Established by the Research Council of Norway

Norwegian Centre of Excellence

BCCR – Bjerknes Centre for

Climate Research

ANNUAL REPORT 2010

Centre of Excellence Activities

Universitas Bergensis | Havforskningsinstituttet | NERSC Nansen Center, Bergen | uni Research

PHOTO: TERJE HEIESTAD, MILIMETERPRESS

2010 – A YEAR IN TRANSITION

2010 has in many ways been a year in *transition* for the Bjerknes Centre. In terms of peer review publications, 2010 was the most productive year ever, totalling 105 published papers. This strong publication record covers all main science themes in the Bjerknes Centre. It paves the way for the last two years of the Centre of Excellence (CoE) funding in 2011 and 2012, which will focus on scientific syntheses to summarise key findings and provide conclusions on many of the central topics we have been working on over the last years. As in previous years, the bulk of the science output was produced by those of our scientists affiliated with the University of Bergen and Uni Research who produced 85% of the peer review publications.

Together with national partners we finalised the development of the Norwegian Earth System Model (NorESM), which is being used to develop new climate scenarios for the next IPCC-report. This is a major development that allows climate simulations with interactive carbon-cycle and atmospheric chemistry. The first papers originating from this development process were published in 2010, with interesting information on carbon-cycle feedbacks, which may amplify global warming. NorESM will become the main workhorse for the Centre's climate simulations in the coming years, both with respect to simulations of future climates and modelling and hindcasting past climates.

New model results provide insight into the main drivers of climate change: in terms of what drove natural changes prior to industrialisation, such as volcanic and solar activity, and how these factors interacted with human causes to provide climate change as it has been observed during the past 100 years. The Centre has also emphasised mechanisms of abrupt, surprising changes and is now close to completing a model for the occurrence of such events during glacial conditions.

Our studies further document how human perturbations are changing the ocean's chemical signature, and how man-made carbon emissions are absorbed by the ocean, resulting in the ongoing ocean acidification.

After the fact that all investigations in the wake of "Climategate" have concluded that climate science is on firm ground and found no evidence for scientific wrongdoing, we can finally look past this interlude and focus more of our outreach on the new and exciting science, rather than spending time on the numerous unfounded allegations and scientific misconceptions that flooded media and blogs in 2009. In this respect, both the published results from our own research and those of other research groups reaffirm the key conclusions of the IPCC

and bring new results to the table in terms of how the complex climate system operates.

As we now *transit* into the next phase of the IPCC with the start-up of the 5th Assessment Report, we note that Bjerknes Centre scientists will be involved both in IPCC Working Group 1 on the Natural Science Basis and in Working Group 2 on climate impacts and vulnerabilities.

Climate change is a major global challenge and the Bjerknes Centre aims to be a knowledge resource for handling the potential consequences on global and regional scales. Hence, we have in recent years created a number of new partnerships in Asia and developed strengths in regional climate modelling. Results based on the new IPCC scenario simulations will provide an invaluable resource for future studies of climate impacts and vulnerabilities, both in our own region and in several regions of the world.

In 2010 the Bjerknes Centre community also initiated implementation of the new long-term funding from the Government. Although not an official part of the CoE activities, this new 12-year funding provides a solid base for maintaining our strong research base. The new funding will be separately organised as the *Centre for Climate Dynamics at the Bjerknes Centre*, and the *transition* into this organisation will occur in 2011 and 2012.

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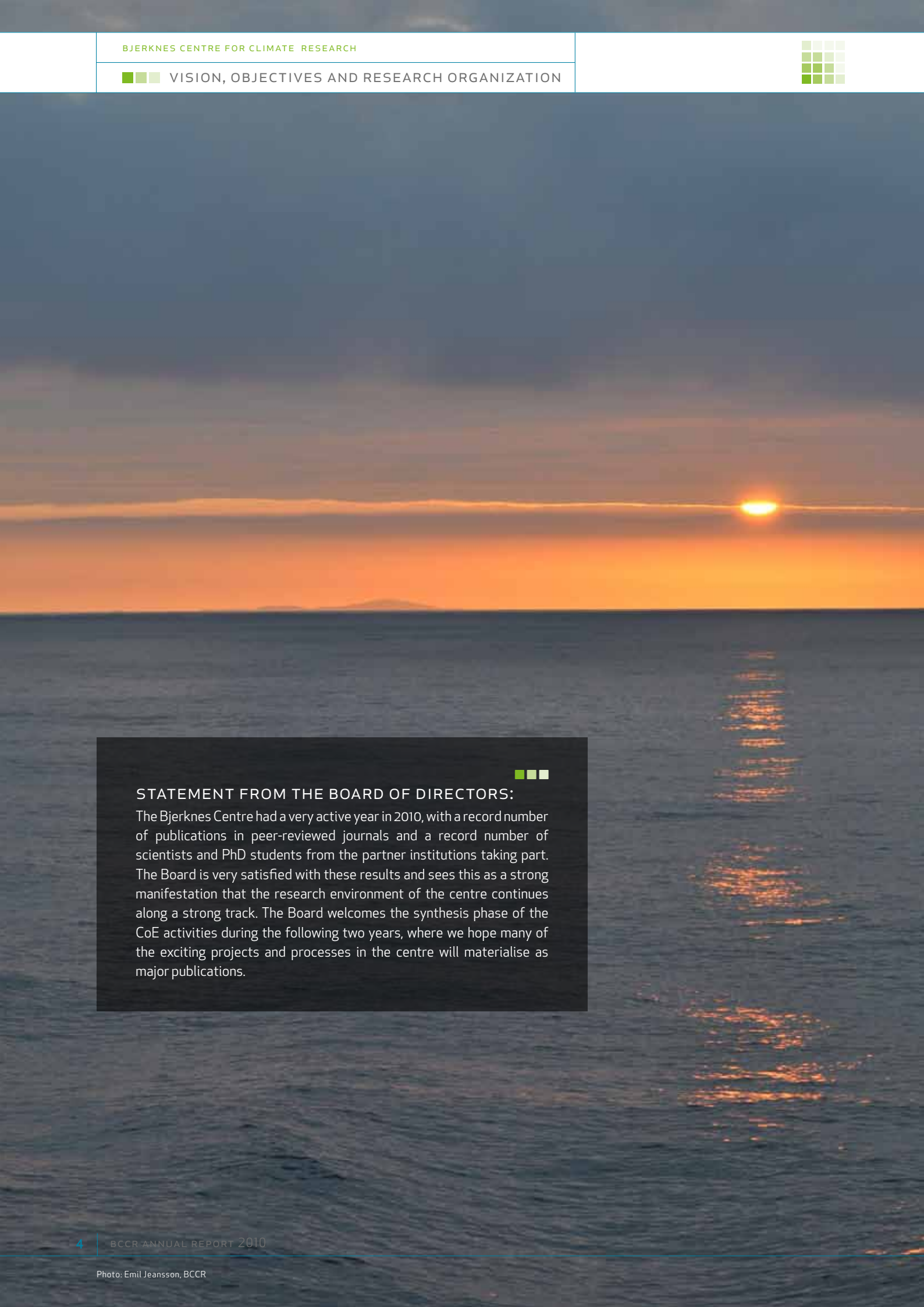
Ny Ålesund (photo: Anna Silyakova, BCCR)



STATEMENT FROM THE BOARD OF DIRECTORS:

The Bjerknes Centre had a very active year in 2010, with a record number of publications in peer-reviewed journals and a record number of scientists and PhD students from the partner institutions taking part. The Board is very satisfied with these results and sees this as a strong manifestation that the research environment of the centre continues along a strong track. The Board welcomes the synthesis phase of the CoE activities during the following two years, where we hope many of the exciting projects and processes in the centre will materialise as major publications.

Photo: Emil Jeansson, BCCR

AN EXCELLENT RESEARCH CENTER – 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 within a global context. As part of the more pressing need 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.

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

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

Past Climate Changes

Understanding long-term natural climate variability of the past is essential for understanding present and future climate changes.

Present-day Climate Change and Climate Variability

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.

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.

Biogeochemical Cycles

Biogeochemical processes are important in the global climate system and affect how much of man-made CO_2 emissions are taken up by the ocean and land surfaces.

Future Climate Scenarios 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 Uni Research, Nansen Environmental and Remote Sensing Center, and the Institute of Marine Research.


Illustration photo: AADI


Photo: The Bjerknes-BAS drilling team


Photo: Jill Johannessen, BCCR

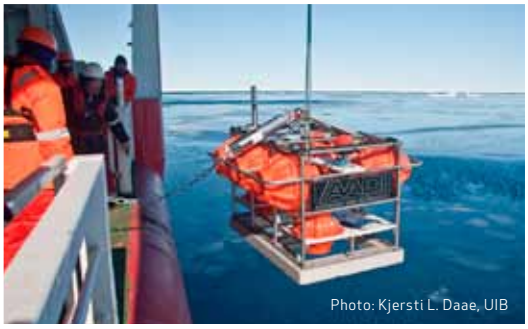


Photo: Kjersti L. Daae, UIB


Photo: Emil Jeansson, BCCR

Successful projects near completion

Scientists from all partner institutions of the Bjerknes Centre contributed to the successful completion of NORKLIMA and IPY research projects in 2010.

Here you can read about some of the key results from a handful of major projects financed by the Norwegian Research Council, which were finalised or near completion in 2010, pertaining to ocean circulation and heat transport, atmospheric wind patterns, and climate modelling. In the IPY *Bipolar Atlantic Thermohaline Circulation* (BIAC) scientists have studied the Arctic and Southern Ocean shelf ventilation processes and are determining their impacts on the bipolar Atlantic Thermohaline Circulation. BIAC measurements indicate a slower uptake of CO_2 in the ocean than predicted and, in contrast to earlier understanding, that ice formation is enhancing the ocean CO_2 uptake. Measurements indicate that the heat transport from deeper layers towards the surface is small and don't contribute significant to sea ice melting. Analysis also shows that the Storfjorden ice formation is effective, because favourable winds keep polynyas open. Furthermore, water sample analysis reveals that the increased salinity results in higher carbon concentration. Five PhD and several MSc students have been assigned to the BIAC project. Laboratory experiments, analytical and numerical models have been applied to aid in interpretation of the data and design of field experiments. New advanced instrumented platforms for long-term observations and remote data upload has been developed and deployed. This instrument cluster is now available on a commercial basis.

ARCTIC HEAT TRANSPORT

The climate of mainland Norway and Svalbard is exceptionally mild for their Arctic location. This results from the heat carried north by the atmosphere and ocean circulation, i.e., by the Norwegian Atlantic Current. Scientists from all partner institutions of the Bjerknes Centre contributed to the successful completion of the NORKLIMA project *Polar Climate and Heat Transport* (POCAHONTAS); a project dedicated to understanding Arctic heat. The main findings were that extreme Norwegian weather can find its source in Caribbean tornados, that the ocean circulation between the Norwegian Sea and Atlantic Ocean is remarkably stable, and that ocean heat maintains a largely ice free Barents Sea (see also page 24).

MODELLING THE FUTURE

Through the NorClim project, the Bjerknes Centre together with national partners finalised the development of the Norwegian Earth System Model (NorESM) in 2010. The earth system model, in contrast to previous climate models, includes a dynamic


Photo: Emil Jeansson, BCCR


Photo: Anna Silyakova, BCCR

carbon cycle, which is important because the natural sources and sinks of carbon are likely to change under global warming. The first published results originating from this development process show that carbon-cycle feedbacks may amplify global warming as a result of a future decrease in the ocean uptake of carbon. NorESM is currently being run to complete the global climate simulations that will form a key part of the next IPCC report due in 2013/2014. This will be essential knowledge for future emission targets and mitigation strategies (see also page 24).

Another main objective of the NorClim project has been to provide climate impact researchers, authorities and the general public with detailed atmospheric and oceanic projections for Norway during the 21st century, including projections for extreme events and assessment of uncertainty. This activity is summarised in the report "Klima i Norge 2100" issued by the Official Norwegian Report "NOU-klimatilpasning" (see also: http://www.norclim.no).

WHAT FACTORS CAUSE CLIMATE VARIABILITY?

Arctic sea ice and wind patterns in the stratosphere are important for understanding climate variations in Northern Europe.

