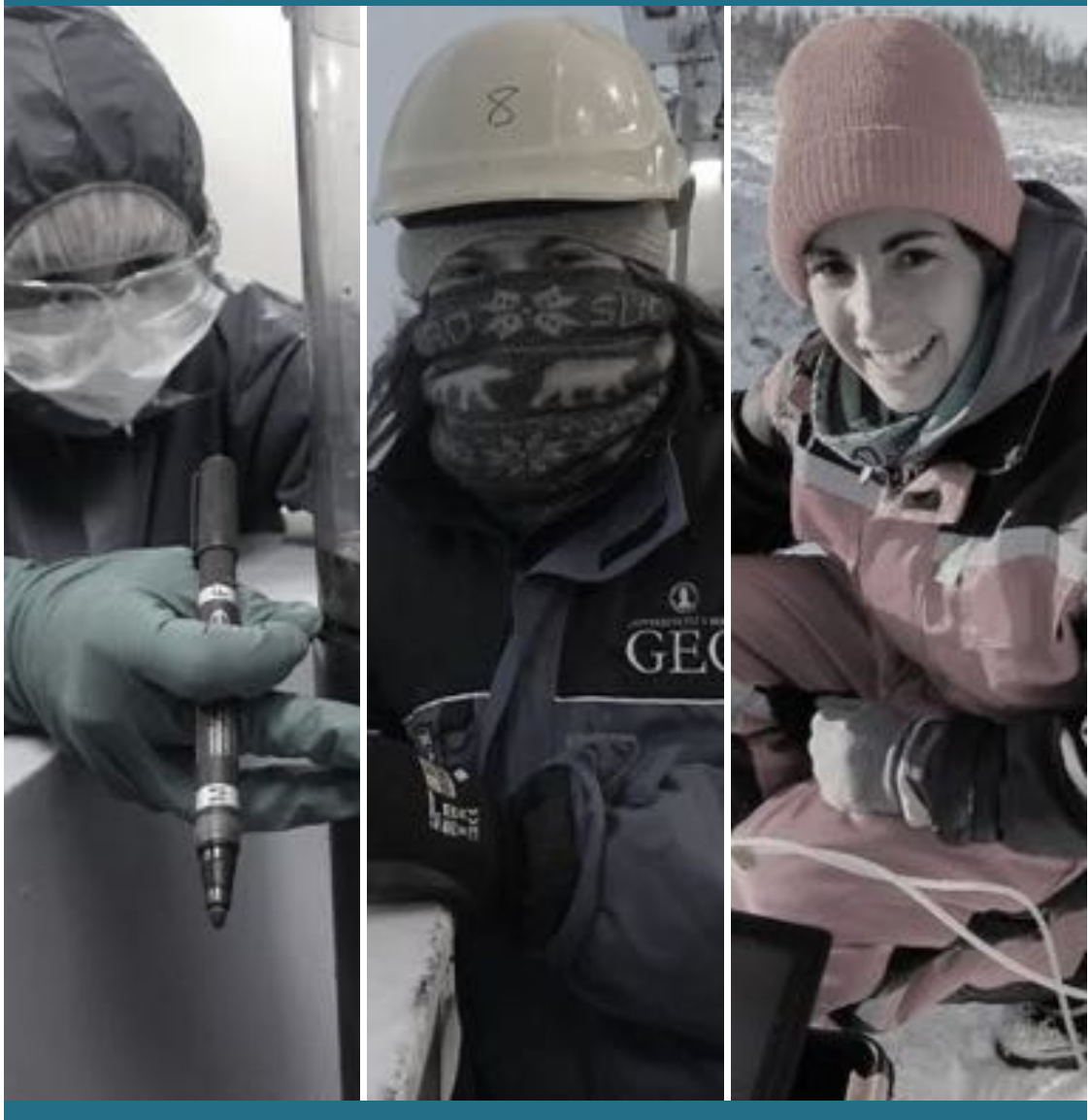
Twenty Years of Science
2020

BJERKNES CENTRE
for Climate Research



Out to measure the world.
Danielle Grant, page 11
Kristin Steinsland, page 28
Inge Althuizen, page 24.

UNIVERSITAS BERGENSIS

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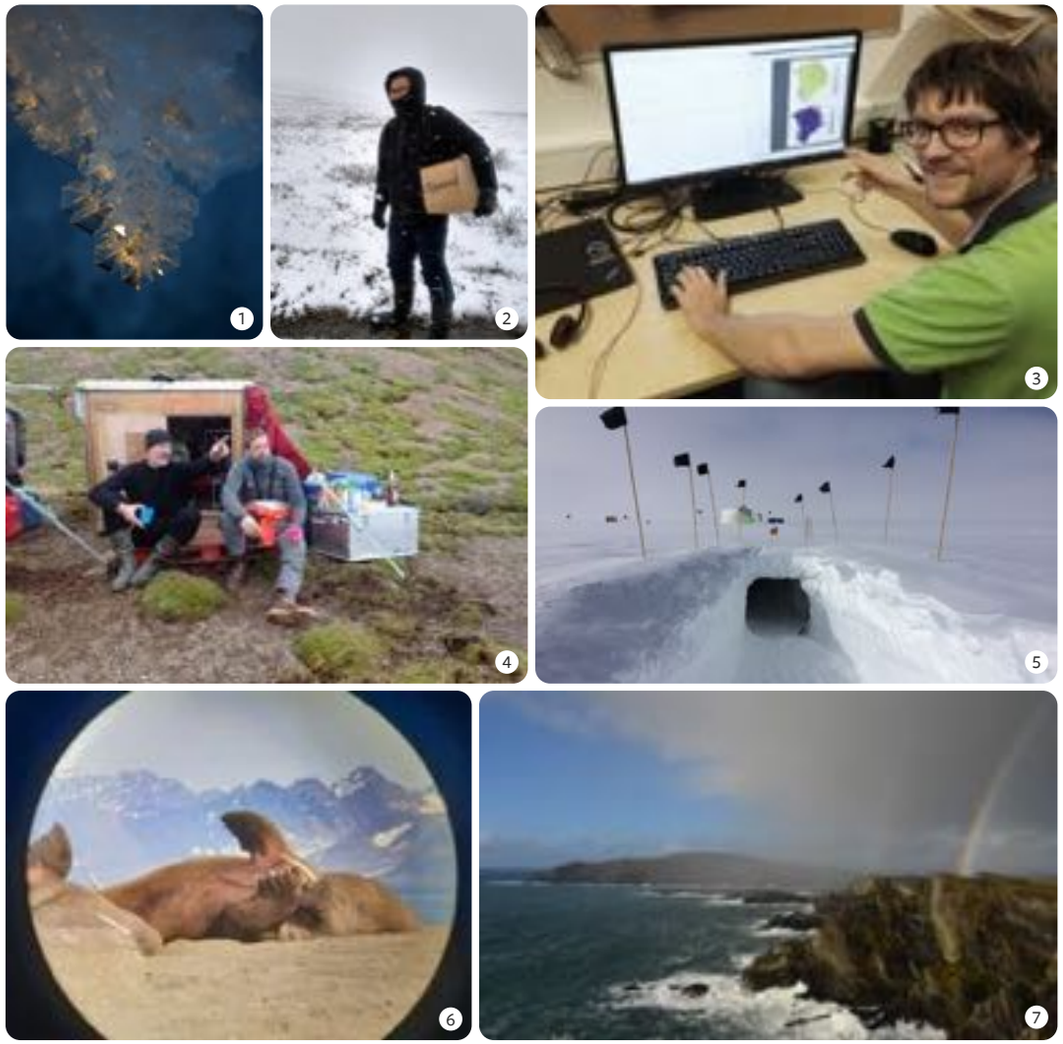

