Established by the Research Council of Norway

Norwegian Centre of Excellence

ANNUAL REPORT 2009

Centre of Excellence Activities

Nansen Center, Bergen

uni Research

PHOTO: TERJE HEIESTAD, MILLIMETERPRESS

A STRONG OUTLOOK

In 2009 the Bjerknes Centre consolidated its activities in the key research topics, but also followed up initiatives with several countries in Asia that were initiated last year.

2009 was a very productive year. More than ninety peer-reviewed papers were published. The number of science presentations, popular science activities and other outreach activities has been impressive.

The second version of the Bergen Climate Model saw its first published results. This is an upgrade of the model system used for climate simulations in the Intergovernmental Panel of Climate Change 2007 report. It is used for long integrations of climate variability both in pre-industrial and industrial times forced with solar, volcanic and anthropogenic drivers of climate change. We had a further strengthening of the coupling of climate modeling with paleoclimate observations, and many papers are under preparation.

The same model version was also expanded with interactive land- and ocean carbon cycle modules. Thus, we now run a full scale Earth System Model, which is a milestone for the Centre. The first results on future climates with this system were released in 2009. This created significant media attention as they show that future climates likely will reduce uptake of CO_2 in nature, thereby making it more difficult to reach stabilization targets by mitigation than indicated by the previous generation of models. Similar indications of reduced ocean uptake of CO_2 now also come from our carbon cycle observations, published in several papers.

Investigations of the inflow of warm waters from the Atlantic towards the Arctic and the counterpart towards the south of cold deep-water masses have been a key element of the centre. In 2009, we published in Nature Geoscience a novel data synthesis of the origins of the outflow that document how the outflow is generated by processes and properties of the inflow. We also had a stream of publications from field experiments on key ocean and ocean-sea-ice-atmosphere processes that are critical to such water mass transformations. I hope these studies will help improving our model skills.

New directions initiated last year were further developed in 2009. We now have our first publications on dynamical downscaling, an area which will be further developed in the future. We saw the first major project funding for the partnership with the Nansen-Zhu Centre in Beijing and partnerships are established in India, Bangladesh and Vietnam. This means that we in 2010 will have a core group of scientists working on various aspects of Asian climates.

Finally. The success of the Bjerknes Centre to have become a national knowledge resource on the climate system was rewarded in 2009, when the Government announced a long-term funding of the research competence developed through the Centre of Excellence period, with funding starting in 2010. This will give us a solid foundation to continue activities beyond the CoE period, not as a centre under the CoE scheme – but still a centre where excellent research continues to take place.

PROF. EYSTEIN JANSEN

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STATEMENT FROM THE BOARD OF DIRECTORS:

The Board is pleased to note that the Bjerknes Centre has continued its high activity in 2009 and obtained very good results. The scientific output is large and growing, the interactions with the public, stakeholders and media are also very good and is growing. The centre has evolved according to its plans and to our full satisfaction. The Bjerknes Centre constitutes an invaluable climate research and climate knowledge resource both nationally and internationally. The Board is extremely pleased that the Government has acknowedged these achievements and as a response to this development decided to support the research environment that was developed through the Centre of Excellence with a long-term funding. This secures a strong climate research centre in Bergen and ensures that this broad scientific expertise can continue and further develop in the years to come.

From December 2009 through March 2010 Bergen had unusual good skiing conditions. Picture is taken from the top of Ulriken (photo: Andreas Born, UIB/BCCR).

AN EXCELLENT RESEARCH CENTER – ON THE TOP OF EUROPE

The Bjerknes Centre is the largest climate research centre in the Nordic countries, with a focus on the natural science aspects of climate change.

Our ambition is to be a leading international centre for climate research, focusing on northern Europe and the Polar Regions within a global context. As part of the more pressing needs for climate change information relevant for societal planning and adaptation both in Norway and in developing nations and nations in transition, we have also entered into the field of regional climate modelling.

The centre has an international profile with leading expertise within climate understanding, climate modelling and scenarios for future climate changes and quantification of climate changes. In order to carry out its ambitions, the research activity is organized into five interdisciplinary research groups that provide knowledge of the following main research themes:

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

RESEARCH GROUPS

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

Past Climate Variability

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

Present-Day Climate Changes

The North Atlantic ocean circulation and storm tracks heat up the North, but also make it a challenge to assess the natural modes of variability in the region.

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.

Ocean Carbon Cycle

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.

Future Climate and Regional Effects

Global climate changes have local effects and might influence extreme weather and marine ecosystems in Norway and the Arctic, as well as having effects on water resources and health in lesser-developed countries.

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

Established by the Research Council of Norway

Norwegian Centre of Excellence

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

From Bergen to Svalbard. During summer 2009, a research team from the Bjerknes Centre led a cruise covering all the important aspects of physical, chemical and biological properties in the Nordic Seas (photos top and bottom no. 2 from left: Emil Jeansson, BCCR). Photos bottom no. 1 and 3 from left (Andreas Volbers): School cruise investigating seawater in the Hjelte Fjord, equipped with plankton net, water sampler and sensor for hydrographic measurements.

EU PROJECT ON MARINE CARBON CYCLE SUCCESSFULLY CONCLUDES

The largest EU project on marine carbon sources and sinks assessment concludes after five years of study:

- Ocean carbon sink for human-produced CO_2 is regionally highly variable.
- Carbon cycle climate feedback re-enforces climate change .
- Increase of ocean acidification.

Since the onset of the industrial revolution, mankind has increasingly released carbon dioxide (CO_2) to the atmosphere, which significantly contributes to human induced climate change. At present, about half of the annual CO_2 emissions is absorbed by the ocean and terrestrial vegetation. The other half remains in the atmosphere. Changes in these sources and sinks of CO_2 are, therefore, of great importance for future climate changes. The Marin carbon sources and sinks assessment project (CarboOcean) aimed at an accurate scientific assessment of the marine sources and sinks for CO^2. The project placed special emphasis on the Atlantic and Southern Oceans and a time interval of –200 to +200 years from now. CarboOcean resulted in a huge number of peer-reviewed publications and contributed to key international data syntheses. CarboOcean is a Bjerknes Centre project coordinated by the University of Bergen.

THE OCEAN CARBON SINK FOR HUMAN-PRODUCED CO_2 IS REGIONALLY HIGHLY VARIABLE

The ocean carbon sink for human-produced CO_2 is very vulnerable to climate change. The carbon sink variability in large domains of the two areas in the world ocean where CO_2 can be mixed downward efficiently – the North Atlantic and the Southern Ocean – proved to be considerably larger than previously thought. However, long-term observations are needed. The North Atlantic has experienced a significant decrease in the CO_2 sink strength in recent decades. It needs to be determined whether this decrease is part of natural variation in the ocean system or of long-term change. In this region, the surface ocean CO_2 pressure increased faster than in the atmosphere, indicating a holdup of CO_2 in the surface layer. Furthermore, the efficiency of the Southern Ocean CO_2 sink may have decreased over the past decades.

CARBON CYCLE CLIMATE FEEDBACK RE-ENFORCES CLIMATE CHANGE

Earth system models include an integrated marine and terrestrial carbon cycle. Studies using this model revealed that the carbon cycle climate feedback re-enforces climate change due to the combined effect of changes in physics and biogeochemical cycles under warming and higher CO_2 concentrations in the atmosphere. The feedback intensifies dynamically with the timing and extent of increases in atmospheric CO_2 concentrations. When taking the carbon cycle climate feedback into account

CarboOcean, together with the terrestrial sister project CarboEurope-IP, produced an EU-publication on the European and North Atlantic carbon balance (see facsimile above, to the left). The assessment report is available online at: http://bookshop.europa.eu/eubookshop/publicationDetails.action?pubuid=10054922

An info film about CarboOcean was produced through the University of Bergen's TV group Univisjon (see facsimile above, to the right). The movie gives an overview of the latest project results and calls for greater reduction of CO_2 emissions. The DVD can be ordered from BCCR. It is also available at: http://www.carboocean.org/upload/flowplayer/carboocean/index.html

appropriately, emission targets for CO_2 have to be corrected towards even lower emission rates. According to the model results, the CO_2 uptake by oceans and land together would be reduced by about 25% due to the carbon cycle climate feedback over the coming 90 years for a business as usual emission scenario.

INCREASE OF OCEAN ACIDIFICATION

A consequence of absorption of human-produced CO_2 in the oceans is acidification due to a decrease of the seawater pH-value. This has been simultaneously confirmed by direct field observations of pH and new reconstructions of anthropogenic carbon in the oceans. Ocean acidification has detrimental effects on corals and is a threat for marine ecosystems. High-latitude oceans show the fastest decline in pH. In order to avoid the Arctic Ocean surface layer becoming corrosive for aragonite shells (key organisms in the food chain), the atmospheric CO_2 concentration needs to stay under 450 ppm.

SCHOOL PROJECT

A spin-off from the CarboOcean project was the 3-year EC-funded CarboSchools project that linked the latest results with secondary schools. Three Bergen schools participated in the project together with scientists from BCCR. The pupils were taken on short research cruises, performed experiments at the lab and analyzed the data from the cruises. The CarboSchool booklet "What we have learned, what we still don't know and what we must do to combat climate change" can be ordered from BCCR.

FACTS/CARBOOCEAN

- Marine carbon sources and sinks assessment (CarboOcean) consisted of 50 partner groups from Europe, Morocco and North America, comprising about 200 scientists.
- UiB-BCCR coordinated the project through an international project office, with Christoph Heinze as responsible project director (2005–2009).
- The overall funding from the European Commission was 14.5 million EUR.

Homepage: www.carboocean.org

THE WETTEST CITY IN EUROPE

Bergen is a city located in a vulnerable region for changes in future climate. These changes have to be investigated and taken into account in future planning.

Bergen is known for its rain, and the precipitation rate has had an increasing trend since the start of measurements at the end of the 19th century. The future climate predictions made for the Intergovernmental Panel of Climate Change Report 2007 suggest an even wetter climate, but these global simulations do not provide enough detail for the Bergen area because of its complex geography. To add more regional detail into future predictions, the Municipality of Bergen has established the project WestPrecip in cooperation with the Bjerknes Centre. The aim is to investigate future frequency and intensity of extreme precipitation events and their connection to hydrology, such as floods. The project is part of the larger MARE project, which is a joint effort with other European countries, such as Great Britain and the Netherlands. These are countries that are expected to experience similar challenges as the Norwegian west coast in the future.

SEA LEVEL RISE ALONG THE NORWEGIAN WEST COAST

The global sea level is rising due to increasing ocean temperatures and melting of land-based ice. At the same time, different land areas are still rising after the retreat of the last glacial ice sheets. Among other factors affecting sea level rise regionally are ocean temperature distribution by ocean currents and changing heating patterns, freshwater discharges (floods and coastal currents), as well as possible changes in storm surges.

Scientists from the Bjerknes Centre and Nansen Center aim to improve the future predictions of sea level rise for the coast of western Norway and neighboring regions in a project funded by the Municipality of Bergen. Using all available data for the different factors behind sea level rise, the project will assess its development over the last 50 years, establish the status of today, and make projections for the 21st and 22nd century.

The project is tightly linked to the European MARE project, which focuses on managing adaptive responses to changing flood risk in the North Sea region.

CLIMATE ´FLICKERING´ ENDED THE ICE AGE IN NORTHERN EUROPE

An article published in the prestigious science magazine *Nature Geoscience* shows that the period toward the end of the ice age was marked by extreme and short-lived variations, which finally terminated the ice age.

