Norwegian Centre of Excellence

BCCR – Bjerknes Centre for Climate Research

ANNUAL REPORT 2006

Centre of Excellence Activities

NERSC Nansen Center, Bergen

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A GOOD YEAR FOR BCCR

The most important result in 2006 was the outcome of the Midway Evaluation of the Norwegian Centres of Excellence (CoE). Thanks to the many contributions from the Bjerknes Centre staff, the overall grading of achievements from the International Evaluation Committee was: Exceptionally Good. This has given us a strong inspiration to continue to work against new objectives, and continue to progress during the next 5 years as a CoE.

"BCCR has produced outstanding research results and is on the forefront of development in their field. The evaluation remarks that the centre is on the way to become one of the leading centres worldwide and has an excellent reputation at the national and international levels. The cooperation among various disciplines is considered as exemplary" (CoE evaluation).

Another cornerstone of our 2006 activities took place within and for the 4th Assessment Report of Working Group 1 of the Intergovernmental Panel on Climate Change. BCCR is one of the four European centres which performed climate scenario simulations with global coupled Atmosphere-Ocean Global Circulation Models for the report. BCCR scientists were heavily involved in writing the report as co-ordinating lead author, lead author and contributing authors. In June 2006 BCCR hosted the 4th lead-author meeting of Working Group 1 with 170 participants, where the authors prepared the final version of the report.

The third major activity was to rejuvenate major portions of the project portfolio of the Centre. Many of the key projects were phased out in 2006, hence the Centre made great efforts to submit new proposals. These efforts were successful, and at the end of the year 11 new proposals were accepted. The Centre enters 2007 as co-ordinator of a large project to develop new national climate scenarios (NorClim), and is heavily involved as co-ordinator and participant in a number of polar climate projects inside and outside of the International Polar Year.

The Bjerknes Centre kept high focus of scientific production in 2006. Altogether 72 articles in international peer-review journals were published. In addition there were 17 books and chapters in books, 11 reports, and finally 20 popular scientific articles. This is approximately at the same level as in 2005. Altogether this is satisfactory, considering the great effort that had to be placed on the midway evaluation documents and on writing new proposals in 2006.

At the end of 2006 the Bjerknes Centre has secured a good funding base, and has been deeply involved in key international activities. The Centre has continued to emphasise new initiatives and collaboration during 2006 nationally and internationally. A new initiative was the agreement between BCCR and the Department of Atmospheric Sciences at the University of Washington to establish a "Climate Change Network with focus on summer schools and workshops".

The visibility of the Bjerknes Centre has increased remarkably compared to 2005 as we have improved and professionalised our media and outreach efforts. From 2005 to 2006 the amount of Norwegian media coverage doubled, from 89 to 162 items. Furthermore, the Bjerknes web site is now the main communication channel about our activities to policy-makers, journalists, educators, and the general public – a makeover that started in 2005. During 2006 we have improved our web pages even further. All in all, our increased efforts toward communication and the media have started to bear fruit and we will continue to strengthen our outreach to the media and society even further in 2007.

Climate change is a challenge that will be a key aspect of human life in the next decades and the need for a good science base to underpin policy measures will increase. As Director of the Centre, I am convinced that the Centre has made an exceptionally good base, and is strategically placed to meet these challenges.

PROF. EYSTEIN JANSEN

Bergen – the city of the founding fathers of Bergen School of Meteorology, Wilhelm Bjerknes and his son Jacob. Their work laid the basis for modern weather forecasting as well as modern research on climate change and the role of the ocean in the climate system. The centre is thus named as a tribute to their efforts.

PHOTO: LENE KRISTENSEN, UNIS

VISION, OBJECTIVES & RESEARCH ORGANISATION

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

The overall objective of the Bjerknes Centre (BCCR) is to *understand and quantify* regional climate changes in the context of the global climate system. To reach this objective the research at the BCCR is organised into five interdisciplinary research groups that provide knowledge of the following main research themes:

- Past, present and future climate changes and to distinguish between 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 and feedback mechanisms caused by the marine carbon cycle and other processes.

Research groups at BCCR

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

1. **Past Climate Variability**
   Understanding long-term natural climate variability of the past is essential for understanding present and future climate changes.
2. **Present-Day Climate Changes**
   The North Atlantic ocean circulation and storm tracks heat up the North, but also make it a challenge to assess the natural modes of variability in the region.
3. **Ocean–Ice–Atmosphere Processes**
   Ocean, sea-ice and atmosphere processes, and their interaction, are crucial to the climate system, and our models of the future climate depend on their proper representation.
4. **Biogeochemicical 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 surface.
5. **Future Climate Scenarios and Effects**
   Global climate changes have local effects and might influence extreme weather and marine ecosystems in Norway and the Arctic, as well as effects on water resources and health in lesser-developed countries.

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

Norwegian Centre of Excellence

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

IPCC PANEL GATHERS IN BERGEN

Over 170 internationally acknowledged climate scientists came together in Bergen to work on the United Nations Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report. The Bjerknes Centre for Climate Research hosted the meeting.

Dr. Rajendra Pachauri, the leader of the Intergovernmental Panel on Climate Change (IPCC), joined the meeting in Solstrand, Bergen. He stated that the BCCR's contributions to climate research are valuable in particular the Arctic region. (Photo: Jill Johannessen, BCCR).

The Bjerknes Centre's contributions to the IPCC 4th Assessment Report (AR4) continued throughout 2006. From 25 June to 1 July 2006, BCCR hosted the final Working Group 1 (WG1) Lead Authors meeting at the Solstrand Hotel outside Bergen, to finalise the last version of the report. Among the participants: IPCCs leader Dr. Rajendra Pachauri from India, Dr. Susan Solomon from USA and Dr. Qin Dahe from China who led IPCC WG1. The meeting was the most crucial phase of the process because the panel had to respond, in writing, to each comment to its second draft following an expert and governmental review. In addition, the "Summary for Policymakers" was also prepared in Bergen, a key chapter that will be read by governments worldwide, and the "Technical Summary", which is a more extensive summary version of the report. The final publication of the IPCC AR4 occurred on 2 February 2007.

The Bjerknes Centre strongly represented

Professor Eystein Jansen is coordinating lead author of Chapter 6 on "Palaeoclimates", and Professor Christoph Heinze is lead author of Chapter 7 on "Couplings Between Changes in the Climate System and Biogeochemistry". In addition, four Bjerknes scientists participated as contributing authors. BCCR is also one of four European modelling groups, and the only one from the Nordic countries, to provide a full set of climate scenarios to the report using the IPCC AR4 protocols. This was carried out with the Bergen Climate Model and included a total of 1600 years of different simulations on climate developments between 1850 and 2100, in addition to a set of idealised climate simulations. The runs have

Average Arctic temperatures increased at almost twice the global average rate in the past 100 years leading to massive reduction in sea-ice. In the last part of this century, projections from the IPCC show that the Arctic might become ice-free in the summer. (Photo: Karolina Windell, BCCR).

Photo: iStockphoto

been carried out thanks to the support of the *Norwegian High Performance Computing Programme* (NOTUR) and the *Bergen Center for Computational Science (BCCS)*. These activities have produced about 40 terabytes of modelling fields, all accessible from IPCC's database and the BCCR.

The most important climate document

The IPCC reports are the scientific document that politicians all over the world relate to when it comes to climate change issues. Previous assessments have provided the main scientific impetus for the Kyoto Protocol, and The Fourth Assessment Report will be decisive for the negotiations starting in the fall 2007 on new measures to curb greenhouse gases to kick in when the Kyoto pact expires at the end of 2012.

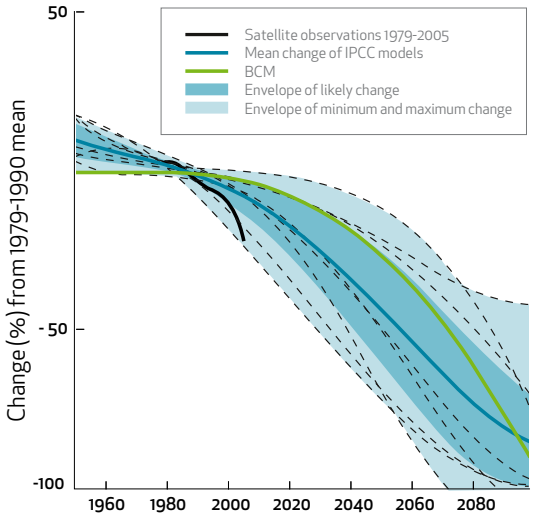


Figure 1. The figure shows areal distribution of Arctic sea-ice over time and into the future in the A1B emissions scenario, which is a scenario with a mid-level increase in 21st century greenhouse content, among the scenarios used by the Intergovernmental Panel on Climate Change WG1. Black curve: Observations of sea-ice cover change based on satellites. Turquoise curve: The mean of IPCC AR4 model runs. Green curve: The Bergen Climate Model simulated sea-ice (provided by the Bjerknes Centre). Shaded areas are uncertainty ranges of model experiments. Note: Observed decline of sea-ice is faster than the results from climate model experiments.

GLOBAL WARMING LEADS TO A FRESHER ARCTIC

Enhanced atmospheric-moisture transports to the high northern latitudes, together with melting of Arctic sea-ice and glaciers, can lead to a freshening of the northern North Atlantic, and thus reduce the strength of the Atlantic Meridional Overturning Circulation, study suggests.

Bjerknes researchers Ingo Bethke, Tore Furevik, and Helge Drange present in this *Geophysical Research Letters* paper, new results from the Bergen Climate Model. Most atmosphere-ocean general circulation models (GCMs) forced with increasing greenhouse gas concentrations predict enhanced atmospheric moisture transports to the high northern latitudes. Together with melting of Arctic sea-ice and glaciers, this has led to the expectation of a gradual freshening of the northern North Atlantic, tending to reduce the strength of the Atlantic Meridional Overturning Circulation (AMOC).

Bergen Climate Model

Here six 80-year model simulations with the Bergen Climate Model have been analysed. For each simulation, the model has been integrated with a 1% per year increase in atmospheric CO_2, leading to a doubling after 70 years. The main conclusions of the paper are that the inflow of Atlantic Water to the Nordic Seas may increase despite a reduced AMOC, and that the combined result of more saline water from the south, and less ice export from the north, is a more saline North Atlantic and a fresher Arctic under global warming.

Reference: ***Bethke, I., Furevik T., and Drange H.*** *(2006), Towards a more saline North Atlantic and a fresher Arctic under global warming, Geophysical Research Letters, 33, L21712, doi: 10.1029/ 2006GL027264.*

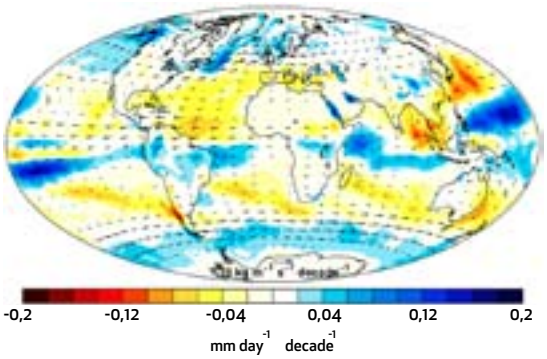


Figure2: Mean change in precipitation minus evaporation (mm day-1 decade-1, colour scale) and atmospheric water vapour transports (kg m-1s-1, arrows). The simulations show a decrease (dryer climate) in the subtropical belts, and an increase (wetter climate) in the equatorial region and in the middle and high latitudes. Note the enhanced water vapour transport from the North Atlantic and North Pacific into the high Arctic.

