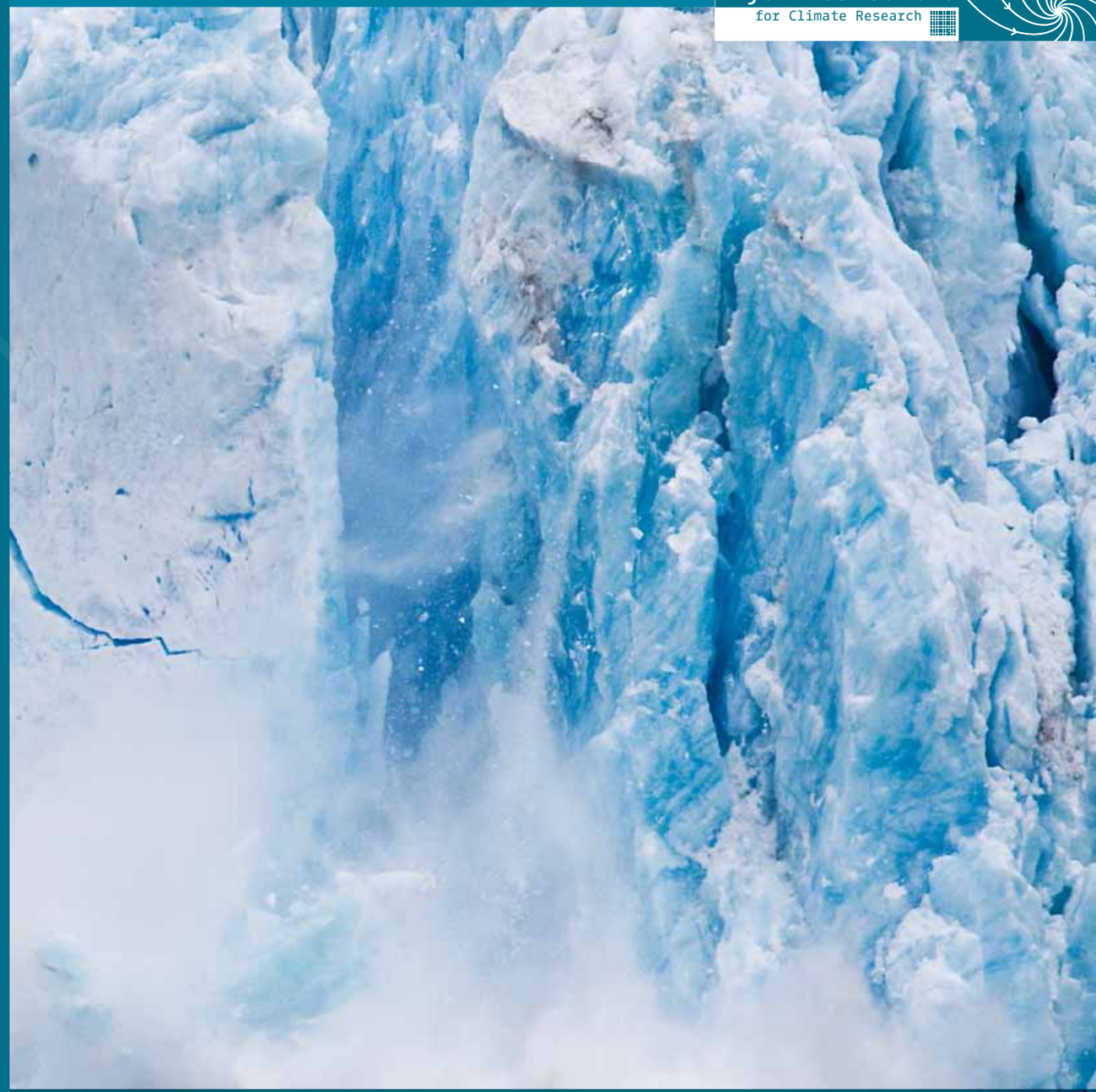
ANNUAL REPORT

Centre of Excellence Activities and Centre for Climate Dynamics

11

Bjerknes Centre
for Climate Research



The Bjerknes Centre is named in honour of the efforts of **Vilhelm and Jack Bjerknes**

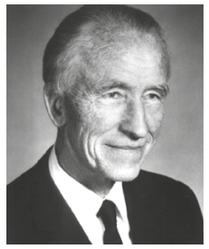
Vilhelm Bjerknes (1862-1951) was a central figure in the pioneering stage of modern meteorology and oceanography. The work by Bjerknes marked a turning point in atmospheric science and remains remarkably unaltered to this day.

As a professor in physics in Stockholm around 1900, Vilhelm Bjerknes worked out a synthesis of hydrodynamics and thermodynamics, which was applicable to large-scale circulation in the atmosphere and the oceans. Based on his theorems, he published a programmatic paper in 1904 on "The problem of weather forecasting as a problem in mechanics and physics" where he postulated the procedure now know as numerical weather forecasting. This was the first scientific description of weather forecasting.

Today, practically all weather forecasting is based on the principles Vilhelm Bjerknes described in his paper of 1904, and modern climate science builds on his work.

A reanalysed surface map from 30 September 1918. The situation was investigated using observations made available by Germany, France. Britain and the Nordic countries. Upper air analyses were also made from German kite observations.

Vilhelm Bjerknes



Jacob (Jack) Bjerknes

After publishing his article, Bjerknes attained substantial funding for developing reliable weather forecasts. At the Geophysical Institute in Bergen in 1917, Vilhelm Bjerknes established the "Bergen School of Meteorology" together with his son Jack Bjerknes. Jacob (Jack) Bjerknes was as his father an acknowledged meteorologist, who put forward the acclaimed "polar front theory".

Vilhelm and Jacob Bjerknes conducted several studies of the ocean circulation, air-sea exchange, and climate variability that laid the basis for modern research on climate change and the role of the ocean in the climate system. Jacob Bjerknes carried out pioneer studies on the El Nino/ Southern Oscillation in the Pacific, defining how the ocean and atmosphere interact to create the phenomenon, and the North Atlantic Oscillation (NAO), by describing its major features and how it influences the currents and temperature conditions in the North Atlantic.

Nowadays the vision provided by the Bjerknes family has been taken further by simulating climate variability in models that couple the atmosphere, land, and oceans, in an attempt to estimate the response of the climate system to driving forces.

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Nansen Center, Bergen

uniResearch

Established by the Research Council of Norway

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Photo: Anna Silyakova

Statement from the Board of Directors

"The board is satisfied that the Bjerknes Centre in its second to last year as a CoE continues its steady growth in terms of scientific output and quality. The evaluation by the international panel that evaluated Norwegian Earth Science in 2011 was very positive for the Centre, and the Board is content that international peers evaluate the activities so positively. With the start of the synthesis period in the last two years the Centre is on a very good track to reach its objectives and leave lasting scientific legacies."

2011 - SYNTHESIS TIME

Eystein Jansen. Photo: Gudrun Sylte

2011 was another active year at the Bjerknes Centre with record numbers of peer review publications. The evaluation of Norwegian Earth Science commissioned by the Research Council gave high praise to the Bjerknes Centre, concluding that it is on a leading international level and a stronghold in Norwegian Earth Science. Also the groups participating in the centre received high marks. It is clear that our centre is scientifically vibrant and visible.

While we are harvesting from the collaborations and integration that the CoE funding has led to, we have initiated a process further integrating people, ideas and results. In order to ensure that major findings are properly integrated and that we can finish our 10-years within the CoE system, we will in the last two years of the CoE activities concentrate CoE resources on what we call syntheses. These will lead to scientific papers where key results are brought together and hopefully lead to lasting legacies from our CoE period.

The syntheses cover all the major science objectives; they encompass all research groups, often pulling together activities and people from different groups. The activities in the syntheses comprise several topics we have been working extensively on in the Centre:

- The development and dynamics of the abrupt changes occurring during the last deglaciation.
- Multidecadal and longer term variations after the last ice age - i.e. how, how much and why did climate in our region change before human interventions.
- The role of the subpolar gyre in the North Atlantic in driving climate variability in high latitudes, synthesising both model data, instrumental data and unique, high-quality paleoclimatic proxy data.
- Dynamics and role of the Barents Sea in the climate system
- Quantifying carbon fluxes in the North Atlantic
- Southern Ocean ventilation and biogeochemical cycles
- Dynamical downscaling in atmosphere and ocean.

A number of recent PhD theses by young Bjerknes scientists have given high quality input to these syntheses and in many ways refined our thinking on how the ocean and atmosphere links to drive climate variability in our region.

The syntheses have come off to a good start and I anticipate that much of the results will be reported at the Bjerknes Centre 10-year anniversary conference in September 2012. The conference will focus on high latitude climate change and will be an arena for internal and international scientists to meet and exchange ideas and results. We expect a large attendance.

Another highlight in 2011 was the delivery of CMIP5 simulations for the next IPCC report, due in 2013, from the Norwegian Earth System Model (NorESM). The development of this state-of-the-art model was done in collaboration with the Oslo group (primarily met.no), and we anticipate this to be the workhorse for our future climate simulations. A low-resolution version has also been set up for long paleoclimate simulations.

Initial results from the CMIP5 simulations were presented to stakeholders, politicians and media during COP17 in Durban, December 2011. The results received lots of media coverage, indicating that the model simulates historical climate well, with intriguing results on the sensitivity to aerosol forcing and on the urgency of mitigation measures if one were to stop global warming at 2 degrees above pre-industrial temperatures.

This major achievement lays the foundation for the future of the Bjerknes Centre. NorESM will be extensively used in the projects defined under the new Centre for Climate Dynamics at the Bjerknes Centre (SKD). SKD is a result of the CoE achievements and the status they have given to the Bjerknes Centre. Through new long-term funding from the ministry of higher education and research, SKD gives the Bjerknes Centre a core activity to fuel its continuation after the termination of the CoE. To mark the formal start of SKD in 2011, we include a special section from SKD in this report, in addition to the normal CoE report. Hence the annual report now consists of both CoE activities and the SKD activities.

At the time of writing, we are well into the final year of the CoE and lots of nice work will be wrapped up and presented to the world in the following months.

TABLE OF **CONTENTS**

Director's comments 3
Vision, objectives and research organisation 5
Scientific highlights 6
SKD – Centre for Climate Dynamics 18
Outreach and media highlights 24
New initiatives, education and cooperation 28
International meetings and engagements 30
Organisation and finances 34
Appendix 1 Staff 38
Appendix 2 Research projects 42
Appendix 3 Selected publications 45

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A CENTRE FOR **EXCELLENT RESEARCH 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 activities are 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.

1. **PAST CLIMATE CHANGES**
   Understanding long-term natural climate variability of the past is essential for understanding present and future climate changes.

2. **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.

3. **OCEAN, SEA ICE AND ATMOSPHERE PROCESSES**
   Exchanges between ocean, sea ice and atmosphere are crucial to the climate system, and simulations of the future climate depend on their proper representation.

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

5. **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

SFF 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.

THE SHALLOW BANKS OF THE BARENTS SEA **PRODUCE COLD DEEP WATER**

The Barents Banks produce about 30 percent of the deep water exiting the Barents Sea to the Arctic Ocean. This formation of deep water is an important part of the overall ocean circulation.

The banks produce about 400 thousand m^3 of cold and dense water every second. This water is Atlantic Water that has passed Norway, entered the Barents Sea, been cooled below zero degrees, and also added salt from sea ice growth in the area.

Observations and simulations from a numerical ice-ocean model are compared over the years 1948–2007. There are large inter-annual overall variations, but the banks produces a quite steady volume of dense water. In cold periods, like the 1970's when overall cooling was low and less dense water was produced, the banks provided as much as 50 percent of the dense water production.

Three main processes contribute to the dense water production; the salinity in the autumn, the heat loss to the atmosphere during winter, and the volume of ice produced. In the southern Barents Sea, Atlantic Water inflow controls the autumn salinity and heat loss to the air, while in the Northern Barents Sea it is the water from the Russian rivers and sea ice production that dominates.

REFERENCE:

Åthun, Marius (UiB), Randi B. Ingvaldsen (HI), Lars Henrik Smedsrud (Uni), Corinna Schrum (UiB), (2011), Dense water formation and circulation in the Barents Sea, *Deep Sea Research Part I: Oceanographic Research Papers* Volume 58, Issue 8, August 2011, Pages 801-817

View from the research vessel Lance North West of Svalbard, July 2011. Photo: Anna Silyakova

CONTRIBUTION TO THE IPCC 5TH ASSESSMENT REPORT

Asgeir Sorteberg. Photo: UiB

Starting in 2001, the climate modelling group at the Bjerknes centre for climate research (BCCR) developed the Bergen Climate Model (BCM), one of the five European global coupled ocean-atmosphere climate models that contributed with historical and future climate change simulations to the IPCC 4th assessment report published in 2007. Since then, the modelling efforts from Bergen have been merged with resources in Oslo in order to develop a national climate model, the Norwegian Earth System Model (NorESM). NorESM will thus constitute the backbone in the national efforts for the provision of climate projections in the years to come. In this regard, NorESM has already delivered a range of simulations to the international data archive (CMIP5) to be used in the upcoming IPCC 5th assessment report (AR5), due by 2014.

