2017—2018

BJERKNES CENTRE for Climate Research

Under the moon. Andrew Seidl on nighttime operation of drones on the ice of the Baltic Sea, during the ISOBAR field campaign in Hailuoto, Finland in February 2018.
PHOTO: JOACHIM REUDER

NERSC Nansen Center, Bergen
uni Research

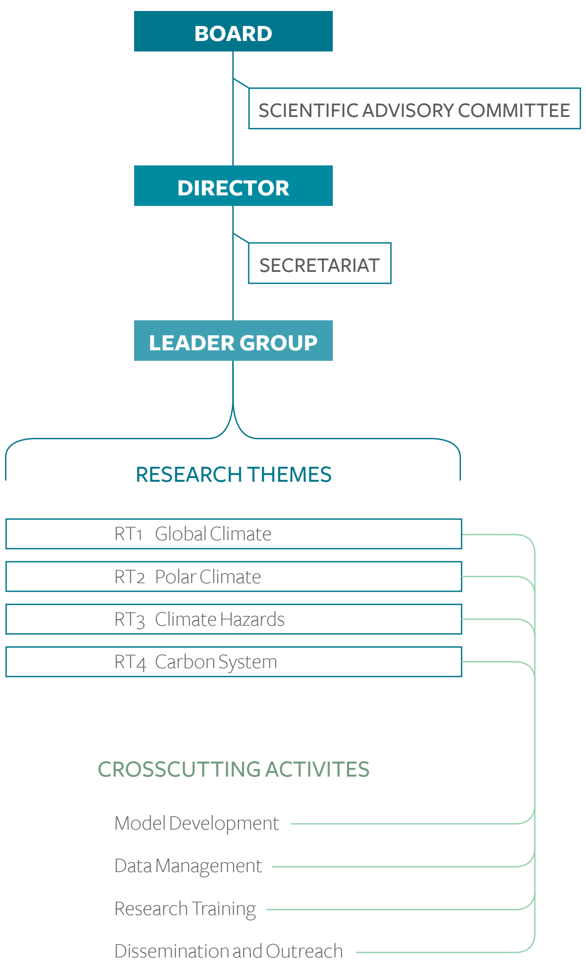
Objectives and research

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

The Bjerknes Centre for Climate Research is a collaboration between four partner institutions:

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

Organisation



Editor
Gudrun Sylte

Copyediting
Cathy Jenks

Layout
Haltenbanken

Frontpage photo
Joachim Reuder, Professor in Meteorology, UiB and the Bjerknes Centre for Climate Research

Print
Bodoni As, bodoni.no

TORE FUREVIK
DIRECTOR OF THE BJERKNES CENTRE FOR CLIMATE RESEARCH

We are here to make a difference

Since its start 15 years ago, the Bjerknes Centre for Climate Research has seen a healthy growth in scientific competence and output, and in its interaction with the academic and public domain. More than 200 PhD students, postdocs, and researchers are presently dedicated to understanding and quantifying climate for the benefit of society. Every second day, there is a new Bjerknes publication, and 30 others that are citing our research.

Eventful year at the Centre

An international expert evaluation of our Centre took place in the autumn of 2017. With two hundred scientists from four partner institutions, several hundred projects, and more than 1000 publications published over the reporting period, our Centre can be a challenge to evaluate. However, the evaluation committee was pleased with the scientific progress documented and presented by what the committee reported as enthusiastic staff. The committee accordingly concluded that the government funding was well spent and recommended that it should be continued.

And just before summer, after many years of waiting, many of us moved into modern offices, with a new auditorium and a fantastic meeting room. Prime Minister Erna Solberg opened the refurbished West Wing of the Geophysical Institute, and thereby launched our "new beginning" with the Bjerknes Centre having its own building, organised into the four themes Global Climate, Polar Climate, Climate Hazards, and Carbon System.

New knowledge and new talents

The essence of basic research is to foster new knowledge and promote new talent. Since 2010, more than 50 PhD students have completed their work at the Centre, with a record number of six new female and four new male doctors in 2017. We continue to offer training programmes for our PhD students within the national research school CHESS that will run until 2023. The 10th ACDC summer school will be held at Finse in September 2018 and funding for another two has already been secured.

In 2017 we received one advanced, one consolidator, and one starting ERC grant, giving a total of six ERC projects at the Centre. With new large infrastructure grants for Earth system modelling and for ocean observations, we should be well positioned to continue to deliver world-class research and research training.

Extending our collaboration

During 2017, we reconfirmed our commitment and capability to understand the causes and consequences of climate change, taking both an earth system and a more Norwegian perspective. Our main expertise is still on the understanding of the natural climate system, but we foresee a further extension of our collaboration with other disciplines and with sectors outside academia.

The 2030 agenda for sustainable development and the Paris agreement require a strong effort from the scientific community. Climate research is important for all seventeen global goals, and the Bjerknes Centre will commit to being an important player in climate adaptation and climate mitigation locally, nationally, and internationally. We are here to make a difference!

Global climate

Global warming is not evenly distributed around the globe. Changes in temperature and wind patterns can affect the weather in regions far away from where they happen.

