Established by the Research Council of Norway

Norwegian Centre of Excellence

BCCR – Bjerknes Centre for

Climate Research

ANNUAL REPORT 2008

Centre of Excellence Activities

Nansen Center, Bergen

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FIELD EXPEDITION IN NY ÅLESUND, SVALBARD. PHOTO: RICHARD BELLERBY, BCCR

A GLOBAL PERSPECTIVE

PHOTO: TOR ERIK MATHIESEN, TRYGG VESTA.

After 2007 with all its media engagements due to the Intergovernmental Panel on Climate Change and the Nobel Peace prize, 2008 was a more normal year for the Bjerknes Centre.

In addition to a record number of peer-reviewed papers, we have maintained a strong outreach profile and the number of popular science presentations and media outlets are impressive. It testifies to the fact that climate change is widely recognized as a major challenge to societies, that our expertise is highly relevant for the challenges we are facing and that the Bjerknes Centre is a much needed national resource of knowledge and expertise.

There are still important gaps in our knowledge about the climate system that are a hindrance to our ability to predict climate change. At the Bjerknes Centre, we have recently started to strengthen our expertise in order to project to which degree changes in the Earth's carbon sources and sinks will affect and be affected by climate change. Model simulations indicate that the sinks will likely weaken and constitute a positive feedback, which will strengthen global warming, but the uncertainty is large. In 2008 the first runs with our Earth System Model with interactive carbon cycle were performed, thanks to highly dedicated work from several of our scientists. This is a major breakthrough with encouraging results. For the Bjerknes Centre, this capacity will also be important for our future path and relevance. It complements our leading role internationally in observing and quantifying the ocean uptake of CO_2, which represents the major sink for man-made CO_2 emissions. Without such capacities, we will be unable to evaluate the degree to which we can avoid harmful climate change and the degree to which emission regulations are effective.

Societies need more precise predictions of climate change in the coming decades, particularly on regional scales. But, a lack of scientific understanding of the drivers of climate variability represents a major challenge particularly on regional scales. While observing this variability and how it affects global warming trends, the science community needs to further explore its causes. Therefore, there is a strong push within the Bjerknes Centre to join forces across disciplines to tackle this major scientific challenge. With its competence in climate modelling, paleoclimatology and ocean observations, the Centre is uniquely well positioned to deliver key results.

In 2008 we decided to more actively establish international partnerships. This is due to a realization that we have expertise of global significance and that through such partnerships our competence will be better and more relevant for the global challenges we face. A 4-year partnership programme with the University of Washington, Seattle, and Massachusetts Institute of Technology was funded. We strengthened our collaboration with the Nansen-Zhu Centre at the Institute of Atmospheric Physics in Beijing, and new partnerships in South Africa and India are about to be established. As part of this internationalization and with the more pressing needs for climate change information relevant for societal planning and adaptation, both in Norway and in developing nations and nations in transition, we have also entered into the field of regional climate modelling. Last, but not the least, we succeeded in obtaining an 8-year funding for a research school in climate dynamics, hosted by the University of Bergen, with national and international partners.

PROF. EYSTEIN JANSEN

STATEMENT FROM THE BOARD OF DIRECTORS:

The Board is pleased to note that the Bjerknes Centre has continued its high activity in 2008. The scientific output is large and growing, the interactions with the public, stakeholders and media are also very good. The centre has evolved according to its plans and to our full satisfaction. The Bjerknes Centre now constitutes an invaluable climate research and climate knowledge resource both nationally and internationally. As a response to this development, the Board in 2008 initiated a process to secure the long-term continuation of the centre's expertice. This led to a new agreement of collaboration between the partner institutions of the Bjerknes Centre with a perspective well beyond the period as a Centre of Excellence (CoE). With this agreement, the partners strengthened their commitment to work together for a strong climate research centre in Bergen.

BERGEN ON A RAINY DAY (PHOTO: PREVIOUS SUMMER SCHOOL STUDENT)

AN EXCELLENT RESEARCH CENTRE ON THE TOP OF EUROPE

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 climate research, focusing on northern Europe and the Polar Regions, as well as being a key provider of first-rate knowledge on climate change to policymakers, industry, and the general public.

The centre has an international profile with leading expertise within climate understanding, climate modelling and scenarios for future climate changes and quantification of climate changes. In order to carry out its ambitions, the research activity is organized into five interdisciplinary 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, Sea Ice and Atmosphere Processes

Exchanges between ocean, sea ice and atmosphere are crucial to the climate system, and simulations of the future climate depend on their proper representation.

4 Ocean Carbon 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 and Regional 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.

More about our research groups at www.bjerknes.uib.no/research/

Established by the Research Council of Norway

Norwegian Centre of Excellence

The Bjerknes Centre is a Norwegian Centre of Excellence (CoE) in climate research, and is coordinated by the University of Bergen in cooperation with the Institute of Marine Research, Nansen Environmental and Remote Sensing Center and Unifob AS.

As long as the concentration of carbon dioxide in surface waters is increasing, the oceans will take up less of human-induced CO2 emissions, and a greater part of the emissions will remain in the atmosphere (photo: iStockphoto.com).

THE NORTH ATLANTIC IS SATURATED WITH CO_2 DURING WINTER

The first dataset of carbon dioxide covering an annual cycle across the northern North Atlantic shows that the surface water is saturated with CO_2 during winter, contradicting the widely held view that this region is a significant sink for CO_2 in winter.

Since the industrial revolution the oceans have absorbed about half of the CO_2 emissions caused by the burning of fossil fuels. Changes in the uptake may affect future climate through its impact on the atmospheric CO_2 concentration. Hence, to fully account for the changing atmospheric concentration, ocean uptake and release of CO_2 must be understood and quantified.

Are Olsen and co-workers at the Bjerknes Centre published the first annual dataset covering the northern North Atlantic in a paper in *Biogeosciences*. The data was obtained by using an autonomous instrument measuring the concentration of CO_2 in surface water onboard the container carrier Nuka Arctica, which crosses the Atlantic between Greenland and Denmark on a biweekly schedule. This data were obtained in 2005 and reveal several new features of the northern North Atlantic carbon cycle. Perhaps the most significant finding is that surface waters are saturated with CO_2 during winter, implying that the northern North Atlantic does not absorb CO_2 in this season. This result contrasts with the widely held view that this region is a significant sink for CO_2, which is due to the cooling of the Gulf Stream waters as they travel northwards.

The reason for the saturation along 60°N is not clear. It may be a very local phenomenon, as a consequence of the slow-moving nature of the North Atlantic Current in this area or deep mixing in winter that can bring up CO_2-rich waters from depth to the surface. It may also be a consequence of the extra ocean CO_2 uptake that follows from the increasing CO_2 concentrations in the atmosphere, or it may be the result of recent changes in the surface circulation of the North Atlantic induced by the North Atlantic Oscillation. These options are being further explored in several ongoing research projects. The Bjerknes Centre plans to sustain the measurement program on Nuka Arctica providing insight into the year-to-year changes in the behavior of the North Atlantic CO_2 sink and its sensitivity to climate change, which is highly relevant to mitigation strategies aiming to stabilize the atmospheric CO_2 concentration.

Reference:
Olsen, **A., K. R. Brown**, *M. Chierici*, **T. Johannessen**, *and* **C. Neill** *(2008): Sea-surface CO_2 fugacity in the subpolar North Atlantic, Biogeosciences, 5, 535–547.*

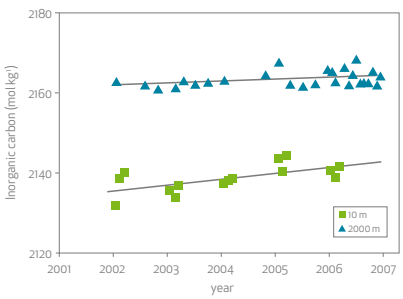
DECREASING SINK FOR ATMOSPHERIC CARBON

A new time series of inorganic carbon at the Ocean Weather Station M in the Norwegian Sea shows that the surface ocean carbon content increases faster than what is observed in the atmosphere, and thus the sink for atmospheric carbon is decreasing.

Dissolved inorganic carbon (C_T) has been collected at Ocean Weather Station M in the Norwegian Sea since 2001. This is brief compared to time series of salinity and temperature, which have been sampled at Station M for more than 60 years. Nevertheless, the carbon data have already contributed to our knowledge about interannual variations and distribution of man-made carbon in the water column. From winter to summer, the surface C_T concentration drops due to carbon being fixed in organic matter, but below 50 meters no clear seasonal signal is found. Observations show an annual increase in surface inorganic carbon concentration (Figure 1, green squares). When compared to equivalent measurements of the atmospheric CO_2 concentration in the same area, it becomes apparent that the surface ocean carbon content increases faster than what is observed in the atmosphere, and thus the sink for atmospheric carbon is decreasing.

Observations also show an annual increase in inorganic carbon in deep water (Figure 1, blue triangles). About a tenth of this is due to inflow of old Arctic water with larger amounts of re-mineralised matter, i.e. inorganic carbon, compared to previously. The remainder of the deep-water carbon increase has an anthropogenic origin and sources for this might be Greenland Sea surface water, Iceland Sea surface water, and/or re-circulated Atlantic Water.

Figure 1. Inorganic carbon concentration 01-07



The figure shows how the inorganic carbon concentration increases over years in surface (green squares) and deep (blue triangles) water.

M/S Polarfront operates Station M, which is the last weather station in the Atlantic Ocean, at 66°N 2°E. It is the oldest oceanographic station in the world (1948) and provides time series that are crucial for documenting and understanding climate change (photo: unknown).

Reference:

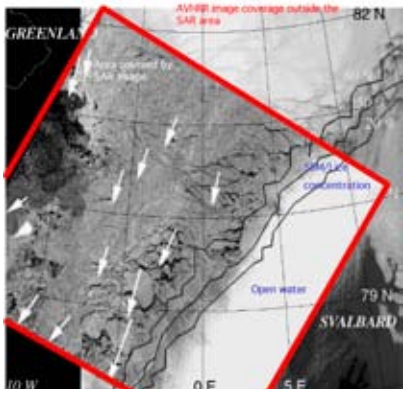
Skjelvan, **I., E. Falck**, *F. Rey, and* **S. B. Kringstad** *(2008): Inorganic carbon time series at Ocean Weather Station M in the Norwegian Sea, Biogeosciences 5(2), 549-560..*

LARS H. SMEDSRUD, BCCR

DRIFT OF THE ARCTIC SEA ICE COVER

The record low Arctic summer sea ice cover the last two years is mainly caused by increased southward export of sea ice through the Fram Strait, out of the Arctic Ocean.

Figure 2: Ice movement, Fram Strait 2008



The satellite image shows ice drifting through the Fram Strait. The arrows show the ice movement during three days in February 2008 (source: Kjell Kloster, NERSC, ASAR image).

The finding was presented in *Geophysical Research Letters* by a group of scientists led by Lars H. Smedsrud at the Bjerknes Centre. They based their investigation on satellite images measuring the drift of sea ice through the Fram strait between Svalbard and Greenland. The images were taken every three days over the past four years. During this period a steady increase in the sea ice export out of the Arctic was found.

