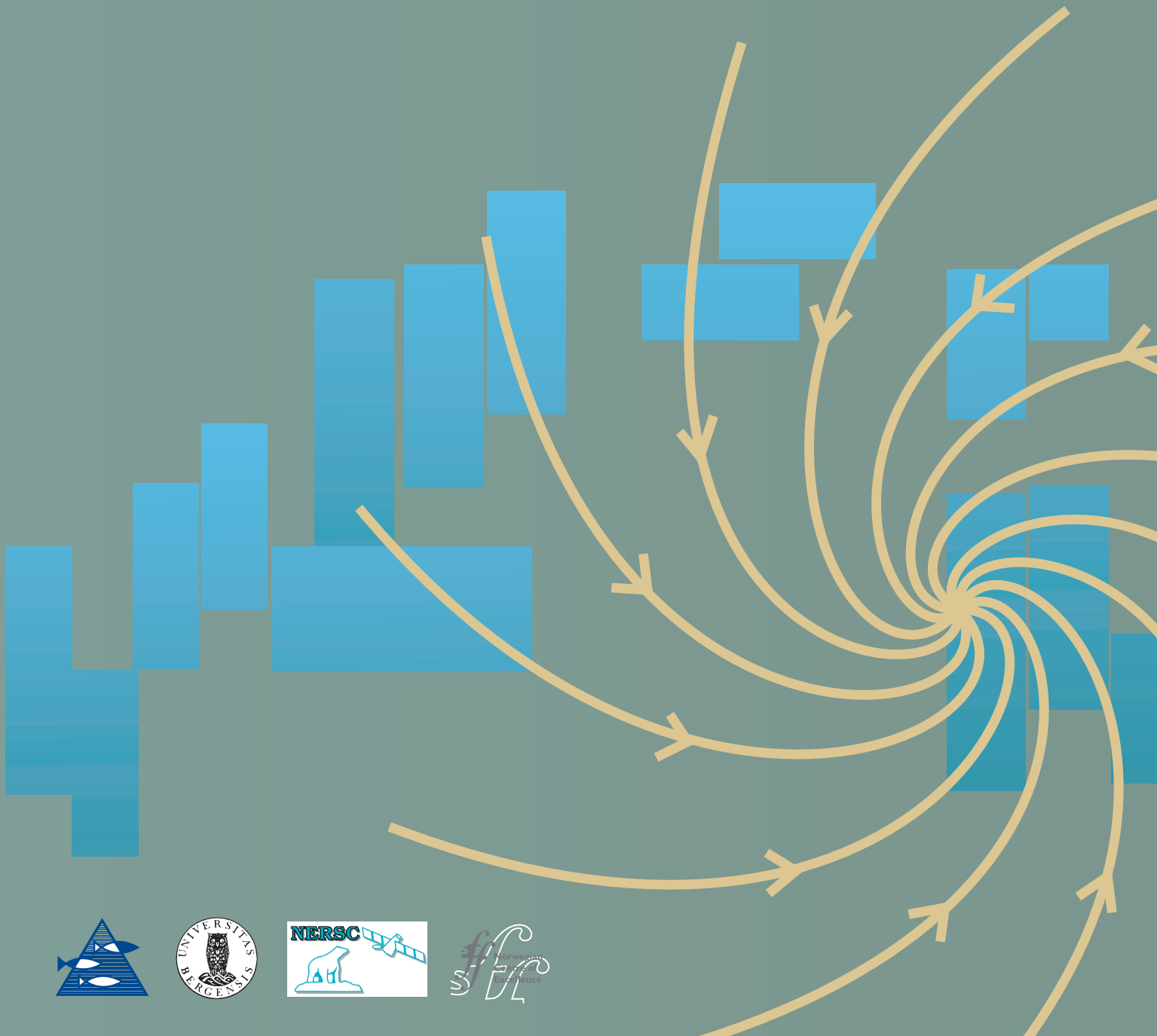
Norwegian Centre of Excellence

Bjerknes Centre for Climate Research

Annual Report 2004

Centre of Excellence activities



Norwegian Centre of Excellence

The ambition of the Bjerknes Centre for Climate Research (BCCR) is to become a leading international centre for climate research in the high latitudes and a key provider of top quality knowledge on climate change to stakeholders, i.e policy makers, industry and the general public.

The BCCR is a joint venture between the University of Bergen (UoB), the Institute of Marine Research (IMR) and the Nansen Environmental and Remote Sensing Center (NERSC). The Collaboration was formally established in August 2000 with the aim of creating a Center of Excellence in climate research. The BCCR constitutes the largest climate research group in Norway and provides excellent opportunities to conduct top quality climate research in high-latitudes by virtue of its breadth, research infrastructure and unique extensive data series.

In 2002 the BCCR was awarded the status of national Center of Excellence by the Research Council of Norway

Editors: Beatriz Balino and Eystein Jansen
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Words from the director

In the second year as a CoE, the BCCR implemented its research strategy, developed in the first year, and its new organisation, through which we have organised the research groups into topical activities with specific scientific objectives.

This has created new interdisciplinary research teams, and a strong momentum. Important progress has been achieved in several areas.

■ We have continued our efforts to unravel the mechanisms and dynamics of the northward ocean and atmospheric heat flux from the Atlantic towards the Arctic. These results open up new possibilities for predicating climates on seasonal and longer time scales.

■ The Bergen Climate Model, developed by BCCR scientists gives many new results documenting the applicability of the model system for the research at the BCCR. The model and its compartments is a key research hub for the activities.

◢ Natural climate change is a central research area of the BCCR and new high quality reconstructions of past climate variability has been produced from both hemispheres. These results provide insights into key questions concerning how the high latitudes and the tropics interact, both in terms of abrupt climate changes and modes of climate variability.

■ BCCR has expanded its activities in carbon cycle studies with a new emphasis on global carbon cycle modelling, and the Centre leads a 42 partner European team with the purpose of unravelling how the ocean controls the global CO2-budget. This takes place in the EU integrated project CarboOcean co-ordinated from the Bjerknes Centre.

■ BCCR is very active in the 4th assessment report of the IPCC, both as Co-ordinating lead authors, lead authors and contributing authors, as well as providing scientific input to the report to be due in 2007.

I wish to thank all BCCR staff for their dedication and hard work, our sponsors in the Research Council and elsewhere, and our host and partner institutions for their trust and support. With the results obtained in 2004, we are on good track to reach our goals.

Prof. Eystein Jansen

Table of content

Research strategy & organisation

The overall objective of the BCCR is to understand and quantify regional climate changes in the context of the global climate system

To reach this objective the BCCR is organised in multi-disciplinary research activities and forums to provide insight and answers to the following three main research themes:

1 Abrupt climate change

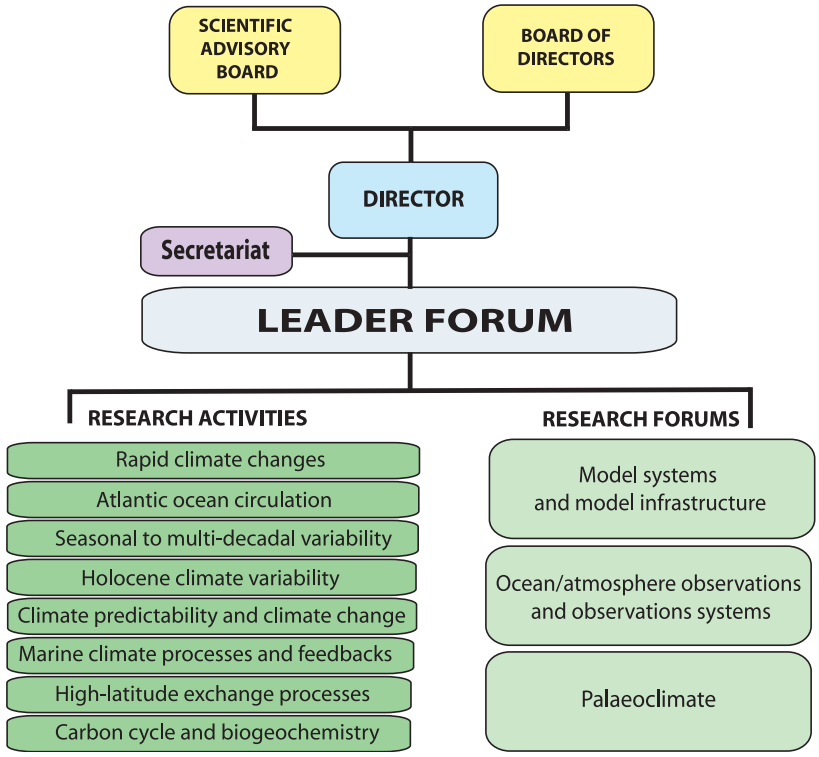
To understand the causes and likelihood of high-amplitude rapid climate change and assess the possibilities for major climate surprises affecting our region.

