Bolin Centre for Climate Research

Annual Report 2024–2025

Including research highlight articles:

Monsoon rainfall in East Asia has shifted abruptly in the past – and could do so in the future Page 14

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Climate, food, and death: temperature-related mortality in pre-industrial Sweden Page 24

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 for the Bolin Centre to be 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.

Cover photo: Inês Jakobsson
Production: Bolin Centre for Climate Research, 2025. Research highlights produced by Laila Islamovic and Sara Gershagen in collaboration with the co-leaders for each Research Theme. The text has been proofread by CBG Konsult & Information AB. Graphic layout by Inês Jakobsson. Printed by Ljungbergs Tryckeri AB, 2025.

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Photo: Inês Jakobsson

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 by Stockholm University, and in 2010 the KTH Royal Institute of Technology and the Swedish Meteorological and Hydrological Institute joined the centre. 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 fundamental knowledge about the coupled climate system and its interactions with life on Earth; climate-impacting processes; climate modelling; human impact on the climate; and climate impacts on ecosystems, biodiversity, and humanity; as well as the ways in which society can minimise the negative impacts of climate change. It contributes to the knowledge base on climate mitigation and adaptation 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 work of the IPCC and others led to 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, in 2006, the SUCLIM (Stockholm University Climate Research Centre) research programme was awarded a 10-year Linnaeus Grant by the Swedish government.

In 2008, SUCLIM was renamed the 'Bert Bolin Centre for Climate Research', a name which was afterwards shortened to the 'Bolin Centre for Climate Research' in 2013. In 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. As a result of the merger, the Bolin Centre's strategic funding now surpasses 20MSEK per year.

In early 2023, the Bolin Centre completed a process of redefining its strategic plan and strategic goals for 2023–2027. This collaborative initiative aimed to redefine priorities and unite leadership, Research Theme leaders, and active members in discussions of the centre's essentials and its future development path.

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

Stockholm University

KTH VETENSKAP OCH KONST

SMHI

Organisation

The Bolin Centre aims to bring climate scientists together. The centre follows four Research Themes (RTs), where scientists from different disciplines come together to tackle key questions about climate. The Bolin Centre organises seminars, workshops, conferences, outreach projects and research education.
The Bolin Centre aims to foster collaboration and interdisciplinary research among climate scientists. To this end, the centre has established four Research Themes that bring together experts from diverse fields to address key questions related to climate. In addition, the Bolin Centre organises a range of activities, such as seminars, workshops, conferences, and outreach projects, and also provides research education opportunities.

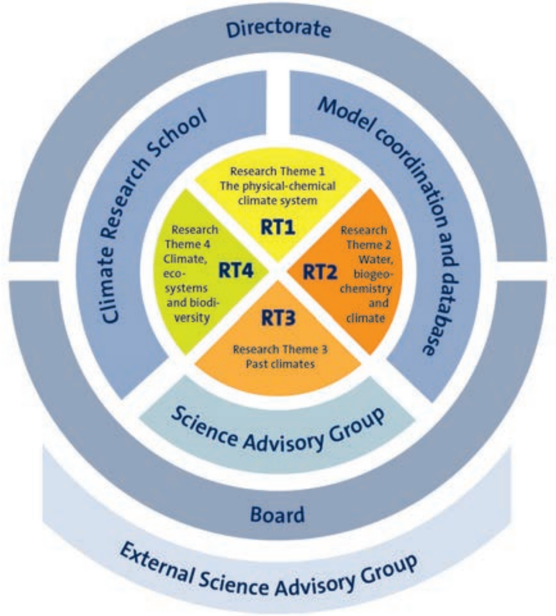
The Bolin Centre is built around its four multi-disciplinary Research Themes, each of which is led by two (or three) scientists:

- Research Theme 1 | The physical-chemical climate system
- Research Theme 2 | Water, biogeochemistry and climate
- Research Theme 3 | Past climates
- Research Theme 4 | Climate, ecosystems and biodiversity.

The centre hosts a research school and an open-access database and also provides communication support and support for climate modelling activities.

The directorate consist of a director, a co-director and a coordinator, who share the centre's daily tasks. All Research Themes' co-leaders and the directorate meet regularly in the Science Advisory Group, working to support 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 aim to 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

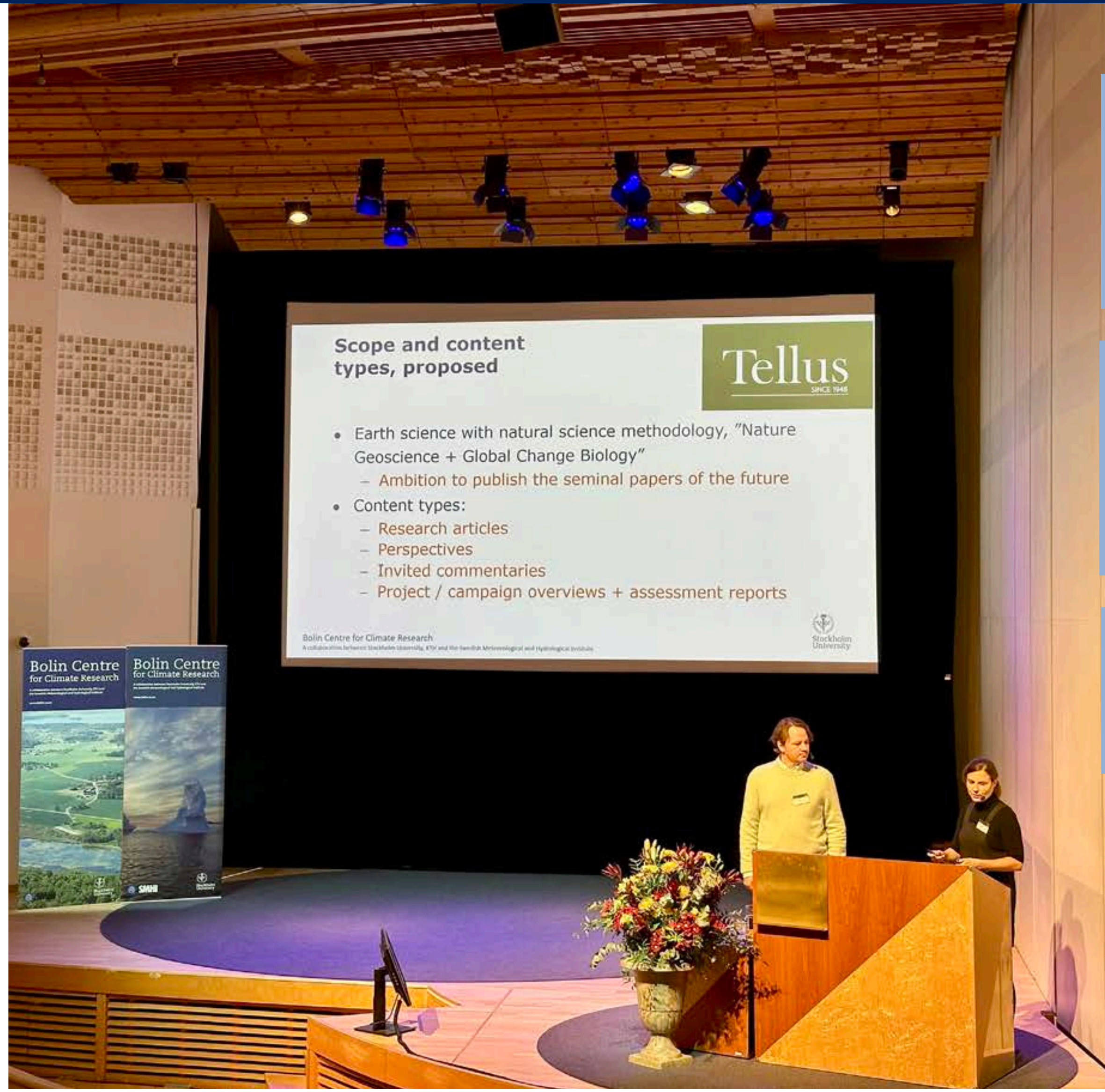
The Bolin Centre has evolved from an idea among a few inspired individuals to a thriving research hub with more than 400 scientists focusing on science, education and outreach activities related to the Earth's climate.
The Bolin Centre is a common effort, and its success is the success of its members.

Climate and life on Earth are intertwined. Since their emergence, lifeforms have evolved within Earth’s atmosphere, creating conditions characterised by the levels of oxygen and carbon dioxide to which plants and animals are now adapted. Rapid climate change sets new challenging constraints for the organisms of the biosphere – not least for humans impacted by extreme weather events, like the decreased availability of water or sea level rise. It is increasingly evident that links between regional climate change, biodiversity loss, and distortions to the hydrological cycle are central for human wellbeing. Public awareness of anthropogenic impacts on climate change is also rising. Risks associated with global environmental changes associated with, e.g., ecosystem collapse or large-scale ocean circulation changes, are frequently in public discussion. Because uncertainties in our ability to detect, quantify, and project these changes are still great, new fundamental knowledge of the workings of the Earth system is still relevant and timely.