SEA-ICE MODELLING OF THE STORFJORDEN POLYNYA

Lead by Lars Smedsrud, this modelling paper published in the *Annals of Glaciology* was a joint effort by four Bjerknes scientists from two institutions.

A polynya (open water area) appears regularly in Storfjorden on the east side of the Svalbard archipelago. It is forced principally by northerly offshore winds and associated sea-ice formation in the polynya contributes approximately 10% of the brine water produced on all of the Arctic shelves.

A regional ocean model (ROMS), including a sea-ice model, on a fine-scale 2 km grid was developed to simulate a full year of sea-ice growth and melting in the polynya beginning on 1 August 1999. The model was able to reproduce some of the key observations associated with the opening and closing events in the polynya during January to April of 2000. It was found that the polynya remains open as long as the offshore winds exist and attains a downwind size of 10-20 km under such conditions. Results showed a general freeze-up during December and January, with a mean polynya area during February to April of 33 by 50 km representing 13% of the total area of Storfjorden. Model

EXPLORING THE MYSTERIOUS 41,000-YEAR GLACIAL CYCLES

In this Science paper highlighted in *Science Express*, Bjerknes researcher Kerim H. Nisancioglu and colleagues from Bosten University present a new model of ice volume change to explore the origins of the mysterious ~41,000-year glacial cycles.

Although glacial–interglacial cycles of the past 3 million years represent some of the largest and most studied climate variations of the past, the physical mechanisms driving these cycles in ice volume are not well understood. For the past thirty years, the prevalent theory has been that fluctuations in the large land-based glacial ice sheets were caused by variations in the amount of solar radiation received at high northern latitudes during the summer melt season. However, a long standing problem is that high latitude summer radiation is controlled by the ~23,000-year period of the precession of the equinoxes, whereas in the interval from ~3 to 1 million years ago the ice volume records are dominated by a period of 41,000 years, the primary period of variations in the tilt of the Earth's axis.

A new model of Antarctic ice volume changes

In this research article Nisancioglu and his colleagues use a simple model of ice volume change to explore the origins of the 41,000-year glacial cycles. The crucial difference between their study and previous attempts is that the model allows for a dynamic Antarctic ice sheet, as supported by sea level data from the time period in question. The researchers propose that from ~3 to 1 million years ago ice volume changes occurred in both the northern and southern hemispheres, each controlled by local summer solar radiation. In this new model, the individual ice sheets are dominated by both obliquity (41,000-year cycles) and precession (23,000-year cycles) partly due to the dependence of ice melt on summer temperatures. However, because the response of orbital precession is exactly out of phase between hemispheres, the 23,000-year cycles in ice volume in each hemisphere cancel in globally integrated proxies for ice volume, leaving the in-phase obliquity (41,000 years) component of solar radiation to dominate the record.

In the context of global climate change this new theory, which suggests a critical role for the Antarctic ice sheet in past glacial–interglacial cycles, poses the question of the vulnerability of Antarctica in a future warm climate. As argued in the article, Antarctica could have contributed as much as ~10–20 meters of sea level rise during past warm interglacials, as its margins melted back onto the continent.

*Reference: Raymo, Maureen E., Lisiecki, L. E., **Nisancioglu K.H.** (2006). Plio-Pleistocene Ice Volume, Antarctic Climate, and the Global $\delta^{18}O$ Record. Science, 313, pp. 492–495, doi:10.1126/science.1123296.*

simulations also showed the strength of the horizontal gradients in sea-ice concentrations and thickness depended upon the wind and the air-sea fluxes. The areal extent of the sea-ice coverage and the drift speed of the ice were partially validated using satellite imagery and field data, but new measurements from the polynya's interior are needed to further improve the modelling of solid and grease-ice processes.

*Reference: **Smedsrud, L.H., Budgell, W.P., Jenkins, A.D., Ådlandsvik, B.** (2006) Fine-scale sea-ice modelling of the Storfjorden polynya, Svalbard. Annals of Glaciology, 44, 73-79.*

Field measurements of sea-ice are necessary to validate climate models; here Lars H. Smedsrud measures grease ice thickness in the Storfjorden Polynya in April 2004. (Photo: Ragnheid Skogseth, UNIS).

The upper part of the Younger Dryas and the start of Preboreal in a core from Kvaltjern. Note the colour difference at the transition. Shells and other macrofossils were rinsed and placed back on top the core.

PHOTO: STEIN BONDEVIK, UNIVERSITETET I TROMSØ

IMPROVED CORRECTION FOR RADIOCARBON DATES DURING THE ALLERØD AND YOUNGER DRYAS

Dr. philos, Professor, Quaternary geology
Jan Mangerud.

In this publication in *Science* by Bjerknes researchers Jan Mangerud and Hilary Birks, in cooperation with several other researchers, have determined the correction for the North Atlantic for a critical period with large and abrupt climatic changes at the end of the last ice age.

Marine samples yield higher ^{14}C ages than terrestrial plants of the same age. This offset is called the marine reservoir age and it has to be corrected for in order to correlate marine and terrestrial records of late Quaternary climate. The problem is made complicated by the reservoir age varying geographically and over time. We have determined the correction for the North Atlantic for a critical period with large and abrupt climatic changes at the end of the last ice age.

The method we used was to date marine shells and terrestrial plant remains deposited in two marine bays on Norway's west coast between 11,000 and 14,000 years ago, a time of large and abrupt climatic changes that includes the Younger Dryas cold episode. The radiocarbon-age difference between the shells and the plants shows that reservoir ages increased from 400 to 600 years in the early Younger Dryas, stabilised for 900 years, and dropped by 300 years within a century across the YD–Holocene transition.

*Reference: Bondevik, Stein, **Mangerud J., Birks H.H.**, Gulliksen S., Reimer P. (2006). Changes in North Atlantic radiocarbon reservoir ages during the Allerd and Younger Dryas. Science, 312, pp. 1514–1517.*

PRIZES AND HONOURS

Jan Mangerud has been elected an Honorary Member of the British Quaternary Research Association.

A nice account of him was written in the QRA Quaternary Newsletter 109, June 2006, p.2.

GREAT RESPONSES IN FISH MOVEMENT DURING PAST WARM PERIODS

A dramatic warming during the 1920s and 1930s in the North Atlantic Ocean led to a northward shift in several fish species, which for the next forty years led to a large cod fishery that dominated revenue in the Greenland economy.

Photo: The School for Marine Science and Technology, University of Massachusetts Dartmouth.

This paper published by Bjerknes researcher Ken Drinkwater in *Progress in Oceanography* highlights the ecosystem responses to the dramatic warming during the 1920s and 1930s of the northern North Atlantic Ocean and the Arctic Ocean. Warmer-than-normal sea temperatures continued through to the 1950s and 1960s.

High cod production

One of the major responses was a general northward shift in the distribution of several fish species. Boreal species such as cod, haddock and herring expanded northward while colder water species such as capelin and polar cod retreated farther northward into the Arctic waters. The most significant movement involved Atlantic cod off West Greenland. In the early 1900s Denmark explored West Greenland waters in search of commercial concentrations of fish but found none. However, as the waters warmed, cod from Iceland drifted across to West Greenland and survived. Over the course of the next two decades the cod increased dramatically and spread approximately 1200 km northward along the coast. A large cod fishery developed which dominated the Greenland economy for the next 40 years. In the Barents Sea, cod also moved northward eventually reoccupying Bear Island Bank and re-establishing a fishery there after an absence of almost 40 years.

Visitors from the south

Migration patterns of herring, capelin, and several species of whales also changed with earlier arrivals and later departures. Capelin in Icelandic waters no longer needed to migrate to the south coast of Iceland to spawn but instead spawned along the north coast. For cod the relative contribution from northern spawning sites off the coast of Norway increased significantly. Several southern species of fish unknown in northern areas prior to the warming became occasional visitors, and in some cases, remained for long periods during the summers. Higher recruitment and growth led to an increase in the biomass of cod and herring throughout much of the northern North Atlantic. Indeed, the period from the 1930s to the 1960s witnessed the highest production and catches of cod and herring in the northern North Atlantic in recorded history.

The primary cause of the higher fish production appears to have been largely due to increased phytoplankton and zooplankton production. Higher phytoplankton production is thought to be a combination of the retreat in sea-ice and the increased influence of nutrient rich Atlantic Water into the region. The warming in the 1920s and 1930s is suggested to constitute the most significant regime shift experienced in the North Atlantic in the 20th century.

Reference: ***Drinkwater, K.F. (2006)*** *The regime shift of the 1920s and 1930s in the North Atlantic. Progress in Oceanography, 68, 134-151.*

DECREASING UPTAKE OF CO_2 IN THE NORDIC SEAS SINCE 1981

A group of scientists led by Are Olsen of the Bjerknes Centre has shown in an article published in *Global Biogeochemical Cycles* that the uptake of CO_2 from the atmosphere has decreased in the eastern parts of the Nordic Seas. The decreasing uptake appears to be the consequence of lateral transport of man-made carbon with ocean currents from farther south.

Photo: Erling Dagfinn Lein

Due to the consumption of fossil fuels, the concentration of CO_2 in the atmosphere is increasing, and for undersaturated ocean regions one expects that the transfer of CO_2 from the atmosphere to the ocean will increase. However, Bjerknes scientists have earlier reported that the sea surface CO_2 partial pressure (pCO_2) has increased at a greater rate than the atmospheric in the North Atlantic, implying the uptake of CO_2 from the atmosphere is decreasing here. They worry that the uptake of atmospheric CO_2 will come to a halt. This may increase the atmospheric CO_2 growth rate, resulting in more rapid climate change.

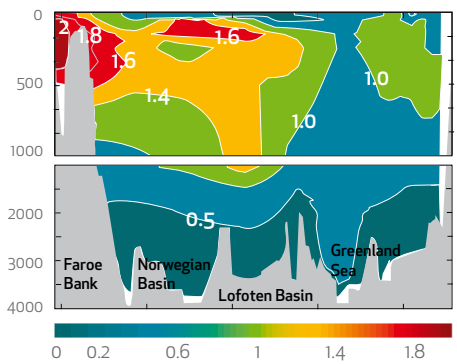


Figure 3. Increase in pCO_2 [in µatm/yr] due to anthropogenic CO_2 invasion between 1981 and 2003 over a S-N section in the Nordic Seas. For comparison the atmospheric increase was 1.6 µatm/yr.

Ocean uptake of anthropogenic CO_2

To investigate further the authors compared ocean carbon data collected at the Nordic Seas parts of the TTO cruise of 1981 with data collected on recent cruises to the Nordic Seas. This revealed substantial changes, in particular in the Atlantic Water to the east. Here the surface ocean pCO_2 has increased at a greater rate than the atmospheric pCO_2 and the uptake from the atmosphere must be decreasing.

