Bolin Centre
for Climate Research

Bolin Centre strategic plan 2023–2027

Anthropogenic climate change is one of the most pressing challenges of our society. We must find the necessary solutions to mitigate climate change and adapt to the change that we are already committed to. To achieve this, there is a need for improved knowledge on the fundamental functioning of the climate system and its interactions with ecosystems and society.

Bolin Centre mission: The mission of the Bolin Centre is to create and communicate fundamental knowledge about the coupled climate system and its interactions with life on Earth in the past, present and future, and to connect this knowledge to effective societal actions.

Bolin Centre vision: Our vision is the Bolin Centre as a thriving research environment at the international forefront, uniting experts across disciplines, training future generations of climate scientists, and delivering climate knowledge that supports societal action to mitigate and adapt to climate change.

WHERE WILL WE BE AFTER THE SECOND DECADE IN THE BOLIN CENTRE HISTORY?

STRATEGIC GOALS FOR 2023–2027

Bolin Centre seeks to expand its influence across climate-related research disciplines and within Earth System science via the following strategic goals:

1. **Resources.**

   To secure the necessary resources to reach the strategic goals below, including (i) long-term base funding to sustain the breadth of our research fields and enhance integration across them, in particular related to the biosphere component of the Earth system, and support infrastructures, (ii) new investments into strategic partnerships and (iii) external competitive grants raised by the Bolin Centre PIs.

2. **Local, regional and national partnerships.**

   To be an integrated key part of the larger research environment for climate and sustainability in Sweden. Regionally, the research and outreach at the Bolin Centre will be aligned with the strategic goals of Stockholm University (SU), the Royal Institute for Technology (KTH) and Swedish Meteorological and Hydrological Institute (SMHI), and synergistic with other collaborating centers.

3. **Integration.**

   To further enhance internal communication and integration of the research within the Bolin Centre, providing an environment that promotes scientific inquiry and output of high-quality peer-reviewed publications, fostering collaboration among Bolin Centre members and Research Themes (RTs, see Appendices A and B).

4. **Infrastructure.**

   To further develop the national landscape for technical support of climate research, including science infrastructures for modeling, observation and data science as well as open, fair and transparent publication of scientific data and knowledge – in collaboration with other relevant Swedish and international research environments.

5. **Career opportunities.**

   To host a vibrant and diverse community of climate researchers and offer a research environment that sustains their further development. We build a foundation for future employment opportunities of early career researchers through networking and exposure to diverse career pathways. We support and strengthen the recruitment of staff to SU, KTH and SMHI and offer attractive possibilities for international researchers to visit our research environment.

6. **External communication.**

   To have a strategic approach to external communication to optimally answer to the growing demand for our expertise by various stakeholders, with a particular focus on future generations of experts, decision-makers and members of society.

We will work towards these goals through the annually-updated plan of action (see Appendix C).

1. WHERE ARE WE NOW?

BACKGROUND TO THE STRATEGIC FOCAL POINTS

1.1 The scientific landscape in late 2022

Climate determines the living conditions on Earth – for humans and other organisms. The rapid increase in the global mean temperature, caused by anthropogenic greenhouse gas (GHG) emissions ha already caused drastic changes to the environment and the Earth System[1,2]. The warming will continue in the coming decades and centuries, and its magnitude and consequences will depend largely on the choices made by humankind. In the UNFCCC Paris Agreement, ratified by 193 countries, the governments committed to the necessary actions needed to keep the increase of the global mean temperature below 2˚C, preferably below 1.5˚C, compared to preindustrial levels. *The political process leading to the ratification of the Paris agreement would not have been possible without long observational time series and robust scientific knowledge on the fundamental functioning of the climate system*. Continuous and evolving research on the features and responses of the Earth system to various anthropogenic and natural perturbations is still needed to 1) improve the predictive power of climate projections; 2) design safe and effective actions to meet the targets of the Paris agreement and; 3) choose appropriate strategies for adapting to and mitigating the changes caused by climate and environmental change, hopefully minimizing their negative consequences for life on Earth. While the human influence on the recent increase in the global mean temperature is clear and well-established, important knowledge gaps still remain, including (see Appendix B):

- precise projections of different Earth system responses to changes in radiative forcing, particularly on the regional and local scales;
- the linkages between climate variation and cycles of water, carbon and nutrients;
- the interaction between ice sheets, the oceans and climate influencing global sea-level rise;
- the effects of climate variation on life through ecological and evolutionary processes from genes to ecosystems;
- the similarities and differences between past climate variability and ongoing/projected climate change;
- the feedbacks between the climate and the biosphere, and the links between biodiversity loss, climate change and land-use change.

