climate change and its impacts, and advisor to the public, the authorities and industries on issues regarding climate change by providing research-based knowledge that supports national climate policy in the international arena. The NKS will strengthen and develop. further existing expertise in climate research and development, thus securing the long-term expertise in climate research in Norway. The cooperation between BCCR and Met.no will span from basic to applied research, i.e. from the fundamental understanding of the climate system to the development of products targeted to policymaking, and mitigation/adaptation measures. NKS will provide information, results and products on regional and global climate changes for use by management, industry, research and the general public.

Status update: The board has been constituted, and an interim leader team was appointed to prepare a strategic plan. A secretariat has been established at BCCR and will be staffed with a scientific coordinator.

Department of Atmospheric Sciences at the University of Washington, Seattle, USA

BCCR and the Program on Climate Change at the Department of Atmospheric Sciences at the University of Washington, Seattle (UW), lead by Prof. David Battisti, agreed to establish a joint network for climate change research. The purpose of the network is to bring together scientists and graduate students from both partners to pursue joint research projects as well as the organization of joint high-level workshops and a Summer School in Climate Change. The network will be jointly run and hosted by the Bjerknes Centre and the Program on Climate Change at the University of Washington. The Summer School will bring together an international community of exceptional graduate students, postdoctoral fellows and leading climate scientists in order to provide a unique opportunity for an intense learning experience and a vigorous discussion of vital concepts on key problems in climate change that span a number of disciplines. The Summer School and workshops will run for four years on a rotating basis between Bergen and Seattle. The US government and US foundations are expected to commit to sponsor the Climate Change Network at UW. In this regard, the BCCR sougth the support of the Internationalization Programme from the Bergen Research Foundation of about one million NOK in matching funds to support the Norwegian commitment of the Network.

Status update: We have been informed that the Bergen Foundation favourably evaluated BCCR´s proposal and that funds have been granted. The activities will start in September of 2006.

International Arctic Research Center at the University of Fairbanks, Alaska, USA

Throughout 2005, the BCCR continued to strengthen on-going research cooperation with the climate group lead by Prof. John Walsh at the International Arctic Research Center (IARC) at the University of Fairbanks, Alaska, by exchanges of visiting scientists. The cooperation aims at establishing the critical mass and expertise necessary to enhance our understanding of the processes and feedbacks governing the climate of the Arctic and sub-Arctic regions in order to reduce the uncertainty of climate change projections. The potential to produce cutting-edge research is high, by virtue of the synergy of critical mass and expertise together with common interests and research complementarity in the procurement of a common and ambitious goal in climate research. Specifically, BCCR and IARC have agreed to pursue joint research projects around each of the following topics: (i) The role of Arctic cyclones/anticyclones on associated climate and weather extremes, (ii) Freshwater budgets, dense water formation, and the meridional overturning circulation, (iii) Natural variability vs. anthropogenic forcing in the Arctic/sub-Arctic regions, (iv) Sea-air CO2 exchanges and impacts on the Arctic/sub-Arctic ocean ecosystems. IARC and BCCR plan to organise workshops to prepare four proposals for joint research projects targeted to NORKLIMA´s call for proposals in 2006 and as well as funding agencies in the USA.

Education & Recruitment

In 2005, BCCR scientists provided supervision and training in climate research to 21 doctoral students.

Following the seven dissertations defended in 2004, one doctoral student, Frode Vikebø, defended his PhD dissertation in 2005, entitled: The impact of climate on early stages of Arcto-Norwegian cod – a model approach. The research was carried out at the Institute of Marine Research, Dept. of Oceanography and Climate.

The CARBOOCEAN project management office at BCCR started, together with the Integrated Project Carbo-Europe, an outreach project entitled CarboSchools: Global Change and Research for Secondary Schools (web site http://www.carboschools.org/). This initiative invites teachers and scientists to join forces to develop young people's understanding of global climate change, discover scientific research on the topic and act locally to reduce emissions of greenhouse gases. In this regard, the CARBOOCEAN management office invited fifteen teachers from secondary schools in Bergen under the lead of Dr. Ingunn Skjelvan in order to plan concrete interactions between scientists and students. The office also produced an informative CarboSchools leaflet as a template for CarboSchools across Europe.

Outreach activities

An important mission of the BCCR is to enhance public awareness and the understanding of key processes involved in the climate system and the potential consequences of climate change.

In this regard, the secretariat and the leaders recognized that the Centre´s outreach needed to be strengthened and proceeded to outline a communication strategy to ensure that BCCR´s scientific results and activities were properly channelled to a number of audiences, e.g. other scientific communities, policy makers, journalists, schools as well as the general public. It was agreed that the BCCR´s web page would be the main channel reaching those audiences, and so the web site was totally revamped accordingly.
Finally, a Communication Officer was employed to implement the Centre´s strategy in collaboration with an internal editorial group and personnel from the Communication Department, UiB. The list below highlights some of the new products available at BCCR's web page.