2 Climate variability

To understand causes of climate variability, both natural and man made, to asses climate trends and the predictability of climate changes in order to deliver high quality scenarios of future climate change

3 Processes & feedbacks

To study and understand key processes and feedbacks governing the response and sensitivity to climate forcing



The director and the leader forum

Prof. **Eystein Jansen,** Palaeoclimatology, BCCR -Director
Ass. Prof. **Tore Furevik,** Climate modelling, UoB - Deputy director
Dr. **Trond Dokken,** Palaeoclimatology, BCCR
Prof. **Helge Drange,** Climate modelling, NERSC
Dr. **Tor Eldevik,** Ocean processes & modelling, NERSC
Prof. **Peter Haugan,** Polar oceanography, UoB
Prof. **Christoph Heinze**, Carbon cycle modelling, UoB
Prof. **Truls Johannessen**, Chemical oceanography, UoB
Ass. Prof. **Nils-Gunnar Kvamstø** Atmospheric modelling, UoB
Prof. **Atle Nesje**, Palaeoclimatology, UoB
Dr. **Asgeir Sorteberg**, Climate modelling, BCCR
Prof. **Svein Sundby**, Ocean climates, IMR

Board of directors

Ola M. Johannessen, director, Nansen Environmental and Remote Sensing Center (Chair)
Kåre Rommetveit, director general, UoB
Dag Aksnes, dean, Faculty of Mathematics and Natural Sciences, UoB
Tore Nepstad, director, Institute of Marine Research

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Thomas Rossby, Graduate School of Oceanography, University of Rhode Island, USA
Andrew Watson, School of Environmental Sciences, University of East Anglia, UK

Research activities

	Leader (deputy leader)
Rapid Climate Changes: causal connections	T. Dokken (K. Nisancioglu)
Atlantic Ocean Circulation	H. Drange (H.F. Kleiven)
Seasonal to Multi-decadal Variability	T. Furevik (I. Kindem)
Holocene Climate Variability and Forcing	A. Nesje (O. H. Otterå)
Climate Predictability and Future Climate Change	A. Sorteberg (S. Sundby)
Marine Climate Processes and Feedbacks	T. Eldevik (P. Haugan)
High-latitude Exchange Processes	N.-G. Kvamstø (F. Flatøy)
	C. Heinze (A. Olsen)

Research forums

	Co-leaders
Model systems and model infrastructure	Mats Bentsen, NERSC Paul Budgell, IMR
Ocean/atmosphere observations and observation systems	Henrik Søiland, IMR Richard Bellerby, BCCR
Palaeoclimate	Ulysses Ninnemann, UoB Øyvind Lie, BCCR

The BCCR approach

The approach of the BCCR is to combine cutting-edge research with top-level education and outreach activities.

The BCCR will:

- Facilitate top research in key areas in order to establish the BCCR among the leading international climate research centres
- Become a visible contributor to national and international research programs and assessments, such as the World Climate Research Programme (WRCP), the International Geosphere-Biosphere Programme (IGBP) and the Inter–governmental Panel on Climate Change (IPCC).
- Become the primary national centre of competence on climate change for education, policy makers, the media and the general public.

Assessment

The BCCR is subject to annual critical assessments of its scientific advancement and the timely fulfilment of its objectives by the Scientific Advisory Board, an external panel of acknowledged climate scientists. The key evaluating criteria are:

- High quality papers in peer-review, leading international journals addressing the objectives of the research Activities
- Multi-authorship across disciplinary boundaries within the BCCR
- Memberships in scientific steering committees of national and international programs and activities
- Media exposure and public outreach
- Interaction with stakeholders (governmental bodies, decision and policy makers, enterprises, NGOs, etc.)

Gender issues

During 2004, several female PhD students defended their doctoral dissertation, and started at postdoc positions at BCCR. This has increased the fraction of female postdocs from 29% in 2003 to 43%. The current development fits the BCCR´s promotion and incentive plans to increase the number of female scientists at the leader and senior levels.

Summary of accomplishments

During its second year as CoE, the BCCR implemented the research strategy developed in 2003 and resulted in a new organisational structure to accommodate the new functional groups.

REGARDING NEW RESEARCH, BCCR participated in a number of applications during the 2nd call of EU´s 6 Framework Programme that culminated in 4 successful applications with BCCR involvement: the Integrated Projects CARBOOCEAN and ENSEMBLES, the Network of Excellence EUROCEANS, and the STREP project DYNAMITE. Of these, CARBOOCEAN and DYNAMITE are co-ordinated by Bjerknes scientists Prof. Christoph Heinze and Prof. Helge Drange, respectively.

BCCR´s international engagement during 2004 included participation in IPCC preparatory meetings for the upcoming 4th Assessment Report and contribution to the Arctic Climate Impact Assessment (ACIA) report, officially launched during a conference in Reykjavik in November. In addition, BCCR scientists authored a number of review articles in prestigious journals such as in Science´s "Perspectives" and Nature´s "News & Views". The article of Prof. O.M. Johannessen and co-workers was promoted in Science Editor´s Choice while Quaternary Science Reviews claimed the articles of Prof. John Inge Svendsen and co-workers and Richard Telford and co-workers to be among the 5 most requested articles during 2004.

BCCR successfully organised an international open science conference in Bergen to commemorate the centenary of Vilhem Bjerknes pivotal paper of 1904. The conference gathered many of the world´s premier climate scientists and a total of 281 delegates from around the world to discuss aspects of modern climate research in a truly interdisciplinary effort. BCCR also co-organised an international seminar, in honour of retiring Prof. Jan Mangerud, which brought a number of worldclass palaeo climatologists to Bergen. The CoE´s scientific production included 72 research articles in the international peer review literature (including one paper in Nature and one in Science), 2 books and 2 chapters in books and 192 presentations (oral and poster) at national and international science meetings. Outreach activities included popular articles, invited lectures, and media coverage.

Key contributions

BCCR scientists are indicated in bold

Scientific papers

Krinner, G., J. **Mangerud**, M. Jakobsson, M. Crucifix, C. Ritz and J. I. **Svendsen** (2004),
"Enhanced ice sheet growth in Eurasia owing to adjacent ice-dammed lakes."
Nature 427: 429 - 432

- Lamy, F., J. Kaiser, U. **Ninnemann**, D. Hebbeln, H.W. Arz and J. Stoner (2004)
"Antarctic timing of surface water changes off Chile and Patagonian ice sheet response"
Science 304, 1959-1962.

- **Bentsen**, M., H. **Drange**, T. **Furevik** and T. Zhou (2004).
"Simulated variability of the Atlantic thermohaline meridional circulation."
Climate Dynamics 22(6-7): 701-720.

- **Otterå**, O. H., H. **Drange**, M. **Bentsen**, and N. G. **Kvamstø** and D. Jiang (2004).
"Transient response of the Atlantic Meridional Overturning Circulation to enhanced freshwater input to the Nordic Seas-Arctic Ocean in the Bergen Climate Model."
*TELLUS Series A 56(*A): 342-361.

Scientific Reviews

- **Birks**, H.J.C and H. **Birks**.
"The rise and fall of forests". Perspectives.
Science 305, 484-485, 23 July 2004

- Hansen, B., S. **Østerhus**, D. Quadfasel and W. Turrell.
"Already the day after tomorrow?"
Perspectives.
Science 305,953-954, 13 August 2004

- **Dokken**, T. and K. H. **Nisancioglu**.
"Fresh angle on the polar seesaw".
News & Views, Nature 430, 19 aug. 2004

Science Editors´ choice on Climate Science:
"An ice-free Arctic?"

- Promotion of the article of **Johannessen**, O. M., L. Bengtsson, M. W. **Miles**, S. I. Kuzmina, V. A. Semenov, G. V. Alekseev, A. P. Nagurny, V. F. Zakharov, L. P. Bobylev, L. H. Petterson, H. K. and H. P. Cattle (2004)
"Arctic climate change: observed and modeled temperature and sea-ice variability".
Tellus A 56:328

New evidence shows that the hemispheres responded asynchronously to rapid climate changes in the past 80 000 years.

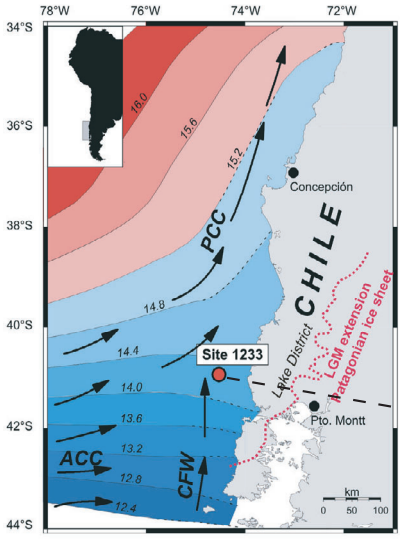
THE CLIMATE OF much of the Northern Hemisphere underwent rapid and dramatic changes during the cool periods of the past 80,000 years and during the transition out of the last ice age. When Greenland warmed, the surface waters of the North Atlantic warmed, the trade winds strengthened, changes in North Pacific ventilation occurred, and the Asian monsoon intensified. These changes are well documented by the numerous paleo-reconstructions from across the whole of the Northern Hemisphere.