A group of scientists at the Bjerknes Centre and the University of Bergen, led by Jostein Bakke, together with colleagues from Zürich combined terrestrial and marine proxy paleo-data covering the latest part of the ice age to improve our understanding of the mechanisms leading to rapid climatic changes.

The period at the very end of the last ice age is called the Younger Dryas, starting approximately 12,900 years ago. It was distinguished by rapid cooling in the Northern Hemisphere, driven by reorganization of large-scale patterns of atmospheric and oceanic circulation. Environmental changes during this period have been documented by both proxy-based reconstructions from sediment archives and model simulations, but there is currently no consensus on the exact mechanisms of onset, stabilization or termination of the Younger Dryas. In contrast to existing knowledge, the *Nature Geoscience* article shows that the climate shifted repeatedly from cold and dry to wet and less cold, from decade to decade, before interglacial conditions were finally reached and the climate system became more stable. The results give new insight into the complex behaviour of atmosphere interactions with a changing sea-ice cover in the North Atlantic and Arctic Ocean during a period of rapid climate change.

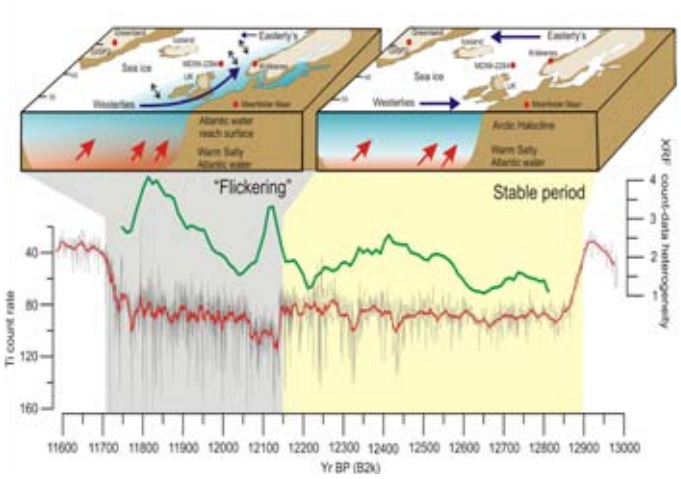


FIGURE 1. Atmospheric and oceanic conditions during the Younger Dryas. The early Younger Dryas was kept in glacial conditions by a prevailing halocline in the North Atlantic that resulted in a near-permanent sea-ice cover. These boundary climatic and oceanic conditions over the high latitudes of Europe, Greenland and the North Atlantic displaced the westerly wind track southwards. The last 400 years were characterized by a regime that repeatedly 'flickered' towards interglacial conditions, controlled by a highly dynamic sea-ice cover in the North Atlantic as the halocline was periodically absent.

RAPID CLIMATE ALTERNATION BEFORE INTERGLACIAL TRANSITION

In this study the research team presents high-resolution records from two sediment cores obtained from Lake Kråkenes in western Norway and from the Nordic Seas. Multiple proxies from Lake Kråkenes indicate rapid alternations between glacial growth and melting during the second half of the Younger Dryas. Meanwhile, reconstructed sea-surface temperature and salinity from the Nordic Seas show corresponding alternations between an extensive seaice cover and melting due to the influx of warm, salty North Atlantic waters. The article suggests that the influx of warm water enabled the westerly wind systems to drift northward, closer to their present-day positions. Thus, the winds brought relatively warm maritime air to Northern Europe, resulting in rising temperatures and melting of glaciers.

However, the resulting input of fresh meltwater into the ocean caused the renewed formation of sea ice, which forced the westerly winds back to the south, cooling Northern Europe again. The research team concludes that rapid alternations between these two states immediately preceded the termination of the Younger Dryas and the permanent transition into an interglacial state. The high-resolution archive covers the transition between pre-and post-tipping point states through a period of flickering, which could provide a possible analogue for the greenhouse-gas influenced climate of the 21st century. These types of processes are at present not covered by any Earth System Models and are therefore an unknown factor when projecting future climate change.

Reference:
Bakke, Jostein; Lie, Øivind; Heegaard, Einar; Dokken, Trond Martin; *Haug, Gerald;* ***Birks, Hilary H;*** *Dulski, Peter; Nilsen, Trygve, 2009. Rapid oceanic and atmospheric changes during the Younger Dryas cold period. Nature Geoscience 2, pp. 202–205.*

The Atlantic Ocean's large-scale overturning circulation from warm into cold water masses is a mediator of climate variability and change. *The Nature Geoscience* paper takes the pulse of its northern variability (photo: Ilker Fer, BCCR).

SURVEY OF OCEAN CLIMATE MAY IMPROVE CLIMATE PREDICTIONS

A recent paper in *Nature Geoscience* provides a unique assessment of ocean circulation and climate variability, and thus adds to the basis for improved climate prediction.

A research team from the Nansen Environmental and Remote Sensing Center, and the Bjerknes Centre for Climate Research, has studied observed anomalies in ocean climate, and identified the anomalies' progression with the circulation of the Nordic Seas, and the Norwegian Sea in particular. The Nordic Seas have been much surveyed by Norwegian, Faroese, Icelandic, and (Soviet) Russian research vessels since the 1950s. The present study is the first large-scale synthesis of this long-term observational record on annual to decadal time scales.

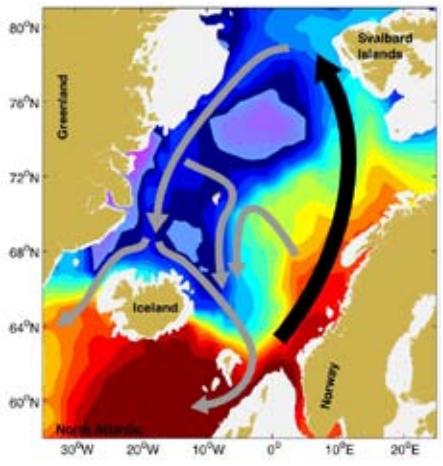


FIGURE 2. The Atlantic overturning circulation. The overturning from warm (red) into cold water masses (blue) in the Nordic Seas. The black arrow indicates the extension of the Gulf Stream into the Norwegian Sea, and the gray arrows the cold return flow at depth.

CHALLENGING THE UNDERSTANDING OF WATER MASSES EXCHANGE

Traditionally, the change in the exchange of water masses between the Nordic Seas and the North Atlantic Ocean has been understood as controlled by change in the northern deep waters. The study in *Nature Geoscience*, led by Tor Eldevik, challenges this concept. The authors find that observed anomalies trace back to the extension of the Gulf Stream into the Norwegian Sea.

A NEW BENCHMARK FOR FUTURE MONITORING- AND MODEL SYSTEMS

This Bjerknes study improves the understanding of the Atlantic Ocean's overturning circulation from a warm Gulf Stream in the surface to a cold return flow at depth. The analysis thus offer a new benchmark for evaluating which ocean regions and observations are the most appropriate for understanding past and present climate change. The study in particular provides an observational basis for the development of future monitoring or model systems for climate prediction covering the North Atlantic/Nordic Seas region.

Reference:
Eldevik, T., J.E.Ø. Nilsen, *D. Iovino, K.A. Olsson,* ***A.B. Sandø,*** *and* ***H. Drange****, 2009: Observed sources and variability of Nordic seas overflow. Nature Geoscience, 2, pp. 406–410.*

Vulnerable coastline. The Alaskan coastline is vulnerable for climate changes. The frequent storms have lead to accelerating erosion as well as impacting on people's everyday life (photo: Gary Clow, The U.S. Geological Survey (USGS), Alaska).

THE GRAVEYARD OF STORMS IN THE NORTH PACIFIC

The Gulf of Alaska is the "graveyard" of storms in the North Pacific. These storms do not form locally and include tropical cyclones that reach the Gulf of Alaska.

Bjerknes researcher Michel d. S. Mesquita and international colleagues describe a complete climatology of extra-tropical storm tracks in the North Pacific, published in the *Journal of Climate*. The term "extra-tropical storms" refers to storm systems that travel outside the tropics. The study includes "lysis density", a variable that shows where storms die, shedding more light on the Gulf of Alaska. It is one of the first papers to provide a complete climatology of storm tracks in the North Pacific and it is relevant for the coastal erosion adaptation projects in the state of Alaska.

STORMS INFLUENCE THE ATLANTIC INFLOW

For the first time the effects of winter storms on the Atlantic inflow has been quantified.

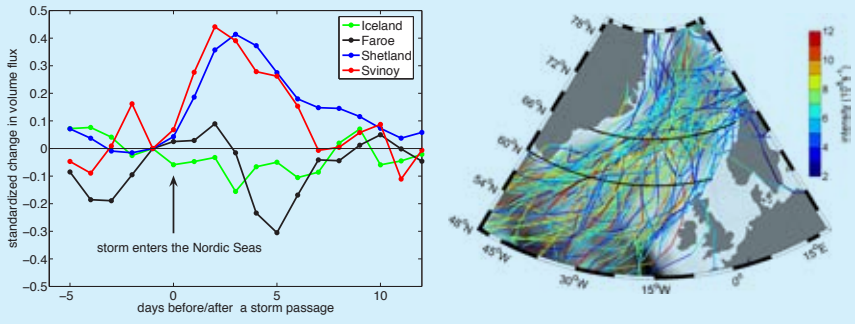


FIGURE 4. Storms entering the Nordic Seas and inflow variations. To the left, tracks of the 99 winter storms crossing 60°N and 66°N latitude during the period 1994–2006 with reliable ocean transport measurements. The color coding shows the intensity of the storm. To the right, the mean response in oceanic volume transports in the four analyzed sections from 5 days before to 12 days after the storms crossed the 60°N section. Note the maximum in the (Faroe–)Shetland and Svinøy sections 2 to 3 days after storm passage, and the minimum at the (Iceland–)Faroe section 5 days after storm passage.

STORM TRACK VARIABILITY

The North Pacific and the Bering Sea regions represent loci of cyclogenesis (where storms are born) and storm track activity. In this paper climatological properties of extra-tropical storms in the North Pacific/Bering Sea are presented based upon aggregate statistics of individual storm tracks calculated by means of the feature-tracking algorithm by Hodges (University of Reading, UK) for the period from 1948(49) to 2008.

Results show that the inter-seasonal variability is not as large during the spring and autumn seasons. Most of the storm variables – where storms start, their intensity, and where they travel to – exhibited a maxima pattern that was oriented along a zonal axis. From season to season this axis underwent a north-south shift and, in some cases, a rotation to the northeast. This was determined to be a result of zonal heating variations and mid-tropospheric moisture patterns. Summer storms tended to be longest in duration. Temporal trends tended to be weak over the study area. Sea surface temperature did not emerge as a major cyclogenesis control in the Gulf of Alaska.