1 Ice crystals growing from the ceiling in the ice tunnel at EastGRIP.
PHOTO: ANDREAS BORN

2 Fieldwork in Finnmark in June.
PHOTO: CASPER T. CHRISTIANSEN

3 Tobias Zolles studies the Greenland ice sheet using a computer model.
PHOTO: ANDREAS BORN

4 Aart Verhage and Jostein Bakke outside one of the tiny, wooden houses used during fieldwork on the windy Kerguelen Islands.
PHOTO: EIVIND STØREN

5 To keep the ice cold, the scientists drilling a core at the EastGRIP station on Greenland work in an ice tunnel.
PHOTO: PETRA LANGEBROEK

6 Walrus in Svalbard.
PHOTO: MORVEN MUILWIJK

7 The Iveragh Peninsula, Ireland.
PHOTO: CHRISTOPH HEINZE

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TORE FUREVIK
Director of
the Bjerknes Centre
for Climate Research

Twenty years of excellence in climate science

The Bjerknes Centre for Climate Research was established in June 2000, named after father and son Vilhelm and Jacob Bjerknes, who were true visionaries and pioneers in meteorology and climate. Climate scientists from the University of Bergen, the Institute of Marine Research, and the Nansen Environmental and Remote Sensing Center joined forces to create common strategies, assemble new research groups, and develop projects under a strong branding. Twenty years later, we are four partners, as NORCE has become a crucial climate research institution in Bergen.

This early effort, championed by Eystein Jansen, led to a successful bid to become one of the first ten Norwegian Centres of Excellence. This new programme launched by the Norwegian Research Council provided generous funding from 2003 to 2012. After only a few years of operation, the Bjerknes Centre for Climate Research became a well-known international institution and its mid-term evaluation concluded that the centre had produced outstanding research results and is at the forefront of developments in our field. A key to success has been the integration of the expertise represented by the four partners, and continued dedication to this unique science cluster has been vital to its development.

From the very beginning, the Bjerknes Centre has had a strong focus on societal relevance, and since its infancy provided society with valuable insights through cutting-edge research and through our engagement in public debates on climate. In 2010, the Stoltenberg government decided to give us a 12-year grant through the Ministry of Education and Research. An international evaluation conducted in late 2017 concluded that *the investment has been a wise one*, and that the committee *recommends continuance of funding*. As we approach the end of the 12-year funding period, it is worthwhile to reflect on where we are today.

The Bjerknes Centre currently includes more than 250 people from 39 nations; it ranks among the largest climate research communities in Europe in terms of size, interdisciplinarity, production, and visibility. We publish, on average, five scientific papers per week and are cited in 180 others. Bjerknes publication number 2000 is just around the corner. We publish in high-ranked journals and often provide background materials for national and interannual synthesis reports and policy briefings.

Apart from providing a steady flow of scientific papers we're devoted to research training and education. Since 2009 we have coordinated the national research schools in climate, as well as a number of international partnership programmes involving summer schools and student mobility. The Advanced Climate Dynamics Coursers (ACDC)

Former director Eystein Jansen at the 10th anniversary conference in 2012.
PHOTO: EIVIND SENNESET

has become an internationally acclaimed summer school, with the 11th in a row taking place in Abisko in Sweden this year. Likewise, the 9th biannual Nansen-Zhu summer school that will take place in China underscores our strong collaboration with Asia.

There is a growing number of PhD and Post Doc fellows in the research groups and in 2019 we had an all-time high with no less than 13 PhD students defending their theses. Teaching and education at a high level is also evident from the two national Centres of Excellence in Education – BioCEED and iEARTH – that are both led by Bjerknes scientists. It is slightly more than 100 years since Vilhelm Bjerknes established the Bergen School of Meteorology, supervising his son Jacob and many others in an admirable effort to understand the weather and motion of the atmosphere. Since then, the atmospheric concentration of CO_2 has risen by over 100 parts per million, transforming the climate system with far-reaching consequences that will continue to affect generations to come.

Tackling the many challenges associated with climate change requires that scientific knowledge is made accessible and communicated broadly. This is, in part, why we are in continuous dialogue with society on many different platforms and venues. We frequently organise discussions and debates at national meeting platforms such as Arctic Frontiers and Arendalsuka, and have recently launched the new public debate series "På Vippen" (literally: at the tipping point), where we discuss different types of climatic and political thresholds and what impacts they might have. We also collaborate with the Bergen Philharmonic Orchestra on a "Next step" concert series, where scientists tell stories in front of a full orchestra on the stage.

The Bjerknes Centre has never been more relevant. There is a growing need for an improved understanding of past, present, and future climate change, including the key processes and aggregated climate sensitivity. Concurrently with this trend, there is an increasing demand for more applied research: for instance, detailed information on possible climate futures, especially from seasonal to decadal time scales and at resolutions relevant to users. And society needs to assess the risks associated with climate hazards, or with the various mitigation options that are proposed.

The research challenges are many and diverse. After 20 years, we are still in pursuit of new scientific discoveries, with the ultimate goal to provide knowledge-based information for the benefit of society.

Former director Eystein Jansen and the rest of the Bjerknes Centre celebrates the Nobel Peace Prize, awarded jointly to the Intergovernmental Panel on Climate Change (IPCC) and Al Gore, in 2007.
PHOTO: HELGE SKODVIN

Prime Minister Erna Solberg cuts the ribbon marking the opening of the newly renovated west wing of the Geophysical Institute, housing several of the Bjerknes partners, in 2017.
PHOTO: GUDRUN SYLTE

The Norwegian Minister of the Environment, Erik Solheim, receives the IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) from Farrokh Nadim from the Norwegian Geotechnical Institute and Asgeir Sorteberg from the Bjerknes Centre, in 2011.
PHOTO: GUDRUN SYLTE

Global Climate

Current climate change
in a broader context.

Forecasting fish
Sardinella off the coast of Senegal and cod in the North Atlantic have one thing in common: they change their migration routes when the ocean gets warmer. Our scientists work to improve predictions of fish stocks up to ten years ahead, both in the Arctic and in the tropical Atlantic. Predicting ecosystem dynamics requires being able to predict the climate for the coming seasons and decade. This is a field combining methods from traditional weather forecasting with those used in longer-term climate projections. Such predictions have improved over the last years, thanks both to better climate models and to more advanced assimilation of observations of sea ice and ocean temperatures. Using this to improve predictions of our marine food-chain is the natural next step. The group also develops climate services and predictions over land.