Weather in Europe and other mid-latitude regions depends strongly on storm tracks. Today most low-pressure systems veer northwards as they cross the Atlantic. Our scientists work to find out how future changes in tropical ocean temperatures, Arctic sea ice, and winds high above the polar cap will affect the storm tracks.

In 2017, the Indian summer monsoon was slightly drier than normal. For populous countries like India and China, monsoon information on all time scales is vital. Bjerknes Centre scientists study various aspects of monsoons, such as how monsoon rains are influenced by climate change, how moisture flows from the oceans into China, the weather behind extreme rainfall events in Nepal, and how phenomena like El Niño in the Pacific cause drier summer monsoons in southern Asia.

2017 was the warmest year on record without an El Niño – the Pacific warming that, together with climate change, made 2016 the warmest year recorded.

During El Niños, warmer surface water in the east Pacific Ocean changes the world's weather, especially in the tropics. This occurs every 2–7 years and accounts for the largest variations observed, after seasonal changes. How much Europe is affected is still an open question. In a new study, Bjerknes Centre scientists find that El Niños are associated with wetter and warmer weather in north-western Europe in the autumn.

Sea-surface temperature gradients in the tropical Atlantic influence how far north the tropical rainbelt moves in the Northern Hemisphere summer. Warmer water in the south in some decades has been linked to Sahelian droughts. Our scientists work on understanding and quantifying such connections, to improve future predictions of African rainfall.

Outlook for 2018

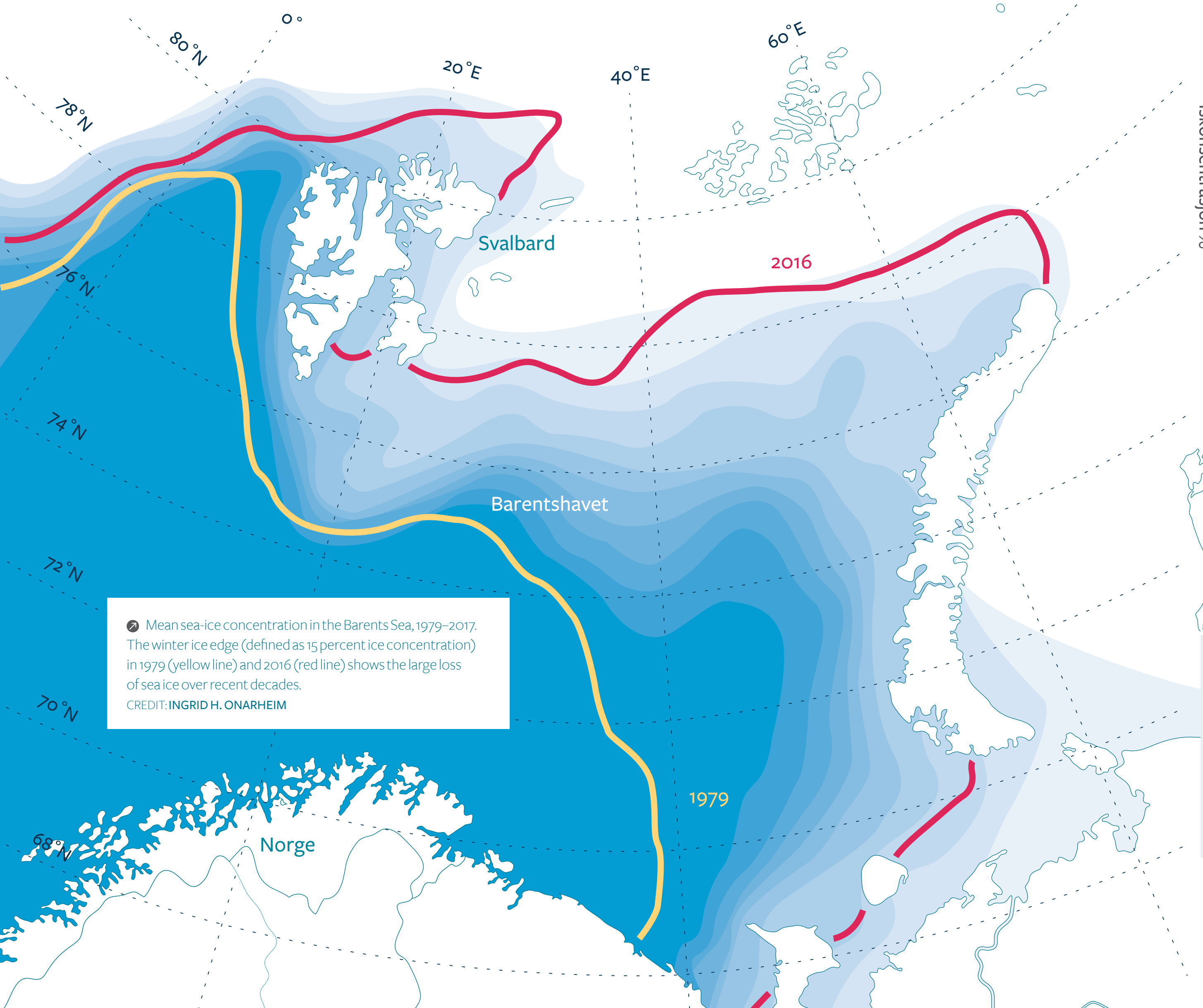
In Paris in 2015, nations agreed to work to keep the global temperature well below 2 degrees Celsius above pre-industrial levels. A special report on the impacts of a 1.5 degree warming will come this autumn. "The research is just coming out on which impacts we may avoid by stabilizing at 1.5 degrees", says **Camille Li, leader of our Global Climate research theme.** "The results will be especially important for vulnerable regions."