The authors also showed that the isotopic composition of the inorganic carbon in the Atlantic Water has changed at the same rate as in the atmosphere, where it changes because of the special isotopic signature of fossil CO_2. These changes must have been advected into the region since the residence time for Atlantic Water is too short to allow for establishment of atmosphere-ocean isotopic equilibrium locally.

Anthropogenic carbon transport can also explain why the surface ocean pCO_2 is increasing at a greater rate than the atmospheric. Basically, if warm waters (farther south) saturated with anthropogenic CO_2 are transported northwards, the cooling and CO_2 uptake will eventually cause the pCO_2 of these waters to increase at a greater rate than the atmospheric, because the ability of seawater to absorb fossil fuel CO_2 declines as temperature decreases as shown by Are Olsen and Leif Anderson in 2002.

Conclusion

The authors conclude that advection of waters saturated with anthropogenic CO_2 is a very likely cause for the observed changes. Ultimately this water is brought down to depth and the atmosphere is shielded from the CO_2. This process acts to reduce the atmospheric CO_2 growth rate. It has also become clear that ocean uptake of anthropogenic CO_2 is closely tied to the ocean circulation and so there are numerous possible feedbacks to atmospheric CO_2 levels that should be taken into consideration when projecting future atmospheric CO_2 concentrations.

Reference: ***Olsen Are; Omar, Abdirahman; Bellerby, Richard; Johannessen, Truls; Ninnemann, Ulysses S; Brown, Kelly; Olsson, Anders;*** *Olafsson, J.; Nondal, Gisle; Kivimæe, Caroline; Kringstad, Solveig Barbro;* ***Neill, Craig Chandler****; Olafsdottir, S. (2006). Magnitude and origin of the anthropogenic CO_2 increase and 13C Suess effect in the Nordic seas since 1981. Global Biogeochemical Cycles, 20, GB3027, doi:10.1029/2005GB002669.*

CLIMATE RESEARCHERS HELP SOLVE DEBATE IN BIOLOGY

Fortunately for penguins, there are no polar bears in Antarctica. Such geographic range restrictions are typical among macroscopic organisms; in contrast, most micro-organisms appear to have cosmopolitan distributions. Or do they?

Bjerknes researchers Richard J. Telford and H. John B. Birks, together with Vigdis Vandvik at the Department of Biology, University of Bergen, presented in *Science* an innovative method for testing a classical theory of microbial biogeography.

Since the age of the great explorations, the excitement of travelling to new parts of the planet has been unequally distributed among biologists. For those studying large plants and animals, every new region, every new continent would offer floras and faunas consisting of large numbers of new and exotic species. For those studying microbial life, wherever they turned their microscopes they kept finding more of the same. Why? The classical hypothesis is that the enormous population sizes of microbial species drive ubiquitous dispersal of these species, so that, as formulated by the Dutch microbiologist Baas Becking in the 1930, "Everything is everywhere, but the environment selects". Recent attempts to resolve the debate by searching for endemic species, or by exploring geographic patterns in genetic data, has stranded over taxonomic uncertainties and methodological disagreements.

"Everything is Everywhere" put to a test

Telford, Vandvik and Birks circumvent these problems by using regional biodiversity patterns to test the "Everything is Everywhere" hypothesis. To do so they combine new ecological theory developed for entirely different habitats and organisms (trees in tropical rainforests) with enormous databases on species distributions collected through decennia of climate- and environmental-change research. They argue that if dispersal is ubiquitous, all regions should share one underlying richness–environment relationship, governed by the availability of species in the global species pool. If dispersal is limited, the global relationship should break down so that different regions end up with different richness–environment relationships. Specifically, they predict that there should be a match between regional availability of a particular habitat, and the local diversity in that habitat. And that was exactly what they found: within each region the highest diversity was always found in the lakes with the most common pH values.

Marine diatomes are a major group of eukaryotic algae. Most diatoms are unicellular and usually consist of two asymmetrical sides with a split between them. (Photo: Limnology Lab, the University of Regina)

Microbial species maybe not so different

This research has implications for the reconstruction of past environments: Transfer functions may for example not be as 'transferable' between regions as has previously been assumed. More generally, there are also implications for our understanding of global biodiversity patterns: Microbial species may not be as fundamentally different as the "Everything is Everywhere" hypothesis has suggested. This means that large-scale biogeographic patterns like endemism and vicariance (different species doing the same 'job' on different continents), which contribute a significant proportion of the global biodiversity of macrobial species, may be important among micro-organisms as well. Such patterns are just more difficult to spot through a microscope.

Reference: ***Telford Richard R.J.****, Vandvik V.,* ***Birks H.J.B.,*** *(2006). Dispersal Limitations Matter for Microbial Morphospecies. Science, 312, doi:10.1126/science.1125669.*

PHOTO: UNITED STATES COAST GUARD

The year 2005 was at the time reckoned as the warmest year globally in at least 500 years. It was also famous for extreme weather events, breaking records for tropical storms, with Hurricane Katrina in New Orleans as a gloomy example.

EXTREME WEATHER WEEK CREATE POPULAR SCIENCE HISTORY

The Norwegian Public Service Channel NRK dedicated an entire week of programming related to extreme weather and climate.

Approximately 100 000 school children and others were involved in measuring rainfall and reporting it every day via an internet registration system throughout the extreme weather week (Photo: Rune Nøklebust, NRK).

The Extreme Weather Week was the single largest popular science effort in NRK's history and probably the largest-ever media venture in Norwegian popular science. In total, 140 radio and television programs were devoted partly or entirely to weather and climate issues during the last week of September 2006. The Extreme Weather Week definitely contributed to strengthening BCCR's role as a leading institution for climate research and dissemination of its results.

An extraordinary week for Bjerknes exposure

For the Bjerknes Centre, this was an extraordinary opportunity to pass on climate research findings to the public and to increase the centre's visibility. BCCR has therefore cooperated with NRK since the idea was launched in 2005. The result can only be described as a big success, with Bjerknes researchers represented in 25 programs. In addition, researchers from BCCR have contributed with a weather blog and expertise in an Internet meeting and to several articles at NRK.no. BCCR was also visible during this week in the newspapers with three chronicles, three articles and a portrait of the Bjerknes director. In total, BCCR researchers were at some level involved in 40 media items during this one week.

Making a difference

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. The link between global warming and extreme weather continued to have a central position on the media's agenda throughout the year. An exceptionally warm winter and heat records both in Norway and abroad kept fuelling into the media's attention to climate-weather issues continuing into 2007.

"UVÆR" BY ERIK KOLSTAD

One year after Hurricane Katrina, Erik Kolstad launched his book "Uvær" (Extreme Weather). His book is a popular science treatment aiming at a broad readership. He wanted to give ordinary people knowledge at a time when the need for information on weather- and climate issues is growing. He writes about extreme weather as phenomena, and takes us back in history and up to the latest extreme events from all over the world.

Kolstad was a Ph.D. student at the BCCR and has written his dissertation on extreme weather in the Nordic Seas. Kolstad also had his TV debut as a guest-commentator in the popular science program for children, Newton, during NRKs Extreme Weather Week, and initiated and moderated an extreme weather blog during fall 2006.

IPCC MEETING RECEIVES GREAT MEDIA ATTENTION

The IPCC meeting in Bergen, hosted by the Bjerknes Centre, received extensive media coverage from both national and local media, which has contributed greatly to acknowledge BCCR locally, nationally and internationally.

The Intergovernmental Panel of Climate Change (IPCC) convened in Bergen, 25 June to 1 July 2006, as part of their preparation for the Fourth Assessment Report. The meeting was first and foremost an internal working meeting for the authors of IPCC Working Group 1 concerned with physical science basis for climate change. However, the opening was open for the media and followed by a press briefing with questions. As this was the last meeting before the report would be published 2 February 2007, what was to be decided here would be of great significance for those involved in climate change and climate policy decisions. Therefore, a detailed media plan was developed and implemented, resulting in extensive media coverage.

The meeting gave the BCCR excellent exposure internationally and via the media here in Norway. From the BCCR side, we focused on news from the opening, relevant issues without going into conclusions from the report, and provision of background material. The total media coverage was 23 items, reaching both local and national newspapers, radio and television news. The regional media (Bergens Tidende and NRK) put a lot of effort into covering the event resulting in broad media coverage of relevant issues. Unfortunately, NRK had a labour strike right before the event and some of the staff was still out during the event. Therefore, the event was not covered by its popular science radio magazines "Verdt å vite". The event also received exposure through the European news service Alpha Galileo. We believe that the exposure of this event has contributed greatly to acknowledge BCCR locally, nationally and internationally.

BEING A "REAL" SCIENTIST FOR A DAY

Cooperation between Bjerknes researchers and a secondary school class have given the students first hand research experience that could promote learning in a very favourable way and give them an idea of what it is like to be a research scientist.

A student from Bergen Kathedralskole takes a water sample for further analysis in the laboratory during her first educational CarboSchools research cruise on RV *Hans Brattstrøm* (Photo: Andrea Volbers, BCCR).

CarboSchools is an education project of the EU's CARBOEUROPE and CARBOOCEAN Integrated Projects. It promotes carbon-related research to schools, and individual initiatives have already been launched in the participating countries (visit http://www.carboschools.org). The two first Norwegian CarboSchools cruises were launched 25 August and 1 September 2006. Around 25 students and their science teachers from the upper secondary school Bergen Katedralskole met with BCCR scientists onboard the research vessel , *Hans Brattstrøm* to sail to Hjeltefjorden. The 16 to 17 year old students chose additional science classes in school and were given the opportunity to get in direct contact with researchers to experience "real science" and to get involved in hands-on experiments for a whole day. *Hans Brattstrøm* is equipped with a plankton net and water sampler giving the students the chance to measure temperature and salinity of the sea water and to investigate the plankton samples onboard. Both teachers and students pointed out that in this project, experience and adventure were directly linked to information and knowledge that could promote learning in a very favourable way and give them an idea of what it is like to be a researcher. BT journalist Tor Kristiansen, who participated on one of the CarboSchools cruises, indicated that "living science" like the CarboSchools cruises, helped to engage the general public in research and scientific questions.

ENGAGING THE NATIONAL MEDIA

The media coverage of the Bjerknes Centre has more than doubled over the last year, which mirrors an increased visibility in national media and society.

The development of media exposure of BCCR has been very positive, as can be seen in Figure 4. From 2005 to 2006 the amount of Norwegian media coverage increased from 89 to 162 items. The strong increase in program participation is related to BCCR's active involvement in NRK's Extreme Weather Week, while the amount of newspaper interviews nearly doubled since 2005. The increasing visibility of the centre has made the national media recognise the expertise that the centre possesses and we are used progressively more often as an authoritative source for climate issues in the media. In addition to the IPCC meeting and the NRK extreme weather week already described, the melting of glaciers in Norway and abroad was a big media issue during 2006, accounting for 25 media items. Fuelled by the Stern report, economic consequences of climate change have also started to get media exposure.

BCCR has had a breakthrough with national media in 2006. Articles in national newspapers totaled 25, compared to 6 articles the year before. The visibility in the electronic media also took a huge step ahead from 2005. Two events have been particularly important for this advancement: the IPCC meeting that took place in Solstrand in June and The Extreme Weather Week in September. Our increased efforts toward communication and the media have started to bear fruit and we will continue to strengthen our outreach to the media and society even further in 2007.

