Bolin Centre for Climate Research

Report 2019

Bolin Centre Vision

Our vision is the Bolin Centre as the nationally leading and an internationally recognised centre for interdisciplinary climate research and a primary Swedish contact point for scientists, media and the public on issues relating to the past, present and future climate.

Bolin Centre Mission

The mission of the Bolin Centre is to create and communicate fundamental knowledge about climate and the Earth system as part of an evolving global effort to understand and adapt to the Earth's changing climate.

Front page: One evening in August, Russels Glacier in western Greenland. Photo: Petter Hällberg

Production: Bolin Centre for Climate Research, 2020.

Contents

Photo: Regina Lindborg

The Bolin Centre for Climate Research

The Bolin Centre is a multi-disciplinary consortium of more than 400 scientists in Sweden who conduct research, graduate education and outreach related to the Earth's climate. It was formed in 2006 of Stockholm University, the KTH Royal Institute of Technology and the Swedish Meteorological and Hydrological Institute. The Bolin Centre is named in honour of Professor Bert Bolin of Stockholm University, a world leader in climate and carbon cycle research.

The Bolin Centre focuses on extending and disseminating knowledge about the Earth's natural climate system, climate impacting processes, climate modelling, human impact on the climate and climate impacts on ecosystems, biodiversity and humanity as well as how society can minimise the negative impacts of climate change. It contributes to the knowledge base for climate mitigation and adaption policies nationally and internationally.

The Bolin Centre is named after Professor Bert Bolin of Stockholm University, one of the founders of the Intergovernmental Panel on Climate Change (IPCC). The publication of the first IPCC report led to the recognition of the need for cross-disciplinary collaboration on climate science at Stockholm University. This resulted in a Climate Research School being established in 2005 and shortly thereafter the research program SUCLIM (Stockholm University Climate Research Centre) being awarded a 10 year Linneaus grant from the Swedish government in 2006.

In 2008, SUCLIM was renamed the Bert Bolin Centre for Climate Research, a name which was shortened to the Bolin Centre for Climate Research in 2013. From 2010, the Swedish Hydrological and Meteorological Institute and the KTH Royal Institute of Technology joined the Bolin Centre in a collaboration aimed at strengthening climate modelling within the centre. This initiative was funded as a strategic research area by the Swedish government.

In June 2016, the Bolin Centre merged with another strategic research area at Stockholm University: EkoKlim – A multiscale, cross-disciplinary approach to the study of climate change on natural resources, ecosystem services and biodiversity. This merger widened the scope of the Bolin Centre to include the impacts of climate change on landscape processes and biodiversity.

Following this merger, the combined SFO funding of the Bolin Centre exceeds 30MSEK annually.

Bolin Centre for Climate Research
A collaboration between Stockholm University, KTH and the Swedish Meteorological and Hydrological Institute

Stockholm University

KTH

SMHI

Bolin Centre organisation

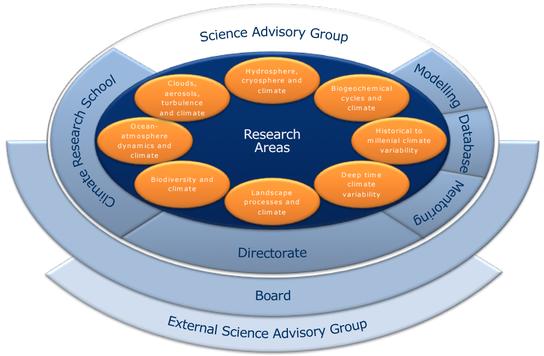
The Bolin Centre aims to bring climate scientists together. The centre comprises eight cross-disciplinary research areas, within which scientists from different disciplines join together to tackle key questions about climate.
The Bolin Centre organises regular seminars, workshops, conferences, outreach projects, summer schools and mentoring.

The Bolin Centre is built around its eight multi-disciplinary research areas, each of which is led by two (or three) scientists. The centre hosts a research school and an open access database as well as provides communication support and support for climate modelling activities. There is also a mentoring programme which is open to all of its members and a journal club for its postdoctoral community.

The directorate comprises two co-directors and two communicators and coordinators, who share the day-to-day tasks of centre operations. All research area co-leaders, coordinators and the directorate meet regularly in the Science Advisory Group, working to facilitate excellence in climate-related science conducted by the Bolin Centre members.

The Bolin Centre is led by its board, which includes heads of participating departments at Stockholm University, representatives from KTH Royal Institute of Technology and the Swedish Hydrological and Meteorological Institute, and external members. The Bolin Centre receives guidance from its External Science Advisory Group. These internationally recognised leaders in climate science visit the Bolin Centre annually at its internal conference: the Bolin Days.

The operational philosophy of the Bolin Centre is one of mutual respect and trust – a philosophy which is reflected in the form of paired leadership which is applied throughout the organisation.



Directors' corner

The Bolin Centre has evolved from an idea among a few inspired individuals to a thriwing node embracing more than 400 scientists focusing on science, education and outreach activities related to the Earth's climate. The Bolin Centre is a common effort, and it's success is the success of its members.

The year 2019 will always be connotated with the outbreak of the global pandemic caused by the Coronavirus SARS-CoV-2. First human cases of the disease caused by the virus, commonly also referred to as Covid-19, were reported from China in December 2019, from where the virus spread rapidly and unopposed, with severe and all too often fatal consequences, to all parts of the globe. The year 2019 will also be remembered as "the year before everything changed", and the future will show that we learned to cope with drastic measures put in place to restrict the spreading of the virus. This spreads hope that we will not let the window of opportunity for sustainable transformation pass by when the pandemic starts to fall behind us. As Directors of the Bolin Centre, we are enormously pleased to see that our members continue to create the fundamental knowledge on which this transformation must be based.

Scientific advances made at the Bolin Centre

Our scientists are contributing to the 6th Coupled Model Intercomparison Project (CMIP6). These model comparisons allow the IPCC to build the future climate scenarios based on which policymakers can make educated decisions. In the Horizon 2020 project FORCeS, our members are reducing the uncertainties in these future scenarios by advancing our understanding of how aerosols affect the climate.

Our scientists were at the 25th Conference of the Parties (COP25) in Madrid. The COP is the decision-making body of the United Nations Framework Convention on Climate Change. In Madrid, our scientists presented research highlights about the cryosphere and its vulnerability to climate change. These include how abrupt permafrost thaw affects greenhouse gas emissions as well as measurements of permafrost warming during the last decade.

Our scientists are underpinning future climate scenarios with work on deep time analogues. This includes work on the Miocene Epoch, a warm "future analogue" from Earth's geological past, from 23.0 to 5.3 million years ago.

Co-director | Alasdair Skelton is a professor of geochemistry and petrology. He works at the Department of Geological Sciences, Stockholm University. Most of his published works are on climate of the past, earthquake forecasting and metamorphic petrology. Photo: Eva Dalin

Co-director | Nina Kichner is an associate professor of glaciology at the Department of Physical Geography at Stockholm University. Her research focuses on ice-ocean interaction at marine ice margins in order to improve reconstructions of ice sheet complexes and modelling of their present and future dynamics. Photo: Riko Noormets

Wetlands have been a focal point for research at the Bolin Centre. Their importance as carbon sinks, for nutrient and pollutant retention and for biodiversity support as well as the Sustainable Development Goals (SDG) that are critical for their management and preservation are among the questions being tackled by our scientists.

The impacts of climate change on plant populations and insect species are other important questions which have been published by our scientists.

Many of our scientists are also actively involved in communicating new and established knowledge to a broader audience beyond academia. Highlight of this work include the annual Bolin Centre Climate Festival, and a cooperation with Nordiska museet, where the exhibition "Arctic – while the ice is melting" was inaugurated by Her Royal Highness, Crown Princess Victoria of Sweden, in November. The cover of the book "Arktiska Spår – Natur och kultur i rörelse" (Arctic traces – nature and culture in motion), accompanies the exhibition and features Warming Stripes for Sweden, based on datasets archived in the Bolin Centre Database.

These and other highlights of work at the Bolin Centre are presented in the following pages.

Finally, we warmly welcome several prestigious new members to our External Science Advisory Group during 2020:

- Maureen E. Raymo, Bruce C. Heezen Lamont Research Professor and Director of the Lamont-Doherty Core Repository of Columbia University.
- Veerabhadran Ramanathan, Distinguished Professor of Atmospheric and Climate Sciences at the Scripps Institution of Oceanography, University of California, San Diego.
- Jay Famiglietti, Professor, School of Environment and Sustainability, and Department of Geography and Planning, University of Saskatchewan, Executive Director Global Institute for Water Security.

Nina Kirchner and Alasdair Skelton

Publications

Bolin Centre scientists have published at least 231 climate-related articles in scientific journals in 2019. See full list on *bolin.su.se/publications2019*

PhD day

For the first time ever, the Climate Research School hosted a PhD day in October 2019. Nearly 60 PhD students and postdoctoral researchers attended to share their research, and connect beyond institutions and disciplines. Read more on page 24.

The Bolin Centre Database

The Bolin Centre Database promotes and visualizes research results and data. In February 2020, the database hosted 203 datasets with metadata and a number of thematic data presentations. Read more on page 27.

Communication channels

Visit *www.bolin.se* and *@BolinCentre* on twitter for latest news and events.

Ocean-atmosphere dynamics and climate

Research Area 1 conducts fundamental research on the dynamics of the atmosphere and oceans and their influence on climate. We develop, evaluate and apply different models, ranging from simple box models to regional and global component models up to fully coupled global Earth system models. Models and observational based data sets are used to gain insight into the underlying mechanisms that govern the variability of oceanic and atmospheric circulation, exchanges of heat and water between atmosphere and ocean, predictability of the climate systems and extremes as well as potential future climate changes under different future emission scenarios.