- **News/Nyheter** from BCCR and the media in general.
- **Pressekontakt:** This module targets journalists to ease their search for expert declaration or interviews. It tells who answers what at BCCR on a variety of climate issues.
- **Fakta om klima:** This module provides "Infosheets" about a number of topics on climate and climate issues, prepared by the scientists, in a popular language.
- **Spør oss om klima:** This is an interactive module run jointly by BCCR, the Geophysical Institute, UiB and Værvarslinga på Vestlandet (met.no). It targets students from s econdary schools and aims to answer inquiries on meteorology, oceanography and climate issues.
- **New publications:** BCCR´s latest articles and books are announced here.

Internship at Bergens Tidende

As part of its strive to train its young scientists in science communication, BCCR came to an agreement with the local newspaper Bergens Tidende to provide PhD student Erik Kolstad with a 3-week internship at BT´s offices during the autumn in order to get acquainted with, and participate in, the newspapers´ editorial practices. Kolstad implemented a weather blog, which is still ongoing.

National exhibition

The BCCR contributed to the national exhibition Havlandet in connection to Norway´s Centennial commemoration as an independent country. The exhibition was officially inaugurated by Queen Sonja and displayed for four months at Permanenten in Bergen and later moved to Sølvberget, Kulturhuset i Stavanger for another four months. BCCR contributed to the stand entitled Havlandets fremtid by providing computer simulations of scenarios of future climate conditions for the West coast of Norway and their impact on industry and society. Plans are underway to transform Havlandet into a travelling exhibition in 2006.

Miscellaneous

In 2005, Bjerknes scientists contributed more-than-ever to the popularisation of its science through the publication of popular articles, invited lectures and presentations and participation in the mass media (newspapers, radio and TV). See "Publications" for further details.

International engagement

In 2005, Bjerknes scientists participated in several scientific or assessment committees and working groups from the following international programmes:

UN Intergovernmental Panel for Climate Change (IPCC)

Prof. Eystein Jansen is Coordinating Lead Author of Chapter 6 "Palaeoclimates" and Prof. Christoph Heinze is Lead Author of Chapter 8 "Couplings Between Changes in the Climate System and Bio-geochemistry". Both participated in the IPCC meetings held in 2005 in Beijing, China and Christchurch, New Zealand. In addition, the Bergen Climate Model group produced 1600 simulations of climate developments using IPCC 4AR protocols.

European Climate Forum

The Bjerknes Centre for Climate Research has been accepted as a member of the European Climate Forum (ECF), a non-profit organisation located at PIK, Potsdam, Germany. ECF is a platform for joint studies and science-based stakeholder dialogues on climatic change and brings together representatives of different parties concerned with the climate problem, such as energy industries, companies engaged in renewables, major energy users, insurance and finance, policy-makers, environmental NGOs, and scientists.

Arctic Research Planning – ICARP

Prof. Helge Drange and Dr. Trond Dokken were invited to contribute to Working Groups (WG) in order to draft science plans around critical research themes concerning future trends and pattern of change in climate, ozone, ecosystem and other systems in the Arctic. The WGs produced a white paper (i.e., science plan) presented at the Second International Conference for Arctic Research Planning (ICARP II) in Copenhagen, Denmark, November 2005, with the final plans to be presented at the 2006 Arctic Science Summit Week.

International Geosphere–Biosphere Programme (IGBP)

- Integrated Project CAR-BOOCEAN, coordinated by Prof. Christoph Heinze, BCCR was endorsed by the IGBP/SCOR sponsored projects SOLAS and IMBER. It is also listed as a LOICZ project

- International Ocean Carbon Coordination Project (IOCCP). Prof. Truls Johannessen is ex-officio SSC member. IOCCP was created jointly by the SCOR-IOC advisory panel on ocean CO2 and the Global Carbon Project (under the auspices of IGBP, IHDP and WCRP)

- Surface Ocean Low Atmosphere Study (SOLAS). Prof. Truls Johannessen is member of the SSC

- Global Ocean Ecosystem Dynamics (GLOBEC). Prof. Svein Sundby was appointed member of the SSC

- Past Global Changes (PAGES). Prof. Eystein Jansen is member of the SSC.

- PAGES/CLIVAR intersection panel. Prof. Eystein Jansen co-chairs the panel together with Prof. Andrew Weaver of the University of Victoria, Canada. The panel coordinates research between the PAGES and CLIVAR programmes

- PAGES international marine past global changes study (IMAGES). Assoc. Prof. Ulysses Ninnemann is member of the SSC

- Integrated Marine Biogeochemistry and Ecosystem Research (IMBER). Prof. Svein Sundby contributed to the Science Plan and Implementation Strategy, published in 2005.

Barents Sea phytoplankton bloom, July 2003, as seen GSFC.

Global Change Committee

Prof. Svein Sundby, IMR/BCCR was appointed member of the newly created Global Change Committee for Norway by the Research Council of Norway.

National Implementation Plan on Climate Research

Prof. Helge Drange, NERSC/ BCCR was appointed member of the committee that will prepare this plan, requested by the Norwegian Ministry

by the MODIS satellite sensor. Image courtesy of MODIS Land Rapid Response Team, NASA

of Environment and to be coordinated by the Research Council of Norway

- **Visiting Fellow Programme**

BCCR sponsors a Visiting Fellow Programme that aims at fostering international research collaboration in climate change. In 2005, the Centre hosted 40 scientists from the countries to the right.

