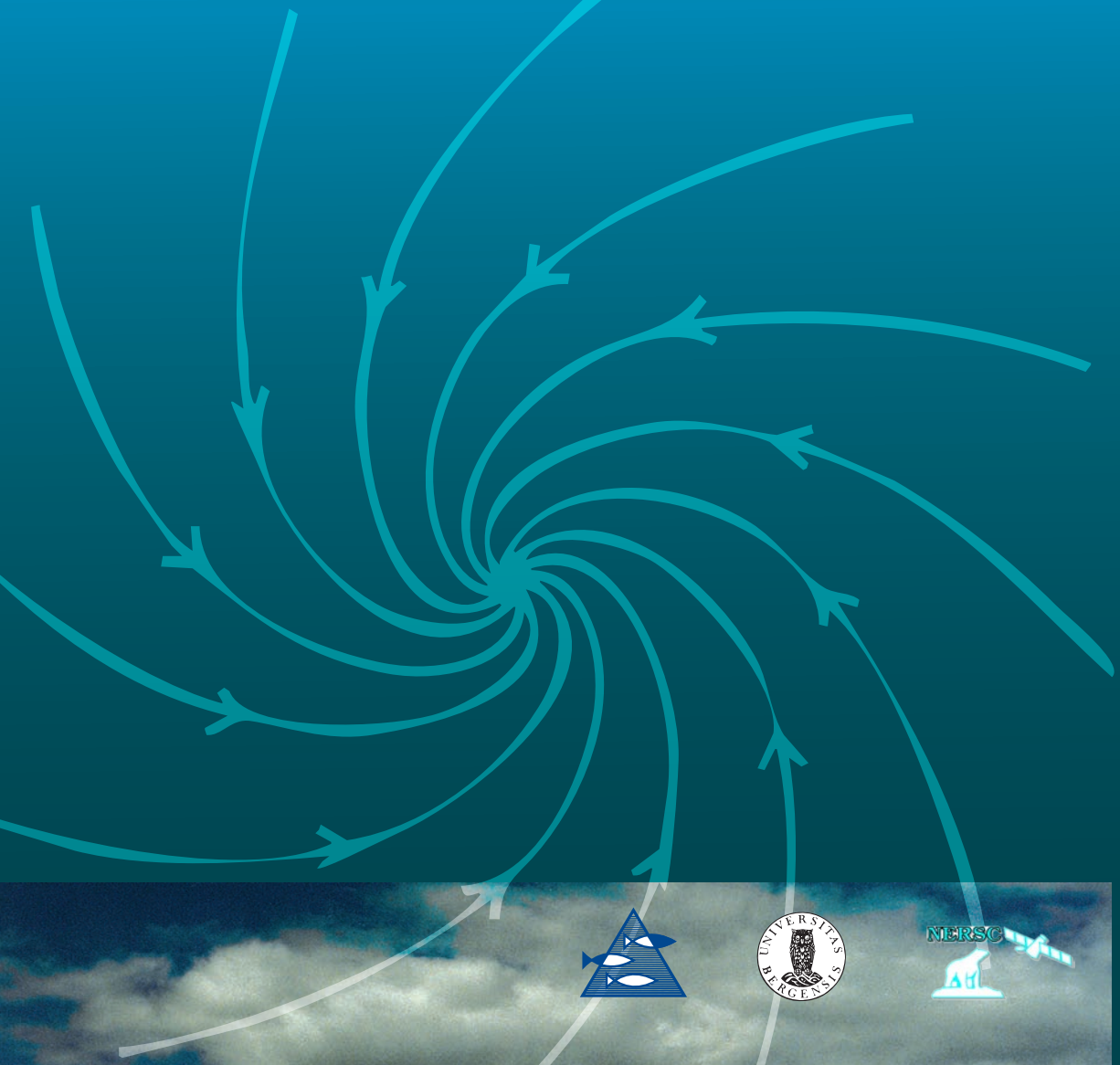
Norwegian Centre of Excellence

Bjerknes Centre for Climate Research

Annual Report 2003

Centre of Excellence activities



Some words from the Director

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 the key provider of top quality 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 (UoB), 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 the natural sciences in Norway and provides excellent opportunities to conduct top quality climate science in high-latitudes by virtue of its unique research infrastructure consisting of complementary installations, facilities, *state-of-the-art* equipment, services and extensive unique data series.

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

With the increasing levels of human-induced greenhouse gases in the atmosphere, climate changes will play a prominent role for society. Climate changes will have both regional and global impacts, and will affect natural systems, societies, economy and trade, and thereby the political processes. To underpin policymaking and public awareness, there is a pressing need for updated and accurate understanding of the magnitude and expression of climate changes. This should be based on the best available knowledge of the climate system and its operation.

The BCCR is a climate research centre with a key interdisciplinary competence encompassing climate observations (present and past) integrated with state-of-the-art climate modelling. The BCCR specifically aims to deliver key research results in order to understand and quantify regional climate changes in the context of the global climate system. It has a special focus on the role of the ocean in the climate system and the climate processes and climate variability in high latitude regions.

In the next years, the BCCR will address key processes of climate change and variability and climate change, both at the global and regional scale but with focus on the high latitudes, specifically the North Atlantic, the Nordic Seas and the Arctic. Through mobilisation of the resources of its three partner institutions, we hope that by 2012 the BCCR shall have:

- Enhanced our understanding of the causes and processes involved in abrupt climate changes in the past
- Detected key processes of the meridional overturning circulation: its variability and sensitivity to climate change
- Reduced the uncertainty of climate predictions for the high-latitude regions

Prof. Eystein Jansen

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RESEARCH STRATEGY

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

To reach this objective the research at the BCCR is organised in eight multi-disciplinary Research Activities (RA), which provide insight and answers to the following three 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 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 .*

The RAs are focused teams including scientists, students and technical staff that combine observations with numerical modelling. The eight RAs are:

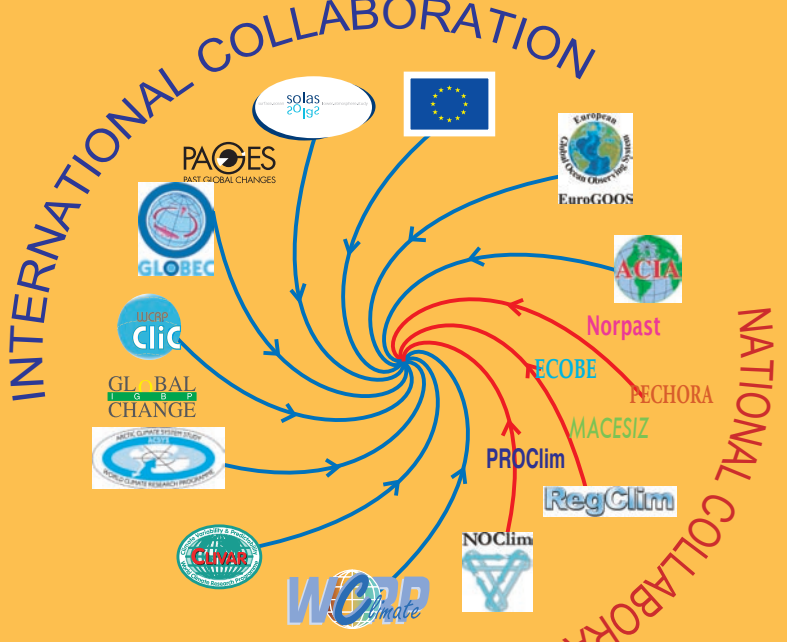
- RA 1: Rapid Climate Changes: causal connections
- RA 2: Atlantic Ocean circulation
- RA 3: Seasonal to multi-decadal variability
- RA 4: Dynamics of Holocene climate variability
- RA 5: Climate predictability and future climate change
- RA 6: Marine climate processes and feedbacks
- RA 7: High-latitude exchange processes
- RA 8: Carbon cycle and biogeochemistry

In addition to the RAs, the BCCR organises three discipline based fora for infrastructure, innovation, disciplinary development and quality control, as follows:

- Forum 1: Model systems and model infrastructure
- Forum 2: Ocean/atmosphere observations and observation systems
- Forum 3: Instrumental climate records

PARTNERSHIP & NETWORKS

The strength of the BCCR relies on the integration of existing expertise of its founding partners and exhaustive networking both at the national and international level.



THE BCCR APPROACH

The approach of the BCCR is to combine cutting-edge research with top-level education and outreach activities. The BCCR will:

- 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, 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.