Until now, it has been assumed that the record-low summer sea ice cover in the Arctic has been due primarily to a warmer climate. Three factors that influence the heating of the Arctic Ocean are atmospheric heat transport, warm water transported by the Gulf Stream, and increasing atmospheric CO_2 concentration. In this study, however, the scientists point out that the atmospheric heat transport has been constant since 1990. The warm water transport in the ocean has increased in both the Fram Strait and the Bering Strait between Alaska and Siberia, but cannot explain the record-low summer ice cover in the Arctic. The extra heat in the ocean stays more or less at 200-500 meters depth, because the stable water masses of the Arctic Ocean prevent efficient mixing of heat. The drift of sea ice has increased by approximately 35 percent

A NEW GENERATION CLIMATE MODEL ON TRACK

The new generation climate model includes a dynamic carbon cycle, which is important because the natural sources and sinks of carbon are likely to change under global warming.

The Bjerknes Centre provided, as one of four European climate research groups, scenario simulations to the 2007 report from the Intergovernmental Panel on Climate Change (IPCC). The creation of a new generation of climate models, so-called earth system models, is underway. The new Norwegian climate model, NorESM, is coordinated by the Bjerknes Centre through the Norclim project, with partners from the Meteorological Institute, the Norwegian Polar Institute and the Universities of Bergen and Oslo.

The inclusion of a dynamic carbon cycle has important and far-reaching implications. First, the natural sources and sinks of carbon are likely to change under global warming. It is expected that the ocean uptake of carbon will decrease and the release of carbon from land will increase as the world warms. As result, a larger fraction of human-in-

over the last two years. The scientists conclude, therefore, that the record-low summer ice cover the past two years is caused less by melting of sea ice in the in the Arctic Ocean, than by southward export, largely driven by strong winds. The ice later melted in warmer waters in the Atlantic Ocean.

Short-term variations

Large ice export out of the Arctic, as seen the last two years, and warm water transport into the Arctic, may cause new record-low ice extent in the future. However, if the winds change direction or strength, or a reduced Gulf Stream pumps less warm water into the North Atlantic, supplying the Arctic Ocean, the ice cover can become thicker and more extensive in the future. The dramatic decline in sea ice, with 40% reduction in September 2007, is probably a short-term variation. Nevertheless, in a long-term perspective the summer sea ice cover will be reduced due to global warming.

Greenhouse gases reducing ice thickness

The scientists also used a model that connects the ice with the ocean and the atmosphere above, allowing them to make future predictions of the sea ice cover. A central assumption in this model is that the increase of greenhouse gases in the atmosphere leads to a gradual increase of long-wave radiation towards the earth surface, which will reduce the sea ice thickness. During the 1950s and 60s the ice thickness was on average three meters over the entire Arctic. Today, the average ice thickness has been reduced to only one meter. Given that the greenhouse gases in the atmosphere continue to increase at today's rate, the Arctic will be 95% open water during the summer in 2050. The ice will then cover an area about the size of Norway, and will only be a small reminder of the ice cover as it was 100 years ago, when it covered an area the size of Europe.

Bjerknes Centre researcher Lars H. Smedsrud and co-authors conclude that the transport of sea ice through the Fram Strait had greater impact on the record-low summer ice cover in the Arctic than is the heat supply from the ocean (photo: UNIS).

Reference:
Smedsrud, L. H., **A. Sorteberg**, *and K. Kloster (2008), Recent and future changes of the Arctic sea ice cover, Geophysical Research Letters, 35.*

duced emission of CO_2 will remain in the atmosphere, amplifying global warming. Second, NorESM will not be forced with prescribed atmospheric concentrations of, for instance, CO_2, but with prescribed emissions of greenhouse gases and particles. The model system will then compute the atmospheric concentration of these constituents based on the simulated sources and sinks.

Feedback mechanisms, particularly linked to clouds, snow and sea ice are also improved based on national efforts using field experiments, theoretical studies and process modeling.

NorESM is built up of a number of modules, each of which communicates with the other modules. The key modules are the newest version of the NCAR Climate Community Model (CCM) model system, the Bergen version of the Miami isopycnic coordinate ocean model, and the marine carbon cycle HAMOCC model from the Max-Planck Institute for Meteorology in Hamburg. As a result of the extensive activity on aerosol particles and clouds in Oslo, updated aerosol-cloud-climate interaction schemes are an integrated part of NorESM.

The new Norwegian climate model is presently being tested on a new 5000-processor supercomputer in Bergen. The new scenario integrations, adding up to a total of about 4500 model integration years and generating about 200 TeraBytes of data, will start in summer 2009 and be finished by the end of 2010.

DOWNSCALING GIVES PROMISING RESULTS

Photo: Istockphoto.com

Bjerknes researchers downscale precipitation, temperature and wind in Norway.

The results were published in *Climate Dynamics*, and show great improvements for the spatial and temporal resolution for the dataset covering a 40-year time period (1961–2000).

The research group has downscaled observation-adjusted model data from the European forecasting centre (ECMWF; ERA40) in Reading, England, for 40 years. The new dataset has a grid spacing of about 30 km in Norwegian waters. The downscaling method is based on a global model applying a stretched grid focused on Norwegian waters. The resolution is thus improved in the focus area at the expense of areas at the opposite side of the earth. This approach allows for more economical use of CPU time.

The large-scale solution of the old dataset (ERA40) has been imposed on the new one, and as a consequence, the large-scale circulation is similar in the two datasets. The small scales have been free to evolve, and due to this, extremes of wind speed and precipitation intensities are better reproduced.

Compared with independent daily observations of precipitation, temperature and wind over a 30 year period (1961–1990), the scientists find significant improvements. In the new dataset, the deviation in daily precipitation is significantly reduced from 50% to 11%, and the extremes significantly improved, e.g. from –59% to –29% for the 99.9 percentile. The temperature deviation has been reduced by about a degree and the wind estimates also show some improvements.

Reference:
Barstad, I., A. Sorteberg, F. Flatøy *and M. Deque (2008): Precipitation, temperature and wind in Norway: dynamical downscaling of ERA40, Climate Dynamics.*

Photo: Istockphoto.com

WEAKER STORMINESS IN LATE WINTER

Fram Strait, Svalbard (photo: Anders Sirevaag, BCCR).

A new paper published in *Climate Dynamics* shows that the isolated effect of a reduced Arctic sea ice cover will lead to weaker North Atlantic storminess in late winter.

Arctic sea ice extent has declined over the past few decades with the greatest reduction occurring in late summer. The current generation of climate models predict that global warming may make the Arctic virtually ice free in summer towards the end of the century. When sea ice retreats, the atmosphere becomes exposed to the warm ocean underneath. As a result, heat fluxes from the ocean are allowed to warm the atmosphere. The largest anomalous heat fluxes are during winter when the air temperature is coolest relative to the ice and open water. The greatest sea ice reduction is in late summer, but this has little impact on the atmosphere as the change in heat fluxes is small.

Simulations show that the large heat fluxes during winter reduces storminess over the Barents Sea, Labrador Sea and northern Russia. However, a substantially larger reduction in North Atlantic storminess was found in March. The study shows that this was the only time when the complex feedback processes associated with the negative phase of the North Atlantic Oscillation (NAO) were triggered. The NAO is a pattern that represents shifts in the strength and direction of westerly winds and storminess across the North Atlantic. A negative NAO gives less rainfall and colder temperatures over northern Europe.

That sea ice anomalies are able to influence the NAO in late winter is unexpected because the heat fluxes from the ocean are actually smaller than the rest of the winter. This indicates a potentially more important role of sea ice anomalies for our weather in the transition between winter and spring than previously accounted for.

To isolate the impact of a new seasonal cycle of sea ice, this study uses simulations of the atmospheric climate model ECHAM5 developed at the Max-Planck-Institute for Meteorology. Simulations were carried out using a present-day sea ice cover and a new seasonal cycle projected for the end of the century.

Reference:
Seierstad, I. A. *and* **J. Bader** *(2008): Impact of a projected future Arctic sea ice reduction on extratropical storminess and the NAO, Climate Dynamics.*

Field work on the ice (photo: Anders Sirevaag, BCCR).

NORWEGIAN MOUNTAIN GLACIERS IN THE PAST, PRESENT AND FUTURE

Documentation of glacier changes is a key element for reconstruction of past climate variability and early detection of present and future climate change.

A group of scientists, led by Atle Nesje at the Bjerknes Centre, has synthesised records of the Holocene (the period after the last Ice Age) glacier variations in different regions of Norway, data that has taken more than 20 years to provide.

Norwegian glaciers melted

During the period from approximately 8000 to 6000 years ago, most glaciers in Norway were completely melted away at least once, due to high summer temperatures and/or reduced winter precipitation. Subsequent to approximately 6000 years before present, the glaciers started to advance and the period with the most extensive glaciers was during the 'Little Ice Age', which lasted from 1500 to 1920.

The "Little Ice Age"

Moraines at Jostedalsbreen, Hardangerjøkulen, Folgefonna, and in Jotunheimen were used to extend records of glacier-length variations back to their maximum position during the "Little Ice Age". The timing of the maximum glacial advance in different parts of southern Norway varied considerably, ranging from the early 18th century to the late 19th century. Records of frontal variations of glaciers in southern Norway show an overall retreat from 1750 to the 1920s. In the 1930s-40s most Norwegian glaciers retreated significantly. Short maritime outlet glaciers with a short response time (<10–15 years) started to advance in the mid 1950s, whereas long outlet glaciers with longer frontal time lag (>15–20 years) continued their retreat to the 1980s.

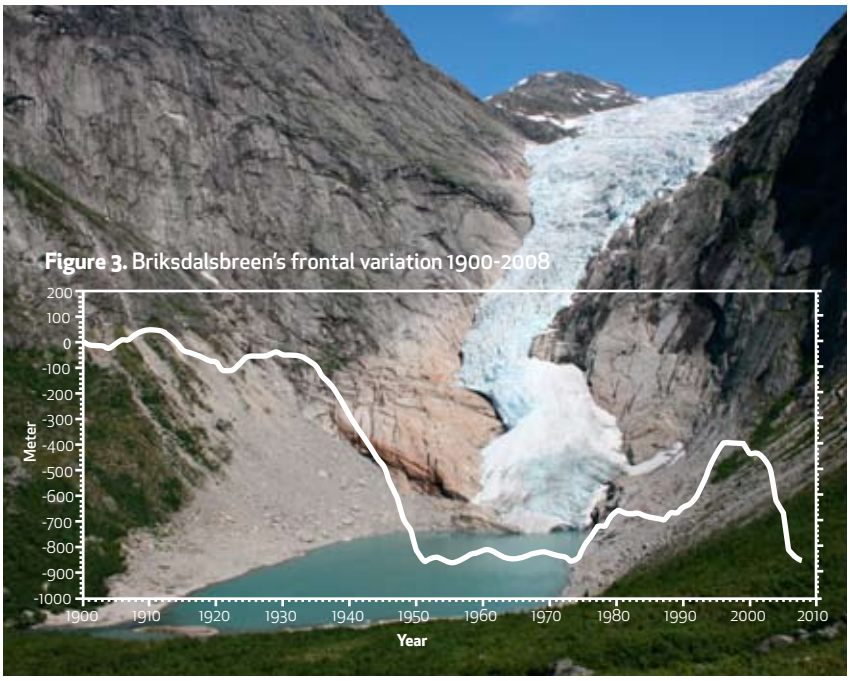


Figure 3. Briksdalsbreen's frontal variation 1900-2008

Briksdalsbreen, a western glacial arm from Jostedalsbreen, completely covered the lake in 1996/97. During the last 10 years the front has withdrawn approximately 470 meters (note the vegetation-free area). The graph shows the development of Briksdalsbreens front variations between 1900–2008 (photo and graph: Atle Nesje, UiB/BCCR).

