Science strategy for the Bjerknes Centre for Climate Research

Bjerknes Centre
for Climate Research

Front page:
Icebergs in the fjord by the
Eqip Sermia Glacier, East Greenland.
Photo: Iselin Medhaug

Winter at Mjølfjell, Norway
Photo: Erik Kolstad

The aim of the Bjerknes Centre is to understand and quantify the climate system for the benefit of society

The centre engages more than 180 scientists from 32 countries, and is one of the largest climate research units in Europe.

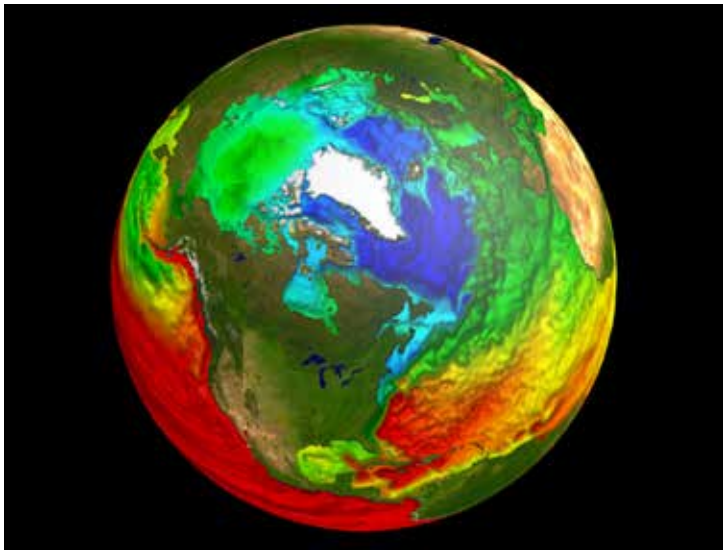
The research is organised into seven research groups, each with specific goals, objectives and implementation plans.

The Bjerknes Centre is an umbrella organisation gathering the major institutions in climate research in Bergen, Norway, as follows:

- University of Bergen
- Uni Research Ltd
- Nansen Environmental and Remote Sensing Center
- Institute of Marine Research

The Bjerknes Centre combines observations with theoretical and modelling studies of past, present and future climates. The centre will:

- Identify processes controlling natural and human induced climate change.
- Understand large-scale teleconnections and couplings in atmosphere and ocean.
- Understand and quantify past climate variations at regional and global scales
- Determine changes in the earth's cryosphere (sea ice, permafrost, glaciers and ice sheets).
- Understand and quantify global and regional sea level changes.
- Quantify global biogeochemical cycles and their couplings to the climate system.
- Provide scenarios for future climate at global and regional scales.
- Develop methods for providing seasonal to decadal climate predictions.
- Contribute actively to the climate change mitigation and adaptation processes.
- Play an important role in training of future generations of climate scientists.
- Communicate research results to stakeholders and society at large.



The picture shows the elevation of the ocean surface in the northern hemisphere as simulated by Norwegian Earth System Model. The Gulf Stream (sharp boundary between blue and green) is seen flowing from the eastern North American Atlantic coast towards Europe. Eddies form on both sides of the Gulf Stream.
Source: Mehmet Ilicak/ Bjerknes Centre

To comply with its aim and goals, the Bjerknes Centre will:

Enhance modelling capacities, such as:

- The Norwegian Earth System Model: continue to lead the national effort to improve the model and deliver data for research and assessments.
- The Norwegian Climate Prediction system: test methods and systems for climate prediction at seasonal to decadal scales.
- Regional models: test methods and systems for regional downscaling and process studies of air-sea-ice interaction, and provide data for mitigation and adaptation studies.

Develop research infrastructure and data acquisition capabilities by:

- Contributing to improve the national and international e-infrastructure.
- Testing and adopting new technology for data acquisition.
- State-of-the art data management including web-based portals.

Collaborate nationally and internationally by:

- Contributing to regional and global assessments and syntheses (e.g. IPCC).
- Participating in international field campaigns and long-term monitoring programs.
- Participating in the development and implementation of national and international research agendas and science programs.

Contribute to research education and recruitment of young scientists by:

- Coordinating courses and summer schools under the national research school in climate.
- Participating in coordinated outreach and training activities (e.g. Bergen Science Centre and the Norwegian Science Week).

Be a key provider of knowledge on climate to society by:

- Publishing research findings in high-ranked peer-review literature.
- Disseminating new results through traditional media channels and social media.
- Providing research-based knowledge to stakeholders for mitigation and adaptation strategies at the local and national levels.

Summer at the Ammassalik Island, East Greenland, July 2014
Foto: Willem van der Bilt

RG1 Climate model development and climate projections

Goal

To maintain the Norwegian Earth System Model (NorESM) as a state-of-the-art Earth System modelling tool.

NorESM is used for studies covering past, present and future climate, integrating the physics and biogeochemistry of the atmosphere, ocean and land components. The model provides simulations as part of the internationally coordinated Climate Model Intercomparison Project (CMIP), laying the basis for the provision of climate scenarios to the Assessment Reports of the UN´s International Panel on Climate Change (IPCC). The activity is coordinated from Bergen in a joint endeavour with scientists in Oslo, notably from the Meteorological Institute and the University of Oslo.