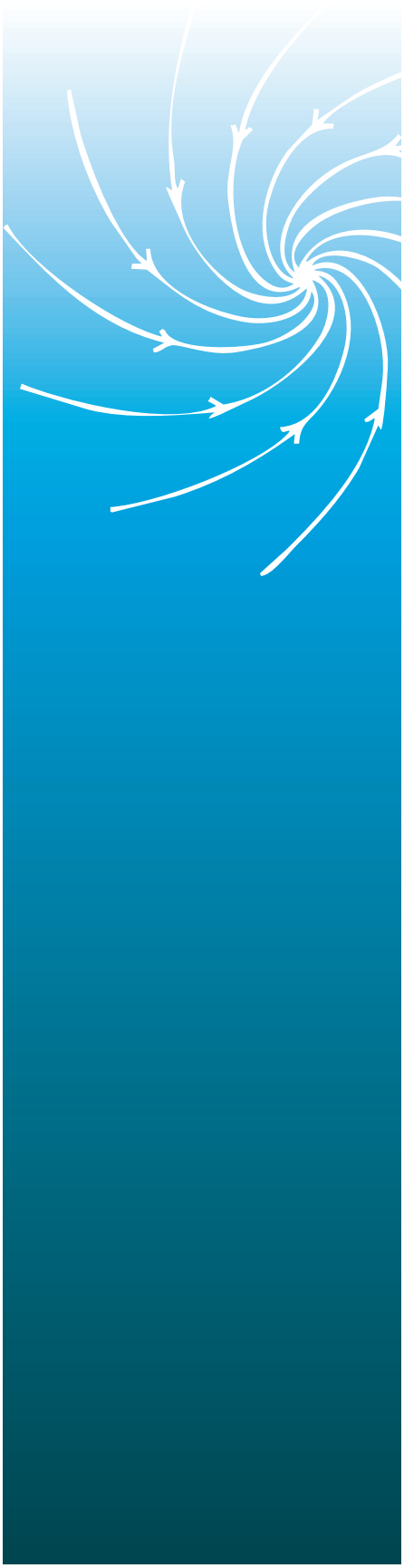
Assessment

In collaboration with the Scientific Advisory Board, an external panel of acknowledged climate scientists, the BCCR will be subject to annual critical assessments of the scientific advancement and the timely fulfilment of its objectives. The key evaluating criteria will be:

- High quality papers in peer-review, leading international journals addressing the objectives of the research Activities
- Multi-authorship across disciplinary boundaries within the BCCR
- International co-authorships and joint publications with new collaborative partners
- 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 2003, 60% of the PhD students at BCCR were women. Throughout its lifetime, the BCCR will proactively work to increase the number of female scientists at the leader and senior levels, by implementing a promotion and incentive plan.



SUMMARY OF ACCOMPLISHMENTS

During its first life year as a Center of Excellence the BCCR designed its research strategy, furnished working space to accommodate 24 new positions and purchased new research equipment. New research projects were launched while the Centre was involved in 28 project proposals which were submitted to the Research Council of Norway (RCN) spring call (6 proposals), the 2nd call of the EU 6th Framework Programme (13 proposals), and to the Joint UK/Dutch/Norwegian call for proposals –RAPID (9). New liaisons were established at the national and international level. The BCCR organised 17 meetings in Norway and Bjerknes scientists engaged in assessment/scientific committees and working groups of international research programmes. A total of 71 science articles, 1 book and 4 book chapters were published in refereed international journals, and 160 oral and poster presentations were made in national and international conferences and seminars. Bjerknes scientists contributed to the popularisation of scientific findings through popular articles, invited lectures and being present in the media.

New research

Ten research projects were launched in 2003 under the auspices of RCN major national programmes: Research programme on climate and climate change – KLIMAPROG (5 projects): Polar Climate Research - POLARKLIM (4) and Research programme on impacts of and adaptations to climate change KLIMA-EFFEKTER (1). Eight of these initiatives are coordinated by the BCCR. See page 17 for a complete listing of all on-going research projects at BCCR.

A proposal for an Integrated Project under EU 6th FP entitled CARBOCEAN, to be coordinated by the BCCR, passed the evaluations and will proceed to contract negotiations in 2004.

New Positions

- Recruitment positions: 10 PhD

students, 11 postdocs and 3 scientists

- New professor I in Carbon cycle modelling: Christoph Heinze, Max Planck Institute, Hamburg.
- 1 professor II in Atmospheric dynamics: David Stephenson, University of Reading, UK.
- 1 associate professor/professor in Dynamical oceanography. Position announced and presently under evaluation.
- 2 postdoc (K. Nisancioglou & O.H. Otterå) recruited to develop palaeoclimate modelling.
- 1 postdoc (H. Linge) to develop dating with cosmogenic isotopes

Education & Recruitment

In 2003 BCCR scientists provided supervision and training in climate research to 19 doctoral students, 7 of which defended their PhD dissertations (see box for details).

PhD dissertations in 2003

- Yonqi Gao. *Evaluation of the Ocean Ventilation Processes in an Isopycnic Coordinate Ocean General Circulation Model.* NERSC and Geophysical Institute, UoB
- Randi Ingvaldsen. *The Atlantic inflow to the Barents Sea.* Institute of Marine Research and Geophysical Institute, UoB.
- Jan E. Ø. Nielsen *Aspects of the Atlantic Flow through the Norwegian Sea.* NERSC and Geophysical Institute, UoB
- Abidrahman Omar. *Carbon dioxide in northern high latitude oceans: anthropogenic increase and air-sea flux variability.* Geophysical Institute, UoB and BCCR.
- Odd-Helge Otterå. *The sensitivity of the North Atlantic-Arctic climate system to isostatic elevation changes, freshwater and solar forcings.* NERSC and Department of Mathematics, UoB
- Ragnheid Skogseth. *Dense water production processes in Storfjorden.* Geophysical Institute, UoB and UNIS
- Ida M. Berstad. *Quaternary climate variability in the Eastern Nordic Sea region inferred from speleothemes and deep-sea cores.* Dept. of Earth Science, UoB.

Visiting Fellow Programme

BCCR sponsors a Visiting Fellow Programme that aims at fostering international research collaboration in climate change. In 2003, the Centre received the visit of 44 scientists from Europe (Denmark, France, Netherlands, Sweden, Switzerland, Germany, UK), Asia (India, Japan), South Africa and the USA.

Outreach activities

An important social mission of the BCCR is to enhance public awareness and understanding of key processes involved in the climate system and the potential consequences of climate change. In 2003, Bjerknes scientists contributed to the popularisation of its science through the publication of non-academic articles (27), invited lectures (17) and more than 30 chronicles, articles and interviews in newspapers, radio and TV.

International engagement

In 2003, Bjerknes scientists participated in a number of scientific or assessment committees and working groups from the following international programmes:

International Geosphere-Biosphere programme (IGBP):

- Surface Ocean Low Atmosphere Study (SOLAS)
- Climate variability and the responses of the Barents Sea (ESSAS/GLOBEC),
- PAGES´ international marine past global changes study (IMAGES)
- Integrated Marine Biogeochemistry and Ecosystem Research (IMBER)

Artic Council and the International Arctic Science Committee (IASC)

- Arctic Climate International Assessment (ACIA)

UK´s Natural Environmental Research Council and the Research Council of Norway

- Rapid Climate Change (RAPID)

Meetings

International conferences and workshops under the auspices of BCCR

- "ICES/Working Group on Oceanic Hydrography", workshop, Bergen 7 April
- "POLARCLIM2 land-ocean workshop", workshop, Bergen 8-9 May
- "International Conference on Climate Change Research in the Arctic – Future Challenges", Svalbard 25-27 July 2003.
- "IMAGES/Holocene Working Group", workshop, Hafslo 27-29 August
- "Ventilation, pathways and overflows of the Nordic Seas", workshop Bergen 7-8 October,
- "High latitude climate change and carbon biogeochemistry", workshop, Bergen 6-7 November

Seminars and meetings organised by BCCR in Bergen:

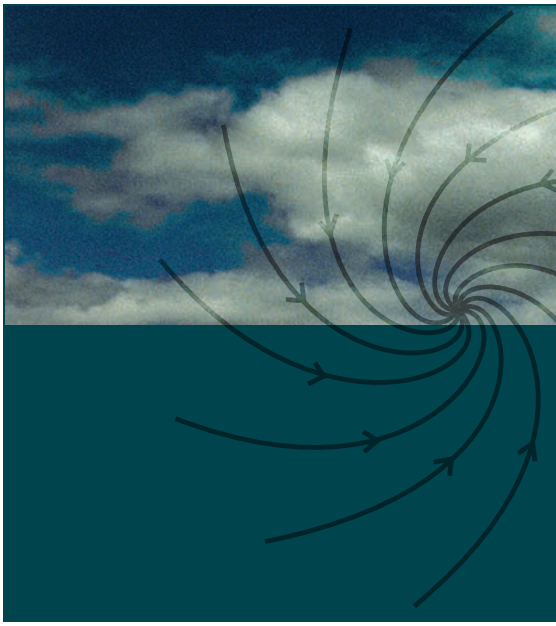
- "Process modelling", Feb 3
- "The thermohaline circulation", Mar 13
- "Meridional overturning exchange with the Nordic Seas (MOEN)", kick-off workshop organised by BCCR, Mar 20-21, Bergen
- "Polar Day", RCN seminar, May 13
- "Bjerknes Days", May 22-23
- "Antarctic Day", June 12
- "Inertial coupling hypothesis", Sept 12
- "Paleo proxies", Sept 23
- "NOClim/PROClim meeting", Sep28-Oct 3
- "Time series analyses", Oct 14