Activities and Resources

RA1 received 400 kSEK in 2019. The resources were used to organize and co-fund workshops and supported research activities, such as field work and conference attendance, through two openly announced calls.

RA1 organised the 3rd workshop on North Atlantic – Nordic Seas exchanges, 4–6 December, 2019. The workshop gathered scientists to work on ocean exchanges between the North Atlantic and the Nordic Seas and explored ways towards a more complete understanding of the physics and dynamics of this central link in the global meridional overturning circulation. The northward oceanic heat transport has a strong impact on Arctic sea ice and climate and is one important contributor to the Arctic tempeature amplification.

RA1-scientists contributed to the 6th Coupled Model Intercomparison Project organised by the World Climate Research Project, by development and simulations with EC-Earth and MPI-ESM models. SMHI performed in particular a large ensemble of simulations with EC-Earth for four different future emission scenarios (50 ensemble members each) to explore the role of natural variability versus external forcing.

Further research activities focused e.g. on water mass transformation in the ocean, the Arctic freshwater budget, oceanic convection in the North Atlantic, and hydro and paleoclimatology.

Scientists from RA1 were successful with several European H2020, European Reseach Council, Swedish Research Council, and Formas grants.

Co-leader | Thorsten Mauritsen studied in Copenhagen and took his PhD at Stockholm University in 2007, followed by a post-doc on an Arctic field experiment (ASCOS). Mauritsen is a senior lecturer at Dept. of Meteorology, Stockholm University, and works to constrain Earth's climate sensitivity. He is active as a lead author on the upcoming IPCC sixth assessment report. Photo: Krister Junghahn

Co-leader | Torben Koenigk has a diploma in Meteorology and holds a PhD in oceanography. He works at the Rossby Centre/SMHI since 2008 and is now Head of the Global Climate Modelling Group at SMHI. His work focuses on development of global climate models and understanding of climate variability and change. He is particularly interested in Arctic sea ice changes, its impact on climate, and in interactions between ocean and atmosphere. Photo: Jacob Fräjdin

Highlights from Research Area 1

Climate change is a global challenge that does not respect national borders and affects societies all around the globe. It requires urgent science-based policy actions for mitigation, limiting the global warming to less than 2 degrees, and limiting the impacts for societal and natural systems to acceptable levels.

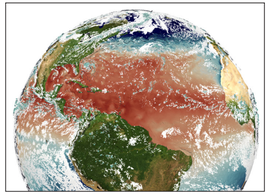
Winds, waves and currents within Earth's fluid envelope play a central role in climate. Such motions transport heat around the globe exerting a fundamental control on the global temperature distribution. The atmospheric circulation also plays a key role in shaping the global distributions of humidity and precipitation, and of minor constituents such as CO_2, aerosols, and ozone. These constituents can absorb and reflect solar and thermal radiation, profoundly influencing local and global temperatures. The ocean circulation, on the other hand, transports salt and biogeochemical properties such as dissolved inorganic carbon and nutrients, which play a crucial role for the Earth's marine ecosystems and the concentration of CO_2 in the atmosphere.

To understand and simulate how climate will change in the future, it is essential to understand all these processes. The work of the Bolin Centre's RA 1 contributed to this understanding through a range of analysis, with focus on e.g. the dynamics of the oceans (if and how ocean circulation varies and changes and why), sea ice changes and their potential impact on lower latitudes, heat and freshwater fluxes, and an analysis of the hydrological cycle and extreme events.

Further, many RA 1 activities this year were dominated by performing climate model simulations for the Coupled Model Intercomparison Project Phase 6 (CMIP6), which co-ordinates global model simulations around the world with common protocols for the simulations and the data output. CMIP6 is a main source of information for the next IPCC-report, in which RA 1 members were heavily involved in 2019, both through scientific contributions in form of articles and through co-authorship of the report itself.

Next-generation model development

Scientists from RA1 contributed to the development of the first 1-year simulation with a global climate model capable of resolving both individual clouds in the atmosphere and eddies in the oceans called ICON-ESM. The scientists found that when exposed to increasing CO_2 the model exhibits a more diversified response than current-generation climate models. Some examples are regionally stronger and weaker sea surface warming, as well as both stronger droughts and floods. In the coming years, as computers grow larger, these types of simulations will see more applications.



The picture shows sea surface temperature and clouds. Photo: Niklas Röber

EU-H2020 project PRIMAVERA

RA1 scientists contributed to an analysis of the impact of increasing resolution in global climate models on the ocean circulation. Results show that higher oceanic resolution increases deep convection in the Labrador Sea, leads to a stronger Atlantic Meridional Overturning Circulation and increased northward oceanic heat fluxes.

The ocean at the Faroe Islands, a region that is important for the oceanic overflows. Photo: Torben Koenigk

Clouds, aerosols, turbulence and climate

Clouds, aerosols and their interactions with each other and with the climate remain the main uncertainty in future climate projection. Within Research Area 2, we work across scales to improve understanding, observation and model representation of these highly important processes. Our modelling activities range from Large Eddy Simulations to Earth System Modelling, and our experimental efforts range from lab experiments to ice breaker expeditions to the high Arctic. By understanding aerosols and clouds, their interactions, and the roles they play in the climate system, our work contributes to refined estimates of anthropogenic forcing and of the sensitivity of the climate system to this forcing.

Activities and Resources

During 2019, RA2 has supported research and collaboration within the research area and our continual call for proposals from our members has resulted in funding for a wide range of activities. With regard to the Arctic Ocean campaign 2018, with the ice breaker Oden that involved several RA2 scientists, we have this year supported a workshop organized by Paul Zieger, as well as microscope analysis of collected samples led by Caroline Leck. As part of the NASCENT campaign, we supported Yvette Gramlich to improve and update a cloud water sampler. We supported a winter-course on e-science in climate science, by covering Bolin Centre students' costs to attend the course in Abisko in northern Sweden. In addition we supported travel to meetings and courses for several young researchers within the research area.

RA2 research has resulted in numerous articles in peer-review journals including high-profile publications like a study on organic vapour contribution to nano-particle growth led by Claudia Mohr. A study on cloud response to surface-active organics led by Samuel Lowe, led to several successful grant applications during the year, including an ERC consolidator grant awarded to Ilona Riipinen for the project INTEGRATE, and an ERC Training Netorks grant iMIRACLI (innovative MachIne learning to constrain Aerosol-cloud CLimate Impacts) led by the University of Oxford, with SU contribution from Ilona Riipinen and Annica Ekman.

Several RA2 graduate students have been awarded their PhD degrees: Erik Johansson (Dept. of Meteorology/SMHI), Lena Frey (Dept. of Meteorology) and Friederike Höpner (Dept. of Meteorology) successfully defended their theses during 2019.

Co-leader | Frida Bender is an associate professor and senior lecturer in climate modelling at the Department of Meteorology at Stockholm University, with research interests in aerosols, clouds and climate. As a member of the Young Academy of Sweden, Frida works to promote internationalization, interdisciplinarity, outreach and science policy. Photo: Niklas Björnling

Co-leader | Matt Salter is a researcher at the Department of Environmental Science at Stockholm University. A major theme of Matt's research is understanding air-sea interaction in the context of Earth's climate.
Photo: Niklas Björnling

A number of our members have engaged in "Climate answers by scientists", and media appearances in national radio, television, newspapers and podcasts have been frequent. Michael Tjernström's prestigious invitation to host a 1.5 hour traditional summer talk-show on national radio is worth a special mention.

Highlights from Research Area 2

NASCENT – field campaign in the Arctic

The ongoing field campaign NASCENT (Ny-Ålesund Aerosol Cloud Experiment) uses a range of novel instruments and techniques to study the microphysical and chemical properties of aerosols and clouds in the Arctic. Cloud and aerosol measurements at the Zeppelin observatory at 475 m above sea level, will be combined with in-situ and remote sensing instruments below the mountain, and taken together the observations will help characterize the role of aerosols and clouds in regulating the energy transport at this high-latitude site.
The campaign is coordinated by Stockholm University, and involves several international partners from Europe as well as Asia.

View along the Kongsfjorden at Ny-Ålesund, Svalbard, where the NASCENT campaign is conducted. Photo: Paul Zieger

FORCeS brings together 20 research teams

Ilona Riipinen, Department of Environmental Science, and Annica Ekman, Department of Meteorology. Foto: Annika Hallman

The European Research Commission Horizon 2020 project Forces, "Constrained aerosol forcing for improved climate projections", funded by the European Commission with approximately 8 M€ had its kick-off meeting at Stockholm University in November 2019. The project brings together 20 European research teams, including several RA2 scientists, in an unprecedented effort to reduce uncertainty in aerosol effects on climate. FORCeS is coordinated by RA2-scientists, and former RA2-leaders, Annica Ekman and Ilona Riipinen, and is the first project of its kind to be coordinated by Stockholm University.

Maldives Climate Observatory at Hanimaadhoo

Climate observatory in the Maldives. Photo: Frida Bender

Bolin Centre scientists have a long-standing engagement in the Maldives Climate Observatory at Hanimaadhoo (MCOH). One of the PhD theses defended by RA2 students in 2019 was Friederike Höpner's dissertation "Multiple perspectives on absorbing aerosols over the northern Indian Ocean and Asia", based largely on data from MCOH. Measurements from ground-based lidar and unmanned aerial vehicles during the 2012 field campaign CARDEX were used to characterize elevated aerosol layers; long-term surface measurements of absorption provided a way for intercomparison and evaluation of different measurement techniques; and the observations were also used to point out way of improving aerosol absorption in climate models.

Hydrosphere, cryosphere and climate

Water circulation at, or near, Earth's surface occurs by rainfall, evapotranspiration, surface water and groundwater flows. Frozen water forms snow cover, glaciers, ice sheets and permafrost. We study couplings between water in all physical states and climate systems and their changes in time, along with their repercussions for socioecological systems. These changes may be effects of natural or man-made changes in land cover, vegetation, water flow paths, stocks, or effects of climate change on water-borne flows of substances including contaminants.