Country	# visiting scientists
Australia	1
Canada	1
Denmark	2
Faroe Is	1
Germany	6
Iceland	1
Japan	1
Netherlands	2
Russia	4
Scotland	1
South Africa	1
Sweden	1
UK	5
USA	13
TOTAL	**40**

Awards and Prizes

- **EU Descartes Prize** in Research 2005 was awarded to Prof. Ola M. Johannessen, affiliated to BCCR, together with partners Prof. Lennart Bengtsson, MPI, and Leonid Bobylev, NIERSC Russia, for their decade of collaborative research entitled "Climate Project Climate and Environmental Change in the Arctic (CECA)". The research carried out by CECA, has strengthened the capacity to detect, understand and predict climate and environmental change with a focus on the high latitudes. BCCR has contributed to this research which is highly relevant to activities under international research programmes (e.g., CLIVAR), monitoring and assessment (e.g., ACIA) and policy making (e.g., IPCC).

- **Brøgger Prize 2005** was awarded to Prof. emeritus Jan Mangerud in recognition of his outstanding scientific contribution, inspiration and leading role in the development of quaternary geology and palaeoclimatology in Norway in general and at the University of Bergen in particular. The Brøgger Prize is awarded by the Norwegian Geological Union in recognition of geologists with a life-long, outstanding career promoting the understanding of Norwegian geology in particular or geosciences in general.

- **University College London:** Special session in honour of Prof. H. John. B. Birks. The University College London organised a one-day seminar entitled Numerical Methods in Palaeocology, in honour of Prof. John Birks, affiliated with BCCR, for his contribution to methodology development in Palaeocology the past 20 years.

Budget

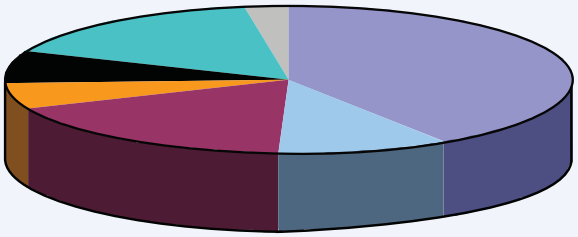
Funding sources

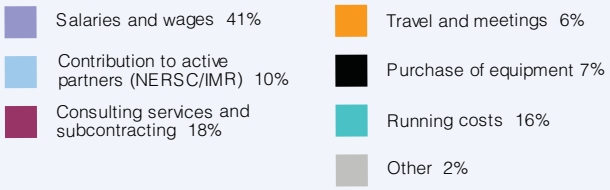
The Research Council of Norway (RCN) contributed 26% of the BCCR budget. The University of Bergen, the host institution, contributed with 29% in the form of in-kind support of faculty and recruiting positions, infrastructure, ship-time, and communications. IMR and NERSC, as active partners, each contributed 5%. Research grants (projects) provided 40% of the income, both from national (e.g., RCN and industry) and international (e.g. EU, international agreements) funds.

Funding Sources	MNOK
Research Council og Norway	19.7
University og Bergen	22.0
Nansen Environmental & Remote Sensing Center	4
Institute of Marine Research	4
Research grants (national funds)	26.6
Research grants (international funds)	3.9
Total	**80.2**

Expenditures

Salaries and wages (41%), consulting and subcontracting (18%), running costs (16%) and contribution to the active partners NERSC and IMR (together 10%) comprised the largest expenditures during 2005. Other costs included purchase of equipment (7%), travel and miscellaneous other costs (2%).





Glacier panorama from western Norway. Photo: Jostein Bakke.

Personnel

Scientists

Bjørn	Ådlandsvik	Physical oceanography & modelling
Lars	Asplin	Physical oseanografi & modelling
Richard	Bellerby (UK)	Biogeochemistry
Mats	Bentsen	Climate modelling
Hilary	Birks (UK)	Numerical methods in palaeoclimatology
H. John B.	Birks (UK)	Terrestrial biological climate proxies
Yngve	Børsheim	Marine biology, biogeochemistry
Paul	Budgell (Canada)	Ocean modelling
Carin A.	Dahl (Sweden)	Palaeoclimatology
Svein Olaf	Dahl	Glaciers & palaeoclimatology
Trond	Dokken	Palaeoclimatology
Helge	Drange	Climate modelling
Ken	Drinkwater (Canada)	Oceanography & impacts of climate change
Tor	Eldevik	Ocean processes & modelling
Ilker	Fer (Turkey)	Ocean processes
Frode	Flatøy	Atmospheric chemistry & modelling
Tore	Furevik	Climate modelling
Tor	Gammelsrød	Polar oceanography
Sigbjørn	Grønås	Synoptic meteorology
Peter	Haugan	Polar oceanography
Chrisoph	Heinze (Germany)	Carbon cycle modelling
Solfrid	Hjøllo	Ocean circulation
Eystein	Jansen	Palaeoclimatology
Alastair	Jenkins (UK)	Boundary layer physics
Ola M.	Johannessen	Remote sensing, marginal ice dynamics
Truls	Johannessen	Biogeochemistry
Ina	Kindem	Stratospheric physics
Helga F.	Kleiven	Palaeoclimatology
Nils Gunnar	Kvamstø	Atmospheric modelling
Henriette	Linge	Palaeoclimatology
Harald	Loeng	Physical oceanography, arctic climate
Ketil	Lygre	Biogeochemistry & modelling
Jan	Mangerud	Palaeoclimatology
Martin	Miles (USA)	Climate time series analysis
Kjell Arne	Mork	Physical oceanography
Atle	Nesje	Palaeoclimatology
Ulysses	Ninnemann (USA)	Palaeoclimatology
Svein	Østerhus	Physical oceanography
Geir	Ottersen	Fisheries biology and climate
Benjamin	Pfeil (Germany)	Data management
Anne Britt	Sandø	Ocean modelling
Anne	Sandvik	Mesoscale atmospheric modelling
Øystein	Skagseth	Ocean circulation
Ingunn	Skjelvan	Chemical oceanography
Morten	Skogen	Coupled physical and biological modelling
Lars Henrik	Smedsrud	Polar Oceanography
Henrik	Søiland	Ocean modelling
Asgeir	Sorteberg	Climate modelling
David	Stephenson (UK)	Atmospheric processes and climate modelling
Jan E.	Stiansen	Impact of climate change on ecosystems
Svein	Sundby	Ocean climates
Einar	Svendsen	Physical oceanography & modelling
John Inge	Svendsen	Palaeoclimatology
Richard	Telford (UK)	Palaeoclimatology
Andrea	Volbers (Germany)	Palaeoclimatology and biogeochemistry
Hans	Wackernagel (Switzerl.)	Geostatistics, multivariate analyses