Explaining ice-age heat waves
During the last ice age, temperatures on Greenland repeatedly rose 8–10 degrees in a few decades, before gradually sinking to their previous level over the next 500–1000 years. These Dansgaard-Oeschger (DO) events are pervasive in climate reconstructions all over the Northern Hemisphere, but tricky to simulate in climate models. By putting our understanding of modern climate dynamics in the context of a colder glacial world, Bjerknes scientists conclude that DO events result from a balance between the height of the Laurentide ice sheet over North America, a more extensive sea-ice cover over the North Atlantic, and ocean heat transport variability. The ice sheet intensified westerly winds downstream over the North Atlantic, similar to what the Rocky Mountains do today. Stronger winds and thicker sea ice had opposing effects on the northward transport of heat in the ocean and toward Greenland, resulting in a tug-of-war where sometimes ice, sometimes winds gained the upper hand. The need for such a fine balance explains why climate models often fail to capture DO events. The new DO framework offers a way to address this shortcoming.

In the Blombos Cave in South Africa, archaeologists and climate scientists like Margit Simon work together to reveal the history of early humans.
PHOTO: SIMON ARMITAGE

Bringing the ocean floor to shore. A multi-coring device has collected four sediment samples from the bottom of the sea.
PHOTO: DANIELLE GRANT

Outlook
"The last five years have been the warmest ever recorded", says Camille Li, leader of our Global climate research. "While mitigation and adaptation measures are essential, so are continued efforts to understand how the global climate system operates and its range of behaviour."

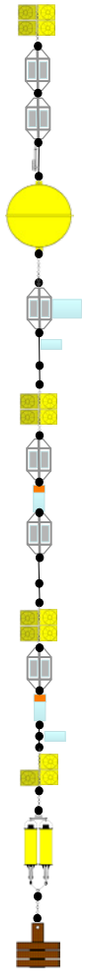
Shifting winds across the latitudes
Over the two-thirds of the globe covered by oceans, heat and moisture is continuously exchanged between the sea and the air. This is an important driver for weather and climate, though also affected by it. The intensity of the exchange increases with the wind. Often, monthly mean winds are used to calculate the mean exchange. In the tropics and the subtropics that may be fine, as daily variations are comparatively small. Bjerknes scientists have shown that more detailed data are needed for middle and higher latitudes, where the weather is dominated by cyclones and cold air outbreaks. While mid-latitude mean winds are predominantly westerly, the air–sea heat exchange is dominated by equator- or poleward-winds associated with passing weather systems. The wind may shift from day to day or even during the course of a day.

Strong winds do not only transport moisture (white), but also increase evaporation (pink).
ILLUSTRATION: MATS BENTSEN

Carbon System

The flow of carbon in the Earth system.

Observing land from sea
In the Arctic Ocean north of Svalbard, a chain of instruments extends from just below the surface to a depth of 850 metres. Behind the mooring is a wish to understand how thawing tundra will affect the CO_2 concentration in the atmosphere. Carbon stored in permafrost soil equals 12–16 times the amount of carbon so far emitted as man-made CO_2. It is unlikely that all this would be released, but even a few percent would mean a lot. When permafrost thaws, greenhouse gases are released directly to the atmosphere, and soil and other organic material are led through the great rivers from Russia and Canada into the Arctic Ocean. The mooring north of Svalbard is a prototype which may later be developed for measurements in the rivers. Already, the instruments register how much water enters the Arctic Ocean from the Atlantic and how much anthropogenic carbon this water contains. The water from the south is warm, so the more of this water, the more sea ice will melt. Our scientists would like to find out whether new, ice-free ocean regions will release CO_2 to the atmosphere. In some regions, a surplus of CO_2 is stored in the water under the ice and may be released. In other places, water with little CO_2 can take up more from the air.



The 850-m-long chain of instruments has been in the water for about a year. It is part of an international collaboration to gather more observations and knowledge about climate change in the Arctic. SOURCE: INTAROS

Southern Ocean biology in the ice age
The atmosphere now contains one half more CO_2 than at the time of the industrial revolution. During the ice ages it contained one third less. More CO_2 was stored in the ocean – partly because of differences in the ocean circulation, but also due to biological and chemical changes. Like land plants, algae in the upper water layers photosynthesise CO_2 into organic matter. When the algae die and sink, their carbon is brought into the deep ocean, where it may be stored for thousands of years. Combining climate models with palaeoproxy data, our scientists have estimated that this biological carbon pump must have been twice as efficient 21,000 years ago, at the height of the last ice age. Exactly why biological processes stored much more carbon in the ocean during the ice ages is still an unsolved question. But the Southern Ocean likely played a central role.

Norwegian wood
As trees grow, they take up CO_2 from the air. What could be better for the global climate than planting trees? The Norwegian government has termed afforestation a viable means of climate mitigation in Norway. Bjerknes Centre scientists are finding out whether this really is a good idea. Deforestation of the Amazon is certainly negative for climate, but boreal forests differ from their tropical counterparts. It takes 80 years for a tree to grow to its mature stage, storing carbon – provided it is never cut and burned, which would release the CO_2 again. On the other hand, forests are dark, reflecting less of the energy from the sun back to space. The extra energy leads to local and global warming. This effect is particularly noticeable at higher latitudes, where white and highly reflective winter snow covers flat landscapes rather than forests. Altering vegetation – whether cutting or planting – also reduces biodiversity and affects the storage of carbon in the soil. Aesthetic concerns and people's feelings for and their use of landscapes are other factors to be considered, especially if the climate effect is marginal. Our scientists cooperate with social scientists to calculate the true footprint of old and new trees.

Outlook
"The transformation to a low carbon society has to happen in the next ten years and insight into the carbon system is essential for this process", says Are Olsen, leader of the Carbon System research theme. "It is essential for defining the risks associated with the various possible emission pathways, for planning climate actions, and for evaluating their efficiency in reducing atmospheric CO_2. Our central goal is to provide this insight to society by developing and using the best possible models and observations."

In western Norway, planted Sitka spruce represents a fierce competition for the coastal heathlands. PHOTO: HEIDI SAURE

Polar Climate

Arctic and Antarctic climate change.

Changing waters
In the deep of the Norwegian fjords, the water is only exchanged once a year; in some fjords as seldom as every fourth or fifth year. As the ocean off the coast warms, such exchange becomes even rarer. This may worsen the conditions for life in many fjords, as water that has not been near the surface in a long time, contains little oxygen. The situation may be worse in fjords with fish-farms, where waste from the farms decomposes at the bottom, using up the oxygen in the water. At the mouth of a fjord there is a shallow sill, but the basin inside than can be several hundred metres deep. The water at the bottom is only renewed during upwelling events on the shelf outside. Heavy, saline water is brought up, and some of this water can slosh over the sill and sink to the bottom of the fjord. The temperature at the coast has already increased, and warmer surface water stabilises the water column, which reduces the chances of upwelling. Reduced exchange of bottom water has already been observed in some fjords. Our scientists now use a high-resolution ocean model to assess whether this occurs in all fjords and whether some fjords are more vulnerable than others.