Several papers completed under the NORKLIMA-COMPAS project have addressed the physics controlling the leading patterns of climate variability, in order to understand today's climate and how the climate might change in the future. The North Atlantic Oscillation (NAO) is probably the most robust pattern of climate variability outside the tropics, and it has a strong influence on the climate conditions in Europe and Scandinavia, especially during winter. For example, the unusually cold and dry winter of 2009–2010 across much of Scandinavia and northern Europe was strongly associated with the negative phase of the NAO.

SEA ICE PLAYS AN UNEXPECTED ROLE

The geographical extent of sea ice plays an important and somewhat unexpected role in the development of the NAO. By incorporating projected future reductions of Arctic sea ice into computer simulations of the atmospheric flow, COMPAS project members observed that the overall amount of winter storminess decreased over the North Atlantic and the North Atlantic Oscillation correspondingly shifted toward a phase commonly associated with colder and drier Scandinavian winters.

THE JET STREAM AND STORMS

It is easier and more reliable to make high-quality observations of the atmosphere near the Earth's surface. Hence, climate variability patterns like the NAO have tended to be defined based on near-surface observations. This tradition has, however, obscured the fact that the surface climate variability patterns have strong and consistent relationships to the shape and intensity of the jet streams and to patterns of storm activity in the upper troposphere. The strong link between jet stream and storm behavior in a range of climate variability patterns in the North Atlantic, North Pacific and in the Southern Hemisphere suggests that the climate variability patterns might be the surface expression of the interaction of these two fundamental features of the upper-tropospheric circulation. If so, determining future changes to the intensity and location of storms and the jet stream is important for predicting the response of climate variability patterns and anticipating regional climate change.

RELEVANT PAPERS UNDER COMPAS

(Climate and Ocean in mid-to-high latitudes: Mechanisms of variability in paleo and modern records):

- **Breiteig, T.**, 2008. Extra-tropical synoptic cyclones and downward propagating anomalies in the Northern Annular Mode. Geophysical Research Letters 35: L07809.
- **Seierstad, I. A. and Bader, J.**, 2009. Impact of a projected future Arctic Sea Ice reduction on extratropical storminess and the NAO. Climate Dynamics 33: 937-943.
- **Wettstein, J.J. and Wallace, J.M.**, 2010. Observed patterns of month-to-month storm track variability and their relationship to the background flow. Journal of the Atmospheric Sciences 67: 1420-1437.

THE PUZZLE OF CONFLICTING PALEO-OCEAN TEMPERATURE TRENDS

Carin Andersson (photo: private)

Photo: Carin Andersson, BCCR

Conflicting trends in reconstructed surface ocean temperatures for the North Atlantic and Norwegian Sea since the last ice age have puzzled scientists for years. Bjerknes scientists present new findings explaining the differing trends.

The early to mid-Holocene (6000 years before present) temperature optimum is a well-known feature in a wide variety of land-based paleo archives from the Northern Hemisphere. For the marine realm, however, Holocene trends in sea-surface temperature reconstructions for the North Atlantic and Norwegian Sea do not exhibit a consistent pattern of early- to mid-Holocene warmth. In a recent study published in *Climate of the Past*, Carin Andersson and co-workers at the Bjerknes Centre compare paleoclimate reconstructions of ocean temperatures and model results focusing on the mid-Holocene.

RECONSTRUCTED TEMPERATURES DEPEND ON PLANKTON TYPE

Sea-surface temperature records based on phytoplankton (alkenones and diatoms) generally show the existence of a warm early to mid-Holocene optimum. In contrast, several zooplankton (foraminifer and radiolarian) based temperature records from the North Atlantic and Norwegian Sea show a cool mid-Holocene anomaly and a trend towards warmer temperatures in the late Holocene.

WARM AND COLD WATER MASSES

Model results indicate that while the seasonal summer warming of the sea surface was stronger during the mid-Holocene, sub-surface depths experienced a cooling. These results also show that the strong summer warming appears to be restricted to the upper 30–75 m. This hydrographic setting (Figure 1) can explain the discrepancies between the Holocene trends exhibited by phytoplankton and zooplankton based temperature proxy records. The relatively cool mid-Holocene zooplankton-based (foraminifer) temperatures can be explained by the presence of cool sub-surface waters during summer (July, August and September).

Reference:
Andersson, C., Pausata, F., Jansen, E., Risebrobakken, R., *and* ***Telford, R.J.,*** *2010. Holocene trends in the foraminifer record from the Norwegian Sea and the North Atlantic Ocean. Climate of the Past, 6: 179-193.*

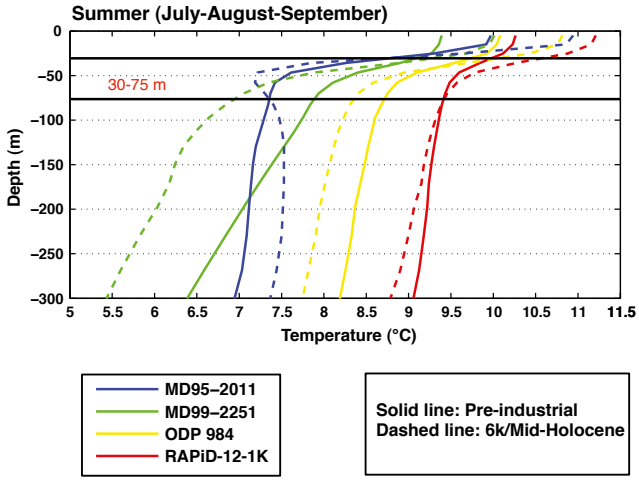


FIGURE 1. Modelled pre-industrial and Mid-Holocene (6000 years ago) temperature depth profiles for marine sites in the North Atlantic and eastern Norwegian Sea.

THE SUN AND VOLCANIC ERUPTIONS PACE CLIMATE SWINGS

A study presented in the prestigious journal *Nature Geoscience* suggests that changes in solar intensity and volcanic eruptions act as a metronome for temperature variations in the North Atlantic climate.

A research team led by Odd-Helge Otterå from the Bjerknes Centre has studied the climate in the North Atlantic region over the past 600 years using the Bergen Climate Model. They point to changes in the solar intensity and explosive volcanic eruptions as important causes for climate variations in the North Atlantic during this period.

THE SUN, VOLCANOES AND OCEAN CURRENTS

A common view is that climate variations in the North Atlantic, lasting a decade and more, are governed by changes in the large-scale ocean circulation. The analysis published in *Nature Geoscience* supports this common perception, but only when the climate effects from changes in the solar intensity and volcanic eruptions are left out. The scientists find a strong causal link between external forcing, including actual solar changes and climate effects of volcanic eruptions, and variations in the Atlantic surface temperature. In particular, the study highlights volcanic eruptions as important for long-term variations in the Atlantic climate both due to a strong cooling effect and impact on atmosphere and ocean circulation.

REGIONAL CLIMATE VARIATIONS

A wide range of regional climate variations of high societal importance have been linked to temperature variations in the North Atlantic. These include periods of prolonged droughts in the U.S., changes in European summer temperatures, long-term changes in the East Asian monsoon and variations in the intensity of Atlantic hurricanes. The governing mechanisms behind such long-term variations are, however, not well understood.

The study provides new insight into the causes and timing of long-term variations in the Atlantic and, consequently, for the potential for developing decadal prediction schemes for the Atlantic climate. However, observed warming in the North Atlantic during the 20th century cannot be explained by the solar and volcanic forcing, but rather by the increased emissions of CO_2 and other well-mixed greenhouse gases to the atmosphere since the onset of the industrial revolution.

The study presented in *Nature Geoscience* indicates that natural forcing, such as explosive volcanism and variations in solar irradiance, has played an important role in the Atlantic multidecadal variability during the past 600 years (photo: Michael Doukas, US Geological Survey).

Reference:
Otterå, O. H., M. Bentsen, H. Drange *and* ***L. Suo 2010.*** *External forcing as a metronome for Atlantic multidecadal variability, Nature Geoscience, 3, 688–694.*

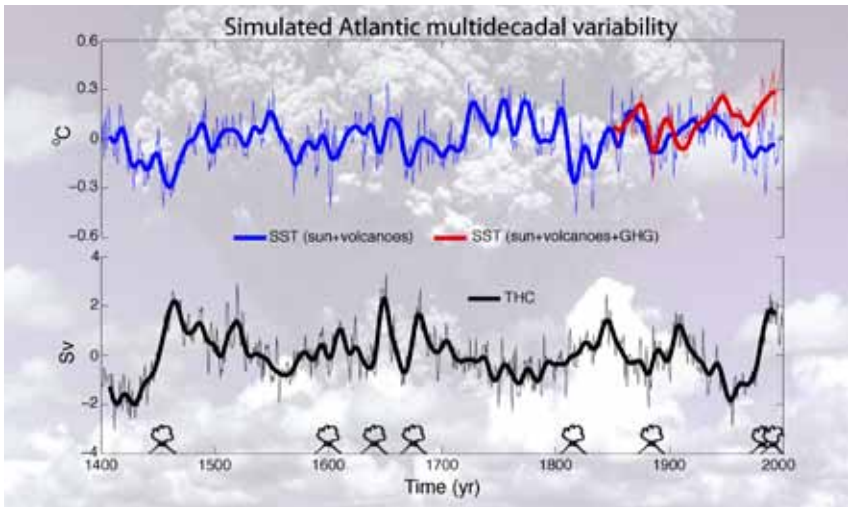


FIGURE 2. Simulated Atlantic multidecadal variability. The upper panel shows the variations in North Atlantic Ocean basin wide sea surface temperatures in a simulation that includes historical variations in total solar irradiance and volcanic aerosols (blue), and in a simulation that in addition to the natural external forcings also include anthropogenic forcings for the last 150 years (red). Up to year 1900, the blue curve is consistent with available temperature observations, whereas only the red curve matches the observed temperature evolution in the 20th century. The lower panel shows variations in the large-scale ocean circulation in the Atlantic (black) in the simulation that includes natural external forcings for the last 600 years. Large volcanic eruptions (illustrated on the time axis) tend to strengthen this large-scale ocean circulation.

An important factor in the success of Are Olsen (right) and Ulysses Ninnemann (left) in finding a new method for interpreting past ocean circulation trends is that they represent two different disciplines, chemical oceanography and paleooceanography, respectively (photo: Jill Johannessen, BCCR).

NEW METHOD MAY REVOLUTIONIZE INTERPRETATION OF PAST OCEAN CLIMATE

Anthropogenic carbon dioxide has limited the understanding of observed changes in sediment cores and thereby how ocean climate has varied in the past. In the renowned scientific journal *Science*, Bjerknes scientists present a new method to overcome this problem.

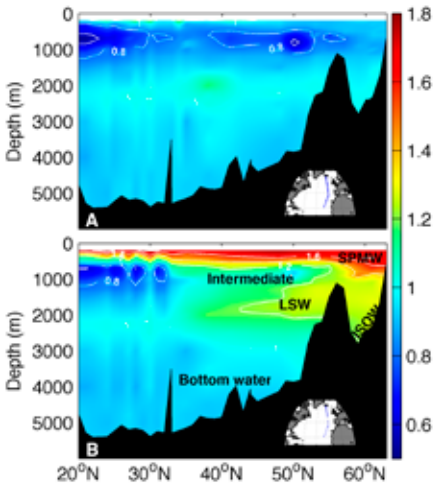


FIGURE 3. Upper panel displays the distribution of ^{13}C, a measure of the ^{13}C vs.^{12}C relationship in the modern – anthropocene – North Atlantic Ocean, whereas the lower shows the Suess effect corrected – preindustrial – distribution. The Suess effect has erased the ^{13}C signature of important, recently-ventilated water masses such as the Labrador Sea Water (LSW), the Subpolar Mode Water (SPMW) and the Iceland-Scotland Overflow Water (ISOW), whereas older intermediate and bottom waters have not been affected to the same extent.

Microfossils deposited in deep ocean sediments through time reflect changes of past ocean circulation. Hence, these fossils represent one of the most important archives of past climate variability. In a recent article in the journal *Science*, Are Olsen and Ulysses Ninnemann find that the modern isotopic ratio of carbon in the ocean – which is used when interpreting marine sediment cores – is strongly influenced by anthropogenic CO_2. This has limited the ability to explain the observed changes in sediments and hence our understanding of how ocean currents have varied in in the past.