Conversely, the way the Southern Hemisphere reacted to these climate changes in the North is still a matter of debate because discrepancies in the little bit of data that is available do not depict a clear picture. While Antarctic ice cores indicate a warming in the Southern Hemisphere when the Northern Hemisphere was cooling (i.e. asynchronous behaviour), the timing of glacial advance and changes in terrestrial vegetation in both South America and New Zealand indicate that global climate varied synchronously, i.e. the South cooled along with the Northern Hemisphere. Much of the controversy is very much due to the poor data coverage in the Southern Hemisphere. Why is this important? Because by establishing the spatial pattern of rapid climate changes one will contribute to a better understanding of the mechanisms driving them.

In this regard, Bjerknes scientists together with colleagues from Germany and the USA have made an important contribution to the Southern Hemisphere records, by analyzing marine sediment cores off the coast of Chile in the southeast Pacific (Figure 1). They produced an exceptionally high-resolution history of sea surface temperatures during the past 50 000 years which supports the model of asynchronous temperature changes between both Hemispheres.

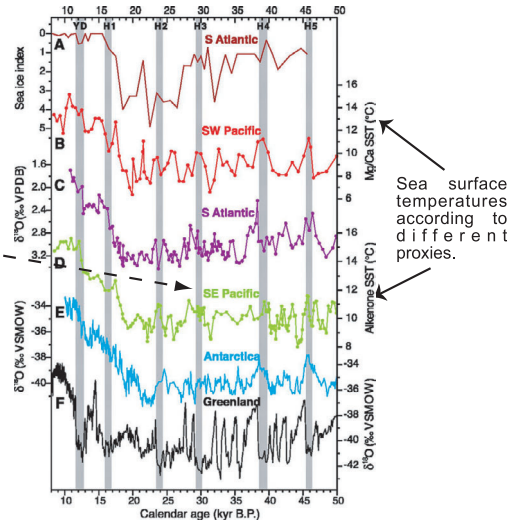
The asynchronous model implies that rapid climate changes represent changes in the way the ocean currents transport heat around the globe. Because the ocean currents that bring heat to one area must take it away from another, this model predicts that Northern Hemisphere warming should be accompanied by a cooling of the Southern Hemisphere. Surface waters become dense and sink in the North Atlantic. As these deep waters flow south, warm surface waters travel northward to replace them, bringing warmth to the North Atlantic. When deep-water production slackens, the North Atlantic cools. The discrepancy with the land-based data can be due to the slow response of glaciers, in that glacial maxima do not necessarily correspond to the coolest conditions in the atmosphere, while vegetation will be influenced not only by the regional climate changes, but also by the presence of large ice-sheets nearby.

- **Scientist involved:**
  Ulysses **Ninnemann**, Dept. of Earth Sciences, UoB and BCCR
- Research project: Ocean Drilling Program Leg 202, Site 1233 (NRC, NSF and JOI)
- Reference: Lamy et al. (2004), "Antarctic timing of surface water changes off Chile and Patagonian ice sheet response", *Science* 304, 1959-1962



Location of Drilling Site 1233, where marine sediments cores were gathered to reconstruct the history of the sea surface temperature off the coast of Chile during the past 50 000 years (Present sea surface temperatures gradients are drawn). PCC: Peru-Chile Current; CFW: Chilean Fjord Water; ACC: Antarctic Circumpolar Current; LGM: Last glacial maximum

Reconstruction of climate proxies at different sites in the Southern Hemisphere (A-D), compared to temperatures from ice cores in Antarctica (E) and Greenland (F). The figure shows that maxima in the Southern Hemisphere records correspond with minima in the Greenland ice core (which represents the Northern Hemisphere), adding to the evidence that climatic variations between the Northern and Southern hemispheres are asynchronous.



Sea surface temperatures according to different proxies.

The role of the tropical ocean on the fate of arctic sea-ice

The observed warming of the Arctic climate in the past couple of decades has lead scientists to consider past changes in the northern high-latitude climate to assess whether the warming is caused by natural variability or is a response to man-made greenhouse gas emissions.

OVER 100 YEARS OF measurements of surface air temperature and sea ice distribution spanning the time period from 1891 to 1999 have been acquainted, quality checked and analysed in combination with global coupled atmosphere-sea ice-ocean climate models.

Temperature records throughout the 20th century have identified two distinct periods of pronounced warming: one between mid-20s to mid-40s and a second starting about 1980 and still ongoing. While the early warming was largely confined to latitudes poleward of 60 degrees N, the second warming also extends into the sub-tropical regions. A common feature is that the warming is amplified in the Arctic region, notably during the winter season. In an attempt to simulate these phenomena, a modelling exercise gave important information about the causal factors for these events: while the increase of air temperature early in the century was a consequence of natural climate variability, the warming that started in 1980 is, at least partly, caused by human induced global warming. The causal factor can be tracked back to the slow but steady warming of the tropical oceans since 1950 which has forced a commensurate trend toward an extreme positive phase of North Atlantic Oscillation (NAO). A strong positive NAO strengthens the middle latitude westerly winds and impacts the atmospheric circulation of the Northern Hemisphere. The measurable consequences of this are an increase in the surface air temperature as well as large-scale changes in precipitation patterns over Europe and the Middle East.

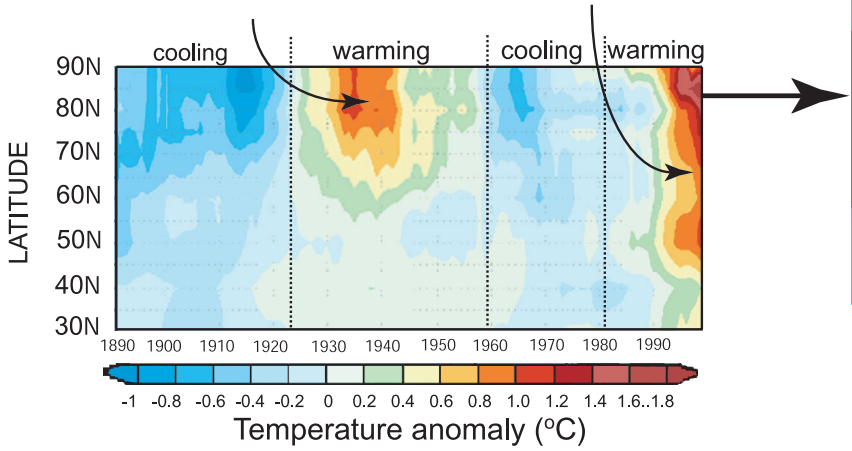
The question then arises: How will global warming affect the Arctic climate system in the future? Model projections into the 21st century with similar rate of greenhouse emissions as of today (i.e. "business as usual") indicate that the Arctic Ocean will be ice-free in summer by the end of the century.

The potential consequences of the ongoing Arctic warming and concomitant decrease of sea-ice will be many and varied. For instance, more open water in the Arctic will affect the energy balance and the atmospheric and oceanic circulations in the northern latitudes. In addition, a sea-ice free Arctic Ocean will alter the present-day air-sea exchange of CO2. It is also expected that impacts on the arctic ecosystem will be considerable, both in favourable and unfavourable ways. At last, but not least, it will affect the density of the water masses and concomitant deep-water formation in the Nordic Seas, with repercussions on the Atlantic Meridional Overturning Circulation, which will ultimately affect the climate of the northern latitudes.

- **Scientists involved**
  Ola M. Johannessen, NERSC and Martin Miles, BCCR
- **Research projects**
  AICSEX (EU), ROLARC & MACESIZ (RNC), INTAS
- **Reference**
  Johannessen et al. (2004). "Arctic climate change: observed and modelled temperature and sea-ice variability". *Tellus* 56A(4): 328-341

The warming in the 20s was amplified in the Arctic (70N-90N) with air temperatures 1-2 degrees above the normal. Model simulations indicate that this was due to internal (natural) variability of the climate system

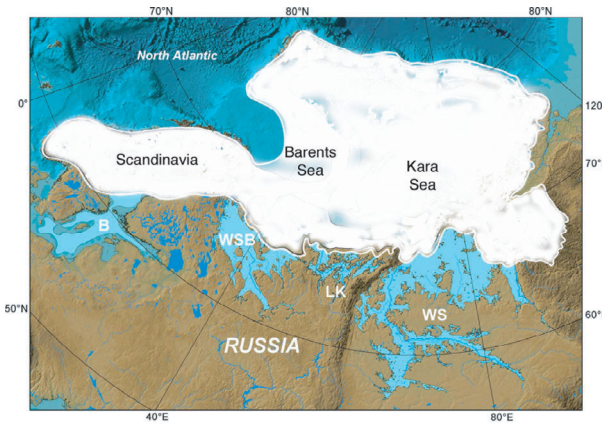
The warming after 80s was stronger and extended far south into the sub-tropics. Model simulations suggest that this warming event (still ongoing) is human induced. See text for details.