Figure 4. Media exposure of the Bjerknes Centre by category, year 2003-05

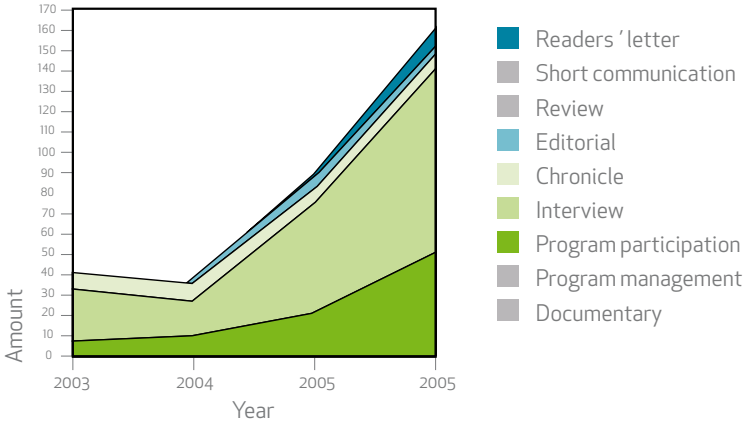
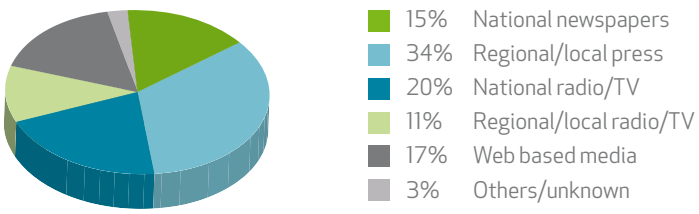


Figure 5. Media exposure of the Bjerknes Centre by type of media 2006

Medium 2006	
National newspapers	25
Regional/local press	55
National radio/TV	33
Regional/local radio/TV	18
Web based media	27
Others/unknown	4
Sum	**162**



Hiking in the glacier takes more than good shoes...
here you see an unfortunate result of stepping into mud at the glacier front edge, from Bjerknes Summer School at Finse, Hardangerjøkulen.

PHOTO: LARS H. URSIN, PA HØYDEN/UIB

NEW INITIATIVES, EDUCATION AND COLLABORATION

Beijing has been famous for its many bicycles; but now thirty thousand new cars enter the streets of Beijing every week. (Photo: Istockphoto).

The Nansen–Zhu International Climate Research Center, Beijing, China

The cooperation with Nansen–Zhu Center (NZC) continued throughout 2006.

In September 10 Ph.D. students from NZC and the Beijing University attended the *Summer School in Climate Change*, which was a joint research school between Seattle, Bergen and Beijing.

In November 2006, 7 researchers from BCCR and 15 researcher and research fellows from NZC attended a joint workshop on paleoclimates and natural climate variability. A number of joint research projects were discussed and initiated, including fieldwork connected to glacier variations in Tibet, model activity and the connection between observations and modelling. The management at BCCR also met with the management for Chinese Academy of Sciences to discuss the further development of the research cooperation.

Ph.D. stipendiat Ingo Bethke has continued the work with the ABOT-system "partial coupling", developed in Beijing. A number of projects including this system are now operative and are used by participants from both Beijing and Bergen to study teleconnections and high-to-low-latitude interactions. Researcher Yonqi Gao is employed both at Nansen Center in Bergen and in Beijing and has established project funds in China through NZC.

Since the official opening of NZC in 2003, researchers from BCCR and NZC have published 11 articles in international peer-review journals.

International Arctic Research Center (IARC), University of Fairbanks, Alaska, USA

Asgeir Sorteberg and Øyvind Byrkjedal have developed cooperation with IARC to establish joint research projects in Arctic research topics. The scientific purpose of the network is to 1) Research the fundamental processes that influence the climate in Arctic and sub-Arctic regions, and 2) Improve model predictions of extreme weather under climate change. The cooperation is funded by the Leif Eriksson programme.

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

BCCR and the Department of Atmospheric Sciences at the University of Washington, Seattle (UW) agreed to establish a "Climate Change Network". The purpose of the network is to bring together scientists, postdoctoral fellows and graduate students from both partners to purpose joint research projects as well as exchanges of visiting scientists.

The network has established a Summer School in Climate Change to develop an international community of leading climate scientists. The Summer School will run for four years on a rotating basis between Bergen and Seattle. BCCR has been funded by Bergen Foundation, while US government and US foundations are expected to commit to sponsor the Climate Change Network at UW. The first *Summer School in Climate Change* was organised by BCCR in September 2006 at Finse and Bergen. For two weeks, a total of 28 students from seven different countries were invited to Finse and Bergen to learn more about climate variability and teleconnection dynamics.

Norwegian Climate Center (NKS)

BCCR and the Norwegian Meteorological Institute (met.no) in Oslo formalised a comprehensive cooperation in climate research entitled Norsk Klimasenter (Norwegian Climate Centre) in 2005. During 2006 the agreement was enlarged to include the University of Oslo and the Norwegian Polar Institute. Researchers from these institutions collaborated on a large proposal (NorClim) for the NORKLIMA programme to develop new regional climate scenarios and a Norwegian Earth System model. A secretariat will be established at BCCR and will be staffed with a scientific co-ordinator during spring 2007.

PHOTO: JUSTIN WETTSTEIN, UNIVERSITY OF WASHINGTON

Manager of the Research School, Tore Furevik.

Bjerknes research school in climate studies

The establishment of a new research school in climate change is an important milestone in education and training. The school was formally opened by UiB Vice Rector Anne Gro Vea Salvanes on Friday 9 June 2006 and around 25 people attended the opening ceremony in the cafeteria at the Geophysical Institute. The research school is coordinated from the Geophysical Institute, in close collaboration with the Bjerknes Centre, the Department of Earth Science, the Nansen Center and UNIS. The goal for the school is to offer a training site for national and international doctoral and post-doctoral students, producing candidates at the highest international level. Key elements are:

- Coordination and information of all existing UiB courses related to climate studies
- Organise and coordinate specialised courses with invited top-level national or international scientists
- Organise and coordinate summer schools focusing on different topics within the climate science
- Strengthen the interactions between doctoral student, the post-doctoral fellows, and the research scientists through organised doctoral and post-doctoral seminars and discussion groups

In 2006 two summer schools were carried out: Summer School in Climate Change and CARBOOCEAN Modelling Summer School. More information on the school's web site: http://web.gfi.uib.no/forskning/Forskerskole/.

SUMMER SCHOOL IN CLIMATE CHANGE

"Multidecadal Climate Variability and Teleconnection Dynamics", Finse and Bergen, Norway, 11–22 September 2006.

In 2006, the BCCR and the Program on Climate Change at the Department of Atmospheric Sciences at the University of Washington, Seattle (UW), lead by Prof. David Battisti, launched a joint network for climate change research. The network brings together scientists and graduate students from both partners to pursue joint research projects as well as the organisation of joint high-level workshops and a *Summer School in Climate Change*. The network will be jointly run and hosted by the Bjerknes Centre and the Program on Climate Change at UW. The summer school is intended to bring together an international community of exceptional graduate students, postdoctoral fellows and leading climate scientists in order to provide a unique opportunity for an intense learning experience and a vigorous discussion of vital concepts on key problems in climate change that span a number of disciplines. The *Summer School* and workshops will run for four years on an alternating basis between Bergen and Seattle. The BCCR received one million NOK from the Internationalisation Programme of the Bergen Research Foundation to support the Norwegian commitment of the Network, while the US government and US foundations are expected to commit to sponsor matching funds.

The main goal of the summer school was to provide an overview of – and recent findings in – multidecadal variability and teleconnection patterns both in paleo and modern records, and the underlying dynamic/thermodynamic forcing mechanisms. A secondary goal of the summer school was to strengthen the cooperation between the University of Bergen and University of Washington, both on students and scientists' levels. The summer school was arranged as a collaborative effort between the Bjerknes Centre and the University of Washington, and in cooperation with Nansen Environmental and Remote Sensing Center (NERSC) and Nansen–Zhu Center, Beijing. The summer school was sponsored by Bergen research foundation. More information at: http://www.nersc.no/~oddho/SummerSchool/.

Summer school participants strap on crampons to get a first-hand look at glaciers on an excursion to Folgefonna. (Photo: Alexandra Jahn, McGill University).

We brought together 28 students from a wide range of disciplinary backgrounds in the earth and environmental sciences, and had a total of 18 lecturers at top international level providing a tight and exciting programme. The programme included science lectures on topics ranging from paleoclimate reconstruction to future climate modelling, from statistical methods to dynamical considerations. Keynote talks were given by Rowan Sutton and Andrey Ganopolski, and local and external scientists gave presentations on a wide range of topics. In addition there were stimulating discussions, scientist and student interactions and two glacier excursions to Hardangerjøkulen and Folgefonna in beautiful sunny weather, making the summer-school a truly memorable experience for all participants. Based on feedback from the participants, the first summer school week at Finse, with the communal living quarters (far away from the distractions of the big city) and sharing tasks (kitchen and cleaning duties etc.), was very helpful in getting to know everyone quickly. The second week took place in downtown Bergen. The summer school programme was completed on Friday with a tour for all participants to the different institutions that are part of the BCCR.

CARBOOCEAN MODELLING SUMMER SCHOOL

"Modelling of the marine carbon cycle from small to global scale", 18–25 June 2006, University of Bergen, Bjerknes Centre for Climate Research.

Goals of the summer school were to:

- Provide an overview about state-of-the-art modelling methods and model applications for marine carbon cycle research
- Introduce students to actual modelling tools through exercises on the computer
- Enable students to formulate their own ideas on modelling projects about the marine carbon cycle

On 19 June 2006, 17 international and 4 national students arrived at Geophysical Institute to attend the CARBOOCEAN summer school 2006. Most of them are associated with the ongoing Integrated Project "CARBOOCEAN" which combines the key European experts and scientific resources on marine carbon cycling through an integrated research effort (IP, EU Framework Program 6, with 14.5 mill € funding over the period from 2005–2009). CARBOOCEAN's aim is to determine the ocean's quantitative role for uptake of atmospheric carbon dioxide (CO_2) because the correct quantification of this sink is a fundamental and necessary condition for all realistic prognostic climate simulations. In this respect, the second CARBOOCEAN summer school concentrated on the modelling of the marine carbon cycle from small to global scale and gave Ph.D. students and Post-docs from nine countries the chance to learn directly from five experts of the field: Marion Gehlen (LSCE, France), Dieter-Wolf Gladrow (AWI, Germany), Christoph Heinze (GFI, UiB), Reiner Schlitzer (AWI, Germany) and Christoph Voelker (AWI, Germany). All talks and presentation will be made available on the CARBOOCEAN training web side (http://www.carboocean.org).