Activities and Resources

In 2019, Research Area 3 focused on the two themes of aerial rivers, which is the movement of water as vapor between regions and countries, and the relationship between carbon storage and the water cycle. Researcher Lang Wang Erlandsson from the Stockholm Resilience Center at Stockholm University gave the Annual Bolin Lecture for RA3 on aerial rivers and moisture recycling. Prof. Dr. Obbe Tuinenburg, Copernicus Institute for Sustainable Development, Utrecht University, was also invited and funded to discuss the implications and modelling of aerial rivers.

During 2019, our members presented water-related research in countries such as Chile, Ecuador, Colombia, China, Austria, United States, Canada, and many other countries. In China, we communicted the activities of RA3 at three of the most prestigeious universities in Beijing, Tsinghua University, department of Civil Engineering, Beijing Normal University, School of Environment and Northwest A&F University, Institute of Soil and Water Conservation.

We funded several strategic research projects focusing on water resources in Iran, measuring ocean temperatures near glaciers, installing a hydrological network in a tropical flood plain in Colombia, groundwater discharge monitoring along the Swedish shoreline, and using ground penetrating radar for lake bathymetry in Norway.

We also funded research outreach and training in Australia and China for some of our PhD students. Besides the support from the RA3 funding, our members also secured funding from other sources such as the Swedish Research Council, Formas, the Swedish Space Agency and the Royal Swedish Academy of Engineering Sciences.

Co-leader | Fernando Jaramillo is a civil engineer with a PhD in Physical Geography with focus in hydrology and water resources, Stockholm University. He studies the historical, current and future climatic effects of both atmospheric climate change and anthropogenic activities on the terrestrial freshwater system and implications for societies and ecosystems. Photo: Private

Co-leader | Anne Soerensen has a PhD in Atmospheric Chemistry, Aarhus University, Denmark but is now mostly working on contaminants in marine environments. Anne was a researcher at the Department of Environmental Science at Stockholm University until the end of 2019 and can now be found at the Swedish Museum of Natural History next door. Photo: Niklas Björling

Highlights from Research Area 3

- We received a record number of applications for funding, and selected seven that best identified with the interests of RA3 and with the highest scientific quality.
- We found that radar data can be used efficiently to detect water level changes in wetlands to the precision of millimeters (Palomino et al., Water, 2019).
- We determined how rice irrigation strategies decrease water footprint at the cost of long-term soil health (Livsey et al., 2019).
- We found an unexpectedly high agreement between models and observations for water flow in rivers for the Nordic-Arctic region, that is about as high as the model-observation agreement for temperature. This confirms to researchers the adequate use of runoff simulated data in this region (Bring et al. 2019).
- We published an article on the priorities of Sustainable Development Goals with focus on wetlands which used survey information from 51 wetland researchers, all of them co-authors of the article. We found that SDG targets 6.3. "Improve water quality"; 2.4. "Sustainable food production"; and 12.2. "Sustainable management of resources" are critical in order to achieve sustainable development in wetland systems (Jaramillo et al., 2019).

Monitoring of water levels in tropical wetlands, Colombia. Photo: Imenne Åhlen

Geophysical surveying to image a proglacial lake at Hardangerjøkulen, Norway. Photo: Hannah Watts

Forest canopy in Manaus, Brazil. Photo: Arie Staal

Biogeochemical cycles and climate

Research Area 4 studies interactions between climate and carbon-nutrient cycles through modeling, experimental, and observational studies. Biogeochemical cycles are influenced by feedback on climate, ecosystems and societies. Understanding the processes and dynamics of biogeochemical cycles is a fundamental part of understanding the Earth system and how it responds to climate change.

Activities and Resources

In 2019, RA4 researchers worked on diverse topics ranging from hemisphere-scale maps of wetlands, the role of Greenland ice sheet melting for Arctic marine biological production and Arctic ocean acidification, sea-air exchange measurements of carbon dioxide and methane in the Arctic and the Baltic Sea, to genetic studies of engineered wood stability.

RA4 member Birgit Wild used river monitoring data to determine patterns of organic carbon release from thawing permafrost in Siberia.

The Bolin Centre and RA4 supported the "Cryosphere pavilion" at the COP25 climate summit where permafrost research from the Bolin Centre was presented, including a new paper that highlights the impact of abrupt permafrost thaw processes on greenhouse gas emissions.

With funding from the Bolin Centre and the Swedish Research Council, co-leader Volker Brüchert participated in the Swedish-led international expedition on icebreaker Oden to the Ryder glacier in northern Greenland to study the glacial retreat processes and their impact on fertilization of the Arctic Ocean and Arctic ocean acidification.

Funded by EU Horizon 2020, the Swedish Research Council and the Bolin Centre, Gustaf Hugelius has led the work of mapping northern hemisphere wetlands and their climate impacts, and organized an expedition to the Canadian Arctic with participation from five different universities.

Hugelius has contributed wetland maps to the new global methane budget from the Global Carbon Project and with funding from RA8, helped establish a new experimental site to investigate how grassland management may work to bind carbon in soils.

Co-leader | Volker Brüchert is a senior Lecturer of Biogeochemistry at the Department of Geological Sciences, Stockholm University. His research is concerned with studies of carbon mineralization processes in marine sediments, marine trace gas biogeochemistry, and sediment-seawater exchange and sea-air exchange of carbon dioxide, methane, and nitrous oxide. Photo: Eva Dalin

Co-leader | Gustaf Hugelius is a senior Lecturer at the Department of Physical Geography, Stockholm University. He has studied biology and earth science. His research spans from Swedish grassland to Arctic permafrost, but with a common focus on the carbon cycle and climate. Photo: Niklas Björling

Highlights from Research Area 4

Gustaf Hugelius at Cryopshere pavilion in Madrid. Photo: Pam Pearson

Bolin Centre Science at COP25

At the 25th Conference of the Parties in Madrid, December 2019, the "Cryopshere pavilion" was dedicated to presenting peer reviewed science on the cryosphere (permafrost, snow, sea ice, glaciers and ice-sheets). There was a particular focus on what the science tells us about consequences of +1.5 vs +2 degrees of global warming. The pavilion was organized by the International Climate and Cryosphere Initiative and the Bolin Centre was a key partner supporting the pavilion and presenting the latest science. One important recent finding is that abrupt permafrost thaw will cause even stronger emissions than previously thaws, which greatly reduces the amount of CO_2 humans can emit and still stay below our warming targets.

Bolin Centre leads Canadian Arctic expedition

During the summer of 2019, Bolin Centre scientists organized and led an international expedition to the Canadian Beaufort Coast. The expedition included scientists from Sweden, Austria, Canada, Germany, Italy and The Netherlands, all working in the EU H2020 consortium Nunataryuk. The focus of the research is to study Arctic coastal environments and how they will change under permafrost thaw. The expedition collected extensive samples of soils, sediments, vegetation and water to study the dynamics of biogeochemical cycles and environmental pollutants. There was also a strong focus on collection of ground-truth data for validation and development of new remote sensing and modelling tools and techniques.

Sampling of permafrost soils as well as tundra vegetation at Komakuk Beach, August 2019. Photo: Victoria Martin

The Ryder 2019 expedition to northern Greenland

During the 2019 Oden icebreaker expedition to the Ryder glacier, Bolin centre scientists studied the effects of sub-glacial runoff and retreating fjord glaciers for the water chemistry of northern Greenland fjords and sediments.

An important finding of this work was a clear fertilization and carbon productivity increase in the open-water fjord that is controlled by complex interactions between glacial runoff, Arctic ocean water intrusion, open water conditions, and fjord bathymet.

Scientists recovering surface sediments from a multicorer onboard Icebreaker Oden. *Photo: Private*

Historical to millennial climate variability

Research Area 5 reconstruct past climate evolution by investigating natural records such as marine, lake and terrestrial sediment cores, ice cores, cave deposits, tree rings, landforms and historical documents. By developing appropriate statistical methods and comparing with climate model simulations, we aim to better understand and interpret past climate variability on historical and millennial timescales. This work helps us better predict the climate of the future.

Activities and Resources

RA5 has actively worked to build more connections between its members. A full-day off-campus workshop was organized in the spring allowing for scientific presentations, discussions and reflections on open research questions, challenges and future collaborations.

One of the most important scientific meetings for RA5 members in 2019 was the INQUA Congress in Dublin. Our research area was very well represented at this meeting thanks to financial support by RA5.

In total RA5 members were in involved in convening three sessions as well as giving seventeen talks including a session keynote and being lead authors on six posters.

In 2019, Ben Chandler and Benedict Reinardy received KVA funding of 100 kSEK to carry out geophysical surveys of moraine sequences in Sarek, International Ocean Discovery Program Expedition 379 down to the Amundsen Sea on-board JOIDES Resolution.

Malin Kylander was awarded project grants from Vetenskapsrådet (3.4 MSEK) and FORMAS (2.9 MSEK) for research on “Storminess in the Eastern North Atlantic Region During the Holocene” involving several RA5 members.

Frederik Schenk was a co-applicant of two successful grants from Deutsche Forschungsgemeinschaft of 4 MSEK and the Russian Science Foundation with 1.8 MSEK for research on impacts of abrupt climate shifts in the Neotropics of Central America and the Arctic, North Siberian Lowland, Russia.

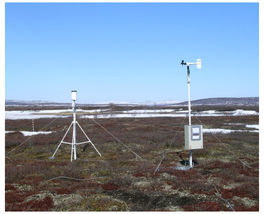
RA5 supported Björn Gunnarson to participate at the Typhoon symposium at NTU, Taipei, with the aim to found a large collaboration on long-term typhoon variability with potential partners from Gothenburg University, Czech Academy of Science, the National Taiwan University (NTU) and Fuijan Normal University, Fuzhou China.