Recent glaciers advance and retreat

In the 1990s, several of the maritime glaciers started to advance as a response to higher winter accumulation during the first part of the 1990s. Since 2000 most of the observed glaciers have retreated remarkably fast (annual frontal retreat >100 m) mainly due to high summer temperatures.

Norwegian glaciers in a future climate

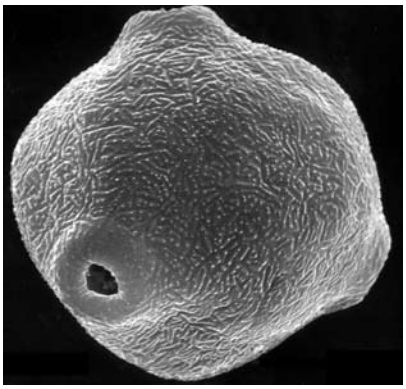
The long-term climate prediction for western Norway indicates a rise in the summer temperature of 2.3 °C and an increase in the winter precipitation of 16% by the end of the 21st century (RegClim project). This climate scenario may, if it occurs, cause the equilibrium-line altitude (ELA) to raise 350 ± 100 m. As a result, about 98% of the Norwegian glaciers are likely to disappear and the glacier area may be reduced ~34% by the end of our century.

Reference:

Nesje, A., J. Bakke, S. O. Dahl, Ø. Lie *and J. A. Matthews (2008): Norwegian mountain glaciers in the past, present and future, Global and Planetary Change, 60, 10-27.*

PINE FORREST (PHOTO: ISTOCKPHOTO.COM)

POLLEN REVEALS LARGE CHANGES SINCE THE LAST ICE AGE



Pollen from birch (photo: Jan Berge, UiB)

Analysis of pollen tells us that it has been warmer and wetter than at present time, which provided good growing conditions for both birch and pine.

A paper published in *Boreas* by Anne Bjune and John Birks shows large changes in climate and vegetation development during the Holocene (period after the last Ice Age). The results are based on pollen and plant macrofossil analysis of sediments from lake Svanåvatnet close to Mo i Rana, in northern Norway.

Reconstructions of past climate show a rapid increase in temperature and precipitation during the early Holocene (8700–7700 years before present). At this time, pioneer plants dominated the vegetation, but a rapid establishment of trees and shrubs are observed at the investigated site. Pollen accumulation rates and the presence of macrofossils show that tree birch was present already 8500 years ago, while pine established at around 8600 years ago. In the following period, from 8000 to 3500 years before present, the mean temperature both in winter and summer is reconstructed to be about 2 °C higher than today. During the same period a wetter climate is inferred, with mean annual precipitation 300-400 mm higher than today. In this period, tree species abundance and diversity is high and tree-line altitude is at its highest in the region. From 3500 years before present and until today, a gradual decrease is observed in all reconstructed climate parameters together with a reduction in tree abundance and the development of a more open landscape.

The climate history at Svanåvatnet indicates similarities with reconstructed temperature at other localities in northern and central parts of Scandinavia. Reconstructed annual precipitation shows larger discrepancies with these localities, possibly due to regional differences in precipitation patterns during the Holocene.

Reference:

Bjune, A. E. *and* **H. J. B. Birks** *(2008): Holocene vegetation dynamics and inferred climate changes at Svanåvatnet, Mo i Rana, northern Norway. Boreas, 37, 146–156.*

WARMING TEMPERATURES PUSH COD SPAWNING SITES NORTHWARD

Lofoten region is an important spawing site for Arcto-Norwegian cod (photo: Filipa Silva, Erasmus student, IMR).

A new study shows that warming ocean temperatures increase the amount of spawning in the north and decrease it in the south.

The finding was published in *Journal of Marine Science* by Bjerknes researcher Svein Sundby and his colleague Odd Nakken. With warming ocean temperatures and the threat of potential further warming, because of increasing CO_2 due to human-induced emissions, questions are being raised about the effect that this warming will have on commercial fish stocks. One of the most important fish stock off Norway is the Arcto-Norwegian cod that inhabits the Barents Sea. The Barents Sea cod stock tends to be more abundant in warmer years compared to colder years. However, it is not only abundance that is affected by warming temperatures.

Photo: Kathrine Michalsen, IMR.

Young Arcto-Norwegian cod grow up in the Barents Sea and tend to remain there as adults. However, the adult cod migrate each year to the coast of Norway to spawn. Their spawning sites extend along approximately 1500 km of the coastline of Norway from Møre in the south to Finnmark in the north, although the major spawning occurs in the Lofoten region. The eggs and larval cod are carried northward by the currents from these spawning sites and eventually enter the Barents Sea.

Sundby and Nakken show that during the general warming that occurred from the 1930s to the 1950s and again in recent years, there is proportionately more spawning in the north and a reduced amount in the south. The opposite was observed during the intervening cold period and in the early part of the 20th century. This was established during the early cold and warm periods by data on the amount of fish eggs or roe in the spawning fish each year from 1900 to 1976. After 1976, qualitative observations show that there have been reduced levels of spawning in the south during the present warm period.

From 2003, spawning has been observed along the coast of east Finnmark where it has not been seen the previous 40 years. Another significant finding in this study was that the changes in the relative amount of spawning occur over long periods, which entails slow changes in the spawning sites over periods of several decades.

Reference:

S. Sundby *and O. Nakken (2008): Spatial shifts in spawning habitats of Arcto-Norwegian cod related to multidecadal climate oscillations and climate change. ICES Journal of Marine Science, 65: 953–962.*

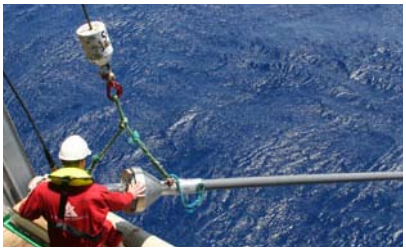
RESEARCH AT SEA, ON LAND AND ICE, AND IN THE ATMOSPHERE

Bergen rain taken from inside the Geophysical Institute, UiB (photo: Erik Kolstad, BCCR).

CarboOcean cruise in the Antarctic, 2007 (photo: Craig Neill, BCCR).

BIAC field expedition in Svalbard, 2007 (photo: Coastal guard, Svalbard).

THORPEX campaign in the Arctic (photo: Erik Kolstad, BCCR).



RETRO cruise, Brazil 2007 (photo: Jill Johannessen, BCCR).

Our research efforts combine modelling and field observations at sea, on land and ice, and in the atmosphere.

The Bjerknes Centre is involved in about thirty research projects. The Research Council of Norway and the European Union finance most of the projects. A selection of the projects is given below, whereas a complete list of research projects is given in Appendix 2.

NorClim is the single biggest national research project in Norway, financed by the Research Council of Norway, and is coordinated by the Bjerknes Centre. One of NorClim's aims is to provide new climate scenarios for Norway and the northern region for the periods 2030 and 2100. A second aim is to establish a national Earth System Model – named NorESM – to be used for the next IPCC report and by the climate modeling communities in Norway in the years to come. In 2008, initial test integrations with NorESM with interactive carbon cycle were performed. Read also article page 8-9 and 11.

Marine carbon sources and sinks assessment (CarboOcean) consists of 47 international partners, financed by the EU, and is coordinated by the Bjerknes Centre. The aim is to determine the ocean's quantitative role for uptake of CO_2, which is essential knowledge to determine on the expected consequences of rising atmospheric CO_2 concentrations and to guide the management of CO_2 emission reductions. Local, regional and basin wide time series sampling has continued in 2008, e.g. by a basin wide cruise in the North Sea and several cruises in the Mediterranean basin. Read also article page 6 and 25.

Bipolar Atlantic Thermohaline Circulation (BIAC) 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. In 2008 a research cruise was carried out in Storfjorden, Svalbard, in order to study the ice-freezing processes and its impact on water masses. BIAC scientists also participated in cruises in order to pick up current meter rigs that were deployed in 2007 in Storfjorden and in the eastern Barents Sea.

IPY-THORPEX is an international, Norwegian-led research project, which aims to improve forecasting of severe weather in the Arctic region. The observational campaign includes a wide range of platforms. During a three-week campaign in March this year, a highly advanced German aircraft was used to fly directly into the storms. Three flights were made, and for the first time, the entire life cycle of a polar low was documented with scientific measurements. Read also article page 18.

RETRO is an international project led by the Bjerknes Centre, with partners in Brazil and Europe, financed by the European Science Foundation. The project aims to improve the understanding of the couplings between the tropics and the North Atlantic region, in particular how heat is transported through the Gulf Stream. The second cruise of RETRO was carried out in May this year with the purpose of sampling deep-sea sediments along the Namibian margin. The result is a total amount of approximately 230 meters of sediment, which will be used to reconstruct past climate variations.

Lake sediments from Juklavatnet disclose the history of Folgefonna Glacier thousands of years back (photo: from "Folgefonna and the fjord villages").

Research on the Folgefonna peninsula leads to outreach about past and present climate changes and its impact on the landscape and settlement.

The Folgefonna Glacier is well known for excellent summer skiing, blue ice climbing and a magnificent view overlooking the fjord landscape. Its location only 100 km away from Bergen makes the area popular for locals and for tourists from all over the world. Scientists from the Bjerknes Centre and the University of Bergen have conducted research in this area for ten years, and have taken this unique opportunity to reach out to the public through two outreach projects in 2008.

In August, a nature trail in front of the Folgefonna glacier was launched. Based on concepts from "geocatching" (a hide-and-seek game), visitors find the information points by using satellite navigation GPS equipment. The trail takes you around in the glacier foreland and gives information about the landscape, botany, and the transition from "The Little Ice Age" towards the present situation in which glaciers all over the world are melting due to global warming. The project is in collaboration with Folgefonna Glacier Team and Folgefonna National Park, and will be continued with more information points in 2009.

Folgefonna and the fjord villages

In November the book "Folgefonna and the fjord villages" was released after five years of preparation. The book release was accompanied by intensive cross-disciplinary public outreach. The book is for those that want in-depth knowledge about the glacier, the landscape, the fjords and the settlement at the Folgefonna Peninsula. The overall aim with the book is to tie knowledge about our physical environment and the history of settlement closer together, both in a historic and a prehistoric perspective. "Folgefonna and the fjord villages" elaborates in depth the linkages between landscape and how the humans utilize natural resources thorough farming, fruit production, hunting and fishing. Several scientists from the Bjerknes Centre and the University of Bergen took part in the project, which resulted in a book of 600 pages illustrated with magnificent pictures and graphic illustrations.

A NATURAL CLASSROOM FOR CLIMATE OUTREACH

PHOTO: SVEIN NORD/FORLAGET NORD4

NRK EXTREME WEATHER WEEK

For the third time, during a whole week at the end of September, the Norwegian Public Broadcasting (NRK) arranged the Extreme Weather Week with a focus on weather and climate issues in television and radio programming and on the Internet. The Extreme Weather Week is the single largest popular science effort in NRK's history and probably the largest-ever media venture in Norwegian popular science. This week is a co-operation between the NRK, the Bjerknes Centre and the Norwegian Meteorological Institute. The Extreme Weather Week was again a success for the Bjerknes Centre, whose scientists have contributed to about 20 programs in radio and television – in news, popular science magazines like *Verdt å vite* and *Newton*, and broader radio programs like *Norgesglasset*. This would not be possible without the involvement of some dedicated scientists.