Postdocs

Karen	Assmann (Germany)	Carbon cycle and chemical oceanography
Jostein	Bakke	Palaeoclimatology
Idar	Barstad	Climate modelling
Anne	Bjune	Palaeobotany
Wenche	Eide	Palaeobotany
Igor	Ezau (Russia)	Environmental boundary layers
Yonqi	Gao (China)	Ocean circulation modelling

Postdocs (cont.)

Richard	Gyllencreutz (Sweden)	Palaeoclimatology
Einar	Heegaard	Palaeoecology
Mona	Henriksen	Palaeoclimatology
Randi	Ingvaldsen	Physical oceanography
Yoshie	Kasajima (Japan)	Mesocale oceanography
Øyvind	Lie	Palaeoclimatology
Katja	Lohmann (Germany)	Ocean climate variability and modelling
Shujie	Ma (China)	Modelling, downscaling
Jan Even Ø.	Nilsen	Climate modelling
Kerim H.	Nisancioglu	Palaeoclimatology
Are	Olsen	Biogeochemistry
Anders	Olsson (Sweden)	Chemical oceanography
Abidrahman	Omar (Somalia)	Chemical oceanography
Odd Helge	Otterå	Climate modelling
Øyvind	Paasche	Palaeoclimatology
Bjørg	Risebrobakken	Palaeoclimatology
Frode	Vikebø	Climate impacts on marine ecosystems

PhD students

Christophe	Bernard (France)	Biogeochemistry
Ingo	Bethke (Germany)	Ocean modelling
Øivind	Byrkjedal	Meteorology
Anne-Grethe	Bøe	Palaeoclimatology
Elin	Darelius (Sweden)	Polar oceanography
Christine	Euler (Germany)	Palaeoclimatology
Florian	Geyer (Germany)	Climate modelling
Dorothea	Iovino (Italy)	Meridional overturning circulation
Caroline	Kivimäe (Sweden)	Chemical oceanography
Erik	Kolstad	Climate downscaling
Ben	Marzeion (Germany)	Meridional overturning circulation
Marius	Meland	Palaeoclimatology
Svetlana	Milutinovic (Croatia)	Remote sensing, climate modelling
Cathrine	Myhrmehl	Climate modelling
Birgitte F.	Nyland	Palaeoclimatology
Steinar	Orre	Climate modelling
Ivar	Seierstad	Meteorology & teleconnections
Anders	Sirevaag	Physical Oceanography
Yongjia	Song (China)	Climate downscaling
Dag Johan	Steinskog	Climate modelling
Karolina	Widell (Sweden)	Physical oceanography

Technical staff

Dag Inge	Blindheim	Palaeoclimatology
Wenche	Breyholtz	Palaeoclimatology
Kelly	Brown (USA)	Chemical Oceanography
Odd	Hansen	Palaeoclimatology
Bjørn Chr.	Kvisvik	Palaeoclimatology
Solveig	Kringstad	Chemical Oceanography
Craig	Neill (USA)	Chemical Oceanography
Ann Kristin	Østrem	Oceanographic time series, databases
Liv	Senneset	Palaeoclimatology
Jørund	Strømsøe	Palaeoclimatology
Rune	Søraas	Palaeoclimatology

Secretariat/ personnel summary

Beatriz Balino	Science coordinator	**Person-years**	
Marit Eikemo	Communication officer	Scientists	33.5
Connie Engstad	Human resources	Postdocs	21.4
Tordis Lerøen	Adm. consultant	PhD students	20.2
Charla M. Olsen (USA)	Senior secretary	Technicians	9.3
Geir S. Skaten	Financial officer	Administration	5.5
		Total	**89.9**