During the past academic year, researchers at the Bolin Centre have studied the fundamental processes of the Earth system, including the atmosphere, the biosphere, the cycling of water and carbon, and their interactions with human activities. Research highlights chosen by Bolin Centre Research Theme (RT) leaders include studies investigating the ways humans and livestock modify land and interact with local ecosystems and hydrology (see p.18 and p.28), with boundary conditions provided by the changing regional and global climate. Concrete impacts of elevated temperatures on bumblebees and their interactions with plants have been studied in a laboratory setting (see p.26), providing important data on the mechanisms through which anthropogenic climate change might influence insect populations. Bolin researchers have also played a leading role in, e.g., setting improved constraints on the present carbon budget (see p.20), reconstructing past CO_2 concentrations (see p.22), and evaluating the ability for present Earth System Models (ESMs) to represent feedback associated with forests, biogenic hydrocarbons, aerosols, clouds, and climate (see p.16). Past events of abrupt changes coupling temperature, hydrological cycles, and large-scale circulation have been identified and studied both observationally and through numerical modelling (see p.14), improving our ability to understand and project such potential future changes and their consequences. The Bert Bolin Climate Lecturer 2024, Professor Ricarda Winkelmann, gave us insight into another crucial feedback – the one between ice, atmosphere, ocean, and solid earth on Greenland and Antarctica. She highlights that if tipping points and thresholds are crossed here, it could trigger irreversible consequences, calling for stronger intergenerational climate responsibility (see p.38).

Much of the centre’s research is performed by Early Career Researchers (ECRs) – PhD students, postdocs, and early-stage academics – who are also among the most loyal visitors of Bolin Days. In our strategic plan we aim to “build a foundation for future employment opportunities for ECRs through networking and exposure to diverse career pathways” and “offer attractive possibilities for international researchers to visit our research environment.” In a research landscape that often drives specialisation, the Bolin Centre enables development as broadly knowledgeable climate scientists. This breadth was especially evident during Bolin Days 2024, which featured excellent talks from our first cohort of postdoctoral fellows. New initiatives supporting the ECR community will follow in the coming year, led by the new Bolin ECR Council, to whom we extend our thanks.

One challenge of an academic career is balancing pressure to publish with research quality. This is especially pressing for ECRs navigating faculty and proposal evaluations. An overemphasis on quantity, metrics, and publishing revenues has resulted in negative impacts: the fragmentation of knowledge; an overwhelming volume of information; and even fraudulent studies, plagiarism, and paper mills. Such problems threaten the foundations of science, the attractiveness of research careers, and public trust in peer review. Publishing practices are key to retaining this trust and enhancing research quality. Evaluation must emphasise quality over quantity, and researcher-led journals should be promoted over commercially driven ones. Therefore, beginning in 2025, the Bolin Centre is proud to relaunch the scientific journal *Tellus*. Founded by Carl-Gustaf Rossby in 1948, *Tellus* is likely the world’s first journal focused on the Earth’s system. Read more on page 30–31.



Gustaf & Ilona, Bolin Days. Photo: Laila Islamovic

Publications

The total number of publications where researchers have listed an affiliation to the Bolin Centre in 2024 is around 250. The total number of publications by researchers (listed as Bolin-members on our website) in 2024 is around 599.

The Bolin Centre Database

The Database promotes research results and visualises data. As of December 2024, the Database hosts almost 500 datasets and several thematic data collections and interactive visualisations. Read more on page 32.

Communication channels

Visit www.bolin.su.se and follow @BolinCentre on LinkedIn and Bluesky for the latest news and events.

Bolin Centre's 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:

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, particularly in relation to the biosphere component of the Earth system and support infrastructures; (ii) new investments into strategic partnerships; and (iii) external competitive grants raised by Bolin Centre PIs.

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, the Royal Institute for Technology, the Swedish Meteorological and Hydrological Institute, and synergistic with other collaborating centres.

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 RTs.

Infrastructure

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

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 for 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.

External communication.

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

Climate and health: advancing solutions through the Stockholm Trio collaboration

In 2024, the Bolin Centre for Climate Research continued to contribute actively to the Stockholm Trio's joint work on climate and health, building on the foundation laid in previous years. Through ongoing interdisciplinary collaboration and research-driven input, the Bolin Centre supported efforts to move from understanding risks to developing actionable solutions – particularly in areas such as sustainable food systems, urban resilience, and the health benefits of climate mitigation. These activities reflected the Bolin Centre's commitment to translating scientific knowledge into practical guidance for policy and planning.

From science to solutions: 2024 Climate and Health Symposium

On November 12, 2024, the Bolin Centre co-led the Second Symposium on Climate and Health, shifting the focus from identifying risks to implementing solutions. Co-organised with the Royal Swedish Academy of Sciences and Stockholm Trio partners, the event brought together researchers, policymakers, and industry leaders to explore how climate-smart food systems and healthier lifestyles can serve both people and the planet.

The Bolin Centre helped shape the agenda, with discussions targeting actionable strategies, cross-sector collaboration, and policy integration. The message was clear: science must not only inform – it must drive change.

Empowering the next generation: student competition

The Bolin Centre supported the "Climate and Health: A Vision for Stockholm 2029" student challenge, led by KTH Climate Action Centre. Promoting the event, joining the organising team, and providing a jury member, the Bolin Centre helped inspire bold student ideas – from heat-resilient cities to climate-smart diets. The competition showcased the Trio's commitment to engaging young minds in shaping a sustainable future.

Looking ahead, the Bolin Centre's 2024 work within the Stockholm Trio has strengthened the foundation for integrating scientific evidence into climate and health policy. Building on interdisciplinary collaborations, the Bolin Centre is now advancing targeted research areas, including the use of machine learning to better predict climate-related health impacts and define effective points for intervention. Planning has also begun for the 2026 Swedish Climate Symposium, where the Stockholm Trio plans to present joint findings on how climate policy can generate measurable health co-benefits. These initiatives reflect a clear move toward data-driven, applied research that directly supports decision-making and cross-sector solutions.

Illustration: The 2R Artificiality, Adobe Stock

The Bolin Centre Research Themes

Until the end of 2021, the research was structured into eight multi-disciplinary research areas (you can read more about them on our website). Since the beginning of 2022, the Bolin Centre is reorganised into four ‘Research Themes’, with the following titles:

Research Theme 1 | The physical-chemical climate system

Research Theme 1 addresses some of the major knowledge gaps in the physical-chemical climate system. Covering a range of scales, we study aerosols and clouds; the dynamics of the atmosphere, ocean and cryosphere; risk of reaching climate system tipping points and regional effects of global warming; and climate sensitivity and the carbon budget. We develop and use tools ranging from Large Eddy Simulation to Earth system models, ranging from in-situ observations to satellite and reanalysis products.

Co-leaders:
Geert Brethouwer, FLOW, Dept. of Engineering Mechanics, KTH
Léon Chafik, Dept. of Meteorology, Stockholm University
Ramón Fuentes Franco, Rossby Centre, SMHI
Liine Heikkinen, Dept. of Environmental Science, Stockholm University

Research Theme 2 | Water, biogeochemistry, and climate

Research Theme 2 studies the coupled water and biogeochemical cycles and their interactions with climate and society over multiple spatial and temporal scales. Our ultimate goal is to define the adaptation necessary to address climate risks related to these cycles and to guide policy towards the mitigation of these risks. For this task, we rely on field- and space-based observations, modelling, monitoring, and experiments on land, in the ocean, and in the atmosphere.

Co-leaders:
Fernando Jaramillo, Dept. of Physical Geography, Stockholm University
Volker Brüchert, Dept. of Geological Sciences, Stockholm University
Andrea Popp, Hydrology department at the Swedish Meteorological and Hydrological Institute (SMHI)

Research Theme 3 | Past climates

Research on past climates encompasses climate variability on tectonic, orbital, millennial, centennial, and historical timescales. We use a wide range of geoscientific data to reconstruct the evolution of the climate system, including its landscapes and ecosystems, from local to global scales. Climate models are used to simulate extreme climate states in the past, and to study impacts, mechanisms, and feedback operating in the climate system under different climate forcings. Past climates provide a thorough test of models to project future changes in a confident way.

Co-leaders:
Frederik Schenk, Dept. of Geological Sciences, Stockholm University
Fredrik Charpentier Ljungqvist, Dept. of History, Stockholm University
Natasha Barbolini, Dept. of Ecology, Environment, and Plant Sciences, Stockholm University
Margret Steinthorsdottir, Swedish Museum of Natural History, affiliated with Dept. of Geological Sciences, Stockholm University.

Research Theme 4 | Climate, ecosystems, and biodiversity

Research on climate, ecosystems, and biodiversity at the Bolin Centre aims to understand how the climate affects ecological, evolutionary, and biophysical processes, as well as to understand the possible feedback of these processes on climate and human use of land and water. The research relies on using field observations, experiments, and modelling to examine the effects of the climate on different aspects of ecosystems and biodiversity.

Co-leaders:
Stefano Manzoni, Dept. of Physical Geography, Stockholm University
Rhonda Snook, Dept. of Zoology, Stockholm University

Please note that the list of SAG RT co-leaders is accurate as of December 2024. Later changes to the SAG leadership may have occurred. The most up-to-date information can be found on our website: https://www.su.se/bolin-centre-for-climate-research/about-the-centre/organisation

RT1 | Monsoon rainfall in East Asia has shifted abruptly in the past – and could do so in the future

A study co-authored by Research Theme 1 member Qiong Zhang presents the most detailed reconstruction to date of East Asian summer monsoon rainfall over the past 22,000 years. The findings reveal a climate system marked not by gradual change, but by abrupt tipping points—sudden, large, and irreversible shifts in key components of the climate system. In this regard, rainfall over the region that persisted for thousands of years. The research provides new insight into how the monsoon system has responded to global climate disruptions in the past, raising concerns about the risks of future instability of the climate system under continued warming.

A natural archive reveals abrupt rainfall shifts

The study, representing the work of RT1, centres on a unique natural archive: Qingtongyam Maar Lake in southern China. As a closed-basin crater lake sensitive to local rainfall, it offers a high-resolution record of hydroclimate change. By applying nine independent statistical and machine learning methods to multiple geochemical and biological proxy records, the researchers were able to produce a robust reconstruction of annual rainfall anomalies, relative to the modern 1961–1990 average of 159 mm.