For the IPCC AR5, priority has been given to improve the representation of aerosol-cloud interactions, biogeochemical feedbacks and mixing processes in the ocean. Emphasis will be made on the validation of the model system, analysis of global temperature sensitivity to increased greenhouse gasses and understanding key processes for our regional climate. An example of such key process is the variability and long-term changes in the atmospheric and oceanic poleward heat transport. SKD scientists are contributing to the following research topics:

MODEL DEVELOPMENT & SIMULATIONS

- **The global carbon cycle.** The Earth System modelling group at BCCR has developed the interactive carbon cycle climate model (BCM-C) based on the former BCM. The model will be modified and ported to the NorESM system
- **High-latitude oceanic processes.** SKD funded scientists will work on developing and implementing an improved physical representation of high latitude oceanic processes such as sea ice dynamics and deep-water formation in NorESM. These processes are important for a better simulation of the Arctic climate
- **Modelling paleoclimates.** A computationally more efficient low-resolution version of NorESM has been developed for simulations over thousands of years. If the NorESM model system is capable of reproducing climate states significantly different from the present, this will enhance our faith in the model as a reliable tool for simulating future climate change

MODEL VALIDATION AND ANALYSIS

- Observations show that the ice extent over the Arctic has declined rapidly the last 30 years. SKD will first validate the model ability to simulate such recent changes and then explore the impact on the climate of Arctic and sub-Arctic regions using both observations and climate simulations
- The number, intensity and path of low-pressure systems (storm tracks) are important for the climate in Norway as they are the main transporter of both heat and moisture. Small changes in the path of storm tracks may give large regional climate changes. SKD will study the natural variability and response of storm tracks to global warming
- Near the Earth's surface, turbulence play a vital role in redistributing heat between the surface and the lower atmosphere. SKD funded scientists will quantify how the description of turbulence is impacting the simulated climate change signal in different climate models
- Indian monsoon: Quantify the magnitude of internal variability and the sensitivity of the to external forcing

STAFF AND INSTITUTIONS INVOLVED

- **UiB:** Asgeir Sorteberg (Leader), Ilker Fer, Peter M. Haugan, Christoph Heinze, Erlend M. Knudsen, Nils Gunnar Kvamstø, Benjamin Pfeil, Dhanya Pushpadas, Corinna Schrum, Anders Sirevaag, Silje Sørland, Ellen Viste
- **Uni Research:** Mats Bentsen, Eystein Jansen, Petra Langebroek, Camille Li, Kerim Nisancioglu, Odd Helge Otterå, Lars H. Smedsrud, Jerry Tjiputra, Zhongshi Zhang
- **NERSC:** Igor Ezau, Yongqi Gao, Florian Geyer, Helene Langehaug, Svetlana Sorokina, Lingling Suo
- **IMR:** Ken Drinkwater, Anne Britt Sandø, Svein Sundby

COOLING OF THE OCEAN **REDUCES THE MONSOON**

Expansion of Arctic sea ice gave rapid changes in the monsoon rains over India and China during the last ice age. This is shown again in Asian stalactite caves.

Kerim Nisancioglu. Photo: UiB.

Francesco Pausata. Photo: Private.

The Indian and East Asian monsoon is very important for millions of people in India and China. Monsoons bring large amounts of rainfall over land areas, and affect all parts of society. A monsoon at the wrong time, and with a different strength than expected may have major consequences including affecting food production in the area.

An article published in june 2011 in *Nature Geoscience*, Francesco S.R. Pausata and Kerim H. Nisancioglu at the Bjerknes Centre for Climate Research in Bergen, together with colleagues at the University of Washington in Seattle, show how in earlier times rapid changes in the Indian and East Asian monsoon system are related to changes in Arctic sea ice.

REDUCED MONSOON

Using a global climate model, they simulated rapid changes in Arctic sea ice during the last ice age. These rapid changes are also known as Heinrich Events (H events) with a sharp cooling in and around the North Atlantic, caused by the addition of large amounts of icebergs and meltwater from ice sheets that covered much of North America and Northern Europe.

The model shows that the meltwater provides a rapid expansion of Arctic sea ice and a cooling in many parts of the northern hemisphere, including the Indian Ocean. What is interesting in this study is that such a cooling of the Indian Ocean also provides a significant reduction in rainfall locally and across the Indian continent, including a strongly reduced Indian monsoon.

SPELEOTHEM = CLIMATE ARCHIVES

One of the best climate records we have of the strength of the monsoon rains in the past, speleothems are found in caves in India and China. The best-known stalactite cave is Hulu, Northeastern China. Analyses of oxygen isotope composition of dripstones in these caves have provided a unique climate record of the strength of the monsoon rains as far back as the last glaciation (~ 110,000 to 10,000 years ago). Here we see extremely rapid and large changes in the East Asian monsoon, but what caused these changes has been unclear.

This new study in *Nature Geoscience* shows that these rapid changes in the monsoon rain known from limestone caves are a response to a major expansion of Arctic sea ice in a cold ice age climate.

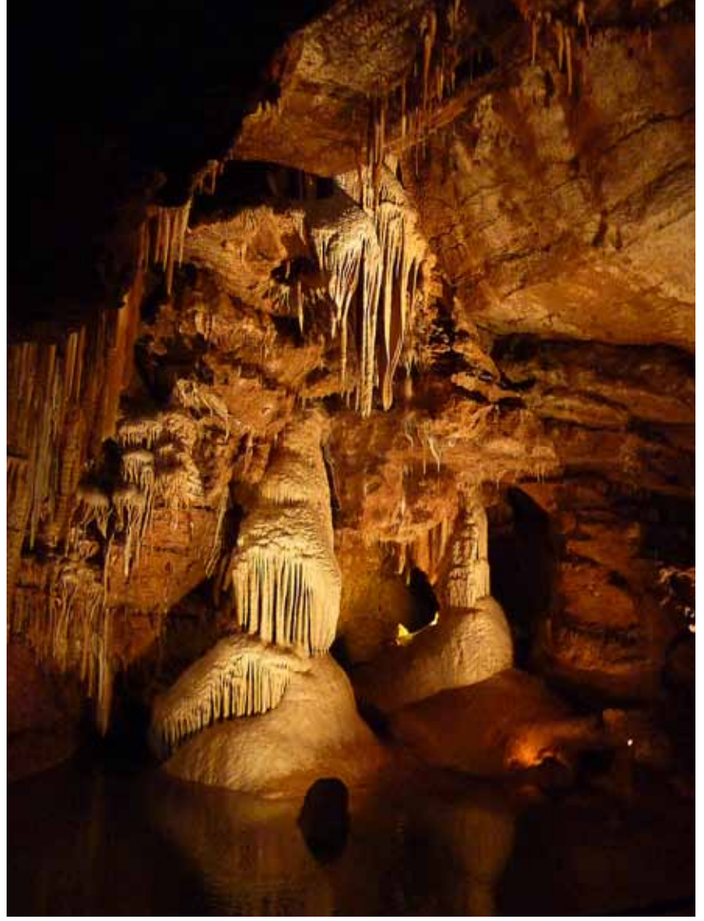
CHANGES DURING THE ICE AGE LINKED TO THE EXPANSION OF SEA ICE

The probability that one can expect similar rapid changes in the monsoon rain in a climate under global warming has been much debated. What this study shows is that the rapid changes in the Indian and East Asian monsoon, where stalactite caves show that the monsoon was greatly reduced, is dependent on an expansion of Arctic sea ice. This is most likely under a cold ice age climate, and less likely under the current warm climate with decreasing sea ice in the Arctic.

Researchers in the study believe that this shows that the abrupt climate changes that took place during the last ice age, therefore, are not about the concentration of CO_2 in the atmosphere, but rather are related to changes in North Atlantic and the expansion of Arctic sea ice.

REFERENCE

Pausata, Francesco S.R.; Battisti, David S.; Nisancioglu, Kerim H. and Blitz, Cecilia M. (2011), "Chinese stalagmite $\delta^{18}O$ controlled by changes in the Indian monsoon hum a Simulated Heinrich event," *Nature Geoscience 4, 474-480*, published online 19 June 2011.



Speleothems (stalagtites and stalagmites), here from in Grottes de Lacave, France. Photo: ColourBox

A model study reveals that future large and episodic volcanic eruptions induce favourable climate condition for more land and oceanic carbon uptake and delay climate change effect. Here the Semuru volcano, Indonesia. Photo: iStockphoto

VOLCANIC ERUPTIONS DELAY CLIMATE CHANGE EFFECT

Until recently, all future climate projections using models did not include external forcing such as volcanic eruptions. However, studies have shown that this forcing plays an important role and influences past climate variability over years to decadal time scales. At the Bjerknes Center for Climate Research, Jerry Tjiputra and Odd Helge Otterå used a sophisticated Earth system model to investigate the potential effect of volcanic eruptions (or injection of sulphur aerosols into the stratosphere) on future climate change.

In addition to the business-as-usual carbon emissions, they introduced volcanic eruptions varying in frequencies and magnitudes to a series of future climate simulations. In one of the cases where large volcanic eruptions were included every five-years, the model simulates a persistent cooler climate through the end of the 21st century relative to the case without any volcanic eruption. This short term cooling effect is mainly attributed by the eruption-released sulphur aerosols, which stays in the lower stratosphere for a few years and reduces the short wave radiation reaching the Earth's surface.

Despite some cooling effects of the volcanic eruptions, the study emphasizes that the future concentration of anthropogenic carbon in the atmosphere remains the dominant driver for long-term climate variability. There are also other remaining issues associated with the high CO_2 world that is not significantly affected by volcanic eruptions, for example the ocean acidification.

REFERENCE:

Tjiputra, Jerry F. and Odd Helge Otterå (2011), Role of volcanic forcing on future global carbon cycle, *Earth System Dynamics*, 2, 53-67.

FREQUENT AVALANCHES DURING THE «LITTLE ICE AGE»

During the period AD 1650–1760, farmers living in Nordfjord were repeatedly forced to apply for tax reductions following damage to farms and farmland caused by snow-avalanches.

A study based on analyses of lake sediments and seismic profiles from Lake Oldevatnet indicates that this period featured the highest avalanche frequency of the last 7000 years. During this period the increase in avalanches observed for Olden was higher relative to other areas in western Norway.

In addition to meteorological factors that influence the risk of avalanches, local factors may also play a significant role in the observed avalanche activity. For example, most avalanches in Olden are triggered along the margins of local glaciers. During the 'little ice age' these glaciers grew closer to the steep valley sides around Oldevatnet.

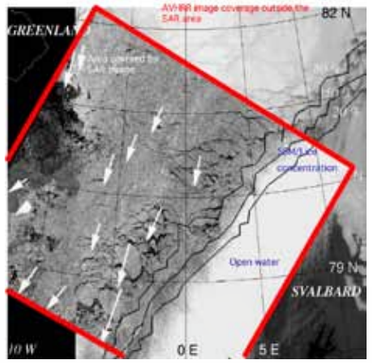
The scientists hope that continued research in the same region will enable them to separate local and regional factors and thereby increase our understanding of the relationship between long-term climate change and avalanche activity.

REFERENCE:

Vasskog, K., Nesje, A., Støren, E. N., Waldmann, N., Chapron, E., and Ariztegui, D. A. (2011) Holocene record of snow-avalanche and flood activity reconstructed from a lacustrine sedimentary sequence in Oldevatnet, western Norway. *The Holocene*, doi:10.1177/ 0959683610391316

INCREASING EXPORT OF SEA ICE IN THE FRAM STRAIT

Lars Henrik Smedsrud. Photo: Gudrun Sylte



Sea ice drift was calculated from recognizing the same sea ice flow in two radar satellite images, and locating their position. The ice drift was then interpolated to 79°N between Svalbard to the right and Greenland to the left. Illustration: Kjell Kloster, NERSC.

Arctic sea ice area has been decreasing for the past two decades. A study estimates that the sea ice area export in recent years is about 25 percent larger than during the 1960's, and suggests that this change has been an important player in the overall loss of Arctic Sea ice since then.

Within the Arctic Ocean the ice can melt due to heating from the air above, from the ocean below, or the ice can be exported southward through the Fram Strait between Svalbard and Greenland.

Under the sea ice in the Fram Strait, the East Greenland Current flows steadily southwards, and this carries the sea ice at a background constant southward speed close to 5 cm/s. This current has driven around a third of the ice export over the years. The wind, derived as geostrophic wind from reanalysis data, were used to calculate the Fram Strait ice area export back to 1957.