Number of scientific positions

sorted by category and partner

	Partner					Foreigners	Women
Catergory	BCCR	UiB	IMR	NERSC	Total	%	%
Scientists	20	16	12	7	**55**	27	16
Postdocs	9	9	5	2	**25**	40	36
PhD students	0	13	0	8	**21**	30	43
Total	**29**	**38**	**17**	**17**	**101**		

Percentages of non-Norwegians and female scientists are indicated

Research projects

Projects funded by the Research Council of Norway

TITLE	DURATION	Leader/partner
Atmosphere–ice–ocean interactions studies (AIO)	2003–05	P. Haugan ◆
Climate effects on dynamic biodiversity	2003–06	E. Heegaard ◆
Carbon flux and ecosystem feedback in the northern Barents Sea in an era of climate change (CABANERA)	2002–06	T. Johannessen ●
Effects of North Atlantic Climate Variability on the Barents Sea Ecosystem (ECOBE)	2003–06	S. Sundby ◆
External and internal forced variability of the Atlantic European climate system over the last millennium (EUROCLIMATE)	2003–06	H. Drange ◆
Geohazards, Climatic Change, and Extreme Weather Events (GeoEXTREME)	2005–08	A. Sorteberg ●
Impact of changing freshwater flows on the thermohaline circulation and European climate - analysis and modelling of the last deglaciation (ORMEN)	2005–08	T. Dokken ◆
Marine climate and ecosystems in the seasonal ice zone (MACESIZ)	2003–06	O. M. Johannessen ◆
Norwegian Ocean Climate Projec (NOClim II)	2003–06	P. Haugan ◆
Past Climates of the Norwegian Regio (NORPAST II)	2003–06	A. Nesje ●
Paleo environment and climate history of the Russian Arctic (PECHORA II)	2003–06	J.I. Svendsen ◆
Polar Ocean Climate processes (PROCLIM)	2003–06	P. Haugan ◆
Regional Climate Development under Global Warming (RegCLIM III)	2003–06	S. Grønås ◆
Spatial and temporal variability of currents and transport of warm waters in the Nordic Seas (NUKA ARCTICA)	2002–06	H. Svendsen ◆
Variations of the Atlantic Meridional overturning circulation during rapid climate changes: calibration, modelling and palaeoceanographic observations (VAMOC)	2005–08	J. I. Svendsen ◆

◆ Leader ● Partner

Research projects funded by EU's 6th Framework Programme

TITLE	DURATION	TYPE	LEADER/SCIENTIST
Developing Arctic Modelling and Observing Capabilities for Longterm Environmental Studies - Integrated Project (DAMOCLES)	2005–08	IP ◆	P. Haugan
ENSEMBLE-based Predictions of Climate Changes and their Impacts (ENSEMBLES)	2004–09	IP ◆	H. Drange
European Network of Excellence for Ocean Ecosystem Analysis (EUROCEANS)	2004–08	NoE ◆	T. Johannessen
Marine carbon sources and sinks assessment (CARBOOCEAN)	2005–09	IP ●	C. Heinze
Meridional Overturning Exchange with the Nordic Seas (MOEN)	2002-05	RTD ●	S. Østerhus
Model and observation test climate feedback (MOTIF)	2003–06	RTD ◆	E. Jansen
Natural and anthropogenic modifications of the Sicycle along the land-ocean continuum: Worldwide Ecological, Biogeochemical and Socio-economical consequences (Si-WEBS)	2005–06	RTN ◆	C. Heinze
Patterns of Climate Variability in the North Atlantic (PACLIVA)	2002–05	RTD ●	E. Jansen
Proxies in Paleoclimatology: Education and Research (PROPER)	2003–06	MCTN ◆	E. Jansen
Role of ice-ocean-atmosphere processes in high-latitude climate change (Bjerknes MCTS)	2001–05	MCTS ●	P. Haugan
Quantitative palaeoclimatic reconstructions from lake sediments (QPALCLIM)	2001–05	MCTS ◆	J. Birks
Understanding the dynamics of the coupled climate system (DYNAMITE)	2005–08	STREP ◆	H. Drange

BCCR is ● Coordinator or ◆ Partner

MCTS: Marie Curie Training Site, NoE: Networks of Excellence; MCTN: Marie Curie Teaching Network; IP: Integrated Project; RTD: Research, Technology and Demonstration project; STREP: Specific Targeted Research Projects; RTN: Research and Training Network

Projects funded by other sources

TITLE	SCIENTISTS	FUNDING AGENCY
A Lagrangian study of pathways and mixing of Arctic and Atlantic waters in the Norwegian Sea (PATHMIX)	H. Søiland, K. A. Mork	BCCR & National Science Foundation, USA
Autonomous underway pCO2 sensors for VOS applications	R. Bellerby	National Oceanographic & Atmospheric Administration (NOAA)
Development of a web-based tool for modeling marine biogeochemical cycles	C. Heinze	World University Network
Eutrophication in the Baltic Sea	R. Telford	Nordisk Ministerråd
Filschner ice shelf water plume study	S. Østerhus	British Antarctic Survey
High-latitude climate variability and its effects on human settlement and fishery resources as revealed by fossil otoliths	C. A. Dahl	Meltzer Foundation
Palaeoclimate in the Southern Ocean	U. Ninnemann	COMER foundation

Selected publications

Bjerknes Scientists are indicated in bold

1) **Bakke, J., S. O. Dahl, Ø. Paasche,** R. Løvlie and **A. Nesje** (2005). "Glacier fluctuations, equilibrium-line altitudes and palaeoclimate in Lyngen, northern Norway during the Lateglacial and Holocene." *The Holocene* 15(4): 518–540.