Co-leader | Malin Kylander has a PhD in Environmental Geochemistry from Imperial College London, UK and is now at the Department of Geological Sciences, Stockholm University. Kylanders work looks at past climate change using lake sediments and peats. Photo: Eva Dalin

Co-leader | Frederik Schenk has a PhD in Meteorology from the University of Hamburg, Germany, PostDoc at KTH Royal Institute of Technology, Mechanics and is now at the Department of Geological Sciences, Stockholm University. He uses climate models and multi-proxy climate reconstructions to study the impacts and mechanisms behind climate instabilities and abrupt climate change. Photo: Private

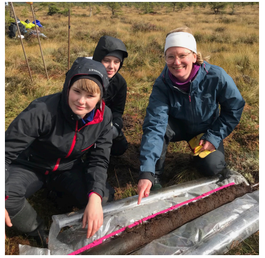
Highlights from Research Area 5

Permafrost is warming at a global scale



Monitoring of ground temperatures in a permafrost peatland in Tavvavuoma, northern Sweden. Photo: Britta Sannel

As permafrost thaws, large amounts of carbon previously locked in frozen ground can decay and produce greenhouse gases, further amplifying global warming. A large international study, involving RA5 scientist and Steering Committee Chair of Arctic Avenue Britta Sannel, has been published in Nature Communications (Biskaborn et al. 2019). For the first time, very important long-term monitoring data of ground temperatures across the circumpolar permafrost region has been provided. This is critical for understanding ongoing and future changes and feedbacks related to climate change. A compilation of permafrost temperature data from >150 boreholes around the globe suggests that the permafrost has warmed by 0.3°C during the last decade (2007–2016) (Biskaborn et al., 2019).



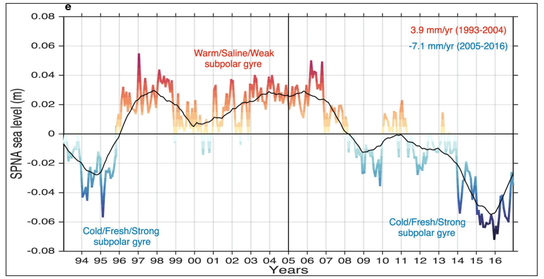
Jenny Sjöström (right) and two participating students. Photo: Malin Kylander

Gymnasium students lend a hand in studying past dust deposition

Jenny Sjöström has been working to reconstruct past changes in mineral dust deposition using geochemical analyses of peat sequences from southern Sweden. The hope is to provide more quantified data to better understand past changes in this poorly understood component of the climate system. Within the framework of this project gymnasium students from Per Brahegymnasium, Jönköping, have been helping with data collection including measuring the depths of the peatland deposit and identifying key changes in plant communities. The latter was included in Jenny’s most recent publication in Chemical Geology “Paleodust deposition and peat accumulation rates – bog size matters” providing a rewarding experience for all.

North Atlantic Ocean Circulation variability contributes to large regional sea-level change

Changes in the North Atlantic Ocean Circulation are not only important for our weather and climate but also a strong driver behind large regional sea-level variations. A new study by Léon Chafik (Chafik et al. 2019) investigates mechanism behind the decadal variability of sea level in the North Atlantic Ocean and along the European coasts. They find strong decadal sea-level variability in the Subpolar North Atlantic Ocean. This variability is a response to ocean circulation changes. Interestingly, this decadal variability is also observed from tide gauge records along the northern European coasts. In summary, the decadal-scale sea-level in the open ocean strongly co-varies with that along the coasts, which may have implication for coastal sea-level predictions based on the climate state in the North Atlantic Ocean.



Sea level variability (m) in the Subpolar North Atlantic Ocean. (Bottom)

Deep time climate variability

To appreciate the full range of Earth's climate variability it is necessary to look far back into geologic time where we find intervals when the world has been much warmer and colder than today. Research Area 6's mission is to reconstruct and interpret past climate variations on long timescales by comparing computer simulations and data from natural archives such as rocks, sediments and fossils. This helps us place limits on natural climate variability and better understand the Earth system. It also provides context for current global change. We would not understand that Earth's climate is rushing towards extreme change, unprecedented in historical experiences, without the deep time perspective.

Activities and Resources

During 2019, RA6 funded a range of activities that are fundamental to understanding the long-term behavior of climate. This included spear-heading new data-model community networks, maintaining visibility in the national and international arena, and disseminating research findings to diverse audiences.

RA6 co-funded an international workshop on Miocene climate (a warm "future analogue" climate period ~23–5 million years ago) – MioMeet 2019 – with support from the Swedish Research Council, RA1 and the Swedish Museum of Natural History. Attended by ~65 international and national experts, MioMeet resulted in delegates writing a long over-due review paper on the Miocene (Steinthorsdottir, Coxall et al., submitted), as well as catalyzing interest in a new Miocene data-model inter comparison project.

Other RA6 research highlights include efforts to quantify climatically important carbon budgets at subduction zones, dating feed-back responses to snowball Earth glaciations and mapping 'Ikkaite' pillars in Ikka Fjord, Greenland as a possible mineral tracer of past water temperatures.

Communicating research is central to science and RA6 supported attendance for nine PhD students, postdocs and academic staff at international conferences.

Other grants were awarded to support laboratory analyses, including; radiocarbon dating of Late Quaternary samples, and C and N isotope analysis of Jurassic sediments, as well as fieldwork, including expeditions to Greenland, Tibet, Scotland and Greece.

Co-leader | Docent Helen Coxall is a senior lecturer in Marine Micropaleontology at the department of Geological Sciences, Stockholm University. She uses palaeontological and geochemical ocean-climate proxies to reconstruct patterns and drivers of climate change.
Photo: Eva Dalin

Co-leader | Dr. Margret Steinthorsdottir is a palaeoclimate researcher at the Department of Palaeobiology, Swedish Museum of Natural History, who uses fossil and living plants to reconstruct CO_2 concentrations in the past.
Photo: Oskar Omne

RA6 members published numerous peer-reviewed articles (some of which RA6 funded to be open access), contributed to several review papers and participated in outreach activities.

Especially novel was a collaboration with musicians from the UK, resulting in the public performance 'Striations', which celebrates the Earth and laments its changing climate through improvised music and visuals.

Highlights from Research Area 6

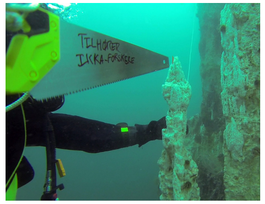
Investigating how extreme future changes could become

How much carbon and sulphur is released or put into storage when tectonic plates meet and are recycled back into the Earth? When precisely did the Earth become completely ice covered from top to bottom 700 million years ago and what were the consequences for global systems? How did climate effect Earth biology and drive extinctions during the height of dinosaur reign in the Jurassic period? Can an unusual magnesium-rich mineral called Ikaaite found in a fjord in Greenland help us learn something about water temperatures in the past?

These are all questions that RA6 is helping researchers to answer by awarding small research grants that contribute towards analysis and field work and supporting attendance at conferences so that scientists can present and debate their findings.

A larger part of this year's RA6 budget was focused on learning as much as possible about the most recent warm climate period of the geological past, the Miocene period. Scientists have shown that CO_2 in the atmosphere during the Miocene epoch, 27–7 million years ago, was at the same level as that predicted by computer simulations of our future if we don't cut carbon emissions soon. For this reason, we need to study the Miocene and find out what such high levels of CO_2 do to Earth's climate and it's physical and biological systems. For example, how much of the Antarctic ice sheet melts? How much does sea level rise and what happens to seasonal climate patterns that our human societies rely upon? Such long-term perspectives are needed to understand how extreme the future changes could become.

Investigating the 'fossil Garden of Eden in Antarctica'. Fieldwork focuses on gathering vertebrate fossils to document 200 million years of Antarctic biodiversity and paleoecology through the last greenhouse climate and beyond. Photo: Thomas Mörs



Sampling of an Ikkaite pillar in Ikka Fjord, Greenland. These unusual Magnesium carbonate deposits are important to study because finding Ikkaite in the past could be an important paleotemperature proxy. Photo: Private

Fossilized leaf from the Miocene warm period, Idaho, USA. The exceptional preservation of the leaves allows stomata on the leaf surface to be analyzed, which has been shown to provide estimates of atmospheric CO_2 in the geological past. Photo: Margret Steinthorsdottir

Snowball Earth climate feedbacks, 700 million years ago. A 10 cm thick Iron-rich within the Port Asking formation, Garvellach Islands, Scotland. Fe formations are a common constituent of "Snowball Earth" sequences of rock. They form as a chemical precipitate when Fe-rich marine water is oxidised during due to melting of sea ice. The layer is composed of 80% hematite. Photo: Private

Landscape processes and climate

The combined effects of changes in climate, land-use and water-use may heavily influence natural resources in terrestrial and marine environments in the coming decades. Research Area 7 gather natural and social scientists to study the effects of climate change on ecosystems including its abiotic and biotic components and integrated effects on human well-being. The focus is both on fundamental questions of how natural and anthropogenic processes at multiple scales play out in the landscape and on how the society can respond to this, for example by adaptive governance. We are interested in climate and climate change projections on various relevant scales for different processes and for land-use, water-use and natural resource management and governance.

Activities and Resources

Seven large projects that are funded by RA7 during 2017 and 2018 are all running with recruited PhD-students and postdocs. The RA7 project portfolio covers a broad set of complementary questions. Many researchers from many departments are involved and new collaborations are beginning.

The RA7 seed money of 2019 were distributed among 9 smaller projects including equipment, analyses, visits to conferences and arrangements of workshops.