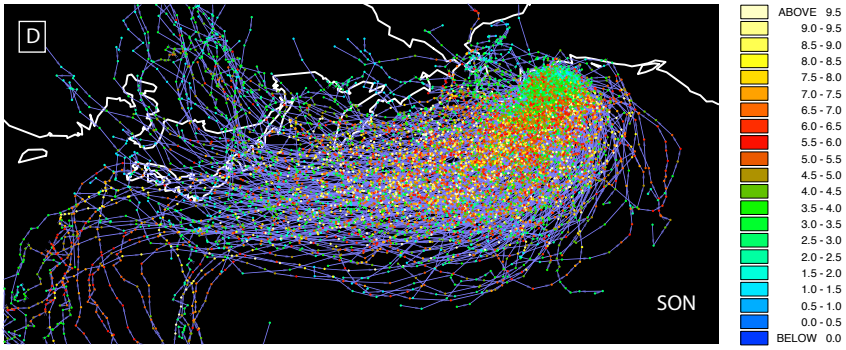


FIGURE 3. Storms in the Gulf of Alaska. Plots of all autumn (September, October and November) storms possessing end-points in the Gulf of Alaska from 1948(9) to 2008. The figure also shows tropical systems undergoing extratropical transition during that season. The color scheme represents the T42 intensities with background removed – units of 10–5 s–1. Figure created by Dr. Kevin Hodges (University of Reading, UK) based on his tracking algorithm called TRACK (illustration by Dr. Kevin Hodges).

EXTRA-TROPICAL CYCLONES

Barotropic processes (when pressure is a function of density only) have an influence in shaping the downstream end of storm tracks and, together with the blocking influence of the coastal orography of northwest North America, result in high lysis concentrations, effectively making the Gulf of Alaska the "graveyard" of Pacific storms.

The results suggest that most of the storm systems that end up in the Gulf of Alaska do not form locally. A targeted assessment confirms that for all seasons with the exception of summer, for which a source region in the Aleutian Islands is indicated. There are indications of tropical cyclones undergoing extra-tropical transitions reaching the Gulf of Alaska, especially during summer and autumn (see Figure 3).

Reference:
Mesquita, M.d.S., *D.E. Atkinson and K.I. Hodges (2009): Characteristics and Variability of Storm Tracks in the North Pacific, Bering Sea and Alaska. J. Climate, 23, 294-311.*

The flow of warm Atlantic water over the Greenland–Scotland Ridge strongly impacts on the ocean climate and marine biomass production in the Nordic Seas, as well as being a prerequisite for dense water formation north of the ridge.

The inflow of volume, heat and salt from the North Atlantic to the Nordic Seas occurs in three branches, one minor branch west of Iceland (ca. 10% of inflow), one between Iceland and the Faroe Islands (ca. 40%), and one between the Faroe and Shetland Islands (ca. 50%). The flow in these three branches and the flow through the Svinøy section off the west coast of Norway have been monitored for more than a decade. This unique data set has been combined with storm track data from the Nordic Seas, and for the first time the connection between the atmospheric lows and the variability in the inflow has been established at daily time scales.

The analysis shows that two to three days after a storm enters the Nordic Seas, the inflow between the Faroe and Shetland Islands and the flow through the Svinøy section increase by 20–30%. A few days later there is a reduced inflow west of the Faroes, which possibly is a response to accumulation of water and higher sea level north of the ridge (see figure 4). Averaged over a full winter season, as much as 4/5 of the variations in the flow measured in the Svinøy section can be explained by the lows.

Reference:
Richter, K., T. Furevik, *and K. A. Orvik (2009): Effect of wintertime low-pressure systems on the Atlantic inflow to the Nordic seas, J. Geophys. Res., 114.*

COOLING OF ATLANTIC WATER
AT THE ARCTIC ENTRANCE

In this area north of Svalbard, researchers conducted direct measurements of heat fluxes and amounts of mixing within the water column (photo: Anders Sirevaag , BCCR).

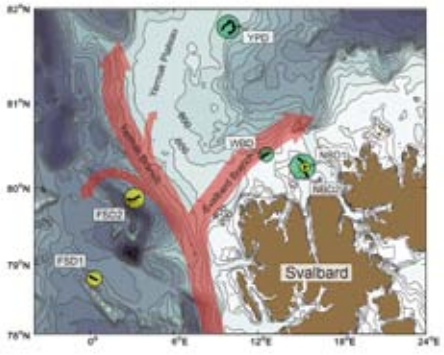


FIGURE 5. Ice drift experiments. The map shows the study area north and northwest of Svalbard. Black arrows show the individual ice drift experiments included in this study, and the large red arrow indicates the pathways of the West Spitsbergen Current along the coast of Svalbard, transporting warm and salty Atlantic water into the Arctic.

As warm Atlantic water flows north- and eastward along the coast of Svalbard it experiences strong cooling by heat loss to the atmosphere and to melting of ice. Direct measurements show the importance of strong tidal currents and shallow topography for the efficiency of this cooling.

The recent – and expected future – decline in Arctic sea ice cover has become an icon of climate change. As parts of the ice cover are replaced by open waters, more heat can be released directly from the ocean to the atmosphere above, and thus temperate the regional climate. As opposed to the central Arctic Ocean where a cold halocline insulates the surface ocean from the warmer waters below, net ocean heat is directly available for the atmosphere in the shelf regions where temperate waters from the Nordic Seas meet the ice edge.

Heat and salt are transported into the Arctic by the West Spitsbergen Current (WSC), which flows northward along the western coast of Svalbard and then turns eastward into the Arctic. Along its way, the WSC looses large amounts of heat due to heat loss to the atmosphere, melting of sea ice and mixing with other water masses. This loss of heat has previously been determined by observing the decreasing temperature of the WSC as it progresses northwards.

LARGE HEAT LOSS OVER SHALLOW WATER

A new study published in *Journal of Physical Oceanography* by the Bjerknes researchers Anders Sirevaag and Ilker Fer presents observations from several drifting ice stations in the area north of Svalbard. The drift stations, which took place in

Reference:
Sirevaag, A. and I. Fer *(2009). Early spring oceanic heat fluxes and mixing observed from drift stations north of Svalbard. Journal of Physical Oceanography, Volume 39, issue 12, pp. 3049–3069.*

SEA ICE ALTERS
OCEAN CURRENTS IN WARM CLIMATE

Recent climate warming is most pronounced in the Arctic, where sea ice cover might be the canary in the coal mine for future changes.

Bjerknes researchers Andreas Born and Kerim H. Nisancioglu show in a paper presented in *Climate Dynamics* that changes in sea ice induces drastic changes in ocean currents. They have studied past climate changes in a similar but warmer climate than present.

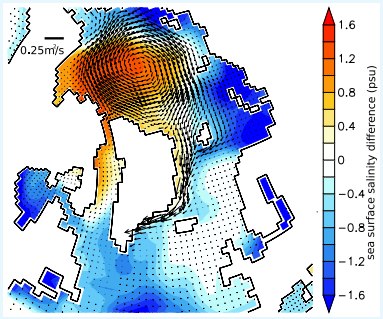


FIGURE 6. Changes of sea surface salinity (colors) and sea ice transport (arrows) after the Eemian interglacial. Increased export of Arctic sea ice along the east coast of Greenland reduces salinities in the North Atlantic. One consequence is a major reorganization of the surface current system.

LOOKING INTO THE GEOLOGICAL PAST

While future projections of climate continuously improve, an independent estimate can be achieved by looking into the geological past. The Eemian interglacial 126,000 years ago, thus predating the last ice age, has often been used as an example for the warmer climate expected for the end of this century.

Output from a comprehensive climate model shows that as Arctic climate cooled towards the end of the Eemian interglacial, more sea ice was exported along the east coast of Greenland and into the North Atlantic. Since salt is rejected during the freezing process, this event also enhanced the southward transport of freshwater and resulted in a drastic weakening of the surface ocean current system called the subpolar gyre. Among the consequences of a weaker gyre is the northward displacement of the North Atlantic Current bringing warm subtropical waters to the European shores and increased heat transport into the Nordic Seas, counteracting the general high latitude cooling.

IMPLICATIONS OF A WARMER ARCTIC

With a warming Arctic in the next decades a similar – albeit reverse – change can be expected. Less freshwater transport by a shrinking sea ice cover might result in a stronger subpolar gyre circulation, eventually decreasing the amount of Atlantic water entering the Nordic Seas. Exploiting the usefulness of paleo climate analogues, this study highlights that the loss of Arctic sea ice not only affects local communities and ecosystems, but also has implications that go beyond the Arctic realm. It introduces a new mechanism to explain climate changes found in geological archives, emphasizing the surface circulation changes as opposed to the deep overturning circulation.

early spring in the years 2003–2007, contain direct measurements of heat fluxes and amounts of mixing within the water column. The measurements that were made within the main branches of the WSC or over the shelves close to Svalbard show large heat fluxes and mixing due to strong currents and impact of strong tides and shallow topography.

The measurements made outside the WSC and far off the shelves, show heat exchange and mixing rates similar to observations made within the central Arctic Ocean. The results also show that in the area north of Svalbard, water masses are more modified by heat loss to the atmosphere than by ice melting. The study emphasizes the importance of mixing along the boundaries and over shelves and topography for the cooling of the relatively warm water that flows into the Arctic.

Reference:
***Born, A., K.H. Nisancioglu** and P. Braconnot (2009): Sea ice induced changes in ocean circulation during the Eemian. Climate Dynamics (published online Dec. 2009).*

MARINE CARBON OBSERVATIONS FROM THE ARCTIC TO THE ANTARCTIC

A new database of marine carbon observations covering the Atlantic Ocean was released in 2009. This will be an invaluable resource for future carbon cycle science.

CARINA (CARbon in the Atlantic), as the database is called, is truly the result of an international effort, and several scientists from the Bjerknes Centre have been central in establishing the new database. It has turned out to be a huge success, securing accessibility and safe storage of marine carbon data collected at 188 cruises from the Bering Strait through the Arctic Ocean, the Nordic Seas and the Atlantic Ocean to the Southern Ocean, and will be a key resource for future marine carbon science.

INTERNATIONAL EFFORT

CARINA was first initiated in 1999, aiming for a database of marine carbon data from research cruises in the North Atlantic, but because of funding issues the effort went dormant after a few years. With the EU Integrated Project CarboOcean (coordinated by the Bjerknes Centre) fresh funding became available in 2005, and a group of European and U.S. scientists decided to build on the foundations and expand CARINA into a consistent and well documented database of carbon variables collected on research cruises covering the Arctic, Atlantic and Southern oceans.

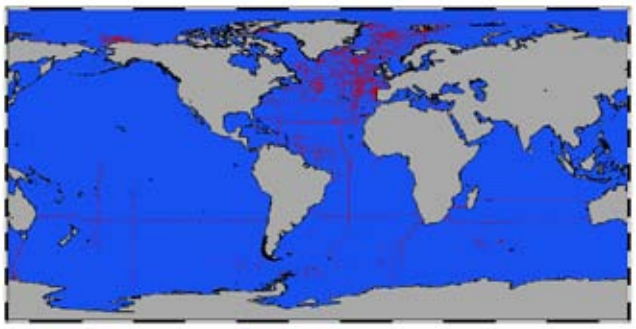


FIGURE 7. The map shows the station locations of the data included in CARINA (red dots and lines).

From here on, CARINA quickly evolved into an international groundbreaking venture, and the CARINA data holdings increased from 30 to 188 campaigns, with scientists from all across Europe and the U.S. subjecting these data to higher level quality control, including development of novel techniques for highly automated analyses of data quality and consistency, and for sharing this information over the web. A detailed account of the quality control and data assembly is provided through a series of articles appearing in a special issue of *Earth System Science Data* (www.earth-syst-sci-data.net/special_issue2.html).

MORE COD EXPECTED IN NORDIC WATERS

Under future climate change, the populations of Atlantic cod in the Barents Sea, around Iceland and off West Greenland are expected to increase, but how much they might rise will largely depend on the intensity of fishing.