Assistant professor Jostein Bakke guiding his family through the "Natural trail" in front of the Folgefonna glacier (photo: private).

Jostein Bakke, the originator behind "Natural Trail" guided the radio host of "Norgesglasset" through the trail, which resulted in five radio reportages during NRK's extreme weather week, reaching out to about 800 000 listeners daily, with issues related to glaciers and climate.

Erik Kolstad and Øyvind Paasche were in Utsira, an island outside Haugesund, and were on the air commenting upon different climate issues during the week. NRK chose to broadcast from this island because of its hard weather environment and due to the vision of becoming a zero-emission society. We believe that this week has made a difference in people's understanding of weather and climate issues and increased awareness for climate change and possible effects for people and society.

With this the German aircraft scientists flew into a cyclone formed near Svalbard (photo: Gudmund Dalsbø, met.no).

POLAR LOWS HIT THE MEDIA

Throughout Norwegian history, polar lows have claimed many lives along the coast of northern Norway.

Polar lows are intense cyclones that form only at high latitudes. But what is it that makes the polar regions so prone to this phenomenon? To find out, more than 20 scientists, with Bjerknes Centre reseachers among them, hired a German aircraft with the aim of flying directly into the storms. The team hit the jackpot on 3–4 March, when a beautiful cyclone formed near Svalbard and moved slowly southward along the Norwegian coast. Three flights were made, and for the first time, the entire life-cycle of a polar low was documented with scientific measurements.

The flight campaign is part of the project IPY-THORPEX, which was also a media hit. A film team followed the scientists day and night for three weeks and captured the ups and downs of life on a field campaign. The resulting 50-minute documentary was shown on national TV in Norway during Christmas and was seen by more than 800,000 people. A number of articles about polar lows and their impact in the marginal ice zone in the Arctic also appeared in international media outlets such as *USA Today* and *Scientific American*.

ENERGY - CLIMATE - TECHNOLOGY

The Energy – climate – technology (ECT) conference was launched for the first time in Grieghallen in April 2008. It was a great success with approximately 300 participants and more than 40 presentations.

Read more at
www.ect2008.com.

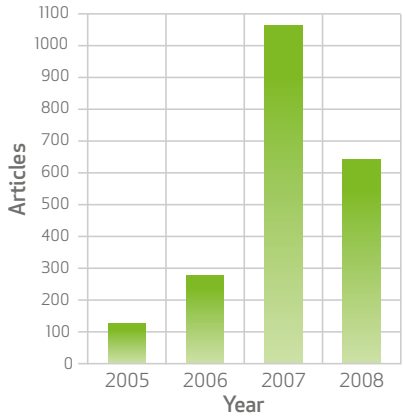
Major institutions from research, education and industry sectors from Norway and abroad gave contributions in the interface between climate change, energy and technology. The Bjerknes Centre participated in the Programme Committee together with representatives from Bergen Chamber of Commerce and Industry, CMR, BKK, UiB, StatoilHydro, Energiforum EF and BergenScenarier 2020. BCCR had special responsibility for the plenary session on Climate change and challenges for offshore energy and technology.

The purpose of the ECT Conference was to give a knowledge-based perspective on issues and policy solutions in the interface between energy resource use, climate change and technology development, with relevance for decision-makers in industry, government and research. The plan is to make this as a yearly event in Bergen.

CLIMATE ISSUES REMAINS STRONG IN MEDIA AND OUTREACH

While 2007 was an exceptional media year for the Bjerknes Centre, this year might be termed a more "normal year". The statistics, including newspapers and web-based sources, show that the media coverage in 2007 amounted to almost 1100 items, a surge that was linked to the release of the IPCC reports and to the Nobel Peace Prize (see Figure 4). For 2008, the statistics show that the media coverage dropped to approximately 700 articles, which still is more than twice as many as in 2006. The number of popular presentations has held the same level as last year and comprises 125 presentations in 2008 (source: FRIDA, which is a national database for research results, information and documentation of scientific activities). The high activity during 2007 seems to have strengthened BCCR's position in the media and society compared to the years before.

Figure 4. Media coverage 2005–2008.



Source: Retriever. Only including newspapers and web -based sources.

Time-use survey

The high media and outreach activity at the Bjerknes Centre, with the peak in 2007 in mind, produced some concern among scientists that the amount of time that we spend on media and outreach activity was reaching a point that could endanger the production rate. Hence, the Leader Forum decided to conduct a survey in order to map out the time spent on media and outreach at the Centre and how many of the researchers were involved in such activities. The results from the survey indicated that the amount of time that BCCR scientists and post docs used on media and outreach, with 2008 as a "normal year", could be roughly calculated to 3 person-years. About half of this time was spent on popular presentations. The survey indicated that there might be an unused potential in the organization to spread popular presentations on more hands. A reasonable spread was found among scientists who had regular contact with the media.

All in all, the Bjerknes Centre had broad activity concerning media and outreach in 2008, which is of great value to the Centre. During 2008 there was a debate in the media claiming that scientists are too silent in the public sphere. It is a general trend that a few scientists do most of the outreach. Numbers based on FRIDA show that scientists in general contributes with only one media outlet each per year. While using the same source for BCCR, the contribution per scientist was five articles in 2008. This should give a solid picture that the scientists at BCCR are far from silent, and aware of their responsibility to reach out to the media and society.

CLIMATE CHANGE INSPIRES ARTIST

On September 19th the international acknowledged artist Charlie Hooker opened his installation named *Timeline* at the Student Centre in Bergen. Hooker has made the art project in cooperation with the Bjerknes Centre. The work features two large drums that bang every time cosmic particles fall on them. This happens about once every three seconds, which is the same rate as particles pass through people on earth, like invisible rain. Between the two drums is a six-metre long mud core, which represents a finely detailed record of our climate over the past 11,000 years. This was one of the samples taken from the bottom of a lake in Norway as part of scientists' work on climate change. According to Hooker, the mud core acts not only as a signifier of the passage of time, but also as a metaphor for our own mortality. Timeline is a successful example of the way scientific concepts can be illustrated by artists, and promote reflection over time and our place in the universe. Charlie Hooker is a Professor of Sculpture at the University of Brighton, England, and leads a research group comprising artists, scientists and musicians.

Timeline (photo: Jill Johannessen, BCCR).

STUDENTS EXPLORING SEDIMENT CORES AT THE AMOCINT CRUISE ALONG THE NORTH ATLANTIC DRIFT 2008 (PHOTO: TOR L. MJELL, MASTER STUDENT UIB).

PH.D. DISSERTATIONS 2008

BCCR scientists provided supervision and training in climate research to 35 doctoral students during 2008. The following Ph.D. dissertations were defended:

Dag Johan Steinskog (NERSC)
Title: Applications of extreme value theory in temperature records in extra-tropical and Arctic regions.

Ivar Ambjørn Seierstad (UiB)
Title: On the relationships between large scale flow patterns, storminess and a reduced Arctic sea ice cover.

Aline Govin (LSCE/UiB)
Title: Instability of the ocean circulation in the northern and southern high latitudes over the last Interglacial and the last glacial inception (130-60 ka).

NEW INITIATIVES, EDUCATION AND COOPERATION

Photo: Tor L. Fjell, Master student, UiB.

Educational and research cruise along the North Atlantic drift

Atlantic Meridional Overturning Circulation During Interglacials (AMOCINT) is a 3-year project within the European Science foundation programme EuroMARC. It is coordinated by the Bjerknes Centre, with partners from 3 other universities in Europe. As a part of this project, an AMOCINT team consisting of researchers and students left Las Palmas on June 15 onboard the R/V Marion Dufresne. Onboard were Bjerknes researcher and cruise leader Kikki Kleiven, three of her master's students and one undergraduate student, who hopefully will be convinced to become a graduate student after the cruise experience.

The mission was to find the best and most expanded interglacial sections in the North Atlantic and Nordic Seas to reconstruct past climate variability during warm intervals. After coring off Morocco, the team set course for the Azores, then to the southern Reykjanes ridge, to the Gardar sediment drift south of Iceland, and at last to the Vøring plateau. Finally, the team returned to western France.

Unique onboard was the teacher's program where six high school teachers from Italy, Portugal, Spain, France, USA and Norway (Bergen Katedralskole) were part of the team. They received regular lectures while onboard, participated on the daily chores on deck and in the laboratories, and in addition sent regular reports back to high school teachers from all over the world about the mission. They also brought home mud and teaching exercises for their students at home, built a web page and kept up with the AMOCINT project as it proceeded.

National Research School in Climate Dynamics

In order to improve the quality of the national research training at the PhD level, there was a call from the Research Council of Norway in spring 2008 for so-called national research schools. The National Research School in Climate Dynamics, coordinated by the University in Bergen as part of the Bjerknes Centre for Climate Research, was one of the five proposals that were funded. The research school has been funded for 8 years, with 3 million kroner per year.

The main aim of the research school is to establish an internationally recognized research-training environment for PhD candidates in climate dynamics. The school gives them in-depth knowledge in their specialization, cross-disciplinary knowledge in the dynamics of the entire climate system, insight into the political and societal impacts of climate change, and the necessary skills to play an active role in appropriately predicting, mitigating, and adapting to climatic and environmental change.

Within the framework of the research school, a range of activities will be established. This includes intensive courses, specialized workshops, summer schools, symposia on climate change and global challenges, transferrable skills training, research stays abroad, network building and much more. For the around 60 PhD students belonging to the research school, half of them in Bergen, the school should make a real difference.

The research school consists of 10 partners from Bergen, Oslo, Tromsø and Svalbard, and covers all major institutions doing climate research with the natural sciences. A strong network with partners in Sweden, Denmark, Scotland, England, Germany, USA, and China will further support the school.

Partnership programme with the University of Washington, Seattle, and MIT

In 2008 the Bjerknes Centre received a 4-year grant, totalling NOK 1.6 mill. in support of scientific collaboration, exchange visits among students and staff, summer schools and workshops with the University of Washington, Seattle, and Massachusetts Institute of Technology (MIT). The Norwegian Centre for International Cooperation in Higher Education (SIU) awarded the grant. SIU coordinates this new partnership programme for research collaboration between Norway and North America, and the award came after a highly competitive process. This places a solid foundation under the already strong links between BCCR and these key centres of excellence in the USA.

More than 70 Master and PdD students and 20 lectures attended the Summer School in Bejing (photo: MR. Yufei Zhou, Institute of Atmospheric Physics, Chinese Academy of Sciences).

The Nansen-Zhu Centre Summer School in Beijing

The third Nansen-Zhu Centre (NZS) International Summer School took place in Beijing 27–31 October 2008. More than 70 Master's and PhD students, mainly from China and Norway, but also from Russia, India, France and Germany, attended the summer school. The theme of the school was climate teleconnections between low and high latitudes, with lectures and group work discussions. Topics presented and discussed at the school covered the basic understanding of the dynamics of the East Asian Summer Monsoon and the El Niño-Southern Oscillation, implications for a gradual shift in the background climate in the Indo-Pacific region, remote influence of variations in sea-surface temperature in the Atlantic Ocean and the strength of the Atlantic Meridional Overturning Circulation, the role of a melting Greenland ice sheet, and possible implications of reduced Arctic sea ice cover. In addition to the total of 27 plenary presentations, there was an extensive poster session presenting the students' research. And of course, a mix of history, culture, cuisine and social activities framed the school. The summer school has strengthened the collaboration in climate research between China and Norway, and it is likely that parts of the school will materialise as new research projects. The event was sponsored by the Institute for Atmospheric Physics (Chinese Academy of Sciences), the Nansen Center-Bergen, the Nansen Scientific Society, the University of Bergen, and the Bjerknes Centre-Unifob AS.