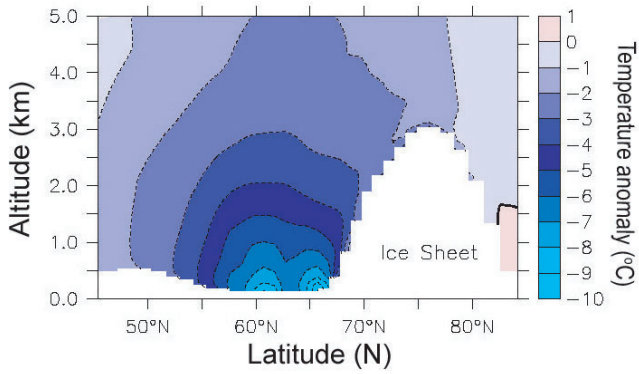
Air temperature anomalies recorded since 1890 in the northern hemisphere. An "anomaly" means a deviation from the expected average conditions. The figure above denotes areas where the air temperature is lower (shades of blue) or higher (yellow to red) than the expected average temperature for the given latitude. Redrawn from Johannesen et al (2004)

Fate of sea ice?

Extension of sea ice in the Artic during the summer at present (red area) compared the situation predicted for the year 2080 (white area). Modell predict that the Artic Ocean will be ice-free by the end of 21st century.
Source: Bergen Climate Model



Reconstruction of the Eurasian ice sheet during its maximum extension about 90 000 years ago. The glacial lakes in northern Russia are indicated: WS: West Siberian Lake; LK: Lake Komi, WSB: Whte Sea Basin Lake and B: Baltic Lake. (Redrawn from Krinner et al (2004)



Model simulation of temperature anomalies throughout the lower atmosphere during the summer (June, July and August). It shows that, where glacial lakes are adjacent to the Eurasian ice sheet, the air temperature is up to 10 degrees lower than expected. Redrawn from Krinner et al

Climate change during the ice ages:

Positive feedback from eurasian glacial lakes

Profs Jan Mangerud and John Inge Svendsen from the Department of Earth Sciences at the University of Bergen and affiliated to the BCCR, have lead field studies in the Pechora Basin, Russia over the last decade in order to reconstruct the glaciation history and the climate development through the last inter-glacial-glacial cycle in Northern Russia.

A RECENT STUDY paid particularl attention to the impact of ice-dammed lakes on the climate of the region. Several large ice-dammed lakes, with a combined area twice that of the Caspian Sea, were formed in northern Eurasia about 90,000 years ago when an ice sheet centred over the Barents and Kara seas blocked the large northbound Russian rivers.

The field data acquired by Mangerud and Svendsen were used to feed climate models developed by French scientists in Grenoble and Paris with the purpose of elucidating how the ice-dammed lakes influenced the climate and the ice sheet. The model indicates that glacial lakes impacted the Eurasian continent climate considerably by cooling the summers. The identified mechanism is that the lakes had very low summer temperatures and they cooled effectively the air-layer above them.

Because of their large size and heat capacity, they decreased the summer temperatures around them as much as 8-100C. As a consequence, glaciers melted less during the summers. So, this became a positive feedback: as soon as the ice sheet was large enough to dam lakes, the summers became cooler and ice sheet growth accelerated. It is assumed that the same mechanism also operated in North America as soon as the ice sheet blocked the Hudson Strait.

The field data and reconstructions by Svendsen, Mangerud and co-workers have also greatly improved the reconstruction of the global Last Glacial Maximum (some 20, 000 years ago) ice sheets, which is regularly used to test and validate climate models.

- **Scientists involved**
  Jan Mangerud, John Inge Svendsen, Dept of Earth Science, UoB and Bjerknes Centre for Climate Research
- **Research projects**
  QUEEN (ESF), Pechora II (RCN)
- **Reference**
  Krinner et al. 2004,
  "Enhanced ice sheet growth in Eurasia owing to adjacent ice-dammed lakes",
  Nature 427, 429-432,
  and Svendsen, J. I. et al. 2004,
  "Late Quaternary ice sheet history of Northern Eurasia".
  Quaternary Science Reviews 23, 1229-1271

Effects of climate changes:

Impact of overfishing and climate variability on the Barents sea cod stock

Atlantic Cod is one of the commercially most important fish species in the North Atlantic and plays a central role in a number of ecosystems. Overfishing over prolonged periods has resulted in dramatic declines in the abundance of many stocks. The Arcto-Norwegian cod stock in the Barents Sea is today the largest stock of Atlantic Cod but the recruitment has varied extensively during the last 60 years.

SCIENTISTS FROM THE Institute of Marine Research affiliated with the BCCR try to understand how fishing and climate variability impact marine ecosystems throughout time. The stock of the Barents Sea cod has been subject to a dual pressure during the last century: overexploitation by fishing and climate fluctuations. For instance, size-selective overfishing has changed the age and size composition of the spawning stock dramatically since 1945: today an average spawner is 3 years younger and 10 cm shorter.

Sea temperature was early recognized as an important influence on fish recruitment. In northerly regions early life stages (i.e. eggs, larvae and juveniles) survive better in "warm" than in cold years. It has recently been shown that the correlation between Barents Sea temperature and cod recruitment has become increasingly stronger during the last decades (Figure 3). Why is it so? It is hypothesised that as the cod stock in the Barents Sea changed its age and size structure (due to size-selective fishing), and it concurrently developed a higher sensitivity to environmental fluctuations, in particular temperature. However, it should be noted that during the same period there have been significant changes in the large-scale atmospheric circulation in the North Atlantic, changes that also may influence the correlation between regional Barents Sea climate and cod recruitment.

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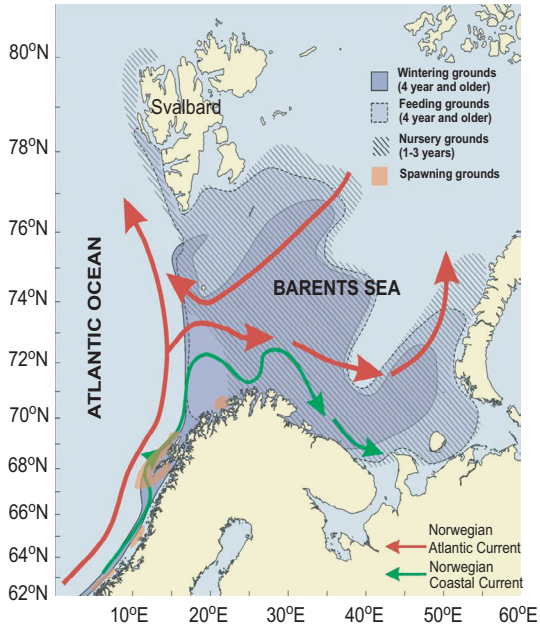
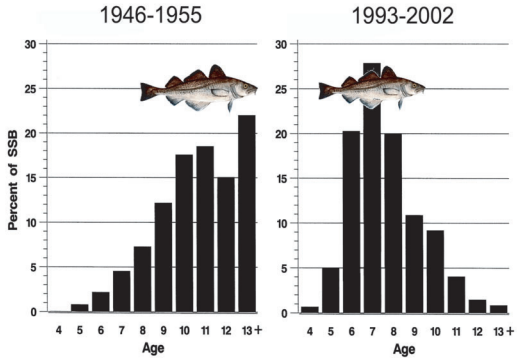
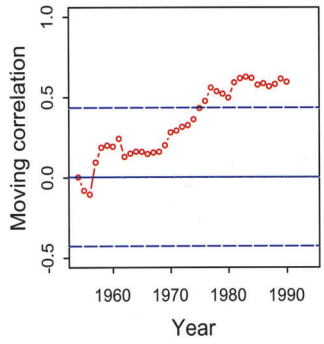


Mean features of the Barents Sea circulation and areas of distribution of the cod population.



The percentage of spawning stock biomass per age group in two time intervals shows that the average cod spawner nowadays is younger and smaller compared to an average spawner 50 years

Sea temperature vs cod recruitment age 3



The positive correlation between the temperature in the Barents Sea and cod recruitment has grown stronger during the last decades

New insight into the gulf stream system

The Gulf Stream system, including the Norwegian Atlantic Current, can be described as the upper limb of the "Atlantic Meridional Overturning Circulation" (AMOC) cell. The AMOC transports large amounts of heat poleward from the Tropical Atlantic. The excess heat is gradually lost to the atmosphere thus contributing critically to the temperate climate of Northern Europe. The northward warm flow in the surface "overturns" at high northern latitudes and returns south as a cold flow in the deep ocean.

THE NORDIC SEAS play a crucial role in the AMOC since much of the actual overturning takes place here. The inflowing warm Norwegian Atlantic Current is transformed from a warm surface current into a deep and cold outflow. This transformation has to take place at a rate that matches the overturning circulation. Otherwise, the properties of the AMOC will be perturbed and the associated heat transport, and ultimately our climate, may change dramatically. Bjerknes scientists study key aspects of this system by a combination of unique observational data sets and state-of-the-art numerical ocean models.