Concern about future human-induced warming has lead to demands for information on what might happen to fish and fisheries. One suggestion has been to use past events as a predictor of the future. To test how reliable this might be, a comparison was carried out between the cod responses in to two major warm periods in the North Atlantic. The first began during the 1920s and 1930s and remained relatively warm through to the 1960s, while the second began in the 1990s and has continued to the present day.

EARLY WARM PERIOD

During the earlier warm period, the most northern of the cod stocks in the Atlantic (off West Greenland, around Iceland and in the Barents Sea) increased in abundance. Between the early 1920s and 1930 the cod population also spread northwards to occupy new grounds, e.g. over 1200 km from southwestern Greenland to north of Disko Island. These changes were a result of a combination of more food and a northward expansion of suitable water temperatures for cod.

Fishing pressure greatly increased during this warm period due to motorized vessels replacing sailing vessels, the introduction of bottom trawling, and improved

ENSURING FUTURE CREDIBILITY

The CARINA project was a response to the increasing recognition among scientists of the need to get their data out of the drawers and into permanently archived open-access databases. This practice will ensure that future generations have an instrumental record of climate variables, which is important for securing the credibility of climate science, and opens up new avenues for research and collaboration.

The CARINA data are available through the Carbon Dioxide Information Analysis Centre at: http://cdiac.ornl.gov/oceans/CARINA/Carina_inv.html.

Bjerknes people involved:
Are Olsen, Emil Jeansson, Eva Falck, Ingunn Skjelvan, Abdirahman Omar, Richard Bellerby, Benjamin Pfeil and Truls Johannessen.

Reference:
*CARINA: a consistent carbon-relevant database for the Arctic, Atlantic and Southern Oceans, Editor(s): T. Tanhua, **A. Olsen,** M. Hoppema, and V. Gouretski, Earth System Sciences Data 2009-2010.*

MONITORING THE ATLANTIC PULSE

Bergen researchers monitor the coldest ocean current in the world.

Scientists at the Bjerknes Centre and the University of Bergen successfully installed the first advanced monitoring station in the southern Weddell Sea in Antarctica early 2009. The station will make long-term observations of climate changes in the coldest and one of the most important ocean currents in the world. The aim is to monitor the dense water formation processes and any changes in the ice shelf in West Antarctica. The monitoring station is placed on the edge of the continental shelf and registers current speed and direction, temperature and salinity. If the southern current changes, it is an indication that something drastic is happening to the Antarctic ice shelf, which plays a key role in the global climate.

The majority of the deep and bottom water production takes place in the northern and southern extremes of the Atlantic Ocean, and is believed to be an important driving force for the bipolar Atlantic Thermohaline Circulation (THC).

The monitoring station is as part of the research project Bipolar Atlantic Thermohaline Circulation, which is one of the largest projects in the International Polar Year and coordinated by the Bjerknes Centre. It has been developed in cooperation with engineers from the Bergen-based company Aanderaa Data Instruments. Data are stored onboard as well as transmitted acoustically to ships passing by when ice conditions permit (January and February).

The Bjerknes Centre is also involved in building two equivalent ocean observing systems for the North Atlantic component of the THC, tailored to monitor the overflow across the Greenland Scotland Ridge as well as in the Arctic (part of the THOR project).

Read more about BIAC: www.bccr.no/biac

navigation. The intense fishing, together with declining food and cooler temperatures, resulted in a decline in the cod stocks during the 1950s and 1960s. The cod also retreated farther south and individuals were generally smaller in size as growth rates declined.

RECENT WARM PERIOD

With the return to warming conditions in the 1990s, the population of cod in the Barents Sea again increased, survival rates of the young cod rose, and the stock spread northward. The cod population off West Greenland also increased, however, the number of cod is still very low compared to the earlier warm period. The abundance of Icelandic cod on the other hand, has shown no signs of increasing and is currently at a level near the lowest on record.

CLIMATE CHANGE AND FISHING PRESSURE

The different cod responses to the two warm events, in particular the lower production during the recent warm period, are attributed to the effects of intense fishing pressure during the recent period and possibly related ecosystem changes. These results indicate that the projections of cod in the future due to climate change must take into account the expected fishing intensity. The fishing industry and the fisherie's managers will need to consider both climate and fishing intensity to maximize future cod catches.

Reference:
***Drinkwater, K.** (2009): Comparison of the response of Atlantic cod (Gadus morhua) in the high-latitude regions of the North Atlantic during the warm periods of the 1920s–1960s and the 1990s–2000s, Deep-Sea Research II, 56, 2087–2096.*

A STRONG YEAR FOR MEDIA AND OUTREACH

The media coverage and other outreach activities have been impressive during 2009.

The number of newspaper articles (paper and web) counted 1580 articles, which is thirty percent higher than the year before (source: Retriever). The statistics also showed that the coverage is well spread all around the country. Most of our outreach activity is on a local or national level, but from time to time international media picks up on our publications. For example, Reuters published an article based on a Bjerknes publication authored by Erik Kolstad and his British colleague, which received coverage in several American media, including USA Today and CNBC News. The article was concerned with the increase in the potential for extreme weather events due to global warming found along the entire southern rim of the Arctic Ocean, which can be a threat to possible new businesses such as oil and gas exploration, fisheries or shipping.

INTENSIFYING FUTURE CLIMATE CHANGE

The first results on future climates from the Bergen Earth System Model developed at the Bjerknes Centre, including interactive land- and ocean carbon cycle modules, were communicated through the mass media prior to the Copenhagen meeting. This attracted significant media attention, because the simulations showed that human induced climate change probably will reduce nature's ability to absorb carbon dioxide towards the end of the century (92 articles). An implication is that more carbon will remain in the atmosphere, and thereby intensify future climate change making it even more difficult to and reach stabilization targets by mitigation than indicated by the previous generation of models.

Spring tides possibly enhanced by rising sea level towards the end of our century could paralyze key parts of Bergen. The illustration shows how one of the busiest main roads and tunnels leading into the city center could be filled with water, thereby obstructing traffic if adaptation measures are not taken. (illustration: Ramboll)

Similar indications of reduced ocean uptake of CO_2 also came from our carbon cycle observations. An example is a *Science* paper, involving several Bjerknes co-authors, which received broad media coverage (55 articles). The paper showed that the ocean uptake in the North Atlantic, which is reckoned to be the most efficient sink of CO_2 in the world oceans, is less stable and efficient than previously thought.

In the near future, we will apply the new national Earth System Model to explore the relevant mitigation scenarios, such as ambitions to stabilize climate change to below two degrees Celsius warming.

IF BERGEN DROWNS

A report on Regional Sea Level Rise (Regional havstigning) showed the dramatic consequences that sea level rise might have for Bergen, entailing adaptation measures and costs. Many groups have contributed to the report, including the Bjerknes Centre, the Institute of Marine Research and engineering consultant firms. It comprises a framework that can also be used in other coastal cities in Norway. The Grieg Foundation, G. C. Rieber Fondene and Visjon Vest funded the report and initiated a press conference where the report was presented and handed over to the Chief Commissioner of the Bergen City Government. Due to sea level rise constituting such a significant issue for the future of Norwegian costal towns, and not the least how to prepare for a higher sea level, the report was presented in many newspapers all over the country (82 articles with BCCR sources).

FROM BERGEN TO COPENHAGEN

A handful of Bjerknes scientists were accredited under the negotiations taking place at the COP 15, together with more than 20 000 lobbyists trying to influence the meeting in order to reach an ambitious and fair climate deal.


Marsjerte ut i protest

COP15 COPENHAGEN

Alarmerende issmelting

The Nobel Prize winner and previous US vice-president AL Gore presented a new report under a press conference inside the Bella Center together with the Norwegian foreign minister Jonas Gahr Støre. The conclusion was that glaciers and ice caps disappear faster than previously thought, but the presentation received mixed response in the media. Professor Tore Furevik at the BCCR, who did not participate in the report, could confirm for the journalists that new measure instruments show that the Greenland ice-sheet and ice caps in West Antarctica melt with an accelerating rate.

The key aspect was the negotiations, but these events are also a meeting point for media, NGOs, various businesses and other organizations interested in climate change, mitigation and adaptation. Around the negotiations there were great activity with numerous side events. Our intention was to contribute with science-based climate information and to be available for journalists, politicians and others who needed our expertise. Hence, Bjerknes scientists spent time at the Bella Center, where the negotiations took place. BCCR also organized a side event on climate modeling and future emission targets that was supposed to take place at the Bella Center, but it was moved to downtown due to the very strict admission rules imposed during the last days of the summit. Two of our scientists gave a talk to a group of journalists as well. Furthermore, BCCR had a stand at the "Arctic Venue", with a focus on Arctic weather and on ocean carbon sources and sinks. Prior to the summit, BCCR prepared a number of fact sheets covering different themes concerning the science basis of climate change. These were widely distributed at the summit.

SCIENCE TO GUIDE POLITICS

The COP 15 negotiations and the failure to reach a binding agreement documented a profound gap between developed and less developed countries. It also documented the problem of distinguishing between emerging strong economies and the poorest countries that have had no part in the creation of the problem, but which may be most severely hurt. President Obama said in his farewell address in Copenhagen that there is a long way to go to reach a binding global agreement. He also said that such an agreement must be guided by science. He said if science says that even stronger commitments are needed, than the leaders must use science as their basis. The science at hand clearly calls for much stronger obligations if the stated stabilization targets shall be reached, as the results from the Bergen Earth System Model indicate (see previous article).

The Bjerknes Centre strives not only to produce top international research that can underpin political decisions, but also to communicate the results to the wider society.

Øyvind Paasche (left) and Tore Furevik (right) prepare for the opening of the Bjerknes Centre stand at the Arctic Venue (photo: BCCR archives).

AWARD FOR POPULAR SCIENCE COMMUNICATION

Helge Drange received the University of Bergen ' s Meltzer Prize 2009 award for outstanding science communication.

Helge Drange (left) illustrates for the reporter Nord Røv in Schrödingers katt (popular science TV magazine on Norwegian Public Broadcasting) an estimated upper range of a storm surge in Bergen by the end of the century if we continue to emit climate gasses at the same rate as today (photo: Per Ingvar Rognes, NRK).

Drange is professor at the University of Bergen and scientist at the Bjerknes Centre. The committee emphasized Drange's excellent dissemination skills and ability to attract the attention of the public: "People listen when Helge Drange speaks. That is because they understand what he is talking about."

On an average, Drange has held one popular lecture a week during the last two to three years, and is frequently visible in local and national media through both interviews and debates. Drange strongly believes in the idea of scientists being active outside academia, reaching people where people are – in schools, businesses, organizations and city spaces. According to Drange, he can spend so much time on media and outreach because of the support and input from the large and dynamic climate science milieu in Bergen.

Part of Drange's outreach activity during 2009 was also related to his role in the National Committee on Climate Adaptation (NOU klimatilpassing), issued by the Norwegian government. To raise awareness of and getting communities engaged in climate adaptation, Drange has traveled all around the country holding popular presentations to inform about the possible effects of climate change. Drange also participated in the Governmental-appointed forum on climate research, Climate21 (Klima21), with a mandate to assess the organization of climate research in Norway, and to identify and prioritize future research needs.

Drange is project leader for the largest climate research project in Norway funded by the Research Council of Norway, NorClim. The project is coordinated by the Bjerknes Centre. He also contributed to the IPCC Assessment Report 2007, and leads the international CLIVAR expert group on Ocean Model Development.