The partners in the NZC are the Institute of atmospheric physics and the Peking University in Beijing, and the Nansen Centre, the Bjerknes Centre, and the University of Bergen.

Bergen Summer Research School

The Bjerknes Centre together with the Center for International Health were responsible for a researchers course where the goal was to explore the connections between climate changes and health. The course was part of the Bergen Summer Research School, which gathered together PhD students and prominent scientists from the whole world to discuss how we can solve the global development challenges. Climate change is one of these challenges, which particularly affects poor countries in Africa and parts of Asia.

Nordic network of paleoclimatology training course at Espeland, Norway

As a joint venture, the Bjerknes Centre and the Department of Biology at the University of Bergen organised a training course on 'quantitative methods in palaeoecology and palaeoclimatology' at the Espeland Marine Biological Station August 19–23. The course was part of the NordForsk Nordic network of paleoclimatology. Fourteen doc-

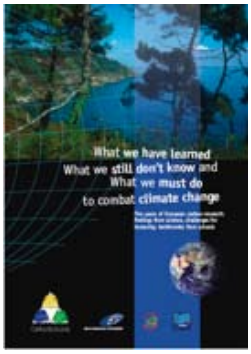


Photo top left: CarboSchools lab work (Andrea Volbers, BCCR), bottom left: AMOCINT cruise (Erik Galaasen, Master student UiB), CarboSchools booklet, to the right: AMOCINT cruise (Erik Galaasen, Master student UiB).

toral or post-doctoral researchers from five countries attended. Everyone enjoyed the excellent facilities at Espeland and the magnificent coastal scenery and the participants seemed to enjoy total immersion in numerical methods.

CarboSchools update

In 2008, CarboSchools received funding from the Science in Society programme of the EU. Due to this funding, the Norwegian CarboSchools project has been successfully extended by "Bjørgvin videregående skole" and "Danielsen videregående skole" this year. The Norwegian CarboSchools cooperation between Bergen Katedralskole and scientists from BCCR/UiB has existed since 2006. During three days in September, 45 students aged 17–18 and 5 teachers joined R/V Hans Brattstrøm to investigate physical, chemical and biological conditions of the fjords outside Bergen. The students and teachers from three Bergen schools participate in the project as part of their biology, technology and science, and geoscience subjects, respectively; as a result of these different approaches, several aspects of the project are highlighted. Close contact between the schools and BCCR/UiB has been established by several visits of students to the institute and vice versa. The students learned about report writing, data compilation and calculation, performing experiments at the lab, and finally analysing the data from the research cruises. The Bergen CarboSchool project is part of the latest CarboSchools booklet "What we have learned, what we still don't know and what we must do to combat climate change". The booklet was finalized in 2008 and is now available at the CarboOcean project office at the Bjerknes Centre.

Possible research collaboration in Latin America on climate research

The minister of higher education and research – Tora Aasland – invited representatives from various research institutions in Norway, and the Research Council of Norway to join her on an official visit to Argentina, Brazil and Chile to stimulate increased cooperation in research, education and student exchange between Latin-American countries and Norway. Norway is about to launch a Latin-America program, which will be administrated by the Research Council.

The Bjerknes Centre was represented in this delegation, which had meetings at the political level, research councils and universities. Topics of interests within the wide range of climate research already mentioned from those meetings were: Polar research (Antarctica/Southern Ocean), (Paleo)-oceanography, mapping of mountain glaciers (water reservoir), carbon cycle coupled to the deforestation and changes of land use in Brazil, and earth-system modelling and regional prediction/downscaling. BCCR has been asked to identify areas of interests in the Latin-American program, and to invite potential collaborators to arrange a workshop.

PHOTO: ISTOCKPHOTO.COM

INTERNATIONAL MEETINGS AND ENGAGEMENTS

CARBOOCEAN 4th annual meeting

More than 100 of Europe's leading ocean researchers met in Dourdan, France, 8–12 December in order to assess the ocean's role in taking up human-produced carbon dioxide (CO_2). The Dourdan meeting was the 4th annual meeting of the 5-year FP6 Integrated Project CARBOOCEAN, which is coordinated by the Bjerknes Centre.

Recent CARBOOCEAN research results reveal higher-than-anticipated year-to-year variability in marine uptake of human-produced CO_2. The results are from both direct measurements of surface-ocean CO_2 partial pressure and from reconstructing the human-produced carbon inventory. In particular, the sub-polar and polar oceans show a strong variability in uptake of anthropogenic carbon. The variability in air–sea CO_2 fluxes is coupled to the annual and decadal variability of the physical climate system. Changes in biological productivity and ice cover can modulate the air–sea CO_2 flux considerably, with as yet difficult-to-quantify specific feedback rates to climate change. This means that the oceanic uptake kinetics has to be controlled in the future by a considerably improved network of marine carbon observations in order to check the efficiency of the marine carbon uptake mechanisms with time.

Controlled experiments on natural plankton communities ("meso-cosms") reveal the possibility of enhanced biological carbon production and nutrient utilization efficiency at high CO_2 levels. Changes in ocean pH value and carbonate saturation will soon show significant effects from the sea surface down to the ocean sediments in several 1000m depth. Implications for the marine food chain may be severe, but are not yet identified in detail.

Cold water corals in the Norwegian Sea may suffer from acidification due to increased concentrations of CO_2 (photo: IMR).

Ocean Acidification and its Consequences on Ecosystems

The European Project on Ocean Acidification (EPOCA) was launched on 10 June 2008. EPOCA is run by a consortium of 27 partners across 9 countries with a budget of 16.5 M€, including a contribution from the European Commission of 6.5 M€. The goal of the 4-year FP7 project is to document ocean acidification, investigate its impact on biological processes, predict its consequences over the next 100 years, and advise policy-makers on potential thresholds or tipping points that should not be exceeded.

The Nordic Seas Exchanges Workshop

The workshop was hosted by the Bjerknes Centre, 14–15 January. The Nordic Seas provides the main transport routes between the North Atlantic and the Arctic, and is a key area to monitor both the northward flow of warm, salty water as well as the southward flow of dense water filling the deepest part of the North Atlantic. The exchanges of mass, heat and salt have been monitored for more than a decade by means of instrumented moorings in all three openings; the Fram Strait, the Barents Sea and the Greenland–Scotland Ridge. The objective of the workshop was to synthesise both the measurements and the modelling results from these key locations. Results from four different numerical models were presented and compared with the observations. The observations and model results obtained are generally impressive, but also revealed serious gaps in the observations. The transport through all these gaps can be monitored in a combined effort by Norway and on a Nordic and European level.

Transatlantic Science Week

The Transatlantic Science Week was this year shared between Ottawa and Washington DC, with the first two days being in Canada and the last two in USA. The Bjerknes Centre was responsible for hosting a plenary "Climate Update" workshop in Washington on 22 October. The audience, comprising 60–80 persons, received reports on the need for sustained ocean monitoring, the state of the Arctic sea ice, the

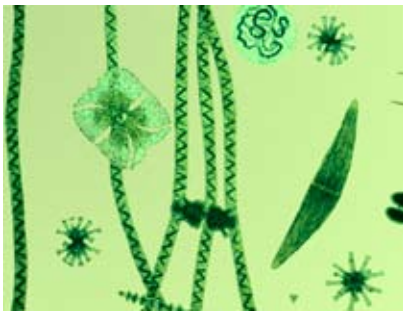


PHOTO: GETTYIMAGES

Greenland ice sheet, climate change and food supply, and the progress towards the Norwegian Earth System Model, which will become a new generation of climate models.

The venue also worked as a kick-off meeting for a new partnership programme for research collaboration between Norway and North America funded by the Norwegian Centre for International Cooperation in Higher Education (SIU). An outcome of this week is a strengthening of the partnership between the Bjerknes Centre, the Massachusetts Institute of Technology, and the University of Washington in a 4-year program (see also page 21). The collaboration plan to produce a number of summer schools in advanced climate dynamics, with the first summer school taking place outside Bergen in June 2009. Detailed plans were also made for strengthening the collaboration around the climate modelling activities between the partnership institutions, and in particular paleoclimate modelling.

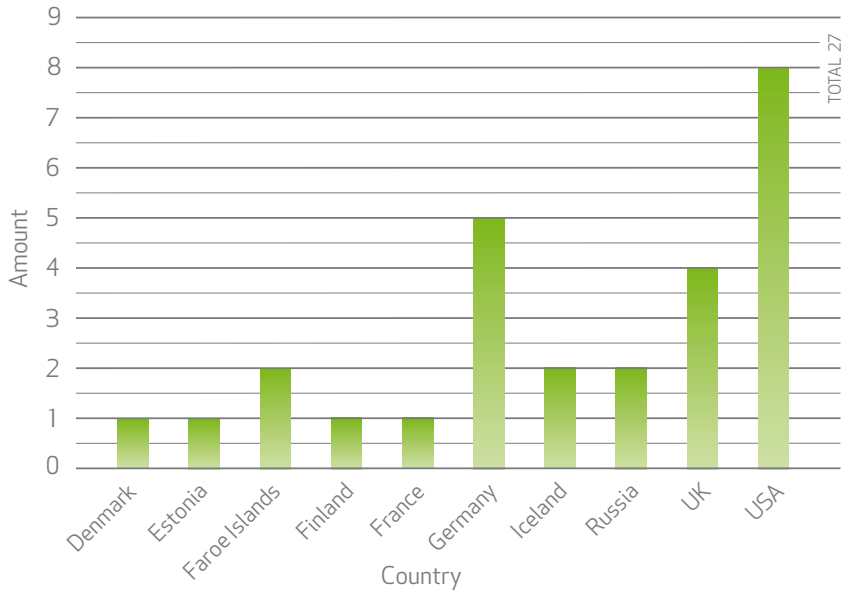
Arctic Sea Ice Minimum Workshop

An international workshop and conference were co-organised and co-chaired by Bjerknes Centre scientist Martin Miles. The "Lessons from the 2007 Arctic Sea Ice Minimum Workshop" was held in New York NY, 19–20 March. The 2008 Arctic Forum on "Tipping Points: The Arctic and Global Change" was held in Washington DC, 13–15 May, during which Miles also served as a presenter and panelist at a US Congressional Science Briefing on Arctic change.

BCCR Visiting Fellow Programme

The Bjerknes Centre sponsors a Visiting Fellow Programme aimed at fostering international research collaboration in climate change. In 2008, the Centre hosted 27 scientists from 10 countries. See Figure 5.

Figure 5. Visiting scientists by country



PRIZES AND HONOURS

Kristian Vasskog (photo: Jill Johannessen, BCCR).