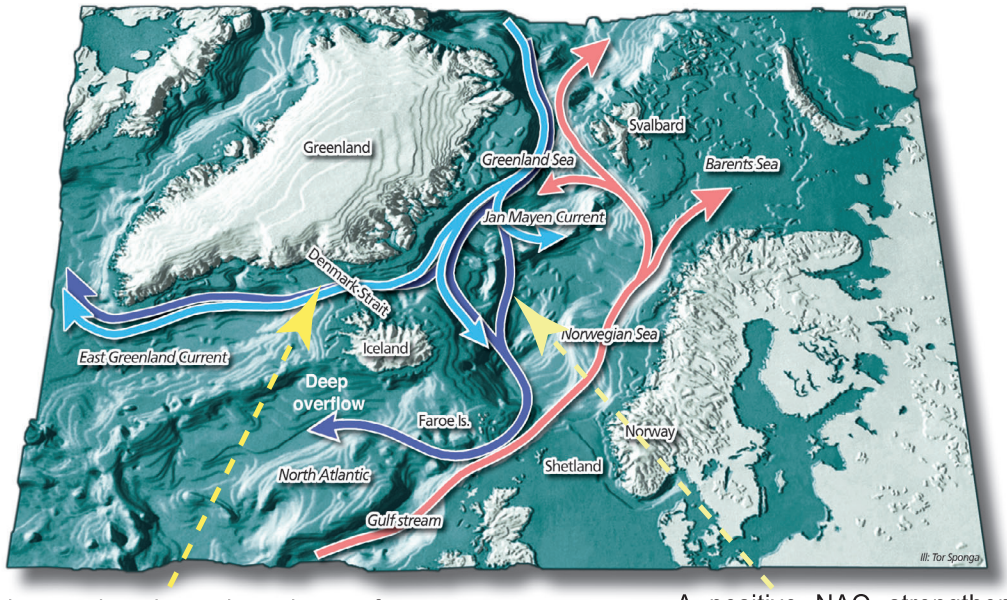
The Greenland-Scotland Ridge separates the North Atlantic Ocean from the Nordic Seas. Cold water from the Nordic Seas overflows the ridge through the Denmark Strait and in the Faroe-Shetland Channel, and descends into the abyss of the North Atlantic to become a dominant part of the AMOC. The strength of the overflows has been found to be relatively constant, but the deep water's way through the Nordic Seas to the exits can vary substantially. The pathways are decisive for the source and composition of the overflowing water masses, and influence therefore the characteristics of the AMOC. The Jan Mayen Current (JMC) plays a key role in this as it provides a direct pathway from the northern "overturning" parts of the Nordic Seas to the Norwegian Sea in south.

In general the JMC is weak compared to the East Greenland Current (EGC), and it is the deeper part of the EGC that feeds the overflows. The waters that do not leave through the Denmark Strait continue southeast via the Norwegian Sea to overflow at the Faroe-Shetland Channel. The setting is very different in years of a persistent and positive NAO-like atmospheric forcing like most of the 1990s.

In this case the JMC is well pronounced and the prime source for the Faroe-Shetland Channel overflow. The JMC may therefore "shortcut" a significant part of the Nordic Seas' overturning loop.

- **Scientists involved**
  Tor Eldevik, Anne-Britt Sandø (NERSC/BCCR), Tore Furevik (GFI/BCCR) and Fiammeta Straneo (Woods Hole Oceanographic Institution, USA)
- **Research project**
  TRACTOR (EU), ProClim I and II (NRC), West Nordic Ocean Climate (Nordic Council of Ministers), NSF #0240378
- **Reference**
  Eldevik et al. Pathways and export of Greenland Sea Water, In: Climate variability of the Nordic Seas (Drange, H., T. Dokken, T. Furevik, R. Gerdes and W. Berger, Eds.), AGU monograph (in press).

Sketch of the main circulation in the Nordic Seas. Red arrows indicate the surface inflow of Atlantic water (warm and saline), the light blue arrows denote surface Polar water (fresh and cold) while the dark blue arrows indicate the deep overflows (cold and dense)



When NAO is negative, the main pathway of deep flow out of the Nordic Seas is the Denmark Strait, following the East Greenland Current. The rest overflow crosses the Faroe-Shetland Channel

A positive NAO strengthens the Jan Mayen Current and it becomes the prime source of the Faroe-Shetland Channel deep overflow

From page 9

Unexploited fish stocks that have many old, larger spawners and a wide age and size distribution are generally in better shape to produce strong class years and survive years of unfavourable natural conditions. The tendency towards a spawning stock dominated by younger, smaller fish and fewer year classes, as seen for Barents Sea cod, is an unfavourable development for the reproductive capability of a stock.

The current results indicate that the present Barents Sea cod stock has difficulties in producing strong year classes even when the environmental conditions are favourable. As we face a century with high climate variability and frequency of extreme events concomitant with overfishing practices (unless drastic policy changes occur) the Barents Sea cod stock in particular and many of the worlds other fish stocks will be severely threatened.

The case study presented here emphasises the importance of shifting from a species-based fisheries to an ecosystem-based management of the world fisheries in order to support sustainable development.

- **Scientists involved**
  Geir Ottersen, Institute of Marine Research and BCCR
- **Research projects**
  "Variations in time and space of cod and other gadoids" and ECOBE (RCN), within the framework of ICES and GLOBEC´s Cod and Climate Change Programme
- **Reference**
  "Changes in spawning stock structure strengthens the link between climate and recruitment in a heavily fished cod stock". Fisheries Oceanography (accepted)

The Bjerknes-Neill VOS pCO2 system

Novel technology:

The assessment of the oceanic CO2 sources and sinks requires an accurate quantification of sea-air CO2 fluxes and their variability at all spatial and temporal scales. After 40 years of fieldwork by the international community amassed about 1 million measurements of the partial pressure of carbon dioxide (pCO2).

THIS DATA IS STILL inadequate to resolve the variability of the fluxes from days to seasons. Mapping the diurnal to seasonal variations of CO2 fluxes is decisive to assess errors and uncertainties in existing pCO2 climatologies as well as for a realistic parameterization of CO2 fluxes in ocean carbon cycle models. It became obvious that the acquisition of data at the necessary temporal resolution required new instrumentation capable of continuous measurements of pCO2.

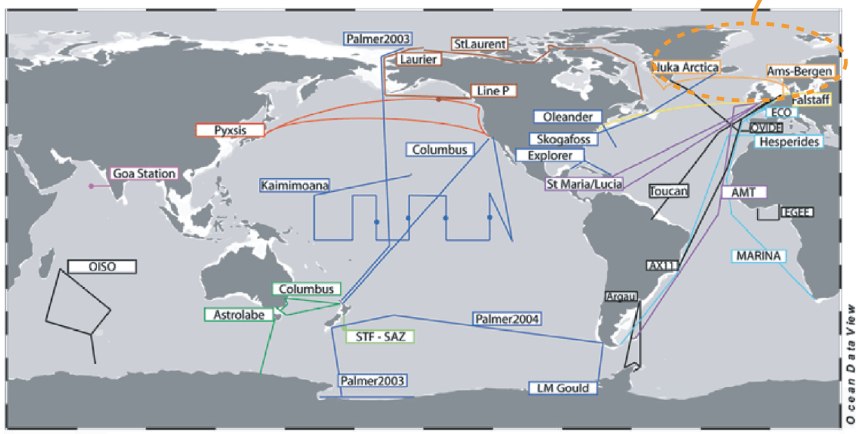
In this regard, Bjerknes Centre engineers and scientists have developed and built a high-end state-of-the-art autonomous underway pCO2 instrumentation sytem, the Bjerknes-Neill VOS pCO2 system. Two units are currently operative on R/V G.O. Sars and M/V Nuka Arctica while a third one will be soon operational at Weather Station Mike in the Norwegian Sea. These measurement systems are used to monitor the CO2 fluxes in the Nordic Seas and provide BCCR´s contribution to a global network of carbon underway measurements coordinated by the International Ocean Carbon Coordination Project (IOCCP), under the auspices of IOC/UNESCO and SCOR. The ultimate goal is to develop an international implementation strategy for a global network of earth system observations within the international Earth System Science Partnership (ESSP).

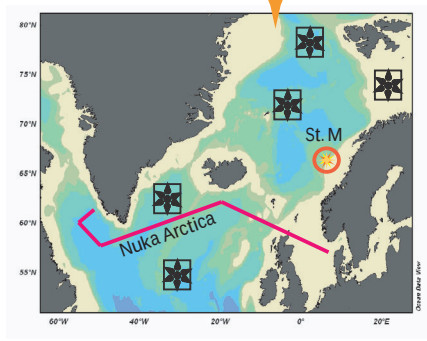
The Bjerknes-Neill VOS pCO2 system has proved to be robust, reliable and delivers high quality data, proof of which is the big demand for the instrument, e.g. 5 units were delivered to the National Oceanic and Atmospheric Administration (NOAA) in the USA, one to the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia and 3 to European partners in the EU CARBOOCEAN Integrated Project coordinated by the University of Bergen and the Bjerknes Centre for Climate Research.

Personnel involved
Craig Neill, Kelly Brown and Abdirahman Omar, BCCR.