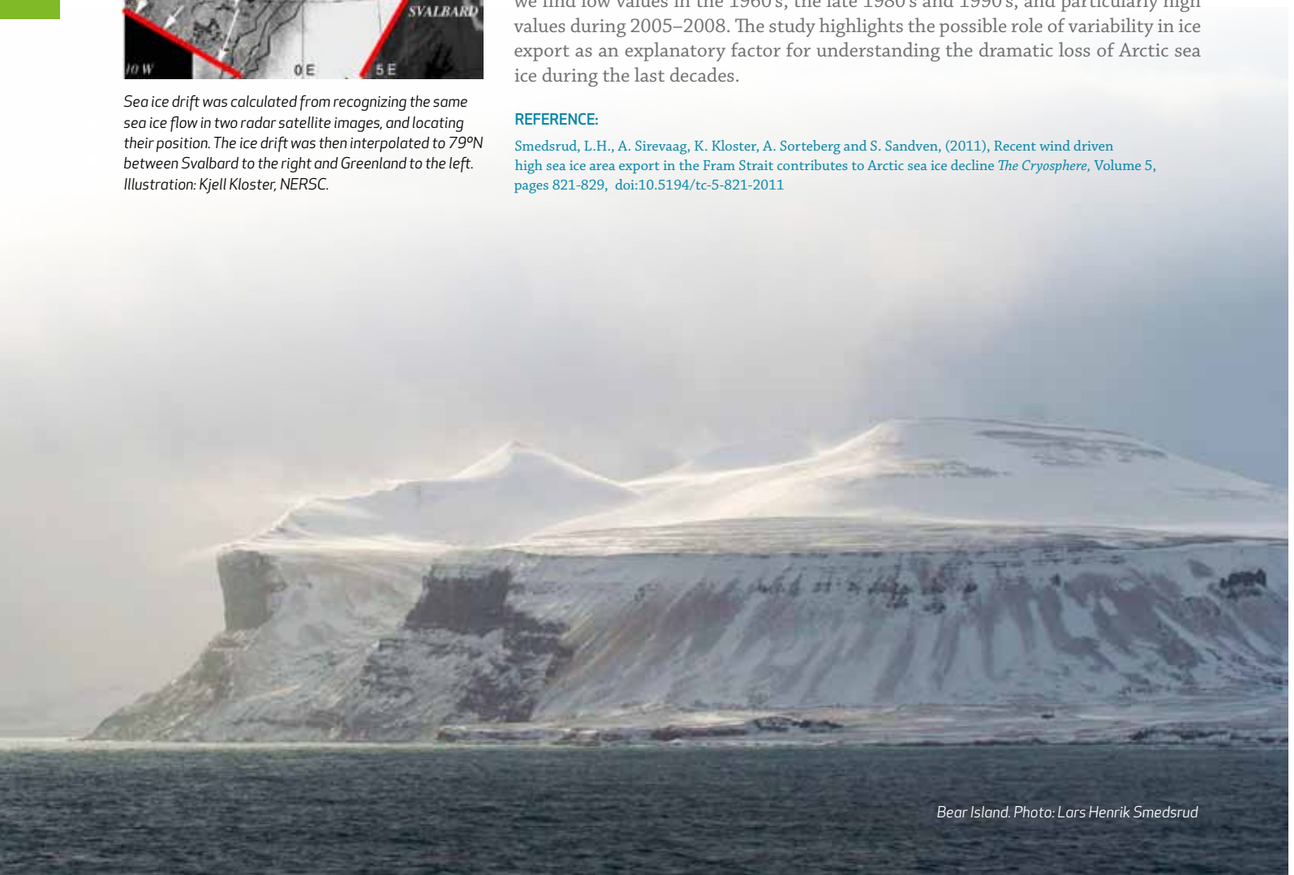
This resulted in an estimated close to 5 percent increase in ice export each decade. The increase in ice export occurred mostly during winter and is directly connected to higher southward ice drift velocities, due to the stronger geostrophic winds. The increase in ice drift is large enough to counteract the effect of a lower area concentration of the exported sea ice.

The study presents high resolution sea ice drift data across 79°N from 2004 to 2010, derived from radar satellite data. The tracking of individual floes has been done manually by Kjell Kloster at NERSC since 2004, and the ice drift corresponds well with variability in local wind.

Tracking of storms in the North Atlantic shows that changes in geostrophic winds are linked to more intense Nordic Sea low-pressure systems. Annual sea ice area export likely has a significant influence on the summer sea ice variability and we find low values in the 1960's, the late 1980's and 1990's, and particularly high values during 2005–2008. The study highlights the possible role of variability in ice export as an explanatory factor for understanding the dramatic loss of Arctic sea ice during the last decades.

REFERENCE:

Smedsrud, L.H., A. Sirevaag, K. Kloster, A. Sorteberg and S. Sandven, (2011), Recent wind driven high sea ice area export in the Fram Strait contributes to Arctic sea ice decline *The Cryosphere*, Volume 5, pages 821-829, doi:10.5194/tc-5-821-2011



Bear Island. Photo: Lars Henrik Smedsrud

THE FUTURE OF STORMS

The last months of 2011 have shown the powerful impact of storms on the coast of Norway. The storm "Dagmar", which means "glorious", was an example of how powerful these systems can be. With its hurricane force, it produced an estimated cost of more than half a billion Norwegian kroner. It is thus valid to ask what the future holds. Will there be more storms? Will they intensify?

Michel d. S. Mesquita.

Jürgen Bader.

The paper by Bader and co-authors published in *Atmospheric Research* sheds some light in this topic. It is entitled "A Review on Northern Hemisphere Sea-ice, Storminess and Teleconnection patterns: Observations and Projected Changes". It reviews relevant publications in the subject of storm tracks taking into account observational studies, sensitivity studies and future projections.

Bader et al. show that most climate projection studies indicate a poleward shift of storm tracks and a strengthening of the storm tracks north of the British Isles. There is, however, uncertainty over changes in the intensity of storms. Precipitation will increase, but recent studies indicate no apparent change in extreme winds over the Northern Hemisphere. Larger changes may occur regionally.

Could sea-ice variability play a role in the future of storms? Sea-ice has decreased in the past years at a rate of 4% per decade in all seasons. The rate is largest at the end of summer, around 9% per decade. Sea-ice changes have an impact on the intensity of the storms, that is, less sea ice leads to stronger storms. Simulations show that an overall reduction in the number of Arctic winter storms and a northward shift of mid-latitude winter storms in the Pacific are associated with a reduced Arctic sea-ice cover.

What is the projected phase of the North Atlantic Oscillation (NAO)? Several observational and idealised sea-ice-sensitivity simulations indicate a delayed negative NAO-like response in autumn/winter to a reduced Arctic sea-ice cover. However, most coupled ocean–atmosphere models of the last Intergovernmental Panel on Climate Change (IPCC) AR4 forced by the SRESA1B scenario predict a significant future reduction in Arctic sea-ice and a moderate tendency to a positive phase on the NAO at the end of the 21st century. This shows that the forcing of the sea-ice reduction is not the dominant forcing on the NAO in the future. There might be other processes that counteract the impact of the sea-ice loss on the NAO. It is speculated that one candidate could be the tropical ocean warming, which has been shown to induce a positive NAO phase.

The storm Tuva hit the southern part of Norway and Greenland in January 2008 with high rainfall and high water level. Photo: met.no

What could the future hold? The poleward shift of mid-latitude storms, for both the observations and future projections, is the most agreed-upon result. However, results are still unclear when it comes to the number or intensity of mid-latitude storms. The disagreement among the studies might be related to the storm tracking method, model resolution and the region selected for averaging storm statistics. But overall, a northward shift of mid-latitude storms and the positive NAO-like response indicate what the future could hold for northern countries.

REFERENCE:

Bader, Juergen; Michel d. S. Mesquita; Kevin I. Hodges; Svein Osterhus; Noel Keenlyside and Martin Miles (2011): A Review on Northern Hemisphere Sea-Ice, Storminess and the North Atlantic Oscillation: Observations and Projected Changes. *Atmospheric Research*, doi: 10.1016/j.atmosres.2011.04.007

In late summer 2011 an international team of scientists deployed a string of instruments in search of the Denmark Strait Overflow Water. Present on the cruise were Dr. Kjetil Våge from UiB and the Bjerknes Centre. Photo: Sindre Skrede.

NEW SCENARIO FOR THE FORMATION OF DENMARK STRAIT OVERFLOW WATER

A Bjerknes study published in Nature Geoscience in August revised our current understanding of how the dense overflow waters from the Nordic Seas are formed.

Warm Gulf Stream-origin waters flow northward across the Greenland-Scotland Ridge into the Nordic seas and release heat to the atmosphere. The resulting cold and dense waters return southward by flowing through gaps in the ridge as overflow plumes. It is commonly thought that the primary source of the Denmark Strait Overflow Water, the largest of these overflow plumes, is a current flowing southward along the continental slope of Greenland called the East Greenland Current.

Icelandic scientists Steingrímur Jónsson and Héðinn Valdimarsson presented in 2004 the first evidence of a previously unknown current – the North Icelandic Jet – that flows along the continental slope of Iceland toward the Denmark Strait. A team of Norwegian, American, and Icelandic scientists conducted dedicated field surveys in October 2008 and August 2009 that established the existence of the North Icelandic Jet.

The article published by Dr. Kjetil Våge and co-authors shows that the jet supplied approximately half of the total overflow transport and was the primary source of the densest component during the two surveys.

The article also includes simulations with an ocean general circulation model which suggest that the import of warm, salty water from the North Icelandic Irminger Current and water-mass transformation in the interior Iceland Sea are critical to the formation of the jet. This represents a new scenario for the formation of Denmark Strait Overflow Water and raises novel questions about a crucial component of the Earth's climate system.

REFERENCE:

Våge, K., R.S. Pickart, M.A. Spall, H. Valdimarsson, S. Jónsson, D.J. Torres, S. Østerhus, and T. Eldevik, (2011): Significant role of the North Icelandic Jet in the formation of Denmark Strait Overflow Water. *Nature Geoscience*, doi: 10.1038/NGEO1234.

CARBON BUDGET IN THE NORDIC SEAS

Bjerknes researchers have published a study were they present a carbon budget of the Nordic Seas. Combining the most recent carbon data and the present knowledge about ocean exchange into and out of the Nordic Seas, the authors calculated the contemporary carbon budget of the region. They estimated that 12.3 Gt of carbon is transported annually into the Nordic Seas, and 12.5 Gt carbon is exported from the region. Balancing the budget requires an ocean uptake of atmospheric carbon dioxide (CO_2) to the Nordic Seas of 0.2 Gt of carbon each year. This is almost two orders of magnitude smaller than the carbon transported with ocean currents in the region. However, it also indicates that a larger amount of carbon dioxide is taken up by northward flowing water masses before they enter the Nordic Seas, and that this is one of the main sources of carbon to the Nordic Seas.

REFERANSE:

Jeansson, E., A. Olsen, T. Eldevik, I. Skjelvan, A. M. Omar, S. K. Lauvset, J. E. Ø. Nilsen, R. G.J. Bellerby, T. Johannessen and E. Falck, (2011), The Nordic Seas carbon budget: Sources, sinks and uncertainties. *Global Biogeochemical Cycles*, doi:10.1029/2010GB003961.

FORCING AND TRANSPORT OF THE NORWEGIAN COASTAL CURRENT

The Norwegian Coastal Current (NCC) is a key conveyor transporting freshwater northward as far as the Arctic. The current also transports cod eggs and larvae into their Barents Sea nursery area. Despite its importance, the forcing mechanisms are poorly known and flux estimates are sparse, mainly due to a lack of current meter data. In this study, the structure and dynamics of the NCC were investigated using a one-year, full depth profiling current meter at a confluence region of the NCC, combined with hydrographic and atmospheric reanalysis data.

Results suggest NCC transports estimates are about 50% larger than previously reported. Buoyancy forces were found to be important on seasonal and long-term changes, but wind-driven continental shelf waves dominate on scales of days to weeks. Results further suggest that the fluxes and variability of the NCC in the Barents Sea can be diagnosed based on hydrographic conditions at the Ingøy fixed hydrographic station and the large-scale wind field.

REFERENCE:

Skagseth, Ø, K.F. Drinkwater and E. Terrile, 2011, Wind- and buoyancy-induced transport of the Norwegian Coastal Current in the Barents Sea *Journal of Geophysical Research* Res., 116, C08007, doi:10.1029/2011JC006996.

TOWARDS A MORE SEASONAL ARCTIC SEA ICE COVER

Results from a sixteen day long drift experiment in the central Arctic Ocean in 2008 show that the upper central Arctic contained more freshwater in the summer, but was saltier during winter, compared to the early 1990's. This indicates that there has been a transition towards a more seasonal Arctic ice cover, which means that more ice is forming during winter and melting during summer.

The experiment was located on the Swedish icebreaker Oden and was a part of the Arctic Summer Cloud Ocean Study (ASCOS). By making detailed measurements, the researchers could study the evolution of the upper ocean during the transition from melting to freezing season.