The results show that East Asian summer monsoon rainfall was significantly higher during warm periods such as the Bølling–Allerød interstadial and the early to mid-Holocene; up to 440 mm, or nearly 30%, above present-day levels. In contrast, the Last Glacial Maximum, Heinrich Stadial 1, the Younger Dryas, and the late Holocene were marked by notably drier conditions.

What makes this study particularly striking is the identification of five major climate tipping points, each representing a sharp and irreversible shift in monsoon rainfall. These transitions, occurring approximately 18,860, 14,640, 12,870, 11,360, and 4370 years before present, involved rainfall changes of nearly 400 mm on average – an amount equivalent to roughly a quarter of the annual rainfall in the region. In several cases, these shifts happened within a few decades, yet their impacts lasted for millennia.

Global drivers behind monsoon tipping points

The drivers behind these tipping points appear to lie in broader Earth system changes. Two stand out in particular: the weakening of the Atlantic Meridional Overturning Circulation (AMOC) and the collapse of the so-called "Green Sahara."

During Heinrich Stadial 1 and the Younger Dryas, for example, major slowdowns in the AMOC and its associated heat transport caused the interhemispheric temperature gradient to collapse, shifting tropical rain belts southward and suppressing the East Asian monsoon. Similarly, the demise of vegetation in North Africa around 4 000 years ago, which marked the end of the African Humid Period, led to increased Saharan dust, changes in the westerly winds over the North Atlantic, and cooling over the Tibetan Plateau. These cascading effects ultimately drove a significant weakening of the monsoon system.

Together, these findings underscore how the East Asian monsoon is not only sensitive to regional climate conditions, but also highly vulnerable to tipping elements in distant parts of the planet. The system behaves nonlinearly: it doesn't simply follow a smooth response to changing temperatures or greenhouse gas concentrations, but instead jumps between relatively stable states, often in response to multiple interacting drivers.

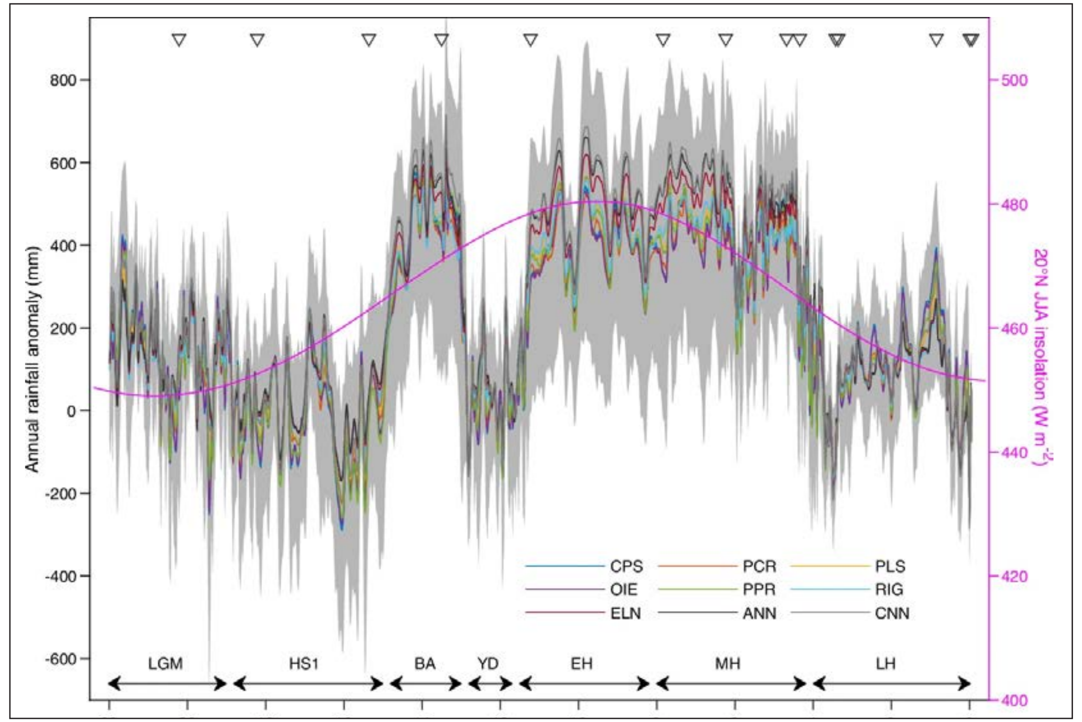
What this means for future climate risks

This has significant implications for our understanding of future climate risks. The monsoon provides critical rainfall to support agriculture and water supply for billions of people across East and Southeast Asia. If warming continues to disrupt ocean circulation or contributes to large-scale land surface changes, such as ongoing deforestation or desertification, the risk of triggering abrupt rainfall shifts could grow.

Importantly, this study moves beyond relying solely on oxygen isotope data from cave records, which are often difficult to interpret directly in terms of rainfall amount. Instead, it provides a quantitative, multi-proxy, ensemble-based reconstruction that sets a new benchmark for understanding long-term monsoon variability.

By linking past rainfall tipping points to global climatic drivers, the researchers offer not only a clearer view of how monsoons have behaved over millennia, but also a warning that the future could hold similar abrupt shifts, should critical thresholds in the Earth system be crossed again.

This text is based on the scientific publication *Tipping point-induced abrupt shifts in East Asian hydroclimate since the Last Glacial Maximum*, published in *Nature Communications* on 8 January 2025. The paper is accessible here: https://doi.org/10.1038/s41467-025-55888-w



Annual rainfall anomalies shown as deviations from the 1961–1990 mean (1592 mm). Gray shading represents the 95% confidence interval of all reconstructions, and colored lines show the means from different reconstruction methods. Triangles mark radiocarbon (^14C) age-control points. The magenta line shows mean summer (JJA) insolation at 20° N. LGM – Last Glacial Maximum; HS1 – Heinrich Stadial 1; BA = Bølling–Allerød; YD = Younger Dryas; EH = early Holocene; MH = mid-Holocene; LH = late Holocene.

RT1 | Shedding new light on the role of forests in the climate and water cycle

Forests are pivotal in terms of carbon storage and the water cycle, covering a third of the Earth's land surface. However, the full scope of their impact remains to be fully understood. A study led by members of Research Theme 1 have now been able to provide new insights into the complex role that forests play in the climate system and water cycle.

The research, involving scientists from eleven institutions across 5 countries, including Sweden, the UK, Finland, Germany, and Brazil, highlights the intricate relationship between forests, particularly their emission of organic gases, and the formation of reflective clouds that could influence global temperatures.

Comparing boreal and tropical forests

The unique aspect of this study is its focus on both boreal and tropical forests, which constitute 27% and 45% of the Earth's forested area, respectively. These ecosystems differ in their emissions and cloud formation processes, leading to varying impacts on the forest-cloud–climate feedback loop.

"This study, utilising long-term data from diverse forest environments in Finland and Brazil, marks the first time observational evidence has been presented for these interactions in tropical rainforests," says lead author Sara Blichner, postdoctoral scientist at the Department of Environmental Science.

Underrepresentation of forests in climate models

The study emphasises the need for improved climate models to accurately represent these complex interactions. "Our findings suggest that current models may underestimate the impact of forests on cloud formation and climate, especially in tropical regions, which are crucial due to high amount of solar radiation these areas receive at these latitudes," Blichner explains.

However, Blichner stresses that while the study highlights areas for improvement in climate modelling, it does not undermine the overall reliability of these models. "Climate models are highly trustworthy in representing the main processes of climate change. Our research aims to refine these models, reducing uncertainties in future climate projections," she asserts.

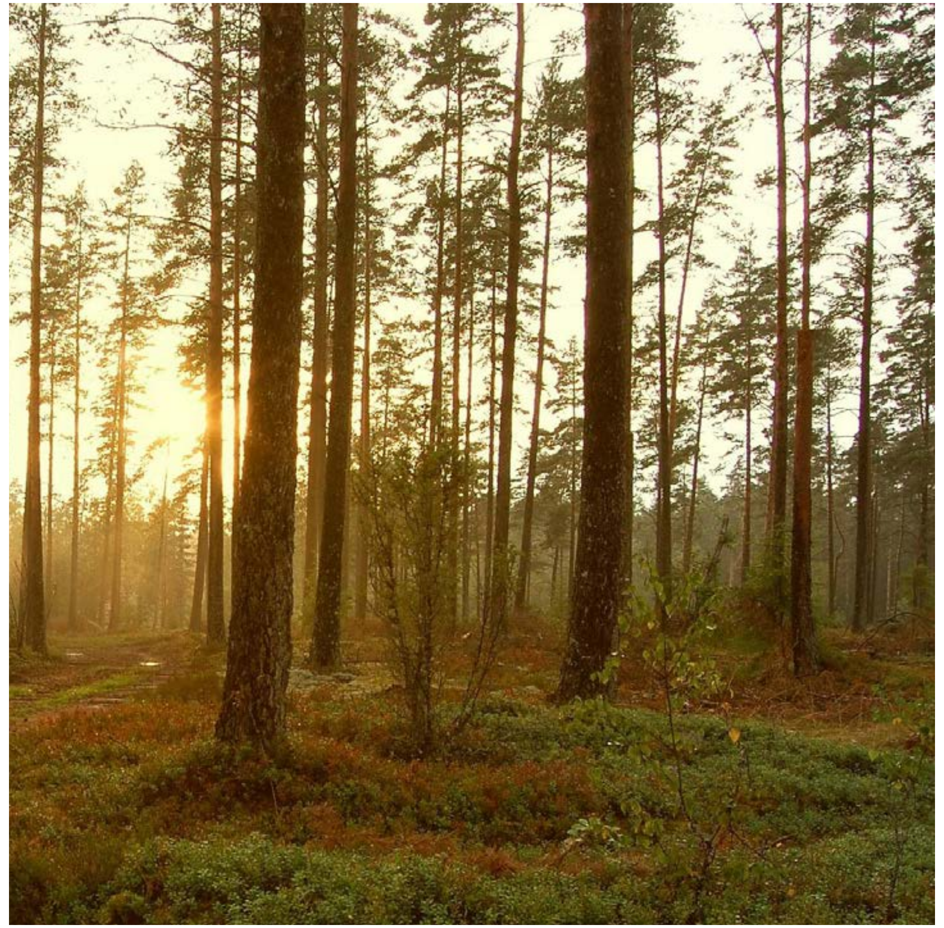
Natural particles and global warming

The research also points out that as man-made particle emissions decrease due to air quality policies, the natural particles from forests become increasingly significant. These feedback loops are more potent in cleaner air environments and could play an important role in moderating global warming.