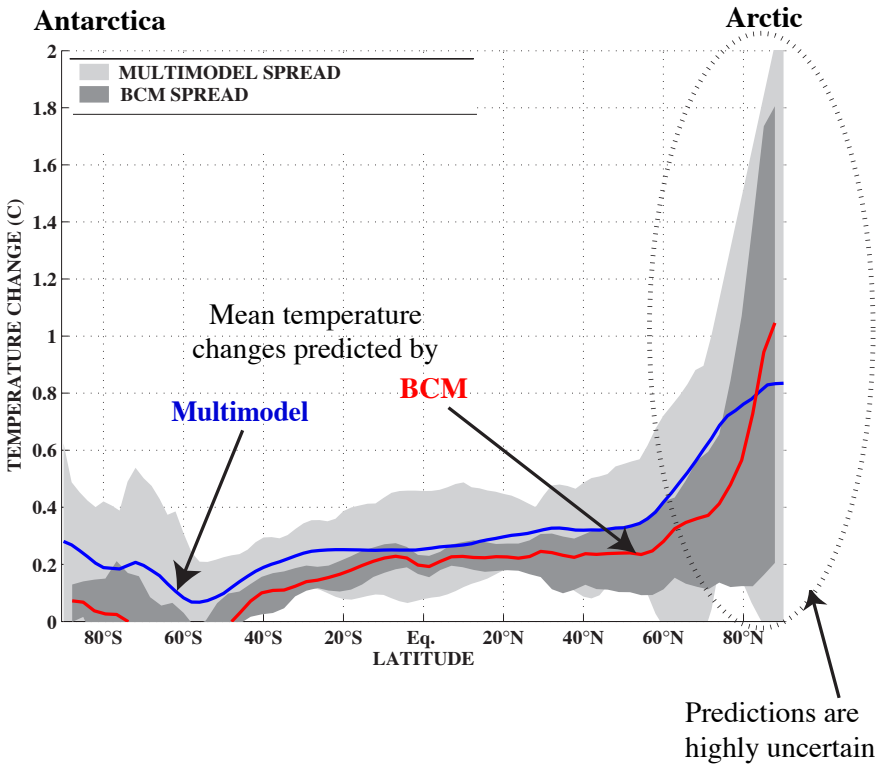
Future climate variability in the high latitudes

Scenario simulations of future climate changes due to increased levels of greenhouse gasses predict not only the strongest warming over the Arctic but also the largest uncertainty. The strong warming is due to enhanced positive feedbacks that exist in the region. A crucial aspect is, however, that the same feedback will also amplify the natural variability inherent to the climate system. Thus, future climate changes in the Arctic will be very much dependent on both changes due to anthropogenic influence as well as natural variability of the climate system. This implies that the uncertainty of model predictions may be due both to differences between models (e.g. level of sophistication or resolution) and to the natural variability of the climate system. In order to investigate how much of the divergence among the models is related to the natural variability, an ensemble of scenario simulation using the coupled Bergen Climate Model (BCM scenario) with different initial conditions was conducted and compared to the simulations of 15 different models (multimodel scenario). The experiment consisted in simulating the climate response to a 1% per year increase in atmospheric CO_2 until doubling of the atmospheric CO_2 concentrations was reached. The figure shows outputs of such ensemble simulations averaged over the first 30 years. Changes in temperature vary with latitude and increases towards the north pole, clearly indicating that the Arctic will be the most sensitive region to future global warming. However, and more important, the region has the largest "spread" around the average, which means that model predictions for the Arctic are highly uncertain. For instance, BCM predicts that the mean annual temperature change over the next 1-30 years, in the Arctic will be, on an average, 0.6°C higher than today, but the spread around the mean (=uncertainty) indicates that the increment can be as low as 0.2 or as high as 1.2°C. And the predictions of the multimodel ensemble are even more uncertain.

The large spread in the BCM ensemble strongly emphasises that the divergence of multimodel ensembles from a single solution should be seen both as a manifestation of real intermodel differences and also the fact that the model spread partly represent the frequency distribution of the natural behaviour of the climate system. Quantifying and decreasing the uncertainty in model predictions is one of the main scientific goals of the BCCR.

Scientists involved: Asgeir Sorteberg, Nils Gunnar Kvamstø, Helge Drange & Tore Furevik. ***Project:*** RegClim





The simulated changes in air temperature assuming 1% increase of CO_2 in the atmosphere, averaged over the next 30 years and at different latitudes between the poles, as predicted by a number of models. Red and blue lines indicate the average temperature increase calculated by the BCM ensemble and the multimodel ensemble respectively, while the spread (=uncertainty) around the mean is indicated in tones of grey

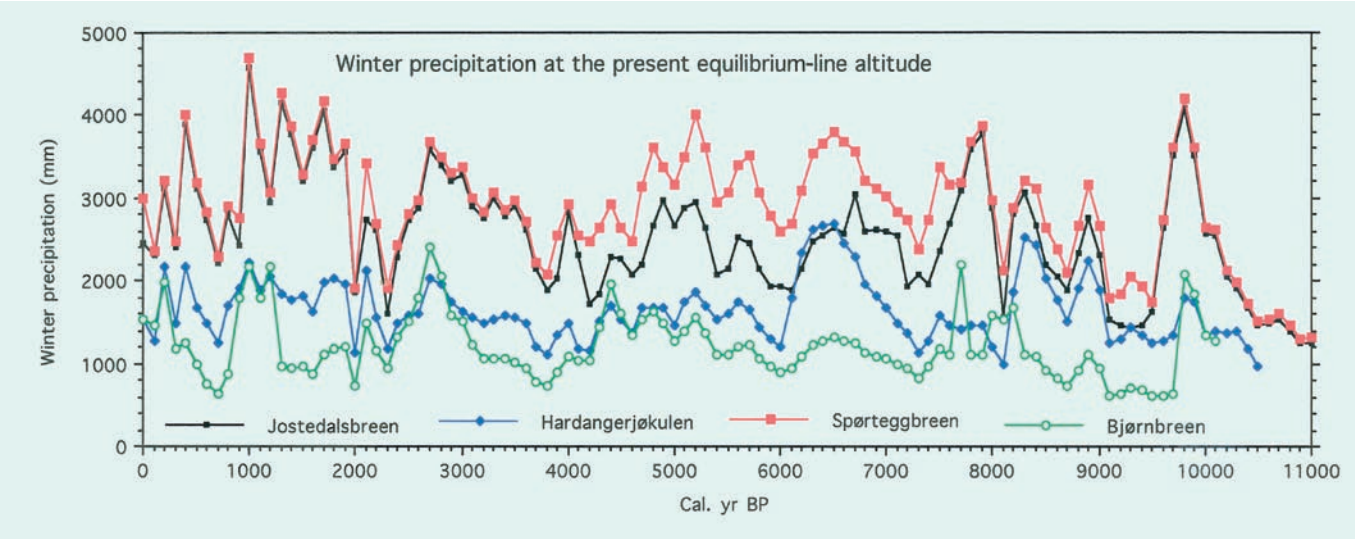
The Bergen Climate Model (BCM) a state-of-the-art global coupled atmosphere-sea ice-ocean general circulation model developed jointly by the Geophysical Institute, UoB and NERSC

Winter precipitation over Norwegian glaciers reconstructed for the past 10,000 years

The size variations of glaciers are mainly a function of winter precipitation (which promotes the formation of new ice) and summer temperatures (which melts the ice), two factors that are in turn sensitive to climate change. It has been inherently difficult to reconstruct winter precipitation beyond the instrumental period (ca. AD 1860) and the period with historical data (early 18th century). In this regard, Bjerknes scientists have developed a methodology that allows reconstruction of winter precipitation by combining data of equilibrium-line altitude variations (inferred from glacier-size variations) and summer temperatures derived from pollen buried in lakes. This novel method, now being adopted by glaciologists world-wide, has allowed the reconstruction of winter precipitation throughout the Holocene (past 10,000 years) at several glaciers in southern Norway at higher temporal resolution than previously possible (See figure). Although fluctuations in winter precipitation are large, the pattern and trends are similar among the glaciers under study, indicating that they are influenced by the same climatic forcing. Indeed, BCCR scientists found a correlation between glacier mass balance and the variability exhibited by the North Atlantic Oscillation (NAO), the largest atmospheric circulation pattern in the North Atlantic influencing the intensity and direction of the Westerlies reaching Europe. This relationship indicates that glaciers expand when NAO is in a positive phase, i.e. rainy and mild winters over Northwest Europe and *vice versa*. The reconstruction of natural climate variations during the Holocene provide key knowledge for the understanding of the magnitude and intensity of present climate changes.