Polar climate

In January 2018, the Arctic sea-ice cover reached its lowest extent for the month since measurements started in 1979. The Antarctic sea-ice extent was the second lowest recorded, as was the total for the globe*.

Predicting sea ice in the Barents Sea

The sea-ice cover extent in the Barents Sea in January 2018 was the second lowest recorded for that month. Still, we expect the winter of 2017–2018 to have more ice than in the previous couple of years. Two to three years ago, the heat transport from the south through the Atlantic was very high. Now, cooler water is on its way northward. According to the Bjerknes Centre's prediction model, this will cause the winter sea-ice cover in the Barents Sea to continue to increase until 2020. Even though the sea ice is generally retreating with global warming, natural variations in the Atlantic water will cause winters with more ice. The expected increase in the coming years is relative to a record low in 2016. Currently, we can predict annual mean sea-ice cover in the Barents Sea as a whole. Starting now, we will explore whether this can be refined to more detailed monthly predictions for specific parts of the Barents Sea.



Mean sea-ice concentration in the Barents Sea, 1979–2017. The winter ice edge (defined as 15 percent ice concentration) in 1979 (yellow line) and 2016 (red line) shows the large loss of sea ice over recent decades.
CREDIT: INGRID H. ONARHEIM

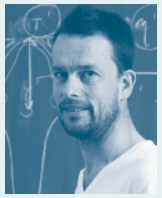
Antarctic ice shelves melt from below

In July 2017, an iceberg half the size of Qatar broke off the Larsen C shelf in Antarctica. The break-off was part of a natural process and cannot be linked to global warming. But, the general thinning of the ice shelves in West Antarctic – as seen in satellite pictures – can. Warm water from the north flows in under the shelves and melts the ice from below. The thinner ice is more fragile and cannot hold back the glaciers that flow from the continent as well as before. More ice melts or breaks off, and the sea level rises.

Bjerknes scientists have followed the Antarctic ice shelves for many years. We have deployed instruments both in the ocean and under the ice, through a hole drilled from the top of the shelf. In September and October, this was expanded with experiments in a water-filled, rotating laboratory tank in Grenoble. Experimenting with a miniature Antarctica in the 13-metre diameter tank, the researchers try to find out how the warm water enters the continental shelf and how it eventually ends up under the ice.

Wetter on Svalbard

People living on the Arctic islands of Svalbard have experienced almost twice as much precipitation as normal in the past two winters. Heavy snow and rain have caused avalanches and flooding. Bjerknes Centre scientists have used sediment cores from Svalbard lakes to reconstruct the regional climate 11,000 years back in time. In the period from 9,000 to 6,000 years ago, temperatures on Svalbard were 3–6 degrees higher than today. Many glaciers disappeared, and this was also a time with more rain-induced floods. With less sea ice and higher temperatures in the air and in the ocean, Svalbard should be prepared for the consequences of a wetter future climate.



Outlook for 2018

"These are exciting times at polar latitudes", says **Tor Eldevik, leader of the Polar Climate research theme**. "Svalbard is literally coming out of the ice, with extremely mild winters as a result. With upstream ocean heat now being somewhat less than at its recent peak, the competition is on between the steady contribution from global warming and influence from the more variable ocean. One can only hope that this will contribute to a more normal winter in 2019."

*SOURCE: NOAA NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION

Carbon system

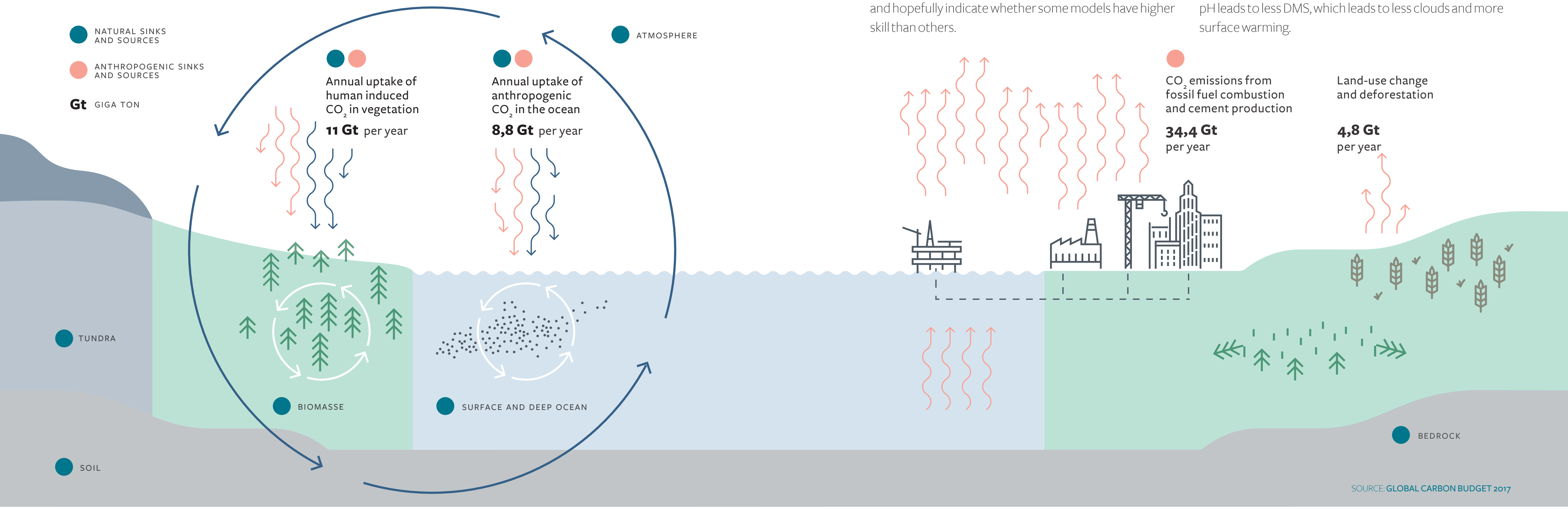
After two years with stable emissions, global emissions of CO_2 increased by two percent in 2017. Not all of this remains in the atmosphere. By absorbing a large fraction of CO_2 we emit, the ocean and the vegetation on land keep the atmospheric greenhouse effect lower than it would otherwise be. Understanding the present efficiencies and climate change sensitivity of these natural carbon sinks are among the core activities of the Bjerknes Centre.