The measurements show that during summer conditions, solar radiation is transferred through the 1.8 m thick ice and accounts for up to one fourth of the heating in the upper ocean. As the winter season approaches, freezing of the ice surface combined with snowfalls, reduces the transfer of solar radiation by 60% and heat will be redistributed internally in the upper ocean.

REFERENCE

Sirevaag, A., de la Rosa, S., Fer, I., Nicolaus, M., Tjernström, M., and McPhee, M. G. (2011): Mixing, heat fluxes and heat content evolution of the Arctic Ocean mixed layer , *Ocean Science*, 7, 335-349, doi:10.5194/os-7-335-2011

CLIMATE VARIABILITY AND THE ECOSYSTEM OF THE BARENTS SEA

Marine ecosystems are affected by climate variability with the response varying regionally. The Norwegian Ecosystem Studies of Sub-Arctic Seas (NESSAS) Project, undertaken by Bjerknes scientists, has improved our understanding of how climate affects the Barents Sea ecosystem.

Illustration: Arild Sæther for the Insititute of Marine Research.

During the warm 1920s–1960s, commercial fish production increased in the Barents Sea due to faster growth rates and improved survival, related, it is believed, to increased plankton production. Fish stocks also moved northwards and several southern species became more frequent visitors. Shifts in the spawning sites of Atlantic cod with a higher proportion of spawning at northern sites during warm periods were documented. The studies highlight that the nature of the ecosystem response depends on the periodicity of climate variations. Multidecadal forcing tends to influence more population characteristics, e.g. large-scale distribution and abundance, while shorter time scale forcing has more influence on individual characteristics, e.g. growth rates and survival. The importance of low frequency forcing (60–80 yr period) was one of three main themes in the NESSAS studies.

The second theme was the role of basin-scale climate forcing at decadal (10 yr) time scales. For example, northward moving North Atlantic cyclones influence Barents Sea ice extent with more cyclones increasing the melt rate through the inflow of more warm water. However, on annual time scales, sea-ice extent is controlled by advection of ice from the Arctic Ocean. Biologically, model studies showed that decadal changes in wind strength vary the extent of ocean mixing, thereby affecting plankton productivity.

The third theme was comparative studies. Comparisons with other ecosystems showed that the annual mean primary productivity in the Barents Sea is relatively low due to a combination of less nutrients and lower light levels. The increased primary productivity during recent warming was confirmed to be related to the reduction in sea ice, as other ice-covered regions showed similar results. Biological responses to the recent warm period are more pronounced in higher latitude systems such as the Barents Sea.

The effects of climate on the ecosystem from the NESSAS results, as well as previously published studies, are being used to develop possible ecosystem scenarios under anthropogenic-induced future climate change.

REFERENCE:

Drinkwater, K., (2011), The influence of climate variability and change on the ecosystems of the Barents Sea and adjacent waters: Review and synthesis of recent studies from the NESSAS Project Progress in Oceanography, doi:10.1016/j.pocean.2011.02.006.

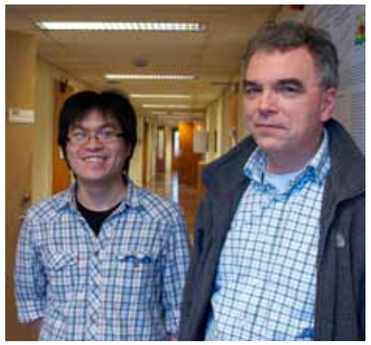
COLD WINDS - WARMER CLIMATE

The heat released by the North Atlantic current in the Nordic Seas contributes to the relatively mild climate of northwestern Europe. When the warm and saline water from the tropics gives up its heat to the colder atmosphere above, the ocean currents gradually cools. The amount of warm water carried by the ocean currents toward the Arctic is affected by the strength of the large-scale northerly winds blowing over the Nordic Seas. The model study of Iselin Medhaug and colleagues shows that stronger cold winds from the Arctic «spins up» the ocean circulation and contribute to force more water out of the Nordic Seas. This cold water is replaced by an increased inflow of warm Atlantic water, which consequently contributes to Arctic sea ice retreat.

REFERENCE:

Medhaug, I., H. R. Langehaug, T. Eldevik, T. Furevik and M. Bentsen (2011): Mechanisms for decadal scale variability in a simulated Atlantic meridional overturning circulation. *Climate Dynamics*, doi: 10.1007/s00382-011-1124-z.

OCEAN CARBON UPTAKE DECREASING IN A WARMER WORLD



Jerry Tjiputra (left) and Christoph Heinze. Photo: Gudrun Sylte

The world oceans uptake of CO_2 will decrease in our century under global warming, but there are big regional differences. The Atlantic Ocean is becoming less efficient.

While the oceans in total will remain a net sink for human-produced CO_2, there are big regional changes in how uptake rates by the ocean will develop in the future.

Until now, the North Atlantic has been the most efficient sink for atmospheric CO_2 per square meter. Model results show that the North Atlantic region is particularly sensitive to freshwater supply changes (from melting of mountain glaciers and Greenland ice sheet) and may experience a considerable decrease in uptake strengths.

REGIONAL IMPACTS OF CLIMATE CHANGE

This is shown in a study that strengthens previous results on the effect of rising atmospheric CO_2 concentration on the future CO_2 uptake by the oceans.

Unlike earlier work in this field based on global models, this is a comparative study on the regional impacts of climate change. It compares model results from four key European laboratories, including France, Germany, Norway, and Switzerland. The Bjerknes Centre contributed with the Norwegian model results.

The simulated climate change by the models causes a reduction of oceanic CO_2 uptake by the end of this century by 41.5 Giga-tons carbon, which is equivalent with approximately five years of the present annual CO_2 emissions.

Photo: iStockphoto.

The study splits the world oceans into four regions and demonstrates the areas that will be most crucial for future uptake: The Arctic, the North Atlantic, the Tropics, the South Atlantic, and the Southern Ocean.

THE SOUTHERN OCEAN: KEY REGION FOR FUTURE UPTAKE

The Southern Ocean around Antarctica has been confirmed to probably develop into a key region for CO_2 uptake in the decades to come. The four different models give qualitatively a broadly consistent picture, but – due to the different representation of physical, biological, and chemical processes – show a quantitative spread in their results for regional air-sea fluxes.

This spread is an indication of our current limitations to predict even more accurately regional CO_2 sink strengths changes. Improving networks of oceanic and atmospheric carbon observations will contribute to reducing these uncertainties in the years to come.

REFERENCE:

Roy, Tilla, Laurent Bopp, Marion Gehlen, Birgit Schneider, Patricia Cadule, Thomas L. Frölicher, Joachim Segschneider, Jerry Tjiputra, Christoph Heinze, and Fortunat Joos (2011): Regional impacts of climate change and atmospheric CO_2 on future ocean carbon uptake: A multi-model linear feedback analysis, *Journal of Climate* 24, 2300–2318. doi: 10.1175/2010JCLI3787.1

View from the Research vessel Lance North West of Svalbard, summer 2011.
Photo: Anna Silyakova

Centre for Climate Dynamics

The Centre for Climate Dynamics at the Bjerknes Center (Senter for klimadynamikk – SKD) is a new research and expertise centre in Bergen for the advancement of the climate science. It draws upon the expertise developed by, and accomplishments of, the BCCR since its inception as a national centre of excellence in 2002.

The SKD is funded by the Ministry of Education and Research for a period of 12 years and was officially opened on December 1st 2011 by Minister Tora Aasland. The SKD combines *expertise* in climate dynamics from the four major research institutions in Bergen: the University of Bergen, the Institute of Marine Research, Uni Research Ltd and the Nansen Environmental and Remote Sensing Center. SKD is hosted by UiB and is organised as an independent unit within the university with its own board. The SKD will be *co-located* at the Geophysical Institute and scientists and graduate students are scheduled to move into the new offices by the end of 2012.

The *vision* of SKD is to become an international competitive research centre on climate dynamics at the high latitudes. It will conduct research to enhance our understanding of climate variability and climate change and develop state-of-the art modelling tools to ensure the provision of global and regional climate scenarios for the North Atlantic and the Arctic, Europe and selected developing countries. At the national level, the SKD will lead the development and maintenance of major climate models and will have a primer position in the training and recruitment of the new generations of climate scientists. At the international level, the SKD will contribute to major climate research initiatives, such as the UN´s Intergovernmental Panel on Climate Change (IPCC), and will play a major role in the coordination of European marine carbon observing systems.

In addition to research activities, SKD will contribute to the *education and recruitment* of climate scientists in Norway, notably through the Norwegian research school in climate dynamics (ResClim) at UiB. The centre will forge *cooperation* with relevant research institutions and networks at the national and international levels. Outreach activities include the dissemination of research-based climate knowledge to schools, local and national policy makers, and to the general public.

SKD CENTRE FOR CLIMATE DYNAMICS AT THE BJERKNES CENTRE

CONTACT

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Web: www.bjerknes.uib.no/skd

Photo: Gudrun Sylte

Organisation


Photo: Sindre Skrede

The Board has one representative from each partner plus an external leader. The board oversees the compliance of the centre's activities according to the conditions stipulated in the grant provision from the Ministry. It also approves the research strategy and plans, cooperation agreements and the centre's budget proposed by the director.

The *Core group* consists of the director, four research leaders and an administrative leader, all employed at UiB. The core group coordinates the scientific activities, deals with the day-to-day administration of the centre and outreach activities. The *Director*, professor Tore Furevik, coordinates the centre's activities, reports to the board, and is SKD´s liaison with the Ministry of Education and Research.

The *Scientific committee* consists of the core group and one representative from each partner. The committee is in charge of the strategic and scientific development of the centre and serves as a communication channel among SKD project leaders.

A *Scientific Advisory Committee* (SAC) with six international acknowledged scholars whose expertise spans across all the strategic thematic areas of the centre has been appointed. It provides advice, assess the quality and foci of the scientific programme, and assists in the international integration of the SKD´s activities.

Membership as of 2011:
Anny Cazenave, Centre National d´Etudes Spatiales, France

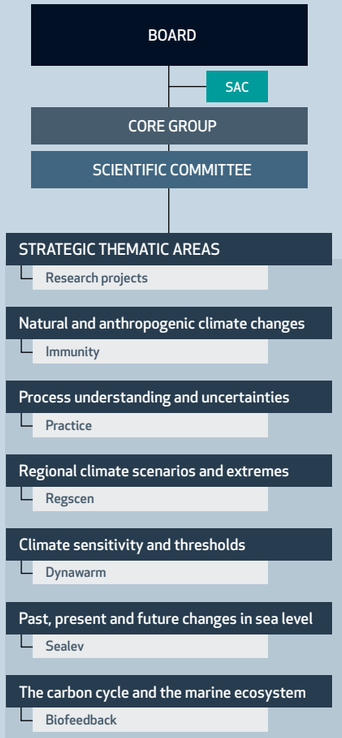
Jens Hesselbjerg Christensen, Danish Climate Centre, Denmark

Michael Schulz, University of Bremen, Germany

Detlef Stammer, University of Hamburg, Germany

David Thompson, Colorado State University, USA

Andrew Watson, University of East Anglia, UK



Strategic thematic areas and research activities

The science of SKD is organised around six research projects covering each of the strategic thematic areas. These projects have a time horizon of 3–4 years and combine expertise from all the partners in a truly interdisciplinary fashion. The activities are financed jointly by SKD grants and substantial in-kind from the partners. In addition, SKD funds a 2-year project specifically targeted to model work (e.g. model development, simulations, validation and analyses) for the IPCC's 5th assessment report due in 2014.

Strategic thematic area:
Natural and anthropogenic climate changes

Project:
Integrated model-data approach for understanding multidecadal natural climate variability - IMMUNITY

IMMUNITY addresses major unresolved issues such as: what are the driving forces and mechanisms of Atlantic multi-decadal variability, and to what extent changes in the Atlantic climate are predictable. The ability of climate models to correctly simulate such fluctuations is crucial for making reliable forecasts of regional climates over the next decades. The research integrates new, high-resolution palaeoclimatic time series and instrumental data with long model simulations to explore long-term variations during the last 1500 years.

Institutions and staff involved

Uni Research:	Odd Helge Otterå (Leader), Carin A. Dahl, Trond Dokken, Øyvind Lie, Martin Miles
UiB:	Jostein Bakke, Svein Olaf Dahl, Tor Eldevik, Noel Keenlyside, Helga Kleiven, Atle Nesje, Iselin Medhaug, Ulysses Ninnemann
NERSC:	Yongqi Gao, Helene Langehaug
IMR:	Øystein Skagseth

Strategic area:
Process understanding and uncertainties

Project:
Predictability of Arctic/North Atlantic climate - PRACTICE

PRACTICE evaluates the feasibility of northern climate prediction by establishing the basis for predicting inter-annual to decadal climate variability in the North Atlantic and Arctic regions. This basis is used to develop the *Norwegian Climate Prediction Model* (NorCPM) towards the eventual implementation of an operational climate prediction system at the Bjerknes Centre. Such a system will be important for, e.g., the national management of marine resources, and for regionally targeted policymaking regarding climate adaptation and mitigation measures.