Scientists involved: Atle Nesje, Anne E. Bjune, S.O. Dahl, Jostein Bakke, Øyvind Paasche, Øyvind Lie, John Birks & Hilary Birks. ***Projects:*** NORPEC and NORPAST.

Winter precipitation over 4 glaciers in Norway (Jostedalsbreen, Hardangerjøkulen, Spørteggbreen and Bjørnbreen) reconstructed for Holocene. Peaks of precipitation are related to mild and humid winters, which in turn correlates with fluctuations of the North Atlantic Oscillation (NAO)



The influence of tropics-high latitude processes on ocean conveyor belt

Central questions in climate research are: What drives the "motor" of the ocean conveyor belt? How resilient is this motor to human-induced global warming? Lack of knowledge of the processes involved is responsible for major uncertainties in the assessments of future climate

Bjerknes scientists are focusing on an important aspect of this field: How does climate variability in the tropics influence the climate of the high latitudes, and what are the feedback mechanisms involved. In a model experiment with the Bergen Climate Model (BCM) a number of complex feedback mechanisms between atmosphere, ocean and sea ice have been identified. The results indicate that the conveyor can be quite robust to enhanced input of freshwater to the Arctic Ocean and the Nordic Seas, partly due to the counteracting effect of anomalously build up and northward transport of saline waters in the tropical Atlantic (Figure 1).

Furthermore, the BCM model experiment shows that anomalous freshwater input to the Nordic Seas triggers changes in the wind-driven circulation, intensifying a coupled North Atlantic Oscillation-like response that tends to maintain the eastern branch of the of Atlantic water entering the Nordic Seas.

Finally, a warming of the thermocline waters is found in the western tropical North Atlantic region (Figure 2), while the high latitudes experiences a general cooling due to the weaker ocean conveyor. This anti-phase response in BCM, i.e. that the tropics warm when the high latitudes cool, is consistent with palaeoclimatic records of abrupt changes 10.000-18.000 years ago, highlighting the potential importance of the tropical Atlantic region for detecting large-scale changes in the past.

The implications from this research are that the climate responses to a reduced ocean conveyor belt, such as temperature and salinity variations in the tropical Atlantic, may be used as indicators of changes in the large-scale ocean circulation and possibly as monitor-parameters of the stability of the conveyor under global warming.

References:

Otterå et al. (2004), *Tellus* 56A, 342-361;
Otterå & Drange (2004), *Tellus* 56A: 154-166;
Otterå et al. (2003), *Geophys.* Res. Let., 30,1898, doi:10.1029/2003GL017578

Projects involved: RegClim and NOClim, Norway; "Programme for Supercomputing", NNSF, China

Figure 1
Model simulation of the changes in salinity and current speed over the tropical and sub-tropical Atlantic (in the upper 600 m water column) after 50 years of enhanced freshwater input to the Arctic Ocean and the Nordic Seas. The model predicts a build-up of highly saline waters due to the increased residence times of the waters in the western Atlantic caused by the reduced surface velocities here.

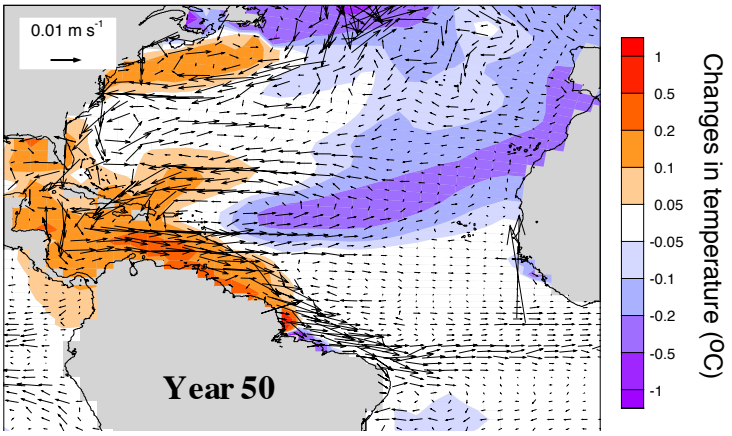
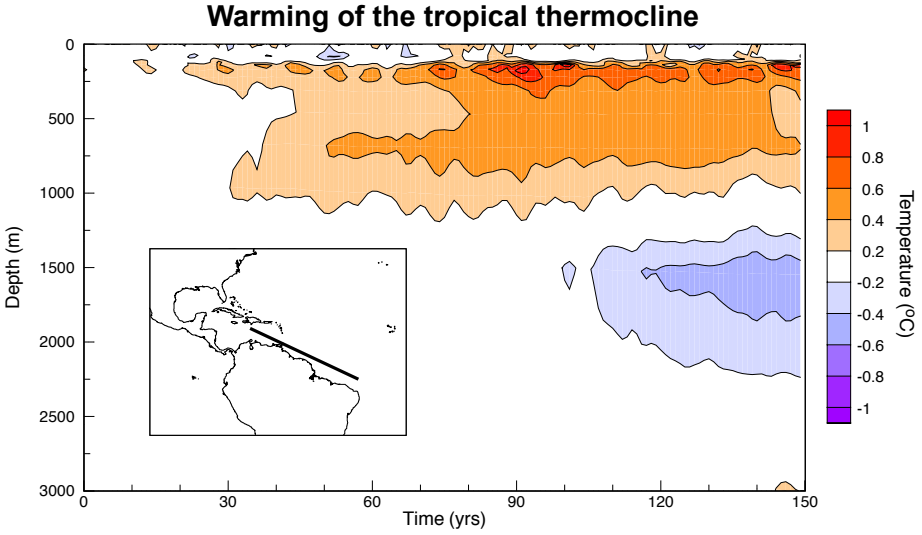


Figure 2
Temporal evolution of the changes in temperature in the tropical Atlantic in a BCM model simulation with enhanced freshwater input to the high latitude seas. The model predicts a warming of the thermocline along the Guyana Current starting around year 50 and persisting throughout the simulation.



Extreme weather events

If there is something we can say for sure about extreme weather events is that we don´t know when and where they will strike. From historical records and water discharge measurements, scientists have now a good overview of incidence of extreme events in the past centuries. Prehistoric storms and floods are, however, difficult to reconstruct, but their signal can be found as light-coloured layers of lake sediments.

Even though floods and other weather extremes are no more than "momentary" events at the geological time scale, there is no doubt climate extremes can severely impact human infrastructure and everyday life (e.g. entire civilizations have collapsed because of extreme climate events).

Evidence shows that the frequency of river floods has increased over the last 100 years in Europe. It is important, however, to elucidate whether this is a trend or just another expression of what we should consider as "normal", i.e. due to natural variability. A study carried out in a small lake in the Glomma catchment area in southern Norway, has revealed as many as than 100 flood events in the last 10,000 years. Their intensity and frequency have been related to existing reconstructions of large atmospheric circulation patterns, such as the North Atlantic Oscillation (NAO), winter precipitation and summer temperatures during the Holocene.

When it comes to ability to predict floods with model simulations, this is still hampered by the lack of more detailed information of past events, beyond that of long-term trends and average weather. Thus, Bjerknes scientists work towards an increased understanding of flood patterns, their variability and frequency and potential connections with climatic processes in order to improve the capability to predict extremes of weather in a time of climate change.

Scientist involved: Anne-Grethe Bøe Pytte, S. O. Dahl, Øyvind Lie and Atle Nesje.
Project: "Holocene summer & winter climate variability in Norway in the past, present and future: effects on nature & society" - HOLClim

Aerial view of Øyeren, SE Norway, during the 1995 flood

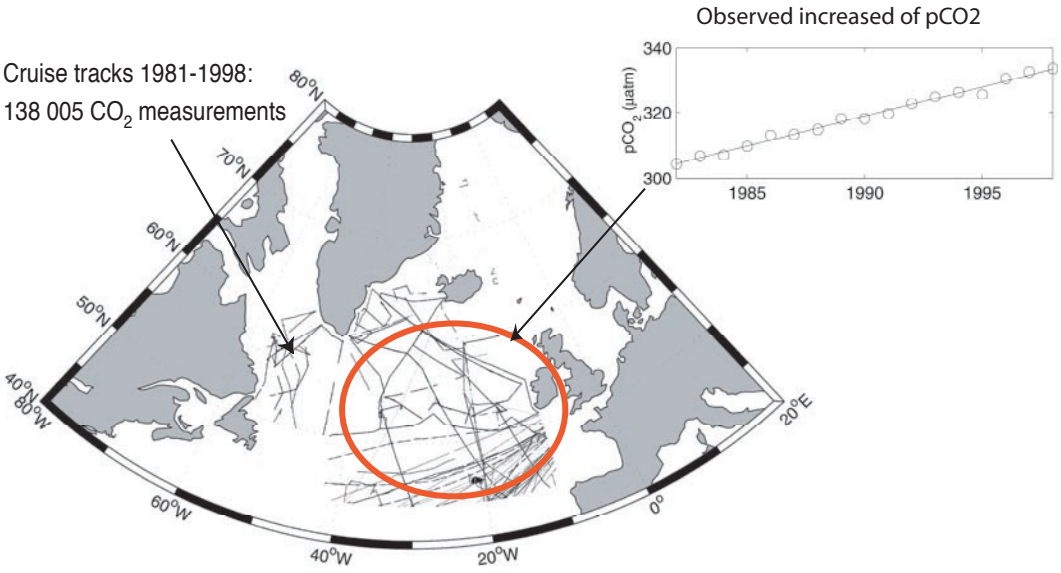
The ocean as a sink for CO2: the story is changing