Natural sinks

More than half of the CO_2 released to the atmosphere from anthropogenic sources is absorbed by the ocean and ecosystems on land. Will these sinks continue to remove CO_2 as efficiently from the atmosphere in a warmer world? Earth system models – climate models that also include the carbon system – do not agree. According to some models, these natural sinks will continue to take up carbon, while other models indicate a reduction in the uptake. Earth system models are becoming more and more complex, more and more data are produced, requiring more time and new methods for analysis. In the coming years, Bjerknes Centre scientists will develop climate data-analysis tools using machine learning and Big Data technology. This will let us analyse more model data and hopefully indicate whether some models have higher skill than others.

Ocean pH affects clouds

As the ocean takes up CO_2 from the atmosphere, the pH of the water decreases. Conditions become more acidic, and this may harm organisms in the ocean. A more indirect feedback to the atmosphere has also been suggested. With decreasing pH, marine algae produce less of the compound dimethyl sulfate (DMS). DMS affects the concentration of cloud condensation nuclei, needed to form clouds. A study by Bjerknes scientists together with colleagues from the Norwegian Meteorological Institute and the Max Planck Institute in Hamburg shows that in a future, warmer world with a more acidic ocean, changes in the DMS production may provide a small, additional contribution to the warming. This is mainly because clouds will reflect less solar radiation back to space. That is, lower pH leads to less DMS, which leads to less clouds and more surface warming.



Monitoring the ocean

Every time Nuka Arctica leaves port, a new data series is started. Nuka Arctica is not a research vessel, but a container ship regularly crossing the North Atlantic between Copenhagen in Denmark and Aasiat on Greenland. Since the early 2000s, scientific instruments onboard have registered temperature, salinity, and CO_2 in the ocean along the route. Together with data from permanent stations, research cruises, and other commercial ships, data from Nuka Arctica go into the Integrated Carbon Observation System (ICOS), a European infrastructure for carbon measurements. The Ocean Thematic Centre of ICOS is hosted by the Bjerknes Centre and its partners Uni Research and the University of Bergen. Through observations from the atmosphere, the ocean, and ecosystems on land, ICOS aims to monitor the effect of reductions in greenhouse gas emissions.

See also nuka.uib.no

Outlook for 2018

After increasing for decades, global emissions of CO_2 remained stable in 2014–2016. It appeared as if the world might have reached the emission peak. In 2017, emissions suddenly increased again, by two percent. "Will we manage to reduce emissions in 2018?", asks **Are Olsen, leader of the Carbon System research theme at the Bjerknes Centre.** "And in the following years? This will be decisive for our ability to reach the 2 degree target."

Climate Hazards

Past floods improve future projections

In 2017, floods caused 59 percent of the financial damage registered in the Norwegian Natural Perils Pool. The most costly disaster was flooding in the counties of Agder and Rogaland in the first week of October. Bjerknes Centre scientists study floods from the past two thousand years to better understand how flooding may affect society in the future. Reconstructed flood levels in sediment cores from lakes in western Norway are compared with the results from hydrological models and climate models. The models' ability to reproduce past floods indicates how well they can project future floods.