The CARBOOCEAN summer school lasted five days with each day divided into two parts, including a morning lecture and a practical/computing afternoon part. The main topics covered were:

- Biogeochemistry of ocean C cycle (overview and biogeochemical OGCM)
- Equilibrium and kinetics/Isotopes and diffusion reactions
- Population models, ecosystem models/ecosystem model in action, fallacies and improvements
- Modelling the fate of marine particles (particle flux)
- Combining data with models

In light of the fact that the number of women in natural sciences and modelling is rather small, a mentoring and discussion session lead by the Marion Gehlen was added to the schedule. The participants focused on the availability of childcare, encouragement and promotion of women to apply for new positions and having an equal number of women in interview panels. Since confusion about the "facts" relating gender issues/women in science/(subconscious) discrimination seemed to exist, credit was given to the idea of inviting "gender experts", e.g., a social scientist who does research on this issue, to the scientific institutes to mark the start of modified thinking and behaviour when it comes to recruitment of women in natural sciences. The participation of a female Ph.D. student from the National Institute of Oceanography and Fisheries of Egypt at the summer school was financed by the CARBOOCEAN project.

Marine measurements of temperatures, conductivity and depth, Billefjorden. (Photo: Anders Sirevaag, BCCR).

PHOTO: ANDERS SIREVAAG, BCCR

PH.D. DISSERTATIONS 2006

BCCR scientists provided supervision and training in climate research to 21 doctoral students during 2006. The following Ph.D. dissertations were defended:

Anne-Grete Bøe
Title: Late Weichselian ice-sheet dynamics and Holocene river floods inferred from depositional chronologies of glaciofluvial and fluvial sediments in east-central southern Norway.

Marius Meland
Title: Paloeoceanography and paleoclimate in the Nordic Seas and the northern North Atlantic during the last 22 000 years: a study based on oxygen isotopes and Mg/Ca ratios in foraminife.

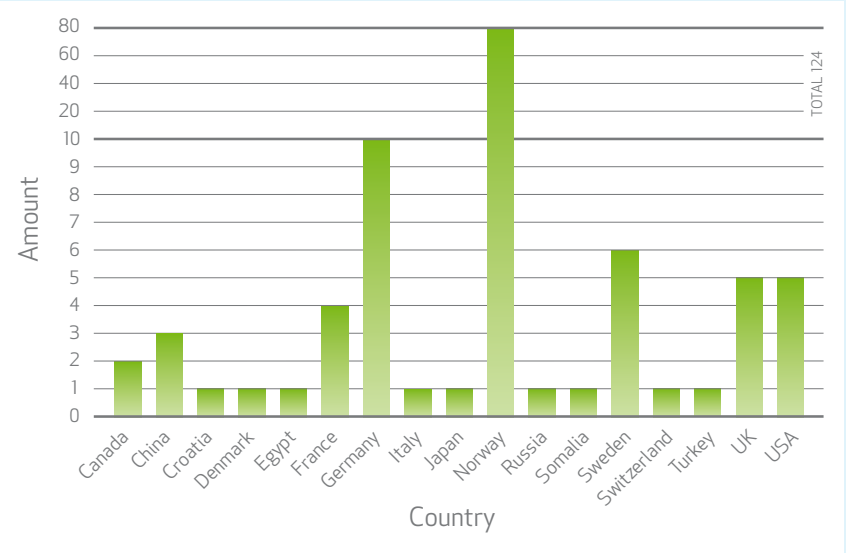
Karolina Widell
Title: Ice–ocean interaction and the under-ice boundary layer in an Arctic fjord.

Øyvind Byrkjedal
Title: Aspects on interactions between mid- to high latitude atmospheric circulation and some surface processes.

Ben Marzeion
Title: The Influence of Vertical Mixing Parameterizations on the Stability of the Atlantic Meridional Overturning Circulation.

BCCR recruits personnel internationally. In 2006 new scientific personnel were recruited from countries within the EU. By the end of the year 17 nationalities were represented at the BCCR .

Table 1. Staff by nationality



Glaciers are natural archives for climate imprints formed through thousands of years, which enables researchers to reconstruct natural climate variations in the past and thereby distinguish natural variations from man-made climate changes today and in the future.

PHOTO: ISTOCKPHOTO

INTERNATIONAL MEETINGS AND ENGAGEMENTS

Transport of coring equipment to glacier-fed lake at Folgefonna. (Photo: Jostein Bakke, BCCR).

Pacliva Final Workshop, Realfagbygget, UiB, 11–13 January 2006

The aim of the meeting was to share the final data and results through presentations and to form working groups for a number of synthesis papers to come out from the PACLIVA effort.

The core objectives of EU-funded project PACLIVA have been to produce marine records for the last 2000 years on hitherto unseen resolution and quality. From presentations of a number of high-quality records spanning from north of Iceland to the Caribbean region, it became readily clear that this objective was achieved. The second objective has been to have similar data from the period between 8000–6000 years before present, when the Northern Hemisphere was warmer than at present, and to compare the high-resolution records between the 2000 warmest and coldest years in the Holocene. Although the records spanning the Holocene Optimum are sparser, it is also clear that the project has produced novel data and insight into these scientific questions. It seems clear that the project has provided evidence for the operation of tropical–extratropical bi-polar ocean response even at multi-decadal time scales. The third objective has been to use land-based records of atmospheric circulation and assess these versus ocean records. The work done within PACLIVA on these subjects has also advanced our understanding. These advances include a 'spatial paradigm' to how European glacier records and Greenland ice-core records can be analysed and understood, and indications of a coupling between ocean and atmospheric variations on Holocene time scales are emerging. The final project workshop was attended by 31 scientists from Spain, France, the Netherlands, Germany, Denmark, Sweden, Iceland, U.K., Switzerland and BCCR.

The PACLIVA project formally reached its end on 1 March. From BCCR, Eystein Jansen was the coordinator of the project, involving also Øyvind Lie, Richard Telford, Atle Nesje, Svein Olaf Dahl and Carin Andersson Dahl as active partners. Several other BCCR scientists have also been involved in parts of the project.

BCCR Workshop: Buoyancy loss in the Nordic Seas: A driver of the Atlantic conveyor?, 3–5 May 2006, Nansen Center, Bergen

The buoyant Atlantic inflow to the Arctic Mediterranean is totally transformed on its route through the Nordic Seas and the Arctic Ocean as it gives up more than 300 TW of heat to the atmosphere. It eventually returns across the Greenland–Scotland Ridge to the Atlantic proper as fresh polar waters at the surface and dense overflow waters at depth. The latter connects directly to the deep circulation of the North Atlantic Ocean and what is commonly visualised as "The great ocean conveyor".

A main focus of the workshop was on the exchanges across the Greenland–Scotland Ridge, particularly the driving mechanisms behind the Atlantic inflow. There were two sessions on this. The first addressed the evidence for a wind-driven inflow, the second the more "traditional" point-of-view of the exchange being set by the thermohaline forcing and circulation north of the ridge. A superficial assessment based on the presentations of the workshop is that there is increasing evidence for a (partly) wind-driven inflow. There is very high co-variability on seasonal to multi-year time scales between Norwegian Atlantic Current and both the wind field and the North Atlantic Drift south of the ridge. There is however a fundamental missing link: the seeming lack of a seasonal signal in the actual inflow at the ridge. Also, more complete analytical and numerical models are being developed that indicate that the thermohaline part is essential, but that the causalities involved are subtle. The workshop had 25 participants, including nine international visitors, constituting a very good mix of "young and promising" researchers and established experts.

Workshop on Arctic Weather Extremes, Strand Hotel, Bergen, 19–20 June 2006

The aim of the meeting was to share information on forthcoming International Polar Year (IPY) projects and form a working group to provide a synthesis paper on the current knowledge of Arctic Weather Extremes. The official workshop started with five open talks on different aspects of weather extremes. Then closed sessions included talks on synoptic storms, extreme winds, polar lows and mesoscale cyclones, sea-ice extremes and reconstruction of past extremes. In addition, there were group

session and plenary discussion on the outline and ideas to an extreme-weather synthesis paper. 30 scientists from Denmark, UK, Germany, USA, Canada and Norway attended the workshop, which was sponsored by Statoil and organised by Erik Kolstad at BCCR. In addition to Erik Kolstad, several BCCR scientists attended the workshop: Idar Barstad, Nils Gunnar Kvamstø, Ina Kindem, Dag Johan Steinskog, Asgeir Sorteberg, Sigbjørn Grønås, Jostein Bakke and Atle Nesje.

W orkshop on abrupt climate change, Birmingham, 24-27 October 2006

The Bjerknes Centre co-organised a workshop on the abrupt climate event that occurred 8200 years ago, which is likely the largest abrupt climate event that occurred after the last ice age. The meeting was organised by the PAGES/CLIVAR joint panel in Birmingham (UK) in conjunction with the UK research programme RAPID's science conference. Co-conveners were Gavin Schmidt, Goddard Institute for Space studies, New York and Eystein Jansen, Bjerknes Centre.

Workshop on Palaeoclimate Research, Nansen–Zhu International Research Centre, Beijing, China, 15–16 November 2006

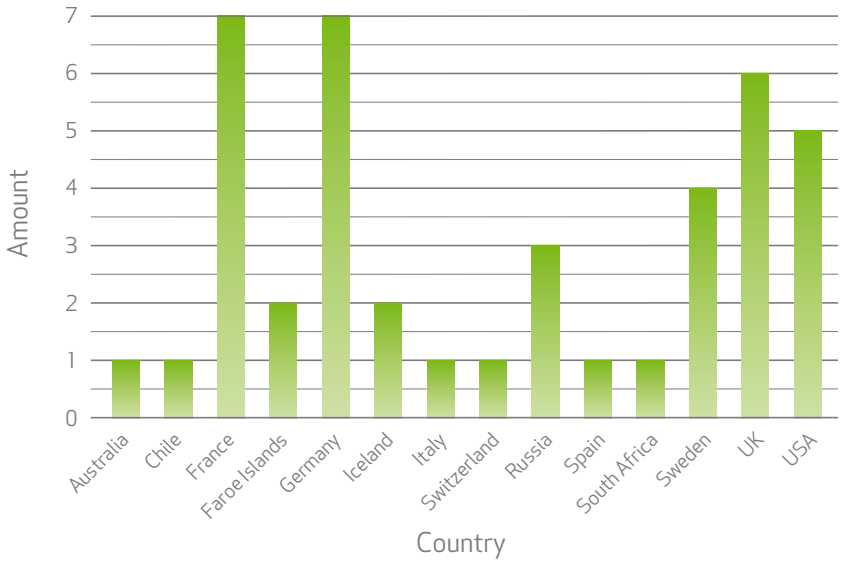
In connection with the annual meeting this November at the Nansen–Zhu International Research Centre (NCZ) in Beijing, China, a two-day workshop on palaeoclimate research was arranged. The workshop was organised by the NCZ, Institute of Atmospheric Physics, Chinese Academy of Sciences. The purpose of the workshop was to discuss possible cooperation between Bergen and Beijing on palaeoclimate research in the near future. From China a number of scientists and students from different institutions in Beijing attended the meeting. From Bergen and BCCR the following scientists participated: Helge Drange, Eystein Jansen, Atle Nesje,

The Norwegian Sea houses the highest known density of cold water reefs in the world.

(Photo: Statoil ASA, Norway).

