Established by the Research Council of Norway

Norwegian Centre of Excellence

BCCR – Bjerknes Centre for

Climate Research

ANNUAL REPORT 2007

Centre of Excellence Activities

HAVFORSKNINGSINSTITUTTET
INSTITUTE OF MARINE RESEARCH

UNIVERSITAS BERGENSIS

NERSC

Nansen Center, Bergen

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PHOTO: FIELD EXPEDITION IN SOUTH GEORGIA, ØYVIND PAASCHE, BCCR

– A TRULY REMARKABLE YEAR

PHOTO: JILL JOHANNESSEN, BCCR

2007 was the year when climate change was acknowledged nationally and globally as the main challenge facing humanity. There were several reasons for this, but chief among them was the release of the reports of the IPCCs 4th assessment, starting with the report from Working Group 1 on the science basis in February.

Working Group 1 had solid BCCR representation with one co-ordinating lead author, one lead author and four contributing authors. Last but not least, the Bjerknes Centre also contributed global climate scenario simulations with the Bergen Climate Model, being one of four European centres and the only centre in the Nordic countries who performed such simulations. The climate year ended with the UN climate change conference in Bali and the Nobel Peace Prize awarded to the IPCC. This was truly a remarkable year and the increased awareness of the climate change challenge led to hundreds of outreach activities and media appearances from BCCR scientists. Thus the Centre is now much better known for what it does than before, which is a good basis for future development and growth.

2007 also marked the start of the International Polar Year, with BCCR scientists involved in major campaigns in the Arctic studying weather mechanisms, ice-ocean interaction and the flow of heat towards the Arctic. The record low sea ice cover in 2007 paints a dramatic picture of a region under change, with the possibility that the accelerated loss of sea ice cover we now observe might give a seasonal ice free Arctic much earlier than previous projections. The root cause for this dramatic change is heavily studied at the BCCR and we aim to be in the forefront of this research also in the future. As the year drew to its close, BCCR scientists started field campaigns in both the tropical Atlantic en route to Antarctica and the Southern Ocean.

In 2007 we strengthened the organisation of the Centre of Excellence (CoE) by clarifying and building up the group leader function. We improved our capacity through recruitment of young talented scientists from the international research environment. A number of new studies were published across the breadth of activities, from process studies of the atmospheric boundary layer, clouds and climate models, to studies of past climates and climate events and assessments of the natural CO_2-sink. Some of the highlights are presented in this report, including key findings published in the prestigious science magazines *Science* and *Nature*. Yet, we must strive even harder to build good research teams, enabling them to produce papers of high impact and breakthroughs that are in the pipeline in the research groups.

We have now started to see the consequences of climate change and realize the huge challenges and wide-ranging impacts that are ahead of us. How we can adapt to these challenges needs to be addressed properly, which depends on the development of better understanding and improved analytical tools and models that can be used to assess regional and local conditions. We need predictions that are useful for public and private sectors in Norway and for activities in the Arctic, and we need to support bilateral and multilateral programmes for sustainable development. We hope to document how we have responded to these challenges in forthcoming annual reports.

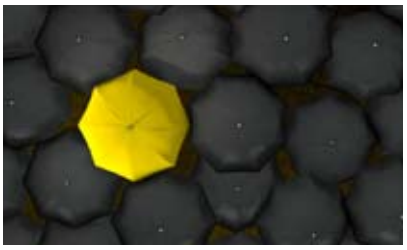
PROF. EYSTEIN JANSEN

Bergen is the wettest city in Europe and home to the founding fathers of the Bergen School of Meteorology, Vilhelm Bjerknes and his son Jacob. Their work laid the basis for modern weather forecasting as well as 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.

PHOTO: BT, JAN M. LILLEBØ

VISION, OBJECTIVES & RESEARCH ORGANISATION

The Bjerknes Centre is the largest climate research centre in the Nordic countries, with a focus on the natural science aspects of climate change. Our ambition is to be a leading international centre for research on high-latitude climate change and a key provider of first-rate knowledge on climate change to policy makers, industry and the general public.



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The overall objective of the Bjerknes Centre (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 into five inter-disciplinary research groups that provide knowledge of the following main research themes:

- Past, present and future climate changes and distinguishing natural and man-made changes.
- Abrupt and regional climate changes in the context of the global climate system.
- The role of the oceans in the climate system, feedback mechanisms caused by the marine carbon cycle and other processes.

Research groups at BCCR

The Research Groups are focused teams including scientists, students and technical staff that combine observations with numerical modelling.

1. **Past Climate Variability**
   Understanding long-term natural climate variability of the past is essential for understanding present and future climate changes.
2. **Present-Day Climate Changes**
   The North Atlantic ocean circulation and storm tracks heat up the North, but also make it a challenge to assess the natural modes of variability in the region.
3. **Ocean–Ice–Atmosphere Processes**
   Exchanges between ocean, ice and atmosphere are crucial to the climate system and simulations of the future climate depend on their proper representation.
4. **Biogeochemical cycles**
   Biogeochemical processes are important in the global climate system and affect how much of man-made CO_2 emissions are taken up by the ocean and land surfaces.
5. **Future Climate Scenarios and Effects**
   Global climate changes have local effects and might influence extreme weather and marine ecosystems in Norway and the Arctic, as well as having effects on water resources and health in lesser-developed countries.

In addition, a number of temporary Working Groups were formed in order to deal with prioritised and focused scientific themes with a view to producing high-impact scientific articles. More information about our research groups at www.bjerknes.uib.no/research/.

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Norwegian Centre of Excellence

The Bjerknes Centre for Climate Research (BCCR) is a joint venture between the Institute of Marine Research (IMR), the Nansen Environmental and Remote Sensing Center (NERSC) and the University of Bergen (UIB). BCCR has been awarded the status of a National Centre of Excellence by the Research Council of Norway (2003–2012). The Centre has an international profile and provides excellent opportunities to conduct top-quality climate research in high latitudes.

BRYAN AND CHERRY ALEXANDER, ARTIC PHOTO UK

NOBEL PEACE PRIZE TO BJERKNES RESEARCHERS

After two decades of scientific efforts to document climate change and the connection between human activities and global warming, the United Nations Intergovernmental Panel on Climate Change (IPCC) received the Nobel Peace Prize, together with former Vice-President Al Gore.

The Bjerknes Centre is one of four European research centres, and the only Nordic research centre, that provided global climate scenarios to the UN climate report, entailing different simulations on climate developments between 1850 and 2100. The director of the Bjerknes Centre, Eystein Jansen, is one of twenty researchers worldwide who coordinated the report on the scientific basis of climate change (Working Group 1 Report). He coordinated the chapter on climate changes in the past.

– The IPCC report provides a broad consensus about the connection between human activities and global warming. It tells us that man-made climate change is a challenge that will be a key aspect facing human societies in the next decades, says Jansen.

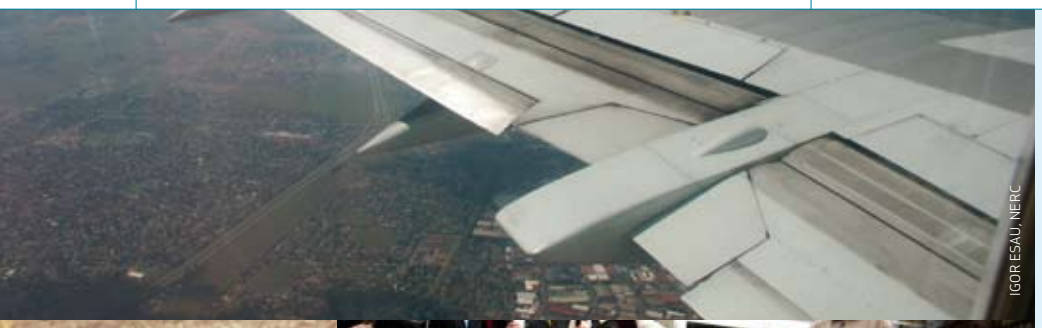
From research to political action

The report from the IPCC is comprised of three scientific sub-reports, together with a synthesis report that includes the policy recommendations. It gives a coherent presentation of the scientific basis of climate change, potential impacts, and options for mitigation and adaptation based on an assessment of published scientific literature. Hundreds of scientists and more than a thousand expert reviewers and officials from more than 130 countries have collaborated to provide an accurate assessment and improved certainty to the scale of the warming and its causes.

– The climate reports go through a broad and open review process in scientific communities and governments all over the world. The sub-report assessed many hundreds of new scientific papers and received and processed more than 30 000 comments. This process gives the IPCC reports the legitimacy to be the scientific basis for political actions and international negotiations concerning climate change, Jansen states.

The planet is changing

In the next decades we will find a different climate everywhere. The Arctic will largely become snow and ice free in the summer. For Norway we can expect a milder and wetter climate, more frequent heavy rains, perhaps also with more storms and floods


IGOR ESAU, NERC


ISTOCKPHOTO.COM


HILDE SKODVIN, BERGENS TIDENDE

Eystein Jansen and his staff celebrated and proudly took part in the peace prize.

and a higher sea level, which can cause serious challenges along the coast during our century.

Extensive climate changes will place particularly heavy burdens on the world's most vulnerable countries, which may threaten the living conditions of large parts of mankind. The potential number of environmental refugees can amount to several hundred million people in this century as a result of droughts, flooding and sea level rise.

– Even if we stop all emissions today the temperature will continue to rise for several decades, but significantly less than if we don't do something about emissions, says Jansen.

Our first climate war

Poor countries in Africa and parts of Asia will face the most serious consequences of climate change, while having the smallest capability to adapt to these changes. This situation will increase tensions and create conflicts akin to the one we have in Darfur at present.

– If the Nobel Peace Prize can contribute to reducing the scale of climate change, it will also contribute to peace by creating stability and preventing new conflicts, says Jansen.

Jansen is happy with the Peace Prize and thinks it signifies that the Bjerknes Centre has contributed to research of great substance and impact on a key global challenge. Hopefully, this process will lead to a new international climate agreement to curb greenhouse gases that will kick in when the Kyoto treaty expires at the end of 2012.

SOME KEY FINDINGS

- Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values.
- Eleven of the last twelve years (1995 –2006) rank among the 12 warmest years in the instrumental record of global surface temperature (since 1850).
- Average Northern Hemisphere temperatures during the second half of the 20th century were very likely higher than during any other 50-year period in the last 500 years and likely the highest in at least the past 1300 years.
- Observations since 1961 show that the average temperature of the global ocean has increased to depths of at least 3000 m. Such warming causes seawater to expand, contributing to sea level rise.
- Mountain glaciers and snow cover have declined on average in both hemispheres. Widespread decreases in glaciers and ice caps have contributed to sea level rise.
- Global average sea level rose at an average rate of 1.8 mm per year between 1961 to 2003. The rate was faster between 1993 to 2003, about 3.1 mm per year.
- More intense and longer droughts have been observed over wider areas since the 1970s, particularly in the tropics and subtropics.
- The frequency of heavy precipitation events has increased over most land areas, consistent with warming and observed increases of atmospheric water vapour.
- Cold days, cold nights and frost have become less frequent, while hot days, hot nights and heat waves have become more frequent the last fifty years.

Source: Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report 2007, Working group I.

ANCIENT FLOOD DISRUPTS OCEAN CIRCULATION

In a research article published in *Science*, Helga Kleiven and co-authors confirm that the deep ocean circulation was disturbed as a result of the outburst from glacial Lake Agassiz, which was followed by a rapid climate cooling.