This collaborative study underscores the need for continued research and improvement in climate modelling to better predict future climate scenarios. Additionally, the findings highlight that these types of effects must be considered when assessing forest conservation as a key strategy in climate change mitigation.

About forest emissions and climate regulation

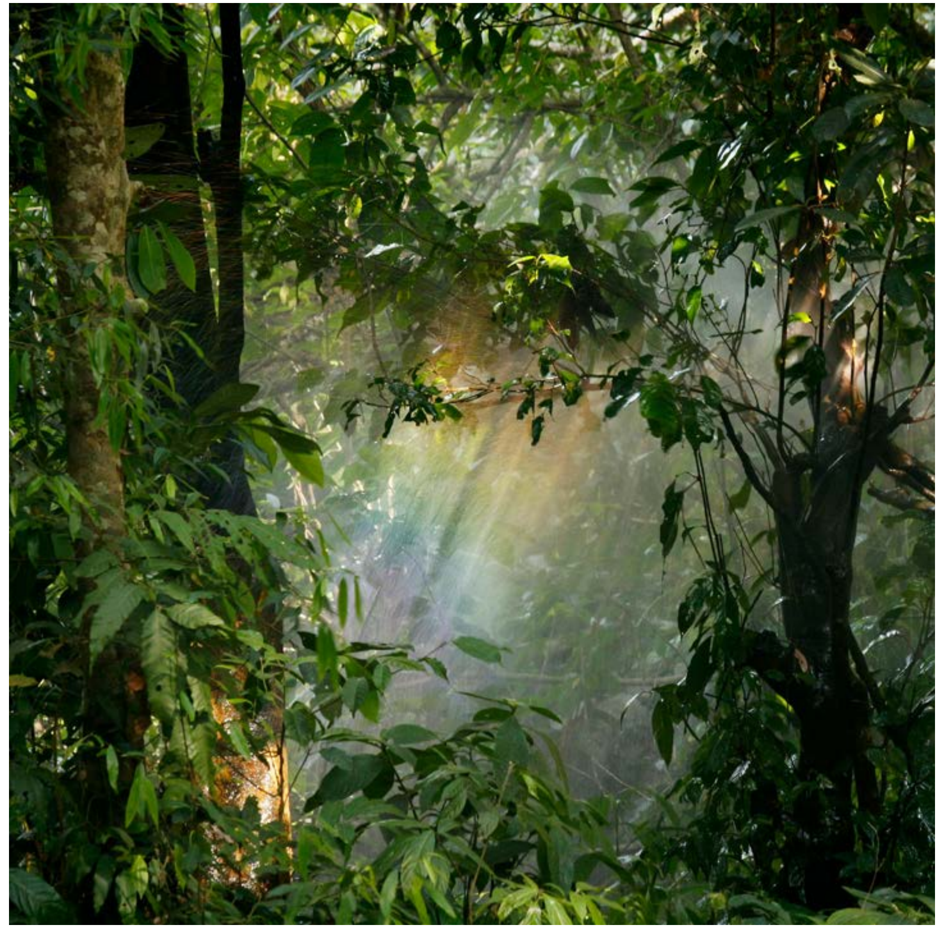
Forests release substantial amounts of organic gases, particularly noticeable as the distinctive scent of a pine forest on a warm day. These gases, once released into the atmosphere, contribute to particle formation.



Boreal Forest, Sweden. Photo: Jonathan Petersson @pexel.com

Clouds are composed of minuscule water droplets, and each of these droplets nucleate around a particle in the air. An increase in atmospheric particles results in clouds with more droplets, enhancing their reflectivity of sunlight and leading to cooler surface temperatures.

As climate change raises temperatures, forests are anticipated to emit more of these gases, thereby creating more particles and potentially more reflective clouds.



Tropical green Forest. Photo: Nandhu Kumar @pexel.com

This research highlight is based on the scientific paper *Process-evaluation of forest aerosol-cloud-climate feedback shows clear evidence from observations and large uncertainty in models.*
The paper is accessible here: https://doi.org/10.1038/s41467-024-45001-y

RT2 | Unravelling the potential of context-based storylines: towards ecosystem-based land use planning for the Tagliamento River

Members of Research Theme 2 have explored how historical land use changes in the Tagliamento River basin – a reference ecosystem for the restoration of Alpine rivers – have influenced flood risk and ecosystem functionality, and how future planning can better integrate both risk reduction and river conservation. The Tagliamento River in northeast Italy is used as a reference model for river restoration in Alpine environments due to its largely unaltered hydromorphological features.

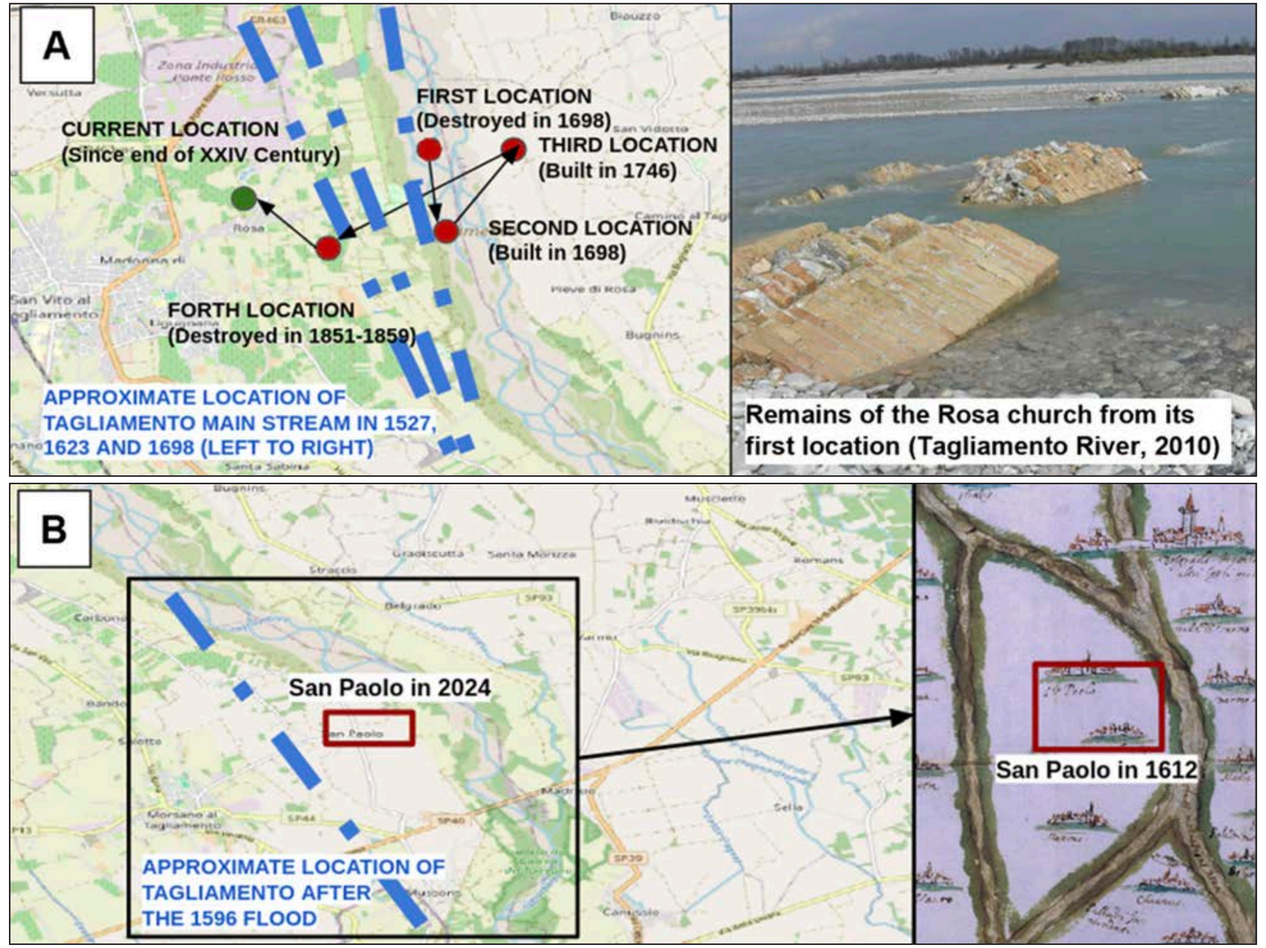
However, urban expansion, infrastructure development, and agricultural land conversion have disrupted natural floodplain processes. This article analyses how land use evolution has altered the capacity of floodplains to absorb and buffer floodwaters over time. To do this, the study incorporates context-based storylines of local knowledge and historical documentation for two villages affected by flood events: one that was relocated across the river after flood events, and a second that became isolated as an island, surrounded by braided channels. These changes provide concrete, narrative-based insights into how communities have historically adapted to the dynamic nature of the river and highlight the need to integrate local experiences and place-based historical data into current and future flood risk management strategies.