↗ The Norwegian ice-breaker Kronprins Håkon in thick ice off Svalbard.
PHOTO: DANIELLE GRANT

→ Mari Myksvoll about to set out a cage with smolt, for surveillance of salmon lice, in Boknafjorden.
PHOTO: LARS ASPLIN / IMR

Islands of heat in the Arctic
That cities are warmer than their surroundings – so-called urban heat islands – has been known for a long time, but only in the last decades has the effect been documented in the Arctic. In a study of 57 Norwegian, Swedish, Finnish and Russian cities north of 64 °N, Bjerknes scientists found that most are between 1 and 2 degrees warmer than their rural surroundings. In the largest cities of Murmansk and Oulu the difference was as high as 3–5 degrees. These differences are higher than in cities of the same size at lower latitudes. Warmer cities can extend outdoor activities and reduce frost damage, but also weaken the soil-bearing capacity and increase the risk of urban flooding. To reduce climate-related risk, information about the urban surface temperature anomalies should be considered in urban planning and adaptation strategies.

Outlook
"The fastest changes in climate now occur in the Arctic", says Kerim H. Nisancioglu, leader of our Climate research. "More than ever, we need to be there to observe and to understand the processes behind these changes".

Searching for the DNA of climate
DNA sequencing has given palaeoclimatologists a new tool. When organisms in the ocean die, they sink and take their DNA with them to the bottom of the sea. DNA in ocean sediments can reveal ancient life, and with that, the sea-ice cover of more than 100,000 years ago can be inferred. Certain algae are only found in sea ice, and if their DNA is found in the sediments, there must have been ice in the region. A varying sea-ice cover tells of changes in the ocean through the ages. Bjerknes scientists now have a new DNA lab. Among the things they hope to be able to do are estimating past sea-ice extent and how thick the ice has been, and possibly distinguishing drift ice from local sea ice. As sediment samples contain very little ancient DNA, it is vital not to contaminate the samples with modern DNA.
In the lab, the scientists must wear lab suits completely covering their bodies, cover up their hair and wear glasses, mouth masks and a double set of gloves.

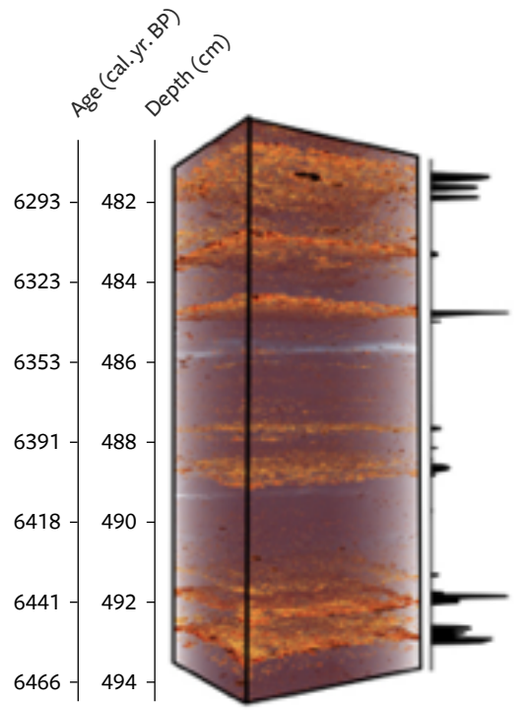
↑ Working with ancient DNA in sediments requires special care to avoid contaminating the samples with other DNA.
PHOTO: KRISTINE STEINSLAND

Climate Hazards

Extreme events and abrupt changes to the climate system.

Ancient floods in southern Norway
Floods in western Norway tend to occur after heavy rain in autumn, while rivers in the east reach their highest levels during snowmelt in spring. What about the southern region between east and west, called Sørlandet? Bjerknes Centre scientists would like to find out more about floods in that region, not only in modern times, but for the entire time since the last ice age. With increasing global temperatures, one may expect more flooding from extreme rainfall, while less winter snow will decrease the severity of meltwater floods. Instrumental data records are short, limiting our knowledge of how river runoff is affected by long-term natural climate variability. Information about past floods can help shed light on this.

From the bottom of the lake Lygne, our scientists have extracted a five-metre-long core of sediments brought in by the river. The lowest part is more than 8000 years old. To the naked eye, the sediments look evenly black, but a CT scan revealed distinct layers of coarse sediments – signs of a swollen river. Analyses of the elements in the sediments highlighted the same layers. By counting the layers, researchers found particularly many floods 6000–7000 years ago, at a time when temperatures in northern Europe were high. The next step is to compare this core to other cores from Sørlandet, and then all of them to records from western and eastern Norway.



A high-resolution X-ray CT image of a lake sediment core makes it possible to identify flood events in the past.
PHOTO: JOHANNES HARDENG

Ready for coring! From a platform on top of two inflatable boats, our scientists can retrieve sediment samples from the bottom of the lake.
PHOTO: JOHANNES HARDENG

Future floods from machine learning
In the future, Norway will be wetter, with more extreme rainfall events. How much more water can we expect in our rivers? Scientists at the Bjerknes Centre try to find out whether machine learning can be used to simplify and improve the process of estimating future flooding. Climate models give a rather coarse picture of the weather, and there is a long way from those data to the water levels measured in an individual river on a specific day. The procedure for predicting changes in river floods has so far involved adjusting data from a climate model to a more local geography and feeding these temperature and precipitation data to a hydrological model to estimate river discharge. This is time consuming and the method requires that established relationships between the weather and the river discharge do not change. In a changing climate, that is not necessarily the case. Therefore, attempts are now being made to capture the relationship between weather data from the climate model and river discharge directly – possibly providing a more efficient method that will also work in a changing climate.

Outlook
"The complexity of the climate system makes it challenging to predict climate hazards such as floods, storms, sea-level rise and ecosystem changes", says Nele Meckler, leader of our Climate Hazard research theme. "To get a solid understanding, we merge all available information from observations, reconstructions of past climate and climate models run at smaller and smaller scales."

Hardangerjøkulen is the most vulnerable of the larger Norwegian glaciers. High-school students visiting during fieldwork in 2017 saw how the glacier has already changed, and how our scientists and their project partners work to map the current state of the glacier.
PHOTO: LU LI

Draining of a diminishing glacier
In the coming decades, melting glaciers may provide more water for Norwegian hydropower stations. But what if the water drains in a new direction? Or shifts to another season? Among the largest of the diminishing Norwegian glaciers, Hardangerjøkulen is the most vulnerable. A team led by Bjerknes scientists has found that snowfall would have to increase 300 percent to compensate for the higher temperatures expected in the coming decades until 2050. More precipitation is expected, though not at that scale. The increased precipitation and thawing will increase runoff in spring and autumn, while in catchments with little ice left, summer runoff will decrease. As the ice disappears and reveals the mountains and valleys under the glacier, both meltwater and rain may take new paths. Some of the runoff will likely be redirected from catchments on the southern and western side of the glacier to the northern and eastern side.