As the giant North American ice sheets melted, an enormous pool of freshwater, many times larger than all of the Great Lakes, formed behind them. About 8400 years ago this pool of freshwater burst free and flooded the North Atlantic. About the same time, a sharp century-long cold spell is observed around the North Atlantic and other areas. Researchers have often speculated that the cooling was the result of changes in ocean circulation triggered by this freshwater flood. The sudden addition of so much freshwater would have curtailed the sinking of deep water in the North Atlantic and as a consequence less warm water would be pulled north in the Gulf Stream.

In their study, Kleiven and co-authors confirm that the deep ocean was disturbed in just the way previous workers had speculated. Using a marine core from south of Greenland, which monitors the southward flowing deep waters formed in the North Atlantic, they show that there is a sudden disruption in the deep circulation pattern at the time of the flood outburst. At the time of the flood, the chemical properties of the deep ocean shift suddenly to values not observed at any other time in the last 10,000 years. The chemical changes suggest that at the site south of Greenland, the new deep waters formed in the north were completely replaced by older deep-water coming from the south. The disruption of the deep ocean following the flood outburst lasted for a century before it snapped back to its near modern state.

Dr. Kikki Kleiven spent many hours in the stable isotope lab to study microfossils to reveal climate changes in the past (photo: Åse Johanne Roti Dahl, På høyden).

The Science article shows that deep circulation is altered over just a few decades, demonstrating that the deep ocean changes fast enough to bring about the sudden cold spell in this past period. There is no modern equivalent source for fresh water to cause a mega flood like the one occurring 8400 years ago. Yet, the fact that these deep ocean changes clearly occur on timescales rapidly enough to impact human societies underscores the importance of determining just how much freshwater is needed to bring about such dramatic changes —given the concerns that melting of the Greenland ice-sheet may accelerate as the globe warms.

Reference: Helga (Kikki) Flesche Kleiven, *Catherine Kissel, Carlo Laj,* ***Ulysses S. Ninnemann,*** *Thomas O. Richter and Elsa Cortijo (2007): Reduced North Atlantic Deep Water Coeval with the Glacial Lake Agassiz Fresh Water Outburst, Science.*

Nigardsbreen, an eastern outlet glacier from Jostedalsbreen, reached its maximum 'Little Ice Age' position in 1748. The moraine ridge in the foreground marks its maximum extent. The distance from the outer moraine to the present glacier front is about 4 km (photo: Finn Loftesnes, Naturfoto).

THE 'LITTLE ICE AGE' GLACIAL EXPANSION IN WESTERN SCANDINAVIA

The main cause of the early 18th century glacial advance in western Scandinavia was probably mild and humid winters associated with increased precipitation and high snowfall on the glaciers rather than cold summers as previously suggested.

The surprising finding was presented in *Climate Dynamics* by a group of scientists led by Atle Nesje at the Bjerknes Centre. The conventional view of the climate development during the last millennium has been that it followed a sequence of a Medieval Warm Period, a cool 'Little Ice Age' and a warming during the later part of the 19th century and in particular during the late 20th/early 21st centuries. However, recent research has challenged this rather simple sequence of climate development. Up to the present, it has been considered most likely that the 'Little Ice Age' glacial expansion in western Scandinavia was due to lower summer temperatures.

The authors conclude, on the other hand, that the main cause of the early 18th century glacial advance in western Scandinavia most likely was mild and humid winters associated with increased precipitation and high snowfall on the glaciers. Reconstructing the temporal and spatial climate development on a seasonal basis during the last few centuries, including the 'Little Ice Age', may help us better understand modern-day interplay between natural and anthropogenic climate variability.

Reference: Nesje, Atle; Dahl, Svein Olaf; *Thun, Terje; Nordli, Øyvind (2007) The 'Little Ice Age' glacial expansion in western Scandinavia – summer temperature or winter precipitation? Climate Dynamics.*

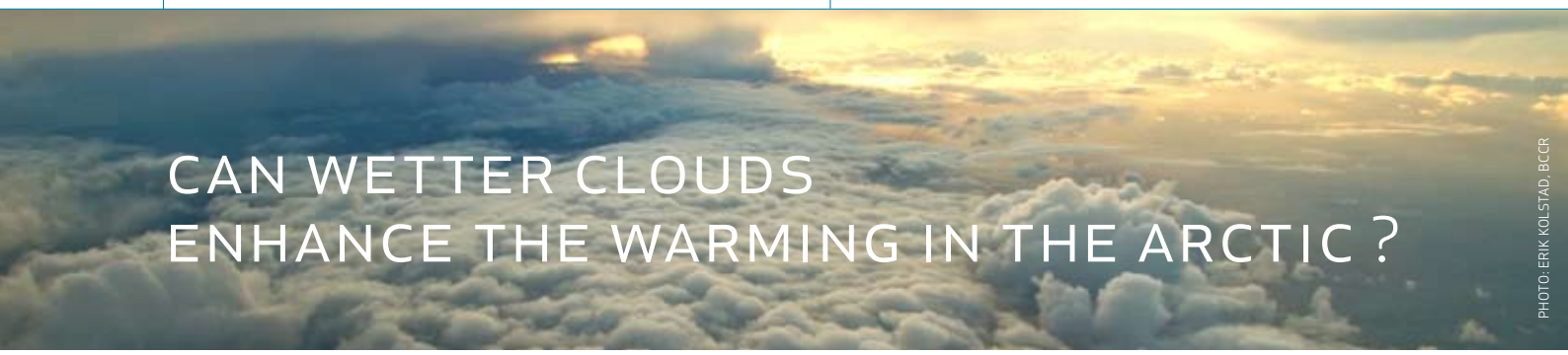


PHOTO: ERIK KOLSTAD, BCCR

CAN WETTER CLOUDS ENHANCE THE WARMING IN THE ARCTIC ?

The under-prediction of the liquid water content in Arctic clouds will have a large impact on the radiation transport and circulation in the atmosphere, leading to the question of the climate impact of wetter Arctic clouds in a scenario of global warming.

In a paper published in the Journal of Geophysical Research, Bjerknes researchers Anne Sandvik and Nils Gunnar Kvamstø together with colleagues found that cold Arctic clouds contain more liquid water than expected and that a state-of-the-art numerical model fails to reproduce this. This shortcoming may have significant consequences for climate predictions.

The strong Arctic amplification of climate change in response to an increase in greenhouse gases is not yet fully understood. Clouds are strong regulators of the Arctic energy budget, and changes in Arctic cloud properties may constitute a dominating feedback mechanism. Current climate models exhibit large model-to-model discrepancies with respect to the treatment of clouds and their optical and microphysical properties. Thus, improved parameterization of clouds and their radiation interaction are key issues that should be emphasized in numerical modelling of the Arctic atmosphere.

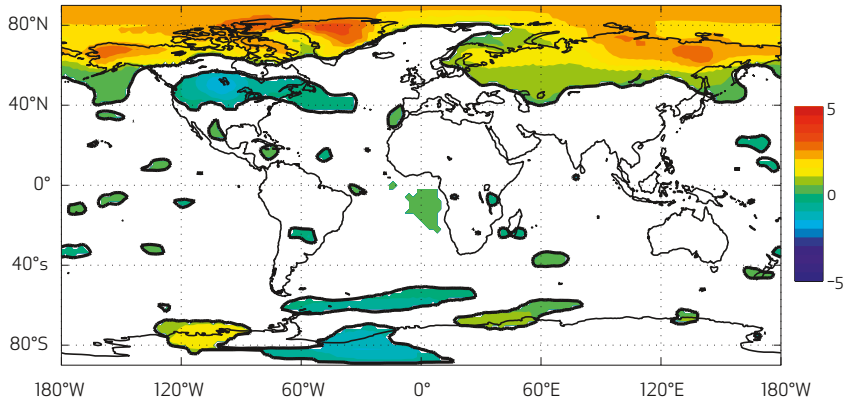
Large discrepancy between measurements and model simulations

This paper includes in situ cloud measurements that were carefully examined to provide new and important time series for both liquid water content and ice water content in Arctic clouds. These time series were used for validation of the numerical weather prediction model MM5. The positive finding of this validation was that the model is able to reproduce the observed cloud cover, provided its resolution is sufficiently high and its description of cloud properties is sufficiently detailed. The negative finding was that even with a detailed description of clouds, the model failed to reproduce the surprisingly high fraction of liquid water measured in Arctic clouds. Since such phase discrepancies will have significant impact on radiation and climate predictions, it is highly important to further investigate and improve this weakness of the model.

In a future climate scenario, with higher temperatures and more liquid water in the clouds, this may contribute to enhance the rapidly increasing Arctic temperatures observed so far. Experiments with the atmospheric component of the Bergen Climate Model (BCM) where used to address this question. In Figure 1 below, the resulting climate change is exemplified by the temperature change two meters above the ground. It shows that wetter clouds lead to a temperature increase, which is mainly localized over the area where the cloud perturbation was made (north of 60 °N) . This is an example of a positive feedback mechanism in the climate system, which, if confirmed by more comprehensive studies, will represent an important finding towards the understanding of Arctic climate changes.

Reference: Sandvik, A., *M. Biryulina,* ***N. G. Kvamstø,*** *J. J. Stamnes, and K. Stamnes (2007) Observed and simulated microphysical composition of arctic clouds: Data properties and model validation, J. Geophys. Res., 112, D05205.*

Figure 1. Temperature 2m



The figure shows calculated changes in the annual mean temperature (mean over 15 years) as a result of substituting ice crystals with water droplets in clouds north of 60 °N. In the white areas the temperature in this numerical experiment was not significantly different from that in the control experiment.

THE EXTENT OF THE NORWEGIAN ATLANTIC CURRENT IS VERY STABLE

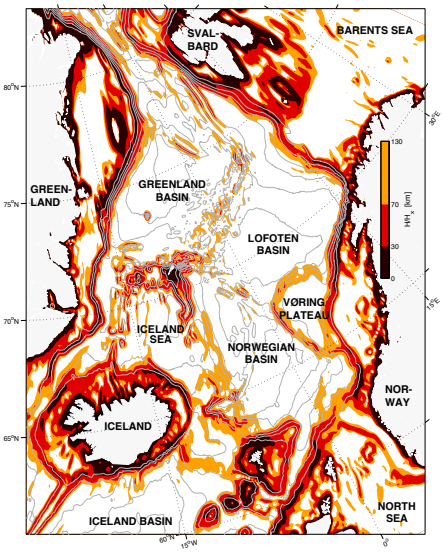


Figure 2. The topographic steepness in the Norwegian Sea and adjacent areas. The smaller the value, the steeper the topography and the more likely is frontal locking.

The western branch of the Norwegian Atlantic Current – which determines the width of the Gulf Stream's extension into the Norwegian Sea and defines the location of the Arctic front – is locked to topography from weekly to decadal timescales.

In this paper the longest existing climatic time series from the deep ocean (Ocean Weather Station M in the Norwegian Sea) is utilized to create mean hydrographical sections across the Arctic front. In concert with a theoretical framework involving the impact of low-pressure systems on oceanic fronts over steep bottom topography, the location of the Arctic front and the western branch of the Norwegian Atlantic Current (NwAC) is determined. Its frontal slope does not change its inclination on seasonal, multi-annual nor decadal timescales, indicating that the dynamic control of this frontal slope does not change appreciably. Further supported by the theoretical framework it is shown that the sub-surface part of this front and the associated western branch of the NwAC is strongly locked by topography along the Vøring Plateau also on weekly timescales.

Reference: Nilsen, J.E.Ø. *and* ***F. Nilsen*** *(2007). The Atlantic Water Flow along the Vøring Plateau: Detecting Frontal Structures in Oceanic Station Time Series. Deep Sea Research Part I, 54(3), p 297-319.*

CLIMATE MODELS SIMULATE TOO WARM TEMPERATURES IN THE ARCTIC

A research team found that wintertime systematic errors in General Circulation Models over the Arctic can largely be attributed to the large vertical distances between computational points employed.