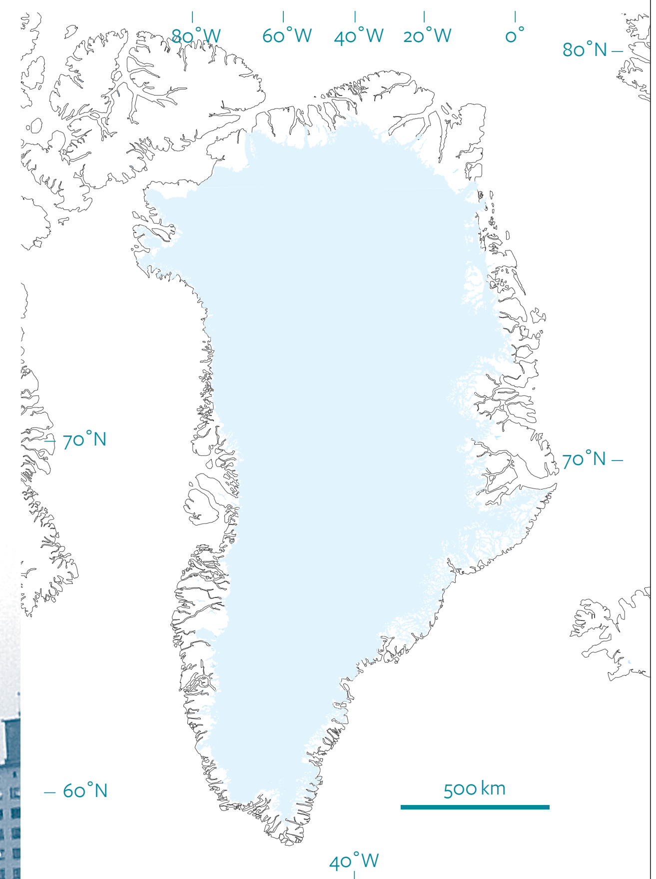
Sea-level rise from Greenland ice sheets unknown

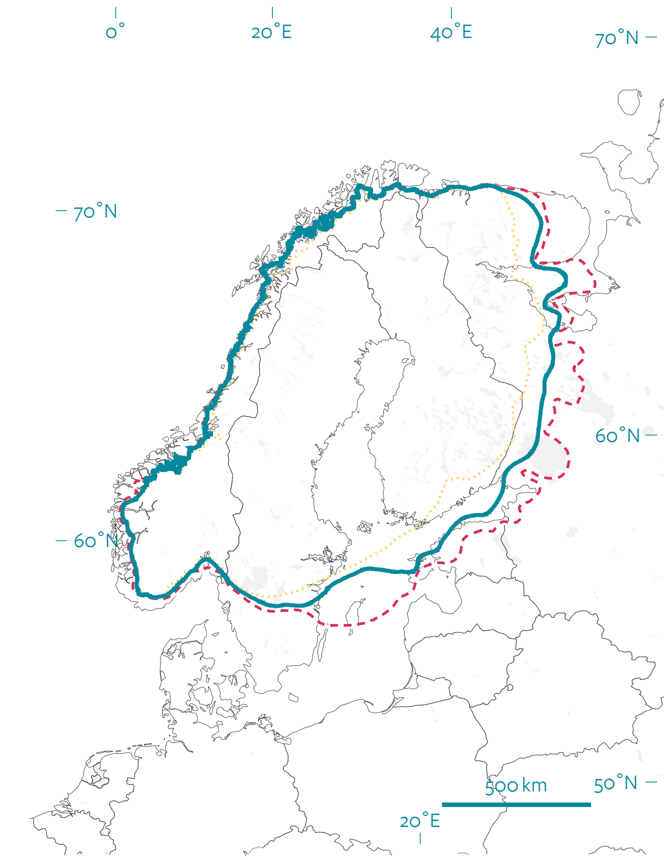
2017 was an unusually good year for the Greenland ice sheet. In the year leading to 31 August, Greenland gained more ice from snowfall than it lost from surface melting. Did the ice sheet grow? When also considering the ice lost to sea, only slightly. Ice flows in huge ice streams from the top of the ice sheet to the sea, where ice melts from below or drifts off as icebergs. This transport represents one of the largest uncertainties in Greenland's contribution to future global sea-level rise, and is not yet included in climate models. Bjerknes scientists work to understand more about the ice flow and how ice loss is influenced by the warming ocean, by sea ice, by weather, and by meltwater systems under the ice. Our work covers both models and fieldwork, including participation in drilling an ice core 2500 metres through an ice stream in north-eastern Greenland.

Local variations in extreme rainfall

In a warmer world, the air will contain more moisture, causing more precipitation in many mid-latitude regions. Bjerknes Centre scientists have studied how the degree of change will depend on local topography. In western Norway, precipitation during extreme events will increase more near the mountains than closer to the coast.

When dangerous weather is about to occur, the need for details goes from decades to hours and from regions to neighbourhoods. Nowcasting is forecasting for the coming hours. Our scientists explore how new data sources such as reductions in cell phone signals and observations from home weather stations can be used to develop new methods for nowcasting rainfall on local scales.





Comparing Greenland and Scandinavian ice sheets

How quickly will Greenland look like Scandinavia? At the end of the last ice age, about 13,000 years ago, Scandinavia was covered by an ice sheet similar to the one on Greenland today. The fjord landscape of western Norway was created by growing and retreating glaciers. Studies of the Scandinavian ice sheet and its withdrawal help our scientists understand the changes we see in Greenland today, and make better projections for what we can experience in a warming climate.

The ice sheet on Greenland today compared with Scandinavia 13,000 years ago. The blue line shows the most likely border, with minimum and maximum range indicated by stippled lines.