We held a Bolin days-collaborative session between RA7 and RA2 with topic: “Earth surface-atmosphere interactions: Physical processes, changes and their impact”.

We arranged a seminar with Professor Henrik Smith, Head of BECC Climate centre, from Lund University about “Managing biodiversity and ecosystem services in a changing world”.

We also organized a half day of seminars where RA7 scientists presented their ongoing work that has been funded through RA7.

RA7 planned a debate about sustainable development goals synergies and conflicts regarding climate, nature and environment. The activity focuses on research presentations and discussions on how we can manage Sustainable Development Goals’ target conflicts to reduce the negative effects of various measures and to increase synergies.

Co-leader | Kristoffer Hylander is a professor in Plant Ecology at Department of Ecology, Environment and Plant Sciences at Stockholm University. He is a landscape ecologist, currently conducting research on the effect of climate on both Swedish boreal forest plants and Ethiopian coffee agroforestry systems.
Photo: Niklas Björkling

Co-leader | Zahra Kalantari is an associate professor in land and water resource engineering at Department of Physical Geography, Stockholm University. She is interested in sustainable urban and rural development and climate change impacts, and vulnerability assessment to water-related disasters and conflicts.
Photo: Niklas Björkling

Co-leader | Regina Lindborg is a professor in Natural Resource management at Department of Physical Geography, Stockholm University. Her primary research field is land use change and effects on biodiversity and ecosystem services in agricultural landscapes with specific emphasis on grassland management and species conservation in relation to climate. Photo: Niklas Björkling

Highlights from Research Area 7

RA7 funded a number of projects. Here are some of the findings.

Consequences of more effective use of water in tropical agricultural systems

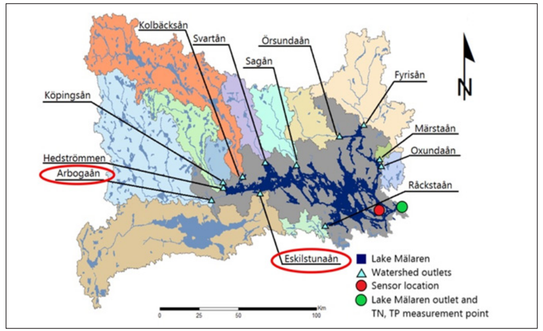
Stefano Manzoni and colleagues investigated the drivers of catchment-scale nitrogen use efficiency, measured as the ratio of nitrogen recovered in harvested agricultural products over nitrogen added to the catchment via fertilization and nitrogen fixation – higher efficiency implies less nutrient losses and less eutrophication problems. Using data from 73 agricultural catchments in the United States, they found that nitrogen use efficiency increases with increasing evaporative ratio (ratio of evapotranspiration to precipitation).

Ecosystem services of constructed, restored and unmanaged wetlands

Jerker Jarsjö and colleagues considered thousands of wetlands in 15 wetlandscape catchments within the extensive Norrström Drainage Basin (NDB; 22 650 km^2), Sweden. They conclude that wetlandscape catchments above a certain threshold (in NDB: ~250 km^2) consistently showed ecohydrological characteristics required to support many functions and ecosystem services of high management interest, including nutrient/pollutant retention and biodiversity support.

Understanding coastal blue carbon sink capacity in seagrass meadows

Martin Dahl and colleagues studied how land-sea connectivity and mangrove deforestation affect carbon sequestration in seagrass meadows. Preliminary findings show that carbon stock levels in seagrass meadows were influenced by seascape configuration and degradation of adjacent mangroves. The fieldwork of this study was performed in seagrass meadows stretched along a coastline with both forested and deforested mangroves in the northwestern Madagascar.



Map of Lake Mälaren and its total catchment divided into unmonitored parts (gray) and monitored watersheds (sub-catchments). The identified dominant watersheds for the effects on water quality are indicated with red elipses. The study, including this figure, is published in Cantoni et al., 2020.

Picture showing a deforested mangrove area in northern Madagascar, leading to erosion and release of sedimentary carbon. Photo: Martin Dahl

Biodiversity and climate

In Research Area 8, we investigate how climate influences ecological and evolutionary processes in natural populations. Field observations and experiments are used to examine effects on abundance and distribution of single species or biodiversity, as well as how climate affects interactions between species, community structure and ecosystem functioning. We also use this information to develop methods to mitigate negative effects of climate change on biodiversity.

Activities and Resources

RA 8 is funding ten PhD/Postdoc projects (started during 2018) at four different departments at Stockholm university. The diverse set of projects explore how variation in climate affects the ecology and evolution of present-day animal- and plant communities, as well as historical changes of plant and animal communities over thousands of years. We are also funding projects that investigate the consequence of artificial carbon amendments on biodiversity in grasslands.

Representatives for all these projects, other members of RA8, and two invited external experts (Lesley Lancaster, University of Aberdeen and Signe Normand, Aarhus University) met at a workshop in February to discuss the ongoing research as well as future research initiatives within the fields of Biodiversity and Climate. Sara Cousins got granted a three-year project from FORMAS on the effects of future sea level rise on fragmented coastal meadows.

Results from these and other projects within RA8 have been presented at many international conferences, such as ESEB (European Society for Evolutionary Biology), ESA (Ecological Society of America) and BES (British Ecological Society).

In 2019 the PhD-student Daniela Guasconi was appointed within the strategic funding from RA 8. She focuses on soil biodiversity and the effects of different carbon amendments and drought. Two of our funded PhD-students won prizes; Daniela Guasconi for the best Bolin student presentation 2019, and Nina Roth for the best poster "Drier and Wetter – what does it mean in climate change studies?" at the Bolin days in November.

Co-leader | Sara Cousins professor at the Dept. of Physical Geography, Stockholm University. She combines plant community ecology and landscape history to explore effects of fragmentation and land use change on plant dispersal, community composition and diversity. Expertise in time-lags and non-linear changes in plant community compositions over time. Photo: Niklas Björkling

Co-leader | Johan Ehrlén is a professor in Plant Ecology, Dept. of Ecology, Environment and Plant Sciences, Stockholm University. Research interest is in identifying the environmental drivers of variation in natural selection and population dynamics. He focuses on how climatic factors, via interactions with insects, influence natural selection on timing of reproduction in plants. Photo: Niklas Björkling

Co-leader | Carl Gotthard is an associate professor in Animal Ecology, Dept. of Zoology, Stockholm University. His research is primarily concerned with life history evolution of insects. Understanding how phenotypic plasticity may be an adaptation to seasonally changing environments and how this may be affected by variation in climatic factors across space and time is a particular interest. Photo: Niklas Björkling

To strengthen the international collaborations of RA 8, we contributed to the yearly Bolin center seminar series by inviting Dr Albert Phillimore from the University of Edinburgh, who gave a seminar entitled "Spatial variation in seasonal timing and its impact on trophic interactions".

In January, we received 21 applications for seed money and funded 12 of these projects. Funding was given primarily for field work and conference attendance.

We also have taken part in the debate on how climate change mitigations and activities might affect biodiversity. One example is a debate article in Swedish newspaper Svenska Dagbladet: "Fel att offra betesmark i Sverige av klimatskäl" (Wrong to sacrifice pasture in Sweden for climate reasons).

Highlights from Research Area 8

During 2019 research performed by members of RA8 has appeared in a large number of international journals and covered a wide range of topics related to climate and biodiversity. In one study, researchers from RA 8 together with international colleagues, reviewed existing research on the effects of different environmental factors on plant populations. The authors concluded that available evidence suggest that the effects of abiotic factors (including climate), species interactions, and direct human influence were of similar magnitude, and that indirect effects of climate change, e.g. through changes in fire frequencies, might be as important as direct effects. (Morris, W.F., Ehrlén, J., Dahlgren, J.P., Loomis, A.K. & Louthan, A.M. 2020. Biotic and anthropogenic forces rival climatic/abiotic factors in determining global plant population growth and fitness PNAS 117:1107-1112)

Another study, which included several researchers from RA8 as co-authors, showed that insect species that have been strongly affected by earlier springs, and that have the capacity to produce multiples generations per year are more likely to increase in abundance and to expand their ranges northwards. In contrast, other species that are more specialized and do not have multiple generations are more likely to be negatively affected by earlier spring emergence in a warmer climate (Macgregor, et al. 2019. Climate-induced phenology shifts linked to range expansions in species with multiple reproductive cycles per year. Nature Communications 10:4455).

Lathyrus vernus *and* Primula veris *– two of the species included in the study reviewing effects of different environmental factors on plant populations. Photo: Katarina Fast Ehrlén*

The Bolin Centre Climate Research School

The Bolin Centre Climate Research School organizes climate-related courses and summer schools for PhD students within the Bolin Centre. The Climate Research School also offers funding to PhD students to support their active participation in conferences and courses.

During 2019, there was a new strategy agreed upon for the Climate Research School. It builds on the years of hard work invested in the school by Björn Gunnarson and Hans-Christen Hansson. The school is now led by the Bolin Centre Directorate and our new Study Coordinators, Otto Hermelin and Carmen Prieto.

Highlights for 2019 include the courses “Historical perspectives” and “Climate science at high latitudes: eScience for linking Arctic measurements and modelling” as well as co-funding of the summer school “Ocean Waves and Abyssal Flow”. The Climate Research School funded conference and course participation for over 30 PhD students.

For the first time ever, the Climate Research School hosted a PhD day in October 2019, and based on its success it was decided that this will be an annual event. Nearly 60 PhD students and postdoctoral researchers attended to share their research, connect beyond institutions and disciplines and to listen to guest lecturers with communication expertise and PhD alumni.

Throughout the day, the focus was the common denominator of PhD students in the Bolin Centre: climate research. Participants in the presentation competition presented their research in 10-minute presentations where the top three communicative presenters were rewarded with research grants. Vivid discussions were held during the guest lecture in scientific communication as well as during the alumni session, with alumni of various career paths.