2) **Bakke, J., Ø. Lie, A. Nesje, S. O. Dahl** and **Ø. Paasche** (2005). "Utilizing physical sediment variability in glacier-fed lakes for continuous glacier reconstructions during the Holocene, northern Folgefonna, western Norway." *The Holocene* 15(2): 161–176.

3) Delille, B., Harlay J., Zondervan I., Jacquet S., Chou L., Wollast R., **Bellerby R. G. J.**, Rankignoulle M., A. R. U. Vieira Borges and J-P. Gattuso (2005). "Response of primary production and calcification to changes of pCO2 during experimental blooms of the coccolithophorid Emiliania huxleyi." *Global Biogeochemical Cycles* GB2023, doi: 10.1029/2004GB002318.

4) **Drange, H., T. Dokken, T. Furevik,** R. Gerdes, and W. Berger (2005) Eds., The Nordic Seas: An Integrated Perspective. *AGU Monograph 158, American Geophysical Union, Washington DC,* 366 pp.

5) **Fer, I.** (2005). "Scaling turbulent dissipation in an Arctic fjord." *Deep-Sea Research II* 53: 77–95.

6) **Gao, Y., H. Drange, M. Bentsen** and **O. M. Johannessen** (2005). "Tracer-derived transient time of the eastern waters in the Nordic Seas." *Tellus* 57B: 332–340.

7) Hátún, H., **A.-B. Sandø, H. Drange,** B. Hansen and H. Valdimarsson (2005). "Influence of the Atlantic subpolar gyre on the thermohaline circulation." *Science* 309: 1841–1844.

8) **Heinze, C.** and N. Dittert (2005). "Impact of paleocirculation on the silicon redistribution in the world ocean." *Marine Geology* 214: 201–213.

9) Holbrook, W. S. and **I. Fer** (2005). "Ocean internal wave spectra inferred from seismic reflection transects." *Geophysical Research Letters,* L15604, doi: 10.1029/ 2005GL023733.

10) **Ingvaldsen, R.B.** (2005). "Width of the North Cape Current and location of the Polar Front in the western Barents Sea". *Geophysical Research Letters,* Vol. 32, L16603, doi: 10.1029/2005GL023440.

11) **Johannessen, O. M.**, K. Khvorostovsky, **M. W. Miles** and L. P. Bobylev (2005). "Recent ice sheet growth in the interior of Greenland." *Science* 310: 1013–1016.

12) Matthews, J. A., M. S. Berrisford, P. Quentin Dresser, **A. Nesje, S. O. Dahl, A. E. Bjune, J. Bakke, H. J. B. Birks, Ø. Lie,** L. Dumayne-Peaty and C. Barnett (2005). "Holocene glacier history of Bjørnbreen and climatic reconstruction in central Jotunheimen, Norway, based on proximal glaciofluvial stream-bank mires." *Quaternary Science Reviews* 24: 67–90.

13) **Meland, M., E. Jansen** and H. Elderfield (2005). "Constraints on SST estimates for the northern North Atlantic/Nordic Seas during the LGM." *Quaternary Science Reviews* 24(7-9): 835–852.

14) **Olsen, A.,** R. Wanninkhof, J. Trinanes and **T. Johannessen** (2005). "The effect of wind speed products and wind speed-gas exchange relationships on interannual variability of the air-sea CO2 gas transfer velocity." *Tellus Series B* 57(2): 95–106.

15) **Olsson, K. A.,** E. Jeansson, L. A. Anderson, B. Hansen, **T. Eldevik**, R.-. Kristiansen, M.-J. Messias, **T. Johannessen** and A. J. Watson (2005). "Intermediate water from the Greenland Sea in the Faroe Bank Channel: spreading of released sulphur hexafluoride." *Deep-Sea Research I* 52: 279–294.

16) **Omar, A.M.** and **A. Olsen.** 2005. Reconstructing the time history of the air-sea CO2 disequilibrium and its rate of change in the eastern subpolar North Atlantic, 1972–1989. *Geophysical Research Letters* 33, L04602, doi: 10.1029/2005GL025425.

17) **Østerhus, S.**, W. R. Turrell, S. Jónsson and B. Hansen (2005). "Measured volume, heat, and salt fluxes from the Atlantic to the Arctic Mediterranean." *Geophysical Research Letters* 23: L07603, doi: 10.1029/2004GL022188.

18) Polyakov, I. V., A. Beszczynska, E. C. Carmack, I. A. Dmitrenko, E. Fahrbach, I. E. Frolov, R. Gerdes, E. Hansen, J. Holfort, V.