The oceans and land have acted as sinks for the excess carbon dioxide (CO_2) emitted by human activities throughout the post-industrial era, and nearly 50% of the CO_2 that humans have pumped into the atmosphere over the last 200 years have been absorbed by the sea. However, it is not certain that these sinks will continue to operate unabated into the future as evidence grows that future climate change and human induced alterations of the global carbon cycle will likely lead to a reduction of the strength of both the oceanic and land sinks. In this regard, the BCCR is paying particular attention to the behaviour of the North Atlantic, the Nordic Seas and the Barents Sea. The analysis of over 100,000 underway seawater measurements of the partial pressure of CO_2 (pCO_2) taken during 220 cruises carried out between 1981 and 1998 in the North Atlantic subpolar gyre reveals that the partial pressure of carbon dioxide in the surface ocean is increasing at similar rate, if not faster, than the CO_2 partial pressure in the atmosphere. This means that the capacity of the North Atlantic carbon sink is changing and that it is not longer removing carbon dioxide from the atmosphere as effectively as before.

The reasons for this change in behaviour are not yet understood, as the carbon cycle involves a wide and complex range of physical and biogeochemical processes. Scientists speculate that the region is receiving CO_2 enriched waters from the tropical Atlantic, which in turn is outgassing less CO_2 than before (i.e. more carbon dioxide is being retained in tropical surface waters). Other possible factors (or a combination of these) are a reduction in the primary production, changes in the buffer capacity of seawater, increase in sea surface temperature and decrease of the mixing of deep waters.

This has important implications for present model predictions of the sources and sinks of CO_2 in that they are biased by inadequately assuming that: (i) the ocean will passively continue to soak carbon dioxide as CO_2 in the atmosphere continues to increase, and that (ii) aspects of the biology, chemistry and hydrology of the oceans remain unchanged with time. The present findings clearly shows that CO_2 parameters should not be constants in models and that their interannual variability should be taken into account in order to realistically predict future changes in the oceanic CO_2 sink. This research is enhancing the understanding of the global carbon cycle and its feedback mechanisms, which will be essential to improve the predictive capability of climate models. Twenty years of carbon measurements are giving results and emphasises the need for the maintenance of existing monitoring systems and implementation of novel ones, as a way to detect early signals of climate change.

Scientists involved: Are Olsen, A. Omar, T. Johannsessen, R. Bellerby, I. Skjelvan (BCCR); Cooperation: A. Watson & N. Lefèvre, University of East Anglia, UK; A.F. Rios & F.f. Perez, CSIC Spain, L. Anderson, Goteborg University, Sweden. ***Projects:*** CAVASSOO & NOCES (EU), NUKA Arctica (RCN)



CO_2 partial pressure in the surface ocean are increasing at a rate close or grater than atmospheric CO_2. This means that the capacity of the North Atlantic to absorb CO_2 from the atmosphere is decreasing

What drives the inflow of Atlantic water to the Arctic Ocean?

The Norwegian Atlantic Current, which serves as a conduit of warm and saline water from the North Atlantic to the Arctic Ocean through the Norwegian Sea, is an important factor for the ecology and climate of our region. The flow varies largely from year to year but the causal factors for the fluctuations in this flow are not yet fully understood. Identifying the main factors controlling the variability of the Norwegian Atlantic Current in its passage to the Arctic is one of the research topics of the BCCR.

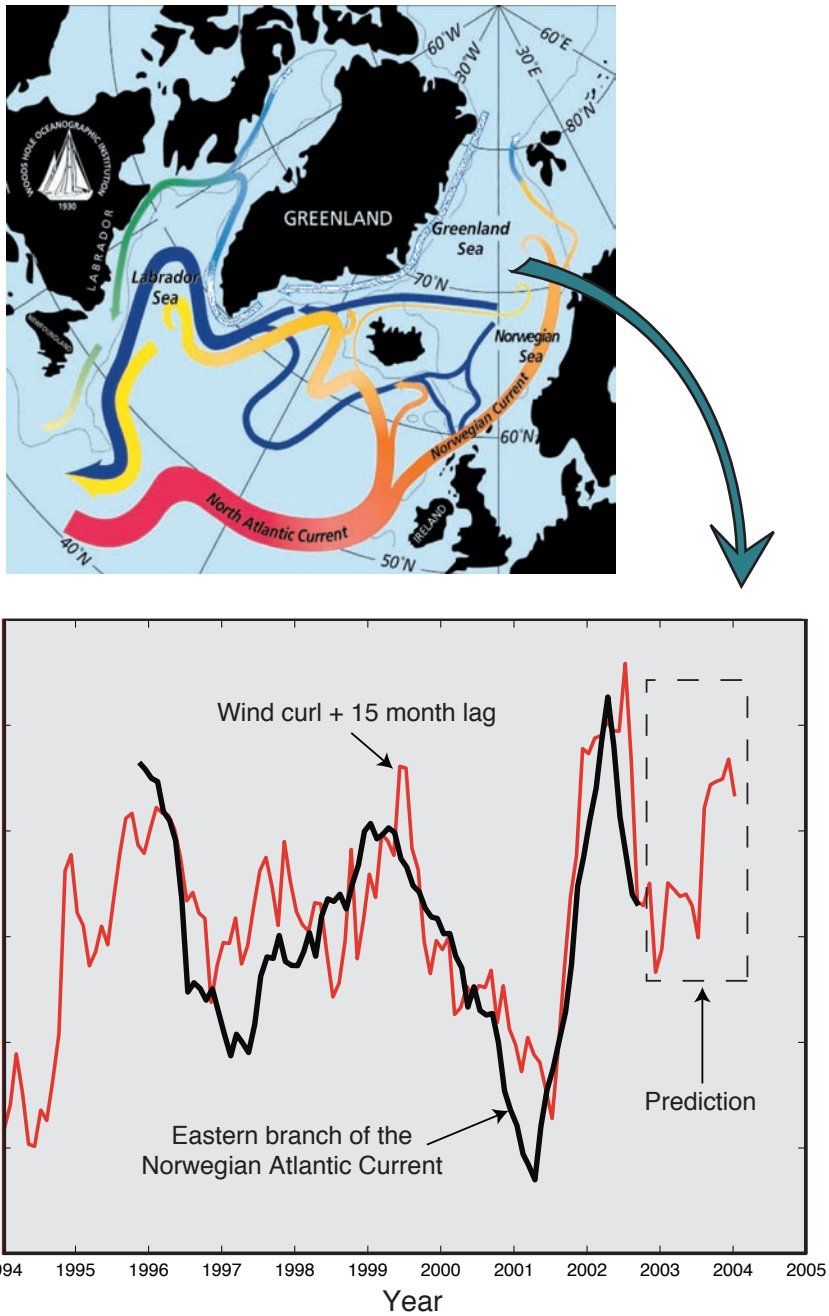
By combining direct current measurements with satellite data (an indirect measure of speed and direction of the flow) of the Norwegian Atlantic Current two distinctly different mechanisms have been identified controlling variability, in time and space, of the eastern branch of this current:

1) Annual variations: Results indicate that the dominant variation is a large-scale pattern in phase from west of Ireland to the Spitzbergen and linked to a North Atlantic Oscillation-like atmospheric circulation pattern

2) Interannual variations: A significant relationship was found between changes in the current flow and the curl of the wind field in the northern North Atlantic 15 months earlier (Figure). This time lag appears to be in accordance with the curl of the wind field changing the oceanic density field in the ocean with corresponding changes in the strength of the North Atlantic Current. Through interaction with topography this appear as a depth-independent response downstream in the Norwegian Sea.

Most importantly this study suggests a possibility of predicting conditions influenced by the eastern branch of the Norwegian Atlantic Current more than a year in advance.

Scientists involved: Øystein Skagseth, Kjell Arvid Orvik & Tore Furevik (BCCR & Geophysical Institute, UoB). ***Project***: NOClim



Time series representing the variability of the eastern branch of the Norwegian Atlantic Current compared to the curl in the wind field in the northern North Atlantic, shifted 15 months forward. The 15-month time lag indicates that the fluctuations of the current might be predicted.