DOCUMENTARY

THE WORLD'S FASTEST MOVING ICE STREAM

A TV team is following Atle Nesje to Ilulissat in western Greenland in order to find out what the fjord landscape in western Norway would have looked like 11,000-12,000 years ago (photo: Steinar Birkeland, NRK).

What did western Norway look like at the end of the last ice age? A TV-team from NRK headed to Greenland to find out.

Professor Atle Nesje (UiB/BCCR) accompanied Steinar Birkeland and Thomas Hellum from the Norwegian Public Broadcasting (NRK), to the town of Ilulissat (the term meaning iceberg) and Jakobshavn Glacier in western Greenland. The result was a spectacular documentary that resembles a travel back in time to a fjord in Western Norway at the end of the last ice age, about 11,000–12,000 years ago. The documentary "Fjorden" was shown on NRK early 2009.

EDUCATING TEACHERS ABOUT CLIMATE CHANGE

From left: Øystein Sørborg (National Center for Natural Science Subjects in Education), Tobias Thorleifsson, Siri Kalvig and Helga Kleiven (photo: Per Jarl Elle, Bodø University College).

Bjerknes scientist Helga Kleiven together with the nationally known weather forecaster and meteorologist Siri Kalvig and social scientist and polar explorer Tobias Thorleifsson visited six teaching colleges around the country to educate teachers and students (in Norwegian called Klimaklok). The one-day course aimed to give the teachers knowledge about climate change, adaptation and mitigation, and to motivate teachers to put climate change into the curriculum. The participants also received a package with material for class room use. The course was developed by the Ministry of Environment and Development, in cooperation with the National Center for Natural Science Subjects in Education (Naturfagsenteret) and the Bjerknes Centre, on behalf of Klimaløftet, which is the Government's climate information campaign.

Jakobshavn Glacier has become an icon of the global warming now impacting on Greenland glaciers. At the front of the glacier, the ice stream flows approximately fourteen km a year and forty meters a day in the summer. It is thus the fastest moving ice stream in the world. While the front of the glacier retreated 300 meters annually between 1851 and 2006, it has since the turn of the century retreated three km a year on average.

The glacier is always calving and spits out small and large icebergs into the fjord of Ilulissat. The enormous icebergs float with the current towards the mouth of the fjord and form a river of ice, which is a spectacular scene from the town of Ilulissat.

At present, about thirty-five cubic kilometers of ice comes from the Jacobshavn Glacier every year, which is ten percent of the ice that comes from the Greenland ice sheet. However, there are large uncertainties as to how fast a partial retreat of the ice sheet might occur, and thereby how much it can contribute to future sea-level rise.

BOOK RELEASE

BJERKNES SCIENTISTS WITH A NEW CLIMATE BOOK

In the book *Hva er KLIMA? (What is climate?)*, the authors Erik Kolstad and Øyvind Paasche share their fascination of how the climate system is continuously changing, from dramatic events such as calving of enormous icebergs at the end of the last ice age, to rapid changes today, for example the formation of a storm or flood.

Kolstad and Paasche, both scientists at the Bjerknes Centre, have written an easy-to-read book that fits into a pocket without difficulty. The format makes for perfect reading on the bus or train. The book explains many of the physical climate processes, divided into chapters according to their typical time scale, from minutes to millions of years. Because man-made climate change is a modern phenomenon, it comprises only a small part of the book. Still, the authors hope that the book will equip the reader to assess the global warming that we experience in our time.

The book is aimed at anyone with an interest in climate issues and those who are concerned with how climate change impacts the earth. According to the authors, it should make complex processes understandable for everyone from youths to grandmothers. The two authors represent two different disciplines within climate research. While Kolstad has a PhD in meteorology and is concerned with weather patterns and future changes, Paasche is Dr. Scient in paleoclimate and studies the long historical timeline.

Bjerknes scientists exploring glaciers in Tibet together with Chinese colleagues. The team collected sediment cores from the bottom of this lake in order to reconstruct how glacier variations in the past are connected to changes in the Southeast Asian monsoon through the last millennium (photo: Kristian Vasskog, UiB/BCCR).

NEW INITIATIVES, EDUCATION AND COOPERATION

EXCITING PROJECT COLLABORATION WITH CHINA

The project "Exploring Decadal to Century Scale Variability and Changes in the East Asian Climate during the last Millennium" (DecCen) started up July 2009. The main objective is to improve the understanding of variations in the East Asian climate on different time scales in order to identify regional and remote causes for variations in temperature, drought and flooding patterns and to reduce the level of uncertainty in climate projections for China.

On seasonal time scales, the East Asian Summer Monsoon (EASM) leads to heavy rainfall in June, July and August along a thousands of kilometers long rain belt affecting parts of Indo-China, China, Japan and Korea, encompassing one third of the world's population. On interannual time scales, variations in the El Nino-Southern Oscillation (ENSO) pattern seems to dominate, while on longer time scales increased sea-surface temperatures in western Pacific and Indian Ocean, and increased amount of soot particles and other local pollutants seem to become important.

A novel approach will be taken, by combining new climate records covering the last millennium through coring and analysis of glaciers in Tibet, historical and instrumental observations, numerical modeling and advanced statistical analysis. The project also focuses on research training and exchange of scientists, and three Chinese PhD students and one postdoc from China will stay for 3 to 6 months in Bergen every year throughout the project period.

PH.D. DISSERTATIONS

BCCR scientists provided supervision and training in climate research to 35 doctoral students during 2009. The following Ph.D. dissertations were defended:

Michel dos Santos Mesquita (Uni Research)
Title: Characteristics and variability of storm tracks in the North Pacific, Bering Sea and Alaska.

Christophe Bernard (UiB)
Title: Land ocean coupling: Contribution of riverine silica fluxes to global ocean biogeochemistry.

Tarjei Breiteig (UiB)
Title: The influence of the ocean and the stratosphere on climate persistence in the North Atlantic region.

Anders Sirevaag (UiB)
Title: Small-scale processes of the under-ice boundary layer.

The DecCen project aims to identify causes for variations in temperature, draught and flood patterns in the Chinese climate (photo: unknown).

DecCen is a Bjerknes project, coordinated by the Geophysical Institute, University of Bergen, in close collaboration with Uni Research, the Nansen Center, the Norwegian Institute for Air Research, and three Chinese institutions: The Peking University in Beijing, the Chinese Academy of Sciences in Lanzhou, and the Institute of Atmospheric Physics/Chinese Academy of Sciences, Beijing. The partnership is linked to the established collaboration in climate research between Norway and China through the Nansen-Zhu International Research Centre, and is the first large joint Norwegian-Chinese project in this collaboration. The project is funded by the Norwegian Research Council and will last for three years.

DecCen homepage: www.bccr.no/deccen

JOINT INDO-NORWEGIAN RESEARCH INITIATIVE

The Norwegian Ministry of Foreign Affairs, through the Norwegian Embassy in New Delhi, agreed to support The Energy and Resources Institute for the next five years to carry out work on energy, environment and climate change issues in partnership with other Indian institutes and Norwegian partners.

India is extremely vulnerable to potential future climate changes. Model projections of future climates are inconclusive as to the direction, leaving the country with a lacking base for initiatives to reduce risks and to plan adaptation measures.

The Bjerknes Centre for Climate Research (BCCR), together with the Nansen Center, The Energy and Resources Institute (TERI) and The Research Council of Norway (RCN), organized a workshop in Delhi in February. The overall objective of the workshop was to identify common interests and outline common priorities for a joint Indo–Norwegian research cooperation. BCCR is now planning a partnership with TERI based on downscaling with regional climate models, teleconnections (India/South East Asia and higher latitudes) and eventually also Earth System Model development and use. A proposal for a bilateral partnership between the BCCR and TERI has been funded by the Norwegian Embassy in Delhi, and will also be submitted for further five year funding from the newly established Norway–India bilateral research program of the RCN.

TRAINING TO TACKLE WORLD CHALLENGES

The Bergen Summer Research School (BSRS) is an initiative of the Bergen academic milieu's commitment to address key challenges in education and research posed by an increasingly knowledge-based, complex, multicultural, religiously diverse and unequal global society. BSRS 2009 gathered more than one hundred PhD candidates from forty countries and all continents, discussing crosscutting issues addressing climate, environment and energy. The Bjerknes Centre was strongly represented in the summer school having two members of the scientific committee, co-leader of the course "Impact of climate change on marine and terrestrial resources", and also a guest course leader on "Economics of cooperation: The case of Climate Change". All five courses had lectures on climate given by the Bjerknes Centre as partners.

The Bergen Summer Research School is a joint venture under the leadership of the University of Bergen with the Norwegian School of Economics and Business Administration, the Christian Michelsen Institute on Human Rights and Development, the Bergen University College and Uni Research as partners.

BSRS homepage www.bsrs.no

Dr. Rajendra Pachauri (left), the leader of IPCC, is also the director of The Energy and Resources Institute (TERI) in India. Here under a visit at the Bjerknes Centre, together with professor Eystein Jansen (photo: Jill Johannessen, BCCR).

Bangladesh's populated river deltas often hit by tropical cyclones, storm surges and flooding (photo: Istockphoto).

NEW COLLABORATIONS WITH BANGLADESH AND VIETNAM

A memorandum of understanding (MoU) between the Bjerknes Centre for Climate Research and the Bangladesh Centre for Advanced Studies in Dhaka was signed at the residence of the Norwegian Ambassador in Bangladesh on October 28. Approximately two months later, a similar MoU was signed with the Vietnam Institute of Meteorology, Hydrology and Environment. The collaborations will be on capacity building for studies of, and adaptation to climate variability and climate change. Four principal areas of collaboration will be:

- Sea level changes and impacts for Bangladesh and Vietnam.
- South Asia and Southeast Asia summer monsoon changes and impacts on Bangladesh and Vietnam.
- Mass balance changes of Himalayan and Tibetan glaciers and its effects on Bangladesh and Vietnam.
- Research training and exchange of scientific staff.

While the Bjerknes Centre is primarily doing research on understanding and modeling of the climate system, the partner institutions in Bangladesh and Vietnam are well known for work on sustainable development from local to global levels, with particular emphasize on climate adaptation and risk assessment and management on local levels.

Bangladesh and Vietnam are extremely vulnerable to climate change and the impacts are expected to be severe. Both countries have large low-lying, extremely densely populated river deltas often hit by tropical cyclones, storm surges and flooding. In concert with the ongoing research cooperation with China (DecCen project) and the new the project on regional climate change in India, the collaboration with Bangladesh and Vietnam will add to BCCR's knowledge of climate change and its impacts in the worlds most populated and climate-vulnerable region in the world. With collaboration and projects in many countries in the region, the Bjerknes Centre can build up expertise on tropical monsoon climate, and in this respect become an important player in both basic research driven and developing aid driven projects in Asia.

THE NORWEGIAN CENTRE FOR OFFSHORE WIND ENERGY

Norwegian Centre for Offshore Wind Energy (NORCOWE) is one of total eight new Centres for Environment-friendly Energy Research (FME) that was supported by the Research Council of Norway. Power production from wind energy at sea is a major new industrial opportunity for Norway and Norwegian private enterprises. NORCOWE is a cross-disciplinary resource centre that contributes to realizing this opportunity. The ambition is to be a leading, creative environment where research and industry collaborate on developing the foundation for new, innovative solutions for offshore wind power that are both environmentally sound and cost-effective. NORCOWE will also help to foster future personnel resources by educating a significant number of master's and doctoral candidates.