A brainstorming session opened for input regarding the future of the Climate Research School, where the participants thoughts and ideas has been incorporated in the planning of the school’s courses, events and organizational strategy.

Otto Hermelin is a senior lecturer and study director of life learning studies at the Department of Geological Science, Stockholm University. He has been doing research on large-scale climate variation, mostly based on proxies as microfossils and geochemistry. Photo: Magnus Atterfors

Carmen Prieto is a research engineer at the Department of Physical Geography, Stockholm University. She does research on the quantity and quality of water resources in different parts of the world. Photo: Magnus Atterfors

Field excursion in Sicily, Monte San Nicola, examining astronomically forced climate cycles within sedimentary successions. The picture shows the base of the Pleistocene Epoch 2.58 million years ago and the start of the Earth’s current Ice Age. Photo: Helen Coxall

The Bolin Centre Database

The Bolin Centre Database provides open access to climate and Earth system data. The database promotes and visualizes research results and data. We want to highlight the story that the data tell. Our database is a natural part of the ongoing world-wide development towards open science, where literature, data and code are accessible and reusable to everybody, including scientists, students, journalists and the general audience. Therefore, it is an important component of the Bolin Centre.

Data in the Bolin Centre Database come from many different research activities around the globe. This includes both longer-term large research projects and monitoring programmes that require a solid host and individual scientists who share a wide range of datasets from finished or ongoing projects.

We strive to make our data repository FAIR, i.e. our data should be Findable, Accessible, Interoperable and Reusable, in line with the policies for research data within the EU, in Sweden nationally, and locally at Stockholm University.

The Bolin Centre Database is funded as an integral part of the center's activity without any external extra funding. Our goal is to be internationally recognized as a trusted repository for research data.

In October 2019, we started to mint Digital Object Identifiers (DOIs) for all new datasets. This was an essential step in the development of our service in order to meet emerging requirements from publishers of research articles.

Another new feature in 2019 was that we launched a GitLab repository for computer code. Bolin Centre scientists can use this service for code development, for sharing code with others and for publishing code that is related to datasets in our data repository.

The Bolin Centre Database currently hosts 203 (February 2020) datasets having metadata and a number of thematic data presentations containing many more individual datasets.

During 2019, we published 53 datasets ranging in size from small ones consisting of just one or a few spreadsheet files to a large one having about 150,000 files comprising together 8.1 TB of data.

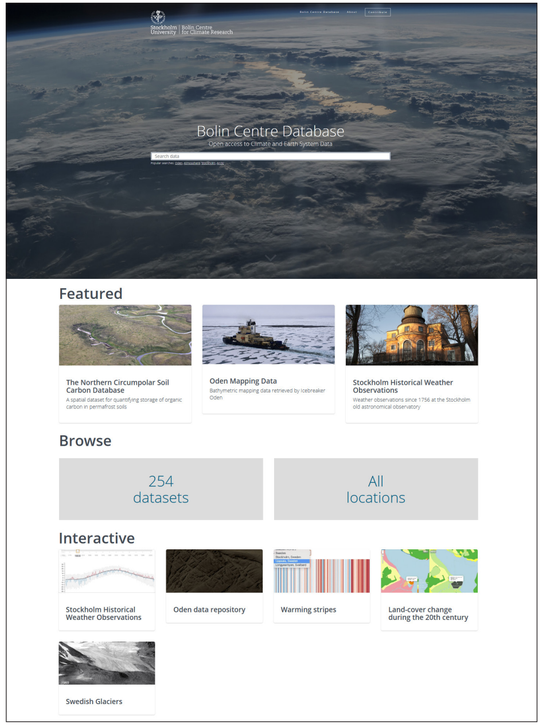
Coordinator | Anders Moberg is a university lecturer at the Department of Physical Geography, Stockholm University. Moberg's career as a climate scientist started in the 1990s, and his current research focuses on climate change and variability within the last 100 to 2000 years. Data quality and availability aspects have always been central in his work. Photo: Eva Dalin

Technical Database Manager | Rezwan Mohammad has a PhD in Oceanography from Stockholm University.
Photo: Björn Eriksson

Examples the kinds of datasets published in 2019:

- Aerosol properties over the northern Indian Ocean.
- Microclimate data in the central Swedish fores.
- Deep-sea sediment records from the equatorial Pacific Ocean.
- Atmospheric circulation index over the North Atlantic.
- Storminess proxy data from Scotland.
- Meteorological data collected from icebreaker Oden in the Arctic Ocean.
- 'Warming stripes' – visualizations of temperature data from the Nordic countries.
- Historical weather observation data from the old astronomical observatory in Stockholm.
- Ocean model circulation data for distant time periods in geological history.
- Water temperature data outside glaciers on Svalbard.
- Lake temperatures from near Abisko in northern Sweden.
- Hydrological data for small Swedish rivers.
- Carbon content in terrestrial pools in Siberia.
- Bottom topography in Lake Tarfala, northern Sweden.
- Marine sediment data from the Arctic Ocean.
- Black carbon measurements from Delhi, India.
- Bottom topography in the Petermann Fjord, northwest Greenland.
- Database of large changes in ecosystem services.
- Brown carbon properties in air over south Asia.
- Carbon and mineral content from peat.
- Simulated temperature data for continental regions during the last 1 200 years.

Visit the Bolin Centre Database on *www.bolin.su.se/data*



Bolin Centre Database website, October 2020.

Bolin Centre modelling

Numerical models of the global climate system are essential in research carried out at the Bolin Centre. Earth system models are used across the research areas to study topics covering deep ocean circulation, land surface processes, atmospheric composition and dynamics and upper atmospheric physics. Bolin Centre researchers also participate in the development of the next generation of Earth System Models. The modelling coordination team ascertains that the necessary computational resources are available for the Bolin Centre researches to be able to carry out this work.

In 2019 the modelling coordination team was restructured and now consists of Qiong Zhang, Modelling coordinator and Anna Lewinschal, Deputy modelling coordinator. Together, the modelling coordination team will continue the work of supporting the climate modelling community within the Bolin Centre by assisting with application for computational resources and providing training opportunities as well as support with modelling activities.

Activities

The annual application for the continuation of the Bolin Centre's computational project provided by the Swedish National Infrastructure for Computing (SNIC) was approved. This secured the Bolin Centre's access to computational resources for the period July 2019 to June 2020.

Researchers from the Bolin Centre participate in the development of the next version of EC-Earth towards the next phase of Coupled Model Intercomparison Project, CMIP6. During 2019, the official version for the CMIP6 project was released and was followed by an intense phase of model simulations. The Bolin Centre contributes a large number of simulations to CMIP6, primarily by the Rossby Centre, SMHI, as well as other Model Intercomparison Projects (MIPs) connected to CMPI6, among those PMIP, Radiative Forcing-MIP and Cloud Feedback-MIP.

In October the Bolin Centre hosted a one-day SNIC training course in collaboration with National Supercomputer Centre (NSC) representatives on how to use Python on the supercomputer Tetralith.

An introductory seminar for new users of the computing system at NSC and the Bolin Centre's computing projects was given in 2019.

We welcomed several new supercomputers users during the year as well as installed new models and codes.

Qiong Zhang is an associate professor in the Dept. of Physical Geography, Stockholm University, and a subject editor in Tellus B. Zhang is also Leading the paleo working group in EC-Earth community. The group led by Qiong Zhang has performed PMIP4/CMIP6 simulations with EC-Earth.
Photo: Eva Dalin

Anna Lewinschal is a scientific programmer at the Department of Meteorology, Stockholm University, where she also got her PhD in Atmospheric Sciences and Oceanography.
Photo: Inês Jakobsson

Insights into Bolin Centre Modelling

Climate models are central tools in today's climate research. These models are large and complex computer codes that require hardware with high capacity both in terms of computational speed and storage. High performance computing facilities of this kind are part of the Swedish research infrastructure on national level, and the modelling coordination team's primary task is to ascertain that adequate resources are available for the researchers within the Bolin Centre.

Without access to this type of resources, so called supercomputers, climate modelling would not be possible at the present scale. Another important part of the modelling coordination team's work is to provide training opportunities and support for efficient use of these computing resources.

Researchers at the Bolin Centre work both with the development of climate models and are conducting research work based on climate model simulations. Members of the Bolin Centre has, for example, produced a large contribution to the Coupled Climate Model Intercomparison Project, an international coordinated climate modelling effort that also forms a basis for analyses for the IPCC report.

Thus, climate modelling activities within the Bolin Centre, both model development and model simulations, contribute to the understanding of past, present as well as our future climate.

The picture shows the supercomputer Tetralith. Photo: Anna Lewinschal

The Bolin Centre mentoring programme

The Bolin Center Mentoring System is a voluntary initiative that links up interested junior and senior scientists in a mentor-mentee relationship. The system runs from the Bolin Days in November each year for at least one year at a time. The system started in 2012 and normally has 20–30 mentee and mentor pairs.

The Bolin Mentoring System links interested senior and junior scientists in a mentor-mentee relationship. The mentorship pairings are made annually at the Bolin Days in November. As a mentee you state your mentor preferences such as discipline, gender, language requirement, seniority, etc. and we do our best to meet these requests from our pool of mentors. The format of the mentorship is agreed on by both the mentor and mentee and can range from informal to formal which means the program meets the individual needs of the mentees.

The program has been increasing in its popularity since its establishment in 2014 where we have grown from 9 to 39 pairs in 2019/2020. The program has been greatly appreciated by mentees and mentors both. This program would however not be possible without our mentors who voluntarily give of their free time to help a junior scientist.

Feedback from our mentees

"The program has been incredibly helpful. At the time I reached out I was the middle of my PhD, I had not much supervisor time and had serious concerns about getting delayed. The mentorship has helped to keep focused and get back on track."