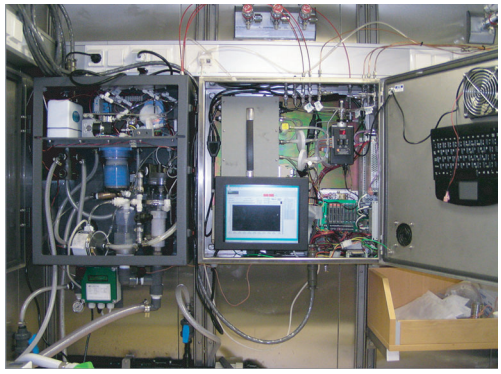
GLOBAL NETWORK OF CARBON UNDERWAY MEASUREMENTS

BCCR contributes to this network together with agencies from Australia, Canada France, Germany, India, Japan, New Zealand, Spain, UK and USA. The *Bjerknes Neill VOS pCO_2 system* is being used by NOAA (5 units) and CSIRO in Australia (1 unit). Another 3 units will be used by European partners in CARBOCEANS.





In 2004, continous measurements of pCO_2 in the Nordic Sea were carried out on the VOS route between Greenland and Denmark (on board M/V Nuka Arctica) and research cruises on board R/V G.O.Sars ✠. Station M will be used as a platform as well in the near future.



Components of the *Bjerknes Neill VOS pCO_2 system* installed on board R/V G.O. Sars.

Quaternary Glaciations- A Global perspective

25-26 November, Realfag-bygget, University of Bergen:

Prof. Jan Mangerud from the Department of Earth Sciences (IGF), UoB and affiliated with the BCCR, retired in the autumn of 2004. Jan´s outstanding scientific contribution, inspirator and leading role behind the growth of Quaternary studies and paleoclimatology in Bergen cannot be overemphasised. For the occasion, IFG and the BCCR co-organised a 2-day scientific seminar in his honour. The seminar featured keynote presentations from eighteen internationally acknowledged scientists in Europe and North America specially invited for the occasion and a total of 24 poster presentations.

Invited speakers to the seminar* Quaternary Glaciations- A global perspective *honouring Prof. Jan Mangerud for a long-life scientific career

Highlights from international meetings

Bjerknes Centenary 2004:
Climate Change in High Latitudes
1-3 September 2004,
Radisson SAS Hotel Bryggen,
Bergen, Norway

The Bjerknes Centre for Climate Research organised a 3-day international open science conference where climate scientists gathered to discuss key issues of the coupled climate system.

THE OBJECTIVE of the meeting was to improve the prediction and assessment of regional impacts of climate change in the polar and sub-polar regions.

The event would also commemorate the centenary of Vilhelm Bjerknes´ seminal paper of 1904 where he proposed the procedure now known as numerical weather forecasting, paving the way for modern meteorology and contributing to modern climate research.

The event gathered a total of 281 delegates from 21 countries in a truly interdisciplinary effort that covered the disciplines of oceanography, geophysics, geology, mathematics, meteorology, biogeochemistry and climate modelling. The unusually wide scope of the conference allowed for observationalists (both paleoclimatologists and oceanographers) and modellers to meet and discuss aspects of modern climate research in an integrated way.

The event was formally opened by the vice-rector of the University of Bergen, Prof. Rune Nilsen, who emphasised that: "Hundred years after Bjerknes fundamental studies leading to modern weather forecasting, the science foundations are now being established to make climate-change forecasting a reality".

The meeting featured three invited lectures, 34 keynote talks and 210 poster presentations distributed among five thematic sessions: (1) Ocean, land, sea-ice response to atmospheric variability; (2) Abrupt climate change; (3) Coupled ocean-land-sea ice- atmosphere processes; (4) High resolution palaeoclimatic reconstructions; and (5) Carbon cycle and high-latitude climate processes. Distinguished guests such as Bob R. Dickson from CEFAS, UK; Anton Eliassen from the Norwegian Meteorological Institute, and Rowan Sutton from the University of Reading lectured on Vilhelm and Jacob Bjerknes legacies.

The Bjerknes Centenary 2004 was co-sponsored by the University of Bergen, the Research Council of Norway, the Norwegian Ministries of Environment, Foreign affairs and Fisheries, the Royal Norwegian Embassy in Washington D.C., STATOIL, the G. C. Rieber Foundations, Aanderaa AS, European Space Agency, the Scientific Committee on Oceanic Research (SCOR) and the Municipality of Bergen.

Invited speakers and sponsors pose in their newly acquired Bergen souvenir during the Conference´s dinner.

Bjerknes Centre
for Climate Research

BJERKNES CENTENARY 2004, Open Science Conference

Climate Change in High Latitudes

September 1-3, 2004 - Bergen, Norway

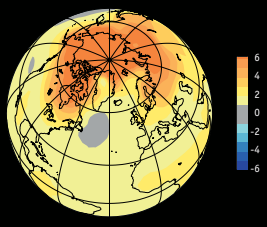
The conference will commemorate the centenary of **Vilhelm Bjerknes'** pioneer publication of 1904: *The problem of weather forecasting as a problem in mechanics and physics* (Met. Zeits., Wien 21:1-7) that paved the way for modern meteorology and practical weather forecasting, and also led to modern climate research.

The conference will focus on climate change in polar and sub-polar regions by featuring:

- Keynote talks by invited speakers
- Plenary and poster presentations
- Discussion forums

Contributions are solicited on research topics that include, but are not limited to:

- Ocean, land, sea ice response to atmospheric variability
- Abrupt climate changes and extreme weather events
- Coupled ocean-land-sea ice- atmosphere processes
- High resolution palaeoclimate reconstructions
- Carbon cycle and high-latitude climate processes



With a doubling of present-day CO_2 concentration in the atmosphere model projections indicate that the largest increases in surface air temperature will occur in the Arctic region (Source: Bergen Climate Model)

Scientific Programme Committee

Eystein Jansen, Bjerknes Centre for Climate Research, Norway - **Chair**
Lennart Bengtsson, Max Planck Institut für Meteorologie, Germany
Svante Björck, Lund University, Sweden
Ray Bradley. University of Massachusetts, USA
Peter deMenocal, Lamont-Doherty Earth Observatory, USA
Jean Claude Gascard, Université Pierre et Marie Curie, France
Sigbjørn Grønås, University of Bergen, Norway
Jens Hesselbjerg Christensen, Danish Meteorological Institute, Denmark
Ola M. Johannessen, Nansen Environmental and Remote Sensing Center, Norway
Fortunat Joos, University of Bern, Switzerland
Jean Jouzel, Université Pierre et Marie Curie, France
Mojib Latif, Max Planck Institut für Meteorologie, Germany
Nick McCave, Cambridge University, UK
Lawrence A. Mysak, Dept. of Atmospheric and Oceanic Sciences, Canada
Ulf Riebesell, Alfred Wegener Institute, Bremerhaven, Germany
Thomas Stocker, University of Bern, Switzerland
Martin Visbek, Lamont-Doherty Earth Observatory, USA

Conference web site & email:

http://www.bjerknes.uib.no/conference2004/
conference2004@bjerknes.uib.no

About the organiser

The **Bjerknes Centre for Climate Research (BCCR)** is a joint climate research venture between the University of Bergen, the Institute of Marine Research and the Nansen Environmental and Remote Sensing Center. The BCCR is the largest climate research group in the natural sciences in Norway and in 2002 it was awarded the status of a national *Center of Excellence* by the Research Council of Norway.

Education & recruitment

In 2004, BCCR scientists provided supervision and training in climate research to 22 doctoral students, 7 of which defended their PhD dissertations, as follows:

1. Anne Bjune
Holocene vegetational and climatic history at or near tree-line in contrasting areas of Norway inferred from pollen and plant microfossils in lake sediments.
Institute of Biology, UoB

2. Jostein Bakke
Late Weischelian and Holocene glacier fluctuations along a south-north coastal transect in Norway - climatic and methodological implications.
Institute of Geography, UoB.

3. Wenche Eide
Plant macrofossils as a terrestrial climate archive for the last 11 000 years in south and central Norway.
Institute of Biology, UoB

4. Mona Henriksen
Late Pleistocene stratigraphy of the Pechora region, Arctic Russia.
Department of Earth Science, UoB

5. Hjálmar Hátún.
The Faroe Current.
Geophysical Institute, UoB

6. Øyvind Paasche
Paleoclimate variability in arctic Norway constrained by physical parameters of lake sediments.
Department of Earth Science, UoB

7 Bjørg Risebrobakken
"Ocean-ice sheet interactions and palaoceanographic variability in the eastern Nordic Seas through the last 140 000 years".
Department of Earth Science, UoB

New research

The following applications to the 2nd call of EU´s 6th Framework Programme successfully passed evaluations and negotiations:

- Marine carbon sources and sinks assessment (CARBOOCEANS). An integrated project coordinated by Prof. Christoph Heinze, BCCR. CARBOOCEANS involves 49 partners from 23 countries and will run for 5 years starting January 1st, 2005.