Outreach

Once a year, actors from industry, public agencies, and science come together at the Klimathon meeting in Bergen to discuss how municipalities can better adapt to climate change. The Bjerknes Centre has been heavily involved since the start. Klimathon 2020 is due in November.
PHOTO: ANDREAS HADSEL OPSVIK

While doing fieldwork on Greenland, Petra Langebroek made a social media story with Lego figures in the main roles – for her sons and everyone else to read. The entire story was later republished by the newspaper Framtida, and Petra's blog post about it was one of the two winners of the EGU Best Blog Post of 2019 Competition.
ILLUSTRATION: PETRA LANGEBROEK

Celebrating the 50th anniversary of the moon landing, Bjerknes scientists took part in the concert series "Neste steg", together with the Bergen Philharmonic Orchestra. Here, Marius Årthun talks about the ocean to a packed concert hall.
PHOTO: OLE MARIUS KVAMME / UIB

In August 2020, the Bjerknes Centre organised a climate cruise from Bergen to Arendal with the barque "Statsraad Lehmkuhl". Around 80 people joined the cruise – scientists, people from industry and public management, politicians, and youth concerned about climate. Between shifts on deck, everybody participated in group work about the future climate and the green shift.
PHOTO: GUDRUN SYLTE

Research Training

Climate science requires researchers who have in-depth knowledge of their specific parts of the climate system, but at the same time a broader knowledge of an Earth system where the ocean, the atmosphere, ice sheets, and living organisms interact. Also, the demand from society can only be met when researchers are able to communicate with experts from other disciplines as well as the general public.

At the Bjerknes Centre, these aspects of the research training are taken care of through the Research School on Changing Climates in the Coupled Earth System (CHESS), and the annual Advanced Climate Dynamics Courses (ACDC).

Outdoor ACDC lecture by Peter Huybers overlooking the Yosemite Valley and the famous Mt. Half Dome. PHOTO: ØYVIND PAASCHE

Doctoral Dissertations 2019

In 2019, Bjerknes scientists provided supervision and training in climate research to 56 PhD candidates. The following successfully defended their dissertations.

February 15th 2019

Kjersti Opstad Strand

Air-sea interaction in biophysical modeling with focus on northeast Arctic Cod

Swimming against the current, cod leave the Barents Sea in spring, and head south for the spawning grounds of Lofoten. Their eggs then follow the current back to the Barents Sea, with ample access to food on the way. Successful fish larvae reach the Barents Sea and become the next generation. What about the less fortunate ones, those that end up in currents diverted by foul weather? Being driven out into open waters is a bad idea when what you need is the food table of a continental shelf. Kjersti Opstad Strand found that these fish larvae can be carried all the way across the ocean and end up on the shelf of north-eastern Greenland, where conditions for survival can also be good. The geographical distinction between different cod populations may not be as clear as we thought.

October 21st 2019

Francesca Jaroszynska

Climate and biotic interactions – Drivers of plant community structure and ecosystem functioning in alpine grasslands

Climate change affects the distribution of species. In southern Norway, Francesca Jaroszynska found that with more precipitation and higher temperatures, alpine meadows will be richer in carbon and have a more stable and homogeneous microclimate. At the same time, grasses will be more dominant and the ecosystems less diverse.

November 15th 2019

Silje Smith-Johnsen

Dynamics of the Northeast Greenland Ice Stream: the role of geothermal heat and subglacial hydrology

In some parts of ice sheets, ice flows faster toward the ocean than elsewhere. In her PhD, Silje Smith-Johnsen shows that the movement of such ice streams in north-eastern Greenland can be explained by geothermal heat under the ice.

March 5th 2019

Andreas Plach

Simulation of the Eemian Greenland ice sheet

During the last interglacial (Eemian), about 125,000 years ago, summers on Greenland were even warmer than today. Andreas Plach used numerical models to simulate the climate on Greenland. By understanding how much of the ice melted in that period, we can better understand how the Greenland ice sheet will react in a future warmer climate, and how much it will contribute to sea-level rise.

February 15th 2019

Henrik Sadatzki

Sea ice variability in the Nordic Seas over Dansgaard–Oeschger climate cycles during the last glacial – A biomarker approach

Between 30,000 and 40,000 years ago, temperatures on Greenland fluctuated, with several abrupt increases. Henrik Sadatzki has reconstructed changes in the sea-ice cover between Norway and Greenland. He found that the sudden changes in climate were largely driven by rapid melting of sea ice, releasing heat from the ocean to the atmosphere.

March 18th 2019

Torgeir Opeland Røthe

Reconstructions of palaeoenvironmental variations from lacustrine sediments in sub-Arctic and Arctic lakes, and their climatic implications

Retreating glaciers may create ice-dammed lakes, in some locations threatening houses and infrastructure downstream. Using a CT scanner on lake sediments, Torgeir Opeland Røthe identified historic floods from an outlet glacier of Folgefonna in western Norway. Although this particular lake will not form in a warmer climate, similar lakes may.

June 14th 2019

Evangeline Sessford

Hydrography in the Nordic Seas during Dansgaard-Oeschger events 8-5

During the last ice age, Greenland experienced several warming events with about ten degrees of change in as little as a few decades. Just before these events, the sea ice in the Nordic Seas retreated. Evangeline Sessford found that the water deep under the ice became increasingly warmer during cold periods. This may have made the water column unstable, letting warm water reach the surface and forcing the ice to withdraw.

June 17th 2019

Marie Pontoppidan

Dynamical downscaling – impact on storm tracks and precipitation

How representative of the real terrain must climate models be to give results that are meaningful? Marie Pontoppidan evaluated a regional model by simulating a flood event in western Norway in October 2014. In rugged terrain like ours, she found that a high spatial resolution clearly improved the results.

June 26th 2019

Balamuralli Rajasakaren

Carbon fluxes related to ventilation and remineralization in the Nordic Seas and Arctic Ocean

Balamuralli Rajasakaren's thesis shows that physical processes bringing water downward are responsible for the variations in the carbon cycle of the Arctic and the North Sea. Such ocean ventilation is responsible for the increasing trend of carbon in Arctic waters.

August 30th 2019

Nora Loose

Adjoint modeling and observing system design in the subpolar North Atlantic

The global ocean is enormous, and we will never be able to observe every drop of it. Perhaps we do not need to? Nora Loose has investigated how we can use knowledge of ocean currents and waves to exploit observations from regions far away. Using a global ocean model as well as mathematical methods new to oceanography, she has quantified the extent to which existing observations describe our climate.

June 28th 2019

Astrid Fremme

Moisture sources for East Asian monsoon precipitation

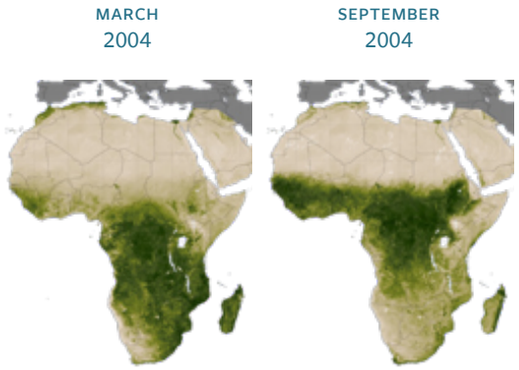
Clouds and rain are often seen to come from the ocean. Looking for sources for summer monsoon rainfall in eastern China, Astrid Fremme found that evaporation from land supplies more than half. This implies that land-use and vegetation can affect rainfall in the region.