NORDFORSK POSTER AWARDS

Kristian Vasskog won NordForsk Poster Awards at the International Geological Congress in Oslo 6-14 August 2008. The poster illustrated 7300 years with reconstructed history of "Climate, floods and colluvial events", by Kristian Vasskog, Eivind Støren, Alte Nesje, Daniel Ariztegui, Emmanuel Chapron, and Nicolas Waldmann.

MOST CITED PAPER 2003-2007 AWARD

Randi Ingvaldsen (IMR) has received Continental Shelf Research Most Cited Paper 2003-2007 Award for the paper entitled: "The seasonal cycle in the Atlantic transport to the Barents Sea during the years 1997-2001", written by Randi Ingvaldsen, Lars Asplin and Harald Loeng. This paper was published in *Continental Shelf Research*, vol. 24, Issue 9 (2004).

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.

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.

European Science Foundation:
Dr. Trond Dokken and Prof. Eystein Jansen are members of the Scientific Steering Committee of the EuroMarc programme.

Norwegian Research Council NORKLIMA Programme:
Prof. Eystein Jansen is a member of the programme board.

National Platform for Climate Research, Klima21, issued by the Norwegian Ministry of Education and Research:
Prof. Helge Drange is a member.

National Committee on Climate Adaptation, issued by the Norwegian Ministry of Environment:
Prof. Svein Sundby and Prof. Helge Drange are members.

International Geosphere-Biosphere programme (IGBP) and World Climate Program (WCP):

- 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*.
- Surface Ocean Lower 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.
- Ecosystem Studies of Subarctic Seas (ESSAS). Ken Drinkwater is co-chair of this GLOBEC regional program and established an international ESSAS Project Office in Bergen in 2008.
- 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. Ken Drinkwater was appointed member of the IMBER SSC.
- Climate Variability and Predictability (CLIVAR) – Prof. Helge Drange is co-leader of the *Working Group for Ocean Model Development* (WGOCMD)

CONTROLLED EXPERIMENT ON NATURAL PLANKTON COMMUNITIES IN NY ÅLESUND, SVALBARD(PHOTO: RICHARD BELLERBY, 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, UiB/Unifob
Tore Furevik	Professor (Deputy director) Climate modelling, UiB
Trond Dokken	Dr. Scient Palaeoclimatology, Unifob
Tor Eldevik	Dr. Scient Ocean processes and modelling, NERSC
Christoph Heinze	Professor Carbon cycle modelling, UiB
Frode Flatøy	Dr. Scient Meteorology, Unifob
Birgit Falch	Cand. Polit Science coordinator, Unifob
Jill Johannessen	Dr. Polit Media and information consultant, Unifob
Lars Fagerli	Financial officer, Unifob
Connie E. Engstad	HR manager, Unifob

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.

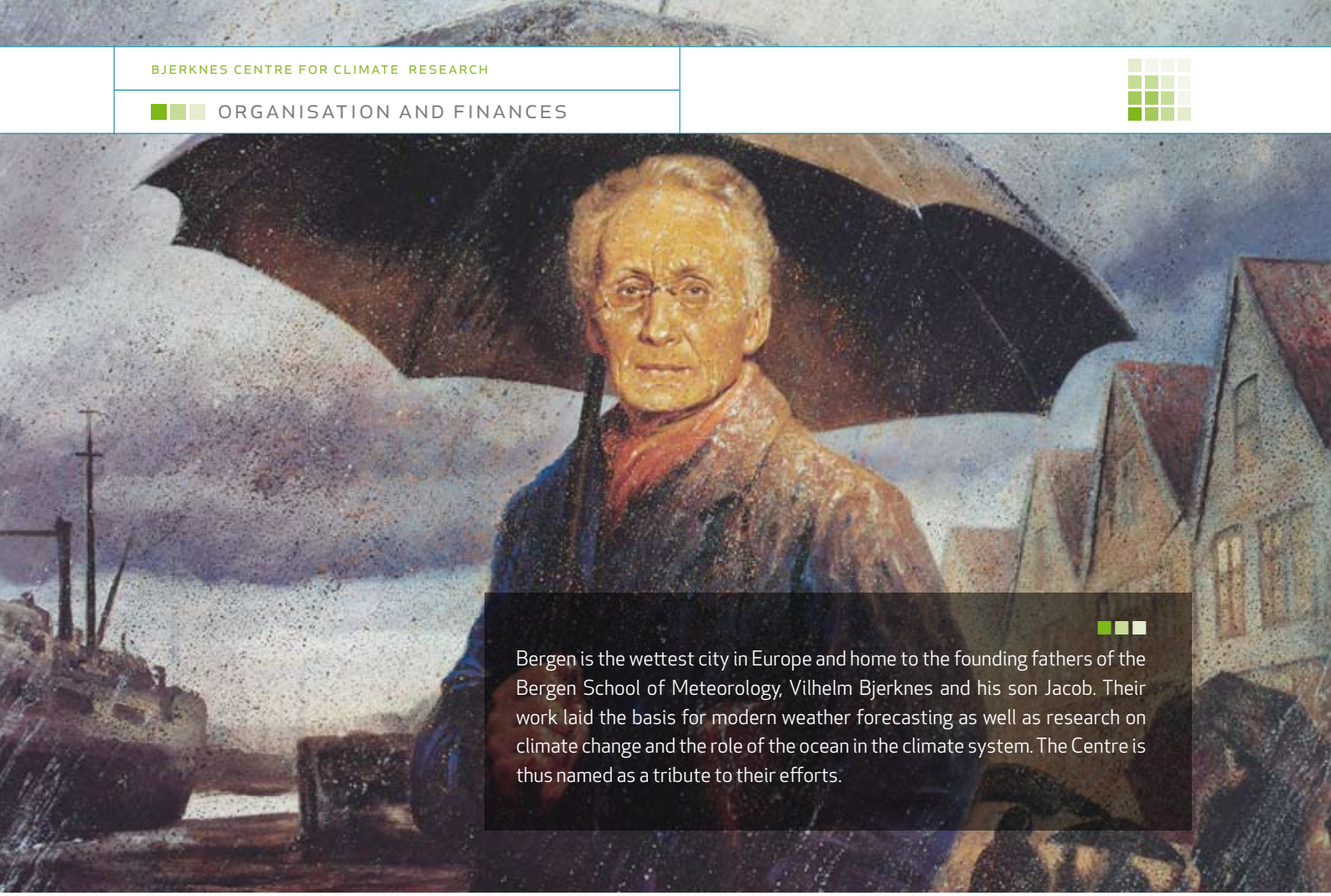
Eystein Jansen	Professor (Director) Palaeoclimatology, UiB/Unifob
Helge Drange	Professor Climate modelling, NERSC
Ken Drinkwater	PhD Oceanography and impacts of climate change, IMR
Tore Furevik	Professor (Deputy director) Climate modelling, UiB
Christoph Heinze	Professor Carbon cycle modelling, UiB
Trond Dokken	Dr. Scient Palaeoclimatology, Unifob
Birgit Falch	Cand. Polit Science coordinator, Unifob
Jill Johannessen	Dr. Polit Media and information consultant, Unifob

ØYVIND PAASCHE, BCCR

Research Groups

The research activity is organised into five interdisciplinary research groups, which combine modelling, paleo- and instrumental observations, and theory.

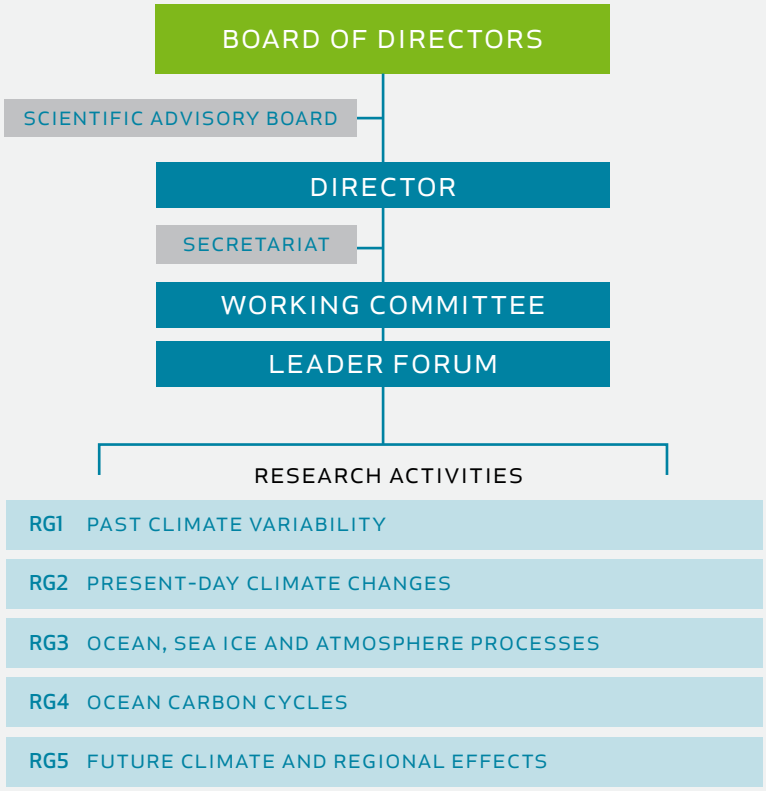
Title		Leader (co-leader)
RG1	Past Climate Variability	T. Dokken (C. A. Dahl)
RG2	Present-Day Climate Changes	T. Furevik (N.G. Kvamstø)
RG3	Ocean, Sea Ice and Atmosphere Processes	T. Eldevik (I. Fer)
RG4	Ocean Carbon Cycles	C. Heinze (A. Olsen)
RG5	Future Climate and Regional Effects	F. Flatøy (F. Vikebø)



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: PAINTING BY ROLF GROVEN, OWNED BY GEOPHYSICAL INSTITUTE, UIB.

Figure 6. Organisation map



THE BOARDS

Boards of Directors

Ola M. Johannessen	Director, Nansen Environmental and Remote Sensing Center (Chair)
Tore Nepstad	Director, Institute of Marine Research
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 of Global Atmospheric Modelling, University of Reading, UK
John Walsh	International Arctic Research Centre, University of Alaska, Fairbanks, USA
Andrew Watson	School of Environmental Sciences, University of East Anglia, UK

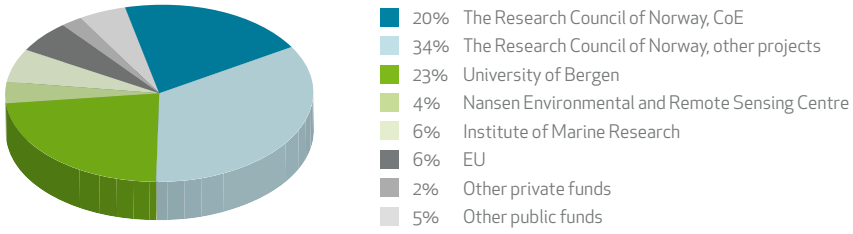
FUNDING & EXPENSES

In Figure 7, the numbers listed for the University of Bergen, the Nansen Environmental and Remote Sensing Centre and the Institute of Marine Research, are the institutions' own contribution to the CoE activities. There are several ongoing programmes in which the Bjerknes Centre is involved. 27 projects are funded by the Research Council of Norway, with BCCR scientists leading 21 of these projects. 11 ongoing projects are funded by the 6th and 7th Framework Programmes of the European Commission, of which BCCR coordinates two of the programmes. 10 projects are funded by other sources. BCCR also coordinates two of the six multinational projects which were funded within the European Science Foundation ESF-Eurochores programme EuroMarc. See Appendix 2 for a complete listing of ongoing research projects.