Institutions and staff involved

UIB:	Tor Eldevik (Leader), Helge Drange, Mirjam Glessmer, Noel Keenlyside
Uni Research:	Mats Bentsen, Ingo Bethke, Odd Helge Otterå
NERSC:	Laurent Bertino, François Counillon, Jan Even Ø. Nilsen
IMR:	Kjell Arne Mork, Anne Britt Sandø, Øystein Skagseth

Strategic thematic area:

Regional climate scenarios and extremes

Project:

Regionalisation of climate scenarios - REGSCEN

REGSCEN applies dynamical climate downscaling over the tropics, Northern Europe and the Nordic Seas (including the North Sea, Barents Sea and the Arctic Ocean). These downscaling activities have both ocean and atmospheric components. The resulting atmospheric scenarios will be used to assess regional scale climate change. The resultant marine scenarios will be used to assess impacts of regional climate change on biological production and on the carbon cycle. Since dynamical downscaling adds another layer of uncertainty to the global climate projections, REGSCEN will evaluate the methodology´s performance as a contribution to the climate research community.

Institutions and staff involved

IMR:	Bjørn Ådlandsvik (Leader), Paul Budgell, Trond Kristiansen, Anne Britt Sandø
Uni Research:	Stefan Sobolowski (vice-leader), Martin King
UiB:	Ute Daewel, Dhanya Pushpadas, Corinna Schrum
NERSC:	Jon Bergh, Igor Ezau, Yiwen Xi

Strategic thematic area:

Climate sensitivity and thresholds

Project:

Dynamics of past warm climates - DYNAWARM

DYNAWARM seeks to improve our understanding of the climate system in a warmer world by studying thresholds, the processes that govern them, and their behaviour in past and future warm climates. Specific topics of investigation include (1) the possibility of thresholds in the response of sea ice cover, ice sheets and Arctic biota to global warming, and (2) characterizing the ocean during past warm periods, in particular the temperature and circulation in the North Atlantic and the El Niño-Southern Oscillation in the tropical Pacific. An interdisciplinary approach combining physical oceanography, paleoceanography and numerical modelling will be used to address these unknowns.

Institutions and staff involved

Uni Research:	Camille Li & Bjørg Risebrobakken (co-leaders), Carin Andersson Dahl, Eystein Jansen, Petra Langebroek, Kerim Nisancioglu, Lars H. Smedsrud, Zhongshi Zhang
UiB:	Hillary Birks, John Birks, Catharine Jenks, Helga Kleiven, Ulysses Ninnemann
NERSC:	Igor Ezau

Strategic thematic area:

Past, present and future changes in sea level

Project:

Sea level change and ice sheet dynamics - SEALEV

SEALEV aims at understanding past and present variations in sea level with focus on the dynamics of the Greenland Ice Sheet, and to predict sea level rise under climate change. Regions of study are the Nordic Seas and selected countries in the south (Bangladesh, India, China and South Africa). SEALEV will use observations (ice mass loss, ocean temperature and salinity, as well as remotely altimetry and gravity) and mathematical models to deliver improved projections of sea level rise for the 21st century, with focus on the northern Atlantic Ocean and the High North.

Institutions and staff involved

NERSC:	Stein Sandven (Leader), Jan Even Ø. Nielsen (viceleader), Lingling Chen, Kirill Khvorostovsky, Johnny Johannessen, Ola Johannessen, Victoria Miles, Sara de la Rosa, Qing Yan
UIB:	Helge Drange, Ilker Fer, Øystein Lohne, Jan Mangerud, Sönke Maus, Atle Nesje, Kristin Ritcher, John Inge Svendsen, Kristian Vasskog
Uni Research:	Mats Bentsen, Martin Miles, Kerim Nisancioglu
IMR:	Lars Asplin, Mari Myksvoll

Strategic thematic area:

The carbon cycle and the marine ecosystem

Project:

Biogeochemical feedback in the climate system – from processes to large-scale effects - BIOFEEDBACK

BIOFEEDBACK quantifies marine and terrestrial coupled cycles of carbon, nutrients, and oxygen in their global and regional context, taking into account multiple drivers such as increasing greenhouse gas emissions, ocean acidification, warming, changes in circulation as well as stratification, and de-oxygenation. We employ a strategic combination of data archaeology, database synthesis, model development and decadal to centennial model simulations with rigorous model performance evaluations to provide new system understanding.

Institutions and staff involved

Uni Research:	Richard Bellerby (co-leader), Emil Jeansson, Aud Larsen, Gisle Nondal, Caroline Roelandt, Jerry Tjiputra
UiB:	Christoph Heinze (co-leader), Truls Johannessen, Benjamin Pfeil, Frede Thingstad
IMR:	Solfrid Hjøllo, Geir Huse, Morten Skogen, Henrik Søiland
NERSC:	Laurent Bertino, Annette Samuelsen, Ehouran Simon

At the launch of the IPCC Special Report on Extreme Weather in Oslo 18, november 2012. *From left: Erik Solheim, Minister of Environment and Development, Farrokh Nadim, director, International Center for Geohazards and professor Asgeir Sorteberg, BCCR. Photo: Gudrun Sylte*

OUTREACH AND MEDIA HIGHLIGHTS

EXTREME WEATHER AND MELTING GLACIERS

A sharp peak in the Bjerknes media activity in 2011 came in late summer, when a rainy summer had melted the glaciers.

A large proportion of the media attention for the Bjerknes Centre follows a seasonal and occasional cycle. This year the peaks came in the autumn, the first occuring in mid august when the Norwegian glaciers had melted to a record low size during the summer. And when the Briksdalsbre glacier had melted into two parts, an article from the NTB press agency with our glacier expert Atle Nesje was spread in 62 newspapers throughout the country. In general, when the storms hit the coastline of Norway, the telephone rings in Professor Helge Drange's and Professor Asgeir Sorteberg's offices. But the second peak of the autumn 2011 was connected to the release of the IPCC Special Report on Extreme Weather. Professor Sorteberg was one of the lead authors of the report, which was launched in Oslo on November 18th, simultaneously with the presentation of the Summary for Policymakers in Kampala, Uganda. In Oslo the report Asgeir Sorteberg and Farrokh Nadim of the International Center for Geohazards handed over the report to the Minister of Environment and Development, Erik Solheim. The last peak in the 2011 media statistics appeares in December, when the world climate interest gather at the COP-meetings. This year Director of the BCCR, Eystein Jansen and vice director Tore Furevik attended the negotiations in Durban, which provided good attention to the BCCR from media and politicians. In total, Bjerknes scientists contributed in over 600 articles in the media, counting only written press and on the web.

PRESENTING THE TWO DEGREE TARGET IN DURBAN

In December a total of 11.000 delegates and lobbyists travelled to Durban, South Africa to attend the 17th Conference of the Parties (COP17) to the United Nations Framework Convention on Climate Change (UNFCCC). In addition to the negotiations taking place, the COP-meetings is an annual meeting point for politicians, NGOs, media, business, scientists and other organizations. What they have in common is an interest for climate change, mitigation and adaptation.

The conference area is like an ants nest where the negotiations rooms are surrounded by a great activity of side events. At the side events, people representing different views come together to discuss various problems and solutions. The BCCR had a group of three persons in Durban, where our intention was to contribute with science-based information on future and present climatechange, and to be available for journalists, politicians and NGOs to provide science based comments to the negotiations.

The BCCR had prepared a short presentation of the latest results from the Norwegian Earth System Model with focus on the mitigation that is required in order to stabilize global warming below two degrees above pre-industrial levels. . The simulations presented are the ones that are contributed to the IPCCs 5th Assesment Report. Attending our presentation was Erik Solheim, the Minister of Environment and Development, along with a group of thirty Norwegian politicians, NGOs and media. This mix of audience showed to be a good combination, as the presentation was followed by interesting discussions and questions. The BCCR was also invited by the Norwegian environmental organization Bellona to hold the presentation in their side events. The presentation in the Bellona room was streamed online, and is available in their web-archives.

Facsimile Bergens Tidende 07.12.2011

Facisimile Dagens Næringsliv 19.11.2011

The big question of the COP17 was the faith of the Kyoto Protocol which came to its end first of January 2012. Two days into overtime, the European Union and several other countries agreed to continue the Kyoto Protocol during a new negotiation period until 2015. According to the two degree target, the result of the negotiations in Durban has left the world with serious challenges. Quoting a press release by UNEP at 11. December: "The key question of the Durban outcome is whether what has been decided will match the science and lead to a peaking of global emissions before 2020 to maintain the world on a path to keep a temperature increase below 2° Celsius."

CLIMATE EDUCATIONAL FILMS

On December 6th 2011, the Norwegian national broadcaster NRK showed a 30-minute program "Landskapsgrublerier" (musings on how the landscape was formed). The film follows the Bjerknes professors Atle Nesje and Svein Olaf Dahl on a fieldtrip with students in geology and physical geography. We follow the group from the Kråkenes lighthouse at the outermost part of the western fjords, and eastwards were glaciers and ice sheets have shaped the spectacular fjord landscape. The trip continues further east to Rondane where the students experienced the different impact the last ice sheet had on the landscape in western and eastern Norway. Whereas the glaciers in the west are termed "warm" or temperate, eroding their way into the bedrock, the ice sheet in the east was cold based or frozen to the ground and therefore did not significantly erode the bedrock underneath. We follow the students to a geologically confusing area in eastern Norway, where the ice sheet during the last ice age melted in a completely different pattern than further to the west. In western Norway, the ice sheet melted away by frontal retreat of numerous fjord and valley glaciers, whereas in the east the ice sheet melted vertically from the top. The program shows frustration and joy when the students are mapping deposits from the last ice age on their own and in smaller groups.

The film production company Snöball Film has specialised on educational movies, and was in 2011 shooting for a film series on climate. In December the shooting ↘

Tore Furevik and Eystein Jansen at the BCCR presentation in Durban. Minister Erik Solheim was among the listeners. Photo: Gudrun Sylte

Pupils and Marianne Petersen at IMR is measuring ph during the illustative experiment on ocean acidification. Photo: Gudrun Sylte

was in Bergen, were professor Asgeir Sorteberg explained the different components of a climate model and how it can be used in climate research. PhD student Helene Frigstad talked about ocean acidification and the potential effects of reduced buffer capacity on the oceanic uptake of atmospheric CO_2. The film series is available on the website Klimafilm.no. The production is a cooperation between Snöball Film, Cicero Center for Climate Research and the national Climate and Pollution Agency.

Snöball Film has also produced an interactive animation for the Bjerknes Center during 2011. This is an interactive presentation of future scenarios on earth temperature and emissions of greenhouse gases. The multimedia animation is available on the Bjerknes Centre web site, and has also been distrubuted on DVD to schools in Hordaland via the Centre for Science Education at the Departent of Mathematics and Natural Sciences.

OCEAN ACIDIFICATION AT THE NORWEGIAN SCIENCE WEEK

This year at the annual Norwegian Science Week the BCCR had a stand at the "Science Fair" in collaboration with the Institute of Marine Research (IMR). The topic was ocean acidification, where the pupils and audience took part in an interactive experiment which illustrated the natural and perturbed marine carbon cycle. It was illustrated that marine organisms which uses carbon for building skeleton and shells will have a hard time in a world with pronounced acidification from increased amount of carbon dioxide absorbed by the ocean.

During the Science Week many talks, discussions and experiments were presented from institutions all over Bergen. On Saturday Kafe Sanaa was the spot for short popular talks. Among six scientists from various fields Michel d.S Mesquita from the BCCR held his talk "Curiosity Matters" on global warming and the challenges of climate modelling.

Atle Nesje and the NRK-team. Photo: Henriette Linge.

Michel d. S. Mesquita held his talk "Curiosity Matters" at Kafe Sanaa during the Science Week. Photo: Gudrun Sylte

Marie Hauge and Ann-Lisbeth Agnalt are showing and explaining at the Bjerknes/IMR stand on ocean acidification at the Science fair. Photo: Gudrun Sylte

NEW INITIATIVES, EDUCATION AND COOPERATION

Tora Aasland, Minister of Higher Education and Research officially opening SKD. Photo: Kim Andreassen, UiB.

Relaxing ACDC summer school students at Friday Harbor Laboratories, USA. Photo: David Battisti.

KICK-OFF FOR SKD

On the first of December, Tora Aasland, the Minister of Higher Education and Research, marked the official opening of the new Centre for Climate Dynamics at the Bjerknes Centre (SKD). The seven new research projects within SKD had already had their early kick-off in May. The new projects follow the main research topics in the SKD: Natural and anthropogenic climate change, Process understanding and uncertainties, Regionalization and extremes, Climate sensitivity and thresholds, Past and future changes in sea level, Carbon cycle and the marine ecosystem.