In a paper in *Climate Dynamics* a group of scientists at the Bjerknes Centre shows that a considerable reduction of the vertical distance between computational points in climate models is needed to obtain a substantial improvement in simulating near-surface structures in the Arctic atmosphere. A massive increase of computational points would make standard General Circulation Model (GCM) simulations too costly and impractical.

Most of the IPCC models simulate systematically too warm surface conditions in high northern latitudes during wintertime under present climate conditions. GCM simulations of 20th century climate, with observed forcing, contain the well known warming north of 60° after the mid-sixties. However, the simulated geographic distribution of the warming is quite different from the observed one. The present work has focused on how turbulence representation in GCMs affects the systematic temperature biases.

Turbulence in the surface layer is a key process in determining the temperature near the ground. This process is unrealistically represented with standard vertical resolution in today's GCMs. An experiment with the ARPEGE GCM demonstrated that the vertical resolution needed to significantly improve the results will increase the number of grid points to an extent that makes standard GCM simulations too costly on present state-of-the-art computers. A turbulence parameterisation that rests on alternative principles is therefore needed to remove the systematic errors.

Reference: Byrkjedal, Øyvind, Igor Esau *and* ***Nils Gunnar Kvamstø*** *(2007). Sensitivity of simulated wintertime Arctic atmosphere to vertical resolution in the ARPEGE/IFS model. Climate Dynamics.*

PLANKTON MAY CURB PEAKING CO_2 EMISSIONS

In a *Nature* article Richard Bellerby and colleagues show how ocean acidification leads to enhanced biological carbon consumption, which may reduce the rate of future atmospheric carbon dioxide increase. The downside is that phytoplankton may become a less nutritional food source for higher trophic levels.

The oceans have absorbed a large proportion of the fossil fuel carbon dioxide (CO_2) emitted into the atmosphere since pre-industrial times, increasing the marine carbon reservoir and causing a reduction in seawater pH. If CO_2 emissions continue to rise at current rates, upper ocean pH will decrease to levels lower than have existed for tens of millions of years and critically at a rate of change 100 times greater than at any time over this period.

Recent studies have shown effects of ocean acidification on a variety of marine life forms, in particular calcifying organisms, which may have difficulties producing calcium carbonate shells in a high CO_2 ocean. Still, consequences at both the species and ecosystem level are largely unknown.

Carbon saturated seawater

The Nature article describes an experiment in which nine bags were filled with seawater from the fjord at the University of Bergen's research station in Espegrend. The bags containing a natural plankton community were given the same amount of nutrients to enable algal growth but were adjusted to different concentrations of CO_2. The highest concentration of CO_2 was equivalent with IPCCs "business-as-usual"-scenario for 2150, equal to three times the current level. The research team observed that more carbon was taken up by the ecosystems under high CO_2 and that the degree of overconsumption was proportional to the initial CO_2 concentration.

Research station in Espegrend.

Positive and negative effects

The observed responses have implications for a variety of marine biological and biogeochemical processes and underscore the importance of biologically-driven feedbacks in the ocean to global change. If this result applies to other highly productive marine systems the oceans may take up more atmospheric CO_2 than previously thought. The article illustrates how the increase in atmospheric CO_2 may be reduced by 70 ppm by the end of this century because of this biological feedback.

Whilst these results illustrate that carbon overconsumption has a beneficial side, the resulting increase in ocean primary production results in food of a lower nutritional value for higher trophic organisms. The consequences of such perturbations on ecosystem energy transfer and climate feedbacks are to be studied in the newly funded FP7 MEECE project of which Bellerby is a leader.

Reference: *U. Riebesell, K. G. Schulz,* ***R. G. J. Bellerby*** *M. Botros1, P. Fritsche1, M. Meyerho¨fer,* ***C. Neill, G. Nondal,*** *A. Oschlies, J. Wohlers & E. Zo¨llner (2007)Enhanced biological carbon consumption in a high CO_2 ocean. NATURE.*

PHOTO: ISTOCKPHOTO.COM

HOW MUCH PHYTOPLANKTON ARE IN THE NORDIC SEAS ?

This question, together with an investigation on what controls the interannual variability in primary production, is discussed in a publication by Morten D. Skogen, Paul W. Budgell and Francisco Rey of the Institute of Marine Research and the Bjerknes Center for Climate Research.

PHOTO: ISTOCKPHOTO.COM

Phytoplankton are often called the grass of the sea and are the basis for life at higher trophic levels. Phytoplankton are grazed by zooplankton, which again are eaten by fish larvae and plankton feeding fish. These are in turn eaten by, for example, cod, which we have for dinner ourselves. The amount of phytoplankton, their distribution and the timing of the bloom will therefore have an impact on how much food can be harvested from the sea. What will happen to the primary production under climate change, and what will be the effect on the fisheries? To answer such questions we need to know first how much phytoplankton are produced today, and what controls the variability of the production.

Very few estimates are available on primary productivity in the Nordic (Greenland, Iceland and Norwegian) Seas. Therefore a numerical model (NORWECOM) has been used to investigate the primary production in the area. The model has been used to simulate a 24 year period (1981-2004). The mean annual production of phytoplankton in the area is found to be 73 grams carbon per square meter per year (73 gC/m^2/year). This is approximately 30% less than, for example, in the North Sea. However, inside the Nordic Seas there are large variations, from less than 60 gC/m^2/year in large parts of the Greenland and Iceland Seas, to more than 120 gC/m^2/year along the Norwegian coast. The interannual variability varies from about 20% for the whole Nordic Seas to almost 50% in the Greenland Sea.

Primary production is to a large extent controlled by wind and weather, and the study concludes that the interannual variability in primary production can be explained by the North Atlantic Oscillation (NAO), variations in ice cover and water transport into and out of the Nordic Seas.

Reference: M.D.Skogen, *W.P.Budgell and F.Rey (2007). Interannual variability in Nordic Seas primary production. ICES Journal of Marine Science 64:889-898.*

THE INTERNATIONAL POLAR YEAR

PHOTO: CRAIG NEILL, BCCR

PHOTO: BJØRN KVISVIK, BCCR

The International Polar Year (IPY) 2007–2008 is an extraordinary initiative that aims to increase our knowledge about the Arctic and the Antarctic. The Research Council of Norway directs the IPY activities in Norway.

IPY-projects at the Bjerknes Centre

BIAC (2007–2010) is one of the biggest IPY-projects and is coordinated by the Bjerknes Centre. The aim is to study all aspects related to bottom water formation on the bipolar Atlantic Ocean shelves and the impact on the thermohaline circulation in the past, present and future. A number of research cruises will be carried out in key areas of the Barents Sea and the southern Weddell Sea.

ICEHUS II (2006–2010) is led by the University of Bergen with Russian partners, and aims at improving our understanding of ice age development and human settlements in the Russian Arctic during the last interglacial-glacial. A main target is to core the bottom sediments in lakes situated in the Ural Mountains, which will be used to reconstruct the glacial history and the climate evolution over the past 130 000 years.

THORPEX (2007–2010) is an international, Norwegian-led research project, which aims to improve forecasting of severe weather in the Arctic region. A key component of the project is an observational campaign during the late winter and spring of 2008. Centred at Andøya in northern Norway, a wide range of platforms, including highly advanced aircraft will be used to capture the fine details of polar storms.

PALEODRAKE (2007–2010) will provide quantitative reconstructions and numerical simulations necessary to first define the magnitude and expression of natural climate variability in the Drake Passage, including ocean and atmosphere circulation patterns. Data from newly recovered sediment cores will allow the project to better portray the decadal-millennial scale climate and ocean variability in the Drake Passage. Paleodrake is coordinated by BCCR and UIB.

Read more at: www.bjerknes.uib.no

PHOTO: ANDERS SIREVAAG, UIB/BCCR

PHOTO: HERBJØRN P. HEGGEN, UIB

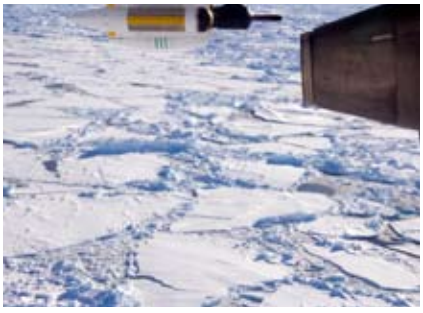
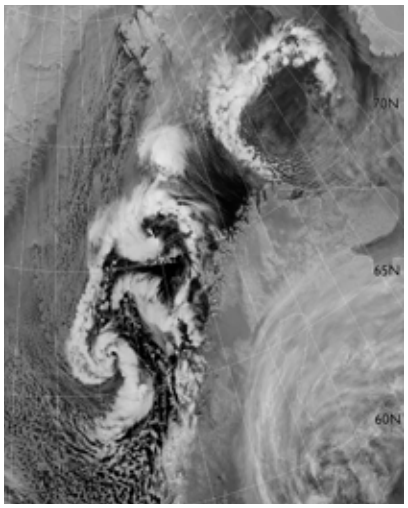


PHOTO: ERIK KOLSTAD, BCCR

PHOTO: ERIK KOLSTAD, BCCR

ARCTIC WEATHER HAS MANY FACES



A marine cold-air outbreak over the Norwegian Sea leads to multiple polar lows (source: Dundee Satellite Receiving Station).

While the weather over the ice sheet surrounding the North Pole is frequently calm and cloudy, the warm regions with open ocean may experience increasingly severe weather.

A new study published in *Climate Dynamics* by Bjerknes Centre researcher Erik Kolstad and Tom Bracegirdle of British Antarctic Survey makes use of the Intergovernmental Panel on Climate Change (IPPC) climate model data to determine how global warming will influence severe weather in Arctic regions.

The cold air does it

Severe weather in the Arctic includes explosive mid-latitude storms, polar lows, arctic fronts and roll clouds. A common feature of these weather types is that they usually form when cold air masses wander out from over the ice sheets onto the warm ocean. In the North Atlantic such conditions arise frequently along the Gulf Stream and its branches. The North-East Atlantic (the Greenland, Iceland, Norwegian and Barents Seas) is particularly prone to such marine cold-air outbreaks (MCAOs), as they are called in this paper.

A fundamental problem with typical MCAO weather is that it is not properly resolved in cost-efficient, coarse-resolution climate models. MCAOs themselves, on the other hand, are large-scale phenomena, and are thus easily distinguished in the same models. This led the authors to use MCAOs as 'proxies' (representatives) of severe weather, allowing them to assess the projected changes over the coming century.

The good news and the bad

Using the climate model results that were prepared for the IPCC Fourth Assessment Report, changes for the whole Arctic region were derived. In the areas that are characterized by warm, open water in the current climate a projected decrease in the strength of MCAOs was found. This is because the ocean is projected to warm less rapidly than the atmosphere, leading to less pronounced vertical temperature differences.

In the warming climate of the century to come, the sea ice in the Northern Hemisphere is expected to retreat rapidly, drawing the regions of most intense MCAOs with it towards the north. This may prove to be good news for the populations near the coasts of Norway, Iceland, the British Isles and northern Europe in general. The bad news is that regions that are now covered with sea-ice during winter will be exposed to new kinds of severe weather. Large increases in the strength and frequency of MCAOs were found along the entire southern rim of the Arctic Ocean ice-sheet, including the Barents, Bering and Beaufort Seas. While these areas are sparsely populated, an increase in commercial marine activity is predicted in the region.