Funding	2008 (1000 NOK)
The Research Council of Norway, CoE	17 000
The Research Council of Norway, other projects	28 495
University of Bergen	19 621
Nansen Environmental and Remote Sensing Centre	3 112
Institute of Marine Research	5 500
EU	4 744
Other private funds	1 989
Other public funds	4 121
Total funding	84 582

Expenses	(1000 NOK)
Salaries and house rental costs	48 496
Research equipment	235
External research services	9 042
Other costs	22 726
Total expenses	80 498

Figure 7. Funding



THIS PHOTO OF "EARTHRISE" OVER THE LUNAR HORIZON WAS TAKEN BY THE APOLLO 8 CREW IN DECEMBER 1968, SHOWING EARTH FOR THE FIRST TIME AS IT APPEARS FROM DEEP SPACE (PHOTO: NASA).

STAFF

Scientists

Idar	Barstad	UNIFOB	Atmospheric modelling
David	Battisti (USA)	UiB	Atmospheric dynamics, palaeo-modelling
Richard	Bellerby (UK)	UNIFOB	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	UNIFOB	Palaeobotany
Knut Yngve	Børsheim	IMR	Marine biology, biogeochemistry
Paul	Budgell (Canada)	IMR	Ocean modelling
Carin A.	Dahl (Sweden)	UNIFOB	Palaeoclimatology
Svein Olaf	Dahl	UiB	Glaciers and palaeoclimatology
Trond	Dokken	UNIFOB	Palaeoclimatology
Helge	Drange	NERSC/UiB	Climate modelling
Ken	Drinkwater (Canada)	IMR	Oceanography and impacts of climate change
Tor	Eldevik	NERSC	Ocean processes and modelling
Igor	Ezau (Russia)	NERSC	Environmental boundary layers
Ilker	Fer (Turkey)	UiB	Ocean processes
Frode	Flatøy	UNIFOB	Atmospheric chemistry and modelling
Tore	Furevik	UiB	Climate dynamics
Tor	Gammelsrød	UiB	Polar oceanography
Yongqi	Gao (China)	NERSC	Ocean circulation modelling
Sigbjørn	Grønås	UiB	Synoptic meteorology
Peter M.	Haugan	UiB	Polar oceanography
Einar	Heegaard	UNIFOB	Palaeoecology
Ulla	Heikkilä (Finland)	UNIFOB	Regional atmospheric modelling
Christoph	Heinze (Germany)	UiB	Carbon cycle modelling
Randi	Ingvaldsen	IMR	Physical oceanography
Eystein	Jansen	UiB/UNIFOB	Palaeoclimatology
Alastair	Jenkins	UiB	Boundary layer physics
Truls	Johannessen	UiB	Biogeochemistry
Ina K.	Kindem	UNIFOB	Stratospheric physics
Helga F.	Kleiven	UNIFOB	Palaeoclimatology
Nils Gunnar	Kvamstø	UiB	Atmospheric modelling
Øyvind	Lie	UNIFOB	Palaeoclimatology
Henriette	Linge	UiB	Palaeoclimatology
Harald	Loeng	IMR	Oceanography and impacts of climate change
Torbjørn	Lorentzen	UNIFOB	Economics, statistics
Kjetil	Lygre	NERSC	Biogeochemistry and modelling
Jan	Mangerud	UNIFOB	Palaeoclimatology
Martin	Miles (USA)	UNIFOB	Climate time series analysis
Kjell Arne	Mork	IMR	Physical oceanography
Atle	Nesje	UiB	Palaeoclimatology
Jan Even Ø.	Nilsen	NERSC	Climate modelling
Ulysses S.	Ninnemann (USA)	UiB	Palaeoclimatology
Kerim Hestnes	Nisancioglu	UNIFOB	Palaeoclimatology and modelling
Are Christian S.	Olsen	UNIFOB	Chemical oceanography
Odd Helge	Otterå	NERSC	Climate modelling
Øyvind	Paasche	UNIFOB	Palaeoclimatology
Bjørg	Risebrobakken	UNIFOB	Palaeoclimatology
Anne Britt	Sandø	NERSC	Ocean modelling
Anne Dagrunn	Sandvik	UNIFOB	Mesoscale atmospheric modelling
Corinna	Schrum (Germany)	UiB/IMR	Ocean modelling
Øystein	Skagseth	IMR	Ocean circulation
Ingunn	Skjelvan	UNIFOB	Chemical oceanography
Morten	Skogen	IMR	Coupled physical and biological modelling
Lars Henrik	Smedsrud	UNIFOB	Polar Oceanography

Henrik	Søiland	IMR	Physical oceanography
Asgeir	Sorteberg	UNIFOB	Climate modelling
David	Stephenson (UK)	UiB	Atmospheric processes and climate modelling
Svein	Sundby	IMR	Ocean climate
John Inge	Svendsen	UiB	Palaeoclimatology
Richard	Telford (UK)	UiB	Palaeoclimatology
Frode	Vikebø	IMR	Climate impacts on marine ecosystems
Andrea	Volbers (Germany)	UNIFOB	Palaeoclimatology and biogeochemistry
Svein	Østerhus	UNIFOB	Physical oceanography
Bjørn	Ådlandsvik	IMR	Physical oceanography and modelling

Postdocs

Karen	Assmann (Germany)	UNIFOB	Chemical oceanography
Jürgen	Bader (Germany)	UNIFOB	Climate modelling
Jostein	Bakke	UiB	Palaeoclimatology
Elin	Darelius (Sweden)	UiB	Polar oceanography
Richard	Gyllencreutz (Sweden)	UiB	Palaeoclimatology
Solfrid	Hjøllo	IMR	Ocean circulation
Emil	Jeansson (Sweden)	UNIFOB	Chemical oceanography
Erik Wilhelm	Kolstad	UNIFOB	Climate downscaling
Camille	Li (Canada)	UiB	Atmospheric dynamics and palaeoclimate
Katja	Lohmann (Germany)	NERSC	Ocean climate variability and modelling
Benjamin	Marzeion (Germany)	NERSC	Meridional overturning circulation
Marius	Meland	UNIFOB	Palaeoclimatology
Abdirahman	Omar (Somalia)	UiB	Chemical oceanography
Jeanne	Scao (France)	UNIFOB	Palaeoclimatology
Lingling	Suo (China)	NERSC	Climate dynamics
Jerry	Tjiputra (Indonesia)	UNIFOB	Carbon cycle modelling
Justin	Wettstein (USA)	UNIFOB	Atmospheric dynamics
Zhongshi	Zhang (China)	UNIFOB	Palaeoclimatology and modelling

Ph.D. Students

Muralidhar	Adakudlu (India)	UiB	Atmospheric modelling
Roohollah	Azad (Iran)	UiB	Regional atmospheric modelling
Christophe	Bernard (France)	UNIFOB	Biogeochemistry
Ingo	Bethke (Germany)	NERSC	Ocean modelling
Andreas	Born (Germany)	UiB	Climate dynamics and palaeoclimate modelling
Tarjei	Breiteig	UiB	Atmospheric dynamics
Giulio Nils	Caroletti (Italy)	UiB	Regional climate change
Sara	de la Rosa Höhn (Spain)	UiB	Polar oceanography
Michel	dos Santos Mesquita (Brazil)	UNIFOB	Atmospheric dynamics
Christine	Euler (Germany)	UiB	Palaeoclimatology
Florian	Geyer (Germany)	NERSC	Climate modelling
Nil	Irvali (Turkey)	UNIFOB	Palaeoclimatology
Marwan	Khalil (Egypt)	NERSC	Climate modelling
Helene	Langehaug	NERSC	Ocean dynamics, climate modelling
Siv Kari	Lauvset	UiB	Chemical oceanography
Vidar	Lien	IMR	Physical oceanography
Iselin	Medhaug	UiB	Climate dynamics
Svetlana	Milutinovic (Croatia)	NERSC	Remote sensing, climate modelling
Birgitte F.	Nyland	UiB/UNIFOB	Palaeoclimatology
Gunn Elisabeth	Olsen	UiB	Atmospheric dynamics
Steinar	Orre	NERSC	Climate modelling
Francesco S.R.	Pausata (Italy)	UiB	Atmospheric dynamics and palaeoclimate
Roshin	Raj (India)	UiB	Ocean dynamics
Kristin	Richter (Germany)	UiB	Ocean dynamics
Ole	Segtnan	UiB	Ocean dynamics
Anna	Silyakova (Russia)	UNIFOB	Biogeochemistry

Anders	Sirevaag	UNIFOB	Physical Oceanography
Svetlana	Sorokina (Russia)	NERSC	Climate variability, Arctic data processing
Dag Johan	Steinskog	NERSC	Climate modelling
Eivind W. N.	Støren	UiB	Palaeoclimatology
Andrea	Tegzes (Hungary)	UNIFOB	Palaeoclimatology
Amandine	Tisserand (France)	UiB	Palaeoclimatology
Kristian	Vasskog	UiB	Extreme weather events in the past
Marius	Årthun	UiB	Ocean modelling
Ingelinn	Aarnes	UiB	Vegetation reconstruction

Technical staff

Kelly	Brown (USA)	UNIFOB	Chemical Oceanography
Dagfinn	Bøe	UNIFOB	Palaeoclimatology
Wenche	Fivelsdal	UiB	Palaeoclimatology
Odd Reidar	Hansen	UiB	Palaeoclimatology
Tor-Villy	Kangas	IMR	Physical Oceanography
Solveig	Kringstad	UiB	Chemical Oceanography
Bjørn Christian	Kvisvik	UNIFOB	Palaeoclimatology
Craig Chandler	Neill (USA)	UNIFOB	Chemical Oceanography
Benjamin	Pfeil (Germany)	UNIFOB	Data manager
Vincent	Scao (France)	UNIFOB	Palaeoclimatology
Jørund	Strømsøe	UNIFOB	Palaeoclimatology
Rune Egil	Søraas	UNIFOB	Palaeoclimatology

Secretariat (Administration)

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

PERSONNEL SUMMARY

CATEGORY	Person-years
Scientists	42,1
Postdocs	14,6
PhD students	29,8
Technicians	9,9
Administration	7,0
Total	103,4

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

PARTNER						FOREIGNERS	WOMEN
Category	**UNIFOB**	**UiB**	**IMR**	**NERSC**	**Total**	**%**	**%**
Scientists	26	19	12	9	66	27	21
Postdocs	9	5	1	3	18	78	39
Ph.D. students	6	20	1	8	35	57	43
Total					**119**		

Figure 8. Staff by nationality

The Bjerknes Centre recruits personnel internationally. At the end of 2008, twenty-one nationalities were represented at the BCCR.