SKD was established as an accomplishment of the success of the Bjerknes Center for Climate Research since its inception as a national centre of excellence in 2002. The SKD will have a 12 years funding horizon, with a midterm evaluation. The four partners of the BCCR, the IMR, NERSC, UiB and Uni Research will continue in the SKD.

ADVANCED CLIMATE DYNAMICS COURSE (ACDC)

In early September, a group of 21 advanced graduate and PhD students gathered to the third ACDC summer school, at Friday Harbor Laboratories northwest of Seattle in Washington, USA. The students represented 11 different nationalities, for two weeks focusing on this years topic: Dynamics of past warm climates using both models of varying complexity and proxy records. The first week gave an introduction to the dynamics of the climate system and an overview of proxy data for past warm climates, outlining open questions regarding constraints and uncertainties. The second week the schedule was adjusted to fill in gaps in the information that had arisen during the first week. The summer school also included three excursions evenly distributed over the two weeks: Whale and wildlife watching in the San Juan Islands, and a whole day sea kayaking at the San Juan Islands. The final trip was an extended lunch break to English Camp on the western side of San Juan Island. This gave the participants an opportunity for relaxing in the park, going swimming in the ocean, hiking around the area and up to the peak of Mount Young. The Advanced Climate Dynamics Courses are coordinated by the Partnership program in climate between the Bjerknes Centre, the University of Washington in Seattle, and the Massachusetts Institute of Technology in Cambridge. They are also activities under the Norwegian Research School in Climate Dynamics.

ResClim summer school students exploring Svalbard. Photo: Juni Vaardal-Lunde, UNIS.

RESCLIM SUMMER SCHOOL IN LONGYEARBYEN, SVALBARD

The ResClim summer school "The Role of Sea Ice in the Climate System" was arranged at the University Centre in Svalbard (UNIS), Longyearbyen, Svalbard, for two weeks in June-July. The main focus was to provide an increased insight into sea ice properties, processes and the interplay between the sea ice and the climate system for PhD students and scientist within climate sciences. The summer school also acts as a meeting place to encourage increased interdisciplinary research and cooperation. Out of 72 applicants, 50 students were admitted to participate. These students represents 16 different nationalities. The summer school also gathered 18 lecturers from institutions in Norway, UK, Germany, Sweden, USA, Belgium and Denmark. All participants had to give either an oral presentation or present a poster during the summer school. In the organised discussion "Tipping points for the Arctic sea ice", the students were split into groups were each group had to find evidence either for or against that tipping points exist, and argue for their view in a plenum discussion. Despite an extensive programme, the students had time to explore Longyearbyen and the area around. There were also an organised trip to Pyramiden, an old Russian mining town. The Norwegian Research School in Climate Dynamics (ResClim) is a national project funded by the Norwegian Research Council which involves all major national institutes educating PhD students within the physical and chemical components of the climate system.

COOPERATION IN SOUTH ASIA AND SOUTH AFRICA

While the Bjerknes Centre traditionally has had its main research concentration in the northern regions, the research area through 2011 was expanding to Asia and South Africa. In June 2011 the collaboration partners from Thailand and Bangladesh came to Bergen and the Bjerknes Centre for a project visit. Along with the project visit, Atiq Rahman, director for the Bangladesh Centre for Advanced Studies (BCAS) had a guest lecture at the Bjerknes Centre. Rahman visited Bergen together with Abu Syed from BCAS, and Rattakul Bhichit, the director for Asian Disaster Preparedness Center (ADPC) in Bangkok.

Additionally a new Memorandum of Understanding (MOU) has been signed between the Bjerknes Centre and ACCESS (Applied Center for Climate and Earth Systems Science) in South Africa. The MOU was signed on 6th December 2011, at the ACCESS side event of the 17th Conference of the Parties (COP17) in Durban. The MOU is named "Capacity Building for Studying Global Climate and Earth System Changes, with emphasis on Southern Africa and adjacent oceans". ↘

In front left: Michel d.S. Mesquita (BCCR), Abu Syed (BCAS), Eystein Jansen (Director, BCCR) and Atiq Rahman (Director, BCAS). Back left: Tore Furevik (BCCR), Birgit Falch (BCCR) and Rattakul Bhichit (Director, ADPC). Photo: Gudrun Sylte.

PhD DISSERTATIONS 2011

BCCR scientists provided supervision and traning in climate research to 25 doctoral students during 2011. The following PhD dissertations were defended:

Eivind Støren (UiB)
"Identifying flood deposits in lake sediments - Changing frequencies and potential links to long-term climate change"

Iselin Medhaug (UiB)
"North Atlantic multidecadal variability in coupled climate models – Mechanisms and responses."

Helene Langehaug (UiB & NERSC)
"Circulation and transformation of Atlantic and Arctic water masses in climate models"

Kristin Richter (UiB)
"Influence of the atmosphere on North Atlantic - Nordic Seas ocean circulation"

Marius Årthun (UiB)
"Water mass transformations and air-sea exchange in the Barents Sea"

Muralidhar Adakudlu (UiB & Uni Research)
"Severe mesoscale weather events over the Nordic Seas: Numerical modelling and sesitivity experiments."

Ole Segtnan (UiB)
"Computing ocean budgets and transports in the Nordic seas from direct and indirect methods"

Sara de la Rosa (UiB & NERSC)
"Temporal changes of sea ice affected by waves and thermal forcing'

Siv Kari Lauvset (UiB)
"Water mass transformations and air-sea exchange in the Barents Sea"

Stephanie Mayer (UiB)
"Application and improvement of the Unmanned Aerial System SUMO for atmospheric boundary layer studies"

Svetlana Milutinovic (UiB & NERSC)
"The influence of input uncertainties on remotely sensed estimates of ocean primary productivity"

Signing of the MOU at the ACCESS side event at COP17 in Durban, December. From left Eystein Jansen, BCCR and Dr. Jimmy Adegoko, Director of ACCESS, South Africa.

Asgeir Sorteberg as best lecturer 2011. Photo: Kristin Svartveit

PROFESSOR ASGEIR SORTEBERG AWARDED BEST LECTURER

Every year the student board of the Faculty of Mathematics and Natural Sciences selects the Faculty's best lecturer based on student nominations. This year the prize was awarded Bjerknes scientist and newly appointed professor at the Geophysical Institute, Asgeir Sorteberg. In the announcement, the jury emphasised Sortebergs commitment to students: He is always available for students eager to learn, even though the questions they ask may be outside the field he is teaching. He also takes time to make sure everyone follows what he is teaching. Asgeir Sorteberg was honoured to receive the prize.

– This prize is very inspiring. At the University, we are usually not awarded for teaching, only for doing research. But research-based teaching is very important for the future of the University, he declared to the Bjerknes Times in October.

100 participants in the NorWRF workshop gathered in front of Vitensenteret. Photo: Gudrun Sylte.

INTERNATIONAL MEETINGS AND ENGAGEMENTS

KICK-OFF FOR CARBOCHANGE

"Changes in carbon uptake and emissions by oceans in a changing climate" This is the long version of the new EU-project CarboChange, coordinated by professor Christoph Heinze of the Bjerknes Centre. The project brings together over 100 scientists from 28 institutions in 15 countries, and representatives from 28 international partner institutions gathered in Bergen in March 2011 to set the project off to a good start. The overall goal is to determine quantitatively the role of the ocean in the uptake of human-produced carbon dioxide, to investigate how large this uptake rate has been in the past, how it is changing at present, and how it will evolve in the future. This is essential knowledge to assess the expected consequences of rising atmospheric CO_2 concentrations and to guide the management of CO_2 emission reductions.

THE FAST GROWING NORWRF-WORKSHOP

In September, BCCR hosted the NorWRF workshop on regional climate modeling for the second time. And the number of participants had dramatically increased – the size was twice that of 2010. 100 participants from 17 countries (Bangladesh, China, Croatia, Denmark, Ethiopia, Finland, France, Germany, Greece, Iceland, India, Japan, Norway, Spain, Sweden, UK, USA) travelled to Bergen for a week of knowledge sharing. The workshop was peppered with key speakers from different atmospheric modelling fields, with emphasis on regional climate modelling, customers/societal demands and wind energy related topics. In addition to the many presentations, a poster session provided the opportunity for young scientists to present their recent work. The NorWRF workshop was also accompanied by social activities, such as a dinner at Bryggenloftet, a concert with the Bergen Philharmonic Orchestra at Grieghallen and a "Norway in a Nutshell" round trip on Friday.

WRF WORKSHOP IN THAILAND

In October, Bjerknes Scientists travelled to Bangkok, to teach at the Asian Disaster Preparedness Center's (ADPC) Bjerknes WRF-Workshop. The National Center for Atmospheric Research (NCAR) in Boulder, Colorado also participated and sent a number of the WRF model developers to describe and encourage use of the model. The workshop was part of a capacity building effort in the Southeast Asian region that aims to boost the capabilities of the regional meteorological agencies and open channels of communication between local researchers/forecasters and their counterparts in Europe and North American. China, Myanmar, Vietnam, Bangladesh, Nepal and Thailand were all represented and brought their own unique experiences to the group. The purpose of this particular workshop was to introduce users to an advanced regional weather and climate model (WRF) and gain some hands-on experience with the model.

THREE ANNUAL MEETINGS IN ONE WEEK

The last week in November was hectic, with three international programmes and projects concerned with North Atlantic and Arctic climate having their annual meetings in Bergen. It started with SubPolar Atlantic - Climate and Ecosystems (SPACE) hosted by IMR on Monday, continued with Arctic/Subarctic Ocean Fluxes (ASOF) hosted by GFI on Tuesday, and ended with the EU-project Thermohaline Overturning – at Risk? (THOR) that had its annual meeting at Rica Hotel Bergen. All participants joined forces Wednesday for the lively (and crowded; 80 participants from

From April through June PhD students Tao Wang (left) and Feifei Luo in the DecCen project visited the Bjerknes Centre, working with modelling and climate teleconnection issues. Photo: Gudrun Sylte

10 countries) workshop Observed North Atlantic/Arctic Ocean climate variability and its predictability. The workshop was most timely for two reasons. Key European groups now have climate prediction systems at work, and climate predictability is a key activity in the start-up of the Center of Climate Dynamics (SKD) at the Bjerknes Centre (the workshop's local host). The most recent developments – including simulations that will be part of the next IPCC assessment – were presented, and accordingly challenged by the participants more rooted in the observational record.

FINAL EUROMARC CONFERENCE IN PORTUGAL

In February, Bjerknes Scientists travelled to Portugal to participate in the official conclusion of the European Research Programme EuroMARC (European Collaboration for Implementation of Marine Research on Cores). This project on challenges of Marine Coring Research provided a framework for the acquisition of key cores from the marine realm from all over the world. It promoted collaboration across both geographic and scientific boundaries. One of its main virtues was that it was researcher-driven. Its projects spanned a diversity of topics from ultraslow spreading ridges and their biospheres to newly discovered carbonate mounds and their role in the global carbonate budget; from the timing and course of sea level rise during the last deglaciation to processes that underlie switches between greenhouse and icehouse worlds. While the programme itself was officially concluded, some of its projects, such as RETRO and AMOCINT, are still ongoing. The former focuses on the tropical Atlantic surface and intermediate waters and investigates their response to changes in meridional overturning circulation. The latter aims at reconstructing Atlantic meridional overturning circulation during interglacials.

GUEST RESEARCHERS AT THE BJERKNES CENTRE

BCCR sponsors a Visiting Fellows Programme as one of several arrangements that aims at fostering international research collaboration in climate change. In 2011, the Centre hosted in total 8 scientists. This included 1 from Russia, 1 from Italy and six scientists from USA.

In addition, a large number of visiting researchers and PhD students related to collaborative projects come to visit. In April, the DecCen project had its annual meeting in Beijing, China with a group of Bjerknes Scientists present. DecCen is a a joint Norwegian- Chinese project funded by the Research Council of Norway, with about 15 people involved from Bergen, Beijing and Lanzhou. As part of the project, four Chinese PhD students have funding through the project to visit the Bjerknes Centre three months every year.

ENGAGEMENTS 2011

IPCC: 5th Assessment report: Prof. Eystein Jansen and Prof. Svein Sundby are Lead Authors in Working Group1 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: Prof. Asgeir Sorteberg is a Lead Author.

RCN Norway-India Programme Advisory Commitee: Prof. Eystein Jansen is a member.

ECRA – European Climate Research Alliance – Prof. Eystein Jansen is member of the executive steering committee.

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

ECO_2: Prof. Christoph Heinze is a member of the Scientific Advisory Board of the EU FP7 project "Sub-seabed CO_2 Storage: Impact on Marine Ecosystems" (ECO_2)

CARBONES: Prof. Christoph Heinze is a member of the Scientific Advisory Board of the EU FP7 project " 30-year re-analysis of CARBON fluxES and pools over Europe and the Globe" (CARBONES)

COST Senior Scientist Svein Østerhus is a member of the EU COST action project Everyone's Gliding Observatories Management Committee.

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

International Ocean Carbon Coordination Project (IOCCP). Are Olsen is a scientific steering committee member.