- ENSEMBLE-based Predictions of Climate Changes and their Impacts (ENSEMBLES). An integrated Project coordinated by D. Griggs, Director of the Hadley Centre, UK. BCCR is partner via NERSC.
Web site: www.ensembles-eu.org

- European Network of Excellence for Ocean Ecosystem Analysis (EUROCEANS). Network of Excellence coordinated by L. Legendre and P. Treguer, CNRS, France. EUROCEANS involve more than 60 research institutions and universities from 25 countries. It will run for 4 years starting January 1st, 2005. BCCR is partner through IMR and NERSC and participates in a joint Norwegian consortium.
Web site http://www.eur-oceans.org

- Understanding the dynamics of the coupled climate system (DYNAMITE). A STREP coordinated by Prof. Helge Drange, NERSC. It will run for 3 years starting March 1st 2005. BCCR is partner.
Web site: http//dynamite.nersc.no/

Outreach activities

An important mission of the BCCR is to enhance public awareness and understanding of key processes involved in the climate system and the potential consequences of climate change. In 2004, Bjerknes scientists contributed to the popularisation of its science through the publication of popular articles (32), invited lectures (8) and more than 36 entries in the mass media (chronicles, articles in newspapers and interviews in radio and TV).

International engagement

In 2004, Bjerknes scientists participated in a number of scientific or assessment committees and working groups from the following international programmes:

UN Intergovernmental Panel for Climate Change (IPCC) 4th Assessment Report

- Prof. Eystein Jansen is Coordinator Lead Author of chapter 6 "Palaeoclimates" while Prof. Christoph Heinze is Lead Author of chapter 8 "Biogeochemistry"

International Geosphere-Biosphere programme (IGBP)

- Surface Ocean Low Atmosphere Study (SOLAS)
- Climate variability and the responses of the Barents Sea (ESSAS/GLOBEC),
- PAGES´ international marine past global changes study (IMAGES)
- Integrated Marine Biogeochemistry and Ecosystem Research (IMBER)
- Past Global Changes (PAGES) and the PAGES/CLIVAR joint panel

Arctic Council and the International Arctic Science Committee (IASC)

- Report of the Arctic Climate International Assessment (ACIA). The following BCCR scientists contributed to the ACIA report: Lead Author Harald Loeng and Contributing authors E. Jansen, H. Drange, R. Bellerby, S. Østerhus, T. Furevik.

Arctic Research Planning

- Prof. H. Drange, NERSC/BCCR participated in the working group (WG) for the Second international conference for Arctic Research Planning (ICARP II) in fall 2005. The WG will address future trends and pattern of change in climate, ozone, ecosystem and other systems in the Arctic. The WG will produce a white paper (i.e a science plan) in advance for the conference. The final paper will be presented at the 2006 Arctic Science Summit Week.

Visiting Fellow Programme

- BCCR sponsors a Visiting Fellow Programme in order to foster research collaboration in climate change with the international community. In 2004, the CoE hosted 71 scientists whose collective stays accounted for about 0.8 person-years. Eighteen percent of the scientists were women.

Country	# visiting scientists
Australia	2
Austria	1
Belgium	1
Canada	2
Chile	1
Croatia	1
Denmark	2
France	7
Germany	10
India	2
Japan	2
Poland	2
South Africa	1
Sweden	2
Switzerland	2
UK	12
USA	21
TOTAL	**71**

Meetings

International conferences and seminars under the auspices of BCCR

- International workshop: Overflows and straits of the Nordic Seas: Processes, causalities and climatic links, March 22-23, Geophysical Institute & NERSC
- Seasonal to annual prediction of the atmosphere, ocean and ecosystems, 30 March, Geophysical Institute
- What's determining Europe's mild climate? June 17, Institute of Marine Research
- Bjerknes Centenary 2004: Climate Change in High Latitudes, 1-3 September 2004, SAS Radisson Hotel Bryggen, Bergen.
- Quaternary Glaciations -A global perspective, 25-26 November, Realfagbygget, UoB
- Meeting of the SOLAS Steering Scientific Committee, June 16-18, BCCR

New initiatives and collaboration

BCCR have established cooperation agreements with Aanderaa AS and the International Centre for Geohazards in Trondheim.

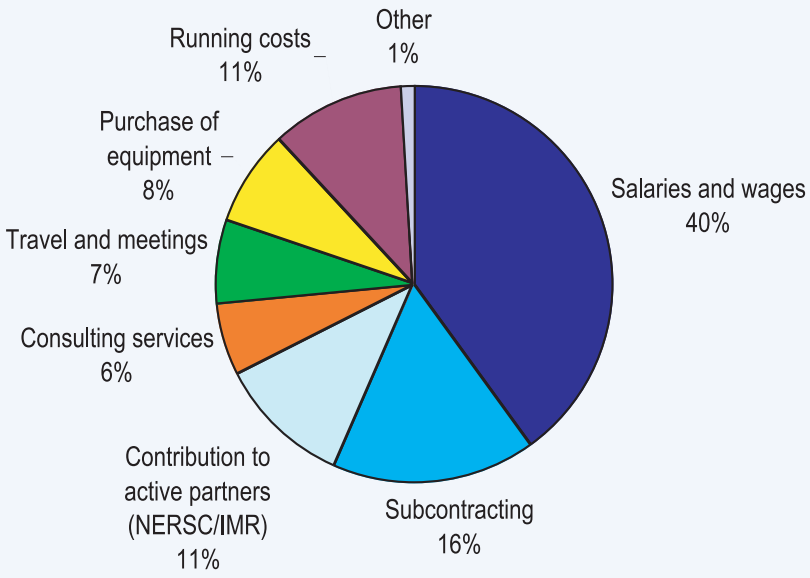
Awardsand prices

- Finn Malgrem Pris 2004 for the amount of 61 000 SEK awarded to Dr. Anna Sjöblom for her outstanding PhD dissertation.
- Honour member of the Botanical Society of Scotland, awarded to Prof. H. John B. Birks for his contribution to the knowledge and understanding of past and present Scottish vegetation.
- COMER foundation awarded 300 000 US dollars to Associate Professor Ulysses Ninnemann in support of palaeoclimate research in the Southern Ocean. In this way Ninnemann become a member of a network of outstanding scientists supported by the COMER foundation.
- Best student oral presentation awarded to doctoral student Anne-Grete B. Pytte at the UK luminescence and ESR Dating Conference, St. Andrews 2004, UK
- Best student poster presentation awarded to doctoral student Ingo Bethke during the Bjerknes Centenary 2004: Climate change in High Latitudes, 1-3 September 2004, Bergen, Norway
- Best student poster presentation awarded to master student student Christine Euler at the 8th International conference on palaeo ceanography, 5-8 September 2004, Biarritz, France.

Budget

Funding sources

The Research Council of Norway contributes 25% of the BCCR budget. The University of Bergen, the host institution, contributes with 32% in the form of in-kind support of faculty and recruiting positions, infrastructure, ship-time, and communications. The BCCR active partners, the Institute of Marine Research and the Nansen Environmental and Remote Sensing Centre (NERSC), contribute altogether 12% of the total. Research grants (projects) provided 30% of the income, both from national (e.g. RCN and industry) and international (e.g. EU, international agreements) funds.



Funding Sources	MNOK
Research Council of Norway	17.0
University of Bergen	21.5
Nansen Environmental & Remote Sensing Center	4.0
Institute of Marine Research	4.0
Research grants (national funds)	14.5
Research grants (international funds)	5.2
Total	**66.2**

Expenditures

Salaries and wages, subcontracting and contribution to the active partners NERSC and IMR comprised the largest expenditures during 2004. Other costs included:

- purchase of equipment (8%)
- travels and meetings (7%)
- consultant services (6%)
- and running costs (11%)

PERSONNEL

Foreign nationalities in parenthesis

Scientists

Bjørn Ådlandsvik	Physical oceanography & modelling
Lars Asplin	Physical oceanography & modelling
Richard Bellerby (UK)	Biogeochemistry
Hilary Birks (UK)	Numerical methods in palaeoclimatology
H. John B. Birks (UK)	Terrestrial biological climate proxies
Paul Budgell (Canada)	Ocean modelling
Carin A. Dahl	Palaeoclimatology
Svein Olaf Dahl	Glaciers & palaeoclimatology
Trond Dokken	Palaeoclimatology
Ken Drinkwater (Canada)	Oceanography & impacts of climate change
Tor Eldevik	Ocean processes & modelling
Ilker Fer (Turkey)	Ocean processes
Frode Flatøy	Atmospheric chemistry & modelling
Tore Furevik	Climate modelling
Tor Gammelsrød	Polar oceanography
Sigbjørn Grønås	Synoptic meteorology
Peter Haugan	Polar oceanography
Chrisoph Heinze	Carbon cycle modelling
Solfrid Hjøllo	Ocean circulation
Eystein Jansen	Palaeoclimatology
Alastair Jenkins (UK)	Boundary layer physics
Ola M. Johannessen	Remote sensing, marginal ice dynamics
Truls Johannessen	Biogeochemistry
Ina Kindem	Stratospheric physics
Helga F. Kleiven	Palaeoclimatology
Nils Gunnar Kvamstø	Atmospheric modelling
Harald Loeng	Physical oceanography, arctic climate
Ketil Lygre	Biogeochemistry & modelling
Jan Mangerud	Palaeoclimatology
Martin Miles (USA)	Climate time series analysis
Kjell A. Mork	Physical oceanography
Atle Nesje	Palaeoclimatology
Ulysses Ninnemann (USA)	Palaeoclimatology
Svein Østerhus	Physical oceanography
Francisco Rey	Ocean climates & biogeochemistry
Anne B. Sandø	Ocean modelling
Øystein Skagseth	Ocean circulation
Morten Skogen	Coupled physical and biological modelling
Henrik Søiland	Ocean modelling
Asgeir Sorteberg	Climate modelling
Jakob Stamnes	Applied physics, climate modelling
Jan E. Stiansen	Impact of climate change on ecosystems
Svein Sundby	Ocean climates
Einar Svendsen	Physical oceanography & modelling
John I. Svendsen	Palaeoclimatology
Richard Telford (UK)	Palaeoclimatology