Uni Bjerknes Centre initiated the Wind and ocean module, drawing on key competence in climate and atmospheric modeling. Bjerknes Centre scientists contribute within numerical modeling on all atmospheric scales and the ocean surface. The Christian

The memorandum of understanding being signed. From left to right, Dr A. Atiq Rahman, Executive Director of the Bangladesh Centre for Advanced Studies, Ms Ingebjørg Støfring, Norwegian Ambassador to Bangladesh, and Professor Tore Furevik, Vice Director at the Bjerknes Centre for Climate Research. (photo: Arne Haug, The Royal Norwegian Embassy, Dhaka).

Michelsen Research coordinates NORCOWE. Other partners include the University of Bergen, the University of Agder, University of Stavanger, Aalborg University and several industrial partners.

NORCOWE homepage www.norcowe.no

OPENING OF THE NATIONAL RESEARCH SCHOOL IN CLIMATE DYNAMICS

The Norwegian Research School in Climate Dynamics (ResClim) was officially opened March 13. ResClim was one of five proposals that were funded by the Research Council of Norway in order to improve the quality of the national research training at the PhD level.

The Norwegian Research School in Climate Dynamics is a national training environment for PhD candidates. The aim is to give the candidates in-depth knowledge in their specific study field within climate research, transdisciplinary knowledge in the dynamics of the entire climate system, insight into the political and societal impacts of climate change, and the necessary skills to play an active role in predicting, mitigating, and adapting to climatic and environmental change.

This first year has been a typical start-up year where efforts have been made to establish a working secretariat, the research school's homepage, and an international evaluation board, as well as registering students and supervisors. The school has a steering group consisting of one member from each of the ten partner institutions. In addition, the school will largely draw experience from an evaluation board with representatives from Sweden, Germany, Scotland, England, Italy and USA. The evaluation board covers all scientific disciplines under the school, and has a wide experience with supervision, research schools, young research networks, and transferable skills training.

PhD students seized the opportunity to go on a trip to Folgefonna Glacier for a hike (2 ½ hours drive from Bergen) between lectures at a summer school course in Advanced Climate Dynamics outside Bergen (photo: Brian Hansen, University of Copenhagen/ DMI).

In June, ResClim organized a one-week course in "Advanced Atmospheric Dynamics" lectured by Dr. David W. J. Thompson from Colorado State University. Later the same month, a summer school on "Ocean Overturning Circulation" was held at Espegrend (see article below). Also under ResClim, a workshop/summer school was held in Tromsø in September on "Arctic Marine Methods and Paleo Proxies". This was coordinated by the University of Tromsø, and had both international and national lectures (including the Bjerknes Centre).

The Geophysical Institute, University of Bergen, coordinates the research school in cooperation with ten national partners and seven international collaborators.

ResClim homepage www.resclim.no

SUMMER SCHOOL AT ESPEGREND

During eleven sunny days in June there was a lot of activity at the University of Bergen's marine research station at Espegrend. The Bjerknes Centre, together with the University of Washington and the Massachusetts Institute of Technology, hosted twenty-six PhD candidates and fifteen lecturers from the US, Norway and Europe.

The summer school was the first in a series of three Advanced Climate Dynamics Courses (ACDC). The main focus this year was on understanding the basic state, variability, forcing and stability of the ocean overturning circulation in the past, present and future. In-house and external top scientists gave twelve lectures during the summer school, only broken up by a trip to Folgefonna Glacier for a hike in deep new powder snow. The summer school provided the students with opportunities to discuss their dissertations with some of the world's leading climate scientists. The feedback from the students was excellent. The Norwegian Centre for International Cooperation in Higher Education (SiU) and the Research Council of Norway sponsored the summer school.

ACDC homepage: www.bccr.no/acdc

Bjerknes scientists and PhD students drilling for sediment cores in a lake in Lofoten, northern Norway. These paleo-records reveal changes in the past climate up to 8 000 years ago (photo: Bjørn Kvisvik, UiB/BCCR).

INTERNATIONAL MEETINGS AND ENGAGEMENTS

THE SURFACE OCEAN CO_2 ATLAS PROJECT MEETING

The Surface Ocean CO_2 Atlas (SOCAT) is the world largest CO_2 database with more than 7 million carbon dioxide measurements from more than 2100 cruises with a time frame of nearly four decades (1968–2007). SOCAT is an international effort supported by UNESCO-IOCCP, SOLAS and IMBER, and involves around 50 scientists from all over the world. It is based on a CO_2 database that has been produced at the Bjerknes Centre, funded partly by the CarboOcean project. All data are in a uniform format and the CO_2 parameters have been re-computed. In a regional meeting held in Kiel, Germany, experts from different coastal areas agreed to perform the final quality control of the coastal data. Four more regional meetings were scheduled. SOCAT was presented to the public at the 8th International Carbon Dioxide conference in Jena, Germany, in September. The data set is meant to serve a wide range of user communities.

ARCTIC SCIENCE SUMMIT WEEK

Arctic Science Summit Week (ASSW) 2009 was held in Bergen, March 22–28. ASSW has become an annual international event aiming to provide opportunities for international coordination, collaboration and cooperation in all areas of Arctic science. ASSW 2009 was organized under the ambitious theme: Arctic Connections – results of 150 years of Arctic research. As such, the summit gave opportunity to focus on a wide spectrum of research activities that have taken place in the Arctic throughout history. The ASSW 2009 was comprised of an open plenary day and two days with four parallel sessions. Side meetings organized by other groups with interests in Arctic science and policy took place during the same week. The ASSW also offered insight into Arctic research undertaken by the host country. There were several presentations from scientists from the institutions behind the Bjerknes Centre. Approximately 300 scientists attended the ASSW 2009. The Institute of Marine Research and the Bjerknes Center were responsible for the arrangement. The University of Bergen, the Institute of Marine Research and the Research Council of Norway were the main sponsors.

An expedition to the Fimbul Ice Shelf. The project Top to Bottom aims to understand the interaction between the Antarctic ice sheet and the ocean below (thus the name). After having drilled holes through several hundred meters thick ice, the scientists needed to lower instruments into the ocean below. Here project participants are pulling 600 meters of cable and a current meter towards the newly hot water drilled access hole (photo: Lars H. Smedsrud, BCCR).

VISIT FROM SOUTH AFRICAN DELEGATION

A delegation from South Africa visited the Bjerknes Centre May 15, with representations from the South African Department for Science and Technology as well as the Department of Environment and Tourism. A central issue under the meeting was a possible cooperation between the African Centre for Climate and Earth System Science (ACCESS) and the Bjerknes Centre for Climate Research (BCCR). The South African government has identified climate change as a prioritized research area, but it needs to go hand in hand with social, economic and development challenges in the region. It is in particular BCCR's expertise within climate modeling and ocean carbon cycles that can give better local and regional knowledge concerning climate change impacts, and as such contribute to reducing the uncertainties in future climate changes for South Africa.

KEY EXPERTS ON MARINE CARBON CYCLE MEET IN BERGEN

More than 80 of Europe's leading ocean scientists participated in the final meeting of the Marin carbon sources and sinks assessment project (CarboOcean) held in Bergen October 5–9. After five years, the EU project CarboOcean concluded that overall emission targets for human-produced CO_2 have to be corrected towards smaller

emissions, due to the positive carbon cycle climate feedback, ocean acidification, and the potential for a weakening of important marine carbon sink areas (see also article on pg. 6–7).

WORKSHOP ARGENTINA-NORWAY ON CLIMATE CHANGE

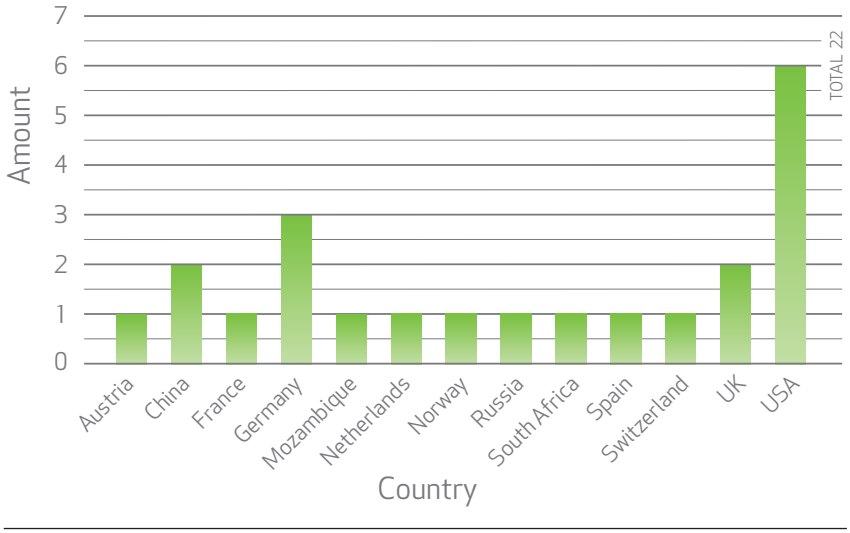
Prompted by the Norwegian Ministry of Education and Research, a workshop was organized by the Research Council of Norway (RCN) and the Bjerknes Centre, together with its counterparts in Buenos Aires, Argentina 28–29 October. The representatives of both delegations agreed to promote cooperation in broad aspects of climate research, training and capacity building. A number of areas of research for joint collaboration between Argentina and Norway were identified to forward to their respective Ministries, among others climate scenarios, relevant for adaptation measures, energy, water and health with links to poverty issues. The trip also included a visit to the Center for Ocean and Atmospheric Research (CIMA). Representations from CIMA and BCCR identified mechanisms of cooperation, such as exchange of students, young scientists and staff as well as joint research projects. The intention of BCCR is to couple cooperation efforts with Argentinean scientific communities with ongoing research collaboration in both Chile and Brazil.

The researchers taking part in the ten-week long expedition on the Fimbul Ice Shelf slept most of the nights in tents. Here with Adelie penguins passing by on New Year's Day 2010 (photo: Lars H. Smedsrud, BCCR).

GUEST RESEARCHERS AT THE BJERKNES CENTRE

BCCR sponsors a Visiting Fellow Programme as one of several arrangements that aims at fostering international research collaboration in climate change. In 2009, the Centre hosted totally 22 scientists from 13 countries.

FIGURE 8. VISITING SCIENTISTS BY COUNTRY



HONORARY FELLOW OF UNIVERSITY COLLEGE IN LONDON

John Birks was elected Honorary Fellow of University College in London (UCL), 2009. Birks is an internationally leading scientist within the field of paleo-ecology, and was elected Honorary Fellow on the ground of his distinguished career and close ties with UCL. Birks has developed methods and theories including pollen analyses and reconstructions of vegetation history and climate in the late glacial and during the last interglacial.

John Birks (photo: Lars Holger Ursin, På høyden-UiB).

ENGAGEMENTS

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

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

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

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

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

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

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

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

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

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

National Committee on Climate Adaptation, issued by the Norwegian Government, hosted by the Ministry of Environment: Prof. Svein Sundby and Prof. Helge Drange are members. Prof. Christoph Heinze is a work group member.

European Climate Forum: BCCR is a member of the European Climate Forum (ECF), a non-profit organization located at PIK in Potsdam, Germany. ECF is a platform for joint studies and science-based stakeholder dialogues on climatic change and brings together representatives of different parties concerned with the climate problems.

Bergen Climate Forum: The climate forum is a local meeting point for people from the industry and commerce, authorities, organizations, and education- 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 Program (WCP):

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

PHOTO: ANDREAS BORN, UIB/BCCR.