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

Surface Ocean CO_2 Atlas (SOCAT): Benjamin Pfeil and Are Olsen are members of the Global Coordination Group.

National Platform for Ocean Research, Hav21, issued by the Norwegian Ministry of Fisheries and coastal affairs: Prof. Helge Drange is a member.

Steering Committee on Climate Change in the Canary Current Large Marine Ecosystem (CCLME): Prof. Svein Sundby is a member of the Steering Committee (under FAO).

European CoOperation in Science and Technology (COST) - Action 735 "Tools for assessing global air-sea CO_2 fluxes of climate and air pollutant relevant gasses". Dr. Abdirahman M. Omar was a member of working group 3 in 2006-2011. He has also served as a deputy member in the 735 Action management Committee.

Norwegian Geophysical Society: Is the national society for Norwegian scientists within meteorology, oceanography, hydrology, earth physics, ionosphere physics and vulcanology, and its aim is an improved collaboration within the geophysical sciences. The society is also a connection point to the members' international associations and unions, such as IUGG and EGU. J. Even Ø. Nilsen is a member of the board.

Global Climate Forum: BCCR is a member of the Global Climate Forum (GCF), a non-profit organization located at PIK in Potsdam, Germany. GCF 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 the 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 CARBOCHANGE, coordinated by Prof. Christoph Heinze, was endorsed by the IGBP/SCOR sponsored projects SOLAS and IMBER.
- Surface Ocean Lower Atmosphere Study (SOLAS). Prof. Christoph Heinze is a member of the SSC. Dr. Abdirahman M. Omar is the Norwegian National Representative.
- 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 a member of the scientific advisory boards of IC3-Climate Centre, Barcelona.
- Helge Drange is on the advisory board of MARUM, University of Bremen

ORGANISATION AND FINANCES 2011

THE DIRECTOR AND THE LEADER FORUM

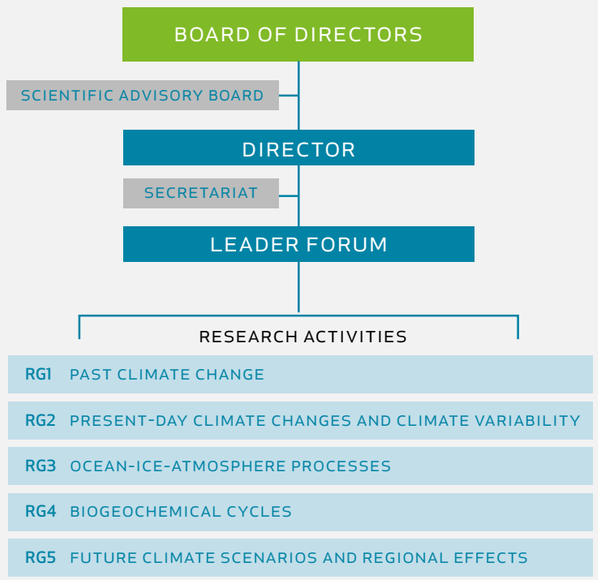
The Director and the Research Group Leaders are key members of the Leader Forum, which deals with scientific and professional issues.

Eystein Jansen	Professor (Director) Paleoclimatology, Uni Research/UiB
Kerim Nisancioglu	Scientist, Paleoclimatology, Uni Research
Helga F. Kleiven	Scientist, Paleoclimatology, UiB/ Uni Research
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
Gudrun Sylte	Head of Communication, Uni Research
Lars Fagerli	Financial officer, Uni Research
Beate Klementsen	HR manager, Uni Research

RESEARCH GROUPS

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

		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)



Rijpfjorden, the most northen fjord of Svalbard at Nordaustlandet (North East Land), summer 2011. Photo: Anna Silyakova.

Bergen by night. Photo: Jerry Tjiputra

THE BOARDS

BOARDS 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)
Lennart Bengtsson	Max Plank Institute for Meteorology, Germany
Raymond Bradley	Climate System Research Center, University of Massachusetts, USA
Øystein Hov	Norwegian Meteorological Institute, Norway
Jerry McManus	Woods Hole Oceanographic Institution, USA
Peter Rhines	Dept. of Oceanography, University of Washington, Seattle, USA
Rowan Sutton	Centre of Global Atmospheric Modelling, University of Reading, UK
John Walsh	International Arctic Research Centre, University of Alaska, Fairbanks, USA
Andrew Watson	School of Environmental Sciences, University of East Anglia, UK

FUNDING & EXPENSES

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 20 projects funded by the Research Council of Norway, with BCCR scientists leading 17 of these projects. Eleven ongoing projects are funded by the 7th Framework Program of the European Commission, of which BCCR coordinates two of the projects. Eight projects are funded by other sources. BCCR also coordinates two of the six multinational projects that were funded within the European Science Foundation ESF-Eurocores 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 institutions, including the University of Bergen, the Nansen Environmental and Remote Sensing Center and the Institute of Marine Research.

FUNDING

	(1000 NOK)
The Research Council of Norway, CoE	17 000
The Research Council of Norway, other projects	12 579
University of Bergen	21 587
Nansen Environmental and Remote Sensing Center	1 372
Institute of Marine Research	4 118
EU projects	8 503
Other private funds	3 563
Other public funds	2 748
Total funding	71 470

EXPENSES

	(1000 NOK)
Salaries and building rental costs	49 096
Research equipment	561
External research services	4 382
Other costs	12 752
Total expenses	66 791

STAFF

SCIENTISTS

Jürgen	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	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
Paul	Budgell	Canada	IMR	Ocean modelling development
Knut Yngve	Børsheim		IMR	Marine biology, biogeochemistry
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	Ocean processes & modelling
Igor	Esau	Russia	NERSC	Environmental boundary layers
Ilker	Fer	Turkey	UiB	Ocean processes
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
Emil	Jeansson	Sweden	Uni Research	Chemical oceanography
Eystein	Jansen		Uni Research	Palaeoclimatology
Truls	Johannessen		UiB	Biogeochemistry
Hans Arnfinn	Karlsen		UiB	Biogeochemistry
Helga Flesche	Kleiven		UiB	Palaeoclimatology
Nils Gunnar	Kvamstø		UiB	Atmospheric modelling
Petra	Langebroek	The Netherlands	Uni Research	Paleoclimatology and modelling
Siv Kari	Lauvset		Uni Research	Chemical oceanography
Camille	Li	Canada	UiB / Uni Research	Atmospheric dynamics and paleoclimate
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
Gisle	Nondal		Uni Research	Chemical oceanography
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
Stephen	Outten	UK	Uni Research	Regional climate modelling
Kristin	Richter	Germany	Uni Research	Ocean dynamics
Bjørg	Risebrobakken		Uni Research	Palaeoclimatology
Anne Britt	Sandø		IMR	Ocean 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
Stefan	Sobolowski	USA	Uni Research	Atmospheric modelling and dynamics
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
Zhongshi	Zhang	China	Uni Research	Paleoclimatology and modelling
Svein	Østerhus		Uni Research	Physical oceanography
Bjørn	Ådlandsvik		IMR	Physical oceanography and modelling

POSTDOCS

Jon	Bergh	Sweden	NERSC	Meteorology, oceanography
Elin Darelius	Chiche	Sweden	UiB	Polar oceanography
Mirjam	Glessmer	Germany	UiB	Climate dynamics
Nadine	Goris	Germany	UiB	Chemical oceanography
Caroline	Roelandt	Belgium	UiB	Terrestrial biogeochemical modelling
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
Yu	Lei	China	UiB	Atmospheric modelling and dynamics

PhD STUDENTS

Muralidhar	Adakudlu	India	UiB	Atmospheric modelling
Roohollah	Azad	Iran	UiB	Regional atmospheric modelling
Ingo	Bethke	Germany	Uni Research	Ocean modelling
Giulio Nils	Caroletti	Italy	UiB	Regional climate change
Vivian Astrup	Felde		Uni Research	Terrestrial plant biodiversity
Helene	Frigstad		UiB	Impacts of ocean acidification
Eirik	Galaasen		UiB	Palaeoclimatology
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
Tor L.	Mjell		UiB	Paleoclimatology
Mari	Myksvoll		IMR	Marine ecosystem effects
Gunn Elisabeth	Olsen		UiB	Atmospheric dynamics
Roshin	Raj	India	UiB	Ocean dynamics
Kristin	Richter	Germany	UiB	Ocean dynamics
Anna	Silyakova	Russia	Uni Research	Biogeochemistry
Eivind Wilhelm Nagel	Støren		UiB	Palaeoclimatology
Andrea	Tegzes	Hungary	Uni Research	Palaeoclimatology
Amandine	Tisserand	France	UiB / Uni Research	Palaeoclimatology
Kristian	Vasskog		UiB	Extreme weather events in the past
Ingelinn	Aarnes		UiB / Uni Research	Vegetation reconstruction
Marius	Årthun		UiB	Ocean modelling

TECHNICAL STAFF

Christian	Baldersheim		UiB	Palaeoclimatology
Dag Inge	Blindheim		Uni Research	Palaeoclimatology
Dagfinn	Bøe		Uni Research	Palaeoclimatology
Tor	de Lange		UiB	Chemical oceanography
Lillian	Elvik		Uni Research	Palaeoclimatology
Ole Magnus	Gjervik		IMR	Oceanography
Martin	Granerød		Uni Research	Regional climate modelling
Odd Reidar	Hansen		UiB	Palaeoclimatology
Ingeborg	Helvik		Uni Research	Paleobotany
Espen	Karlsen		Uni Research	Meteorology, oceanography
Solveig	Kringstad		UiB	Chemical oceanography
Bjørn Christian	Kvisvik		Uni Research	Palaeoclimatology
Lea Toska	Oppedal		Uni Research	Palaeoclimatology
Ronald	Pedersen		IMR	Oceanography
Benjamin	Pfeil	Germany	Uni Research	Data manager
Kjersti Opstad	Strand		Uni Research	Physical oceanography
Rune Egil	Søraas		Uni Research	Palaeoclimatology
Jørund	Strømsøe		Uni Research	Palaeoclimatology
Aslaug Skålevik	Valved		Uni Research	Meteorology, oceanography

ADMINISTRATION

Beatriz	Balino		UiB	Research coordinator
Lars	Fagerli		Uni Research	Financial officer
Birgit	Falch		Uni Research	Research coordinator
Kim-André	Herøy		Uni Research	Senior Secretary
Jill	Johannessen		Uni Research	Head of Communication
Lill Tåve	Jørgensen		Uni Research	Secretary
Beate	Klementsen		Uni Research	HR Manager
Charla Melander	Olsen	USA	Uni Research	Administrative consultant
Kristin	Svartveit		Uni Research	Administrative consultant
Gudrun Urd	Sylte		Uni Research	Head of communication
Andrea	Volbers	Germany	Uni Research	Researcher

Open-topped perspex chambers are widely used in ecology to simulate effects of climate warming. Here from a workshop in Abisko, Swedish Lapland. Photo: Hilary Birks.

PERSONELL SUMMARY

Category	Person-years
Scientists	30,3
Postdocs	6,0
PhD students	14,0
Technicians	10,0
Administration	8,0
Total	68,3

STAFF BY PARTNER INSTITUTION

Number of scientific personell, sorted by category and partners.

Category	Uni Research	UiB	IMR	NERSC	Total	Non-Norwegian (%)	Female (%)
Scientists	33	24	12	4	73	40	24
Postdocs	0	9	0	2	11	82	45
Ph.D students	7	15	2	1	25	44	56
Total					109		

STAFF BY NATIONALITY

The Bjerknes Centre recruits personell internationally. In 2011, 21 nationalities were represented at the BCCR.