DEEP OCEAN CLIMATE ARCHIVES

Changes in the ocean are archived in small unicellular animals, foraminifera, which live mostly on the seafloor. The relationship between light and heavy carbon isotopes is incorporated into the calcareous shells of these animals and gives a distinct chemical signal, reflecting changes in the waters in which they grow. This provides information on the rate and pathways of deep-water renewal in the ocean. Newly-formed deep water is well-ventilated and has a high ^{13}C to ^{12}C ratio, whereas it is lower in older, less ventilated water. Changes in the ^{13}C to ^{12}C values provide the primary evidence that the pattern of ocean circulation in the North Atlantic has changed with past climate, for example during ice ages and rapid climate events.

CORRECTING FOR ANTHROPOGENIC INFLUENCES

Scientists study the modern ocean ^{13}C to ^{12}C relationship, and show how this is affected by anthropogenic carbon, which has particularly low ^{13}C to ^{12}C values, also known as the Suess effect. The results reveal that the Suess effect has removed crucial differences between North Atlantic water masses with respect to their carbon isotopic composition, which changes the frame of reference for interpreting sedimentary carbon isotopic data.

Better understanding of past ocean circulation can contribute to improved models for predicting future climate (photo: Øyvind Paasche, UiB).

Therefore, one should use the preindustrial ocean carbon isotope distributions as a reference when interpreting past ocean changes, as opposed to the modern ocean signal, which altered by anthropogenic CO_2, no longer faithfully reflects ocean processes. This is now established, and thus has contributed to a far better understanding of what has driven changes in the ^{13}C to ^{12}C ratio in the past. For example, it has been difficult to explain the occurrence of very high ^{13}C to ^{12}C ratios in sediments from the ice age because no similar waters exist in the North Atlantic today. Olsen and Ninnemann were able to determine exactly how the distribution of water masses was significantly different during the last ice age by correcting for the Suess effect, and believe that this will set the terms for a clearer understanding of the relationship between climate change and ocean circulation in the future.

Reference: Olsen, A. *and* ***U. Ninnemann,*** *2010. Large $\delta^{13}C$ gradients in the preindustrial North Atlantic revealed. Science, 330: 658-659.*

BARENTS SEA
– AN EFFECTIVE OCEAN COOLER

The Barents Sea now has less sea-ice cover than before. Hence, it loses most of the extra heat from stronger ocean currents. Bear Island, between Norway and Svalbard (photo: Lars H. Smedsrud, BCCR).

Stronger ocean currents have transported more heat to the Barents Sea over the most recent years. Despite this extra heat, the mean temperature has increased only modestly. The reason is a stronger heat loss caused by more open water during wintertime.

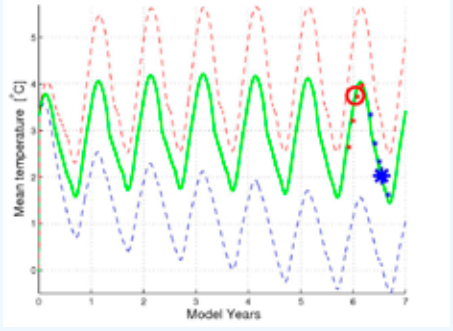
The Barents Sea is a robust and effective ocean cooler. Despite its fairly shallow depth of 230 m, it releases more energy to the atmosphere than any other sea around the Arctic. A new study by four oceanographers in Bergen shows how the Barents Sea responds to variation of heat transport by the ocean. Results show that the northwards migration of the sea ice, and the larger open ocean areas in the south, can compensate for much of the increase in ocean heat transport since the mid 1990's.

The article, published in *Ocean Science*, describes a new approach for understanding the Barents Sea. First, an overall heat budget had to be produced, including mean monthly ocean transport and atmospheric forcing. New estimates including the Norwegian Coastal Current make the total transported heat to the Barents Sea about 70 terawatts (TW), which is equivalent to five times the world energy demand. The researchers have divided the Barents Sea into a northern and southern area, and show that all of the heat is lost to the atmosphere in the south.

The heat is lost by the ocean in the southern Barents Sea through evaporation and sensible fluxes, as there is an approximate balance between the incoming solar, and the outgoing longwave radiation. The northern Barents Sea receives little ocean heat transport, leading to early sea ice formation during winter.

Reference:
Smedsrud, L. H., Ingvaldsen, R., Nilsen, J. E. Ø. *and* ***Skagseth, Ø.****, 2010. Heat in the Barents Sea: Transport, storage and surface fluxes. Ocean Science 6: 219–234.*

FIGURE 4. MEAN TEMPERATURE OF THE SOUTHERN BARENTS SEA. Red circle is the observed summer mean (June – September), and blue star is the winter mean (December – April). The green line shows a stable yearly cycle resulting from ocean heat transport of 73 TW. The red line shows temperature with increased ocean transport, and the blue line shows temperature with decreased ocean transport.



As part of ecosystem management, especially regarding fisheries and coastal management, understanding the role of climate on marine ecosystems is essential (photo: iStockphoto).

BIOLOGICAL RESPONSES TO CLIMATE VARIABILITY

Towards a better understanding of the impact of a changing climate and the multiple forcing on marine ecosystems.

Individual organisms, populations and communities in marine ecosystems fluctuate in response to a multitude of physical processes, variations in the dynamics internal to the population, and interactions with predator, prey and competitive species. This multitude of forcing and pathways can often make it difficult to establish unequivocal connections between climate and ecological responses. It is thus important to understand how physics affects the biology, in particular knowledge of the actual processes involved. To help achieve this, Bjerknes researcher Ken Drinkwater at the Institute of Marine Research and colleagues have carried out a review of ecosystem responses to climate variability as a means to assess the applicability of various proposed hypotheses.

OXYGEN SUPPLY IS TEMPERATURE SENSITIVE

Climate processes affect marine organisms directly through physiological changes, such as the effect of temperature on metabolic rates, or indirectly, such as through effects on their prey or predators. It has long been known that organisms tend to be limited to specific temperature ranges. One of the recent breakthroughs in our process understanding has been derived from laboratory experiments on fish. These studies have shown that sufficient oxygen supply to the organisms only occurs within specific thermal ranges, but that the range is species dependent. There is strong support for the "latitudinal compensation" hypothesis that predicts local evolution should maximize metabolic efficiency and thus favor maximum growth under local temperature conditions. This hypothesis is not universally applicable, however.

RECRUITMENT HYPOTHESES FOR FISH

Numerous recruitment hypotheses for fish were discussed in the review including the "match-mismatch" hypothesis relating to the timing of the emergence of the organism relative to its prey, the "bigger is better" hypothesis that suggests larger individuals of a species have a higher chance of survival, and the "critical period" hypothesis, which states that high mortality and relatively rapid occurs in a particular stage, usually the larval or early juvenile stage. In spite of the difficulties in providing unequivocal support for any particular hypotheses because of the multiforcing that the ecosystem is subjected to, progress is being made. With more and longer time series, new technologies that will allow sampling at finer resolution and in areas previously inaccessible, improved laboratory facilities, and rapid model developments, the future looks bright for better understanding of the processes linking climate to ecological changes. Such understanding is required in order to develop improved and more quantitative ecosystem scenarios under future climate change.

Reference:
***Drinkwater, K.F.**, G. Beaugrand, M. Kaeriyama, S. Kim, G. Ottersen, R. I. Perry, H.-O. Poertner, J.J. Polovina, and A. Takasuka. 2010. On the processes linking climate to ecosystem changes. Journal of Marine Systems, 79: 374-388.*

FUTURE PRECIPITATION ON THE NORWEGIAN WEST COAST

A new regional climate model provides detailed resolution data on temperature and precipitation.

Regional climate models are used to simulate future climate changes, and are a crucial resource for potential climate impacts and adaptation needs at local and regional levels (photo: iStockphoto).

Global climate models project the change in future climate driven by the increase of greenhouse gas concentrations in the atmosphere. These models, however, have a relatively coarse resolution of a few hundred kilometres, which is not suitable for describing the Norwegian climate in detail. The complexity of the coastline, the fjords and the mountains all have a strong impact on precipitation and winds, and have to be well resolved in a climate model. The most commonly used tools are regional climate models, which include only a part of the world in their model domain but with a very high resolution. Regional climate models get their boundary conditions from a global climate model and create their own small-scale processes adding much detail to the smooth global model fields.

INCLUDING THE NORTH ATLANTIC TO IMPROVE PREDICTIONS

In a recent study published in *Climate Dynamics*, the lead author and Bjerknes researcher Ulla Heikkilä and colleagues at the Institute of Marine Research and the University of Bergen employed the WRF regional climate model, developed at NCAR in Boulder. They simulated the 30-year control period of 1961-1990 commonly used for model evaluation. The ERA-40 reanalysis with a resolution of ca. 111-km was used as boundary conditions and downscaled to a 10-km resolution in Norway. A commonly used approach to downscale European climate is to include only the continent, largely excluding the ocean, into the high-resolved regional model domain. However, precipitation on the Norwegian west coast is mostly large-scale advective precipitation driven by low-pressure systems on the North Atlantic. Hence, the research team included the whole North Atlantic into the high-resolved domain to better resolve fronts and improve the precipitation extremes.

COMPARED WITH 12 OTHER REGIONAL MODELS

The model was evaluated using surface observations of precipitation, winds and temperature, obtained from the Norwegian meteorological office, met.no. In order to compare the WRF results with other regional models, the research team applied the analysis for 12 European and Canadian regional models, which are part of the recently finished EU-project ENSEMBLES. The WRF model results were in the front rank within the ENSEMBLES models and were able to reduce the biases between reanalysis and observations significantly, especially in the case of precipitation and winds. Such model setup proved to be useful for downscaling of future climate scenarios. The 10-km resolution precipitation and temperature data created by WRF presents the best gridded data for Norway and can be useful for many applications.

Reference:
Heikkilä, U., A. D. Sandvik, *and* ***A. Sorteberg 2010.*** *Dynamical downscaling of ERA-40 in complex terrain using the WRF regional climate model. Climate Dynamics, DOI 10.1007/s00383-010-0928-6.*

EU SUCCESS

Bjerknes Centre scientists were in 2010 engaged in several projects funded through the 7th Framework Programme of the EU. In the last few years, our success rate for EU projects has increased strongly and is now about 75%. This means that three out of four recent proposals in which we were partners have been successful. The average for Norway in the Environment and Climate Programme is about 27%, also high by EU standards. Four new projects will start early in 2011, two of which are co-ordinated within the Bjerknes Centre institutions. In addition 2 other projects are under contract negotiations with an expected start-up mid 2011. The main reason for these positive results lies in the quality of the Bjerknes Centre scientists, which enables us to become key partners with the best groups in Europe in the respective fields. The Centre of Excellence status and achievements have been a major, underpinning driver for this progress.

A LESS ACTIVE MEDIA YEAR

The media had less focus on climate issues during 2010, which was also reflected in the media coverage of the Bjerknes Centre.

Our experience is that the news threshold has made it harder to communicate science issues through the media. The reason for the attention drop in the media might be "reflecting" a general trend in the public (i.e., opinion polls). The lack of political action and failure of the COP15 meeting in Copenhagen at the end of 2009, and the so-called "Climategate" affair and widespread critique against the IPCC, boosted by the media's pursuit for scandals, have probably contributed to lowering public interest and weakening the credibility to climate research as a whole. However, several independent investigations later cleared the IPCC and scientists involved in the e-mail exchange for scientific misconduct and testified to the solidity of climate science. These vindications, however, did not receive the same media attention.

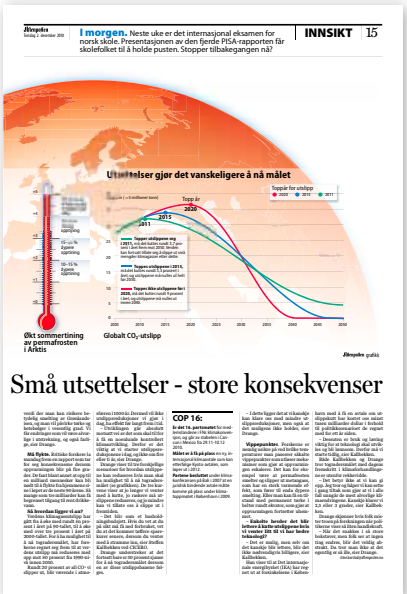

KULDEBOLGEN

Bør nytes innenfra

– Sibir-snødekke gir ny ISKALD VINTER

USA-forsker spådde rett i fjor

kulden


I morgen. Neste uke er det internasjonal eksamen for norsk skole. Presentasjonen av den fjerde PISA-rapporten får skoleforløket til å holde pusten. Stopper tilbakegangen nå?