ORGANIZATION & FINANCES

Archive photo

THE DIRECTOR AND THE LEADER FORUM

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

Eystein Jansen	Professor (Director), Palaeoclimatology, UiB/Uni Research
Trond Dokken	Senior scientist, Palaeoclimatology, Uni Research
Svein Østerhus	Senior scientist, Physical oceanography, Uni Research/UiB
Tor Eldevik	Senior scientist, Ocean processes and modelling, NERSC
Christoph Heinze	Professor, Carbon cycle modelling, UiB/Uni Research
Nils Gunnar Kvamstø	Professor, Meteorology, UiB/Uni Research
Birgit Falch	Cand.Polit Science coordinator, Uni Research
Jill Johannessen	Dr. Polit, Communication leader, Uni Research
Lars Fagerli	Financial officer, Uni Research
Tordis Lerøen	HR manager, Uni Research

SCIENTIFIC COMMITTEE

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

Eystein Jansen	Professor (Director), Palaeoclimatology, UiB/Uni Research
Tore Furevik	Professor (Deputy director), Climate modelling, UiB
Johnny Johannessen	Research Director, Coastal and Ocean Remote Sensing, NERSC
Øystein Skagseth	Senior scientist, Physical oceanography, IMR

Istockphoto

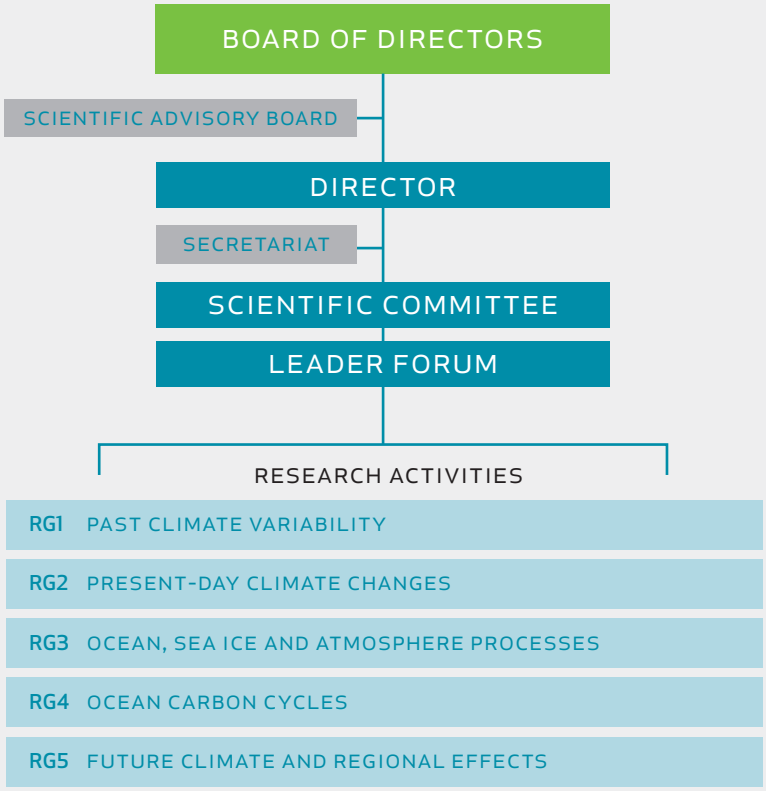
RESEARCH GROUPS

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

Title		Leader (co-leader)
RG1	Past Climate Variability	T. Dokken (C.A. Dahl, A. Nesje)
RG2	Present-Day Climate Changes	S. Østerhus (A.B. Sandø)
RG3	Ocean, sea ice and atmosphere processes	T. Eldevik (I. Fer)
RG4	Biogeochemical Cycles	C. Heinze (A. Olsen)
RG5	Future Climate Scenarios and Effects	N.G. Kvamsø (F. Vikebø)

Photo: Jan Helge Fossa, IMR.

FIGURE 9. ORGANIZATION MAP



THE BOARDS

BOARD OF DIRECTORS

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

Bergen at night (photo: Andreas Born, UiB/BCCR).

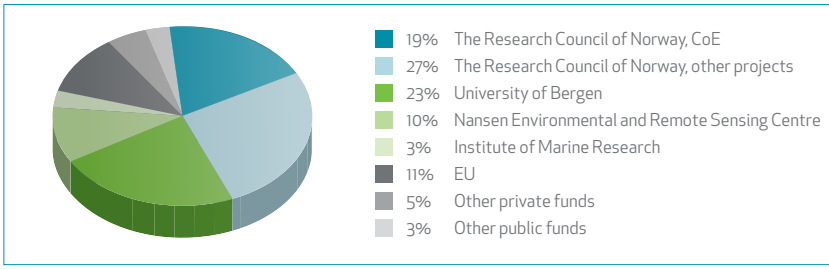
FUNDING & EXPENSES

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 table and figure 10). In total, the Bjerknes Centre is involved in forty-eight projects. There are twenty-five projects funded by the Research Council of Norway, with BCCR scientists leading eighteen of these projects. Twelve ongoing projects are funded by the 6th and 7th Framework Programmes of the European Commission, of which BCCR coordinates one of the projects. Eleven projects are funded by other sources. BCCR also coordinates two of the six multinational projects that were funded within the European Science Foundation ESF-Eurochores programme EuroMarc. See Appendix 2 for a complete listing of ongoing research projects. The second main funding source is the contribution to the CoE activities from the partner institutions, including the University of Bergen, the Nansen Environmental and Remote Sensing Center and the Institute of Marine Reserarch.

FUNDING	2009 (1000 NOK)
The Research Council of Norway, CoE	17 000
The Research Council of Norway, other projects	24 167
University of Bergen	20 440
Nansen Environmental and Remote Sensing Center	8 558
Institute of Marine Research	2 621
EU projects	10 024
Other private funds	4 293
Other public funds	2 553
Total funding	89 656

Expenses	(1000 NOK)
Salaries and building rental costs	58 184
Research equipment	791
External research services	9 667
Other costs	21 403
Total expenses	90 046

FIGURE 10. FUNDING



STAFF

SCIENTISTS

Karen	Assmann	Germany	Uni Research	Chemical Oceanography
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		NERSC	Climate modelling
Hilary	Birks	UK	UiB	Numerical methods in palaeoclimatology
H. John B.	Birks	UK	UiB	Terrestrial biological climate proxies
Anne Elisabeth	Bjune		Uni Research	Palaeobotany
Knut Yngve	Børsheim		IMR	Marine biology, biogeochemistry
Paul	Budgell	Canada	IMR	Ocean modelling
Carin Andersson	Dahl	Sweden	Uni Research	Palaeoclimatology
Svein Olaf	Dahl		UiB	Glaciers & palaeoclimatology
Trond Martin	Dokken		Uni Research	Palaeoclimatology
Helge	Drange		UiB	Climate modelling
Ken	Drinkwater	Canada	IMR	Oceanography & impacts of climate change
Tor	Eldevik		NERSC	Ocean processes & modelling
Igor	Esau	Russia	NERSC	Environmental boundary layers
Eva	Falck		Uni Research	Physical Oceanography
Ilker	Fer	Turkey	UiB	Ocean processes
Frode	Flatøy		Uni Research	Atmospheric chemistry & modelling
Tore	Furevik		UiB	Climate dynamics
Tor	Gammelsrød		UiB	Polar oceanography
Yongqi	Gao	China	NERSC	Ocean circulation modelling
Sigbjørn	Grønås		UiB	Synoptic meteorology
Peter M.	Haugan		UiB	Polar oceanography
Einar	Heegaard		Uni Research	Palaeoecology
Ulla	Heikkilä	Finland	Uni Research	Regional atmospheric modelling
Christoph	Heinze	Germany	UiB	Carbon cycle modelling
Solfrid	Hjøllo		IMR	Ocean circulation
Randi	Ingvaldsen		IMR	Physical oceanography
Eystein	Jansen		UiB/Uni Research	Palaeoclimatology
Alastair	Jenkins		UiB	Boundary layer physics
Truls	Johannessen		UiB	Biogeochemistry
Ina K. T.	Kindem		Uni Research	Stratospheric physics
Helga Flesche	Kleiven		Uni Research	Palaeoclimatology
Nils Gunnar	Kvamstø		UiB	Atmospheric modelling
Øyvind	Lie		Uni Research	Palaeoclimatology
Henriette	Linge		UiB	Palaeoclimatology
Torbjørn	Lorentzen		Uni Research	Economics, statistics
Kjetil	Lygre		NERSC	Biogeochemistry & modelling
Jan	Mangerud		Uni Research	Palaeoclimatology
Martin	Miles	USA	Uni Research	Climate time series analysis
Kjell Arne	Mork		IMR	Physical oceanography
Atle	Nesje		UiB	Palaeoclimatology
Jan Even Øie	Nilsen		NERSC	Climate modelling
Ulysses S.	Ninnemann	USA	UiB	Palaeoclimatology
Kerim Hestnes	Nisancioglu		Uni Research	Palaeoclimatology & modelling
Are Christian S.	Olsen		Uni Research	Chemical oceanography
Svein	Østerhus		Uni Research	Physical oceanography
Odd Helge	Otterå		NERSC/Uni Research	Climate modelling
Øyvind	Paasche		Uni Research	Palaeoclimatology
Bjørg	Risebrobakken		Uni Research	Palaeoclimatology
Anne Britt	Sandø		IMR/NERSC	Ocean modelling
Anne Dagrunn	Sandvik		IMR	Mesoscale atmospheric modelling
Corinna	Schrum	Germany	UiB	Ocean modelling
Øystein	Skagseth		IMR	Ocean circulation
Ingunn	Skjelvan		Uni Research	Chemical oceanography

Morten	Skogen		IMR	Coupled physical and biological modelling
Lars Henrik	Smedsrud		Uni Research	Polar Oceanography
Henrik	Søiland		IMR	Ocean modelling
Asgeir	Sorteberg		UiB	Climate modelling
Svein	Sundby		IMR	Ocean climates
John Inge	Svendsen		UiB	Palaeoclimatology
Richard	Telford	UK	UiB	Palaeoclimatology
Frode	Vikebø		IMR	Climate impacts on marine ecosystems
Andrea	Volbers	Germany	Uni Research	Palaeoclimatology and biogeochemistry
Bjørn	Ådlandsvik		IMR	Physical oceanography and modelling

POSTDOCS

Jürgen	Bader	Germany	Uni Research	Climate modelling
Elin Darelius	Chiche	Sweden	UiB	Polar oceanography
Richard	Gyllencreutz	Sweden	UiB	Palaeoclimatology
Emil	Jeansson	Sweden	Uni Research	Chemical oceanography
Erik Wilhelm	Kolstad		Uni Research	Climate downscaling
Trond	Kristiansen		IMR	Oceanography
Camille	Li	Canada	UiB	Atmospheric dynamics and paleoclimate
Marius	Meland		Uni Research	Palaeoclimatology
Abdirahman	Omar	Somalia	UiB	Chemical oceanography
Caroline	Roelandt	Belgium	UiB	Terrestrial Biogeochemical modelling
Jeanne	Scao	France	Uni Research/UiB	Paleoclimatology
Anders	Sirevaag		UiB	Physical Oceanography
Lingling	Suo	China	NERSC	Climate dynamics
Jerry	Tjiputra	Indonesia	UiB	Carbon cycle modelling
Justin	Wettstein	USA	Uni Research	Atmospheric dynamics
Zhongshi	Zhang	China	Uni Research	Paleoclimatology and modelling