Country	#personell
Brazil	1
Belgium	2
Canada	4
China	4
Finland	1
France	2
Germany	11
Hungary	1
India	2
Indonesia	1
Iran	1
Italy	1
Japan	1
Norway	87
The Netherlands	1
Russia	2
Somalia	1
Sweden	4
Turkey	2
UK	5
USA	5
Total	**139**

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)	2008–11	A. Olsen*
Marine Ecosystem Response to a changing Climate (MERCLIM)	2008–11	R. Bellerby*
Arctic records of climate change – dynamics, feedbacks and processes (ARCTREC)	2007–11	E. Jansen*
Assessment of human impact on the marine Carbon system in arctic regions (A-CARB)	2007–11	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**
Response of tropical Atlantic surface and intermediate waters to changes in the Atlantic meridional overturning circulation (RETRO)	2007–11	T. Dokken*
The effect of climate change on Arctic high-impact weather events (ArcChange)	2007–11	I. Barstad**
Norwegian component of the Ecosystem Studies of Subarctic and Arctic Regions (NESSAR)	2007–11	K. Drinkwater*
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*
Biotic response to climate change in cold climates (BIOCOLD)	2010–13	A. Bjune*
An Integrated Earth System Approach to Explore Natural Variability and Climate Sensitivity (EARTHCLIM)	2011–13	H. Drange*
Impact of Blue Arctic on Climate at High Latitudes (BLUEARC)	2011–13	Y. Gao*
North-Atlantic Ocean- Climate Variability in a Warmer World (NOCWARM)	2011–13	H.F. Kleiven*
Terrestrial biodiversity through time - novel methods and their applications (LAND)	2011–13	A. Bjune*

Projects funded by the 7th Framework Program 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
Development of global plankton data base and model system for eco-climate early warning (GREENSEAS)	2010–13	IP ■	J. Johannessen
Basin-scale Analysis, Synthesis and Integration (EUROBASIN)	2010–14	IP ◆	R. Bellerby
Enabling CLimate Information Services for Europe (ECLISE)	2011–14	IP ◆	N.G. Kvamstø
Changes in Carbon uptake and emissions by oceans in a changing climate (CARBOCHANGE)	2011–15	IP ■	C. Heinze
Quantifying projected impacts under 2°C warming (IMPACT2C)	2011–15	IP ◆	M. Mesquita dos Santos

BCCR is ■ Coordinator or ◆ Partner. BONUS+: Joint Baltic Research Program

Projects funded by other sources

TITLE	Duration	Leader/ Scientist	Funding source
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	SIU
Paleoclimate in the Southern Ocean	2004–13	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	KLIF

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SELECTED PUBLICATIONS

Bjerknes researchers published 118 articles in international peer reviewed journals in 2011.
For a complete listing, please visit www.bjerknes.uib.no/publications. Bjerknes scientists are indicated in **bold**.

1. **Adakudlu, Muralidhar; Barstad, Idar.**
Impacts of the ice-cover and sea-surface temperature on a polar low over the Nordic seas: a numerical case study. *Quarterly Journal of the Royal Meteorological Society* 2011 ;Volume 137.(660) s. 1716-1730.
2. **Bader, Jürgen; Mesquita, Michel D Santos;** Hodges, Kevin I.**; Keenlyside, Noel; Østerhus, Svein; Miles, Martin W..**
A review on Northern Hemisphere sea-ice, storminess and the North Atlantic Oscillation: Observations and projected changes. *Atmospheric research* 2011 ;Volume 101.(4) s. 809-834
3. **Bernard, Christophe Yves;** Dürr, H. H.**; Heinze, Christoph;** Segschneider, J.; Maier-Reimer, E..
Contribution of riverine nutrients to the silicon biogeochemistry of the global ocean - a model study. *Biogeosciences* 2011 ;Volume 8.(3) s. 551-564
4. **Born, Andreas; Nisancioglu, Kerim Hestnes; Risebrobakken, Bjørg.** Late Eemian warming in the Nordic Seas as seen in proxy data and climate models. *Paleoceanography* 2011; Volume 26.
5. Collins, James A.**;** Schefuss, Enno; Heslop, David; Mulitza, Stefan; Prange, Matthias; Zabel, Matthias; Tjallingii, Rik; **Dokken, Trond Martin**; Huang, Enqing; Mackensen, Andreas; Schulz, Michael; Tian, Jun; Zarriess, Michelle; Wefer, Gerold.
Interhemispheric symmetry of the tropical African rainbelt over the past 23,000 years. *Nature Geoscience* 2011; Volume 4.(1) s. 42-45
6. **Darelius, Elin Maria K.; Fer, Ilker;** Quadfasel, Detlef.
Faroe Bank Channel Overflow: Mesoscale Variability. *Journal of Physical Oceanography* 2011 ;Volume 41.(11) s. 2137-2154
7. **Drinkwater, Kennneth F.**
The influence of climate variability and change on the ecosystems of the Barents Sea and adjacent waters: Review and synthesis of recent studies from the NESSAS Project. *Progress in Oceanography* 2011 ;Volume 90.(1-4) s. 47-61
8. **Feifei, Luo; Shuanglin, Li; Furevik, Tore.**
The connection between the Atlantic Multidecadal Oscillation and the Indian Summer Monsoon in Bergen Climate Model Version 2.0. *Journal of Geophysical Research - Atmospheres* 2011 ;Volume 116.
9. Govin, Aline; Braconnot, P.; Capron, E.; Cortijo, E.; Duplessy, J.C.; **Jansen, Eystein;** Labeyrie, L.; Landais, A.; Marti, O.; Michel, E.; Mosquet, E.; **Risebrobakken, Bjørg;** Swingedouw, D.; Waelbroeck, C.. Persistent influence of ice sheet melting on high northern latitude climate during the early Last Interglacial. *Climate of the Past Discussions* 2011 ;Volume 7. s. 3239-3286
10. **Jeansson, Åke Emil; Olsen, Are; Eldevik, Tor; Skjelvan, Ingunn; Omar, Abdirahman; Lauvset, Siv Kari; Nilsen, Jan Even Øie; Bellerby, Richard; Johannessen, Truls; Falck, Eva.** The Nordic Seas carbon budget: Sources, sinks, and uncertainties. *Global Biogeochemical Cycles* 2011 ;Volume 25. s. -
11. **Kleiven, Helga Flesche;** Hall, Ian R.; McCave, Ian Nicholas; Knorr, Gregor; **Jansen, Eystein.**
Coupled deep-water flow and climate variability in the middle Pleistocene North Atlantic. *Geology* 2011 ;Volume 39.(4) s. 343-346
12. **Kolstad, Erik Wilhelm**; Charlton-Perez, Andrew**.** Observed and simulated precursors of stratospheric polar vortex anomalies in the Northern Hemisphere. *Climate Dynamics* 2011 ;Volume 37.(7-8) s. 1443-1456
13. **Kvamstø, Nils Gunnar;** Steinskog, Dag Johan; Stephenson,, David; Tjøstheim, Dag Bjarne. Estimation of trends in extreme melt-season duration at Svalbard. *International Journal of Climatology* 2011
14. **Langehaug, Helene R.; Medhaug, Iselin; Eldevik, Tor; Otterå, Odd Helge.** Arctic/Atlantic exchanges via the Subpolar Gyre. *Journal of Climate* 2011
15. **Lauvset, Siv Kari;** McGills, Wade R.; Bariteau, Ludovic; Fairall, C.W.; **Johannessen, Truls; Olsen, Are;** Zappa, Christopher J..
Direct measurements of CO_2 flux in the Greenland Sea. *Geophysical Research Letters* 2011 ;Volume 38.
16. Lloyd, Jeremy M.; Moros, Matthias; Perner, Kerstin**; Telford, Richard;** Kuijpers, Antoon; **Jansen, Eystein;** McCarthy, David**.**
A 100 yr record of ocean temperature control on the stability of Jakobshavn Isbrae, West Greenland. *Geology* 2011; Volume 39.(9) s. 867-870
17. **Mangerud, Jan**; Richard Gyllencreutz; **Øystein Lohne and John Inge Svendsen** (2011): Chapter 22 - Glacial History of Norway, *Developments in Quaternary Science*. Vol. 15, doi: 10.1016/B978-0-444-53447-7.00022-2
18. **Medhaug, Iselin; Furevik, Tore.**
North Atlantic 20th century multidecadal variability in coupled climate models: Sea surface temperature and ocean overturning circulation. *Ocean Science* 2011 ;Volume 7.(3) s. 389-404

Sollien, Bergen. Photo: Jerry Tjiputra.

19. **Medhaug, Iselin; Langehaug, Helene Reinertsen; Eldevik, Tor; Furevik, Tore; Bentsen, Mats.** Mechanisms for decadal scale variability in a simulated Atlantic Meridional Overturning Circulation. *Climate Dynamics* 2011
20. Mohino, Elsa; Janicot, Serge; **Bader, Jürgen**. Sahel rainfall and decadal to multi-decadal sea surface temperature variability. *Climate Dynamics* 2011 ;Volume 37.(3-4) s. 419-440
21. **Opdal, Anders Frugård; Vikebø, Frode Bendiksen;** Fiksen, Øyvind. Parental migration, climate and thermal exposure of larvae: spawning in southern regions gives Northeast Arctic cod a warm start. *Marine Ecology Progress Series* 2011; Volume 439. s. 255–262
22. **Orsolini, Yvan;** Kindem, Ina K. Thorstensen; **Kvamstø, Nils Gunnar**. On the potential impact of the stratosphere upon seasonal dynamical hindcasts of the North Atlantic Oscillation: a pilot study. *Climate Dynamics* 2011 ;Volume 36.(3-4) s. 579–588
23. **Pausata, Francesco S. Rocco; Li, Camille;** Wettstein, Justin; Kageyama, M.; **Nisancioglu, Kerim Hestnes.** The key role of topography in altering North Atlantic atmospheric circulation during the last glacial period. *Climate of the Past* 2011 ;Volume 7.
24. **Richter, Kristin;** Maus, Sønke. Interannual variability in the hydrography of the Norwegian Atlantic Current: Frontal versus advective response to atmospheric forcing. *Journal of Geophysical Research - Oceans* 2011 ;Volume 116.
25. **Risebrobakken, Bjørg; Dokken, Trond Martin; Smedsrud, Lars Henrik; Andersson, Carin; Jansen, Eystein;** Moros, Matthias; Ivanova, Elena V.. Early Holocene temperature variability in the Nordic Seas: The role of oceanic heat advection versus changes in orbital forcing. *Paleoceanography* 2011 ;Volume 26.
26. Roy, Tilla; Bopp, Laurent; Gehlen, Marion; Schneider, Birgit; Cadule, Patricia; Frölicher, Thomas L.; Segschneider, Joachim; **Tjiputra, Jerry; Heinze, Christoph**; Joos, Fortunat. Regional Impacts of Climate Change and Atmospheric CO_2 on Future Ocean Carbon Uptake: A Multimodel Linear Feedback Analysis. *Journal of Climate* 2011 ;Volume 24.(9) s. 2300–2318
27. Signorini, S.R.; Häkkinen, S.; Gudmundsson, K.; **Olsen, Are; Omar, Abdirahman;** Olafsson, J.; Reverdin, G.; Henson, S.A.; McClain, C.R.. The role of phytoplankton dynamics in the seasonal variability of carbon in the subpolar North Atlantic – a modeling study. *Geoscientific Model Development Discussions* 2011 ;Volume 4. s. 289–342
28. **Skagseth, Øystein; Drinkwater, Kennneth F.;** Terrile, Emanuele. Wind- and buoyancy-induced transport of the Norwegian Coastal Current in the Barents Sea. *Journal of Geophysical Research - Oceans* 2011 ;Volume 116.
29. **Sirevaag, Anders; De La Rosa, Sara; Fer, Ilker;** Nicolaus, Marcel; Tjernström, Michael; McPhee, Miles G.. Mixing, heat fluxes and heat content evolution of the Arctic Ocean mixed layer. *Ocean Science* 2011 ;Volume 7.(3) s. 335–349
30. Slimak, Ludovic; **Svendsen, John-Inge; Mangerud, Jan;** Plisson, Hugues; Heggen, Herbjørn Presthus; Brugère, Alexis; Pavlov, Pavel Yurievich. Late Mousterian Persistence near the Arctic Circle. *Science* 2011 ;Volume 332 , s. 841–845.
31. **Smedsrud, Lars Henrik; Sirevaag, Anders;** Kloster, Kjell**; Sorteberg, Asgeir; Sandven, Stein.** Recent wind driven high sea ice area export in the Fram Strait contributes to Arctic sea ice decline. *The Cryosphere* 2011 ;Volume 5, s. 821–829.
32. **Støren, Eivind Wilhelm Nagel; Kolstad, Erik Wilhelm; Paasche, Øyvind.** Linking past flood frequencies in Norway to regional atmospheric circulation anomalies. *Journal of Quaternary Science* 2011
33. **Tjiputra, Jerry; Otterå, Odd Helge.** Role of volcanic forcing on future global carbon cycle. *Earth System Dynamics* 2011, 2, s. 53–67.
34. **Vasskog, Kristian; Nesje, Atle; Støren, Eivind Wilhelm Nagel;** Waldmann, David Nicolas; Chapron, Emmanuel; Ariztegui, Daniel. A Holocene record of snow-avalanche and flood activity reconstructed from a lacustrine sedimentary sequence in Oldevatnet, western Norway. *The Holocene* 2011 ;Volume 21.(4) s. 597–614
35. **Våge, Kjetil;** Pickart, R.S.; Spall, MA; Valdimarsson, Héðinn; Jónsson, Steingrimur; Torres, Daniel J.; **Østerhus, Svein; Eldevik, Tor**. Significant role of the North Icelandic Jet in the formation of Denmark Strait overflow water. *Nature Geoscience* 2011 ; Volume 4.(10) s. 723–727
36. Zhang, Zhongshi; **Nisancioglu, Kerim Hestnes; Flatøy, Frode; Bentsen, Mats; Bethke, Ingo;** Wang, Huijun. Tropical seaways played a more important role than high latitude seaways in Cenozoic cooling. *Climate of the Past* 2011 ; Volum 7.(3) s. 801–813