INNSIKT 15

Utsettelser gjør det vanskeligere å nå målet

Økt sommersmelting av permafrosten i Arktis

Globalt CO_2-utslipp

Små utsettelser - store konsekvenser

COLD SPELLS FUELLING CLIMATE SCEPTICISM

The Bjerknes Centre was involved in more than 1000 media articles in 2010 (source: Retriever: only newspapers and web sites). The statistics also show that the coverage is well spread all around the country, in national, regional as well as local newspapers. Bergens Tidende had some enlightening articles about the COP16 meeting that emphasised the science aspects, concerned with how delays in terms of reaching agreements make it harder to reach political climate stabilisation targets, e.g., the 2° target. However, the cold weather experienced by Norwegians in this period dominated the public eye. The cold spells the last two winters, which only has regional effects in an otherwise warming plant, are a source of confusion in the public. The so-called climate sceptics utilised this confusion to raise unfounded doubt about climate science. We believe knowledge is a key for understanding these complex issues. Hence, Bjerknes scientists doing outreach try to emphasise the distinction between weather and climate and how natural variations on local and regional scales sometimes override the long-term global warming trend. However, the mass media only constitute one of several channels to communicate our knowledge and results to the public.

COP16 IN CANCUN

The attention given to the COP16 in Cancun was much less profound than the climate meeting in Copenhagen the previous year. In accordance with this picture, Bjerknes scientists were used as sources to a much smaller degree (also the Centre did not send any scientists to Cancun). Overall, the low expectations of the outcome of the meeting, where no one expected a global treaty to emerge, also lowered the media's interest. The urgency of the climate problem has, on the other hand, never been stronger. The CO_2-emissions are back on the 3% growth rate after the dip in 2009 due to the financial crisis. The next climate summit will take place in South Africa in 2011 (COP17), which is the last meeting that can lead to legally committed reductions in emissions before the Kyoto protocol ends in 2012. Hopefully, this will put more pressure on the negotiators and retain the spotlight of the press worldwide.

COMMUNICATION LEADER,
JILL JOHANNESSEN




Photo: Jill Johannessen, BCCR.

CLIMATE SCIENTISTS TOOLBOX

How can scientists know what the climate looked like thousands of years ago, long before thermometers were invented?

Festplassen was filled with research stations and popular lectures during the Norwegian Science Week (Forskningsdagene) in September. The Bjerknes Centre had its own stand where school children, parents and grandparents could explore the different tools climate scientists use to study climate variations in the past and the future. Children enjoyed picking in the mud core that researches use as natural archives over past climates by studying the small microfossils, which once were trapped in the mud. Thereafter, children and grown ups could study these small fossils through the microscope. Finally, audiences could check out animations from advanced climate models used to simulate future climates and hind casting past climates. Also, Tor Eldevik held a popular science talk on the subject of climate models and how to use these as tools to look into future climates. The Norwegian Science Week is a national, annual festival designed to fuel the public's curiosity, interest and understanding of research activities and results, and to promote recruitment of young people toward an academic career.

CLIMATE LANGUAGE CONFUSION

In a poll during 2010, more than one thousand people were asked and responded to questions about the correct definition of 10 commonly used words and phrases in climate challenge communication. The poll showed that while the majority of the population knows the correct definition of "global warming", they have much lower score on the definition of a "climate model". Furthermore, the survey revealed that many people have difficulties distinguishing global warming from the greenhouse effect. The questions were developed by the Bjerknes Centre in collaborating with the Language Council of Norway (Språkrådet), and the results of the poll were commented on by Tore Furevik for more than 300 guests at the Language Day (Språkdagen) in Oslo Concert Hall on November 10. The length of education explains most of the variations in the number of correct answers, but perhaps more interestingly the male population is found to have a significantly higher score than the female population. The poll also indicated that you would get a slightly different definition of "climate sceptics" depending of which political party you ask.

REGION BERGEN GENERATING POLAR SCIENCE

Norwegian polar research traditions are founded on solid research communities in the Bergen area.

It was therefore natural for Bergen-based science communities to join forces during the International Polar Year, Oslo Science Conference. The Bjerknes Centre coordinated the joint outreach effort from Bergen, which included the University of Bergen, the Institute of Marine Research, the Nansen Environmental and Remote Sensing Centre, Uni Research and Aanderaa Instruments. The aim was to give visibility to Bergen as an influential polar science city. Until 2009 Bergen based research institutions received the largest part of the Norwegian funding to the high north. To support this aim the institutions involved made a joint brochure giving a taste of our activities in polar areas as well as a banner for use at the stand.

The Bjerknes Centre is conducting extensive research in the polar areas and has been involved in four IPY-projects, entailing a number of research cruises, development of new monitoring systems and observational campaigns (see also p.p. 6-7). Hence, a dozen of Bjerknes scientists participated in the IPY- Oslo Science Conference, June 8-12, which included a broad spectre of polar research themes. A special section was attributed to polar science education, outreach and communication. By visiting the "Region Bergen Generating Polar Science" stand, participants could learn how Bergen scientists with long polar research traditions discovered and now monitor the world's coldest ocean current, explore the future of Arctic sea ice, and how increasing CO_2 emissions can threaten marine life and ecosystems.

FINAL CARBOSCHOOLS CONFERENCE

The aim of the project CarboSchools has been to enable students and teachers to understand current research in climate change with emphasis on carbon cycling. The students have come primarily from upper secondary schools in Bergen. The project started in 2005 as a joint initiative from the EU projects CARBOOCEAN and CarboEurope, and in 2008, CarboSchools received its own EU funding with 9 partners in 7 countries. The Norwegian part of the project, which has been run by the Geophysical Institute and the Bjerknes Centre, has spent 26 days on cruises together with about 350 students during the last 5 years. During these cruises, they have measured sea temperature, salinity, oxygen and carbon, and also calculated ocean currents and the amount of atmospheric CO2 absorbed in the fjords. The project concluded with a final conference in December 2010 where the students presented their project work and climate scientists from the Bjerknes Centre and Geophysical Institute initiated a climate debate. About 65 students, teachers, headmasters and others participated, and the students impressed others with nice presentations about gas uptake in the ocean and biological diversity.

Photo: Bente Færøvik, Bergen Katedralskole.

The Klimaklok (Climate Wise) Team Siri Kalvig, Tobias Thorleifsson and Helga Kleiven educated high school teachers and students during fall 2010 (photo: Anne-Lise Norheim).

GET "CLIMATE WISE" LECTURE TOUR

The Klimaklok (Climate Wise) team, consisting of the Bjerknes Centre scientist Helga Kleiven; Siri Kalvig, the nationally known weather forecaster, meteorologist and presently also a PhD candidate; and polar explorer Tobias Thorleifsson repeated their formula for success from the previous year. During the fall 2010, the team educated high school teachers, lecturers and students studying to become schoolteachers in Oslo, Stavanger, Bergen and Trondheim. The motto is: through one teacher Klimaklok reaches hundreds of pupils (and homes). All material is quality controlled by the Bjerknes Centre and the participants receive a DVD with course materials as well as handouts to use in their own teaching. Klimaklok is a full-day interactive lecture covering many themes: the climate system, consequences of climate change, national and international climate politics, and climate measures. Klimaklok is part of the Norwegian government campaign *Klimaløftet* to inform and spread knowledge in society regarding all aspects of climate. The campaign is initiated and run by the Ministry of Environment.

Photo: Danielsen Videregående Skole, Bergen.

Participants from the Summer School in the Austrian Alps on excursion (photo: Ben Marzeion, University of Innsbruck).

New initiatives, education and cooperation

COLLABORATION WITH CHINA

The activities with the Nansen-Zhu Centre (NZC) in Beijing, China, form the backbone of the Bjerknes Centre's engagements in East – South East Asia. The centre, established in 2003, conducts research on past, present and future climate, and is particularly strong on teleconnections between climate variability at high and low latitudes. The cooperation between the partners in Bergen and Beijing includes frequent exchange of researchers and students. Four PhD students from Beijing spent 3 months each at the Bjerknes Centre in 2010. The annual board meeting at the NZC was held on November 3 with the directors of Bjerknes Centre and Nansen Centre, as well as the Dean of the Faculty of Mathematics and Natural Sciences, visiting from Bergen.

An important part of the collaboration is the DecCen project funded by the Norwegian Research Council. The project explores decadal to century scale variability and changes in the East Asian climate during the last millennium. Exciting research is done with scientists and students from both Bergen and Beijing. As part of the project a summer school was organized together with the University of Innsbruck in Obergurgl in Ötztal, Austria, 20–30 June. The theme of the school was "Monsoon variability, teleconnections and impacts on mid to high latitude glaciers". The school was followed by a two-day project meeting.

PH.D. DISSERTATIONS 2010

BCCR scientists provided supervision and training in climate research to 33 doctoral students during 2010. The following Ph.D. dissertations were defended:

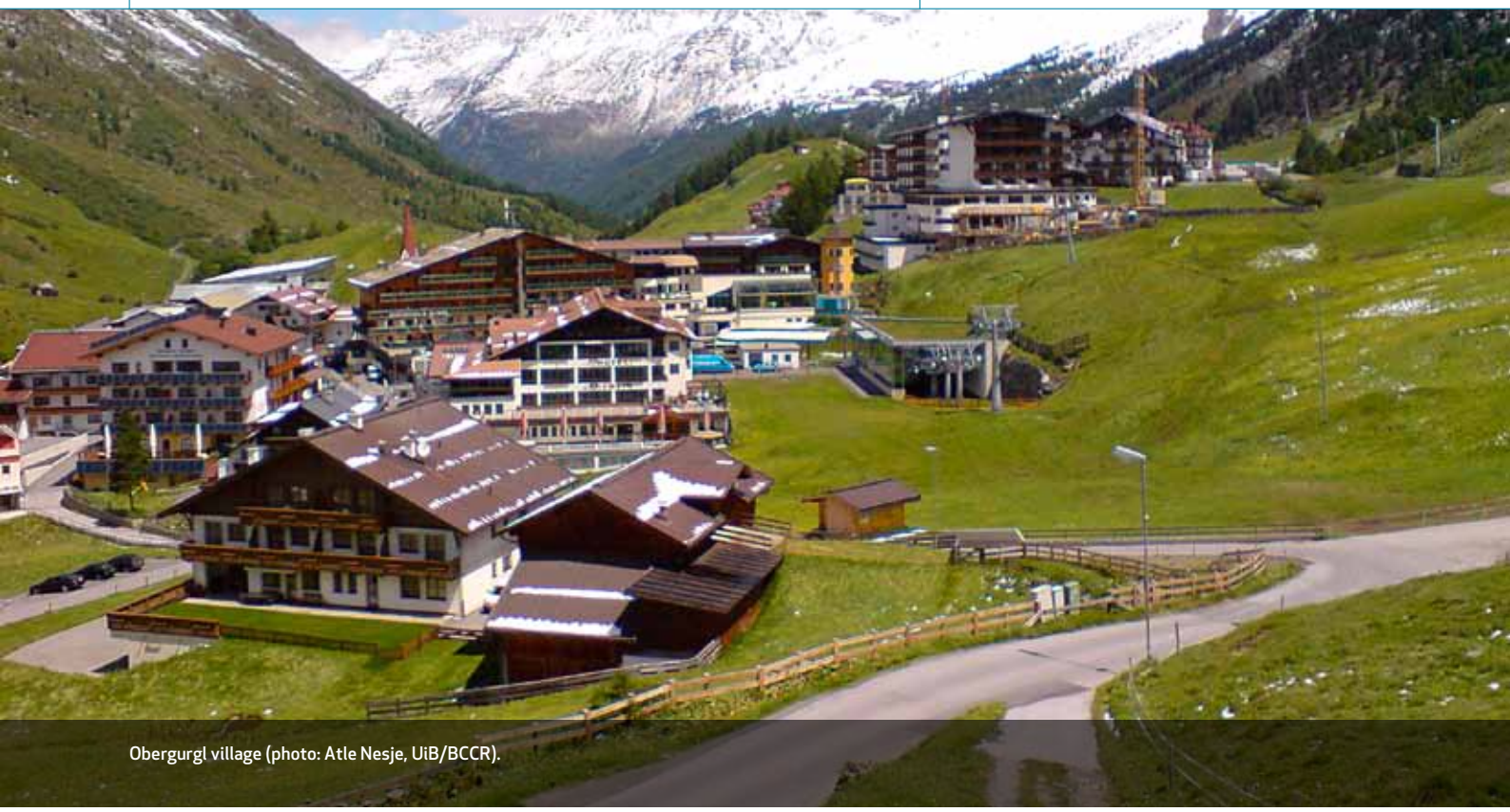
Andreas Born (UiB & Uni Research)
Title: Ocean circulation and climate at the Eemian and last glacial inception.