New collaboration and initiatives

Opening of the Nansen-Zhu International Research Center

The BCCR is funding partner of the Nansen-Zhu International Research Center (NZC) which was officially opened on November 4th in Beijing by Børge Brende, the Norwegian Minister of Environment. The research of the NZC will focus on climatic couplings between the low and high latitudes. The Centre will facilitate and strengthen a two-way communication and exchange of knowledge and ideas, personnel, tools and results between the climate research groups in Bergen and Beijing.
NZC is co-lead by Prof. Huijin Wang from the Institute of Atmospheric Physics, Chinese Academy of Sciences, and Prof. Helge Drange, NERSC/BCCR.
NZC web site: http://nzc.iap.ac.no/

Børge Brende officially opens the Nansen-Zhu Center in Beijing

Worldwide University Network (WUN)

In 2003, the University of Bergen joined the Worldwide University Network (WUN), as one of a small group of European universities that were invited to participate. WUN comprises 11 of the foremost research-led Universities in the USA, UK and China with the goal to foster collaborative research through training opportunities and educational innovation.

The BCCR was chosen to contribute to one of WUN´s grand challenges "Oceanography and Climate". WUN web site: http://www.wun.ac.uk/

IPCC IV Assessment Report on Climate Change

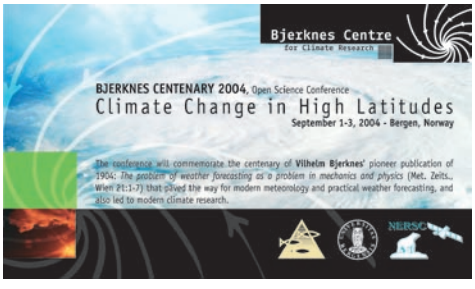
The Intergovernmental Panel on Climate Change started the preparations for its next report for publication in 2007. In this regard, the director of BCCR, Prof. Jansen, was invited to be Coordinating Lead Author for Chapter 6: "Palaeoclimate" of the Working Group 1 contribution to the IV assessment report. In addition, BCCR will perform a number of model simulations and scenario predictions with focus on climate changes in the Nordic region and in the Arctic in a global context and the probability of change including possible extreme events in the ocean and atmosphere of the region.
IPCC web site: http://www.ipcc.ch/

New book: Climate Variability of the Nordic Seas

Preparations of a book edited by the BCCR started this year. The book is entitled: Climate "Variability of the Nordic Seas" and will summarize and present new knowledge about the variability of the climate in the region. The book includes 24 chapters and it will be published in the American Geophysical Union Monographs Series in 2004.

Bjerknes Centenary 2004: an international science conference

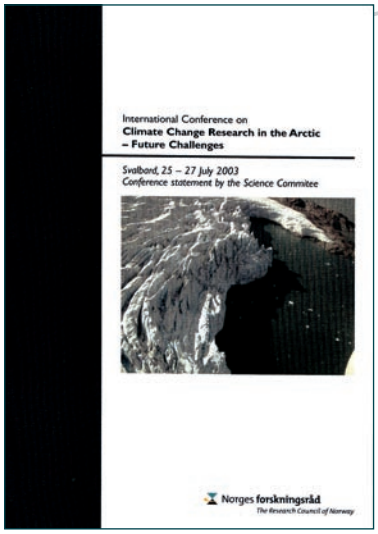
The BCCR started the organisation of an open science conference to be held in Bergen in September 1-3 2004. The event is entitled: "Climate Change in High Latitudes" and will focus on climate change in polar and subpolar regions by featuring keynote talks by invited speakers, plenary and poster presentations and discussion forums. Fifteen world-class climate scientists agreed to constitute the scientific programme committee. This event will commemorate 100 years of Vilhem Bjerknes pioneer publication of 1904 that paved the way for modern meteorology and many applications in practical weather forecasting About 300 climate scientists are expected to gather in Bergen.



Highlights from international meetings

International Conference on Climate Change Research in the Arctic – Future Challenges. Svalbard, 25-27 July 2003

This conference was a meeting point between scientists and policy makers to address the many pressing issues regarding ongoing and future climate changes in the Arctic. Leading research groups and institutions in the field of climate change from Europe, Asia and USA broadly represented the sciences. At the political level, the attendants were: Norwegian Minister for Research and Education Kristin Clemet, EU Commissioner Philippe Busquin and Executive Director from the office of Science and Technology Policy at the White House Kathie Olsen. This gathering was very fruitful and led to a broad overview of status of present knowledge, research challenges and a number of research policy measures. The Norwegian Minister of Education and Research hosted the conference in close cooperation with the Research Council of Norway, in dialogue with the Research Directorate General of the European Commission. Prof. Eystein Jansen from BCCR chaired the Science Committee.



IMAGES Holocene Working Group Workshop, Hafslo 27-29 August 2003

The small community of Hafslo hosted the gathering of fifty world class climate researchers from Europe, Asia, Canada and the USA. The purpose was to analyse the causes and processes involved in the climate changes throughout the Holocene, i.e. the past 10,000 years. The meeting focus on the role of the ocean in the climate system and posed questions such as: what caused major climate changes prior to the influence of humans? how do tropical processes, such as El Nino, influence climate changes in the North Atlantic? and: Will glaciers melt away in the coming century? The workshop was jointly organised by the International Marine Past Global Changes Study (IMAGES) and the BCCR, and was led by Prof. Eystein Jansen, BCCR and Peter deMenocal from Columbia University. The workshop proceedings will be published in 2004 in a special issue of Quaternary Science Reviews

The Nigard Glacier provides an impressive background to workshop participants, guided to the glacier by Atle Nesje, BCCR

A Trans-Atlantic Co-operative Research Conference on Climate Change and New Energy Technologies: Policies, Agreements and Processes to Protect the Global Climate. Washington D.C. 6-8 October 2003

The conference was organised by The Norwegian Research & Technology Forum in the U.S./Canada, under the auspices of the Royal Norwegian Embassy in Washington D.C. The event seek to foster relations for further scientific and industrial research, to educate the various participants about the activities and concerns of those from other areas, and to present suggestions for future collaborative activity. Consensus was established among the participants that a major problem in generating action on the climate change issue is the time lag, or lack of sense of immediacy, and how to make it "worth it" to change behaviour to alleviate climate change. Another paramount consideration is that climate change will affect different areas of the globe differently; with concomitant impact on national interests in developing environmental policies. There was consensus towards the need for joint government-industry projects and cooperative bilateral opportunities between the US and Norway in both climate research and low-carbon energy technology. These ideas will be best examined in follow up meetings between the major stakeholders and participants at the Forum. Asgeir Sorteberg, invited Bjerknes scientist, held a presentation entitled: "Climate modelling: Uncertainties and strategies to reduce them."

BUDGET

Funding sources

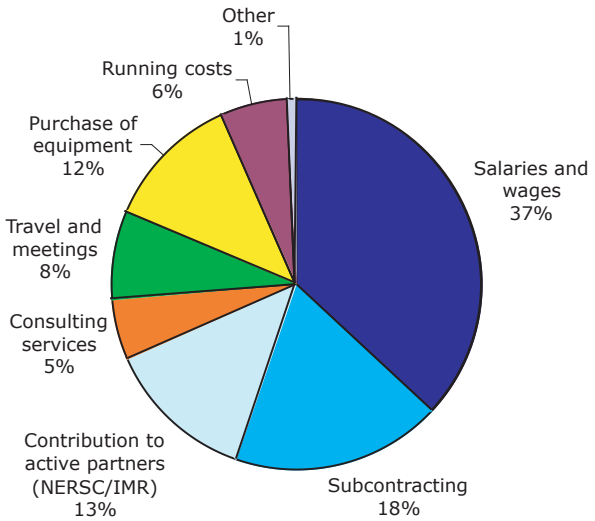
About 30% of the BCCR budget is provided by grants from the Research Council of Norway. The contribution of the University of Bergen, the host institution, accounts 37% of the budget in the form of in-kind support of faculty and recruiting positions, infrastructure, ship-time, and communications. BCCR partners, the Institute of Marine Research (IMR) and the Nansen Environmental and Remote Sensing Centre (NERSC), contribute 12% of the total. Research grants (projects) provided 21% of the income, both from national (e.g. RCN, industry, etc) and international (e.g. EU, international agreements) funds.

Funding Sources	MNOK
RCN*	19.0
UoB	23.6
NERSC	3.5
IMR	3.5
Research grants (national funds)	9.0
Research grants (international funds)	4.5
Total	**63.1**

* Grants from the Research Council of Norway to the CoE and to Strategic Research

Expenditures

Salaries and wages, subcontracting and contribution to the active partners NERSC and IMR comprised the largest amount of BCCR expenditures (68%) during 2003. Other expenditures included purchase of equipment (12%). travels and meetings (8%), consultant services (5%) and running costs (6%).