Reference: Kolstad, E. W. *and T. J. Bracegirdle (2007) Marine cold-air outbreaks in the future: an assessment of IPCC AR4 model results for the Northern Hemisphere. Climate Dynamics.*

The pupils at St. Paul watch the water closely as ice melts in the two aquariums representing the South Pole and the North Pole.

PHOTO: JILL JOHANNESSEN, BCCR

WHAT HAPPENS WHEN THE POLAR ICE MELTS?

The massive melting of the Arctic sea ice surprised a whole world. The sixth graders from St. Paul School explored what happens to the sea level when the ice on the South Pole and the North Pole melt.

Prior to the start of Norwegian Science Week, a class from St. Paul started their school project together with the Bjerknes Centre. What else would be a more intriguing question for school children to explore than melting ice at the poles, as the International Polar Year was the main topic under this year's Science Week.

Polar bears and penguins

Twenty-eight school children are lively engaged in the classroom. The researcher Lars H. Smedsrud wants to know: "Where do the polar bears live?" "They live where the ice floats on the water," one of the pupils answers. "The sea ice is melting," states another little voice. "Okay, so that is in the Arctic. In one of these aquariums we are going to make the sea ice float in the water just as it does at the North Pole," the researcher tells the children and puts a tiny little polar bear on top of the aquarium. "Now, does anybody know where the penguins live?" the researcher continues. In the other aquarium, they leave most of the ice on land (bricks) making it look like Antarctica. A lonely penguin is put on top of the ice cap.

Professor Helge Drange attracts attention by media and audience by dressing up in rain gear with tape demonstrating how high a sea level we can expect at the end of the century (photo: Paul Sigve Amundsen).

The sixth graders carry through the experiment with huge enthusiasm, measuring the water temperature and watching closely to observe whether the water level is rising. On the black board they have made nice diagrams where they carefully, taking turns, register their findings. As the experiment carries on, the dots turn into nice graphs over development in temperature and sea level rise.

Testing hypotheses

The teacher is clearly happy with the project: "This is such nice training for the pupils in testing hypotheses." The pupils didn't meet unprepared. They had searched the Internet for information and assertions, and formulated their own hypotheses. By carrying out the experiment they are able to test what happens to the water level when the ice melts. Many of the pupils were surprised that the melting sea ice in the North Pole aquarium didn't affect the water level. The ice researcher underscored the importance of demonstrating for the kids that the sea level doesn't rise due to melting of sea ice. However, the melting of ice sheets on land does lead to a higher sea level, as does rising ocean temperatures. It is a slow process in the real world, where the sea level over the last decades has risen by three millimetres per year. "It is not in anybody's interest that children have overstated fears of climate change, and think that Bergen will be lying under water tomorrow," Smedsrud declares.

Research station

During Science Week, Festplassen is filled with research stations and popular lectures. The Bjerknes Centre had its own research station where people could watch animations that gave a visual experience of climate change and extreme weather events. The station was popular among youth and grown ups, and sparked many discussions of man-made climate change. Also, professor Helge Drange was telling the naked truth about sea level rise in a popular lecture.

FACTS/NORWEGIAN SCIENCE WEEK

- Norwegian Science Week (Forskningsdagene) is a nationwide event held every year, the last weekend in September.
- The festival is designed to fuel the public's curiosity, interest and understanding of research activities and results, and to promote recruitment of young people to an academic career.
- The main events consist of a school day, exhibitions and popular lectures.

BRIDGING RESEARCH, INDUSTRY AND SOCIETY

Climate change is a challenge that will be a key aspect of society in the next decades, which will influence international and national politics, infrastructure and industry.

The need for a good science base and scientific information to underpin policy measures and business investments will increase. Hence, the Bjerknes Centre has in close collaboration with the Bergen Chamber of Commerce and Industry and Bergen Scenarios 2020 established a Climate Forum.

We proudly launched our first Climate Forum in September 2007, which was concerned with climate change and challenges for the construction industry and real estate. This event was followed up with a second meeting in October, in collaboration with the Bergen Film Festival. It was arranged as a debate on climate change and consumption. Both events attracted a full house, which proves the need for such a meeting point for people from the industry and commerce, authorities, organisations and educational and research institutions.

The Minster of Defence Anne-Grete Strøm-Erichsen touring the new Bergen Science Centre VilVite, where the seminar was held.

CLIMATE CHANGE HAS WIDE-RANGING IMPACTS

The Bjerknes Centre, Visjon Vest and Bergen Scenarios 2020 initiated a seminar on climate change impacts and global challenges; including health and development, security matters and business strategies. The seminar gathered representatives from central research institutions and the business sector as well as prominent local politicians and the Minister of Defence.

– Such meeting venues are important because they engage people on different levels, showing that we all share responsibility and that cooperation is a necessity, said Minister Anne-Grete Strøm-Erichsen .

IPCC REPORT LEADS TO NATIONAL OUTREACH

On the national level the Bjerknes Centre has a substantive role in disseminating the results from the IPCC report.

Professor Eystein Jansen hands over the key findings of the IPCC climate report to the Minister of Environment, Helen Bjørnøy. She called the report "the most important climate document I have seen".

In order to meet the growing need for information about climate change, the Bjerknes Centre joined hands with the CICERO Centre for Climate Research and the Norwegian National Pollution Authority (SFT) to launch the IPCC report nationally.

A key event was the press conference that launched the first sub-report on "The Physical Science Basis" that was held in Oslo February 2. This sub-report answers questions including: To what degree are climate changes man-made? What has been happening with temperature, precipitation, the ocean and ice? What will happen to the climate in the future? We also produced factsheets in Norwegian that summarized key findings and made active use of the institution's web site with updated news on the climate report. The Bjerknes Centre also translated the Technical Summary into Norwegian, and finally we translated the Summary for Policymakers on behalf of SFT.

The work towards the media was an important part of the dissemination strategy of the climate report. Bjerknes director Eystein Jansen held a prominent role in the climate report and soon became a front figure.

A BIG BREAKTHROUGH FOR CLIMATE CHANGE ISSUES

2007 was the big breakthrough year for climate change issues both internationally and nationally. It was the hottest issue in media, politics and in public opinion.

It was in 2007 that Al Gore and the Intergovernmental Panel on Climate Change (IPCC) won the Nobel Peace Prize, with the media and decision makers really becoming aware of the seriousness of climate change and that human activity was to blame for global warming. A recent survey shows that 87% of Norway's population expressed to some extent that they already see consequences of climate change and 86% think those consequences will be negative.

Strong increase in BCCR visibility

The increasing attention to climate change is strongly reflected in BCCR's media and outreach activity, as shown in Figure 3. From 2006 to 2007 the number of media items rose from approximately 160 to 400. As a result, the Bjerknes Centre has increased its visibility, which has led both the media and decision makers to recognize the expertise the Centre possesses. The strongest increase has been in newspaper interviews, which tripled in national newspapers, totaling 86 editorial articles compared to 25 the previous year (see Figure 4). The number of media items represents a lower boundary, as national surveys show that citations from BCCR researchers are about three times higher.

Quality and quantity

The significance of climate change for societal development underlines the importance that the information is received as relevant, substantial and useful for the target groups. Our media and outreach efforts therefore include a variety of activities and topics. For the first time, the Bjerknes Centre has participated in the Norwegian Science Week and established a Climate Forum in cooperation with the Bergen Council and Bergen Scenario 2020. The amount of popular lectures has increased significantly, and totals 128 for 2007. Another characteristic for 2007 are the many climate panels launched by newspapers. The Bjerknes Centre participates with two national newspapers (VG and Dagens Næringsliv) and one regional newspaper (Bergens Tidende).

Sea level rise to the forefront

Not surprisingly, key findings from the IPCC report stand out as the most popular topic both in the media and in popular lectures, which also expand into the political side of climate change. During 2007 the BCCR worked hard to raise awareness of future sea level rise, which moved from a non-issue to one of the most important matters concerning climate change. It has also been a central topic in many popular lectures along the Norwegian coast.

Figure 3. Media exposure of the Bjerknes Centre by type of media

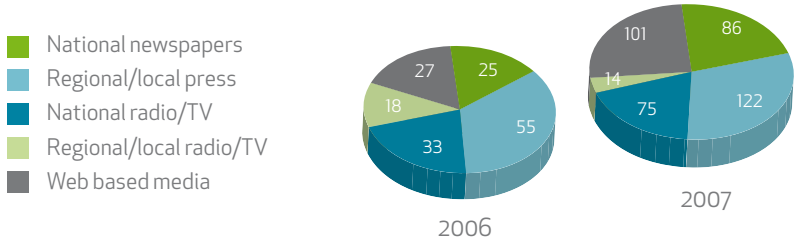


Figure 4. Media exposure of the Bjerknes Centre by category, 2004–2007

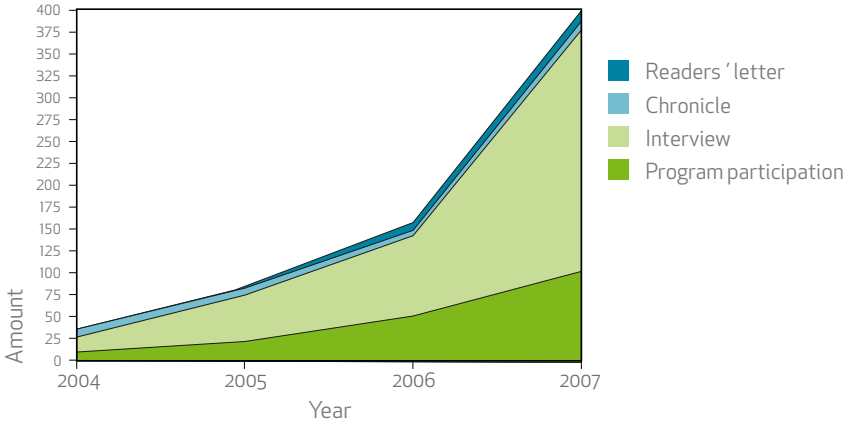


PHOTO: JILL JOHANNESSEN, BCCR

Researchers collect sediment cores from the bottom of the ocean off the Brazilian coast in order to learn how climate variations in the past are connected to changes in the Atlantic Thermohaline Circulation.

NEW INITIATIVES, EDUCATION AND COOPERATION

The Bjerknes Centre is deeply involved in international research activities, collaboration and education.

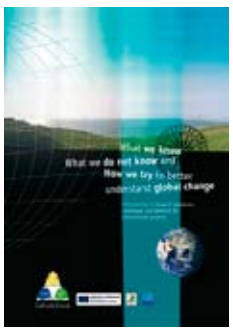
A new cooperation initiative with Brazilian partners

RETRO (Response of tropical Atlantic surface and intermediate waters to changes in the Atlantic meridional overturning circulation) is a project within the European Science Foundation (ESF) programme EUROMARC. It is coordinated by the Bjerknes Centre in conjunction with partners from Germany, the Netherlands, France, the UK and Brazil. The goal of the project is to improve the understanding of the interactions between the tropical Atlantic Ocean and the North Atlantic Ocean, in particular how heat is transported through the Gulf Stream. The researchers wish to better resolve tropical thermocline dynamics and intermediate- and deep water variations. Furthermore, they want to test the role of tropical feedbacks to explain the rapid warming that is most strongly expressed in the North Atlantic region. These aspects of paleoclimatology are poorly understood. The approach provides a novel perspective within palaeoceanography by applying a physical oceanographic experiment design on the selection of sites and cores.