Florian Geyer (UiB & NERSC)
Title: Overflow and topographically induced mixing on the Svalbard shelf.

Vidar Lien (UiB & IMR)
Title: Water mass transformations in the Barents Sea and linkages to the Polar Front.

Gisle Nondal (UiB, NERSC & Uni Research)
Title: A study of the high and mid latitude biogeochemistry in the Atlantic Ocean: the influence of surface processes.

Francesco S.R. Pausata (UiB & Uni Research)
Title: Past climate variability: model analysis and proxy intercomparison.



Obergurgl village (photo: Atle Nesje, UiB/BCCR).

SUMMER SCHOOL IN THE AUSTRIAN ALPS

The summer school on "Monsoon Variability, Teleconnections, and Impacts on Mid to Low Latitude Glaciers" took place at the University Center Obergurgl in the Ötztal Alps in the Austrian state of Tyrol, June 20–30 2010. The University of Innsbruck, the Bjerknes Centre for Climate Research, the Institute of Atmospheric Physics (Beijing), the Research Council of Norway, University of Bergen, Centre of Climate and Cryosphere (Innsbruck), Land Tirol, and the DecCen project supported the summer school. Eighteen PhD students and fifteen lecturers, including several scientists from the Bjerknes Centre, attended the summer school. The daily program consisted of lectures and PhD student presentations and excellent hiking in the afternoons. The numerous peaks, some over 3500 meters, and several glaciers, offered the more adventurous hikers a challenge.

WESTERN NORWAY DELEGATION VISITING CHINA

The Bjerknes Centre was invited to follow a delegation from Bergen and Stavanger to the Asia, during May 19 to May 25. The trip was a joint effort between the regional business organizations in western Norway, in co-operation with companies and official institutions in China and South Korea. Most delegates were politicians or business leaders in finance or technology sectors. Two people from the Bergen University College and one from the Bjerknes Centre/University of Bergen represented the academia. A main activity in Shanghai was the full day "China Summit" conference at the premises of Det Norske Veritas, which has become a meeting place for Norwegian and Chinese business. Among the session themes was "Climate Change – Challenges and Opportunities". For the second part of the trip some people of the delegation, including the Bjerknes representative, went to the coastal city Dalian in the northeast of China. Dalian is a "small" city in China with only 6 million inhabitants. The mayors from Bergen and Dalian signed an agreement of friendship between the two cities. Similar to Bergen, Dalian is a coastal city with a very large maritime industry, and several Bergen-based companies are represented.

WORLD EXPO SHANGHAI

The EXPO 2010 with the theme "Better city – better life" is for Shanghai what the Olympic games were for Beijing – a grand exhibition window of modern China. More than 190 countries were present and there were more than 300,000 visitors a day, all coming and leaving with busses (up to 10,000 busses a day). Several scientists from the Bjerknes Centre, UiB, and the Nansen Centre took part in a Sino-Norwegian workshop at the World EXPO in Shanghai, September 9–10. The workshop was organised by the Research Council of Norway and the Chinese Academy of Sciences (CAS). The objective was to bring Chinese and Norwegian scientists together to

The Norwegian pavilion at the World Expo in Shanghai 2010 (photo: Tore Furevik, UiB/BCCR).

prepare for the Sino-Norwegian NORKLIMA and MILJØ2015 call. Although the headline of the call includes the phrase "climate change", the call itself is very much limited to "environmental pollution". The Bergen involvement will therefore (likely) be fairly small. After the Workshop, the groups joined the opening of the Chinese-Norwegian alumni network.

CAPACITY BUILDING IN BANGLADESH

The kick-off meeting for the "Climate change in Bangladesh" project was held in Dhaka, Bangladesh October 18-19. The project is funded by the Norwegian Ministry of Foreign Affairs, and has a focus on capacity building for studying climate change and adaptation. While the Bjerknes Centre focuses on climate modeling and downscaling, our partner institution in Dhaka, Bangladesh Center of Advanced Studies (BCAS) focuses on local climate impacts. The meeting concluded with the activities that will be carried out in the project, including statistical analysis of newly acquired Bangladeshi meteorological observations, and WRF simulations and downscaling of NorESM and other available climate models. A central part of the project is capacity building. This activity started in September when two of the researchers from BCAS attended the BCCR's WRF workshop in Bergen. And in Dhaka, Bjerknes scientist Mathew Reeve gave an introductory lecture to a large group of BCAS researchers about the driving forces and feedback processes of the South Asian Monsoon.

WEATHER, RESEARCH AND FORECASTING MODEL

Detailed climatological data have become essential for better studies of weather and climate impacts and adaptation. There are several ongoing projects in Europe to address the need for such data and to provide better capacity building in

A very international group visited the Bjerknes Center for the WRF (Weather Research and Forecasting Model) meeting in Bergen. Here a few of the participants visiting the old Wharf in Bergen (photo: Marcio Moraes, WRF participant).

Hike to Blåvatn (photo: Anne Tårand Aasen, phd student).

several countries. During one week in September the Bjerknes Centre organized an international Lecture Series on the need for high-resolution datasets. The WRF (Weather, Research and Forecasting) Lecture Series specifically addressed the technicalities of running the Weather, Research and Forecasting model and presented results from applying the model in different set ups. It also addressed questions related to the need for high-resolution climatology data to disaster-prone regions. Many of the talks also involved the need for using a Regional Climate Model for impact studies in India, Vietnam, Bangladesh, Nepal, Thailand, Brazil and other countries.

The event gathered forty-two participants from twelve different countries, representing institutions such as the National Center for Atmospheric Research (USA), the University of Tokyo, Japan), the Energy and Resources Institute (India), the Bangladesh Center for Advanced Studies (Bangladesh), the Rudjer Boskovic Institute (Croatia), StormGeo (Norway), met.no (Norway), the National Agency of Ethiopia (Ethiopia), the Asian Disaster Preparedness Center (Thailand), the University of Bergen (Norway), the University of Granada (Spain) and many others.

ADVANCED CLIMATE DYNAMICS COURSE

Advanced Climate Dynamics Course (ACDC 2010) was held at MIT FabLab Norway, a centre affiliated to Massachusetts Institute of Technology, and is beautifully situated in Lyngen east of Tromsø. This year's topic for the Bjerknes Centre–University of Washington–Massachusetts Institute of Technology joint summer school was Ice sheet –ocean interactions. A total of twenty-six students and fourteen lecturers participated, including several scientists from the Bjerknes Centre, British Antarctic Survey, and MIT. The format of the school followed previous years, with lectures on the fundamentals during the first week, and more specialized advanced topics during the second week. In addition to the many lectures and student presentations, the summer school included a boat trip on the Lyngen Fjord, an excursion to local glaciers in northern Lyngen, and an excursion to the Finnish biological station in Kilpisjärvi, very close to the triangle point between Norway, Sweden and Finland. The bulk of the funding for the school came from the Norwegian Centre for International Cooperation in Higher Education (SIU), with additional contributions from the US Department of Energy and the National Aeronautics and Space Administration.

International meetings and engagements

During summer 2010, Bjerknes scientists took part in the biggest and the longest ocean acidification experiment that has ever been done in the Arctic. They used nine bags floating in the fjord, filled with a thousand litres of artificially acidified water (photo: Anna Silyakova, BCCR).

In line for picking up materials for the EGU meeting (photo: Michel d.S. Mesquita, BCCR).

THE BJERKNES CENTRE AT THE EGU 2010

The European Geosciences Union 2010 presented a good opportunity for meeting colleagues and for making new contacts. More than 10 000 participated from 94 countries. The total oral presentations were 4,431 and there were 9,370 poster presentations in 594 sessions. Around fifteen people represented BCCR at the EGU conference this year, to get updated on science, to present new results and to meet with colleagues to discuss new and on-going projects and papers. This networking is very important and it is difficult to underestimate the importance of collaborative networks in modern science. Large international meetings are indeed the key to engage in new and sustain existing networks.

IMPROVING PREDICTABILITY OF POLAR CLIMATE

During 25–29 October, the Bjerknes Centre hosted an international workshop on Seasonal to multi-decadal predictability of polar climate in Bergen. The workshop was organized by the World Climate Research Programme (WCRP) and gathered 85 experts from Europe, North America and Asia. The aim was to prepare a set of recommendations on needs for observing systems and monitoring of the Arctic and Antarctic. The recommendations will contribute in the development of a climate prediction system for polar regions. There were a total of 46 talks divided in thematic sessions to elucidate the roles of sea ice, ocean, atmosphere, processes and models in polar predictability, as well as poster presentations. Rapporters summarized the sessions the last day, followed by a plenum discussion. The scientific committee gathered the main points and will build a roadmap for future research on polar climate predictability.

WCRP chose to hold the meeting in Bergen in recognition of its contribution to international climate- and polar research, both in historical and modern perspectives. The Research Council of Norway, the Bjerknes Centre, UiB and BKK sponsored the workshop.

OCEAN ACIDIFICATION MEETING

More than 200 scientists met in Bremerhaven to discuss the most recent results on ocean acidification during September 27–30. The EU project EPOCA (European Project on Ocean Acidification) was organised together with a German and a UK program. The EPOCA consortium alone brings together more than 160 researchers from 31 institutes and 10 European countries (Belgium, France, Germany, Iceland, Italy, The Netherlands, Norway, Sweden, Switzerland, United Kingdom). The overall goal is to advance our understanding of the biological, ecological, biogeochemical, and societal implications of ocean acidification. The first day of the meeting was dedicated to student and post doc meetings, as well as EPOCA panel meetings. The focus of the three following days was on a wide range of topics related to ocean acidification. Several scientists from the Bjerknes Centre participated in the meeting and contributed with presentations and posters.

Participant Peter Rhines on a group hike 900 m above Rosendal (photo: Svein Østerhus).

NORCLIM ANNUAL MEETING

The NorClim Project is in its final phase and will be completed in March 2011. The project is large, with a total budget of 60 million Norwegian kroner distributed over four years. The consortium consists of 10 partners from Tromsø, Oslo and Bergen and is coordinated by the Bjerknes Centre. The third annual meeting was held in Voss on September 2-3, with about 40 attendees from the partners. A central objective of NorClim is to establish a Norwegian Earth System Model. This work has been materialised in NorESM, consisting of NCAR's Community Climate System Model, but with our own ocean component, the Hamburg marine carbon cycle model and advanced cloud and aerosol physics developed in Oslo. NorESM is currently being run to complete the global climate simulations that will form a key part of the next IPCC report due 2013/14 (see also page 6).

POLAR OCEAN SYMPOSIUM IN HARDANGER

The IPY BIAC–POCAHONTAS symposium on "Polar Ocean-Atmosphere Circulation and Processes" took place at the Rosendal Fjordhotell from 20–23 September. Rosendal is a picturesque fjord village in the outer part of Hardangerfjord, two hours from Bergen by boat. The symposium was organized and supported by two major Research Council of Norway projects (IPY-BIAC and POCAHONTAS) and the Bjerknes Centre for Climate Research. The International Polar Year (IPY) "Bipolar Atlantic Thermohaline Circulation" (BIAC) and "Polar Climate and Heat Transport" (POCAHONTAS) projects are near completion. The symposium had 41 participants, including several international scientists from the UK, USA, Faroe Islands, Germany and Switzerland, as well as a number of Ph.D. and Master's students. The daily scientific program consisted of lectures from the projects and invited speakers, as well as student presentations. Part of the agenda was to summarize key results from these projects (see also page 6).