V. Ivanov, M. A. Johnson, M. Karcher, F. Kauker, J. Morison, K. A. Orvik, U. Schauer, H. L. Simmons, **Ø. Skagseth,** V. T. Sokolov, M. Steele, T. L. A., D. Walsh and J. E. Walsh (2005). "One more step toward a warmer Arctic." *Geophysical Research Letters* 32 (17, L176050): 10.1029/2005GL023740.

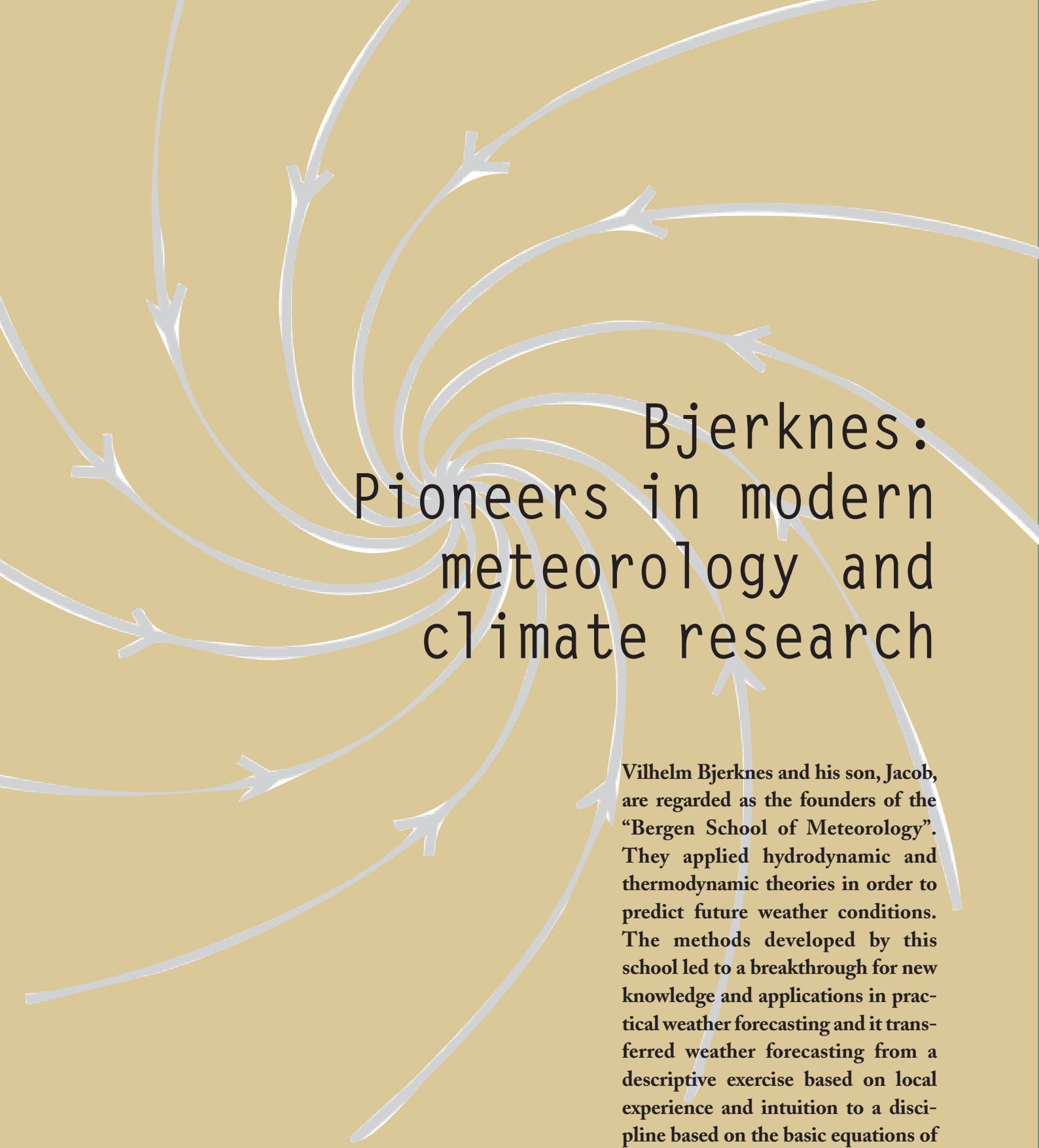
19) Smol, J. P., A. P. Wolfeb, **H. J. B. Birks**, M. S. V. Douglas, V. Jones, A. Korholai, R. Pienitz, K. Rühlanda, S. Sorvari, D. Antoniades, S. J. Brooksk, M.-A. E. Fallu, M. Hughesg, B. E. Keatley, T. E. Laing, N. Michelutti, L. Nazarova, M. Nymani, A. M. Paterson, B. Perrenh, R. Quinlanh, M. Rautio, E. Saulnier-Talbot, S. Siitonen, N. Solovieva and J. Weckström (2005). "Climate-driven regime shifts in the biological communities of arctic lakes." *Proceedings of the National Academy of Sciences PNAS* (10.1073/pnas.0500245102): 1–6.

20) **Sorteberg, A., T. Furevik, H. Drange** and **N.-G. Kvamstø** (2005). "Effects of simulated natural variability on Arctic temperature projections." *Geophysical Research Letters* 32(18): L18708, 10.1029/2005GL023404.