RETRO has opened the door for new research collaborations with institutions in Latin America, and in particular with Brazil. Several institutions in Brazil are involved, and the RETRO project is coordinated by the Fluminense Federal University (UFF) in Rio De Janeiro. The University of Bergen has signed an agreement of international cooperation between UFF and BCCR to contribute to the enhancement of interactions between these institutions, including activities such as data collection and the training of researchers, masters and PhD students at the UiB, "sandwiched" with scholarships financed by the Brazilian government.

A gravity core can collect up to four meters of sediments (photo: Jill Johannessen, BCCR).

CarboSchools



CarboSchools is an educational project initiated by CarboEurope and CARBOOCEAN with the aim to connect scientists working with global climate change-related issues with students and teachers from upper secondary schools. Cooperation between Bergen Katedralskole and scientists from BCCR has existed since 2006, and during 2007 this consisted of several one-day cruises where the students learned about hydrography, marine chemistry and biology, in addition to life onboard a research vessel. In 2007 there were also several student exchanges, where Norwegian students joined a German cruise in the Baltic and German students visited Bergen Katedralskole. A Norwegian translation of an educational booklet on the global carbon cycle written for students, schools and others interested was also launched. Recently a new EC funded project, CarboSchools+, was started, with the aim to extend the school/scientist cooperation, produce additional educational materials and in general raise the awareness among young people about climate change and the associated research going on.

Student fieldtrip to the automatic weather station at the glacier Midtdalsbreen, Finse (photo: Atle Nesje, UIB/BCCR).

Research training at the Bjerknes Centre

In the spring of 2006 the Bjerknes Research School for Climate Studies was established, with the Geophysical Institute as the host institute and the Bjerknes Centre as the major partner (see http://www.uib.no/People/ngftf/Research_School/). With no external funding provided for the research school, the activities have been somewhat less than anticipated. Still a large fraction of the ambitious programme for the research school was implemented this past year.

In 2007 the Bjerknes Centre was involved in two summer school projects, both of which happened to occur during the same two weeks in July. From 1 to 11 July Tore Furevik coordinated a summer school on *Transferable and professional challenges in interdisciplinary global climate research* at the Espegrend Marine Biological Station outside of Bergen. The summer school was financed by the Bergen Research Foundation with a grant of 280 000 NOK and organised through the University of Coimbra network. Twenty-five students and more than 10 lecturers participated in the activity.

From July 2 to 13 the International Sea-Ice Summer School was held in Svalbard. This school was part of the outreach programme of the International Polar Year (IPY). The Bjerknes Centre supported the school financially through the BIAC project and also with lectures. The summer school was a success both scientifically and socially.

In addition to the summer school activities, several formal and informal activities have been implemented by the PhD students and post docs themselves. This includes weekly lunch meetings, a new seminar series (the Bjerknes Seminars) and also an annual seminar for PhDs and post docs at Finse. All this is contributing to forming a good network among the young scientists at the Bjerknes Centre which, hopefully, will result in many good cross-disciplinary projects in the future.

Towards the end of the year a questionnaire was sent to all PhDs and post docs at the Bjerknes Centre. The result of the poll was that the young scientists at the Bjerknes Centre are generally satisfied with their situation, but there are still things that can be improved when it comes to research organising and information flow at the Centre. This will be prioritised in the year to come.

Southern Ocean biogeochemistry, education and research

Combining studies of marine biogeochemistry in the Southern Ocean, the Bjerknes Centre is using its role as a leader in high latitude carbon cycle research in the education and training of South African scientists. This is spearheaded through the Norwegian Research Council project Southern Ocean Biogeochemistry, Education and Research (SOBER) coordinated by Bjerknes scientist Richard Bellerby. The project is designed to promote research excellence and build the foundations for sustainable cooperation and long-term research collaboration beyond the end of the current Norwegian development assistance to South Africa. It will also contribute to developing the capacity to facilitate and promote redress in South Africa and gender equity in both countries.

The project is employing a coordinated programme of observations and models to advance the understanding of carbon export along with carbonate, oxygen and nutrient biogeochemistry that couples the thermohaline upwelling and thermocline water export in the Southern Ocean. During 2007, a team of scientists from the Bjerknes Centre and the University of Cape Town carried out an expedition to the Weddell Sea aboard the German research vessel Polarstern. The expedition was a joint venture with the IPY project Bipolar Atlantic Circulation (BIAC) and will provide new insight into the processes that control carbon and nutrient supply and modification to the Antarctic shelf. Whole water column measurements along the prime meridian have extended a time series of biogeochemical measurements monitoring the development of the anthropogenic carbon content of the Southern Ocean.

The SOBER collaboration extends to the joint supervision of South African students. This training will be extended to the University of Cape Town Oceanography department through a series of seminar courses for South African students and scientists, the first of which will be held in Cape Town in October 2008.

The Bjerkes Center leads a combined research and educational project with the University of Cape Town. Here from a joint expedition to Antarctica in 2007 (photo: Craig Neill, BCCR).

PH.D. DISSERTATIONS 2007

BCCR scientists provided supervision and training in climate research to 24 doctoral students during 2007. The following Ph.D. dissertations were defended:

Elin Darelius

Title: On the influence of small-scale topography on dense plumes, with a special focus on the Filchner Overflow Plume.

Dorotea Iovino

Title: On the Nordic Seas' role in the Atlantic Meridional Overturning Circulation.

Caroline Kivimäe

Title: Carbon and oxygen fluxes in the Barents and Norwegian Seas: Production, air-sea exchange and budget calculations.

Erik W. Kolstad

Title: Extreme winds in the Nordic Seas: Polar lows and Arctic fronts in a changing climate.

Yongjia Song

Title: Modelling of atmospheric circulation at mid- and high latitudes of the northern hemisphere – evaluation studies using ARPEGE.

INTERNATIONAL MEETINGS AND ENGANGEMENTS

Transatlantic Science Week 2007

The Royal Norwegian Embassy in Washington, D.C. arranged the fifth Transatlantic Science Week at the Carnegie Institution. The Transatlantic Science Week has developed into a major meeting place between scientists, research councils and politicians from both sides of the Atlantic. This year's theme was "Climate Action," with conference speakers including climate scientists, lobbyists, politicians, economists and others. The Bjerknes Centre was represented by two scientists, with Tore Furevik giving a presentation in a remote sensing session and Lars Asplin in an aquaculture session.

The Norwegian Minister of Education and Research, Tora Aasland, presented Norway's perspectives on transatlantic cooperation. A declaration involving increased student mobility through the Fulbright program was signed. Alf Bjørseth of Renewable Energy Corporation and Fredric Hauge of Bellona argued, respectively, for renewable energies or carbon capture and storage.

The Transatlantic Science Week offers an important arena not only to meet colleagues from the other side of the Atlantic, but also to strengthen the links to key players at the national level. Many scientists argued that climate change is now accelerating and is already going much faster than synthesised by the IPCC. Examples include atmospheric CO2 concentrations, Arctic sea ice melting, Greenland and Antarctic ice sheet melting, sea level rise and more.

Workshop on ORMEN

A workshop was organized in Bergen as part of the research project Ocean Reconstruction and Modelling of the European Deglaciation (ORMEN). This is a joint international research project involving scientists from the Bjerknes Centre and the University of Bergen, the University of Bristol, the Free University Amsterdam and the Royal Dutch Meteorological Institute as part of the RAPID climate change research program. The main objectives of this research program are to better understand the sensitivity of climate models to changes in forcing, most importantly the location and

PHOTO: ERIK KOLSTAD, BCCR

magnitude of freshwater fluxes to the ocean during the last deglaciation. The most important outcome of the meeting was to give a realistic estimate of freshwater forcing. We have derived estimates of the timing, magnitude and location of freshwater pulses by combining information from marine records of freshwater conditions and interpretation of the sea level record with ICE5G ice sheet modelling.

CARBOOCEAN/CARINA Atlantic Ocean Carbon Synthesis Workshop

The 3rd workshop of the CARBOOCEAN/CARINA Atlantic Ocean Carbon Synthesis Group was held in Bremen. The Bjerknes Centre co-organised the event together with IFM-GEOMAR/Kiel and AWI/Bremerhaven. The aims of this collaboration are to quality control and integrate existing Atlantic Ocean carbon data into an internally consistent carbon dataset that will be used to carry out a large-scale assessment of the Atlantic Ocean carbon sink from the Southern to the Arctic Ocean. The data will be made publicly available and merged with the widely used GLODAP data set. The database for the Arctic Ocean and Nordic Seas includes approximately 200 cruises, which represent a major step forward since these regions were not included in the GLODAP analysis.

Workshop: Reciprocal interactions among viruses and hosts

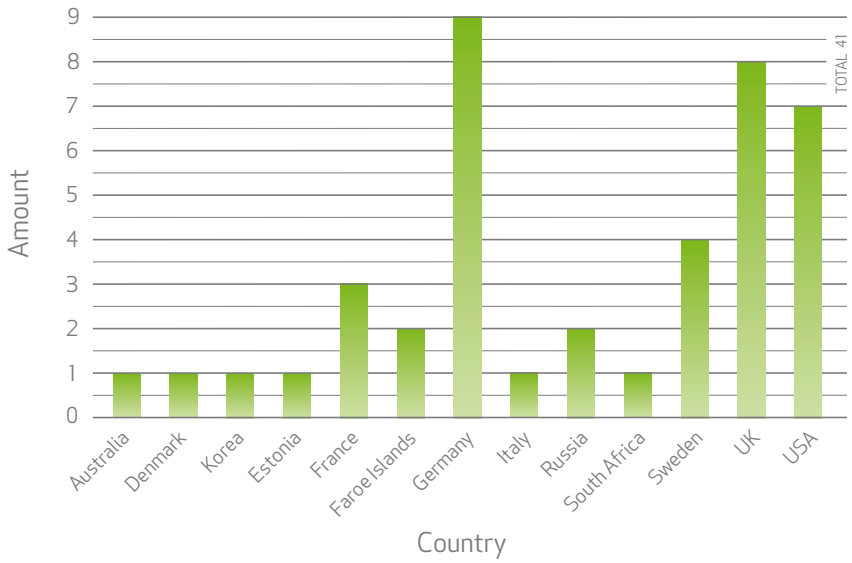
A workshop titled "Reciprocal interactions among viruses and hosts, biodiversity and biogeochemistry" took place at the Espegrend Marine Biological Station. The workshop was arranged in cooperation with the Royal Netherlands Institute for Sea Research, and collected a variety of international specialists for in-depth discussions on viral ecology, covering aspects that are of fundamental importance in the understanding of biodiversity and biogeochemistry. The meeting was held back-to-back with a SCOR workshop with the more practical scope of doing a joint mesocosm experiment to compare methods from a variety of laboratories around the world. Emergent awareness suggests that the response of ecosystems to climate change depends largely on the responses of the underlying microbial community, and that viruses have profound biogeochemical consequences.

PHOTO: ISTOCKPHOTO.COM

CARBOOCEAN annual meeting

The 3rd CARBOOCEAN annual meeting was held in Bremen. A pre-conference event was dedicated to public outreach. The meeting as such hosted up to 125 participants and was deemed very successful. The core theme leaders reported on the work in 2007 including an outstanding publication record of the entire CARBOOCEAN team. Several distinguished guests and the international advisory board attended the meeting and gave seminars on international data synthesis and US collaborations between CARBOOCEAN and North American carbon cycle research programs.

Figure 5. Visiting scientists by country



Visiting Fellow Programme

BCCR sponsors a Visiting Fellow Programme aimed at fostering international research collaboration in climate change. In 2007, the Centre hosted 41 scientists from 13 countries. See Figure 5.