MINI-WORKSHOP ON ABRUPT CLIMATE CHANGE

Members of the Network for Ice sheet and Climate Evolution (NICE) from the Bjerknes Centre, Laboratoire des Sciences du Climat et de l'Environnement, Potsdam Institute for Climate Impact Research and Centre for Ice and Climate (Copenhagen) assembled with special guests from the Bert Bolin Centre for Climate Research (Stockholm), Universidad Complutense de Madrid, Lamont-Doherty Earth Observatory (New York) and UC Berkeley for 2 days at the end of September to share new data and modelling experiments focused on understanding abrupt climate changes during the last glacial period. The meeting was organized by the Bjerknes Centre and took place at the Gamle Bergen Tracteursted, which is a well known historical site.

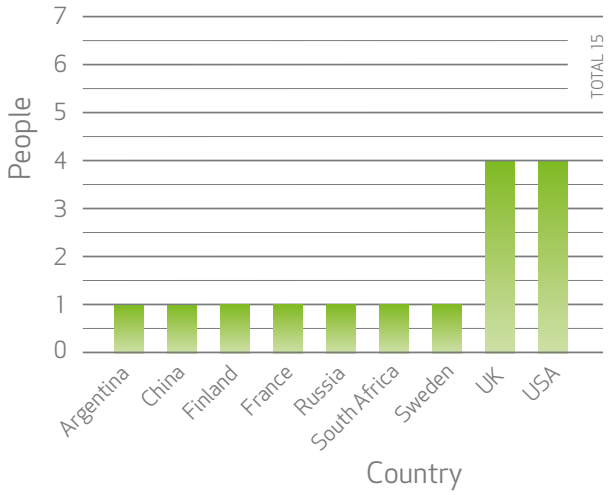
Participants at the symposium in Rosendal (photo: Martin Miles, BCCR)

THE 10TH INTERNATIONAL CONFERENCE ON PALEOCEANOGRAPHY

Every third year, the worldwide society of paleoceanographers meet at changing venues throughout the world for the International Conference on Paleoceanography. This year the event took place at the Scripps Institution of Oceanography, University of California, San Diego, USA. Ten scientists from the Bjerknes Centre attended the conference, which lasted from August 29 to September 3. The meeting provided a state-of-the-art overview of paleo-oceanographic research, ranging from multidecadal to million year timescales and a broad range of proxy methods used and under development. The format of the meeting, with one session of talks in the morning, posters after lunch and a keynote lecture in the evening, made it an intense meeting with a lot of scientific input and plenty of opportunities for networking.

GUEST RESEARCHERS AT THE BJERKNES CENTRE

BCCR sponsors a Visiting Fellow Programme as one of several arrangements that aims at fostering international research collaboration in climate change. In 2010, the Centre hosted totally 15 scientists from 9 countries.



MEETINGS AND ENGAGEMENTS

ENGAGEMENTS

IPCC: 5th Assessment report: Prof. Eystein Jansen and Prof. Svein Sundby are Lead Authors in Working Group 1 and 2, respectively. Prof. Christoph Heinze and Senior Scientist Ken Drinkwater are Review Editors in Working Groups 1 and 2, respectively.

IPCC: Special report on Extremes: Assoc. Prof. Asgeir Sorteberg is Lead Author.

Global Change Committee: Professor Svein Sundby, IMR/BCCR is a member for Norway appointed by the Research Council of Norway (RCN).

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

RCN NORKLIMA Programme: Prof. Eystein Jansen is a member of the programme board.

MyOCEAN: Prof. Christoph Heinze is member of the Scientific Advisory Committee of the EU FP7 project MyOCEAN for implementation of GMES-related marine core services.

IS-ENES: Prof. Christoph Heinze is member of the Scientific Advisory Board of the EU FP7 project "Infrastructure for the European Network for Earth System Modelling" (IS-ENES).

ICES Working Group on Hydrography: Senior scientist Svein Østerhus is a member.

OceanSITES: Senior scientist Svein Østerhus is a member of the Steering Committee.

Arctic Ocean Sciences Board. Harald Loeng, IMR/BCCR is Chair.

European Polar Board. Harald Loeng, IMR/BCCR is a member of the Executive Committee.

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 Government, hosted by the Ministry of Environment: Prof. Svein Sundby and Prof. Helge Drange are members. Prof. Christoph Heinze is working group member.

European Climate Forum: BCCR is a member of the European Climate Forum (ECF), a non-profit organization 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.

Bergen Climate Forum: The climate forum is a local meeting point for people from industry and commerce, authorities, organizations, and educational and research institutions. It is collaboration between the Bjerknes Centre, the Bergen Chamber of Commerce and Industry and the municipality of Bergen.

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

- Integrated Project CARBOOCEAN, coordinated by Prof. Christoph Heinze, was endorsed by the IGBP/SCOR sponsored projects SOLAS and IMBER.
- Surface Ocean Lower Atmosphere Study (SOLAS). Prof. Truls Johannessen is a member of the SSC.
- International Ocean Carbon Coordination Project (IOCCP). Prof. Truls Johannessen is an ex-officio science steering committee member.
- Integrated Marine Biogeochemistry and Ecosystem Research (IMBER). Ken Drinkwater is an SSC member.
- Ecosystem Studies of Subarctic Seas (ESSAS). Ken Drinkwater is co-chair of this IMBER regional program.
- PAGES (Past Global Changes). Ulysses Ninnemann is on the SSC of IMAGES, the marine component of PAGES.
- PAGES Arctic 2k working group. Martin Miles is a member.
- PAGES/CLIVAR joint working group. Eystein Jansen is a member.
- Climate Variability and Predictability (CLIVAR). Ken Drinkwater is a member of the Scientific Steering Group (SSG).
- Prof. Helge Drange is co-leader of the CLIVAR Working Group for Ocean Model Development (WGOCMD).
- CLIVAR Atlantic Implementation Panel: Senior scientist Svein Østerhus is a member.
- Scientific Advisory Boards. Eystein Jansen is member of the scientific advisory boards of IC3-Climate Centre, Barcelona.
- Helge Drange is in the advisory board of MARUM, University of Bremen

PHOTO: ERIK KOLSTAD, BCCR

ORGANIZATION & FINANCES

Vilhelm Bjerknes (archive photo)

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), Paleoclimatology, Uni Research/UiB
Kerim Nisancioglu	Scientist, Paleoclimatology, Uni Research
Helga F. Kleiven	Scientist, Paleoclimatology, Uni Research/UiB
Tor Eldevik	Scientist, Ocean processes and modelling, UiB
Christoph Heinze	Professor, Carbon cycle modelling, UiB/Uni Research
Frode Vikebø	Scientist, Oceanography, IMR
Birgit Falch	Cand.Polit, Science coordinator, Uni Research
Jill Johannessen	Dr. Polit, Communication leader, Uni Research
Lars Fagerli	Financial officer, Uni Research
Tordis Lerøen	HR manager, Uni Research

RESEARCH GROUPS

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

Title		Leader (Co-leader)
RG1	Past Climate Change	K. Nisancioglu (A. Nesje)
RG2	Present-Day Climate Changes and Climate Variability	H. F. Kleiven (A.B. Sandø)
RG3	Ocean-Ice-Atmosphere Processes	T. Eldevik (I.Fer / I.Esau)
RG4	Biogeochemical Cycles	C. Heinze (R. Bellerby)
RG5	Future Climate Scenarios and Regional Effects	F. Vikebø (M.d.s. Mesquita)

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Team members of the Top to Bottom project are taking a break during an expedition to the Fimbul Ice Shelf 2010. The project is a co-operation between ICE, the University of Oslo and the Bjerknes Centre (photo: Lars H. Smedsrud, BCCR).

THE BOARDS

BOARD OF DIRECTORS

Tore Nepstad	Director, Institute of Marine Research (Chair)
Ola M. Johannessen	Director, Nansen Environmental and Remote Sensing Center
Dag Rune Olsen	Dean, Faculty of Mathematics and Natural Sciences, UiB
Arne Svindland	Director, Uni Research

SCIENTIFIC ADVISORY BOARD

Peter Lemke	Alfred Wegener Institute for Polar and Marine Research, Germany (Chair)
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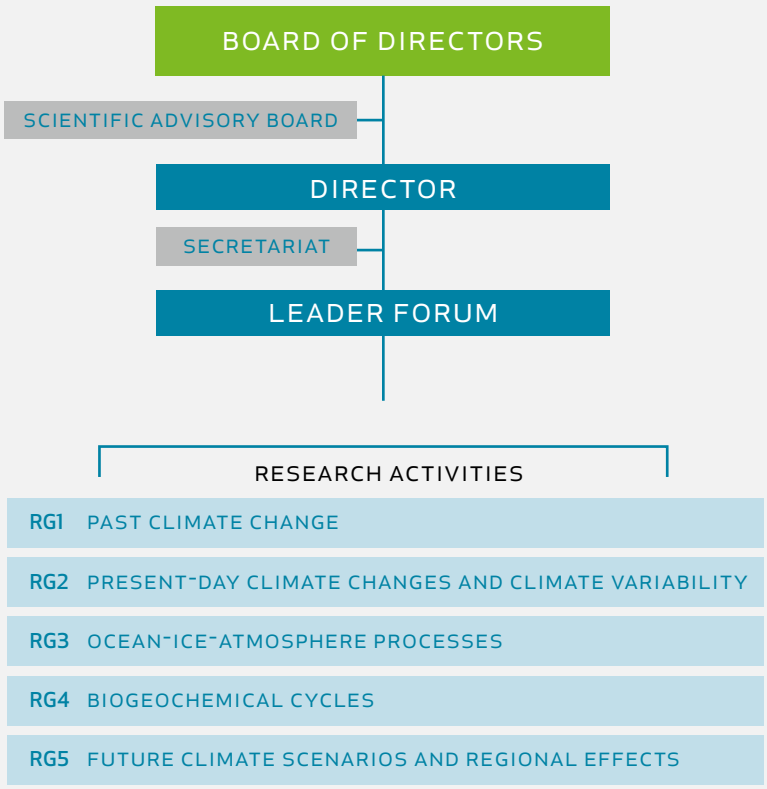
Jerry McManus	Woods Hole Oceanographic Institution, USA
Peter Rhines	Dept. of Oceanography, University of Washington, Seattle, USA
Rowan Sutton	Centre of Global Atmospheric Modelling, University of Reading, UK
John Walsh	International Arctic Research Centre, University of Alaska, Fairbanks, USA
Andrew Watson	School of Environmental Sciences, University of East Anglia, UK

Bergen by night (photo: Jerry Tjiputra, UiB/BCCR).

FIGURE 6. ORGANIZATION MAP



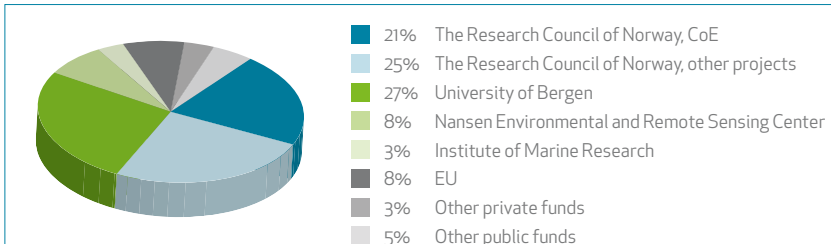
FUNDING & EXPENSES

Project financing constitutes the main funding resource for the Bjerknes Centre for Climate Research (BCCR). The CoE (Centre of Excellence) funding and other projects from the Research Council of Norway are a substantial source of financing for the BCCR (see Figure 7 and the table below). There are several ongoing programmes in which the Bjerknes Centre is involved. There are 26 projects funded by the Research Council of Norway, with BCCR scientists leading 20 of these projects. Ten ongoing projects are funded by the 6th and 7th Framework Programmes of the European Commission, of which BCCR coordinates one of the projects. Nine projects are funded by other sources. BCCR also coordinates two of the six multinational projects that were funded within the European Science Foundation ESF-Eurochores programme EuroMarc. See Appendix 2 for a complete listing of ongoing research projects. The second main funding source is the contribution to the CoE activities from the partner institututions, including the University of Bergen, the Nansen Environmental and Remote Sensing Center and the Institute of Marine Research.