PERSONNEL AT A GLANCE

Nationalities in parenthesis

Leader Forum

Eystein Jansen, Professor	Palaeoclimatology	Director
Trond Dokken, Scientist	Palaeoclimatology	RA1 Leader
Kerim Nisancioglu, Postdoc	Palaeoclimatology	RA1 Co-leader
Helge Drange, Professor	Climate modelling	RA2 Leader
Helga F. Kleiven, Postdoc	Palaeoclimatology	RA2 Co-leader
Tore Furevik, Ass. Professor	Climate modelling	Deputy director RA3 Leader
Ina Kindem, Postdoc	Stratospheric physics	RA3 Co-leader
Atle Nesje, Professor	Palaeoclimatology	RA4 Leader
Odd Helge Otterå, Postdoc	Climate modelling	RA4 Co-leader
Asgeir Sorteberg, Scientist	Climate modelling	RA5 Leader
Svein Sundby, Professor	Ocean climates	RA5 Co-leader
Tor Eldevik, Scientist	Ocean processes & modelling	RA6 Leader
Peter Haugan, Professor	Polar oceanography	RA6 Co-leader
N.G. Kvamstø, Scientist	Atmospheric modelling	RA7 Leader
Frode Flatøy, Scientist	Atmos. chemistry & modelling	RA7 Co-leader
Christoph Heinze (Germany), Professor*	Carbon cycle modelling	RA8 Leader
Are Olsen, Postdoc	Biogeochemistry	RA8 Co-leader
Truls Johannessen, Professor	Chemical oceanography	

* from 1.1.2004

Research Staff

Bjørn Ådlandsvik	Physical oceanography & modelling
Carin Andersson Dahl	Palaeoclimatology
Lars Asplin	Physical oceanography & modelling
Richard Bellerby (UK)	Biogeochemistry, co-leader F2
Hilary Birks (UK)	Numerical methods in palaeoclimatology
John Birks (UK)	Terrestrial biological climate proxies
Paul Budgell (Canada)	Ocean modelling, co-leader F1
Svein Olaf Dahl	Glaciers & climate, palaeoclimatology
Ken Drinkwater (Canada)	Physical oceanography, impacts of climate change
Tor Gammelsrød	Polar oceanography
Sigbjørn Grønås	Synoptic meteorology
Solfrid Hjøllo	Ocean circulation
Alastair Jenkins (UK)	Boundary layer physics
Ola M. Johannessen	Remote sensing, marginal ice dynamics
Harald Loeng	Physical Oceanography, arctic climate
Ketil Lygre	Biogeochemistry & modelling
Jan Mangerud	Palaeoclimatology
Martin Miles (USA)	Climate time series analysis
Kjell A. Mork	Physical oceanography
Ulysses Ninnemann (USA)	Palaeoclimatology
Svein Østerhus	Physical oceanography
Geir Ottersen	Impacts of climate change on the ecosystem
Francisco Rey (Chile)	Marine biology, impacts of climate change
Anne B. Sandø	Ocean modelling
Anne Sandvik	Mesoscale atmospheric modelling
Øystein Skagseth	Ocean circulation
Morten Skogen	Coupled physical and biological modelling
Henrik Søiland	Ocean modelling, co-leader F2
Jakob Stamnes	Applied physics, climate modelling
Jan E. Stiansen	Impact of climate change on ecosystems
Einar Svendsen	Physical oceanography & modelling
John I. Svendsen	Palaeoclimatology

Affiliated staff

Lennart Bengtsson (Germany)	Meteorology, climate dynamics
David Stephenson (UK)	Climate variability, teleconnections
Haflidi Haflidason	Paleoclimatology
Hans P. Sejrup	Paleoclimatology

Postdocs

Mats Bentsen	Climate modelling, co-leader F1
Igor Esau (Russia)	Environmental boundary layers
Ilker Fer (Turkey)	Ocean processes
Yonqi Gao	Ocean circulation modelling
Einar Heegaard	Palaeoecology
Randi Ingvaldsen	Physical oceanography
Yoshie Kasajima (Japan)	Mesocale oceanography
Dorthe Klittgaard-Kristensen	Palaeoclimatology
Øyvind Lie	Palaeoclimatology, co-leader F3
Henriette C. Linge	Palaeoclimatology
Shujie Ma (China)	Modelling, downscaling
Matthias Moros (Germany)	Palaeoclimatology
Jan Even Ø. Nilsen	Climate modelling
Abdirahman Omar	Chemical oceanography
Anders Olsson (Sweden)	Chemical oceanography
Anna Sjöblom (Sweden)	Boundary layer meteorology
Ingunn Skjelvan	Chemical oceanography
Lars H. Smedsrud	Polar Oceanography
Richard Telford (UK)	Palaeoclimatology

PhD students

Jostein Bakke	Palaeoclimatology
Anne Bjune	Palaeobotany
Wenche Eide	Palaeobotany
Johanne Bua	Palaeobotany
Øivind Byrkjedal	Polar oceanography
Aina Dahlø Janbu	Palaeoclimatology
Dorothea Iovino (Italy)	Meridional overturning circulation
Carolina Kivimae (Sweden)	Chemical oceanography
Eirik Kolstad	Climate downscaling
Ben Marzeion (Germany)	Meridional overturning circulation
Marius Meland	Palaeoclimatology
Cathrine Myhrmehl	Climate modelling
Øyvind Paasche	Palaeoclimatology
Anne-Grete B. Pytte	Palaeoclimatology
Bjørg Risebrobakken	Palaeoclimatology
Ivar Seierstad	Meteorology & teleconnections
Yongyia Song (China)	Climate downscaling
Frode Vikebø	Climate impacts on marine ecosystems
Karolina Widdell	Physical oceanography

Technical staff

Wenche Breyholtz	Palaeoclimatology
Dag Blindheim	Palaeoclimatology
Kelly Brown (USA)	Chemical oceanography
Odd Hansen	Palaeoclimatology
Herbjørn Heggen	Palaeoclimatology
Solveig Kringstad	Chemical oceanography
Craig Neill (USA)	Chemical oceanography
Liv Senneset	Palaeoclimatology
Rune Søraas	Palaeoclimatology

Assistants (temporary)

Elin Darelius (Sweden)	Secretariat
Ann Kristin Østrem	Oceanographic time series, databases

Secretariat

Beatriz Balino	Science coordinator
Connie Engstad	Human resources
Charla Melander	Administrative secretary
Geir Skaten	Financial officer

Person-years (2003)

Scientists	28
Postdocs	20
PhD students	16
Technicians	6
Administration	4
Total	74

Number of scientific positions sorted by category and by partner.

	Partner					Foreigners	Women
Position	BCCR	UoB	IMR	NERSC	Sum	%	%
Scientists	15	16	13	4	48	23	15
Postdocs	5	11	1	7	24	42	29
PhD stud	-	14	-	5	19	21	63
Total	20	41	14	16	91	27	29

RESEARCH PROJECTS

Projects funded by the Research Council of Norway

TITLE	*Duration*	**Coordinator/ **Partner*
Effects of North Atlantic Climate Variability on the Barents Sea Ecosystem - ECOBE	03-06	S. Sundby*
Marine climate and ecosystems in the seasonal ice zone- MACESIZ	03-06	O. M. Johannessen*
Norwegian Ocean Climate Project - NOClim II	03-06	P. Haugan*
Past Climates of the Norwegian Region - NORPAST II	03-06	A. Nesje**
Norwegian Palaeo Environment and Climate - NORPEC	00-04	J. Birks*
Paleo environment and climate history of the Russian Arctic PECHORA II	03-06	J.I. Svendsen*
Polar Ocean Climate processes - PROCLIM	03-06	P. Haugan*
Regional Climate Development under Global Warming - REGCLIM III	03-06	S. Grønås*
Improved parameterisation of microphysical and optical properties of clouds in global climate models- CIRAD	03-06	J. Stamnes*
Spatial and temporal variability of currents and transport of warm waters in the Nordic Seas - NUCA ARCTICA	02-06	H. Svendsen*
External and internal forced variability of the Atlantic European climate system over the last millennium	03-06	H. Drange*
Abrupt and large scale climatic and glacial changes in western Norway 14,000-9,000 years BP	02-04	J. Mangerud*
Seasonal forecast of the North Atlantic and Arctic Oscillations with troposphere-stratosphere models	02-04	N.G.Kvamstø*
Decadal to century scale changes in the vertical water mass structure of the Norwegian Sea - climatic implications and possible forcing	02-04	E. Jansen*
Dense water production processes in Storfjord	00-03	P. Haugan*
Marine 14C reservoir ages off western Norway determined from coupled AMS and U-series datings of the coral Lophelia pertusa	02-03	C. A. Dahl*
Atmosphere-ice-ocean interactions studies	03-05	P. Haugan*
Ocean Drilling Program: leg 202 site 1233	00-03	H. Kleiven*
Climate effects on dynamic biodiversity	03-06	E. Heegard*
Carbon flux and ecosystem feedback in the northern Barents Sea in an era of climate change -CABANERA**	02-06	T. Johannessen**