June 27th 2019

Lander Crespo

Ocean-atmosphere interactions in the tropical Atlantic seasonal cycle and multidecadal variability of ENSO

In west Africa, June–September is the rainy season, as the onshore winds of the summer monsoon carry moisture from the ocean. There are two main players influencing the timing and the amount of rain: temperature variations over land and over the ocean. Using climate models, Lander Crespo found that the rainfall patterns on the west African continent are mainly governed by temperatures over land. Sea-surface temperatures govern rainfall over the Gulf of Guinea and also contribute to increasing rainfall over the continent.



↑ Vegetation in the Sahel shows how the rain belt over Africa moves north in summer.
ILLUSTRATION: ROBERT SIMMON & JESSE ALLEN, NASA

December 9th 2019

Sunil Pariyar

Intraseasonal rainfall variability and the extreme rainfall in the western Tropical Pacific

Pacific islanders depend on rain for drinking water. Within seasons, Sunil Pariyar found rainfall in the South Pacific to vary with sea-surface temperatures. Tropical cyclones bring the most extreme rain.

↑ Carrying the boat to the lake, necessary to retrieve sediment cores.
PHOTO: JOHANNES HARDENG

← Stijn De Schepper and Marion Martin sampling a sediment core from the ocean floor off the coast of southern Greenland.
PHOTO: AMANDINE TISSERAND

Engagements 2019

GLOBAL DIMENSION

Argo Programme
Kjell Arne Mork is a member of the Argo Steering Team.

Arctic Fulbright Chair (US-Norway) 2019–2020
Lars H. Smedsrud is the chair.

Arctic-Subarctic Ocean Fluxes (ASOF)
Tor Eldevik, Svein Østerhus, Øystein Skagseth and Kjetil Våge are members of the international scientific steering group.

Biogeosciences
Christoph Heinze is associate editor.

Climate of the Past
Bjørg Risebrobakken is on the editorial board.

The Cryosphere
Kerim H. Nisancioglu is on the editorial board.

Earth System Dynamics
Christoph Heinze is associate editor.

Forum for Research on Ice Shelf Processes (FRISP)
Elin Darelius is an early-career scientist representative and Svein Østerhus represents Norway.

Global Climate Forum (GCF)
BCCR is a member of the Global Climate Forum (GCF), a non-profit organisation located at the Potsdam Institute for Climate Impact Research (PIK), Germany.

Global Ocean Acidification Observing Network (GOA-ON)
Benjamin Pfeil is an executive council member.

Global Ocean Data Analysis Project (GLODAP)
Are Olsen is co-chair.

Global Ocean Data Assimilation Experiment (GODAE, OceanPredict)
Laurent Bertino is member of the science team.

Global Ocean Ship-Based Hydrographic Investigations Program (GO-SHIP)
Elaine McDonagh is co-chair, and Are Olsen is a member of the science committee.

Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO)
- Global Ocean Surface Underway Data (GOSUD): Benjamin Pfeil is a scientific steering group member.
- IOC UNESCO and SCOR's International Ocean Carbon Coordination Project (IOCCP): Siv Lauvset and Benjamin Pfeil are scientific steering committee members.
- IOC UNESCO's methodology working group on UN's SDG target 14.3: Benjamin Pfeil is a member.

International Arctic Science Committee (IASC)
Thomas Spengler is a representative for Norway in the Atmospheric Working Group (AWG) and chair of the AWG through 2019.

International Association of Meteorology and Atmospheric Sciences (IAMAS)
Camille Li is the national correspondent.

International Commission on Dynamical Meteorology (ICDM)
Thomas Spengler is the president.

International Council for the Exploration of the Seas (ICES)
- Working Group on Hydrography: Kjell Arne Mork, Svein Østerhus and Øystein Skagseth are members.
- Study Group on Ocean Acidification: Are Olsen is a member.
- Working Group on Integrated Assessments of the Norwegian Sea WGNIOR: Morten Skogen and Erik Askov is a member.
- Working Group on Integrative Physical-Biological and Ecosystem Modelling WGIPEM: Solfrid Hjøllo is chair. Morten Skogen, Shuang Gao, Erik Askov Mousing and Annette Samuelsen are members.
- Working Group on Seasonal-to-Decadal Prediction of Marine Ecosystems (SGS2D): Anne Britt Sandø is a member.

International Eurasian Academy of Science (IEAS)
Igor Esau is an elected full member.

World Climate Research Programme (WCRP)
- Climate and the Cryosphere Project (CliC): Lars H. Smedsrud is a member of the scientific steering group.
- Past Global Changes (PAGES): Ulysses S. Ninnemann is on the scientific steering committee of IMAGES, the marine component of PAGES.
- PAGES Arctic 2k working group: Jostein Bakke is co-leader.
- PAGES 2k Network project MULTICHRON: Carin Andersson Dahl is the leader and Odd-Helge Otterå is co-leader.
- PAGES EcoRe3: Alistair Seddon is the leader.
- PAGES Early Career Network: Madelyn Mette and Tamara Trofimova are steering committee members.
- PAGES/CLIVAR joint working group: Eystein Jansen is a member.
- CLIVAR Atlantic Region Panel: Noel Keenlyside is a member.
- CLIVAR Climate Dynamics Panel: Noel Keenlyside is a member.
- CLIVAR Global Synthesis and Observations Panel: Are Olsen is a member and Francois Counillon are members.
- CLIVAR Ocean Model Development Panel: Mats Bentsen is a member.
- CLIVAR/ClLiC Northern Oceans Regional Panel (NORP): Tor Eldevik and Laurent Bertino are members.
- CLIVAR Eastern Boundary Upwelling Systems (EBUS): Thomas Toniazzo is a member.
- SPARC stratospheric Network for the Assessment of Predictability (SNAP): Erik Kolstad is a member.
- Arctic CORDEX: Stefan Sobolowski is a member.
- CORDEX Regional Downscaling Experiments in Europe (Euro-CORDEX): Stefan Sobolowski is co-coordinator and point of contact.
- CORDEX Flagship Convection Permitting Modelling over Europe and the Mediterranean: Stefan Sobolowski is co-leader.
- CORDEX Flagship on Land Use and Climate Across Scales (LUCAS): Stefan Sobolowski and Priscilla Mooney are participants.
- Coordination Office for WCRP Regional Activities (CORA): Beatriz Balino is regional coordinator.

IBS Center for Climate Physics, Busan South Korea
Eystein Jansen is a member of the scientific advisory board.

International Marine Global Changes Program (IMAGES)
Ulysses S. Ninnemann is the Norwegian representative.

International Ocean Carbon Coordination Project (IOCCP)
Siv Lauvset and Benjamin Pfeil are members.

International Surface Ocean Lower Atmosphere Study (SOLAS)
Siv Lauvset is the national representative from Norway.