Kerim Nisancioglu, Carin Andersson Dahl and Odd Helge Otterå. A total of about 25 scientists participated in the workshop. The first day was dedicated to scientific talks from the participants, whereas the second day was used to discuss possible cooperation in more detail. A number of themes were identified where a close Bergen–Beijing cooperation will be initiated. These involve cooperation on data analysis on various Holocene model experiments as well as proxy data. Furthermore, the strong cooperation between Bergen and Beijing on the ABOT modelling system will continue. There are also concrete plans to initiate cooperation between BCCR and the Institute of Tibetan Plateau Research on future fieldwork in Tibetan lakes.

Figure 6. Visiting scientists by country



2nd Annual Meeting of EU Integrated Project Carboocean at Maspalomas, Gran Canaria, 4–8 December 2006

The 2nd annual meeting of EU FP6 Integrated Project CARBOOCEAN "Marine Carbon Sources and Sinks Assessment", which is coordinated by BCCR (Christoph Heinze, Andrea Volbers and Hege Høiland), was held at the Gran Hotel Lopesan Costa Meloneras, Gran Canaria, Spain, 4–8 December hosted by Melchor González and Magdalena Santana from the University of Las Palmas About 110 persons attended the meeting. The two first days of the meeting were dedicated to scientific presentations in order to discuss the progress and the new challenges concerning a quantification of marine carbon sources and sinks. The three other days were tightly filled with guest lectures, training seminars, work package discussions, the school project CARBOSCHOOLS, and a gender issues event.

The newly emerging findings from the CARBOOCEAN project give rise to concern, if not alarm:

(1) There is clear evidence that the thus-far most efficient sink for CO_2 in the northern North Atlantic Ocean is weakening. This trend can be traced back until the early 1970s.

(2) If one couples the carbon cycle in global climate models, then the future scenarios for the evolution of climate show that the feedbacks reinforce climate change.

(3) The CO_2 additions to seawater lead to less alkaline conditions than before ("acidification of seawater"). This acidification will certainly happen and is already ongoing. It is quite certain that it will contribute to a widespread destruction of corals, which are very sensitive to acidification. It may also cause changes in marine ecosystems with implications also to fish populations.

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.

National Implementation Plan Climate Research: Professor Helge Drange, NERSC/BCCR was appointed member of committee prepared by the Norwegian Ministry of Environment and coordinated by the Research Council of Norway.

UN Intergovernmental Panel for Climate Change (IPCC): Professor Eystein Jansen is Coordinating Lead Author of Chapter 6 "Palaeoclimates" and Professor Christoph Heinze is Lead Author of Chapter 7 "Couplings between Changes in the Climate System and Biogeochemistry". Four contributing authors. In addition, the Bergen Climate Model group produced 1600 simulations of climate developments using IPCC 4AR protocols.

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

International Geosphere-Biosphere programme (IGBP):

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

Visiting Fellow Programme

BCCR sponsors a Visiting Fellow Programme aimed at fostering international research collaboration in climate change. In 2006, the Centre hosted 42 scientists from 14 countries. See Figure 6.

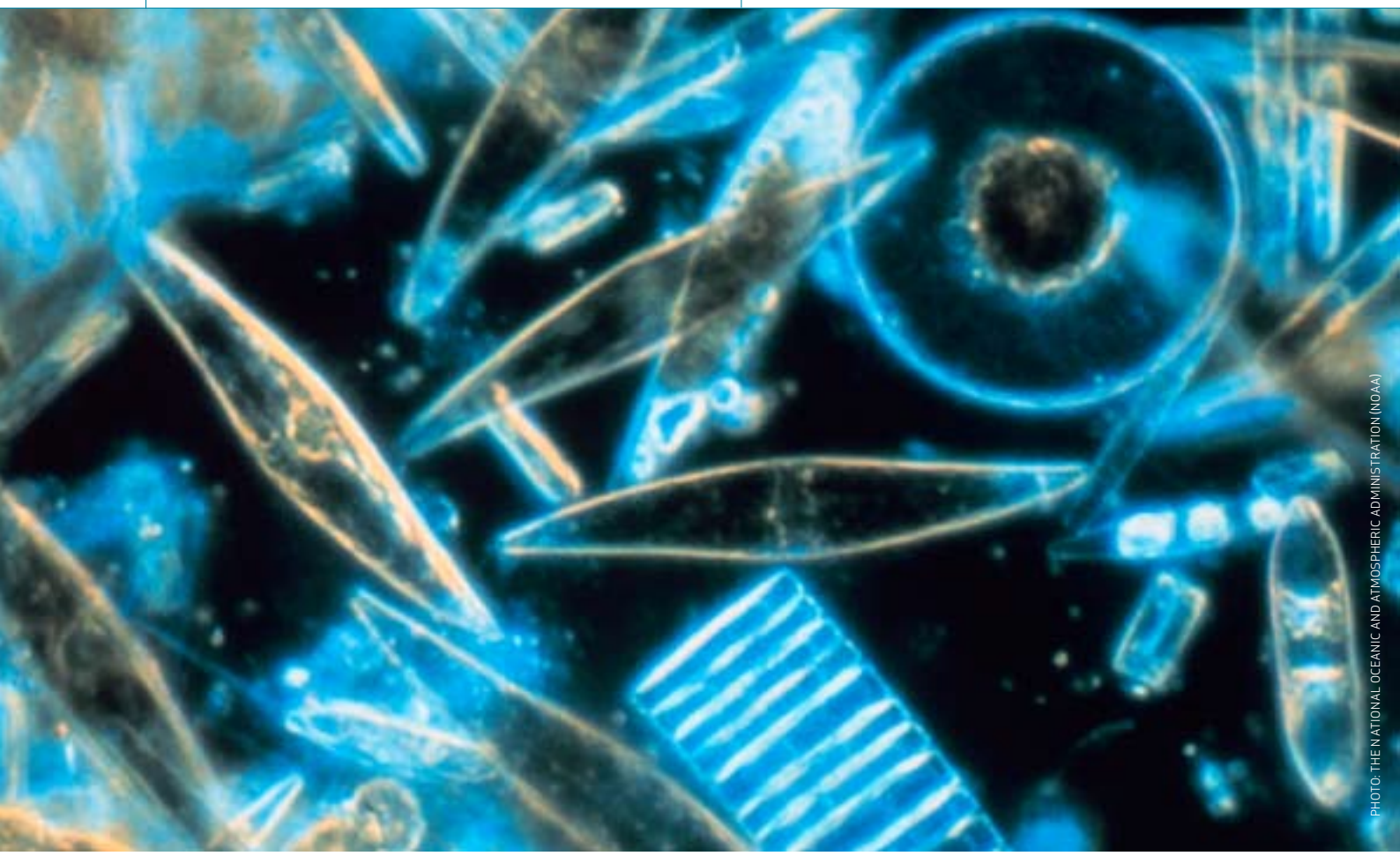


PHOTO: THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

ORGANISATION & FINANCES

The Director and the Leader Forum

Eystein Jansen	Professor (Director) Palaeoclimatology, BCCR
Tore Furevik	Professor (Deputy director) Climate modelling, UiB
Trond Dokken	Dr. Scient Palaeoclimatology, BCCR
Helge Drange	Professor Climate modelling, NERSC
Ken Drinkwater	PhD Oceanography, Fisheries ecology, IMR
Tor Eldevik	Dr. Scient Ocean processes & modelling, NERSC
Peter Haugan	Professor Polar oceanography, UiB
Christoph Heinze	Professor Carbon cycle modelling, UiB
Truls Johannessen	Professor Chemical oceanography, UiB
Atle Nesje	Professor Palaeoclimatology, UiB
Asgeir Sorteberg	Dr. Scient Climate modelling, BCCR
Svein Sundby	Professor Ocean climates, IMR

For the five next years the Centre has decided to keep its main science foci, and to develop a more focused organisation around these areas in five research groups. The development of a more clarified role for the group leaders is a job that will continue in 2007.

Research Groups		Leader (co-leader)	
RG1	Dynamics of past climate variability	Atle Nesje	(Ulysses Ninnemann)
RG2	Dynamics and predictability of present day climate	Tore Furevik	(Ken Drinkwater)
RG3	Ocean–ice–atmosphere processes	Tor Eldevik	(Ilker Fer)
RG4	Biogeochemical cycles	Christoph Heinze	(Are Olsen)
RG5	Climate scenarios and downscaling	Asgeir Sorteberg	(Frode Flatøy)

THE BOARDS

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Kåre Rommetveit	Director, University director, UiB
Hans Petter Sejrup	Dean, Faculty of Mathematics and Natural Sciences, UiB

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Øystein Hov	Norwegian Meteorological Institute, Norway
Jerry McManus	Woods Hole Oceanographic Institution, USA
Peter Rhines	Dept of Oceanography, University of Washington, Seattle, USA
Rowan Sutton	Centre for Global Atmospheric Modelling, University of Reading, UK
John Walsh	International Arctic Research Center, University of Alaska, Fairbanks, USA
Andrew Watson	School of Environmental Sciences, University of East Anglia, UK