Objectives

- To coordinate the development, testing and validation of NorESM.
- To focus on model representation of high-latitude climate processes, and the interaction between the atmosphere and ocean systems on decadal and longer time scales.
- To excel in its unique ocean circulation component, its ability to simulate the marine carbon cycle as well as the impact of natural and man-made particles (e.g sea salt, dust, soot and aerosols) on radiation, clouds and precipitation.

Implementation

Research Group 1 develops new and/or improves physical parameterizations for various model resolutions. It carries out extensive testing and validation of new model versions, code development, optimization and documentation. The group also carries out, and provides assistance to, the analysis of climate simulations as well as analyses of observed and simulated climate.

RG2 Climate predictions and regional scenarios

Goal

To reliably predict climate on seasonal and longer timescales with focus on the northern high-latitudes.

The climate system has strong variability from seasonal to decadal times scales. Thus, climate predictions will be important for adaptation and mitigation measures in a number of industrial sectors (e.g. fisheries, construction, hydropower).

Objectives

The climate variability in our region is heavily influenced by the oceanic and atmospheric variability in heat and moisture transports. In order to predict climate variability, it will be decisive to:

- Understand the mechanisms driving natural variability and the interactions between the near-surface ocean, Arctic sea ice, and atmosphere.
- Develop a realistic climate prediction model with a sophisticated initialization scheme.
- Achieve better representation of uncertainties in model results.

Climate change is global, but its magnitude and impact exhibit a significant regional component. It is therefore important to:

- Downscale oceanic and atmospheric models and couple these to achieve more accurate representation of surface interactions between ocean, ice, and atmosphere.
- Examine added value of downscaling and implications for the larger scale environment.

Implementation

Research group 2´s main tool is the Norwegian Climate Prediction Model (NorCPM), which combines the Norwegian Earth System Model (NorESM) with data assimilation. The group also uses a number of regional models for down-scaling the atmosphere and the ocean (e.g. WRF, ROMS, COAWST). In addition, to process understanding and model development, model evaluation against observations is a major activity of the group. Research Group 2 cooperates extensively with national and international research centres on model development and analysis. Scientific results will be communicated to relevant industrial sectors.

RG3 Carbon cycle and biogeochemistry

Goal

To quantify biogeochemical cycles as part of the climate system in the ocean, atmosphere, and on land.

Objectives

- GREENHOUSE GAS FLUXES: To quantify the various reservoirs of the Earth system. Hot spots of greenhouse gas fluxes will be identified and spatio-temporal variability of these fluxes will be analysed and explained. Next to carbon dioxide (CO_2), also nitrous oxide (N_2O) and methane (CH_4) are taken into account.
- CLIMATE TRACERS: To employ the tracers in the climate system in order to understand the underlying processes and to identify transport pathways. Some tracers are influenced by biological processes and give insight into the functioning of ecosystems while tracers in sediment cores help to elucidate past climates.
- BIOGEOCHEMICAL CYCLES & MULTIPLE CLIMATE TARGETS: To assess the coupled elemental cycles and related impacts of multiple influencing factors - including stressors that affect the environment in a negative way - of the Earth system. The findings are of high societal relevance for adaptation and mitigation to climate change. Limits to future greenhouse gas emission will be evaluated in view of expected environmental impact.
- GLOBAL/HIGH LATITUDE: Focus on global studies as well as high latitude systems such as the Southern Ocean (the major marine CO_2 regulator of the atmosphere) and the Arctic (including permafrost, ocean acidification and future changes in ice cover).

Implementation

Activities include measurements, analyses and modelling. *In situ* measurements, primarily in the northern North Atlantic and Arctic region, contribute to international data compilations. New processes are identified on the basis of empirical evidence. Global Earth system model components (ocean biogeo-chemistry and land biosphere) are developed and maintained to study past, modern, and future climates. Regional modelling complements large-scale modelling, notably for impact studies on decadal scales. Data are systematically combined with models in order to fill in data gaps and for model calibrations. Research Group 3 cooperates extensively with national and international networks.

RG4 Large-scale atmosphere-ocean dynamics

Goal

To understand how winds and ocean currents – and the heat, moisture, and salt they carry – control climate.

Objectives

- HIGH-LATITUDE CLIMATE: To determine the role of atmosphere-ice-ocean interactions in polar climate variability, recent Arctic sea ice decline, and poleward heat transport. A particular concern is the influence of the polar regions on the climates of the lower latitudes, including weather extremes, and vice versa.

- NORTH ATLANTIC PREDICTABILITY: To assess the regional predictability of maritime climate on a one- to ten-year horizon. This requires an ability to separate the effects of natural variability and anthropogenic forcing, and will form the basis for forecasts for infrastructure and transportation planning.

- EXTRATROPICAL ATMOSPHERIC DYNAMICS: To determine what controls the character of the large-scale atmospheric flow. This involves constraining the contributions of tropical heating, high latitude cooling, geography, mountain ranges, teleconnection patterns and oceanic variability.