PRIZES AND HONOURS

Nobel Peace Prize

The Intergovernmental Panel on Climate Change (IPCC) and former Vice-President Al Gore were awarded the Nobel Peace Prize for 2007 for their efforts to build up and disseminate greater knowledge about man-made climate change. Read about the The Bjerknes Centre ' s contributions to the IPCC on page 6.

Prize to John Inge Svendsen

Professor John Inge Svendsen was awarded the Fram Committee's Nansen Award for his activities in Norwegian polar research.

International honourable membership

Professor emeritus Jan Mangerud became the first Norwegian researcher to receive an honourable membership to the International Union of Quaternary Research. Mangerud received the honour due to his international influential research efforts in quaternary geology spanning over decades.

Professor Jon Inge Svendsen (photo: Paul Sigve Amundsen).

ENGAGEMENTS

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

UN Intergovernmental Panel for Climate Change (IPCC)
4th Assesment Report, WG1:
Professor Eystein Jansen was Coordinating Lead Author of Chapter 6 "Palaeoclimates" and Prof. Christoph Heinze was Lead Author of Chapter 7 "Couplings Between Changes in the Climate System and Biogeochemistry". BCCR also had several Contributing Authors. In addition, the Bergen Climate Model group produced simulations of climate scenarios for the IPCC using IPCC 4AR protocols.

European Climate Forum:
The Bjerknes Centre for Climate Research is a member of the European Climate Forum (ECF), a non-profit organisation located at PIK in 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 problems, such as energy industries, companies engaged in renewables, major energy users, insurance and finance, policy-makers, environmental NGOs and scientists.

Norwegian Research Council NORKLIMA Programme:
Prof. Eystein Jansen is a member of the steering committee.

International Geosphere-Biosphere programme (IGBP):

- The Integrated Project CARBOOCEAN, 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 an ex-officio science steering committee (SSC) member. IOCCP was created jointly by the SCOR-IOC advisory panel on ocean CO_2 and the Global Carbon Project (under the auspices of IGBP, IHDP and WCRP).
- Surface Ocean Low Atmosphere Study (SOLAS). Prof. Truls Johannessen is a member of the SSC.
- Global Ocean Ecosystem Dynamics (GLOBEC). Prof. Svein Sundby was appointed member of the SSC.
- PAGES (Past Global Changes): Eystein Jansen is a member of the SSC and is co-chair of the joint CLIVAR-PAGES panel. Ulysses Ninnemann is on the SSC of IMAGES, the marine component of PAGES.
- Integrated Marine Biogeochemistry and Ecosystem Research (IMBER). Prof. Svein Sundby contributed to the Science Plan and Implementation Strategy, published in 2005.
- Climate Variability and Predictability (CLIVAR): Helge Drange is a member of Working Group for Ocean Model Development (WGOCMD).

WITH PERMISSION FROM LEWIS GORDON PUGH, THE NORHT POLE

PHOTO: ØYVIND PAASCHE, BCCR

ORGANISATION & FINANCES

The Director and the Leader Forum

The Director and the Research Group Leaders are key members of the Leader Forum, which deals with scientific and professional issues.

Eystein Jansen	Professor (Director) Palaeoclimatology, BCCR
Tore Furevik	Professor (Deputy director) Climate modelling, UiB
Trond Dokken	Dr. Scient Palaeoclimatology, BCCR
Tor Eldevik	Dr. Scient Ocean processes & modelling, NERSC
Christoph Heinze	Professor Carbon cycle modelling, UiB
Frode Flatøy	Dr. Scient Meteorology, BCCR
Birgit Falck	Cand. Polit Science coordinator, BCCR
Jill Johannessen	Dr. Polit Media and information consultant, BCCR
Lars Fagerli	Financial officer, BCCR
Connie E. Engstad	HR manager, BCCR

Working Committee

The working committee consist of members from the collaborating institutions NERSC, IMR, UiB and Unifob. It deals with administrative issues and long-term strategy for the Centre.

Eystein Jansen	Professor (Director) Palaeoclimatology, BCCR
Helge Drange	Professor Climate modelling, NERSC
Ken Drinkwater	PhD Oceanography, Fisheries ecology, IMR
Tore Furevik	Professor (Deputy director) Climate modelling, UiB
Christoph Heinze	Professor Carbon cycle modelling, UiB
Trond Dokken	Dr. Scient Palaeoclimatology, BCCR
Birgit Falck	Cand. Polit Science coordinator, BCCR
Jill Johannessen	Dr. Polit Media and information consultant, BCCR

Research Groups

In 2007 a lot of effort was put into developing a more clarified role for the Research Group Leaders and the members of the research groups. Mandates have been developed and signed, pointing out the responsibility of the leaders, co-leaders and members of the groups.

Title		Leader (co-leader)
RG1	Dynamics of past climate variability	T. Dokken (A. Nesje)
RG2	Dynamics and predictability of present day climate	T. Furevik (N. G. Kvamstø)
RG3	Ocean–ice–atmosphere processes	T. Eldevik (I. Fer)
RG4	Biogeochemical cycles	C. Heinze (A. Olsen)
RG5	Climate scenarios and downscaling	F. Flatøy (F. Vikebø)

Gender policy

The BCCR has identified areas to improve in order to obtain a better gender balance at the Centre. The Centre faces some challenges in getting more female project leaders and women in the Leader Group. During 2007 the BCCR put Gender Policy at the top of the agenda. A group consisting of scientific and administrative employees has started the work, making a Gender Policy and Gender Action Plan valid from 2008.

Fieldwork, Andøya 2007 (photo: Hilary Birks, UiB /BCCR).

Figure 6. Organisation map

THE BOARDS

Board of Directors

Tore Nepstad	Director, Institute of Marine Research (Chair)
Ola M. Johannessen	Director, Nansen Environmental and Remote Sensing Center
Kari Tove Elvbakken	University Director, UiB
Hans Petter Sejrup	Dean, Faculty of Mathematics and Natural Sciences, UiB

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

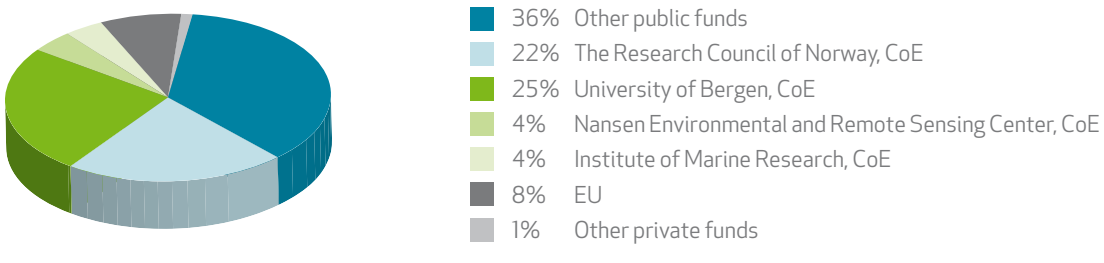
FUNDING & EXPENSES

There are several ongoing programmes in which the Bjerknes Centre is involved. Twenty-seven projects are funded by the Research Council of Norway, with BCCR scientists leading 20 of these projects. Six ongoing projects are funded by the 5th and 6th Framework Programmes of the European Commission, of which BCCR coordinates two of the programmes. Seven projects are funded by other sources. BCCR also coordinates two of the six multinational projects which were funded within the European Science Foundation Eurochores programme EuroMarc. See Appendix 2 for a complete listing of ongoing research projects. In addition, six new proposals were accepted in 2007 and will start in 2008.

Funding	(1000 NOK) 2007
Research Council of Norway, CoE	16 356
University of Bergen	**18 884**
Nansen Environmental and Remote Sensing Centre	**3 000**
Institute of Marine Research	**3 000**
EU	**5 802**
Other private funds	**1 127**
Other public funds	**27 268**
Total funding	**75 437**

Expenses	(1000 NOK)
Salaries and house rental costs	**45 651**
Research equipment	**2 653**
External research services	**9 576**
Other costs	**17 140**
Total expenses	**75 019**

Figure 7. Funding



FIELDWORK FREEMANSUNDET (PHOTO: KYSTVAKTEN SVALBARD)

STAFF

Scientists

Lars	Asplin	IMR	Physical oceanography & modelling
Idar	Barstad	BCCR	Atmospheric modelling
Richard	Bellerby (UK)	BCCR	Biogeochemistry
Mats	Bentsen	NERSC	Climate modelling
Hilary	Birks (UK)	UiB	Numerical methods in palaeoclimatology
H. John B.	Birks (UK)	UiB	Terrestrial biological climate proxies
Anne Elisabeth	Bjune	BCCR	Palaeobotany
Knut Yngve	Børsheim	IMR	Marine biology, biogeochemistry
Paul	Budgell (Canada)	IMR	Ocean modelling
Carin Andersson	Dahl (Sweden)	BCCR	Palaeoclimatology
Svein Olaf	Dahl	UiB	Glaciers & palaeoclimatology
Trond	Dokken	BCCR	Palaeoclimatology
Helge	Drange	NERSC	Climate modelling
Ken	Drinkwater (Canada)	IMR	Oceanography & impacts of climate change
Tor	Eldevik	NERSC	Ocean processes & modelling
Ilker	Fer (Turkey)	BCCR	Ocean processes
Frode	Flatøy	BCCR	Atmospheric chemistry & modelling
Tore	Furevik	UiB	Climate modelling
Tor	Gammelsrød	UiB	Polar oceanography
Sigbjørn	Grønås	UiB	Synoptic meteorology
Peter M.	Haugan	UiB	Polar oceanography
Einar	Heegaard	BCCR	Palaeoecology
Christoph	Heinze (Germany)	BCCR	Carbon cycle modelling
Solfrid	Hjøllo	IMR	Ocean circulation
Eystein	Jansen	BCCR	Palaeoclimatology
Alastair	Jenkins (UK)	UiB	Boundary layer physics
Ola M.	Johannessen	NERSC	Remote sensing, marginal ice dynamics
Truls	Johannessen	BCCR	Biogeochemistry
Ina K.	Kindem	BCCR	Stratospheric physics
Helga F.	Kleiven	BCCR	Palaeoclimatology
Nils Gunnar	Kvamstø	UiB	Atmospheric modelling
Øyvind	Lie	BCCR	Palaeoclimatology
Henriette	Linge	BCCR	Palaeoclimatology
Kjetil	Lygre	NERSC	Biogeochemistry & modelling
Jan	Mangerud	BCCR	Palaeoclimatology
Martin	Miles (USA)	BCCR	Climate time series analysis
Kjell Arne	Mork	IMR	Physical oceanography
Atle	Nesje	UiB	Palaeoclimatology
Ulysses S.	Ninnemann (USA)	UiB	Palaeoclimatology
Kerim Hestnes	Nisancioglu	BCCR	Palaeoclimatology & modelling
Are Christian S.	Olsen	BCCR	Chemical oceanography
Anne Britt	Sandø	NERSC	Ocean modelling
Anne Dagrun	Sandvik	BCCR	Mesoscale atmospheric modelling
Øystein	Skagseth	IMR	Ocean circulation
Ingunn	Skjelvan	BCCR	Chemical oceanography
Morten	Skogen	IMR	Coupled physical and biological modelling
Lars Henrik	Smedsrud	BCCR	Polar oceanography
Henrik	Søiland	IMR	Ocean modelling
Asgeir	Sorteberg	BCCR	Climate modelling
David	Stephenson	UiB	Atmospheric processes and climate modelling
Svein	Sundby	IMR	Ocean climates
Einar	Svendsen	IMR	Physical oceanography & modelling
John Inge	Svendsen	UiB	Palaeoclimatology