"I got good advice on the general timing and prioritizing of different tasks during my PhD."

"I have found it useful to openly discuss my research problems, interactions with other researchers, the nature of criticism and feedback in science, and other issues. It's also great to get a perspective of someone who is not connected to my project, but is very experienced and knowledgeable about this kind of work. I wish I had sought out something like this program when I was a PhD student. I think that would have helped me back then."

"This mentorship program has been a game changer for me. [My mentor] helped me to take charge of my PhD project, keep my goals straight and navigate the occasional conflict. [The] advice... has been spot-on and with key timing. Ultimately, I started applying to post-doc positions very early on her advice, and now I have a job already lined up for next year starting after I defend."

Agatha de Boer is an associate professor in Physical Oceanography and Paleoclimatology at the Department of Geological Sciences, Stockholm University. She uses climate models to investigate the role of the ocean in climate, now and in the geological past.
Photo: Eva Dalin

Malin Kylander has a PhD in Environmental Geochemistry from Imperial College London, UK and is now at the Department of Geological Sciences, Stockholm University. Kylanders work looks at past climate change using lake sediments and peats. Photo: Eva Dalin

Feedback from our mentors

"Great initiative. I enjoyed the meetings [with my mentee] and learned a lot myself. Good to hear how SU and PhD education is working from a different perspective as one's own."

"My mentee was very well organized and already had good mentoring from advisor. In general, it was fun to meet and see that there are good working groups out there across campus."

Characteristics of the Program

Cross-departmental

The mentees are signed up with mentors in other departments to provide more objectivity and avoid conflict of interest.

Voluntary

All mentees and mentors volunteer. This means the program is always only as big as the need it fulfills.

Confidential

We never mention who signs up for the program unless specific permission is given such as for marketing. Mentee-mentor interactions are also strictly confidential.

Mentee-driven

The mentees make the first contact and decide the frequency and format of the meetings. This is because the needs of every mentee are individual and no single format is optimal for all.

A crack in the ice tongue of Ryder Glacier, northwest Greenland. The picture was taken during the Ryder expedition 2019. Photo: Martin Jakobsson

Bolin Centre coordination & communication provides infrastructure for members

The coordinators and communicators handle the coordination, communication and administration of the Bolin Centre. We organize both bigger and smaller events and profile seminars. We also handle various internal meetings and focus on both internal and external communication efforts.

The Bolin Centre's two coordinators and communicators provide the Bolin Centre researchers with coordination and communication support at an organizational level, and manage the centre's digital channels. We also create opportunities for our researchers to meet and share knowledge and ideas through various internal meetings and communication platforms. In addition to this, we organize outreach events which presents a comprehensive understanding of our climate research to society.

The communication and coordination efforts during 2019 included the organization of larger events such as the Bolin Centre Seminar Series, the Bolin Centre Climate Research School PhD Day, the Climate Festival, and the Bolin Days. This year, the Bolin Centre also hosted the inaugural Geoscience & Society Summit, a joint undertaking of the American Geophysical Union and Geology in the Public Interest at Stockholm University.

The 3rd annual Climate Festival reached a record number of attendees; 2,000 middle- and high-school students, teachers, and people from the general public joined us between May 13th–15th. The program offered activities such as learning about climate adaptation in Minecraft (offered by SMHI), climate negotiations through role-play, lectures on floating glaciers and what the world would look like if it was 4C° warmer. The Bolin Centre also offered a climate walk, where participants walked through parts of Stockholm learning about what the city looked like when it was 4C° colder, to get a better perspective on the significance of a 4-degree difference in average mean temperature.

Annika Granebeck has a master of science in geography and extensive work experience of project management. She has worked at different centers of learning in academia and in non-profit associations, with focus on climate and environmental issues.
Photo: Inês Jakobsson

Karin Jonsell Karin Jonsell has a PhD in astrophysics and extensive work experience in communication, coordinating events, graphic design, strategic thinking and research. She has worked at universities both in Sweden and abroad as well as at the Royal Swedish Academy of Sciences. She started a new position as a communicator at SLU Future Food in July 2019. Photo: Inês Jakobsson

Eva Gylfe has a bachelor in Environmental Science from Stockholm University, with an extra focus and interest in scientific communication. In 2019, she received a grant from the Hasselblad Foundation to write research briefs (Digitala forskningsblad) during 2020 for schools and the public in collaboration with the Bolin Centre and the House of Science (Vetenskapens Hus).
Photo: Adam Meyer

We ended the year with the 11th annual Bolin Days which was the most well attended Bolin Days so far with its 252 participants. The program offered cross-disciplinary sessions organized by our research area leaders as well as the themed sessions: Climate Science in the Humanities, Greenland expeditions and FORCeS, Database & Climate Answers.

Additionally, Climate answers by cientists was founded; a group of scientists from various Research Areas and backgrounds who are particularly interested in outreach and communicating their research result. This group engages with the general public by the publics climate-related questions in a FAQ format, among other things. During the past year, the group has developed their communicative skills by participating in media training by experts within the field and taking part in a seminar with journalists to discuss science in media.

During Bolin Days 2019. Photo: Björn Eriksson

The Bert Bolin Climate Lecture

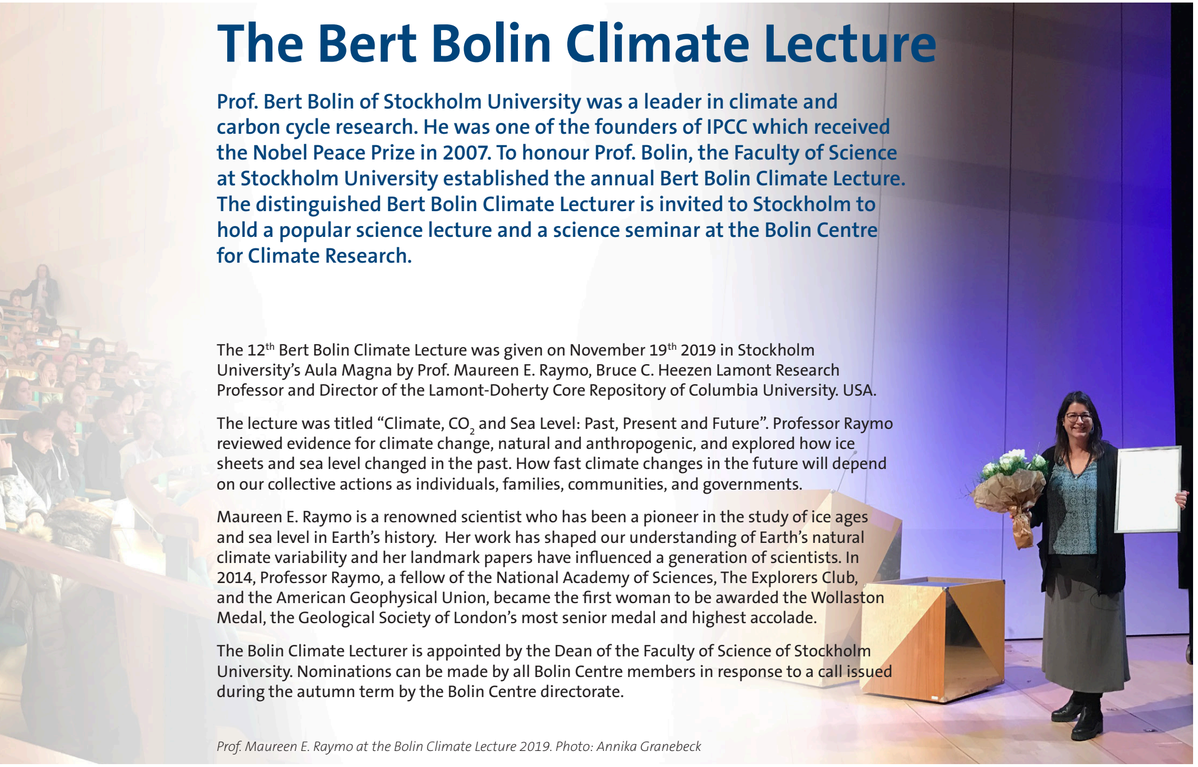
Prof. Bert Bolin of Stockholm University was a leader in climate and carbon cycle research. He was one of the founders of IPCC which received the Nobel Peace Prize in 2007. To honour Prof. Bolin, the Faculty of Science at Stockholm University established the annual Bert Bolin Climate Lecture. The distinguished Bert Bolin Climate Lecturer is invited to Stockholm to hold a popular science lecture and a science seminar at the Bolin Centre for Climate Research.

The 12th Bert Bolin Climate Lecture was given on November 19th 2019 in Stockholm University's Aula Magna by Prof. Maureen E. Raymo, Bruce C. Heezen Lamont Research Professor and Director of the Lamont-Doherty Core Repository of Columbia University. USA.

The lecture was titled "Climate, CO_2 and Sea Level: Past, Present and Future". Professor Raymo reviewed evidence for climate change, natural and anthropogenic, and explored how ice sheets and sea level changed in the past. How fast climate changes in the future will depend on our collective actions as individuals, families, communities, and governments.

Maureen E. Raymo is a renowned scientist who has been a pioneer in the study of ice ages and sea level in Earth's history. Her work has shaped our understanding of Earth's natural climate variability and her landmark papers have influenced a generation of scientists. In 2014, Professor Raymo, a fellow of the National Academy of Sciences, The Explorers Club, and the American Geophysical Union, became the first woman to be awarded the Wollaston Medal, the Geological Society of London's most senior medal and highest accolade.

The Bolin Climate Lecturer is appointed by the Dean of the Faculty of Science of Stockholm University. Nominations can be made by all Bolin Centre members in response to a call issued during the autumn term by the Bolin Centre directorate.