The middle course of the Tagliamento has preserved natural river dynamics, such as sediment transport, meandering, and seasonal flooding, which allow for the preservation of natural flood regulation functions. In contrast, the lower course has been more heavily constrained by levees and urban development. The study suggests opportunities exist to reactivate historical fluvial corridors and wetlands. The two village examples highlight that flood risk adaptation should not rely solely on structural defences like levees. While these measures may offer short-term protection, they often encourage development in high-exposure areas and disconnect the river from its floodplain. Instead, prioritising the restoration of floodplain functions through ecosystem-based land use planning can deliver co-benefits such as biodiversity conservation, groundwater recharge, and climate resilience.

A view of the middle course of the Tagliamento river, characterized by multiple braided channels. Photo: Eugenio Novajra

While flood risk is a central concern in the Tagliamento basin, other hazards like droughts and coastal floods (e.g., from sea-level rise or storm surges) can interact with flooding in compounding or cascading ways. Planning should therefore adopt a multi-hazard perspective, considering multiple, interacting hazards, rather than focusing on floods in isolation. An approach to land use and multi-risk planning is advocated for that draws on historical and local knowledge, accounts for the complexity of hazard interactions, prioritises ecosystem functions and aims to reconcile river conservation with risk reduction goals. Context-dependent storylines such as the ones discussed in this article make complex hydrological and planning concepts more accessible to communities and decision-makers, enhancing risk awareness and supporting more inclusive governance.

This popular science summary is based on the scientific paper: *Unravelling the Potential of Context-Based Storylines: Towards ecosystem-based land use planning for the Tagliamento River, northeastern Italy.* The paper is accessible here: https://doi.org/10.21463/shima.236



A) Progressive relocation of the Rosa village; picture of the old Rosa church emerging from the current riverbed.

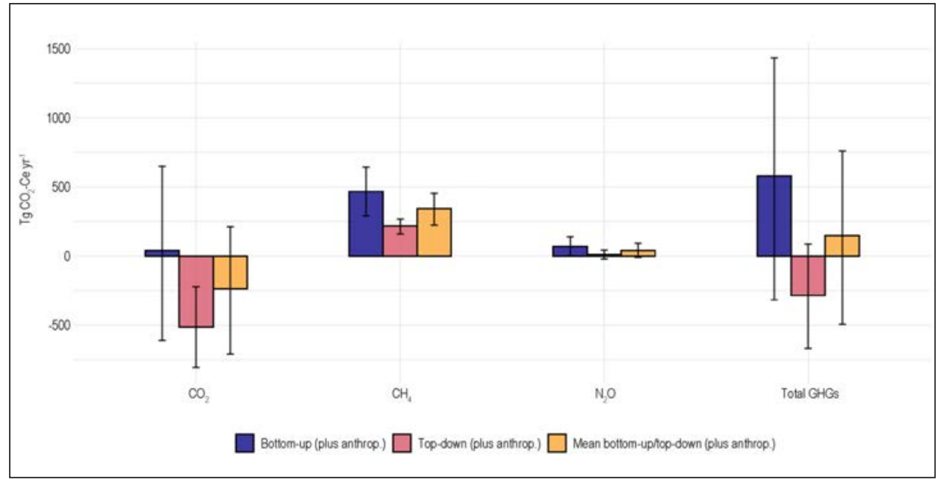
B) Current location of the San Paolo village; 1612 historical map, authored by Conte Savorgnan Vettore, showing the village between river channels, e.g., as a river island. Scaini, C., & Scaini, A. (2025).

RT2 | A first-ever full greenhouse gas budget for permafrost region shows emissions from wetlands and fires offset Boreal Forest uptake

Arctic and Boreal regions are among the most rapidly changing parts of Earth. The northern permafrost region, characterised by permanently frozen soil, is warming two-to-four times faster than the global average. This region is also a key component of global biogeochemical and hydrological cycles.

The northern permafrost region covers large areas, 17 million km^2, and stores very large amounts of carbon and nitrogen in soils and sediments. With climate change, there is concern that thawing permafrost will release greenhouse gases into the atmosphere, shifting the region from long-term cooling of the global climate to a net warming effect.

To determine the current greenhouse gas budgets of permafrost ecosystems, Hugelius et al. (2024) used different techniques to assess carbon dioxide, methane, and nitrous oxide for the 2000–2020 time period. Performed as part of an international effort under the Global Carbon Project, this study was the first combined permafrost region greenhouse gas budget. A team of scientists from 35 research institutions compiled and assessed all available observations and modelling of greenhouse gas emissions on land, in freshwater, and in the atmosphere. A particular focus was to compare different methods for generating budgets, particularly contrasting "bottom-up " ecosystem modelling approaches to "top-down" modelling based on atmospheric measurement and transport models. Overall, it is still not possible to reconcile the two approaches, with bottom-up approaches generally predicting more net greenhouse gas release.



The figure shows the annual global warming potential of the greenhouse gases carbon dioxide, methane, and nitrous oxide for the global permafrost region using bottom-up and top-down scaling approaches. For these budgets, the exchange fluxes from all ecosystem were combined and include the anthropogenic contribution. All numbers were converted to CO_2-equivalents (Tg CO_2-Ceq using a 100-year Global Warming Potential (GWP-100).

Combining the different methods, the study concludes that the region is a net sink of carbon dioxide; mainly located in boreal forests and wetlands. However, carbon dioxide is emitted from inland waters and fires affecting both forest and tundra, giving a near neutral full carbon dioxide budget. Lakes and wetlands are strong sources of methane, which contributes to significantly warming the climate, especially over shorter timescales. Nitrous oxide is emitted at low rates across the region, with a relatively limited impact on climate.

In summary, the climate warming from the northern permafrost region is likely close to neutral when calculated over a 100-year time window, but it warms the climate when calculated over a 20-year time window.

This text is a popular science summary based on the scientific paper *Permafrost region greenhouse gas budgets suggest a weak CO_2 sink and CH_4 and N_2O sources, but magnitudes differ between top-down and bottom-up methods*, accessible here: https://doi.org/10.1029/2023GB007969

Researcher peering down on thawing permafrost during field survey. The photo shows costal erosion accelerated by rapid thaw of ice rich permafrost along the Canadian Beaufort coast. Photo: Gustaf Hugelius

RT3 | Phanerozoic atmospheric CO_2 reconstruction: current insights and future directions

Understanding how atmospheric CO_2 levels have changed throughout Earth's history is critical for predicting how the Earth System might respond to rising CO_2 in the future. Steinthorsdottir et al. (2025) have reviewed and synthesised current knowledge on the proxies and models used to reconstruct paleo-CO_2, recent advances in the field, and key directions for future research.

A range of marine and terrestrial proxies – such as paleosols (ancient soils), stomatal features of fossilised plant leaves, and carbon isotopic compositions – are used to infer past CO_2 levels. Each proxy encodes the atmospheric CO_2 signal through distinct physiological or geochemical mechanisms. The accuracy of these reconstructions is constrained by assumptions about ancient environmental conditions, biological processes, and post-depositional changes. The review details how proxies are linked to atmospheric CO_2 and highlights ongoing efforts to refine proxy application and validation, especially through forward proxy system models.

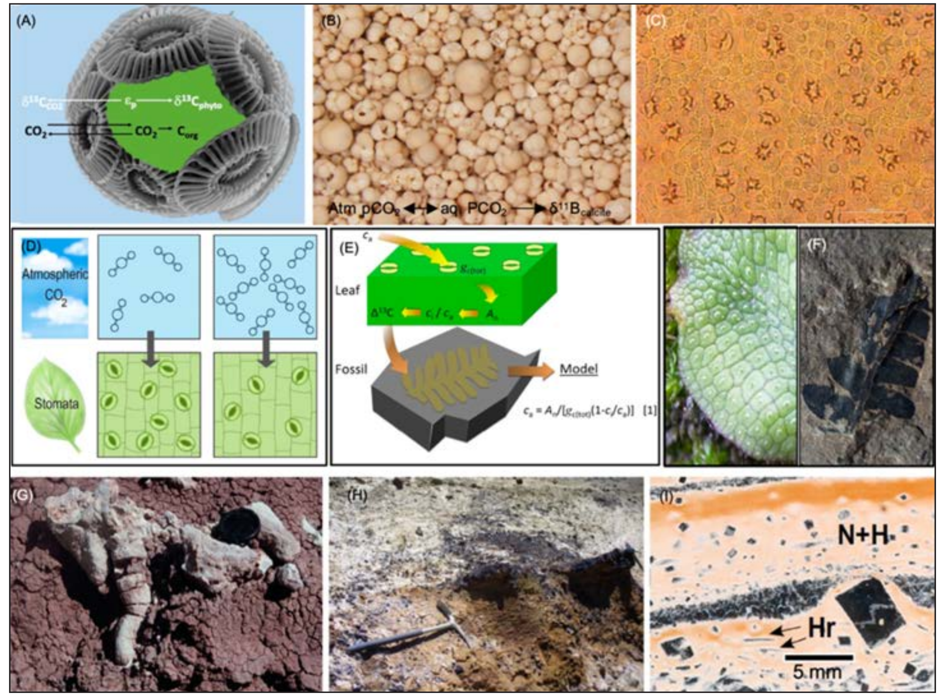
A major advancement highlighted in this review is the compilation of all 4077 published paleo-CO_2 estimates from the Phanerozoic Eon (the last ~540 million years), which captures first-order trends but also reveals significant variability and uncertainty across many intervals. This scatter underscores the need for better constraining of proxy sensitivities and a more systematic approach to quantifying uncertainty. Advances in this area are being driven by the CO_2 Proxy Integration Project (CO_2PIP), which seeks to modernise and standardise proxy datasets, particularly for pre-Cenozoic eras, using contemporary proxy theory and FAIR data principles.