Source

Hughes, A. L. C. et al. (2016): *The last Eurasian ice sheets – a chronological database and time-slice reconstruction*, DATED-1. Boreas 45, 1-45.

Storm surge at Bryggen, Bergen, January 2017.
PHOTO: **GUDRUN SYLTE**

Outlook for 2018

"Discussing with stakeholders is crucial for scientists working with climate risk and hazards", says **Nele Meckler, leader of the Climate Hazards research theme.** "Those affected by climate hazards know best what information they need. Facilitating such exchange of information through common meeting places and collaboration will be a priority for us in the coming year."

Modelling the world

Making climate projections for the coming centuries is a global endeavour.

The model laboratory

Surface temperatures at the end of the century may be seen as a typical climate model output. But as importantly, climate models can be used to understand how the climate system actually works.

Changing temperature and seeing how this affects rainfall, can tell us about the mechanisms producing the rain. Past climates can be modelled and studied, by changing the distribution of continents, ice sheets, and sea level in the model - as well as the atmospheric composition and/or the orbital parameters of Earth that control the distribution of solar radiation. At the Bjerknes Centre, past climates is modelled and studies all the way back to millions of years ago.

Projections for the future

In 2018, climate centres around the world will work hard to get their climate models ready for the sixth phase of the Coupled Model Intercomparison Project, CMIP6. CMIP6 will deliver the climate projections to be assessed in the next IPCC report, scheduled for 2021.

The Norwegian Earth System Model (NorESM) will contribute to CMIP6, as it did to CMIP5 in 2011. The new version will benefit from numerous improvements to the Community Earth System Model of the National Center for Atmospheric Research (NCAR), USA, that NorESM builds on.

Our own development advances in the NorESM community include chemistry-aerosol-cloud-radiation interactions, atmospheric dynamics and physics, ocean-surface turbulence fluxes, and ocean model and biogeochemical components.

Predictions for seasons and decades

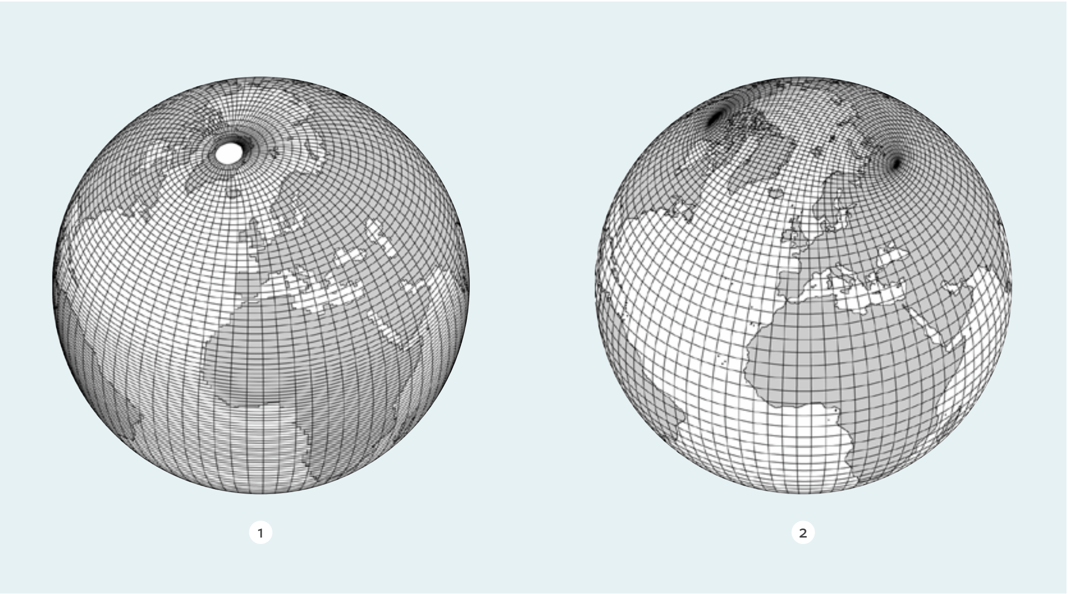
Making climate projections for the coming century means simulating the climate system responses to changes in land-use, solar forcing, and greenhouse gas and aerosol emissions.

When predicting the climate on time-scales of seasons to decades, we combine procedures from weather forecasting and climate models. At the Bjerknes Centre we are involved in developing decadal predictions as part of CMIP6, as well as seasonal predictions tailored for energy companies, the shipping industry, and insurance companies.

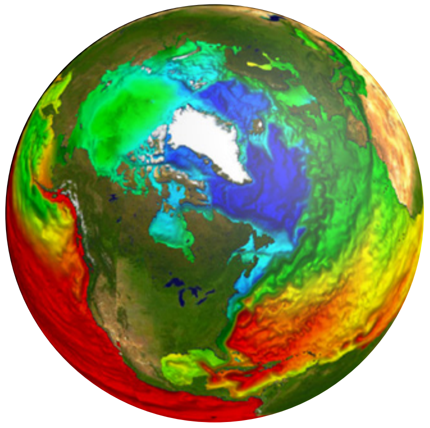
An infrastructure for modelling

Climate modelling is an essential tool for climate research.