- PHYSICAL FRAMEWORKS FOR PALEOCLIMATE: To provide consistent physical models for explaining past climate change from centennial to geological time scales. Examples include quantitatively connecting variability in oceanic reservoirs of heat and freshwater to abrupt changes in the paleoclimate record.

Implementation

Research Group 4 is rooted in observations of the atmosphere, ocean and cryosphere; theoretical knowledge of the dynamics controlling them and numerical modelling of both their separate and interactive behaviour. We capitalise on combining these approaches to disentangle what constrains climate – in the present, the reconstructed past, and under future global warming.

Oldedalen in the Nordfjord area, western Norway.
Photo: Atle Nesje

RG5 Atmosphere, cryosphere and ocean processes

Goal

To support climate research and applications with a deep knowledge about significant climate processes in the atmosphere, the ocean and in elements of the cryosphere.

The earth's climate system is shaped by a multitude of complex physical, bio-chemical and dynamical processes acting across a wide range of spatial and temporal scales. Most processes on small scales are still unresolved in climate models while their understanding and modelling are key features for best possible climate projections.

Objectives

- Participate in field studies, expeditions and observational programmes.
- Pursue theoretical and statistical analysis and develop conceptual models.
- Prepare and test process parameterizations for the earth's system models.
- Interpret climate projections in terms of dynamical, physical, and biological processes.

Implementation

The strategic approach is to: *observe, understand, and simulate*. Distinct to traditional climate science, climate processes can be observed, observations can be repeated, and the understanding and process models can be tested against new observations and, to some degree, against laboratory experiments.

Research Group 5 is a key provider of knowledge on the interactions at the interfaces of the air-ice-ocean system. This knowledge helps to translate global climate projections into risk and opportunity assessments for societal and economic actions.

RG6 Natural climate variability

Goal

To explore modes of natural variability in the climate system, with a special focus on the last two millennia by integrating high-resolution palaeoclimatic and instrumental time series with long simulations from Atmosphere-Ocean General Circulation Models.

The interaction between the forcing and internal processes of the climate system give rise to natural variability on time scales ranging from a few days to several centuries. In order to assess the impact of human-induced changes on the climate system a better understanding of such natural variations is key.

Objectives

- Generate improved high-resolution (seasonal to inter-annual), well-dated quantitative paleo-climate records to assess and elucidate the timing and variability of climate during the last two millennia.
- Perform quantitative data-model comparison analyses using advanced statistical tools as well as dynamical downscaling.
- Assess the relative importance of natural external forcings and internal variability for climate variations.
- Explore mechanisms for decadal to centennial variability in the Atlantic/Arctic regions and their potential teleconnections.
- Develop new and improved methodologies for reconstructing climate.
- Build dynamical frameworks for better interpreting paleo-proxy data.

Implementation

Research Group 6 interacts closely with the new infrastructure for sediment analyses in Bergen: the *Earth Surface Sediment Laboratory* -EARTHLAB.
The group also makes extensive use of the Norwegian Earth System Model (NorESM) to study and test the mechanisms of climate variability. Through collaboration with leading research groups in Europe, USA and China, the group participates in large international multi-model and model-data comparisons such as the 2k Network of the Past Global Changes (PAGES) and Palaeoclimate Modelling Intercomparison Project (PMIP).

RG7 Past climate dynamics

Goal

To understand how and why climate has changed in the past.

The group studies climate changes over the last 65 million years, covering the early greenhouse climates to more recent glacial climates. The main focus is on understanding changes in the ocean and chryosphere at high latitudes.

Objectives

- Reconstruct marine and terrestrial climates at multi-decadal to orbital time scales.
- Assess past climate dynamics through paleoclimate modelling.
- Reconstruct and investigate dynamics of glaciers and ice sheets.
- Actively integrate knowledge from models and reconstructions.

Implementation

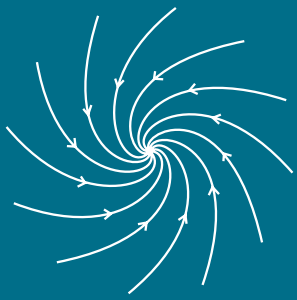
Research Group 7 is highly interdisciplinary and integrates empirical and dynamical studies of past changes in the ocean, atmosphere and cryosphere (both sea ice and land ice) as well as on land. Activities include studies of past warm greenhouse climates, greenhouse-icehouse transitions, interglacial climates, glacial inception, glacial cycles, abrupt climate changes, past ice sheet evolution and deglaciations.

Cloudy sunset, south of Bergen
Norway
Photo: Erik Kolstad

The Centre is named in honour of the visionary scientists Vilhelm and Jacob Bjerknes.

Vilhelm Bjerknes (1862-1951) laid the foundations of modern meteorology and weather forecasting through the "Bergen School of Meteorology" at the Geophysical Institute in Bergen. His son Jacob (1897-1975) carried out pioneer research on climate change and the role of the ocean in the climate system.

The spiral in our logo is taken from Bjerknes´ original drawings of the circulation around a low-pressure system.



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