A significant breakthrough in paleo-CO_2 reconstruction is the development of a high-resolution Cenozoic Era (the past 66 million years) CO_2 curve by the CenCO_2PIP Consortium. This record establishes a new benchmark for post-Paleocene atmospheric CO_2 evolution and demonstrates the benefits of integrating multi-proxy datasets within a robust statistical and mechanistic framework. The ongoing second phase of CO_2PIP aims to extend this approach across the entire Phanerozoic by developing proxy-specific models that account for ecological and diagenetic controls on the CO_2 signal, ultimately enabling data-driven reconstructions via inversion modelling.

Carbon cycle models – such as the GEOCARB, COPSE, and SCION frameworks – remain central to quantifying long-term CO_2 evolution. These models simulate the transfer of carbon among Earth's reservoirs and provide critical context for interpreting proxy records. Recent developments focus on reducing model uncertainty by refining representations of climate sensitivity, silicate weathering, vegetation dynamics, and lithological heterogeneity. Notably, spatially explicit modelling efforts have improved reconstructions for the Cretaceous–Cenozoic interval, aligning model outputs more closely with proxy data.

Emerging directions in modelling include enhancing the spatial and temporal resolution of input data, integrating non-silicate and reverse weathering processes, and better constraining the feedback between climate and carbon cycle processes. These improvements aim to reconcile persistent data – model mismatches and to yield more accurate simulations of CO_2 – climate linkages.

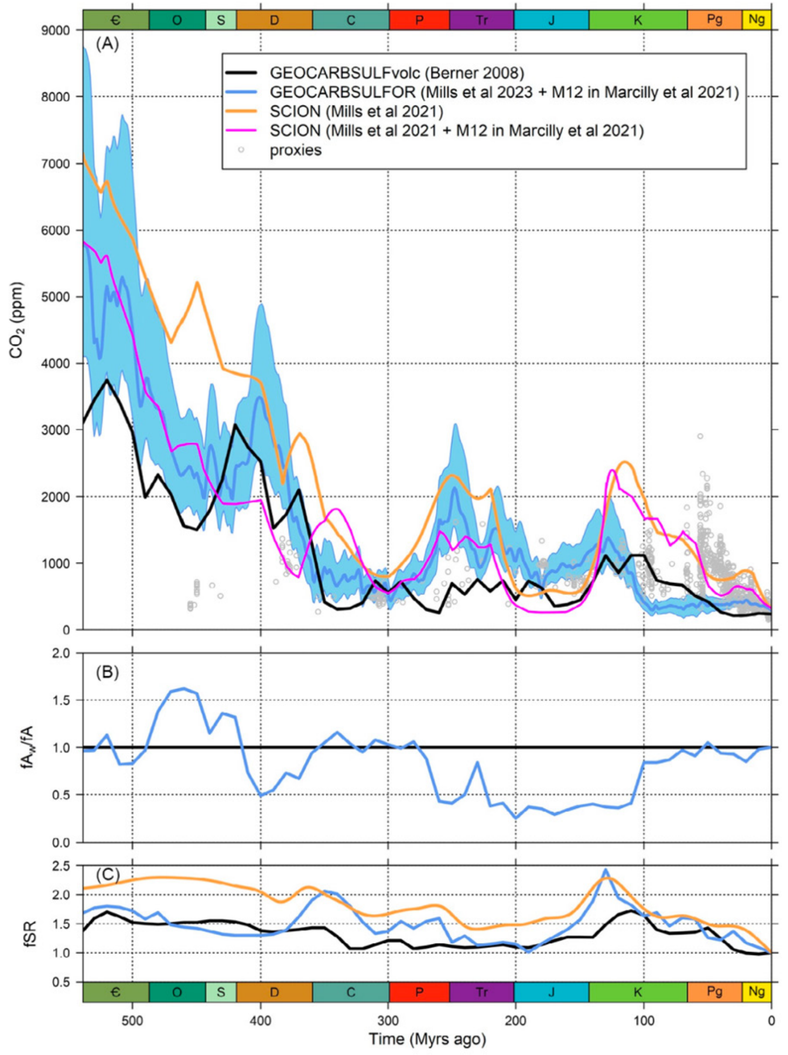
Looking forward, the paleo-CO_2 research community is advancing toward a next-generation, statistically integrated, multi-proxy CO_2 reconstruction for the Phanerozoic. Central to this effort is the development of a curated, updatable community archive hosted at paleo-co2.org, which includes metadata-rich proxy records and tools for standardised data submission and vetting.



Marine and terrestrial CO_2 proxies. (A) Phytoplankton $\delta^{13}C$: relates algal biomarker $\delta^{13}C$ to dissolved CO_2 used in photosynthesis. (B) Boron isotopes ($\delta^{11}B$) in marine carbonates record seawater pH and CO_2. (C) Ginkgo biloba cuticle as modern analog for fossil Ginkgoales, showing epidermal cells and stomata. (D) Stomatal density and index decrease with higher atmospheric CO_2. (E) Mechanistic leaf model linking CO_2 to assimilation, conductance, and CO_2 gradient (after Franks et al., 2014). (F) Terrestrial $\delta^{13}C$: isotopic signals from fossil plants or organic matter (e.g., liverworts, Medullosans). (G) Paleosol carbonates: calcite rhizoliths around roots (Early Permian C_3 plants). (H) Goethite: bog iron formed in ancient soils (Late Paleozoic, Argentina). (I) Nahcolite: layered nahcolite with halite rafts at air–water interface (after Demicco & Lowenstein, 2010).

The integration of forward proxy models, high-resolution datasets, and improved carbon cycle modelling holds promise for resolving outstanding questions about the Earth's CO_2 history, and its climatic and biogeochemical impacts.

This text is based on the scientific publication: *Phanerozoic atmospheric CO_2 reconstructed with proxies and models: Current understanding and future directions*, accessible here: https://doi.org/10.1016/B978-0-323-99762-1.00074-7



Updates to long-term carbon cycle models. (A) Chemical weathering parameterization (fAw/fA), introduced by Royer et al. (2014), scales land area undergoing weathering relative to today (previously fixed at 1). (B) Tectonic degassing parameterization (fSR), scaled to present-day rates. (C) CO_2 estimates comparing GEOCARBSULFvolc (Berner, 2008) and GEOCARBSULFOR (Mills et al., 2023 with Marcilly et al.'s 2021 inputs), with 95% CI in blue. SCION (Mills et al., 2021) is shown in orange, SCION with M12 inputs in pink. Gray circles are CO_2 proxies.

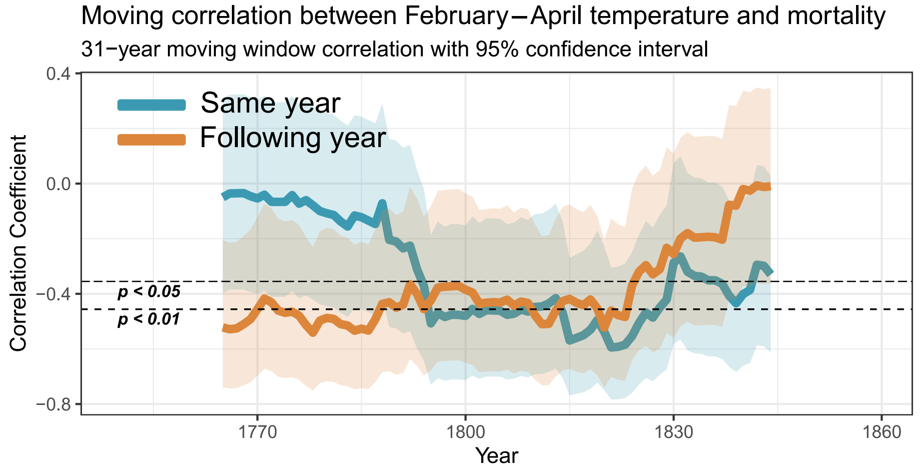
RT3 | Climate, food and death: temperature-related mortality in pre-industrial Sweden

Climate variability has long been recognised as a significant factor influencing human health, particularly in pre-industrial societies dependent on agriculture, and vulnerable to environmental fluctuations. Despite this, climatic impacts on mortality in the past remain poorly understood. Chen et al. examines the relationship between seasonal temperature variations and mortality rates in Sweden during the 1750–1859 time period, a time before modern medical and social interventions.

The study investigates the relationship between temperature and mortality in Sweden during 1750–1859, providing new insights into how seasonal climatic variations influenced population health in the pre-industrial era. By analysing historical mortality records alongside reconstructed temperature data, they find a statistically significant connection between colder temperatures in late winter and spring and increased mortality rates not only within the same year but also extending into the following year.