EU funded research projects by the 5th Framework Programme

TITLE	*DURATION*	*TYPE*	*Coordiantor/*PI
Arctic ice cover simulation experiment- AICSEX	01-03	RD **	O.M .Johannessen
Carbon variability studies by ships of opportunity - CAVASOO	00-03	RD**	R. Bellerby
Coordinated European Surface ocean Palaeo-estimation Collaboration - CESOP	02-04	RD*	E. Jansen
European directory of the initial ocean observing system - EDIOS	01-04	RD**	H. Loeng
Late Holocene Shallow Marine Environments of Europe - HOLSMEER	01-03	RD**	H.P. Sejrup
Meridional Overturning Exchange with the Nordic Seas -MOEN	02-04	RD*	S. Østerhus
Model and observation test climate feedback - MOTIF	02-04	RD*	E. Jansen
Northern ocean-atmosphere carbon exchanges study - NOCES	02-04	RD**	H. Drange
Patterns of Climate Variability in the North Atlantic - PACLIVA	02-04	RD*	E. Jansen
Programme for integrated earth system modelling - PRISM	01-03	RD**	H. Drange
Tracer and circulation in the Nordic Seas - TRACTOR	01-04	RD*	T. Johannessen
Role of ice-ocean-atmosphere processes in high-latitude climate change	01-04	MCTS*	P. Haugan
Quantitative paleoclimatic reconstructions from lake sediments	01-04	MCTS**	J. Birks
Phase relations between changes in the Late Quaternary ocean surface and deep water	02-03	MCFellow*	E. Jansen

BCCR is * Coordinator or ** Partner
RD: Research and Demonstration project, MCTS: Marie Curie Training Site, MCN: MCFellow: Marie Curie Fellowship

Projects funded by other sources

TITLE	*LEADER/ *PI*	*FUNDING AGENCY*
Simulation of decadal-scale variability in the North Atlantic and Arctic oceans	K. Lygre	Nordic Arctic Research Programme
Time series of key hydrographic parameters by Mg/Ca paleothermometry	E. Jansen	STATOIL/VISTA
Plant microfossils as terrestrial climate archive for the last 13.000 years in Norway	J. H. Birks	STATOIL/VISTA
A Lagrangian study of the Iceland-Faroe front, a major link between the North Atlantic and the Nordic Seas	S. Østerhus, H. Søiland, S. Sundby	National Science Fundation & BCCR
Filschner ice shelf water plume study	S. Østerhus	British Antarctic Survey

SELECTED PUBLICATIONS

Peer review articles and books; BCCR scientists are indicated in bold

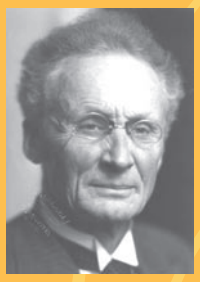
1. **Andersson, C., B. Risebrobakken, E. Jansen, S. O. Dahl** and **M. Meland** (2003). Late Holocene surface-ocean conditions of the Norwegian Sea (Vøring Plateau). Paleoceanography 18(2): 1044, doi: 10.1029/2001PA000654
2. **Bellerby, R. G. J**., M. Hoppema, E. Fahrbach, H. J. W. de Baar and M. Stoll (2003). Inter-annual controls on Wedell Sea surface fCO2 during the autumn-winter transition phase. Deep Sea Research I (accepted).
3. **Bentsen, M., H. Drange, T. Furevik** and T. Zhou (2003). Simulated variability of the Atlantic thermohaline meridional circulation. Climate Dynamics (in press).
4. **Bjune, A. E., H. J. B. Birks** and H. Seppä (2003). Holocene vegetation and climate history on a continental-oceanic transect in Northern Fennoscandia based on pollen and plant macrofossils. Boreas (accepted).
5. **Fer, I., R. Skogseth** and **P. M. Haugan** (2003). Mixing of the Storfjorden overflow (Svalbard Archipelago) inferred from density overturns. Journal of Geophysical Research (in press).
6. **Furevik, T., M. Bentsen, H. Drange, I. K. T. Kindem, N. G. Kvamstø, A. Sorteberg** (2003). Description and validation of the Bergen Climate Model: ARPEGE coupled with MICOM. Climate Dynamics 21(1): 27-51.
7. Hansen, B., **S. Østerhus,** H. Hátún, R. Kristiansen and K. M. H. Larsen (2003). The Iceland-Faroe inflow of Atlantic water to the Nordic Seas. Progress in Oceanography (in press).
8. Hasselmann, K., M. Latif, G. Hooss, C. Azar, O. Edenhofer, C. C. Jaeer, **O. M. Johannessen**, C. Kemfert, M. Welp and A. Wokaun (2003). The challenge of long-term climate change. Science 302: 1923-1925.
9. **Ingvaldsen, R., L. Asplin, H. Loeng** (2003). The velocity field of the western entrance to the Barents Sea. Journal of Geophysical Research (in press).
10. **Kleiven, H. F., E. Jansen**, W. B. Curry, D. A. Hodell, K. Venz (2003). "Atlantic Ocean thermohaline circulation changes on orbital to suborbital timescales during the mid-Pleistocene. Paleoceanography 18(1, 1008): 10.1029/2001PA000629
11. **Lie, Ø., S. O. Dahl** and **A. Nesje** (2003). A theoretical approach to glacier equilibrium-line altitudes using meteorological data and glacier mass-balance records from southern Norway. The Holocene 13(3): 365-372.
12. **Mangerud, J**., R. Lovlie, S. Gulliksen, A. K. Hufthammer, E. Larsen and V. Valen (2003). Paleomagnetic correlations between Scandinavian Ice-Sheet fluctuations and Greenland Dansgaard-Oeschger events, 45,000-25,000 yr BP. Quaternary Research 59(2): 213-222.
13. **Mork, K. A., J. Blindheim** (2003). Heat loss of the Norwegian Atlantic Curent toward the Arctic. ICES Marine Science Symposium 219: 144-149.
14. **Nesje, A., S. O. Dahl** (2003). The Little Ice Age - only temperature? Holocene 13 (1): 139-145.
15. **Nilsen, J.E.Ø., Y. Gao, H. Drange, T. Furevik and M. Bentsen** (2003). Simulated North Atlantic-Nordic Seas water mass exchanges in an isopycnic coordinate OGCM. *Geophysical Research Letters* 30(10): Art. No. 1536
16. **Olsen, A., R. Bellerby, T. Johannessen, A. Omar** and **I. Skjelvan** (2003). Interannual variability in the wintertime air-sea exchange of carbon dioxide in the northern North Atlantic Ocean 1981-2001. Deep Sea Research I 50(10-11): 1323-1338.
17. **Omar, A., T. Johannessen**, S. Kaltin and **A. Olsen** (2003). Anthropogenic increase of oceanic pCO2 in the Barents Sea surface water. Journal of Geophysical Research 108(C12): 3388, doi: 10.1029/2002JC001628
18. Orvik, K. A., **Ø. Skagseth** (2003). The impact of the wind stress curl in the North Atlantic on the Atlantic inflow to the Norwegian Sea toward the Arctic. Geophysical Research Letters 30(17): 1884, doi: 10.1029/2003GL017932
19. **Otterå, H. O.** (2003). Effects of solar irradiance forcing on the ocean circulation and sea ice in the North Atlantic in an isopycnic coordinate OGCM. Tellus Series A (Accepted).
20. **Risebrobakken, B., E. Jansen, C. Andersson**, E. Mjelde, K. Hevrøy (2003). A high-resolution study of Holocene paleoclimatic and paleoceanographic changes in the Nordic Seas. Paleoceanography. 18(1): 1701, doi: 10.1029/2002PA000764
21. **Svendsen, J. I**., G. Gataullin, **J. Mangerud**, L. Polyak (2003). The glacial history of the Barents and Kara sea region. In: Ehlers, J. & Gibbard, P. (eds.): *Quaternary Glaciations - Extent and Chronology*. Vol. 1 Europe, Elsevier, Amsterdam
22. **Vikebø, F., T. Furevik, G. Furnes, N. G. Kvamstø,** M. Reistad (2003). Wave Height Variations in the North Sea and on the Norwegian Continental Shelf, 1881 to 1999. Continental Shelf Research 23: 251-263.
23. Waelbroeck, C., S. Mulitza, H. Spero, **T. Dokken,** T. Kiefer (2003). Harmonized late Holocene planktonic d18O data set: relationship between surface water temperature and d18O. Quaternary Science Review (in press).
24. **Widell, K., S. Østerhus, T. Gammelsrod** (2003). Sea ice velocity in the Fram Strait monitored by moored instruments. Geophysical Research Letters 30(19): Art. No. 1982.

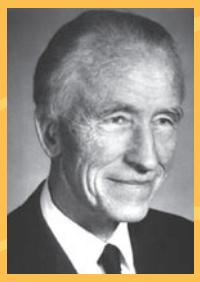
A complete listing of publications is available at http://www.bjerknes.uib.no/publications/publications.html

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. 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.

Vilhelm F. K. Bjerknes (1862-1951)





Jacob A.B. Bjerknes (1897-1975)

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Layout & print: Symbolon Forlag AS, www.symbolon.no