Figure 7. Organistation map


PHOTO: ISTOCKPHOTO

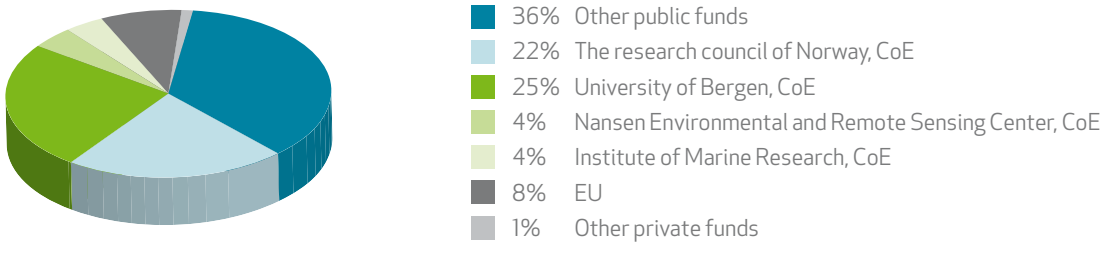
FUNDING & EXPENSES

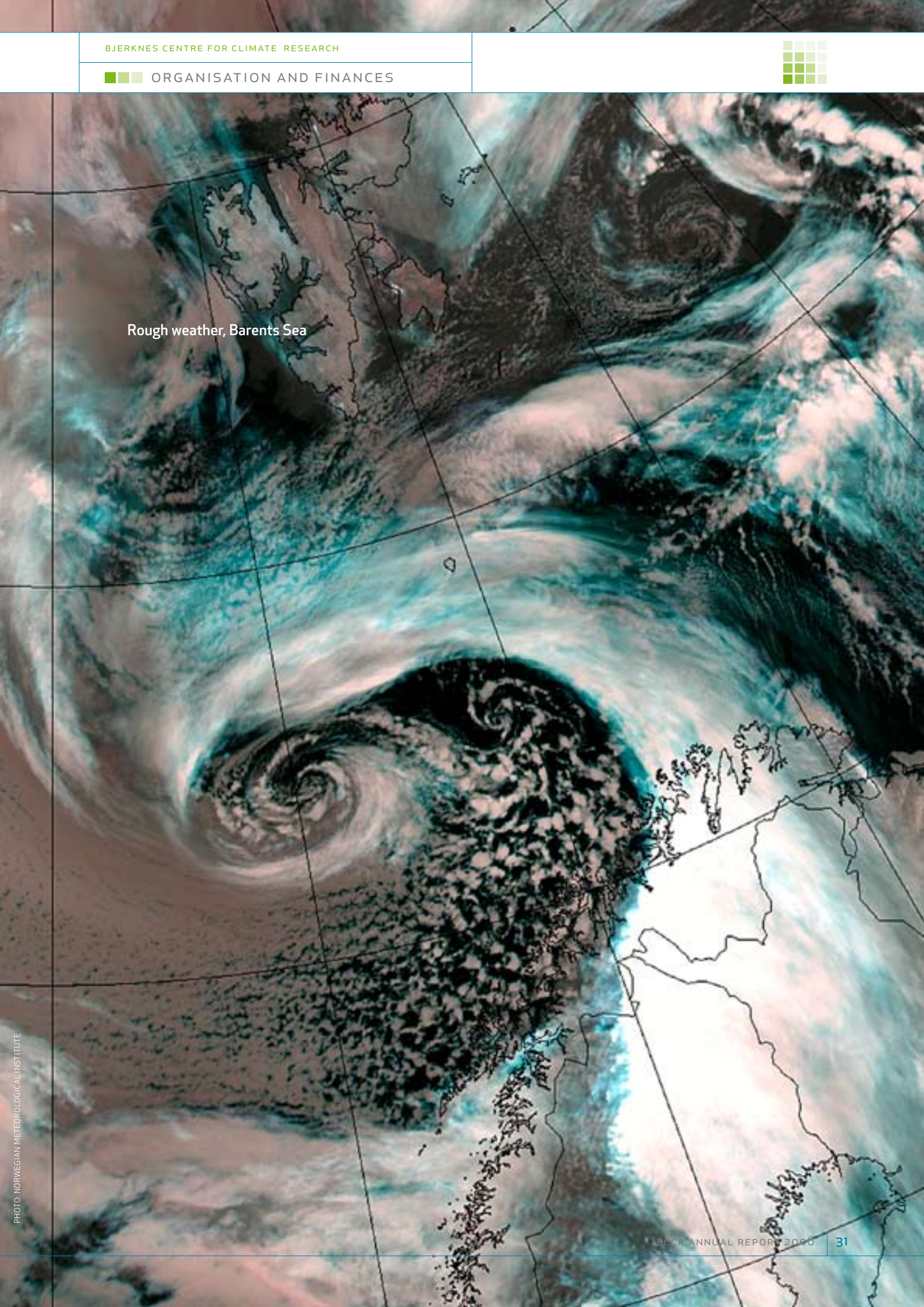
There are several ongoing programmes in which the Bjerknes Centre is involved. Twelve projects are funded by the Research Council of Norway. BCCR scientists lead 8 of these projects. Five ongoing projects are funded by the 5th and 6th Framework Programmes of the European Commission, of which BCCR co-ordinates two of the programmes. Five projects are funded by other sources. BCCR also co-ordinates 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. In addition, 11 new proposals were accepted in 2006, which will start in 2007.

Funding	(1000 NOK)	2006
The Research Council of Norway, CoE		**16 338**
University of Bergen, CoE		**18 138**
Nansen Environmental and Remote Sensing Center, CoE		**3 000**
Institute of Marine Research, CoE		**3 000**
EU		**5 898**
Other private funds		**1 093**
Other public funds (e.g. RCN)		**26 051**
Total		**73 518**

Expenses	(1000 NOK)
Salaries and house rental costs	**42 254**
Research equipment	**3 006**
External research services	**14 599**
Other costs	**16 946**
Total	**76 805**

Figure 8. Funding





Rough weather, Barents Sea

PHOTO: NORWEGIAN METEOROLOGICAL INSTITUTE

STAFF

Scientists

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

John Inge	Svendsen	Palaeoclimatology
Richard	Telford (UK)	Palaeoclimatology
Andrea	Volbers (Germany)	Palaeoclimatology and biogeochemistry
Hans	Wackernagel (Switzerland)	Geostatistics, multivariate analyses
Svein	Østerhus	Physical oceanography
Bjørn	Ådlandsvik	Physical oceanography & modelling

Postdocs

Karen	Assmann (Germany)	Carbon cycle, cand chemical oceanography
Jürgen	Bader (Germany)	Climate modelling
Jostein	Bakke	Palaeoclimatology
Anne Elisabeth	Bjune	Palaeobotany
Øyvind	Byrkjedal	Meteorology
Igor	Esau (Russia)	Environmental boundary layers
Yonqi	Gao (China)	Ocean circulation modelling
Richard	Gyllencreutz (Sweden)	Palaeoclimatology
Einar	Heegaard	Palaeoecology
Randi	Ingvaldsen	Physical oceanography
Øyvind	Lie	Palaeoclimatology
Katjia	Lohmann (Germany)	Ocean climate variability and modelling
Shujie	Ma (China)	Modelling, downscaling
Jan Even Ø.	Nilsen	Climate modelling
Anders	Olsson (Sweden)	Chemical oceanography
Abidrahman	Omar (Somalia)	Chemical oceanography
Odd Helge	Otterå	Climate modelling
Øyvind	Paasche	Palaeoclimatology
Bjørg	Risebrobakken	Palaeoclimatology
Cathrine	Sandal	Climate modelling and observations
Jeanne	Scao (France)	Paleoclimatology
Kristof	Sturm (France)	Carbon cycle modelling and climate modelling
Frode	Vikebø	Climate impacts on marine ecosystems

Ph.D. Students

Bernard	Christophe (France)	Biogeochemistry
Ingo	Bethke (Germany)	Ocean modelling
Tarjei	Breiteig	Climate dynamics
Anne-Grete	Bøe	Palaeoclimatology
Elin	Darelius (Sweden)	Polar oceanography
Christine	Euler (Germany)	Palaeoclimatology
Florian	Geyer (Germany)	Climate modelling
Louise P.	Ghysels (Denmark)	Paleoclimatology
Dorothea	Iovino (Italy)	Meridional overturning circulation
Marwan	Khalil (Egypt)	Climate modelling
Caroline	Kivimäe (Sweden)	Chemical oceanography
Erik W.	Kolstad	Climate downscaling
Ben	Marzeion (Germany)	Meridional overturning circulation
Marius	Meland	Palaeoclimatology
Svetlana	Milutinovic (Croatia)	Remote sensing, climate modelling
Birgitte F.	Nyland	Palaeoclimatology
Steinar	Orre	Climate modelling
Anders	Sirevaag	Physical Oceanography
Yongjia	Song (China)	Climate downscaling
Dag Johan	Steinskog	Climate modelling
Eivind W. N.	Støren	Palaeoclimatology
Karolina	Widell (Sweden)	Physical oceanography

Technical staff

Dag Inge	Blindheim	Palaeoclimatology
Wenche	Breyholtz	Palaeoclimatology
Kelly	Brown (USA)	Chemical Oceanography
Dagfinn	Bø	Paleoclimatology
Odd Reidar	Hansen	Palaeoclimatology
Solveig	Kringstad	Chemical Oceanography
Bjørn Christian	Kvisvik	Palaeoclimatology
Craig	Neill (USA)	Chemical Oceanography
Ann Kristin	Østrem	Oceanographic time series, databases
Vincent	Scao (France)	Palaeoclimatology
Jørund	Strømsøe	Palaeoclimatology
Rune Egil	Søraas	Palaeoclimatology

Secretariat (Administration)

Beatriz	Balino	Science coordinator
Connie	Engstad	Human resources
Lars	Fagerli	Financial officer
Jill	Johannessen	Information consultant
Lill Tåve	Jørgensen	Secretary
Tordis	Lerøen	Administrative consultant
Charla M.	Olsen (USA)	Administrative consultant

PERSONNEL SUMMARY

CATEGORY	Person-years
Scientists	36.3
Postdocs	19.1
PhD students	20.0
Technicians	10.4
Administration	4.7
Total	**90.5**

Scientific personnel sorted by category and partners.
Percentages of non-Norwegians and female scientists are also indicated:

PARTNER

						FOREIGNERS	WOMEN
Category	**BCCR**	**UiB**	**IMR**	**NERSC**	**Total**	**%**	**%**
Scientists	25	14	15	7	**61**	28	18
Postdocs	11	6	2	5	**24**	46	33
Ph.D. students	0	13	0	8	**21**	57	43

RESEARCH PROJECTS

PROJECTS FUNDED BY THE RESEARCH COUNCIL OF NORWAY

Title	Duration	*Leader/ **Partner
Climate and Ocean in mid-to high latitudes: Mechanisms of variability in paleo and modern records (COMPAS)	2006–09	N.G. Kvamstø*
Cooperation between Bjerknes and the International Arctic Research Centre, University of Fairbanks (ArcCOOP)	2006–06	A. Sorteberg*
Interactions of Arctic Sea-ice Cover and Ocean Heat Transport (InACT)	2006–08	B. Risebrobakken*
Inverse Magnetic Modelling of Glacier Activity Using Suspended Sediments (MAGNET)	2006–08	Ø. Paasche*
Reconstruction of natural Holoscene climate variability based on North Atlantic and western Baltic sea sediments	2006–07	E. Jansen*
Resolving chemical element variations in lake sediments through high-resolution XRF analyses (X-LAKE)	2006–08	J. Bakke*
Southeast Pacific CALYPSO coring of expanded Holocene–late glacial sediment sequences (CALYPSO–SEAPACE)	2006–07	U. Ninnemann*
Geohazards, Climatic Change, and Extreme Weather Events (GeoEXTREME)	2005–08	A. Sorteberg**
Impact of changing freshwater flows on the thermohaline circulation and European climate – analysis and modelling of the last deglaciation (ORMEN)	2005–08	T. Dokken*
Norwegian Component of the Ecosystem Studies of Sub-Arctic (NESSAS)	2005–08	A. Sorteberg
Punctuated disintegration of the NW European Ice Sheet and rapid climate change (RAPID)	2005–08	H. Haflidason*
Variations of the Atlantic Meridional overturning circulation during rapid climate changes: calibration, modelling and palaeoceanographic observations (VAMOC)	2005–08	T. Dokken*
Climate effects on dynamic biodiversity	2003–06	E. Heegaard*
Effects of North Atlantic Climate Variability on the Barents Sea Ecosystem (ECOBE)	2003–06	S. Sundby*
External and internal forced variability of the Atlantic European climate system over the last millennium (EUROCLIMATE)	2003–06	H. Drange*
Improved parameterisation of Microphysical and Optical Properties of Clouds in Global Climate Models (CIRAD)	2003–06	J. Stamnes
Marine climate and ecosystems in the seasonal ice zone (MACESIZ)	2003–06	O. M. Johannessen*
Norwegian Ocean Climate Project (NOClim II)	2003–06	P. Haugan*
Past Climates of the Norwegian Region (NORPAST II)	2003–06	A. Nesje**
Paleo environment and climate history of the Russian Arctic (PECHORA II)	2003–06	J.I. Svendsen*
Polar Ocean Climate processes (PROCLIM)	2003–07	P. Haugan*
Regional Climate Development under Global Warming (RegCLIM III)	2003–06	S. Grønås*
Carbon flux and ecosystem feedback in the northern Barents Sea in an era of climate change (CABANERA)	2002–06	T. Johannessen**
Spatial and temporal variability of currents and transport of warm waters in the Nordic Seas (NUCA ARCTICA)	2002–06	H. Svendsen*