COUNTRY	# personnel
Brazil	1
Canada	3
China	3
Croatia	1
Egypt	1
Finland	1
France	4
Germany	13
Hungary	1
India	2
Indonesia	1
Iran	1
Italy	2
Norway	81
Russia	3
Somalia	1
Spain	1
Sweden	4
Turkey	2
UK	5
USA	7
Total	**138**

RESEARCH PROJECTS

PROJECTS FUNDED BY THE RESEARCH COUNCIL OF NORWAY

TITLE	Duration	*Leader/ **Partner
CARBON uptake and fluxes of water and HEAT in the North Atlantic Current (CARBON-HEAT)	2008-10	A. Olsen*
Climate change and the impacts on farming of salmon in the coastal areas of Norway	2008-11	T. Lorentzen*
Marine Ecosystem Response to a changing CLIMate (MERCLIM)	2008-11	R. Bellerby*
Northeast Greenland "Mare Incognitum"	2008-09	M. Miles *
Arctic records of climate change - dynamics, feedbacks and processes (ARCTREC)	2007-10	E. Jansen*
Assessment of human impact on the marine Carbon system in arctic regions (A-CARB)	2007-09	A. Olsen*
Atlantic meridional overturning circulation during interglacials (AMOCINT)	2007-10	E. Jansen*
Bipolar Atlantic Thermohaline Circulation (BIAC)	2007-10	T. Gammelsrød*
Climate of Norway and the Arctic in the 21st century (NORCLIM)	2007-10	H. Drange*
Improved forecasting of adverse weather in the Arctic Region - present and future (IPY- THORPEX)	2007-10	A. Sorteberg**
Land-use and ecosystem function in Norwegian forest landscapes	2007-08	A. Bjune**
Ocean Mixing in the Arctic: Case study at the north pole environmental observatory	2007-08	I. Fer*
Paleoceanagraphic and climatic variability on decadal to millennial timescales across the Drake Passage (Paleodrake)	2007-08	U. Ninnemann*
Polar Climate and Heat Transport (POCHAHONTAS)	2007-10	S. Østerhus*
Response of tropical Atlantic surface and intermediate waters to changes in the Atlantic meridional overturning circulation (RETRO)	2007-10	T. Dokken*
Seasonal Predictability over the Arctic Region - exploring the role of boundary conditions (SPAR)	2007-10	E. Jansen**
Southern Ocean Biogeochemistry: Education and Research (SOBER)	2007-08	R. Bellerby*
The Effect of Climate Change on Arctic High-Impact Weather Events (ArcChange)	2007-10	I. Barstad**
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*
Resolving chemical element variations in lake sediments through high-resolution XRF analyses (X-LAKE)	2006-08	J. Bakke*
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	K. Drinkwater*
Variations of the Atlantic Meridional overturning circulation during rapid climate changes: calibration, modelling and palaeoceanographic observations (VAMOC)	2005-08	T. Dokken*

RESEARCH PROJECTS FUNDED BY THE 6TH AND 7TH FRAMEWORK PROGRAMMES OF THE EUROPEAN COMMISSION

Title	Duration	Type	Leader/ Scientist
Integration and enhancement of key existing European deep-ocean observatories (EUROSITES)	2008-11	IP	◆ T. Gammelsrød
Marine Ecosystem Evolution in a Changing Environment (MEECE)	2008-11	IP	◆ R. Bellerby
The European Project of Ocean Acidification (EPOCA)	2008-11	IP	◆ C. Heinze
Thermohaline Overturning – at Risk? (THOR)	2008-11	IP	◆ T. Furevik
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
Fungi and climate change	2008-09	E. Heegaard	UiO
Megafossiler, tregrenser og fortidsklima i Sør-Norges sentrale fjellstrøk	2008-09	A. Bjune	L. Meltzers Høyskolefond
Klimajustering av kraftbalanse	2008-08	A. Sorteberg	Statnett SF
Ocean Weather Station Mike	2007-08	I. Skjelvan	L. Meltzers Høyskolefond
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
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
Paleoclimate in the Southern Ocean	2004–10	U. Ninnemann	COMER foundation

SELECTED PUBLICATIONS

Bjerknes researchers published 88 articles in international peer review journals in 2008.
For a complete listing please visit www.bjerknes.uib.no/publications/. Bjerknes scientists are indicated in **bold.**

ARTICLES IN INTERNATIONAL PEER REVIEW JOURNALS

1. **Bakke, Jostein; Lie, Øyvind; Dahl, Svein Olaf; Nesje, Atle; Bjune, Anne Elisabeth.,** 2008. Strength and spatial patterns of the Holocene wintertime westerlies in the NE Atlantic region. *Global and Planetary Change 60(1-2), s. 28-41.*
2. **Barstad, Idar; Sorteberg, Asgeir; Flatøy, Frode;** Déqué, M., 2008. Precipitation, temperature and wind in Norway: dynamical downscaling of ERA40. *Climate Dynamics.*
3. **Bellerby, Richard;** Schulz, K. G.; Riebesell, U.; **Neill, Craig Chandler; Nondal, Gisle; Heegaard, Einar; Johannessen, Truls; Brown, Kelly,** 2008. Marine ecosystem community carbon and nutrient uptake stoichiometry under varying ocean acidification during the PeECE III experiment. *Biogeosciences 5, s. 1517-1527.*
4. **Bjune**, **A. E.** *and* **H. J. B. Birks** *(2008): Holocene vegetation dynamics and inferred climate changes at Svanåvatnet, Mo i Rana, northern Norway. Boreas, 37, 146–156.*
5. **Breiteig, Tarjei,** 2008. Extra-tropical synoptic cyclones and downward propagating anomalies in the Northern Annular Mode. *Geophysical Research Letters 35.*
6. **Kleiven, Helga Flesche;** Kissel, Catherine; Laj, Carlo; **Ninnemann, Ulysses S;** Richter, Thomas O.; Cortijo, Elsa, 2008. Reduced North Atlantic Deep Water coeval with the glacial Lake Agassiz freshwater outburst. *Science 319(5859), s. 60-64.*
7. **Kolstad, Erik Wilhelm;** Bracegirdle, Thomas J., 2008. Marine cold-air outbreaks in the future: an assessment of IPCC AR4 model results for the Northern Hemisphere. *Climate Dynamics 30(7-8), s. 871-885.*
8. **Kvamstø, Nils Gunnar; Song, Yongjia;** Seierstad, Ivar Ambjørn; **Sorteberg, Asgeir; Stephenson, David,** 2008. Clustering of cyclones in the ARPEGE general circulation model. *Tellus Series A, Dynamic meteorology and oceanography 60(3), s. 547-556.*
9. **Mangerud, Jan;** Gosse, John; Matiouchkov, Alexei; Dolvik, Tore, 2008. Glaciers in the Polar Urals, Russia, were not much larger during the Last Global Glacial Maximum than today. *Quaternary Science Reviews 27(9-10), s. 1047-1057.*
10. **Meland, Marius; Dokken, Trond Martin; Jansen, Eystein;** Hevrøy, Kjersti, 2008. Water mass properties and exchange between the Nordic seas and the northern North Atlantic during the period 23-6 ka: Benthic oxygen isotopic evidence. *Paleoceanography 23(1).*
11. **Nesje, Atle; Bakke, Jostein; Dahl, Svein Olaf; Lie, Øyvind;** Matthews, John A., 2008. Norwegian mountain glaciers in the past, present and future. *Global and Planetary Change 60(1-2), s. 10-27.*
12. **Nesje, Atle; Dahl, Svein Olaf;** Thun, Terje; Nordli, Øyvind, 2008. The 'Little Ice Age' glacial expansion in western Scandinavia: summer temperature or winter precipitation? *Climate Dynamics 30(7-8), s. 789-801.*
13. **Olsen, Are; Brown, Kelly;** Chierici, Melissa; **Johannessen, Truls; Neill, Craig Chandler,** 2008. Sea-surface CO2 fugacity in the subpolar North Atlantic. *Biogeosciences 5(2), s. 535-547.*
14. Olsen, Steffen Malskær; Hansen, Bogi; Quadfasel, Detlef; **Østerhus, Svein,** 2008. Observed and modelled stability of overflow across the Greenland-Scotland ridge. *Nature 455, s. 519-522.*
15. Orsolini, Yvan; **Kvamstø, Nils Gunnar; Kindem, Ina K. Thorstensen;** Honda, Meiji; Nakamura, Hisashi, 2008. Influence of the Aleutian-Icelandic Low Seesaw and ENSO onto the Stratosphere in Ensemble Winter Hindcasts. *Journal of the Meteorological Society of Japan 86(5), s. 817-825.*
16. **Otterå, Odd Helge,** 2008. Simulating the effects of the 1991 Mount Pinatubo volcanic eruption using the ARPEGE atmosphere general circulation model. *Advances in Atmospheric Sciences 25(2), s. 213-226.*
17. **Sandø, Anne Britt; Furevik, Tore,** 2008. Relation between the wind stress curl in the North Atlantic and the Atlantic inflow to the Nordic Seas. *Journal of Geophysical Research 113.*

18. **Seierstad, I. A.** *and* **J. Bader** *(2008): Impact of a projected future Arctic sea ice reduction on extratropical storminess and the NAO, Climate Dynamics.*

19. **Skagseth, Øystein,** 2008. Recirculation of Atlantic Water in the western Barents Sea. *Geophysical Research Letters 35.*

20. **Skjelvan, Ingunn; Falck, Eva; Rey, Francisco; Kringstad, Solveig Barbro,** 2008. Inorganic carbon time series at Ocean Weather Station M in the Norwegian Sea. *Biogeosciences 5(2), s. 549-560.*

21. **Smedsrud, Lars Henrik; Sorteberg, Asgeir;** Kloster, Kjell, 2008. Recent and future changes of the Arctic sea ice cover. *Geophysical Research Letters 35(20).*

22. **Sorteberg, Asgeir;** Walsh, John E., 2008. Seasonal cyclone variability at 70 degrees N and its impact on moisture transport into the Arctic. *Tellus. Series A, Dynamic meteorology and oceanography 60, s. 570-586.*

23. **Sundby, Svein;** Nakken, Odd, 2008. Spatial shifts in spawning habitats of Arcto-Norwegian cod related to multidecadal climate oscillations and climate change. *ICES Journal of Marine Science 65(6), s. 953-962.*

24. **Søiland, Henrik;** Prater, Mark D.; Rossby, Thomas, 2008. Rigid topographic control of currents in the Nordic Seas. *Geophysical Research Letters 35.*

25. Thingstad, T. Frede; **Bellerby, Richard;** Bratbak, Gunnar; **Børsheim, Knut Yngve;** Egge, Jorun Karin; Heldal, Mikal; Larsen, Aud; **Neill, Craig Chandler;** Nejstgaard, Jens Christian; Norland, Svein; Sandaa, Ruth-Anne; Skjoldal, Evy Foss; Tanaka, Tsuneo; Thyrhaug, Runar; Tøpper, Birte, 2008. Counterintuitive carbon-to-nutrient coupling in an Arctic pelagic ecosystem. *Nature 455, s. 387-391.*

26. Yu, Lei; **Gao, Yongqi;** Wang, Huijun; **Drange, Helge,** 2008. Revisiting effect of ocean diapycnal mixing on Atlantic meridional overturning circulation recovery in a freshwater perturbation simulation. *Advances in Atmospheric Sciences 25(4), s. 597-609.*

27. Zhang, Xiangdong; **Sorteberg, Asgeir;** Zhang, Jing; Gerdes, Rudiger; Comiso, Josefino C., 2008. Recent radical shifts of atmospheric circulations and rapid changes in Arctic climate system. *Geophysical Research Letters 35(22).*

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Mikael Ohlson (left) and Kristian Vasskog preparing a hole in the ice before collecting a sediment core in a lake in Telemark, Norway. The core will help the scientists to reconstruct vegetation history and climate development in the area since the last Ice Age and until today (photo: Anne E. Bjune, BCCR).

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