PHD. STUDENTS

Muralidhar	Adakudlu	India	UiB	Atmospheric modelling
Roohollah	Azad	Iran	UiB	Regional atmospheric modelling
Christophe	Bernard	France	Uni Research	Biogeochemistry
Ingo	Bethke	Germany	Uni Research/NERSC	Ocean modelling
Andreas	Born	Germany	UiB	Climate dynamics and paleoclimate modelling
Tarjei	Breiteig		UiB	Atmospheric dynamics
Giulio Nils	Caroletti	Italy	UiB	Regional climate change
Sara	de la Rosa Höhn	Spain	UiB	Polar oceanography
Michel	dos Santos Mesquita	Brazil	Uni Research	Atmospheric dynamics
Christine	Euler	Germany	UiB	Palaeoclimatology
Helene	Frigstad		UiB	Impacts of ocean acidifidication
Florian	Geyer	Germany	NERSC	Climate modelling
Nil	Irvali	Turkey	Uni Research	Palaeoclimatology
Marwan	Khalil	Egypt	NERSC	Climate modelling
Heidi	Kjennbakken		UiB	Marine geology and geophysics
Helene	Langehaug		NERSC	Ocean dynamics, climate modelling
Siv Kari	Lauvset		UiB	Chemical oceanography
Vidar	Lien		IMR	Regional ocean modelling
Iselin	Medhaug		UiB	Climate dynamics
Svetlana	Milutinovic	Croatia	NERSC	Remote sensing, climate modelling
Tor L.	Mjell		UiB	Paleoclimatology
Mari	Myskvoll		IMR	Marine ecosystem effects
Gunn Elisabeth	Olsen		UiB	Atmospheric dynamics
Francesco S. R.	Pausata	Italy	UiB	Atmospheric dynamics and paleoclimate
Roshin	Raj	India	UiB	Ocean dynamics
Kristin	Richter	Germany	UiB	Ocean dynamics
Ole	Segtnan		UiB	Ocean dynamics

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

TECHNICAL STAFF

Kelly	Brown	USA	Uni Research	Chemical Oceanography
Dagfinn	Bø		Uni Research	Palaeoclimatology
Tor	de Lange		UiB	Chemical Oceanography
Odd Reidar	Hansen		UiB	Palaeoclimatology
Solveig	Kringstad		UiB	Chemical Oceanography
Bjørn Christian	Kvisvik		Uni Research	Palaeoclimatology
Craig Chandler	Neill	USA	Uni Research	Chemical Oceanography
Benjamin	Pfeil	Germany	Uni Research	Data manager
Vincent	Scao	France	Uni Research	Palaeoclimatology
Rune Egil	Søraas		Uni Research	Palaeoclimatology
Jørund	Strømsøe		Uni Research	Palaeoclimatology

ADMINISTRATION

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

PERSONELL SUMMARY

Category	Person-years
Scientists	42,4
Postdocs	11,3
PhD students	32,3
Technicians	9,0
Administration	7,2
Total	102,2

STAFF BY PARTNER INSTITUTION

Number of scientific personell, sorted by category and partners.

Category	Uni Research	UiB	IMR	NERSC	Total	Non-Norwegian (%)	Female (%)
Scientists	24	23	14	7	68	26	25
Postdocs	7	7	1	1	16	75	31
Ph.D students	6	22	2	5	35	57	49
Total					119		

Figure 8. Staff by nationality

The Bjerknes Centre recruits personell internationally. In 2009, 22 nationalities were represented at the BCCR.

COUNTRY	# personnel
Brazil	1
Belgium	1
Canada	3
China	3
Croatia	1
Egypt	1
Finland	1
France	4
Germany	11
Hungary	1
India	2
Indonesia	1
Iran	1
Italy	2
Norway	83
Russia	3
Somalia	1
Spain	1
Sweden	4
Turkey	2
UK	4
USA	7
Total	138

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*
Planetary Boundary Layer Feedback in the Earth's Climate System (PBL-feedback)	2009–12	I. Esau*
Ecosystem Change in the North Sea: Processes, Drivers, Future Scenarios (ECODRIVE)	2009–11	M. Skogen**
CARBON uptake and fluxes of water and HEAT in the North Atlantic Current (CARBON-HEAT)	2008–10	A. Olsen*
Climate change and the impacts on farming of salmon in the coastal areas of Norway	2008–11	T. Lorentzen*
Marine Ecosystem Response to a changing CLIMate (MERCLIM)	2008–11	R. Bellerby*
Arctic and sub-Arctic climate system and ecological response to the early 20th century warming (ARCWARM)	2008–10	O.M. Johannessen*
Northeast Greenland "Mare Incognitum"	2008–09	M. Miles *
Arctic records of climate change - dynamics, feedbacks and processes (ARCTREC)	2007–10	E. Jansen*
Assessment of human impact on the marine Carbon system in arctic regions (A-CARB)	2007–10	A. Olsen*
Atlantic meridional overturning circulation during interglacials (AMOCINT)	2007–11	E. Jansen*
Bipolar Atlantic Thermohaline Circulation (BIAC)	2007–10	T. Gammelsrød*
Climate of Norway and the Arctic in the 21st century (NORCLIM)	2007–10	H. Drange*
Improved forecasting of adverse weather in the Arctic Region - present and future (IPY- Thorpex)	2007–10	A. Sorteberg**
Planetary Boundary Layer Feedbacks Affecting the Polar Amplification of Arctic Climate Change in Seasonal Ice Zone (PAACSIZ)	2007–10	I. Esau
Polar Climate and Heat Transport (POCAHONTAS)	2007–10	S. Østerhus*
Response of tropical Atlantic surface and intermediate waters to changes in the Atlantic meridional overturning circulation (RETRO)	2007–10	T. Dokken*
Seasonal Predictability over the Arctic Region - exploring the role of boundary conditions (SPAR)	2007–10	E. Jansen**
Southern Ocean Biogeochemistry: Education and Research (SOBER)	2007–10	R. Bellerby*
The Effect of Climate Change on Arctic High-Impact Weather Events (ArcChange)	2007–10	I. Barstad**
Integrated Arctic Ocean Observing System - Norway (iAOOS-Norway)	2007–10	Ø. Skagseth**
Glacial Ocean Mixing: Investigating the role of diapycnal ocean mixing for glacial climate stability and sensitivity (GLOMIX)	2007–10	O.H. Otterå
Norwegian component of the Ecosystem Studies of Subarctic and Arctic Regions (NESSAR)	2007–10	K. Drinkwater*
Climate and Ocean in mid-to high latitudes: Mechanisms of variability in Paleo and modern records (COMPAS)	2006–10	N.G. Kvamstø*
Impact of changing freshwater flows on the thermohaline circulation and European climate – analysis and modelling of the last deglaciation (ORMEN)	2005–09	T. Dokken*

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

TITLE	Duration	Type	Leader/ Scientist
Holocene saline water inflow changes into the Baltic Sea, ecosystem responses and future scenarios (INFLOW - BONUS)	2009–11	BONUS + ◆	E. Jansen
Thermohaline Overturning – at Risk? (THOR)	2008–11	IP ◆	H F. Kleiven, T. Eldevik
The European Project of Ocean Acidification (EPOCA)	2008–11	IP ◆	C. Heinze
Marine Ecosystem Evolution in a Changing Environment (MEECE)	2008–11	IP ◆	R. Bellerby
Megacities: Emissions, urban, regional and Global Atmospheric POLlution and climate effects, and Integrated tools for assessment and mitigation (MEGAPOLI)	2008–11	IP ◆	I. Esau
Integration and enhancement of key existing European deep-ocean observatories (EUROSITES)	2008–11	IP ◆	T. Gammelsrød
Network for Ice sheet and Climate Evolution (NICE)	2007–10	MCIF ◆	K. Nisancioglu
Resolving climatic impacts on fish stocks (RECLAIM)	2007–09	IP ◆	K. Drinkwater, C. Schrum
Links between Meridional Overturning Circulation and climate changes during the Holocene (LIMOCINE)	2006–09	MCIF ✖	J. G. Scao
Developing Arctic Modelling and Observing Capabilities for Longterm Environmental Studies – Integrated Project (DAMOCLES)	2005–10	IP ◆	P. Haugan, K. Lygre
Marine carbon sources and sinks assessment (CARBOOCEAN)	2005–09	IP ✖	C. Heinze
ENSEMBLE-based Predictions of Climate Changes and their Impacts (ENSEMBLES)	2004–09	IP ◆	O. H. Otterå

BCCR is: ✖ *Coordinator or* ◆ *Partner*

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

PROJECTS FUNDED BY OTHER SOURCES

TITLE	Duration	Leader/ Scientist	Funding agency
WestPrecip - Scenarios for future precipitation in the Western Norway, a sub project under MARE	2009–12	F. Flatøy	Bergen kommune
Endringer i fortidens. dagens og framtidig havnivå med spesielt fokus på vestlandskysten	2009–12	J.E.Ø. Nilsen	Bergen kommune
North American Arctic Ice and Climate Study	2009	M. Miles	Statoil Petroleum AS
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
Climate Change Impacts Assessments, including Climate Change, Process and Earth System Modelling (TERI-BCCR)	2009–11	E. Jansen	Norwegian Ministry of Foreign Affairs
Norwegian follow-up of the Arctic Climate Impact Assessment (NorACIA)	2007–09	B. Ådlandsvik	Norwegian Ministry of the Environment
Arctic Weather Extremes Workshop 19–20 June 2006	2006–09	A. Sorteberg	Statoil ASA
Paleo-Climate Modeling of Organic Rich Sediments (PALMORC)	2006–09	F. Flatøy	Statoil ASA
University of Washington – University of Bergen Climate Change Network	2006–09	T. Furevik	Bergens Forskningsstiftelse
Paleoclimate in the Southern Ocean	2004–11	U. Ninnemann	COMER foundation

SELECTED PUBLICATIONS

Bjerknes researchers published 91 articles in international peer reviewed journals in 2009.
For a complete listing, please visit www.bjerknes.uib.no/publications. Bjerknes scientists are indicated in **bold.**

ARTICLES IN INTERNATIONAL PEER REVIEWED JOURNALS

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5. **Born, A., K. H. Nisancioglu** and P. Braconnot (2009): Sea ice induced changes in ocean circulation during the Eemian. Climate Dynamics (published online Dec. 2009).

6. **Caroletti, Giulio Nils; Barstad, Idar** (2009): "Future extreme precipitation assessment in Western Norway – using a linear model approach", *Hydrology and Earth System Sciences Discussions* 2009, Volume 6, pp. 7539– 7579.

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9. **Eldevik, Tor; Nilsen, Jan Even Øie**; Iovino, Doroteaciro; Olsson, Anders; **Sandø, Anne Britt; Drange, Helge** (2009): "Observed sources and variability of Nordic seas overflow", *Nature Geoscience* 2009, Volume 2(6), pp. 405–409.

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12. Ilyina, Tatjana; Zeebe, Richard E.; Maier-Reimer, Ernst; **Heinze, Christoph** (2009): "Early detection of ocean acidification effects on marine calcification", *Global Biogeochemical Cycles* 2009, Volume 23.

13. **Jeansson, Emil**; Olsson, Anders; Messias, Marie-José; Kasajima, Yoshie; **Johannessen, Truls** (2009): "Evidence of Greenland Sea water in the Iceland Basin", *Geophysical Research Letters* 2009, Volume 36.

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REPORTS, BOOKS AND CHAPTER IN BOOKS

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