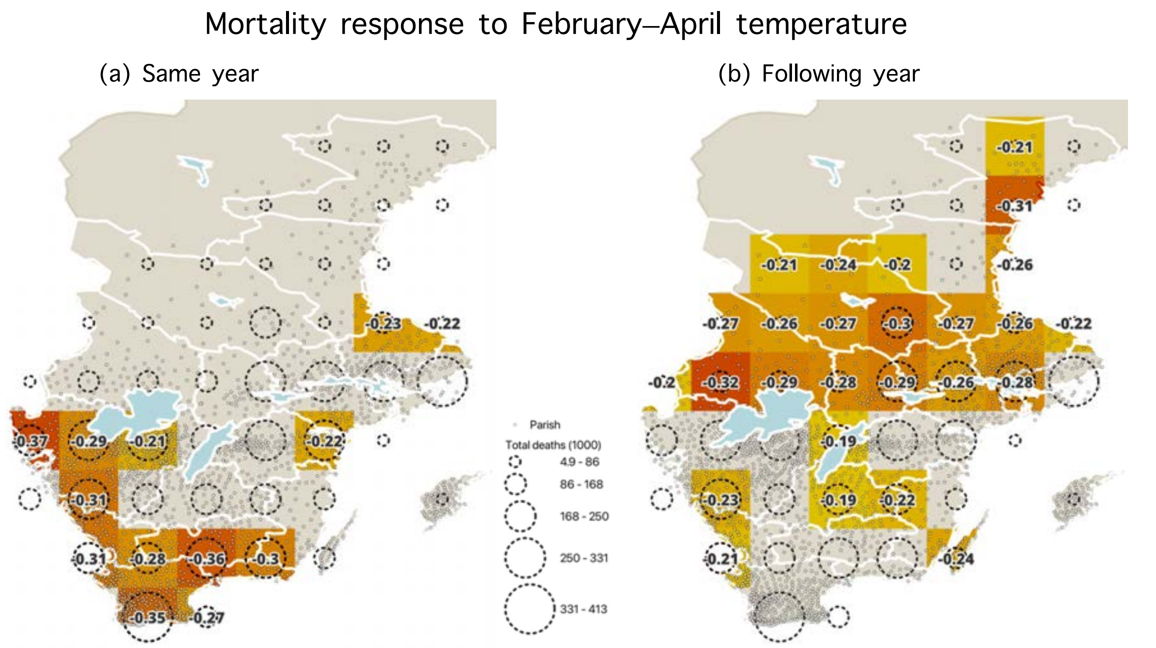
The researchers find that temperatures during February, March, and April have a particularly strong impact on mortality. The effect of cold temperatures during these months manifests both as immediate increases in deaths within the same calendar year and as delayed effects observable in mortality figures for the subsequent year. These findings suggest that temperature-driven mortality is not merely an acute phenomenon but also involves longer-term consequences, likely linked to food production and nutritional status.

Geographical differences emerged clearly in the temperature–mortality relationship. In southern Sweden, the influence of temperature was strongest on mortality within the same year, implying that the immediate physiological stresses caused by cold temperatures played a major role. In contrast, central Sweden exhibited more pronounced temperature effects on mortality in the following year, indicating that food production disruptions – caused by cold winters and late springs – may have led to malnutrition and increased



31-year moving correlation (with 95% confidence range) showing how February–April temperatures relate to excess mortality. Dashed lines mark when the relationship is statistically significant (p<0.05 and p<0.01).

vulnerability over a longer time horizon. This geographical pattern suggests that the southernmost regions were somewhat buffered from harvest-related mortality delays, likely due to their relatively less climate-sensitive agricultural conditions.



Statistically significant correlation coefficients during the 1750–1859 period between February–April temperature and mortality for (a) the same year, and (b) the following year. Stronger correlations are indicated by darker colours on the maps. Parishes are represented by dots, and dashed circles represent the number of total deaths (1000) from parishes within each grid-cell.

The researchers further examine age-specific mortality responses, revealing distinct vulnerability patterns across demographic groups. Child mortality was particularly affected by cold late winter and spring conditions in the previous year, consistent with nutritional deficiencies resulting from poor harvests and food shortages. In contrast, mortality among the elderly showed a more immediate response to cold temperatures within the same year, likely driven by increased incidence of respiratory and cardiovascular illnesses aggravated by cold stress. Adults in the intermediate age group also experienced increased mortality linked to temperature variability, reflecting a combination of direct and indirect effects.

Importantly, the temperature–mortality relationship changed over time. After the 1820s, the association weakened substantially, particularly concerning mortality in the year following cold conditions. This decline is interpreted as evidence of improved food and nutrition security, as well as advances in public health, such as vaccination programmes, which collectively enhanced population resilience to climatic stressors.

The study's methodological approach employs advanced statistical modelling to estimate excess mortality, using quasi-Poisson regression models, which account for long-term trends and inter-annual variability more effectively than simple baseline methods (e.g., five-year averages). This enhances the reliability of detected climate–mortality associations in a period characterised by complex mortality dynamics, including epidemics and wars.

In sum, this study underscores the significant role of late winter and early spring temperatures in shaping mortality patterns in 18th- and 19th-century Sweden, highlighting how climatic stressors interacted with regional agricultural conditions and demographic vulnerabilities. The observed spatial and temporal variations in climate sensitivity provide valuable historical perspectives on how societies have adapted to environmental challenges. These findings contribute to broader efforts to understand the long-term impacts of climate variability on human health and inform discussions about resilience in the face of ongoing climate change.

This text is a popular science summary based on the scientific publication: *Climatic impacts on mortality in pre-industrial Sweden*. The paper is accessible here: https://doi.org/10.5194/cp-21-185-2025

RT4 | Elevated temperatures affect bumblebee foraging and flight speed

As global temperatures rise, the health of ecosystems reliant on robust pollinator activities are at risk. Amongst pollinators, bumblebees are vital players that are increasingly threatened by climate change. This study, led by members of RT4, examines how elevated temperatures influence the foraging behaviour of bumblebees, shedding light on potential disruptions to critical plant–insect interactions.

In a controlled laboratory experiment, bumblebees were studied at two ambient temperatures: 24°C, considered optimal for foraging, and 32°C, which is considered a stressful temperature. Bumblebee colonies were alternated between these two temperatures weekly, allowing us to observe temperature-related changes in foraging behaviour with artificial plants. We measured flower visitation rate and time, total foraging time, flight speed, and the energy expended while flying (i.e., metabolic rate).

The findings revealed significant behavioural changes at 32°C. Bumblebees exhibited a higher flower visitation rate and increased flight speed at 32°C compared to 24°C. However, the time spent on each flower decreased as the temperature rose, leading to an overall decrease on foraging time spent by individuals. This suggests that while bees were quicker, they faced additional stress that may have limited their foraging time.

One possible explanation for these changes in behaviour is linked to the metabolic rate of flying bees, which decreases with higher temperatures. At 32°C, bees expend less energy to achieve the necessary body temperature for flight, allowing for faster and more frequent movements. Yet, the reduced flight activity indicates potential heat stress, suggesting that bumblebees may face challenges while foraging at elevated temperatures.

The findings of this study suggest potential disruptions to plant–animal interactions. Changes in foraging behaviour could disturb the delicate balance between bees and the plants they pollinate, potentially leading to cascading effects on both wild plant communities and agricultural production. As bumblebees make fewer trips and spend less time on flowers, the quantity and quality of pollination could decline, ultimately impacting food availability and biodiversity.

While this study provides valuable insights into how temperature impacts foraging behaviours in bumblebees, it also points to the need for further research. Understanding how temperature continues to affect pollination services will be crucial in addressing threats to biodiversity and global food security. With ongoing climate change, the survival of these crucial pollinators and the ecosystems that depend on them hangs in the balance, highlighting an urgent need to address our warming planet's implications for plant–animal interactions.

This text is a popular science summary of the scientific paper *Experimental elevated temperature affects bumblebee foraging and flight speed*, accessible here: https://royalsocietypublishing.org/doi/10.1098/rspb.2024.1598

*Bumblebee on Blue Thistle in Wenatchee Garden.
Photo: Frank Cone @pexel.com*

RT4 | Love your wet grass: why the resilience of different grazing areas matters for pastoralism

In eastern Africa, livestock is often grazed on vast areas of land that provide grassy and woody vegetation for herds to forage upon. Migratory movements by pastoralists and their livestock herds are therefore highly important, as they follow green flushes after rainfall and let the grazed areas rest. In recent years, changing pastoralist practices and rainfall patterns as well as ever increasing livestock population have led to local overgrazing, and accordingly, degradation in many rangeland areas. This makes it difficult for the grassy layer to recover from high grazing pressure.

To test how different grazing practices and increasing livestock pressure affects the rangeland plant recovery, we established a clipping experiment in three rangeland management types: rangeland that was grazed during the rainy season, rangeland grazed during the dry season, and seasonal exclosures (i.e., excluding livestock from degraded sites), in the Maasai Steppe, northern Tanzania. To better resemble grazing pressure in the model, we clipped grasses down to ground level every month and alternatively, we clipped only once per growing period in a fenced and open grazing area over two consecutive growing periods.

We found that the grasses in the rangeland that were grazed during the rainy season had the lowest regrowth rates and poorest vegetation cover. When rainfall was low, seasonal exclosures showed the best vegetation regrowth. Also, plots that were seasonally clipped showed better vegetation that those that were clipped monthly, showing how important a resting period is. Excluding grazing livestock had a large positive impact on vegetation only when rainfall was high but did not show much recovery potential when rainfall was low.

We conclude that traditional seasonal migratory herding is important for a long-lasting rangeland productivity and resilience under increasing intensity of disturbance. We highlight the differences in grass recovery rate, depending on location, resting time, and duration as well as rainfall conditions. Dry season grazing (providing rest to the grasses during the rainy season) proved to be the most sustainable concept for maintaining regrowth and controlling erosion of these rangelands.

All photos were taken during field experiment setup in Tanzania. Photos: Anna Treydte

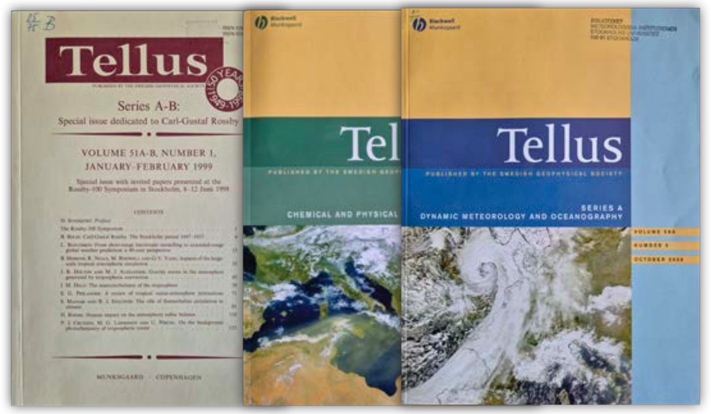
This text is a popular science summary of the scientific paper *Love your wet grass! Dry season grazing reserves show highest grass regrowth in communal semi-arid rangelands of Tanzania*.
The paper is accessible here: https://doi.org/10.1371/journal.pone.0313818

Tellus returns to its roots – relaunching for the future of Earth system science

Founded in 1948 by meteorological pioneer Professor Carl-Gustaf Rossby, *Tellus* is a scientific journal with a long-standing reputation for publishing high-quality research in Earth system science. Over the decades, it has established a strong legacy in dynamic meteorology, oceanography, biogeochemistry, and atmospheric sciences. As a trusted platform for interdisciplinary research, *Tellus* has played a key role in advancing our understanding of the interactions between the atmosphere, oceans, and climate.