FUNDING	2010 (1000 NOK)
The Research Council of Norway, CoE	17 000
The Research Council of Norway, other projects	20 040
University of Bergen	21 224
Nansen Environmental and Remote Sensing Center	6 202
Institute of Marine Research	2 639
EU projects	6 017
Other private funds	2 723
Other public funds	3 931
Total funding	79 776

Expenses	(1000 NOK)
Salaries and building rental costs	55 122
Research equipment	13
External research services	6 950
Other costs	15 727
Total expenses	77 812

FIGURE 7. FUNDING



STAFF

SCIENTISTS

Karen	Assmann	Germany	Uni Research	Chemical Oceanography
Jurgen	Bader	Germany	Uni Research	Climate modelling
Jostein	Bakke		UiB	Palaeoclimatology
Idar	Barstad		Uni Research	Atmospheric modelling
David	Battisti	USA	UiB	Atmospheric dynamics, paleo-modelling
Richard	Bellerby	UK	Uni Research	Biogeochemistry
Mats	Bentsen		Uni Research/ NERSC	Climate modelling
Hilary	Birks	UK	UiB	Numerical methods in palaeoclimatology
H. John B.	Birks	UK	UiB	Terrestrial biological climate proxies
Anne Elisabeth	Bjune		Uni Research	Palaeobotany
Knut Yngve	Børsheim		IMR	Marine biology, biogeochemistry
Francois	Counillon	France	NERSC	Data assimilation / ocean modelling
Carin Andersson	Dahl	Sweden	Uni Research	Palaeoclimatology
Svein Olaf	Dahl		UiB	Glaciers & palaeoclimatology
Trond Martin	Dokken		Uni Research	Palaeoclimatology
Helge	Drange		UiB	Climate modelling
Ken	Drinkwater	Canada	IMR	Oceanography & impacts of climate change
Tor	Eldevik		UiB / NERSC	Ocean processes & modelling
Igor	Esau	Russia	NERSC	Environmental boundary layers
Eva	Falck		Uni Research	Physical Oceanography
Ilker	Fer	Turkey	UiB	Ocean processes
Frode	Flatøy		Uni Research	Atmospheric chemistry & modelling
Tore	Furevik		UiB	Climate dynamics
Tor	Gammelsrød		UiB	Polar oceanography
Yongqi	Gao	China	NERSC	Ocean circulation modelling
Peter M.	Haugan		UiB	Polar oceanography
Ulla	Heikkilä	Finland	Uni Research	Regional atmospheric modelling
Christoph	Heinze	Germany	UiB	Carbon cycle modelling
Solfrid	Hjøllo		IMR	Ocean circulation
Randi	Ingvaldsen		IMR	Physical oceanography
Eystein	Jansen		Uni Research	Palaeoclimatology
Ola M.	Johannessen		NERSC	Oceanography
Truls	Johannessen		UiB	Biogeochemistry
Hans Arnfinn	Karlsen		UiB	Biogeochemistry
Ina K. T.	Kindem		Uni Research	Stratospheric physics
Helga Flesche	Kleiven		Uni Research	Palaeoclimatology
Erik Wilhelm	Kolstad		Uni Research	Climate downscaling
Nils Gunnar	Kvamstø		UiB	Atmospheric modelling
Øyvind	Lie		Uni Research	Palaeoclimatology
Henriette	Linge		UiB	Palaeoclimatology
Torbjørn	Lorentzen		Uni Research	Economics, statistics
Kjetil	Lygre		NERSC	Biogeochemistry & modelling
Jan	Mangerud		Uni Research	Palaeoclimatology
Michel	dos Santos Mesquita	Brazil	Uni Research	Atmospheric dynamics
Martin	Miles	USA	Uni Research	Climate time series analysis
Kjell Arne	Mork		IMR	Physical oceanography
Atle	Nesje		UiB	Palaeoclimatology
Jan Even Øie	Nilsen		NERSC	Climate modelling
Ulysses S.	Ninnemann	USA	UiB	Palaeoclimatology
Kerim Hestnes	Nisancioglu		Uni Research	Palaeoclimatology & modelling
Are Christian S.	Olsen		Uni Research	Chemical oceanography
Abdirahman	Omar	Somalia	UiB	Chemical oceanography
Yvan	Orsolini	Belgium	Uni Research	Atmospheric dynamics
Odd Helge	Otterå		Uni Research	Climate modelling
Bjørg	Risebrobakken		Uni Research	Palaeoclimatology
Anne Britt	Sandø		IMR	Ocean modelling
Anne Dagrunn	Sandvik		IMR	Mesoscale atmospheric modelling
Corinna	Schrum	Germany	UiB	Ocean modelling

Øystein	Skagseth		IMR	Ocean circulation
Ingunn	Skjelvan		Uni Research	Chemical oceanography
Lars Henrik	Smedsrud		Uni Research	Polar Oceanography
Asgeir	Sorteberg		UiB	Climate modelling
Svein	Sundby		IMR	Ocean climates
Tsuneaki	Suzuki	Japan	Uni Research	Tropical meteorology
John Inge	Svendsen		UiB	Palaeoclimatology
Henrik	Søiland		IMR	Ocean modelling
Richard	Telford	UK	UiB	Palaeoclimatology
Frode	Vikebø		IMR	Climate impacts on marine ecosystems
Svein	Østerhus		Uni Research	Physical oceanography
Bjørn	Ådlandsvik		IMR	Physical oceanography and modelling

POSTDOCS

Elin Darelius	Chiche	Sweden	UiB	Polar oceanography
Richard	Gyllencreutz	Sweden	UiB	Palaeoclimatology
Emil	Jeansson	Sweden	Uni Research	Chemical oceanography
Camille	Li	Canada	UiB	Atmospheric dynamics and paleoclimate
Francesco S. R.	Pausata	Italy	UiB	Atmospheric dynamics and paleoclimate
Caroline	Roelandt	Belgium	UiB	Terrestrial Biogeochemical modelling
Jeanne	Scao	France	UiB	Paleoclimatology
Jürg	Schwinger	Germany	UiB	Carbon cycle modelling
Anders	Sirevaag		UiB	Physical Oceanography
Lingling	Suo	China	NERSC	Climate dynamics
Jerry	Tjiputra	Indonesia	UiB	Carbon cycle modelling
Kjetil	Våge		UiB	Physical Oceanography
Justin	Wettstein	USA	Uni Research	Atmospheric dynamics
Zhongshi	Zhang	China	Uni Research	Paleoclimatology and modelling

PHD STUDENTS

Muralidhar	Adakudlu	India	UiB	Atmospheric modelling
Roohollah	Azad	Iran	UiB	Regional atmospheric modelling
Ingo	Bethke	Germany	Uni Research	Ocean modelling
Andreas	Born	Germany	UiB	Climate dynamics and paleoclimate modelling
Giulio Nils	Caroletti	Italy	UiB	Regional climate change
Sara	de la Rosa Höhn	Spain	UiB	Polar oceanography
Birgitte	Friestad		Uni Research	Palaeoclimatology
Helene	Frigstad		UiB	Impacts of ocean acidifidication
Eirik	Galaasen		UiB	Palaeoclimatology
Florian	Geyer	Germany	NERSC	Climate modelling
Nil	Irvali	Turkey	Uni Research	Palaeoclimatology
Helene	Langehaug		NERSC	Ocean dynamics, climate modelling
Siv Kari	Lauvset		UiB	Chemical oceanography
Vidar	Lien		IMR	Regional ocean modelling
Iselin	Medhaug		UiB	Climate dynamics
Svetlana	Milutinovic	Croatia	NERSC	Remote sensing, climate modelling
Tor L.	Mjell		UiB	Paleoclimatology
Mari	Myskvoll		IMR	Marine ecosystem effects
Gisle	Nondal		Uni Research	Chemical oceanography
Gunn Elisabeth	Olsen		UiB	Atmospheric dynamics
Francesco S. R.	Pausata	Italy	UiB	Atmospheric dynamics and paleoclimate
Roshin	Raj	India	UiB	Ocean dynamics

Matthew	Reeve		Uni Research	Tropical meteorology
Kristin	Richter	Germany	UiB	Ocean dynamics
Ole	Segtnan		UiB	Ocean dynamics
Anna	Silyakova	Russia	Uni Research	Biogeochemistry
Svetlana	Sorokina	Russia	NERSC	Climate variability, Arctic data processing
Eivind Wilhelm Nagel	Støren		UiB	Palaeoclimatology
Andrea	Tegzes	Hungary	Uni Research	Palaeoclimatology
Amandine	Tisserand	France	UiB	Palaeoclimatology
Kristian	Vasskog		UiB	Extreme weather events in the past
Ingelinn	Aarnes		UiB	Vegetation reconstruction
Marius	Årthun		UiB	Ocean modelling

TECHNICAL STAFF

Christian	Baldersheim		UiB	Palaeoclimatology
Dagfinn	Bøe		Uni Research	Palaeoclimatology
Tor	de Lange		UiB	Chemical Oceanography
Ole Magnus	Gjervik		IMR	Oceanography
Odd Reidar	Hansen		UiB	Palaeoclimatology
Solveig	Kringstad		UiB	Chemical Oceanography
Bjørn Christian	Kvisvik		Uni Research	Palaeoclimatology
Øystein	Ludvigsen		IMR	Oceanography
Ronald	Pedersen		IMR	Oceanography
Benjamin	Pfeil	Germany	Uni Research	Data manager
Vincent	Scao	France	Uni Research	Palaeoclimatology
Rune Egil	Søraas		Uni Research	Palaeoclimatology
Jørund	Strømsøe		Uni Research	Palaeoclimatology

ADMINISTRATION

Beatriz	Balino		UiB	Research coordinator
Lars	Fagerli		Uni Research	Financial officer
Birgit	Falch		Uni Research	Research coordinator
Jill	Johannessen		Uni Research	Communication leader
Lill Tåve	Jørgensen		Uni Research	Senior Secretary
Tordis	Lerøen		Uni Research	HR Manager
Charla Melander	Olsen	USA	Uni Research	Administrative consultant
Kristin	Svartveit		Uni Research	Administrative consultant

PERSONELL SUMMARY

Category	Person-years
Scientists	38,9
Postdocs	11,0
PhD students	24,5
Technicians	8,8
Administration	7,5
Total	90,7

STAFF BY PARTNER INSTITUTION

Number of scientific personell, sorted by category and partners.

Category	Uni Research	UiB	IMR	NERSC	Total	Non-Norwegian (%)	Female (%)
Scientists	29	23	12	8	72	31	21
Postdocs	3	10	0	1	14	86	36
Ph.D students	7	20	2	4	33	48	48
Total					119		

Figure 8. Staff by nationality

The Bjerknes Centre recruits personell internationally. In 2010, 22 nationalities were represented at the BCCR.

COUNTRY	# personnel
Brazil	1
Belgium	2
Canada	2
China	3
Croatia	1
Finland	1
France	4
Germany	10
Hungary	1
India	2
Indonesia	1
Iran	1
Italy	2
Japan	1
Norway	84
Russia	3
Somalia	1
Spain	1
Sweden	4
Turkey	2
UK	4
USA	5
Total	136

RESEARCH PROJECTS

PROJECTS FUNDED BY THE RESEARCH COUNCIL OF NORWAY

TITLE	Duration	*Leader/ **Partner
East Asian DecCen: Exploring decadal to century scale variability and changes in the East Asian climate during the last millennium (DecCen)	2009–12	T. Furevik*
Ecosystem change in the North Sea: Processes, drivers, future scenarios (ECODRIVE)	2009–11	M. Skogen**
CARBON uptake and fluxes of water and HEAT in the North Atlantic Current (CARBON-HEAT)	2008–10	A. Olsen*
Marine Ecosystem Response to a changing Climate (MERCLIM)	2008–11	R. Bellerby*
Arctic and sub-Arctic climate system and ecological response to the early 20th century warming (ARCWARM)	2008–10	O.M. Johannessen*
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)	2007–10	A. Olsen*
Atlantic Meridional Overturning Circulation during Interglacials (AMOCINT)	2007–12	E. Jansen*
Bipolar Atlantic Thermohaline Circulation (IPY-BIAC)	2007–11	T. Gammelsrød*
Climate of Norway and the Arctic in the 21st century (NORCLIM)	2007–11	H. Drange*
Improved forecasting of adverse weather in the Arctic Region - present and future (IPY-Thorpex)	2007–11	A. Sorteberg**
Polar Climate and Heat Transport (POCAHONTAS)	2007–10	S. Østerhus*
Response of tropical Atlantic surface and intermediate waters to changes in the Atlantic meridional overturning circulation (RETRO)	2007–11	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)	2007–10	R. Bellerby*
The effect of climate change on Arctic high-impact weather events (ArcChange)	2007–11	I. Barstad**
Integrated Arctic Ocean Observing System – Norway (iAOOS-Norway)	2007–10	Ø Skagseth**
Glacial Ocean Mixing: Investigating the role of diapycnal ocean mixing for glacial climate stability and sensitivity (GLOMIX)	2007–10	O.H. Otterå*
Norwegian component of the Ecosystem Studies of Subarctic and Arctic Regions (NESSAR)	2007–10	K. Drinkwater*
Climate and Ocean in mid-to high latitudes: Mechanisms of variability in Paleo and modern records (COMPAS)	2006–10	N.G. Kvamstø*
Impact of changing freshwater flows on the thermohaline circulation and European climate – analysis and modelling of the last deglaciation (ORMEN)	2005–10	T. Dokken*
Storfjorden Polynya Air Sea Ice Exchange Experiment (SPASIE)	2010–12	L.H. Smedsrud*
A user-defined approach to utilize climate change information in local implementation of national construction standards (RECON)	2010–13	I. Ezau*
Organic matter in permafrost: molecular composition and associated response to increasing temperature (PERMASOM)	2010–10	C. Heinze **
Biotic response to climate change in cold climates (BIOCOLD)	2010–13	A. Bjune *
Developing a national strategy for ICOS; the Integrated Carbon Observation System (ICOS)	2009–10	T. Johannessen **