Postdocs

Jostein Bakke	Palaeoclimatology
Mats Bentsen	Climate modelling
Anne Bjune	Palaeobotany
Wenche Eide	Palaeobotany
Igor Esau (Russia)	Environmental boundary layers
Yonqi Gao	Ocean circulation modelling
Einar Heegard	Palaeoecology
Mona Henriksen	Palaeoclimatology
Randi Ingvaldsen	Physical oceanography
Yoshie Kasajima (Japan)	Mesocale oceanography
Dorthe K. Kristensen	Palaeoclimatology
Øyvind Lie	Palaeoclimatology

Postdocs (cont)

Henriette Linge	Palaeoclimatology
Shujie Ma (China)	Modelling, downscaling
Matthias Moros (Germany)	Palaeoclimatology
Jan Even Ø. Nilsen	Climate modelling
Kerim H. Nisancioglu	Palaeoclimatology
Anders Olsson (Sweden)	Chemical oceanography
Are Olssen	Biogeochemistry
Abidrahman Omar	Chemical oceanography
Odd H. Otterå	Climate modelling
Øyvind Paasche	Palaeoclimatology
Bjørg Risebrobakken	Palaeoclimatology
Anne Sandvik	Mesoscale atmospheric modelling
Anna Sjöblom (Sweden)	Boundary layer meteorology
Ingunn Skjelvan	Chemical oceanography
Lars H. Smedsrud	Polar Oceanography
Frode Vikebø	Climate impacts on marine ecosystems

PhD students

Ingo Bethke (Germany)	Ocean modelling
Øivind Byrkjedal	Meteorology
Elin Darelius (Sweden)	Polar oceanography
Dorothea Iovino (Italy)	Meridional overturning circulation
Carolina Kivimae (Sweden)	Chemical oceanography
Eirik Kolstad	Climate downscaling
Ben Marzeion (Germany)	Meridional overturning circulation
Marius Meland	Palaeoclimatology
Birgitte F. Nyland	Palaeoclimatology
Anne-Grete B. Pytte	Palaeoclimatology
Ivar Seierstad	Meteorology & teleconnections
Anders Sirevaag	Physical Oceanography
Yongyia Song (China)	Climate downscaling
Karolina Widell	Physical oceanography

Technical staff

Dag Blindheim	Palaeoclimatology
Wenche Breyholtz	Palaeoclimatology
Kelly Brown (USA)	Chemical Oceanography
Odd Hansen	Palaeoclimatology
Herbjørn Heggen	Palaeoclimatology
Solveig Kringstad	Chemical Oceanography
Craig C. Neill (USA)	Chemical Oceanography
Ann Kristin Østrem	Oceanographic time series, databases
Liv Senneset	Palaeoclimatology
Rune Søraas	Palaeoclimatology

Secretariat

Beatriz Balino	Science coordinator
Connie E. Engstad	Human resources
Tordis Lerøen	Adm. secretary (deputy for Olsen)
Charla M. Olsen	Adm.secretary (on mother´s leave)
Geir S. Skaten	Financial officer

Personnel summary A

Person/years

Pers. summary A

Person-years	
Scientists	26
Postdocs	25
PhD students	14
Technicians	11
Administration	4
Total	**80**

Personnel summary B

Number of scientific positions sorted by category and by partner

Pers. summary B

	Partner					**Foreigners**	**Women**
Position	BCCR	UoB	IMR	NERSC	Total	%	%
Scientists	17	13	11	5	**46**	26	13
Postdocs	14	7	2	5	**28**	29	43
PhD students	-	11	-	3	**14**	43	43
Total	**31**	**31**	**13**	**13**	**88**		

Percentages of non-Norwegians and female scientists are indicated

RESEARCH PROJECTS

Projects funded by the Research Council of Norway

	DURATION	Coordinator/partner
Effects of North Atlantic Climate Variability on the Barents Sea Ecosystem (ECOBE)	2003-06	S. Sundby ■
Marine climate and ecosystems in the seasonal ice zone (MACESIZ)	2003-06	O.M. Johannessen ■
Norwegian Ocean Climate Project (NOClim II)	2003-06	P. Haugan ■
Past Climates of the Norwegian Region (NORPAST II)	2003-06	A. Nesje ●
Norwegian Palaeo Environment and Climate (NORPEC)	2000-04	A. Nesje ●
Palaeo environment and climate history of the Russian Arctic (PECHORA II)	2003-06	J.I. Svendsen ■
Polar Ocean Climate processes (PROCLIM)	2003-06	P. Haugan ■
Regional Climate Development under Global Warming (RegCLIM III)	2003-06	S. Grønås ■
Spatial and temporal variability of currents and transport of warm waters in the Nordic Seas (NUCA ARCTICA)	2002-06	H. Svendsen ■
External and internal forced variability of the Atlantic European climate system over the last millennium	2003-06	H. Drange ■
Abrupt and large scale climatic and glacial changes in western Norway 14,000-9,000 years BP	2002-04	J. Mangerudv ■
Seasonal forecast of the North Atlantic and Arctic Oscillations with troposphere-stratosphere models	2002-04	N.-G. Kvamstøv ■
Decadal to century scale changes in the vertical water mass structure of the Norwegian Sea - climatic implications and possible forcing	2002-04	E. Jansen ■
Atmosphere-ice-ocean interactions studies	2003-05	P. Haugan ■
Carbon flux and ecosystem feedback in the northern Barents Sea in an era of climate change (CABANERA)	2002-06	T. Johannessen ●

■ Coordinator
● Partner

Research projects funded by EU's 5th Framework Programme

	DURATION	TYPE	Coordinator/partner
Coordinated European Surface ocean Palaeo-estimation Collaboration (CESOP)	2002-04	■ RTD	E. Jansen
European directory of the initial ocean observing system (EDIOS)	2001-04	● RTD	H. Loeng
Meridional Overturning Exchange with the Nordic Seas (MOEN)	2002-04	■ RTD	S. Østerhus
Model and observation test climate feedback (MOTIF)	2003-06	■ RTD	E. Jansen
Northern ocean-atmosphere carbon exchanges study (NOCES)	2002-04	● RTD	H. Drange
Patterns of Climate Variability in the North Atlantic (PACLIVA)	2002-04	■ RTD	E. Jansen
Tracer and circulation in the Nordic Seas (TRACTOR)	2001-04	● RTD	T. Johannessen
Role of ice-ocean-atmosphere processes in high-latitude climate change	2001-06	■ MCTS	P. Haugan
Quantitative palaeoclimatic reconstructions from lake sediments (QPALCLIM)	2001-04	● MCTS	J. Birks

BCCR is ■ Coordinator or ● Partner
RTD: Research, Technology and Demonstration project
MCTS: Marie Curie Training Site

Projects funded by other sources

TITLE	SCIENTISTS	FUNDING AGENCY
A Lagrangian study of the Iceland-Faroe front, a major link between the North Atlantic and the Nordic Seas	S. Østerhus, H. Søiland, S. Sundby	US National Science Foundation & BCCR
Filschner ice shelf water plume study	S. Østerhus	British Antarctic Survey

SELECTED PUBLICATIONS

Bjerknes Scientists are indicated in bold

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A complete listing of peer reviewed publications is available at www.bjerknes.uib.no/publications/publications.html

Bjerknes: Pioneers in modern meteorology and climate research

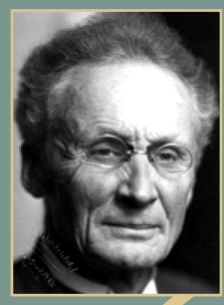
Vilhelm Bjerknes and his son, Jacob, are regarded as the founders of the "Bergen School of Meteorology". They applied hydrodynamic and thermodynamic theories in order to predict future weather conditions.

The methods developed by this school led to a breakthrough for new knowledge and applications in practical weather forecasting and it transferred weather forecasting from a descriptive exercise based on local experience and intuition to a discipline based on the basic equations of fluid dynamics.

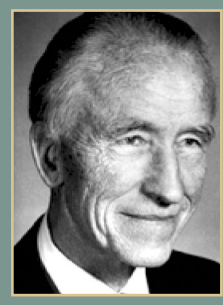
Thereafter, weather forecasting was based to a greater extent on scientific principles, with a much denser network of observation stations and later, with numerical prediction models. Bjerknes' work was vital to our understanding of the movements of air and ocean masses, in particular of how these result from thermal processes.

Vilhelm and Jacob Bjerknes conducted several studies that laid the basis for modern research on climate change and the role of the ocean in the climate system.

The Centre is thus named as a tribute to their efforts.



Vilhelm F.K. Bjerknes
(1862-1951)



Jacob A.B. Bjerknes
(1897-1975)

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