Richard	Telford (UK)	UiB	Palaeoclimatology
Andrea	Volbers (Germany)	BCCR	Palaeoclimatology and biogeochemistry
Svein	Østerhus	BCCR	Physical oceanography
Bjørn	Ådlandsvik	IMR	Physical oceanography & modelling

Postdocs

Karen	Assmann (Germany)	BCCR	Chemical oceanography
Jürgen	Bader (Germany)	BCCR	Climate modelling
Jostein	Bakke	BCCR	Palaeoclimatology
Igor	Esau (Russia)	NERSC	Environmental boundary layers
Yonqi	Gao (China)	NERSC	Ocean circulation modelling
Richard	Gyllencreutz (Sweden)	UiB	Palaeoclimatology
Randi	Ingvaldsen	IMR	Physical oceanography
Emil	Jeansson (Sweden)	BCCR	Chemical oceanography
Erik Wilhelm	Kolstad	BCCR	Climate downscaling
Camille	Li (Canada)	UiB	Atmospheric dynamics and paleoclimate
Katjia	Lohmann (Germany)	NERSC	Ocean climate variability and modelling
Marius	Meland	BCCR	Palaeoclimatology
Jan Even Ø.	Nilsen	NERSC	Climate modelling
Abdirahman	Omar (Somalia)	UiB	Chemical oceanography
Odd Helge	Otterå	NERSC	Climate modelling
Øyvind	Paasche	BCCR	Palaeoclimatology
Bjørg	Risebrobakken	BCCR	Palaeoclimatology
Cathrine	Sandal	BCCR	Climate modelling and observations
Jeanne	Scao (France)	BCCR	Paleoclimatology
Kristof	Sturm (France)	BCCR	Carbon cycle modelling and climate modelling
Jerry	Tjiputra (Indonesia)	BCCR	Carbon cycle modelling
Frode	Vikebø	IMR	Climate impacts on marine ecosystems
Zhongshi	Zhang (China)	BCCR	Palaeoclimatology & modelling

Ph.D. Students

Christophe	Bernard (France)	UiB	Biogeochemistry
Ingo	Bethke (Germany)	NERSC	Ocean modelling
Andreas	Born (Germany)	UiB	Climate dynamics and paleoclimate modeling
Tarjei	Breiteig	UiB	Atmospheric dynamics
Giulio Nils	Caroletti (Italy)	UiB	Regional climate change
Elin	Darelius (Sweden)	UiB	Polar oceanography
Christine	Euler (Germany)	UiB	Palaeoclimatology
Florian	Geyer (Germany)	NERSC	Climate modelling
Louise P.	Ghysels (Denmark)	BCCR	Paleoclimatology
Dorothea	Iovino (Italy)	NERSC	Meridional overturning circulation
Marwan	Khalil (Egypt)	NERSC	Climate modelling
Caroline	Kivimäe (Sweden)	UiB	Chemical oceanography
Ben	Marzeion (Germany)	NERSC	Meridional overturning circulation
Svetlana	Milutinovic (Croatia)	NERSC	Remote sensing, climate modelling
Birgitte F.	Nyland	UiB	Palaeoclimatology
Steinar	Orre	NERSC	Climate modelling
Francesco S. R	Pausata (Italy)	UiB	Atmospheric dynamics and paleoclimate
Anders	Sirevaag	UiB	Physical oceanography
Yongjia	Song (China)	UiB	Climate downscaling
Dag Johan	Steinskog	NERSC	Climate modelling
Eivind W. N.	Støren	UiB	Palaeoclimatology
Amandine	Tisserand (France)	UiB	Palaeoclimatology
Kristian	Vasskog	UiB	Extreme weather events in the past
Ingelinn	Aarnes	UiB	Vegetation reconstruction

Technical staff

Dag Inge	Blindheim	BCCR	Palaeoclimatology
Kelly	Brown (USA)	BCCR	Chemical oceanography
Dagfinn	Bøe	BCCR	Paleoclimatology
Wenche	Fivelsdal	UiB	Palaeoclimatology
Odd Reidar	Hansen	UiB	Palaeoclimatology
Tor-Villy	Kangas	IMR	Physical oceanography
Solveig	Kringstad	UiB	Chemical oceanography
Bjørn Christian	Kvisvik	BCCR	Palaeoclimatology
Craig	Neill (USA)	BCCR	Chemical oceanography
Benjamin	Pfeil (Germany)	BCCR	Data manager
Vincent	Scao (France)	BCCR	Palaeoclimatology
Oddbjørn	Seljeset	BCCR	Palaeoclimatology
Jørund	Strømsøe	BCCR	Palaeoclimatology
Rune Egil	Søraas	BCCR	Palaeoclimatology

Secretariat (Administration)

Connie E.	Engstad	BCCR	HR manager
Lars	Fagerli	BCCR	Financial officer
Birgit	Falch	BCCR	Research coordinator
Jill	Johannessen	BCCR	Information consultant
Lill Tåve	Jørgensen	BCCR	Secretary
Tordis	Lerøen	BCCR	Coordinator
Charla M.	Olsen (USA)	BCCR	Administrative consultant

PERSONNEL SUMMARY

CATEGORY	Person-years
Scientists	36,5
Postdocs	18,2
PhD students	19,0
Technicians	11,7
Administration	7,0
Total	92,4

Number of *scientific* personnel sorted by category and partner institution. Percentages of non-Norwegians and female scientists are also indicated:

PARTNER						FOREIGNERS	WOMEN
Category	**BCCR**	**UiB**	**IMR**	**NERSC**	**Total**	**%**	**%**
Scientists	25	14	13	6	**58**	26	19
Postdocs	13	3	2	5	**23**	57	30
Ph.D. students	0	16	0	8	**24**	67	38
Total					**105**		

Figure 8. Staff by nationality

The Bjerknes Centre recruits personnel internationally. At the end of 2007, sixteen nationalities were represented at the BCCR.

COUNTRY	# personnel
Canada	3
China	3
Croatia	1
Denmark	1
Egypt	1
France	5
Germany	11
Indonesia	1
Italy	3
Norway	78
Russia	1
Somalia	1
Sweden	5
Turkey	1
UK	6
USA	5
Total	**126**

RESEARCH PROJECTS

PROJECTS FUNDED BY THE RESEARCH COUNCIL OF NORWAY

Title	Duration	*Leader/ **Partner
Climate and Ocean in mid-to high latitudes: Mechanisms of variability in Paleo and modern records (COMPAS)	2006–10	N.G. Kvamstø*
Interactions of Arctic Sea Ice Cover and Ocean Heat Transport (InACT)	2006–08	B. Risebrobakken*
Inverse Magnetic Modelling of Glacier Activity Using Suspended Sediments (MAGNET)	2006–08	Ø. Paasche*
Reconstruction of natural Holoscene climate variability based on North Atlantic and western Baltic sea sediments	2006–07	E. Jansen*
Resolving chemical element variations in lake sediments through high-resolution XRF analyses (X-LAKE)	2006–08	J. Bakke*
Southeast Pacific CALYPSO coring of expanded Holocene–late glacial sediment sequences (CALYPSO–SEAPACE)	2006–07	U. Ninnemann*
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*
Norwegian Component of the Ecosystem Studies of Sub-Arctic (NESSAS)	2005–08	A. Sorteberg **
Punctuated disintegration of the NW European Ice Sheet and rapid climate change (RAPID)	2005–08	H. Haflidason*
Variations of the Atlantic Meridional overturning circulation during rapid climate changes: calibration, modelling and palaeoceanographic observations (VAMOC)	2005–08	T. Dokken*
Improved parameterisation of Microphysical and Optical Properties of Clouds in Global Climate Models (CIRAD)	2003–07	J. Stamnes *
Past Climates of the Norwegian Region (NORPAST II)	2003–07	A. Nesje**
Polar Ocean Climate processes (PROCLIM)	2003–07	P. Haugan*
Land-use and ecosystem function in Norwegian forest landscapes	2007–08	A. Bjune**
Seasonal Predictability over the Arctic Region - exploring the role of boundary conditions (SPAR)	2007–10	E. Jansen**
Improved forecasting of adverse weather in the Arctic Region - present and future (IPY- Thorpex)	2007–10	A. Sorteberg**
Assessment of human impact on the marine Carbon system in arctic regions (A-CARB)	2007–09	A. Olsen*
Ocean Mixing in the Arctic: Case study at the north pole environmental observatory	2007–08	I. Fer*
Arctic records of climate change - dynamics, feedbacks and processes (ARCTREC)	2007–10	E. Jansen*
Climate of Norway and the Arctic in the 21st century (NORCLIM)	2007–10	H. Drange*
Polar Climate and Heat Transport (POCHAHONTAS)	2007–10	S. Østerhus*
Bipolar Atlantic Thermohaline Circulation (BIAC)	2007–10	T. Gammelsrød*
Paleoceanagraphic and climatic variability on decadal to millennial timescales across the Drake Passage (Paleodrake)	2007–08	U. Ninnemann*
Southern Ocean Biogeochemistry: Education and Research (SOBER)	2007–08	R. Bellerby*
Response of tropical Atlantic surface and intermediate waters to changes in the Atlantic meridional overturning circulation (RETRO)	2007–10	T. Dokken*
Atlantic meridional overturning circulation during interglacials (AMOCINT)	2007–10	E. Jansen*
The Effect of Climate Change on Arctic High-Impact Weather Events (ArcChange)	2007–10	I. Barstad**

RESEARCH PROJECTS FUNDED BY THE 5TH AND 6TH FRAMEWORK PROGRAMMES OF THE EUROPEAN COMMISSION

Title	Duration	Type		Leader/ Scientist
Network for Ice sheet and Climate Evolution (NICE)	2007–10	MCIF	◆	E. Jansen
Links between Meridional Overturning Circulation and climate changes during the Holocene (LIMOCINE)	2006–08	MCIF	✖	E. Jansen
Developing Arctic Modelling and Observing Capabilities for Longterm Environmental Studies – Integrated Project (DAMOCLES)	2005–09	IP	◆	P. Haugan and H. Drange
Marine carbon sources and sinks assessment (CARBOOCEAN)	2005–09	IP	✖	C. Heinze
Understanding the dynamics of the coupled climate system (DYNAMITE)	2005–08	STREP (NERSC)	✖	H. Drange
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

BCCR is: ✖ *Coordinator or* ◆ *Partner*
IP: Integrated Project, MCIF: Marie Curie Intra-European Fellowship, MCTN: Marie Curie Teaching Network, MCTS: Marie Curie Training Site, NoE: Networks of Excellence, RTD: Research, Technology and Demonstration project, RTN: Research and Training Network, STREP: Specific Targeted Research Projects;

PROJECTS FUNDED BY OTHER SOURCES

Title	Duration	Leader/ Scientist	Funding agency
Arctic-Atlantic Exchanges (ARATEX)	2007–08	S. Østerhus	Nordisk Ministerråd
Vindressurskartlegging i komplekst terreng	2007–08	A. Sandvik	StatoilHydro Petroleum AS
Arctic Weather Extremes Workshop 19–20 June 2006	2006–08	A. Sorteberg	Statoil ASA
Internasjonal dokumentar for fjernsyn – Global oppvarming – styre været	2006–07	E. Jansen	University of Bergen
Paleo-Climate Modeling of Organic Rich Sediments (PALMORC)	2006–09	F. Flatøy	Norsk Hydro Produksjon AS
University of Washington – University of Bergen Climate Change Network	2006–09	T. Furevik	Bergens Forskningsstiftelse
Palaeoclimate in the Southern Ocean	2004–10	U. Ninnemann	COMER foundation

SELECTED PUBLICATIONS

Bjerknes researchers published 70 articles in international peer review journals in 2007. For a complete listing please visit **www.bjerknes.uib.no/publications/.** Bjerknes scientists are indicated in **bold**.