The complete listing of 62 peer reviewed publications for 2005 is available at http://www.bjerknes.uib.no/

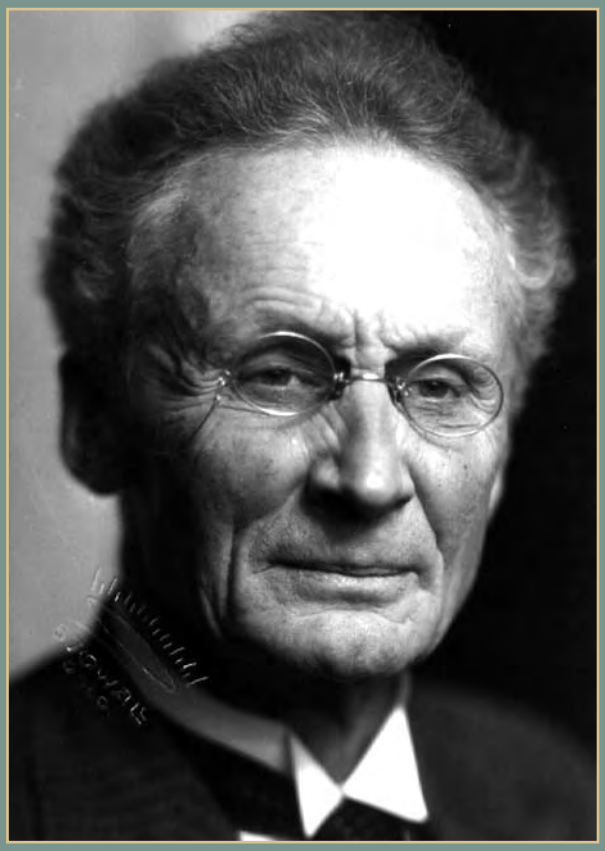
The complete listing of papers in the 2005 AGU monograph *The Nordic Seas: An Integrated Perspective* and ordering information is available at https://www.agu.org/cgi-bin/agubookstore

Terrain, vegetation and lakes in a palaeoclimate fieldwork area, Lyngen, northern Norway. Photo: Jostein Bakke.

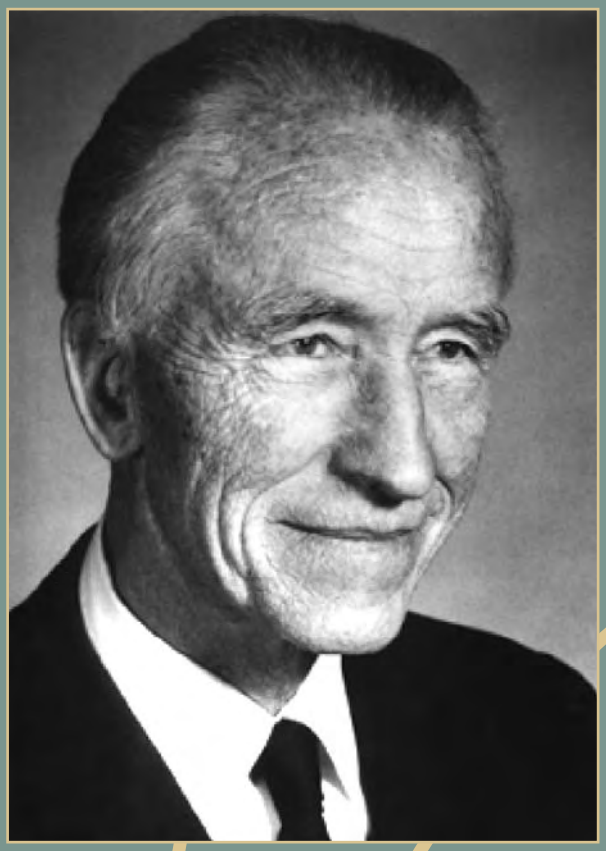


Bjerknes: Pioneers in modern meteorology and climate research

Vilhelm Bjerknes and his son, Jacob, are regarded as the founders of the "Bergen School of Meteorology". They applied hydrodynamic and thermodynamic theories in order to predict future weather conditions. The methods developed by this school led to a breakthrough for new knowledge and applications in practical weather forecasting and it transferred weather forecasting from a descriptive exercise based on local experience and intuition to a discipline based on the basic equations of fluid dynamics.



Vilhelm F.K. Bjerknes (1862-1951)



Jacob A.B. Bjerknes (1897-1975)

Thereafter, weather forecasting was based to a greater extent on scientific principles, with a much denser network of observation stations and later, with numerical prediction models. Bjerknes' work was vital to our understanding of the movements of air and ocean masses, in particular of how these result from thermal processes.

Vilhelm and Jacob Bjerknes conducted several studies that laid the basis for modern research on climate change and the role of the ocean in the climate system. The Centre is thus named as a tribute to their efforts.

Norwegian Centre of Excellence

Bjerknes Centre for Climate Research

Annual Report 2005

Centre of Excellence activities

Bjerknes Centre for Climate Research
Allégaten 55, N-5007 Bergen, Norway
Tel: +47 555 89803
Fax: +47 555 84330
post@bjerknes.uib.no
www.bjerknes.uib.no