RESEARCH PROJECTS FUNDED BY THE 5TH, 6TH AND 7TH FRAMEWORK PROGRAMMES OF THE EUROPEAN COMMISSION

TITLE	Duration	Type	Leader/ Scientist
Holocene saline water inflow changes into the Baltic Sea, ecosystem responses and future scenarios (INFLOW-BONUS)	2009–11	BONUS + ◆	E. Jansen
Thermohaline Overturning – at Risk? (THOR)	2008–11	IP ◆	H F. Kleiven, T. Eldevik
The European Project on Ocean Acidification (EPOCA)	2008–11	IP ◆	C. Heinze
Marine Ecosystem Evolution in a Changing Environment (MEECE)	2008–11	IP ◆	R. Bellerby
Megacities: Emissions, urban, regional and Global Atmospheric Pollution and climate effects, and Integrated tools for assessment and mitigation (MEGAPOLI)	2008–11	IP ◆	I. Esau
Integration and enhancement of key existing European deep-ocean observatories (EUROSITES)	2008–11	IP ◆	T. Gammelsrød
Network for Ice sheet and Climate Evolution (NICE)	2007–10	MCIF ◆	K. Nisancioglu
Developing Arctic Modelling and Observing Capabilities for Long-term Environmental Studies – Integrated Project (DAMOCLES)	2005–10	IP◆	P. Haugan, K. Lygre
Marine carbon sources and sinks assessment (CARBOOCEAN)	2005–10	MCIF ✖	C. Heinze
Climate Change – Learning from the past climate (PAST4FUTURE)	2010–14	IP ◆	T. Dokken

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; BONUS+: Joint Baltic Research Programme

PROJECTS FUNDED BY OTHER SOURCES

TITLE	Duration	Leader/ Scientist	Funding agency
WestPrecip – Scenarios for future precipitation in the Western Norway, a sub project under MARE	2009–12	H. Drange	Bergen municipality
Changes in past, present and future sea level, with focus on Western Norway, linked to MARE	2009–12	J.E.Ø. Nilsen	Bergen municipality
Fimbul ice shelf – Top to bottom	2009–11	L.H. Smedsrud	Norwegian Polar Institute
Earth System Modelling (ESM)	2009–14	K.H. Nisancioglu	Statoil ASA
University of Washington–University of Bergen Climate Change Network	2006–11	T. Furevik	Senter for internasjonalisering av høgre utdanning
Paleoclimate in the Southern Ocean	2004–11	U. Ninnemann	COMERfoundation
Klimaendringenes konsekvenser for kommunal og fylkeskommunal infrastruktur	2010–11	M. Miles	Kommunenes Sentralforbund
Tilførselsprogrammet. Program for overvåkning av havforsuring	2010–11	T. Johannessen	Klima- og forurensningsdirektoratet
North American Arctic Ice and Climate Study	2009-10	M. Miles	Statoil ASA

SELECTED PUBLICATIONS

Bjerknes researchers published 105 articles in international peer reviewed journals in 2020. For a complete listing, please visit www.bjerknes.uib.no/publications. Bjerknes scientists are indicated in **bold.**

ARTICLES IN INTERNATIONAL PEER REVIEWED JOURNALS

1. **Andersson, Carin; Pausata, Francesco S. Rocco; Jansen, Eystein; Risebrobakken, Bjørg; Telford, Richard** (2010): "Holocene trends in the foraminifer record from the Norwegian Sea and the North Atlantic Ocean", *Climate of the Past Discussions*, 6, pp. 179-193.
2. **Assmann, Karen Margarete; Bentsen, Mats** Segschneider, Joachim; **Heinze, Christoph** (2010): "An isopycnic ocean carbon cycle model", *Geoscientific Model Development*, 3, pp. 143-167.
3. **Bader, Jürgen**; Latif, Mojib (2010): "The 1983 drought in the West Sahel: a case study", *Climate Dynamics*, 36, p.p.463-472.
4. **Bakke, Jostein; Dahl, Svein Olaf; Paasche, Øyvind**; Simonsen, Joachim Riis; Kvisvik, **Bjørn Christian**; Bakke, Kristina; **Nesje, Atle** (2010): "A complete record of Holocene glacier variability at Austre Okstindbreen, northern Norway: an integrated approach", *Quaternary Science Reviews*, 29, pp. 1246-1262.
5. **Bjune, Anne Elisabeth; Birks, Harry John Betteley**; Peglar, Sylvia Margaret; Odland, Arvid (2010): "Developing a modern pollen–climate calibration data set for Norway", *Boreas*, 39, pp. 674-688.
6. **Born, Andreas**; Kageyama, M.; **Nisancioglu, Kerim Hestnes** (2010): "Warm Nordic Seas delayed glacial inception in Scandinavia", *Climate of the Past*, 6, pp. 817-826.
7. **Born, Andreas; Nisancioglu, Kerim Hestnes**; Braconnot, Pascale (2010): "Sea ice induced changes in ocean circulation during the Eemian", *Climate Dynamics*, 35, pp. 1361-1371.
8. **Caroletti, Giulio Nils; Barstad, Idar** (2010): "An assessment of future extreme precipitation in western Norway using a linear model", *Hydrology and Earth System Sciences*, 14, pp. 2329-2341.
9. **Drinkwater, Ken;** Beaugrand, Gregory; Kaeriyama, Masahide; Kim, Suam; Ottersen, Geir; Perry, R. Ian; Pörtner, Hans Otto; Polovina, Jeffrey J.; Takasuka, Akinori (2010): "On the processes linking climate to ecosystem changes", *Journal of Marine Systems*, 79, pp. 374-388.
10. **Euler, Christine; Ninnemann, Ulysses Silas** (2010): "Climate and Antarctic intermediate water coupling during the late Holocene", *Geology*, 38, pp. 647-650.
11. **Fer, Ilker**; Voet, Gunnar; Seim, Knut Sponheim; Rudels, Bert; Latarius, Katrin (2010): "Intense mixing of the Faroe Bank Channel overflow", *Geophysical Research Letters*, 37, L02604, doi:10.1029/2009GL041924.
12. **Gherardi, Jeanne-Marie**; Luo, Y; Francois, R.; McManus, JF; Allen, S; Labeyrie, L. (2010): "Reply to comment by S. Peacock on 'Glacial-interglacial circulation changes inferred from Pa-231/Th-230 sedimentary record in the North Atlantic region'", *Paleoceanography*, 25, PA2207, doi:10.1029/2009PA001867.
13. **Heikkila, Ulla Elina; Sandvik, Anne Dagrun; Sorteberg, Asgeir** (2010): "Dynamical downscaling of ERA-40 in complex terrain using the WRF regional climate model", *Climate Dynamics*, DOI 10.1007/s00382-010-0928-6.
14. **Kolstad, Erik Wilhelm; Breiteig, Tarjei;** Scaife, Adam A. (2010): "The association between stratospheric weak polar vortex events and cold air outbreaks in the Northern Hemisphere", *Quarterly Journal of the Royal Meteorological Society*, 136, pp. 886-893.
15. **Li, Camille; Battisti, David Stephen**; Bitz, Cecilia M. (2010): "Can North Atlantic sea ice anomalies account for Dansgaard-Oeschger climate signals?" *Journal of Climate*, 23, pp 5457-5475.
16. **Mesquita, Michel D Santos**; Atkinson, David E.; Hodges, Kevin I. (2010): "Characteristics and variability of storm tracks in the North Pacific, Bering Sea, and Alaska", *Journal of Climate*, 23, pp. 294-311.

17. Metzl, Nicolas; Corbière, Antoine; Reverdin, Gilles; Lenton, Andrew; Takahashi, Taro; **Olsen, Are; Johannessen, Truls**; Pierrot, Denis; Wanninkhof, Rik; Olafsdóttir, Solveig R.; Olafsson, Jón; Ramonet, Michel (2010): "Recent acceleration of the sea surface fCO2 growth rate in the North Atlantic subpolar gyre (1993–2008) revealed by winter observations", *Global Biogeochemical Cycles*, 24, GB4004, doi:10.1029/2009GB003658.

18. Mohino, Elsa; Janicot, Serge; **Bader, Jürgen** (2010): "Sahel rainfall and decadal to multi-decadal sea surface temperature variability", *Climate Dynamics*, DOI 10.1007/s00382-010-0867-2.

19. Mork, Kjell Arne; Skagseth, Øystein (2010): "A quantitative description of the Norwegian Atlantic Current by combining altimetry and hydrography", *Ocean Science*, 6, pp. 901-911.

20. Olsen, Are; Ninnemann, Ulysses S. (2010): "Large delta C-13 gradients in the preindustrial North Atlantic revealed", Science, 330, pp. 658-659.

21. Olsen, Are; Omar, Abdirahman; Jeansson, Emil; Anderson, Leif G.; Bellerby, Richard (2010): "Nordic seas transit time distributions and anthropogenic CO2", *Journal of Geophysical Research – Oceans*, 115, C05005, doi:10.1029/2009JC005488.

22. Orsolini, Yvan; **Kindem, Ina K. Thorstensen; Kvamstø, Nils Gunnar** (2010): "On the potential impact of the stratosphere upon seasonal dynamical hindcasts of the North Atlantic Oscillation: a pilot study", *Climate Dynamics*, 36, pp. 579-588.

23. Otterå, Odd Helge; Bentsen, Mats; Drange, Helge; Suo, Lingling (2010): "External forcing as a metronome for Atlantic multidecadal variability", *Nature Geoscience*, 3, pp. 688-694.

24. Risebrobakken, Bjørg; Moros, Matthias; Ivanova, Elena V.; Chistyakova, Natalia; Rosenberg, Reinhild (2010): "Climate and oceanographic variability in the SW Barents Sea during the Holocene", *The Holocene*, 20, pp. 609-621.

25. Sandø, Anne Britt; Nilsen, Jan Even Øie; Gao, Yongqi; Lohmann, Katja (2010): "Importance of heat transport and local air-sea heat fluxes for Barents Sea climate variability", *Journal of Geophysical Research – Oceans*, 115, C07013, doi:10.1029/2009JC005884.

26. Smedsrud, Lars Henrik; Ingvaldsen, Randi; Nilsen, Jan Even Øie; Skagseth, Øystein (2010): "Heat in the Barents Sea: transport, storage, and surface fluxes", *Ocean Science*, 6, pp. 219-234.

27. Støren, Eivind Wilhelm Nagel; Dahl, Svein Olaf; Nesje, Atle; Paasche, Øyvind (2010): "Identifying the sedimentary imprint of high-frequency Holocene river floods in lake sediments: development and application of a new method", *Quaternary Science Reviews*, 29, pp. 3021-3033.

28. Tjiputra, Jerry; Assmann, Karen Margarete; Bentsen, Mats; Bethke, Ingo; Otterå, Odd Helge; Sturm, Cristophe; **Heinze, Christoph** (2010): "Bergen earth system model (BCM-C): model description and regional climate-carbon cycle feedbacks assessment", *Geoscientific Model Development*, 3, pp. 123-141.

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From Antarctica expedition. Ph.D. student Kjersti L. Daae dancing with penguins (photo: Svein Østerhus, BCCR).

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