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

Title	Duration	Type	Leader/ Scientist
Links between Meridional Overturning Circulation and climate changes during the Holocene (LIMOCINE)	2006–08	MCIF	Ý E. Jansen
Developing Arctic Modelling and Observing Capabilities for Longterm Environmental Studies – Integrated Project (DAMOCLES)	2005–08	IP	⬟ P. Haugan and H. Drange
Marine carbon sources and sinks assessment (CARBOOCEAN)	2005–09	IP	Ý C. Heinze
Natural and anthropogenic modifications of the Si cycle along the land–ocean continuum: Worldwide Ecological, Biogeochemical and Socio-economical consequences (Si-WEBS)	2005–06	RTN	⬟ C. Heinze
Understanding the dynamics of the coupled climate system (DYNAMITE)	2005–08	STREP (NERSC)	Ý 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
Model and observation test climate feedback (MOTIF)	2003–06	RTD	⬟ E. Jansen
Proxies in Paleoclimatology: Education and Research (PROPER)	2003–06	MCTN	⬟ E. Jansen
Role of ice–ocean–atmosphere processes in high-latitude climate change (Bjerknes MCTS)	2001–06	MCTS	Ý P. Haugan

BCCR is Ý Coordinator or ⬟ Partner

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

PROJECTS FUNDED BY OTHER SOURCES

Title	Duration	Leader/Scientist	Funding agency
Arctic Weather Extremes Workshop 19–20 June 2006	2006–06	A. Sorteberg	Statoil ASA
Internasjonal dokumentar for fjernsyn – Global oppvarming – styre været	2006–07	E. Jansen	University of Bergen
Paleo-Climate Modeling of Organic Rich Sediments (PALMORC)	2006–07	F. Flatøy	Norsk Hydro Produksjon AS
University of Washington – University of Bergen Climate Change Network	2006–07	T. Furevik	Bergens Forskningsstiftelse
Autonomous underway pCO_2 sensors for VOS applications	2004–06	R. Bellerby	National Oceanographic & Atmospheric Administration (NOAA)
Palaeoclimate in the Southern Ocean	2004–08	U. Ninnemann	COMER foundation

Visit our web pages to read more about ongoing projects and projects starting in 2007 on **www.bjerknes.uib.no/research/**.

SELECTED PUBLICATIONS

Altogether Bjerknes researchers have been involved in 72 articles in international peer review journals that were published in 2006. For complete listing please visit **www.bjerknes.uib.no/publications/**.
Bjerknes scientists are indicated in **bold.**

ARTICLES IN INTERNATIONAL PEER REVIEW JOURNALS

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2. Bondevik, Stein; **Mangerud, Jan; Birks, Hilary H.**; Gulliksen, Steinar; Reimer, Paula. "Changes in North Atlantic radiocarbon reservoir ages during the Allerød and Younger Dryas". *Science* 2006; 312 (5779): 1514–1517.
3. **Byrkjedal, Øyvind; Kvamstø, Nils Gunnar; Meland, Marius; Jansen, Eystein**. "Sensitivity of last glacial maximum climate to sea-ice conditions in the Nordic Seas". *Climate Dynamics* 2006; 26 (5): 473–487.
4. **Bøe, Anne-Grete; Dahl, Svein Olaf; Lie, Øyvind; Nesje, Atle**. "Holocene river floods in the upper Glomma catchment, southern Norway: a high-resolution multiproxy record from lacustrine sediments". *The Holocene* 2006; 16 (3): 445–455.
5. Collins, Matt; Botzet, A; Carril, AF; **Drange, Helge**; Jouzeau, A; Latif, M.; Masina, S; **Otterå, Odd Helge**; Pohlmann, H; **Sorteberg, Asgeir**; Sutton, R; Terray, L. "Interannual to decadal climate predictability in the North Atlantic: A multimodel-ensemble study". *Journal of Climate* 2006; 19 (7): 1195–1203.
6. **Drinkwater, Ken**. "The regime shift of the 1920s and 1930s in the North Atlantic". *Progress in Oceanography* 2006; 68: 134–151.
7. **Heegaard, Einar**; Lotter, André F.; **Birks, John H.B.** "Aquatic biota and the detection of climate change: Are there consistent aquatic ecotones?" *Journal of Paleolimnology* 2006; 35 (2): 507–518.
8. **Kolstad, Erik Wilhelm**. "A new climatology of favourable conditions for reverse-shear polar lows". *Tellus. Series A, Dynamic meteorology and oceanography* 2006; 58 (3): 344–354.
9. **Lie, Øyvind; Paasche, Øyvind**. "How extreme was northern hemisphere seasonality during the Younger Dryas?". *Quaternary Science Reviews* 2006; 25 (5–6): 404–407.
10. **Marzeion, Ben; Drange, Helge**. "Diapycnal mixing in a conceptual model of the Atlantic Meridional Overturning Circulation". *Deep-Sea Research. Part 2. Topical Studies in Oceanography* 2006; 53 (1–2): 226–238.
11. **Moros, Matthias**; Andrews, J. T.; Eberl, DD; **Jansen, Eystein**. "Holocene history of drift ice in the northern North Atlantic: Evidence for different spatial and temporal modes". *Paleoceanography* 2006; 21.
12. **Nesje, Atle; Bjune, Anne Elisabeth; Bakke, Jostein; Dahl, Svein Olaf; Lie, Øyvind; Birks, John H.B.**. "Holocene palaeoclimate reconstructions at Vanndalsvatnet, western Norway, with particular reference to the 8200 ca. yr BP event". *The Holocene* 2006; 16 (5): 717–729.
13. **Nilsen, Jan Even**; Falck, Eva. "Variations of mixed layer properties in the Norwegian Sea for the period 1948–1999". *Progress in Oceanography* 2006; 70: 58–90.
14. **Olsen, Are ; Omar, Abdirahman; Bellerby, Richard; Johannessen, Truls; Ninnemann, Ulysses S; Brown, Kelly; Olsson, Anders;** Olafsson, J.; Nondal, Gisle; Kivimæe, Caroline; Kringstad, Solveig Barbro; **Neill, Craig Chandler**; Olafsdottir, S. "Magnitude and origin of the anthropogenic CO_2 increase and 13C Suess effect in the Nordic seas since 1981". *Global Biogeochemical Cycles* 2006; 20.
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18. **Smedsrud, Lars Henrik**; Jenkins, Adrian; Holland, David M.; Nøst, Ole Anders. "Modeling ocean processes below Fimbulisen, Antarctica". *Journal of Geophysical Research* 2006; 111 (C1).

19. **Sorteberg, Asgeir**; Kvamstø, Nils Gunnar. "The effect of internal variability on anthropogenic climate projections". *Tellus. Series A, Dynamic meteorology and oceanography* 2006; 58: 565–574.

20. **Sorteberg, Asgeir**; Kvingedal, Børge. "Atmospheric forcing on the Barents Sea winter ice extent". *Journal of Climate* 2006; 19: 4772–4784.

21. **Telford, Richard**; Vandvik, Vigdis; **Birks, John H.B.** "Dispersal limitations matter for microbial morphospecies". *Science* 2006; 312 (5776): 1015–1015.

22. **Widell, Karolina; Fer, Ilker; Haugan, Peter M.** "Salt release from warming sea-ice". *Geophysical Research Letters* 2006; 33.

BOOKS AND CHAPTERS IN BOOKS

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2. **Bakke, Jostein; Dahl, Svein Olaf; Nesje, Atle; Lie, Øyvind**. Winter precipitation anomalies during the Holocene, observed through reconstructed glacier fluctuations along the west coast of Norway. I: Global Change in Mountain Regions: Sapiens Publishing 2006. ISBN 0-9552282-2-0. s. 51–52.

3. **Bakke, Jostein; Lie, Øyvind; Nesje, Atle; Dahl, Svein Olaf; Paasche, Øyvind**. Utilizing physical sediment variability in glacier-fed lakes for continuous glacier reconstructions during the Holocene, northern Folgefonna, western Norway. I: Global Change in Mountain Regions: Sapiens Publishing 2006. ISBN 0-9552282-2-0. s. 53–54.

4. Ehlers, J.; Astakhov, V.; Gibbard, P.L.; Ingólfsson, O.; **Mangerud, Jan;** Svendsen, John-Inge. Early Quaternary. I: Encyclopedia of Quaternary Science, Four-Volume Set, 1–4: Elsevier 2006. ISBN 0-444-51919-X. s. 1031–1032.

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6. Ehlers, J.; Astakhov, V.; Gibbard, P.L.; **Mangerud, Jan**; Svendsen, John-Inge. Mid-Quaternary in Eurasia. I: Encyclopedia of Quaternary Science, Four-Volume Set, 1–4 : Elsevier 2006. ISBN 0-444-51919-X. s. 1036–1043.

7. **Heinze, Christoph**. The long-term oceanic Si cycle and the role of opal sediment. I: The silicon cycle –human perturbations and impacts on aquatic systems. Chicago, Il 60628, USA: Island Press 2006. ISBN 1-59726-114-9. s. 229–243.

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12. **Mangerud, Jan**. Milankovitch' istidsteori –den astronomiske teori for klimavariasjoner. I: Teori og Metode i Geografi. Bergen: Fagbokforlaget 2006. ISBN 82-7674-878-3. s. 311–328.

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15. Vorren, T.; **Mangerud, Jan**. Istider kommer og går. I: Landet blir til. Norges geologi. Trondheim: Norsk Geologisk Forening 2006. ISBN 82-92394-31-1. s. 478–531.

16. Vorren, Tore; **Mangerud, Jan**; Blikra, Lars H.; **Nesje, Atle**; Sveian, Harald. Norge av i dag trer fram. I: Landet blir til. Norges geologi. Trondheim: Norsk Geologisk Forening 2006. ISBN 82-92394-31-1. s. 532–555.

17. Vorren, Tore O.; **Mangerud, Jan**. Istider kommer og går. Sein pliocen og pleistocen; 2,7 Ma til 11 500 år. I: Landet blir til. Norges geologi. Trondheim: Norsk Geologisk Forening 2006. ISBN 82-92394-31-1. s. 478–531.

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2. **Fer, Ilker**. Current Measurements at the Storfjorden Sill: Geophysical Institute, University of Bergen 2006. 41 s.

3. **Fer, Ilker**. Current Measurements at the Storfjorden Sill 76° 58 ' N, 19° 15 ' E, September 2003 – August 2004. Bergen: University of Bergen 2006. ISBN 82-8116-007-1. 41 s.

4. **Fer, Ilker**. Data report from the cruise HM 2004 613 with R.V. Håkon Mosby 1–10 July 2004: Geophysical Institute, University of Bergen 2006. 67 s.

5. **Fer, Ilker; Skagseth, Øystein**; Orvik, Kjell Arild. General and fine scale oceanographic properties on the Norwegian Continental slope inferred from a moored CTD- and current profiler: Geophysical Institute, University of Bergen 2006. 67 s.

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