OceanSITES
Svein Østerhus is a member of the steering committee.

Pan-Eurasian Experiment (PEEX)
Igor Esau is a member.

PANGAEA – Data Publisher for Earth and Environmental Science:
Benjamin Pfeil is a member of the editorial board.

Southern Ocean Observing System (SOOS)
- Benjamin Pfeil is a member of the data committee.
- Elin Darelius is a member of the Weddell Sea/Dronning Maud Land working group.

Strategies for Environmental Monitoring of Marine Carbon Capture and Storage (STEMM-CCS)
- Abdirahman M. Omar is the deputy work package leader and an executive board member.
- Emil Jeansson is a member of the General Assembly.

Supporting EU-African cooperation on Research Infrastructures for Food Security and Greenhouse Gas Observations (SEACRIFOG)
Abdirahman M. Omar is the deputy work package leader and an executive board member.

Surface Ocean CO_2 Atlas (SOCAT)
- Siv Kari Lauvset, Benjamin Pfeil and Are Olsen are members of the Global Coordination Group.
- Camilla Landa, Benjamin Pfeil and Are Olsen are members of the SOCAT automation group.

Synoptic Arctic Survey (SAA)
Øyvind Paasche is chair for the International Scientific Steering Committee.

Weather and Climate Dynamics
Camille Li is an executive editor.

EUROPEAN DIMENSION

Academia Europaea Bergen Region Knowledge Hub
Eystein Jansen is Academic Director with responsibility for the Nordic, Baltic, Arctic region.

Bolin Centre, University of Stockholm
Eystein Jansen is a member of the science advisory board.

Copernicus Marine Environmental Monitoring System In Situ TAC
Benjamin Pfeil is a member of the scientific committee.

COST – European Cooperation in Science and Technology:
- Svein Østerhus is a member of the COST action Everyone's Gliding Observatories management committee.
- Anne Britt Sandø and Laurent Bertino are members of the COST action Evaluation of Ocean Syntheses.

Durham Arctic Research Centre for Training and Interdisciplinary Collaboration (DurhamARCTIC)
Bjørg Risebrobakken is on the external advisory board.

East Greenland ice core drilling project (EGRIP)
Kerim H. Nisancioglu is the Norwegian representative and member of the steering committee.

ECCORD Consortium for Ocean Research Drilling: Science Support and Advisory Committee (ESSAC)
Helga F. Kleiven is the Norwegian delegate.

European Climate Research Alliance (ECRA)
Lars H. Smedsrud is co-chair of the programme on Arctic Climate Stability and Change.

European Marine Board (EMB)
Jerry Tjiputra is a member of the Big Data working group.

European Research Council (ERC)
Eystein Jansen is a member of the scientific council.

European Science and Technology Advisory Group (E-STAG)
Jenny S. Hagen is a young scientist member.

Joint Programming Initiative (JPI) Climate – Module 1
Tore Furevik is a member of the national reference group.

Joint Programming Initiative (JPI) MARUM, University of Bremen
Nele Meckler is a member of the scientific advisory board.

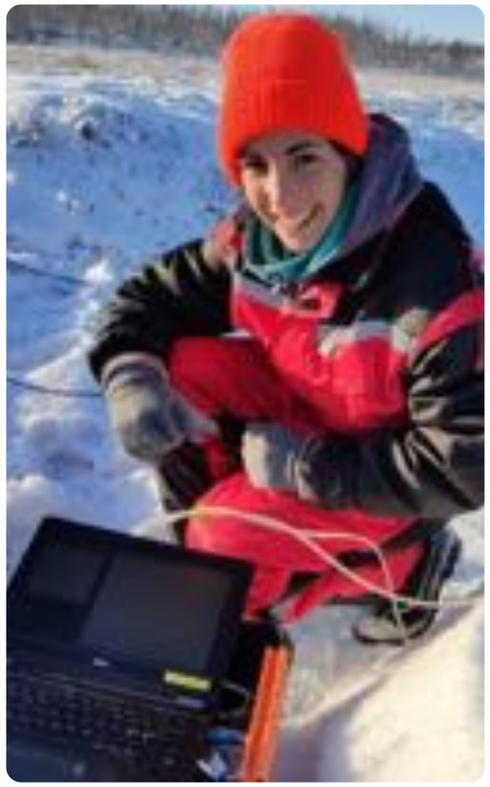
MOSAIC
Benjamin Pfeil is a team coordinator for data.

Oceans
Tor Eldevik is a member of the national reference group.

OSPAR commission
Ingunn Skjelvan is member of the Intersessional Correspondence group on Ocean Acidification.
RINGO
Benjamin Pfeil is an executive board member.
SeaDataCloud
Benjamin Pfeil is a member of the scientific committee.

NATIONAL DIMENSION

Arctic Frontiers
Tor Eldevik is member of the steering committee.
Arts Council Norway
Kerim H. Nisancioglu is a member of the climate panel.
Folgefonnsenteret
Tore Furevik is a board member and Kerim H. Nisancioglu an alternate member.
GRID-Arendal
Helga F. Kleiven is on the board of directors.
Notur/Norstore Resource Allocation
Benjamin Pfeil is a member.
Nansen legacy (Arven etter Nansen) – the Norwegian national research project for the Barents Sea and adjacent Arctic 2017–2023
Nils G. Kvamstø is a member of the steering committee and Tor Eldevik is co-PI.
Norwegian Climate Foundation
Helga F. Kleiven is on the board of directors. Tore Furevik is a member of the council.
Norwegian Climate Service Centre
Tore Furevik is board leader.
Norwegian Meterological Institute
Eystein Jansen is a board member.
Research Council of Norway: Board for Climate and Polar Research
Tor Eldevik is a member.
Research Council of Norway: Norway–India Programme Advisory Committee
Eystein Jansen is a member.
Scientific Committee of Oceanographic Research (SCOR)
Peter M. Haugan is national chair.



Inge Althuizen doing fieldwork in Finnmark.
PHOTO: CASPER T. CHRISTIANSEN

Sometimes it rains. Jostein Bakke tries to shield his laptop during sediment coring of a lake in Sørlandet.
PHOTO: JOHANNES HARDENG

Organisation

THE LEADER GROUP

TORE FUREVIK	Professor (Director), Climate dynamics, UiB
CAMILLE LI	Professor, Atmospheric dynamics, UiB
ARE OLSEN	Professor, Biogeochemistry, UiB
KERIM HESTNES NISANCIOGLU	Professor, Climate dynamics, UiB
NELE MECKLER	Associate professor, Palaeoclimate, UiB
FRANCOIS COUNILLON	Researcher, Oceanography, NERSC
FRODE VIKEBØ	Senior Researcher, Oceanography, IMR
PETRA LANGEBROEK	Senior Researcher, Paleoclimate and ice sheet dynamics, NORCE
GUDRUN SYLTE	Head of Communication, UiB
RAGNHILD STOLT-NIELSEN	Head of Administration, UiB