Improved knowledge to better plan relevant mitigation and adaptation measures, is key for the security and prosperity of Sweden as part of the global community. Since its foundation in 2006, the Bolin Centre for climate research has become a nationally leading and internationally recognized organization, known for its research, education and outreach activities. As of the end 2022, the Bolin Centre is an umbrella organization spanning over eight departments at SU, SMHI and KTH. Collectively the Bolin Centre encompasses over 400 climate researchers, who published nearly 700 international scientific articles in 2021, many in top journals within their respective disciplines[2]. Together with the other strategic research initiatives

[1] IPBES (2019): Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo (editors). IPBES secretariat, Bonn, Germany. 1148 pages. https://doi.org/10.5281/zenodo.3831673
IPCC (2021), Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press *doi:10.1017/9781009157896*.
[2] Bolin Centre annual report, year 2021
https://bolin.su.se/polopoly_fs/1.635657.1668526764!/menu/standard/file/BolinCentre_Report_2021_till-webbplatsen.pdf

established in parallel with the Bolin Centre, particularly BECC and MERGE, the Bolin Centre has been instrumental in forming a Swedish climate research community that enhances knowledge on the coupled Earth system, educates future experts, and communicates key scientific findings to stakeholders.

The Bolin Centre should, naturally, develop in harmony with its immediate research environment, including the Baltic Sea Centre (BSC), the Stockholm Resilience Centre (SRC) and the Stockholm University Centre for Circular and Sustainable Systems (SUCCESS). While working to strengthen collaboration within SU, KTH and SMHI, the Bolin Centre should also look outward to other research disciplines and institutes for strategic partnerships. A particularly interesting opportunity lies within the Stockholm Trio collaboration (involving SU, KTH and Karolinska Institutet KI). Collaborations with KI could emerge around the rapidly growing research field on human health and climate (Romanello et al., 2022). Collaboration with KTH can be further explored in projects linking climate knowledge with climate action and optimizing engineering solutions for sustainable development.