ARTICLES IN INTERNATIONAL PEER REVIEW JOURNALS

1. **Barstad, Idar**; Grabowski, Wojciech W.; Smolarkiewicz, Piotr K. Characteristics of large-scale orographic precipitation: Evaluation of linear model in idealized problems. Journal of Hydrology 2007;340(1-2):78-90.
2. **Bellerby, Richard**; Schulz, K.G.; Riebesell, U.; **Neill, Craig Chandler**; Nondal, Gisle; **Johannessen, Truls; Brown, Kelly**. Marine ecosystem community carbon and nutrient uptake stoichiometry under varying ocean acidification during the PeECE III experiment. Biogeosciences 2007;4:4631-4652.
3. **Byrkjedal, Øyvind; Esau, Igor; Kvamstø, Nils Gunnar**. Sensitivity of simulated wintertime Arctic atmosphere to vertical resolution in the ARPEGE/IFS model. Climate Dynamics 2007.
4. **Esau, Igor; Byrkjedal, Øyvind.** Application of a large-eddy simulation database to optimisation of first-order closures for neutral and stably stratified boundary layers. Boundary-layer Meteorology 2007;125(2):207-225.
5. **Fer, Ilker;** Sundfjord, Arild. Observations of upper ocean boundary layer dynamics in the marginal ice zone. Journal of Geophysical Research 2007;112.
6. Hansen, Bogi; **Østerhus, Svein**. Faroe Bank Channel overflow 1995-2005. Progress in Oceanography 2007;75(4):817-856.
7. **Kleiven, Helga Flesche**; Kissel, Catherine; Laj, Carlo; **Ninnemann, Ulysses S**; Richter, Thomas O.; Cortijo, Elsa. Reduced North Atlantic Deep Water Coeval with the Glacial Lake Agassiz Fresh Water Outburst. Science 2007.
8. **Kolstad, E. W.** and T. J. Bracegirdle (2007) Marine cold-air outbreaks in the future: an assessment of IPCC AR4 model results for the Northern Hemisphere. Climate Dynamics.
9. Lamy, Frank; Kaiser, Jérôme; Arz, Helge W.; Hebbeln, Dierk; **Ninnemann, Ulysses S**; Timm, Oliver; Timmermann, Axel; Toggweiler, J. Robbie. Modulation of the bipolar seesaw in the southeast pacific during Termination 1. Earth and Planetary Science Letters 2007;259(3-4):400-413.
10. **Mangerud, Jan**; Landvik, Jon Y. Younger Dryas cirque glaciers in western Spitsbergen: smaller than during the Little Ice Age. Boreas 2007;36(3):278-285.
11. **Marzeion, Ben**; Levermann, Anders; Mignot, Juliette. The Role of Stratification-Dependent Mixing for the Stability of the Atlantic Overturning in a Global Climate Model. Journal of Physical Oceanography 2007;37:2672-2681.
12. **Nesje, Atle; Dahl, Svein Olaf;** Thun, Terje; Nordli, Øyvind (2007) The 'Little Ice Age' glacial expansion in western Scandinavia – summer temperature or winter precipitation? Climate Dynamics.
13. **Nesje, Atle; Bakke, Jostein**; **Dahl, Svein Olaf**; **Lie, Øyvind; Pytte, Anne-Grete Bøe.** A continuous, high-resolution 8500-yr snow-avalanche record from western Norway. The Holocene 2007;17(2):269-277.
14. **Nilsen, Jan Even**; Nilsen, Frank. The Atlantic Water flow along the Vøring Plateau: Detecting frontal structures in oceanic station time series. Deep-Sea Research Part I. Oceanographic Research Papers 2007;54(3):297-319.
15. **Omar, Abdirahman; Johannessen, Truls; Olsen, Are** ; Kaltin, Staffan; Rey, Francisco. Seasonal and interannual variability of the air-seaCO_2 flux in the Atlantic sector of the Barents Sea. Marine Chemistry 2007;104(3-4):203-213.
16. Riebesell, U.; Schulz, K. G.; **Bellerby, Richard**; Botros, M.; Fritsche, P.; Meyerhöfer, M.; **Neill, Craig Chandler; Nondal, Gisle;** Oschlies, A.; Wohlers, J.; et al. Enhanced biological carbon consumption in a high CO_2 ocean. Nature 2007; 450(7169):545-549.

17. **Risebrobakken, Bjørg; Dokken, Trond Martin; Otterå, Odd Helge; Jansen, Eystein; Gao, Yongqi; Drange, Helge**. Inception of the Northern European ice sheet due to contrasting ocean and insolation forcing. Quaternary Research 2007;67.
18. Roche, Didier M.; **Dokken, Trond Martin**; Goosse, Hugues; Renssen, Hans; Weber, Shanasey L. Climate of the Last Glacial Maximum: sensitivity studies and model-data comparison with the LOVECLIM coupled model. Climate of the Past 2007;3:205-224.
19. **Sandvik, Anne Dagrun**; Biryulina, Marina; **Kvamstø, Nils Gunnar**; Stamnes, Jakob J.; Stamnes, Knut. Observed and simulated microphysical composition of arctic clouds: Data properties and model validation. Journal of Geophysical Research 2007;112.
20. **Seierstad, Ivar Ambjørn**; **Stephenson, David**; **Kvamstø, Nils Gunnar.** How useful are teleconnection patterns for explaining variability in extratropical storminess? Tellus. Series A, Dynamic meteorology and oceanography 2007;59(2):170-181.
21. **Skogen Morten D.,** W. P. Budgell and F. Rey (2007). Interannual variability in Nordic Seas primary production. ICES Journal of Marine Science 64:889-898.
22. **Sorteberg, Asgeir**; Kattsov, Vladimir; Walsh, John E.; Pavlova, Tatyana. The Arctic surface energy budget as simulated with the IPCC AR4 AOGCMs. Climate Dynamics 2007;29(2-3):131-156.
23. **Sundby, Svein; Drinkwater, Ken**. On the mechanisms behind salinity anomaly signals of the northern North Atlantic. Progress in Oceanography 2007;73:190-202.
24. Sundfjord, Arild; **Fer, Ilker; Kasajima, Yoshie;** Svendsen, Harald. Observations of turbulent mixing and hydrography in the Marginal Ice Zone of the Barents Sea. Journal of Geophysical Research 2007;112.
25. **Ådlandsvik, Bjørn; Bentsen, Mats**. Downscaling a twentieth century global climate simulation to the North Sea. Ocean Dynamics 2007;57(4-5):453-466.
26. Lynch-Stieglitz, J; Adkins, JF; Curry, WB; **Dokken, Trond Martin**; Hall, IR; Herguera, JC; Hirschi, JJM; Ivanova, EV; Kissel, C; Marchal, O; **Ninnemann, Ulysses S.** et al. Atlantic meridional overturning circulation during the Last Glacial Maximum. Science 2007;316.

BOOKS AND CHAPTERS IN BOOKS

1. Ammann, B., **Birks, Hilary H.**, Walanus, A., Wasylikova, K. Plant Macrofossil Records | Late Glacial Multidisciplinary Studies. In: Elias, S.A., ed., Encyclopedia of Quaternary Science, 1-4. Elsevier: Oxford 2007, pp. 2475-2486.
2. **Birks, H. John B.** Pollen Methods and Studies | Numerical Analysis Methods. In: Elias, S.A., ed., Encyclopedia of Quaternary Science, 1-4. Elsevier: Oxford 2007, pp. 2514-2521.
3. **Birks, Hilary H.** Plant Macrofossil Introduction. In: Elias, S.A., ed., Encyclopedia of Quaternary Science, 1-4. Elsevier: Oxford 2007, pp. 2266-2288.
4. Denman, K.L., Brasseur, G., Chidthaisong, A., Ciais, P., Cox, P.M., Dickinson, R.E., Hauglustaine, D., **Heinze, Christoph**, et al. Couplings Between Changes in the Climate System and Biogeochemistry. In: Solomon, S., et al. eds., Climate Change 2007: The Physical Basis. Working Group I Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press: New York 2007, pp. 499-588.
5. **Furevik, Tore**, Mauritzen, C., **Ingvaldsen, Randi**. The Flow of Atlantic Water to the Nordic Seas and Arctic Ocean. In: Orbaek, J.B., et al. eds., Arctic Alpine Ecosystems and People in a Changing Environment. Springer Verlag: Berlin 2007, pp. 123-146.
6. Gaillard, M.-J., **Birks, Hilary H**. Plant Macrofossil Methods and Studies | Paleolimnological Applications. In: Elias, S.A., ed., Encyclopedia of Quaternary Science, 1-4. Elsevier: Oxford 2007, pp. 2337-2356.
7. **Jansen, Eystein**, Overpeck, J.T., et al. Paleoclimate. In: Solomon, S., et al. eds., Climate Change 2007: The Physical Science Basis. Working Group I Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press: New York 2007, pp. 433-498.
8. **Jenkins, Alastair David**. The Interaction of Ocean Surface Processes, Waves, and Turbulence in the Adjacent Boundary Layers. In: Garbe, C.S., et al. eds., Transport at the Air-Sea Interface: Measurements, Models and Parametrizations. Springer Verlag: Berlin 2007, pp. 145-158.

The Norwegian television channel TV2 flew Atle Nesje, UiB/ BCCR, to Folgefonna to conduct an interview for the 21.00 O'clock news (photo: Atle Nesje).

9. **Mangerud, Jan**, Fossen, H. Den indre farleia – en sjelden naturgave til folket i Hordaland. In: Fossen, A.B., ed., Leia langs norskekysten. Bodoni Forlag: Bergen 2007, pp. 23-40.
10. **Nesje, Atle**. Glacial Landforms, Ice Sheets | Paleo ELAs. In: Elias, S.A., ed., Encyclopedia of Quaternary Science, 1-4. Elsevier: Oxford 2007, pp. 882-892.

REPORTS

1. Andrén, Elinor; Clarke, Anne Marie; **Telford, Richard**; Weckström, Kaarina; Vilbaste, Silje; Aigars, J.; Conley, Dan; Johnsen, T.; Juggins, Steve; Korhola, Atte. Defining reference conditions for coastal areas in the Baltic Sea: TemaNord 2007. 81 s.
2. Forsberg, R.; Skourup, H.; Andersen, O.B.; Knudsen, P.; Laxon, S.; Ridout, A.; Johannessen, Johnny Andre; Siegismund, F.; **Drange, Helge**; Tscherning, C.C.; et al.. Combination of Spaceborne, Airboren and In-Situ Gravity Measurements in Support of Arctic Sea Ice Thickness Mapping: Danish National Space Center 2007. 141 s.
3. Hansen, Georg; **Flatøy, Frode**. Aerosoler, skyer og stråling i polhavområdet: Norsk institutt for luftforskning (NILU) 2007. 13 s.
4. Mortensen, Ebba; Larsen, Karin Margretha H.; Hansen, Bogi; Kristiansen, Regin; **Østerhus, Svein**. Nordic WOCE ADCP Deployments in Faroese Waters 2006 - 2007: The Faroese Fisheries Laboratory 2007. 61 s.
5. **Nilsen, Jan Even Øie**; Hatun, Hjalmar; **Mork, Kjell Arne**; Valdimarsson, H. The NISE Dataset. Techinical Report: Faroese Fisheries Laboratory 2007
6. **Vasskog, Kristian**. Fremtidig havnivåstigning i norske kystkommuner: Oppdragsrapport overlevert til Direktoratet for Samfunnssikkerhet og Beredskap 2007. 15 s.

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