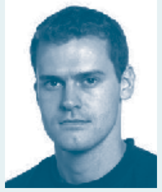
From June 2018, the infrastructure development of the Norwegian Earth System Model (NorESM) will be funded through the Research Council of Norway's National Financing Initiative for Research Infrastructure. The project INES is a co-operation between major climate research institutions in Norway, and will be coordinated by the Bjerknes Centre partner Uni Research.



Our globe on a grid. To set up a global earth system model, scientists in a long list of disciplines are exploring and investigating the earth system. The earth system models are like a laboratory where you can explore the earth through mathematical equations – and compare your result with the observed situation. The figure shows two variations of grid, the first with two poles, the second with three poles for better representation of the ocean.
FIGURE: MATS BENTSEN



The figure shows the elevation of the ocean surface in the northern hemisphere as simulated by the Norwegian Earth System Model. The Gulf Stream (seen as a sharp boundary between blue and green) is flowing from the eastern North American coast towards Europe.
FIGURE: MEHMET ILICAK



Outlook for 2018

Questions have been raised about possible effects of amplified polar warming in anthropogenic climate change scenarios and which observations suggest is already occurring. Among the various climate simulations requested by CMIP6, a group of them have a special focus on this. "How the amplified polar warming and reduced sea-ice cover affect weather and climate in regions south of the Arctic, such as Norway and Europe, is not straightforward", says **Mats Bentsen, leader of the model development cross-cutting activity at the Bjerknes Centre and coordinator of the new national climate modelling infrastructure project INES.** "The new simulations will hopefully give us more knowledge about this – now and as the world warms in the future."

The BCCR in numbers 2017

247 AFFILIATED RESEARCHERS, TECHNICIANS, AND ADMINISTRATIVE PERSONNEL

From 34 nations

Category	Staff	Women %
Scientists	127	25 %
Postdocs	41	37 %
PhDs	58	53 %
Technicians and administrative personnel	21	43 %
Total	247	