1.2 Current strengths, weaknesses and opportunities within the Bolin Centre

Our breadth is our strength, our weakness and a source of endless opportunities

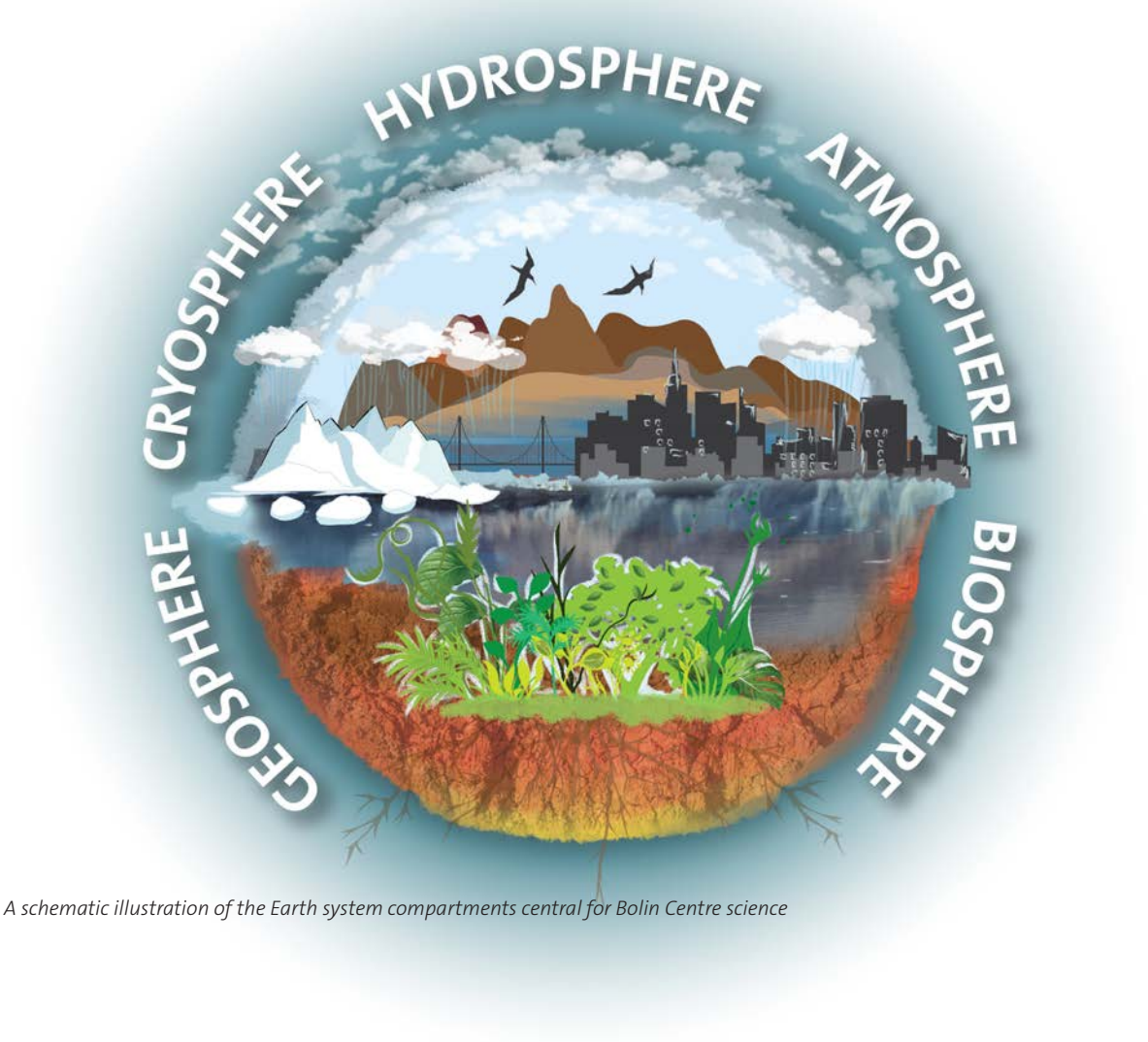

Figure 1. A schematic illustration of the Earth system compartments central for Bolin Centre science

The core expertise in the Bolin Centre is in fundamental science of climate, including all its components (Fig. 1), and the impacts of climate variation on life and society. Bolin researchers study processes whose time scales range from microseconds (10^{-6} s) to millions of years (10^{13} s) and spatial scales from nanometers (10^{-9} m) to thousands of kilometers (10^{6} m). The Bolin Centre hosts a vast body of expertise, ranging from detailed processes to integrated studies for understanding the past as well as projecting the future climate, including the effects of climate on abiotic and biotic processes. It is already among the internationally leading research environments in many of the relevant disciplines (manifested in e.g. ARWU subject-based rankings in subjects like geography, atmospheric science, environmental science and engineering, oceanography to name a few).

Bolin Centre research spans diverse scientific disciplines, and uses a wide range of methodologies – primarily rooted in the natural sciences. The empirical techniques include various laboratory studies, ocean-going expeditions and field experiments, as well as remote sensing and research satellite development. The breadth in research themes and methodologies contributes to the uniqueness of the Bolin Centre, but it also presents challenges. These include communication among the members to ensure cohesion and community identity, while respecting the multiple facets of the members' obligations outside the center. For this reason, and because the Bolin Centre has a large and diverse membership, the structures for internal communication, including membership registration, routines for internal reporting, and organization of an annual internal conference and associated events, are paramount for maintaining member engagement, internally showcasing research and facilitating networking (see Appendix A).

While the Bolin Centre is already very strong in research on processes taking place in the individual compartments of the Earth System, there is large potential for new scientific breakthroughs in studies that target their interfaces (Fig. 1). With deeper interdisciplinary collaborations within the Bolin Centre and with external collaborators, the quality and societal value of the scientific output can be further improved; to help turn knowledge into action. In particular, there is room for better integration of research on the biosphere and the other components of the Earth system – in both past and present, but eventually also future climates. There is a growing societal realization that the two global crises on climate change and biodiversity loss need be tackled together[3]. The Bolin Centre is in a unique position to help provide a sound natural science basis for joint action on these issues. The strong research on both past and present climate is also a specific strength of the Bolin Centre, which has already led to many fruitful collaborations. The scientific potential of this niche has not yet been exploited to its full potential in the form of e.g. implementing the present-day process knowledge to research on the past climates[3] and longer time scales. Other examples of areas where all or several Bolin Research Themes (RTs, see Appendices A and B for details) could collaborate with strong synergies include water cycling and resources throughout the spheres of the Earth system, cryosphere dynamics (e.g. sea ice, ice sheets, permafrost and atmospheric ice), land-atmosphere-climate interactions (e.g. biogeochemistry, ecology, hydrology and their coupling to greenhouse gases, radiative impacts and feedbacks), studies linking oceanic circulation, food-webs, biogeochemical cycles and biodiversity, model development informed by observations and process-models, as well as downscaling of climate to local and micro climates relevant for ecological and evolutionary processes.

[3] IPCC, 2022: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press.

Infrastructures offer platforms for novel findings, exchange and constraints in climate-relevant scales

Continuous observations and model development are of critical importance for climate science. Without long-term observations of e.g. the Earth's temperature, atmospheric CO_2, responses of biogeochemical cycles and abundancies and distribution of species, critical observational evidence of the ongoing and past climate changes, as well as the drivers and impacts of these changes would not be possible. The climate science community is still struggling with having sufficiently large data sets of many of the key parameters at relevant spatio-temporal resolutions. Maintaining the continuity of the necessary infrastructure (e.g. support for research stations, expedition coordination and super-computing) is, however, difficult in the current research funding landscape without a strong commitment from the relevant partner organizations – at a higher level than e.g. any given university department can achieve on its own. Bolin researchers are in central positions within several recently-funded national research infrastructures such as the ACTRIS-Sweden network, the icebreaker *Oden*, and the CoastClim infrastructure at Askö laboratory. Within the centre, the experimental results are used and combined with fundamental theory to improve models on the physico-chemical climate system and to both assess and predict ecological and evolutionary consequences of climate change. The Bolin Centre also has great strength in building climate reconstructions from proxies and other historical evidence. There is large potential for more efficient use of the experimental infrastructures linked to the Bolin Centre members, use of the produced data for improving key processes in climate-related modeling and theory, as well as dissemination of data and modelling results more broadly to the external scientific community, educators and the general public.