Prof. Maureen E. Raymo at the Bolin Climate Lecture 2019. Photo: Annika Granebeck

Lecturers

2019 | Prof. Maureen E. Raymo
Climate, CO_2 and Sea Level: Past, Present and Future

2018 | Prof. Veerabhadran Ramanathan
Bending the Curve: Climate Change Solutions

2017 | Dr. Thomas Cronin
Biological response to climate change: What would Bolin say?

2016 | Sir Brian Hoskins
The Challenge of Climate Change: How large is it and can we meet it?

2015 | Prof. Ulrike Lohmann
Uncertainties in climate projections related to clouds and aerosols

2014 | Prof. Corinne Le Quéré
The role of the carbon cycle in regulating climate

2013 | Prof. Warren M. Washington
Future Development of Climate and Earth System Models for Scientific and Policy Use

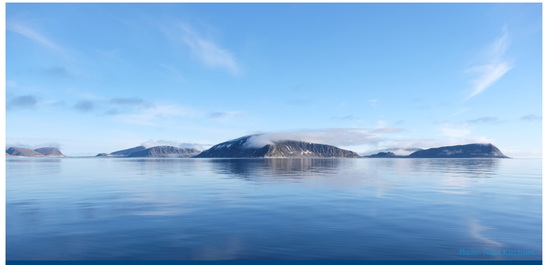
2012 | Prof. Sherilyn Fritz
The climate during the past 10,000 years

2011 | Prof. Ralph Keeling
Rising Carbon Dioxide: A Never Ending Story

2010 | Prof. Robert J. Charlson
Do We Know Enough to Go Ahead with Control of Greenhouse Gas Emissions?

2009 | Prof. Venkatachalam "Ram" Ramaswamy
Dissecting the Roles of Aerosols and Greenhouse Gases in Climate Change

2008 | Prof. Susan Solomon
Linkages between Ozone Depletion and Climate Change



Bert Bolin Climate Lecture 2019

Climate, CO_2 and Sea Level: Past, Present and Future

Speaker: Professor Maureen Raymo, Director of the Lamont-Doherty Core Repository, Lamont-Doherty Earth Observatory

The lecture will be given in English.
Coffee and refreshments will be served after the lecture.
More information about the lecture at science.su.se

Welcome!

19 NOV

FREE ENTRANCE ▶ Time 14h00–15h00
in Aula Magna, Stockholm University

Stockholm University

The Bolin Centre Board

The Bolin Centre is led by the Bolin Centre Board which comprises representatives from all its collaborative partners: Six departments at Stockholm University, the Swedish Meteorological and Hydrological Institute and KTH Royal Institute of Technology. In addition, the board includes an external member and a student representative.

Prof. Cynthia de Wit
Chair of the Bolin Centre
Dept. of Environmental Sciences

Prof. Magnus Breitholtz
Dept. of Environmental Sciences

Prof. Rodrigo Caballero
Dept. of Meteorology

Prof. Gia Destouni
Dept. of Physical Geography

Prof. Ove Eriksson
Dept. of Ecology, Environment and Plant Sciences

Prof. Dan Henningson
KTH Royal Institute of Technology

Prof. Bengt Karlsson
Dept. of Zoology

Prof. Erik Kjellström
Rossby Centre
Swedish Meteorological and Hydrological Institute

Johannes Morfeldt, MSc
Swedish Environmental Protection Agency

Prof. Magnus Mörth
Dept. of Geological Sciences

Sara Bromé, PhD student
Student representative
Dept. of Meteorology

Associate Prof. Nina Kirchner
Ex Officio
Co-Director of the Bolin Centre

Prof. Alasdair Skelton
Ex Officio
Co-Director of the Bolin Centre

Annika Granebeck, MSc
Ex Officio
Coordinator and communicator at the Bolin Centre

Karin Jonsell, PhD
Ex Officio
Coordinator and communicator at the Bolin Centre

The Northen lights, Tarfala research station. Photo: Petter Hällberg

The External Science Advisory Group

The Bolin Centre has appointed an External Scientific Advisory Group comprised of leading national and international scientists within climate research. The group's main tasks are to inform the Bolin Centre of its strengths, weaknesses and possibilities for development as well as increase the Bolin Centre's contacts to international networks and research groups within the climate research area.

Prof. Deliang Chen
August Röhss Chair, Department of Earth Sciences; Assistant Dean for Research, Faculty of Science, University of Gothenburg, Sweden.

Prof. Eystein Jansen
Academic Director Academia Europaea Bergen Knowledge Hub. Former director of the Bjerknes Centre for Climate Research; Department of Earth Science, University of Bergen, Norway.

Prof. Karen Kohfeld
Climate, Oceans, and Paleo-Environments (COPE) Lab at Simon Fraser University, Canada.

Prof. Anders Lindroth
Professor in Physical Geography & Ecosystem Science at the Department of Physical Geography and Ecosystems Analysis, Lund University, Sweden.

Prof. Camille Parmesan
NMA Chair in Public Understanding of Marine Science & Human Health at the School of Biological & Marine Sciences, Plymouth University, UK.

Prof. Raymond T. Pierrehumbert
Halley Professorship of Physics at the Department of Physics at University of Oxford, UK.

Prof. Andrea Rinaldo
Director of Laboratory of Ecohydrology (ECHO), École Polytechnique Fédérale de Lausanne, Switzerland.

In 2019, the first mapping of the Sálajiegna glacial lake's bottom topography was carried out in a collaborative project between Stockholm University and KTH. With autonomous surface vessels called "Ducklings", the bottom was mapped using sonar. Photo: Nina Kirchner

Bert Bolin – a world leading scientist and science organiser

Bert Bolin joined the newly created Department of Meteorology at Stockholm University[1] in 1948 as an assistant to Professor Carl-Gustaf Rossby. With short intervening periods, Bert Bolin remained an active member of the department staff until his death in 2007.

During a productive period as Rossby's student he wrote several fundamental papers on atmospheric circulation and on the basic principles for numerical weather prediction. After he received his PhD in 1956, he broadened his interests to include studies of biogeochemical cycles of key life elements. This became the introduction to his world leading research on the carbon cycle in the atmosphere, oceans and biosphere.

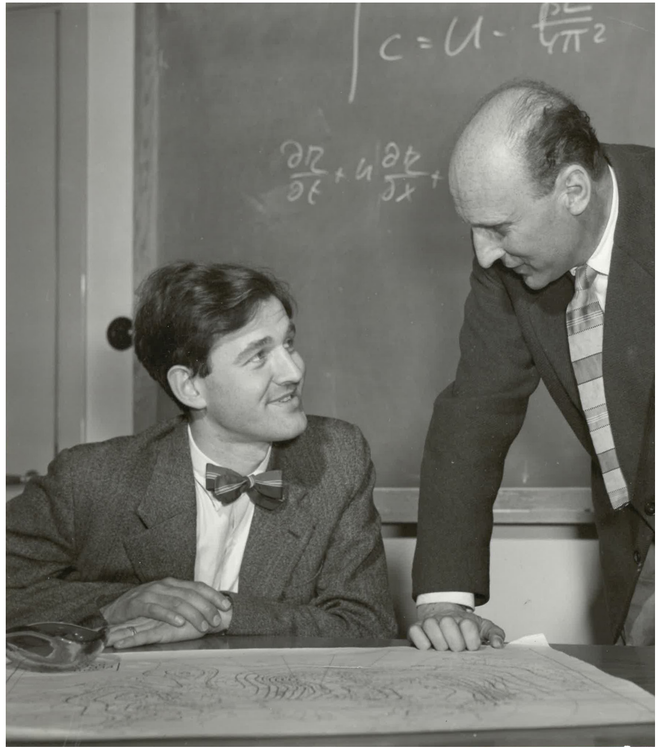
Bert Bolin was not only a prominent scientist. His role as an inspirer and organiser of international climate research has been of outstanding importance. Due to his broad and deep scientific knowledge, his unusual ability to see the big picture, his eminent ability to express himself orally and in writing, and his diplomatic talent, he became the natural leader. He initiated several research programmes focusing the global environment including the World Climate Research Programme (WCRP) and the International Geosphere-Biosphere Programme (IGBP).

Bert Bolin's most important achievement was his contribution to the formation and development of the Intergovernmental Panel on Climate Change (IPCC) under the UN. He chaired this panel during its first ten years (1988–1997). His extremely important role as the founder and initial leader of IPCC has been testified by many. IPCC received the Nobel Peace Prize in 2007.

The legacy of Bert Bolin remains alive among climate scientists at Stockholm University and at many other places through the inspiration that he brought about with lectures, supervision, his scientific approach and his engagement to make research results available to policy makers and the public.

Henning Rodhe
Bert Bolin's student, colleague and friend

[1]Stockholm University was formed 1960 from Stockholms Högskola, which was founded 1878.



Bert Bolin defended his PhD thesis in 1956. Photo credit: MISU, Department of Meteorology, Stockholm University

Bolin Centre for Climate Research

The Bolin Centre is a multi-disciplinary consortium of more than 400 scientists in Sweden who conduct research and graduate education related to the Earth´s climate. It was formed in 2006 by Stockholm University, the KTH Royal Institute of Technology and the Swedish Meteorological and Hydrological Institute (SMHI).

The Bolin Centre focuses on extending and disseminating knowledge about the Earth's natural climate system, climate variations, climate impacting processes, climate modelling, human impact on the climate and climate impacts on ecosystems, biodiversity and human conditions as well as how society can minimise negative impacts through responsible management.

The Bolin Centre for Climate Research is named in honour of Professor Bert Bolin of Stockholm University, a leader in climate and carbon cycle research and one of the founders of the Intergovernmental Panel on Climate Change (IPCC) which received the Nobel Peace Prize in 2007.

Bolin Centre for Climate Research

Stockholm University

KTH VETENSKAP OCH KONST

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