BOARD OF DIRECTORS

ARVID HALLÉN	Leader
MARGARETH HAGEN	Pro-Rector, UiB
ELISABETH MARÅK STØLE	CEO, NORCE
SEBASTIAN H. MERNILD	Managing Director, NERSC
SISSEL ROGNE	Managing Director, IMR

SCIENTIFIC ADVISORY COUNCIL

DOROTHEE BAKKER	University of East Anglia, UK
COLIN JONES	MET Office, UK
GUNHILD ROSQVIST	Stockholm University, Sweden
TAPIO SCHNEIDER	ETH Zurich, Switzerland
CLAIRE WAELBROECK	LSCE/IPSL, France
JUNE-YI LEE	IBS, Pusan National University, Republic of Korea
CARLO BUONTEMPO	Copernicus Climate Change Service, UK

The Bjerknes Centre in numbers 2019

DOCTORAL DISSERTATIONS

- 13 PhD candidates successfully defended their thesis

PUBLICATIONS

- 257 publications

PROJECTS

In total 107 research projects:

- EU – 34
- NFR – 54
- Other – 12
- ERC Grants – 7

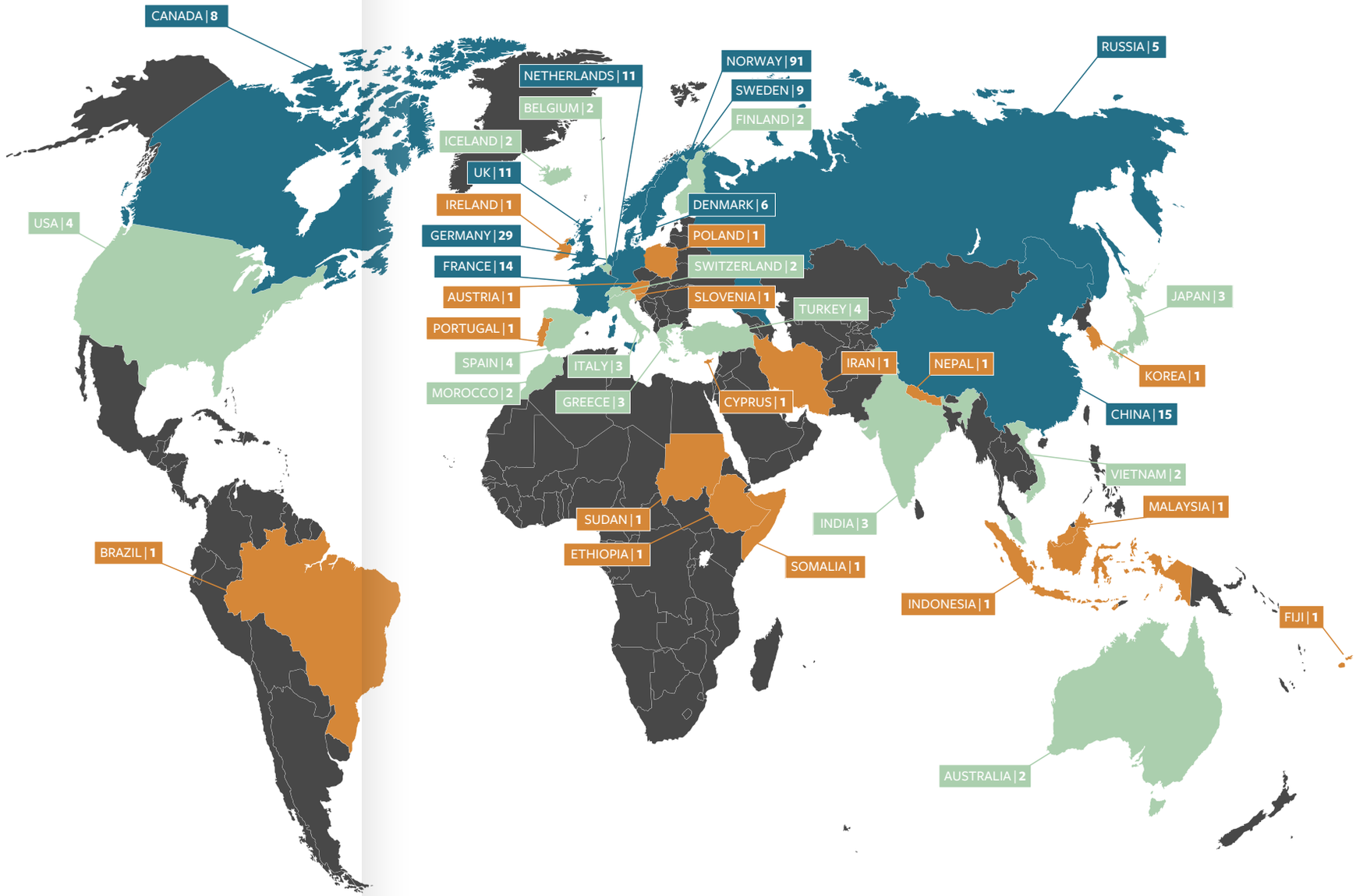
– 1 ERC Synergy Grant
– 1 ERC Advanced Grant
– 3 ERC Consolidator Grant
– 2 ERC Starting Grant

252 AFFILIATED RESEARCHERS, TECHNICIANS, AND ADMINISTRATIVE PERSONNEL

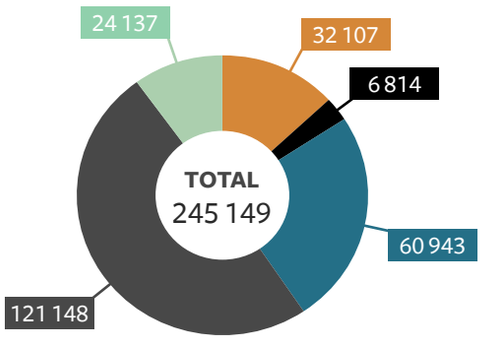
- From 39 nations

SCIENTIFIC STAFF

Category	UiB	NORCE	NERSC	IMR	Total	Foreigners %	Women %
Scientists	64	37	27	16	144	60 %	28 %
Postdocs	23	3	1	1	28	93 %	46 %
PhD candidates	49	5	1	1	56	71 %	54 %
Total	136	45	29	18	228		



FUNDING	NOK 1 000,–
Ministry of Research and Education	32 107
University of Bergen	6 814
European Commission	60 943
Research Council of Norway	121 148
Other	24 137
Total income	245 149



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1 Kristine Steinsland on a research cruise to the Fram Strait.
PHOTO: DANIELLE GRANT

2 A soil-climate scientist's tool – tea bags.
PHOTO: CASPER T. CHRISTIANSEN

3 Microscope view of pollen from South Georgia.
PHOTO: MAAIKE ZWIER

4 Sampling sea water for carbon measurements.
PHOTO: INGUNN SKJELVAN

5 Students on the course Sustainable Arctic Energy Exploration and Development, in Svalbard.
PHOTO: LARS HENRIK SMEDSRUD

6 The chemical composition of dissolved foraminifera can be used to reconstruct past temperatures.
PHOTO: AMANDINE TISSERAND

7 Skellig Islands, Ireland.
PHOTO: CHRISTOPH HEINZE