Models are particularly important scientific tools used within all Bolin research themes. There is special emphasis on the use, evaluation and development of numerical Earth System Models used for global and regional climate simulations, including substantial contributions to global climate research and assessments, that elucidate the climate variability, evolution and dynamics in the past, present and future. The climate research performed at the Bolin Centre, and nationally in Sweden, relies on computational infrastructure and support. This includes access and maintenance of coupled climate models and a range of more specific local/regional models, coordinated supercomputer access and personnel with the specific expertise needed to support all these activities. The modeling coordination at the Bolin Centre has great value and strengthens our research environment. There is currently no long-term computational support infrastructure specializing on climate research at the national level. Such support for climate science, including the whole Bolin Centre but also other climate science centers in Sweden (e.g. BECC, MERGE) would be of considerable national value, and the Bolin Centre is in a natural position to coordinate/contribute to

such efforts. A reinforced modeling support infrastructure would help sustain and increase Sweden's international position as a climate research node, secure Sweden's ability to produce independent and relevant climate projections to support national policy, and yield long-term synergistic and complementary development of the climate research efforts through various universities and research organizations.

The Bolin Centre Database provides long-term storage and transparent access to the research data produced following the FAIR principles (Wilkinson et al., 2016). It provides a user-friendly interface, including interactive visualizations of data, and contributes to the Swedish Government's goal of implementing Open Science by 2026. The database works in collaboration with SUs research data management team, to support the broader university research environment through the experience gained with Bolin Centre activities. However, there is room for further development in this area, with the possibility for the Bolin Centre to strengthen its role as a national and international leader for promoting open science, facilitating the publication and open accessibility of research results and data. Developing new methodologies involving more process-based evaluation and development of climate models, together with routines of the associated open access publication, data storage and handling, is also a field where the Bolin Centre could play an important role – both nationally as well as internationally.

Room for strengthening the community of early-career climate scientists

There is a large and growing community of PhD students and post-doctoral researchers within the Bolin Centre. While the climate research school has been instrumental in creating a community of PhD students, there are opportunities to better integrate these early career researchers (ECRs) into the activities within the Centre, to better coordinate the climate-related advanced-level education given by the Bolin Centre partners, and to prepare them for various roles within society. A particular issue has been the lack of a "home" for the post-doctoral researchers in the Bolin Centre – a group of often very motivated individuals who can also act as important ambassadors of the Bolin Centre as they travel and venture onwards – has not been explicitly addressed in the activities targeting ECRs. By improving the internal communication, and continued mentorship for the ECRs, the Bolin Centre could support the growth of networks and collaborations for these researchers, but also gain more momentum and energy in Bolin Centre activities.

Responding to the demand of external communication is a pressing challenge with current resources

There is an immense need in the society for timely, accurate and well-formulated communication about climate science. The events organized by the Bolin Centre (the Bolin days, the Bolin Climate Arena, the Climate Festival at ForskarFredag in collaboration with Vetenskapens Hus, and perhaps most importantly the annual Bolin Climate Lecture) are generally well attended and appreciated. At the same time, the Bolin Centre cannot meet the demands for external communication in terms of responding to all the requests from the surrounding stakeholders. Furthermore (and consequently), the Bolin Centre's communication strategy needs to be updated and followed-up on to ensure strategic communication for maximum impact. In particular, and following the transition of SU to a new website structure in 2023, the website of the Bolin Centre needs to be reviewed and updated according to the strategic priorities for external and internal communication.

APPENDICES TO THIS DOCUMENT

Appendix A: History, organization and structure of the Bolin Centre

Appendix B: Descriptions of the four Research Themes (RTs)

Appendix C: Bolin Centre plan of action for 2023

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Cover photo by Martin Jakobsson
Page 6: Askölaboratoriet, Baltic Sea Centre Stockholm University's marine field station. Photo: Robert Kautsky, Azote
Page 7: Station in Ny Ålesund. Photo: Radovan Krejci
Page 9: The icebreaker *Oden* on a research expedition in northern Greenland. Photo: Martin Jakobsson

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A collaboration between Stockholm University, KTH and the Swedish Meteorological and Hydrological Institute

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