DOCTORAL DISSERTATIONS

10 PhD candidates successfully defended their thesis

PUBLICATIONS

209 publications

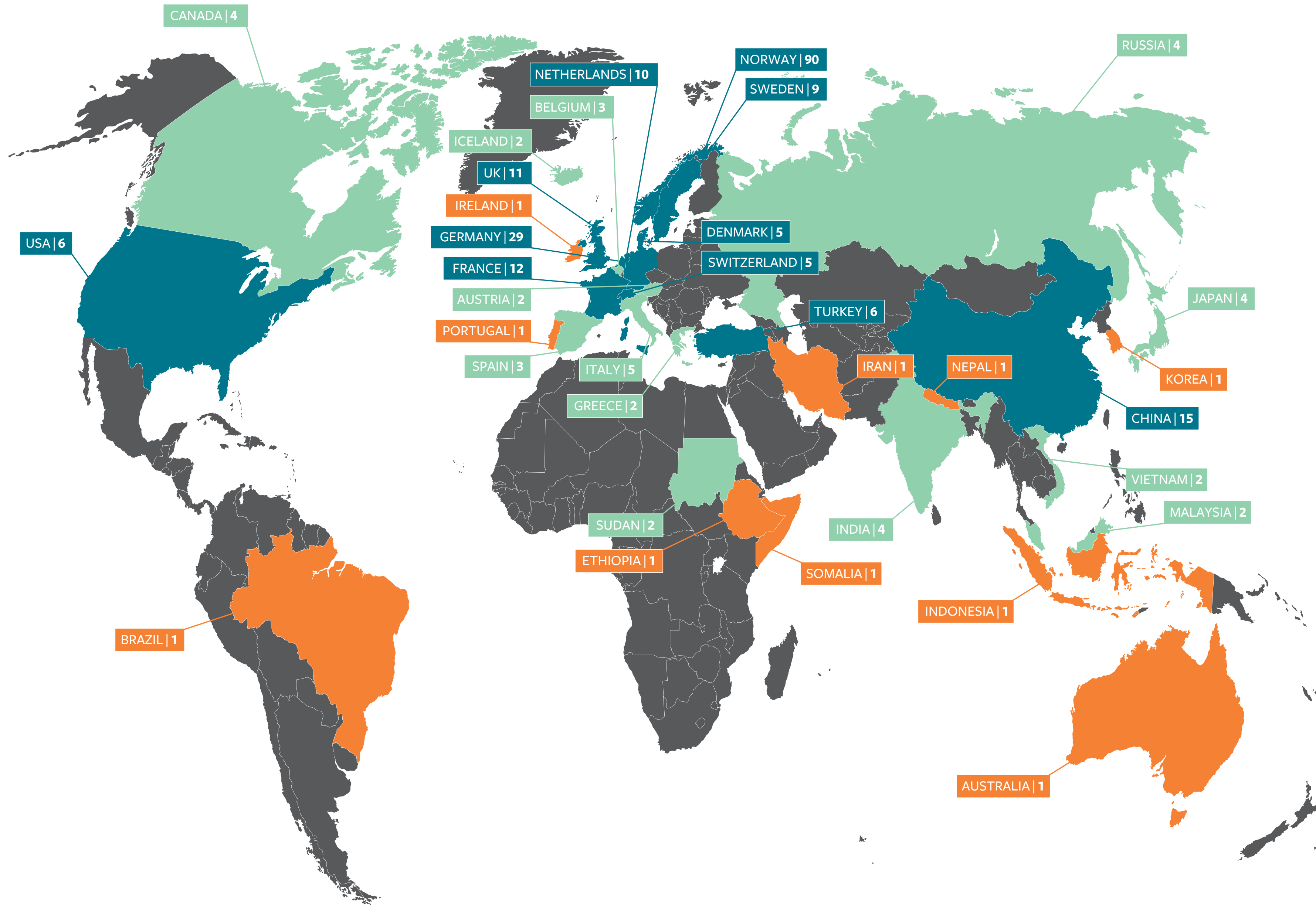
9 in *Nature* journals

PROJECTS

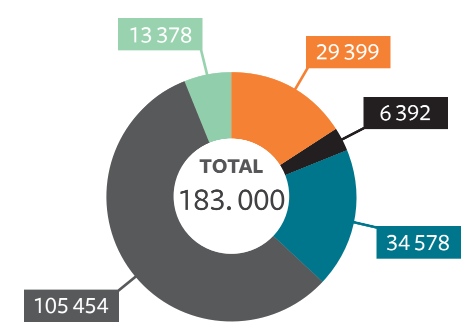
In total 82 research projects

- *EU* – 21
- *NFR* – 53
- *Other* – 8
- *ERC Grants* – 6

- 1 Synergy Grant
- 1 ERC Advanced Grant (starting 2018)
- 2 ERC Consolidator Grant (1 starting 2018)
- 2 ERC Starting Grant (1 starting 2018)



FUNDING	NOK 1 000,–
Ministry of Research and Education	29 399
University of Bergen	6 392
European Commission	34 578
Research Council of Norway	105 454
Other	13 378
Total income	183 000



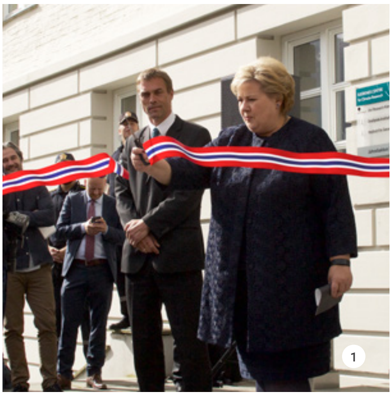
Returadresse:

BCCR – Bjerknes Centre
for Climate Research

Universitetet i Bergen, PB 7803
NO-5020 Bergen, Norway

T +47 55 58 98 03
M post@bjerknes.uib.no

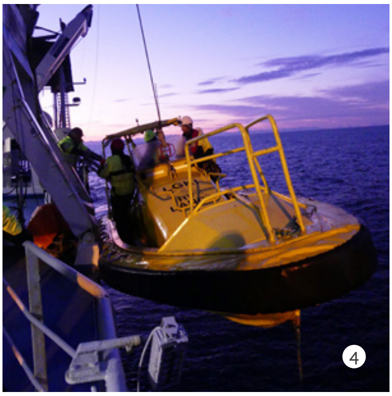
W bjerknes.uib.no
@BjerknesBCCR



1 **The official opening:** Prime Minister of Norway Erna Solberg opens our new premises in May 2017.
PHOTO: **GUDRUN SYLTE**

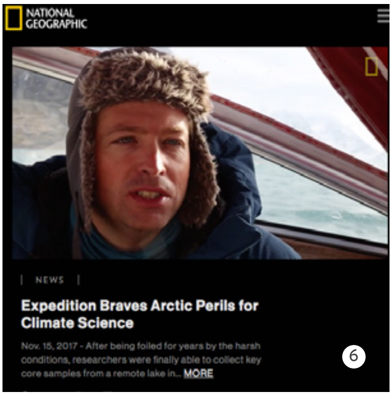
2 **Predicting the Barents Sea Ice:** Ingrid Onarheim and Prime Minister Erna Solberg.
PHOTO: **PAUL SIGVE AMUNDSEN/UIB**

3 **Outdoor office:** Stefan Sobolowski and Lu Li at work at Finse.
PHOTO: **ELLEN VISTE**



4 **Where Atlantic water meets Arctic Ocean:** Morven Muilwijk on cruise in the Norwegian Sea.
PHOTO: **GWÉNAËLLE HAMON/ NORWEGIAN POLAR INSTITUTE**

5 **Recording pCO2:** Abdir Omar and Sigve Naustdal onboard the Trans Carrier starts up the ICOS recording instruments.
PHOTO: **SIGVE NAUSTDAL**



6 **National Geographic:** Jostein Bakke and crew went to Svalbard for the fifth year in a row, with National Geographic covering their field trip.
FACSIMILE **NATIONALGEOGRAPIC.COM**

7 **A different kind of Antarctic expedition:** Elin Darelius and Nadine Steiger perform laboratory experiments in Grenoble, France.
PHOTO: **MIRJAM GLESSMER**

8 **Geology for kids:** Silje Smith-Johnsen talks to a young audience at the political festival Arendalsuka in August.
PHOTO: **ØYVIND PAASCHE**

9 **Field trip in the mountains:** The Advanced Climate Dynamics Course 2017 took place in Rondane National Park.
PHOTO: **KERIM NISANCIOGLU**