For several decades, the journal was published in two separate series – *Tellus A* and *Tellus B* – with each focusing on atmospheric and oceanic sciences, respectively. While both journals upheld high scientific standards, their scopes gradually became more specialised than originally envisioned.

In late 2024, the Bolin Centre for Climate Research made a strategic decision to take over the editorial and administrative responsibility for *Tellus*, merging *Tellus A* and *Tellus B* into a unified journal. This transition has been underway throughout 2025, with the official relaunch planned for autumn 2025.



Earlier covers of Journal Tellus.

A new scope for a new era

The renewed *Tellus* will return to its original form as a single, open-access journal reflecting the complexity and interconnection of the Earth system, with an expanded scope:

Tellus *publishes research that advances understanding of how biological, chemical, and physical processes shape the past, present, and future of Earth systems in the context of the global climate.*

The journal welcomes submissions focusing on interactions across Earth's interconnected systems. Contributions may range from pioneering advances in numerical weather prediction, to process-based modelling and observational or experimental studies of any of the Earth's systems. Emphasis is placed on scientific quality, novelty, and rigour, as well as the potential for broad and long-lasting impact. Tellus *publishes interdisciplinary original research articles, forward-looking perspectives, and assessment reports, as well as commentaries offering critical reflections on the scientific culture and practice of Earth systems research. The journal is guided by an international editorial board of leading scientists and is committed to connecting and strengthening the global Earth science community.*

Photo: Laila Islamovic

Why scientists are choosing *Tellus*

As *Tellus* enters a new chapter, it brings with it a strong foundation of values and practical benefits for authors, reviewers, and readers alike. With over 75 years of scientific excellence, the journal is grounded in a rich tradition of leadership in Earth systems science. Its broad interdisciplinary scope now spans all the Earth spheres, including biosphere– and hydrosphere–climate interactions, in addition to the atmospheric and ocean sciences. Under the guidance of an international editorial board committed to quality and fairness, *Tellus* operates as an open-access, non-profit journal, ensuring low publication costs, high transparency, and full accessibility. The journal emphasises meaningful, rigorously reviewed research over quantity or trends, continuing to attract impactful contributions through its well-established reputation.

By relaunching *Tellus*, the Bolin Centre aims not only to continue a proud scientific tradition but to offer a forward-looking, community-led publishing platform that reflects the values and needs of Earth systems scientists today. In doing so, we are shaping the next chapter in scientific publishing – one rooted in integrity, openness, and excellence.

The Bolin Centre Database

– provides open access to climate and Earth system data

The database serves to promote and visualise research results and data, allowing us to highlight the stories that emerge from the data. By providing accessible and reusable literature, data, and program code to scientists, students, journalists, and the general audience, our data repository actively contributes to the global movement towards Open Science. As such, it plays a crucial role as an integral component of the Bolin Centre.

Data management is vital in scientific research, enabling transparency, reproducibility, and reusability. At the Bolin Centre, we understand the significance of effective research data management and provide comprehensive support to our scientists.

In 2024, we published 83 datasets, of which about half provide data collected during expeditions in the Arctic Ocean with the Swedish icebreaker *Oden* as a research platform. The other half represents a broad range of research, ranging from climate model simulations, to fieldwork in peat and soil, to measurements of aerosol concentrations in clouds.

Data life cycle and Open Science

Adopting an Open Science approach, the Bolin Centre recognises the importance of making scientific processes transparent. A key aspect of Open Science is ensuring that produced data is well-documented, understood, and reusable. To achieve this, we embrace the concept of the data life cycle, which encompasses various stages from planning to archiving.

Supporting the Data life cycle

Plan

Research funders often require a Data Management Plan (DMP) for funded projects. To assist researchers, Stockholm University offers centralised support and an online tool with a template for the Bolin Centre. By integrating DMP into the early stages of research planning, we ensure that data management considerations are addressed comprehensively.

Create and analyse

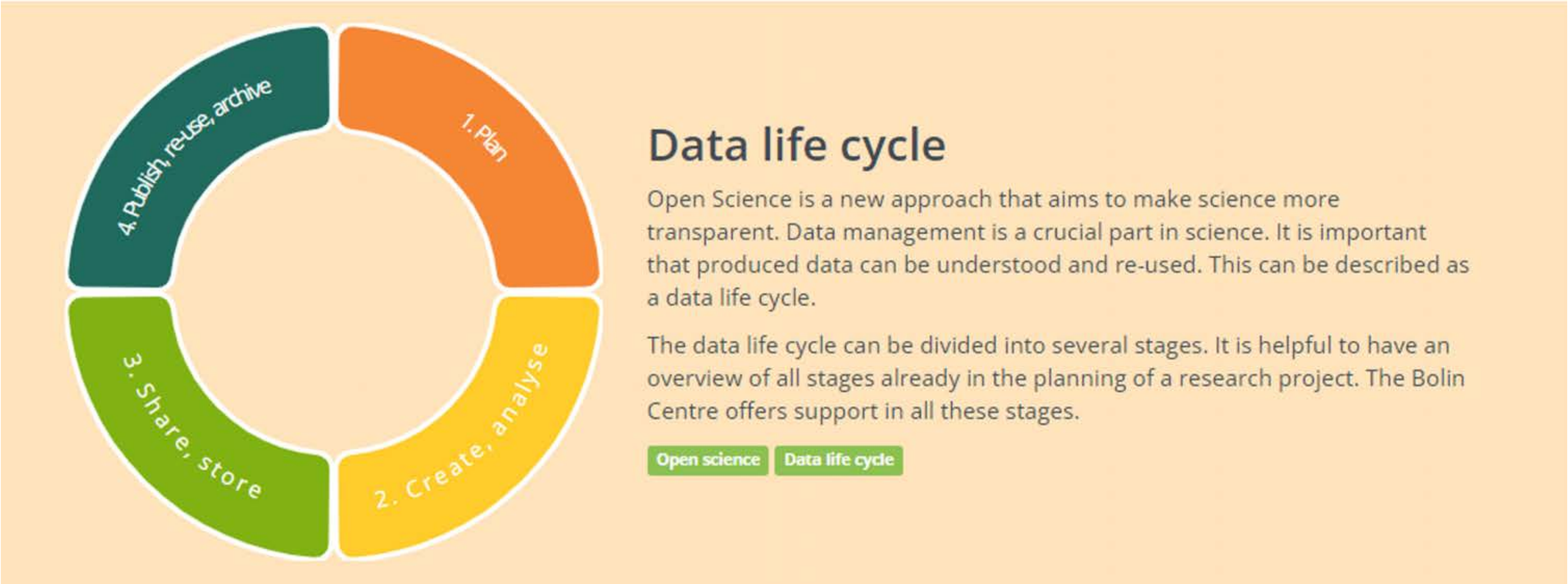
Depending on the research type, data can be generated through diverse methods. The Bolin Centre provides support for high-performance computing and storage through SNIC (Swedish National Infrastructure for Computing). This empowers our scientists by providing them with access to large-scale data resources, thereby facilitating efficient data creation and analysis.

Share and store

To promote collaboration and secure data storage, the Bolin Centre offers two general data storage alternatives. Scientists can utilise Sunet Drive and Swestore for intermediate data storage and sharing.

Publish, reuse, and archive

Journals and research funders increasingly emphasise the publication of data following the FAIR principles (Findable, Accessible, Interoperable, and Reusable) in open repositories. The Bolin Centre strongly recommends utilising the Bolin Centre Database for data publication, ensuring compliance of data with FAIR principles. Additionally, the database provides digital object identifiers (DOIs) for enhanced discoverability, integrates with Git for version control, and connects with Stockholm University's e-archive, ensuring long-term data archiving.



Effective Research Data Management is dominant in modern scientific practices. The Bolin Centre's collaboration with Bolin Centre Modelling Coordination, has resulted in comprehensive documentation and support for Research Data Management. By following the data life cycle and embracing Open Science principles, we empower our scientists to generate high-quality, transparent, and reusable data. With access to HPC resources, storage alternatives, and the Bolin Centre Database, researchers can confidently navigate the complexities of data management, enabling collaboration and innovation, and helping the researchers to make impactful scientific contributions.

Read more here: https://bolin.su.se/data/support

The Bolin Centre's Modelling Coordination team

Numerical models of the global climate system are essential tools in research carried out at the Bolin Centre. Earth system models are used across 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 systems models. The Modelling Coordination team at the centre ascertains that the necessary computational resources are available for Bolin Centre researchers to be able to carry out this work.

Climate models – extensive and complex computer codes – 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 at the national level, and even larger facilities are available within Europe. The Bolin Centre's Modelling Coordination team's primary task is to ascertain that adequate resources are available for researchers within the Bolin Centre.

Climate models are important tools for improving our understanding of climate behaviour and the predictability of its effects on seasonal, annual, decadal, centennial, and millennial time scales. The Bolin Centre uses the climate models EC-Earth and NorESM to understand how the Earth's climate varies in time and space, and how physical and biogeochemical cycles, including human activities, interact with the climate system.

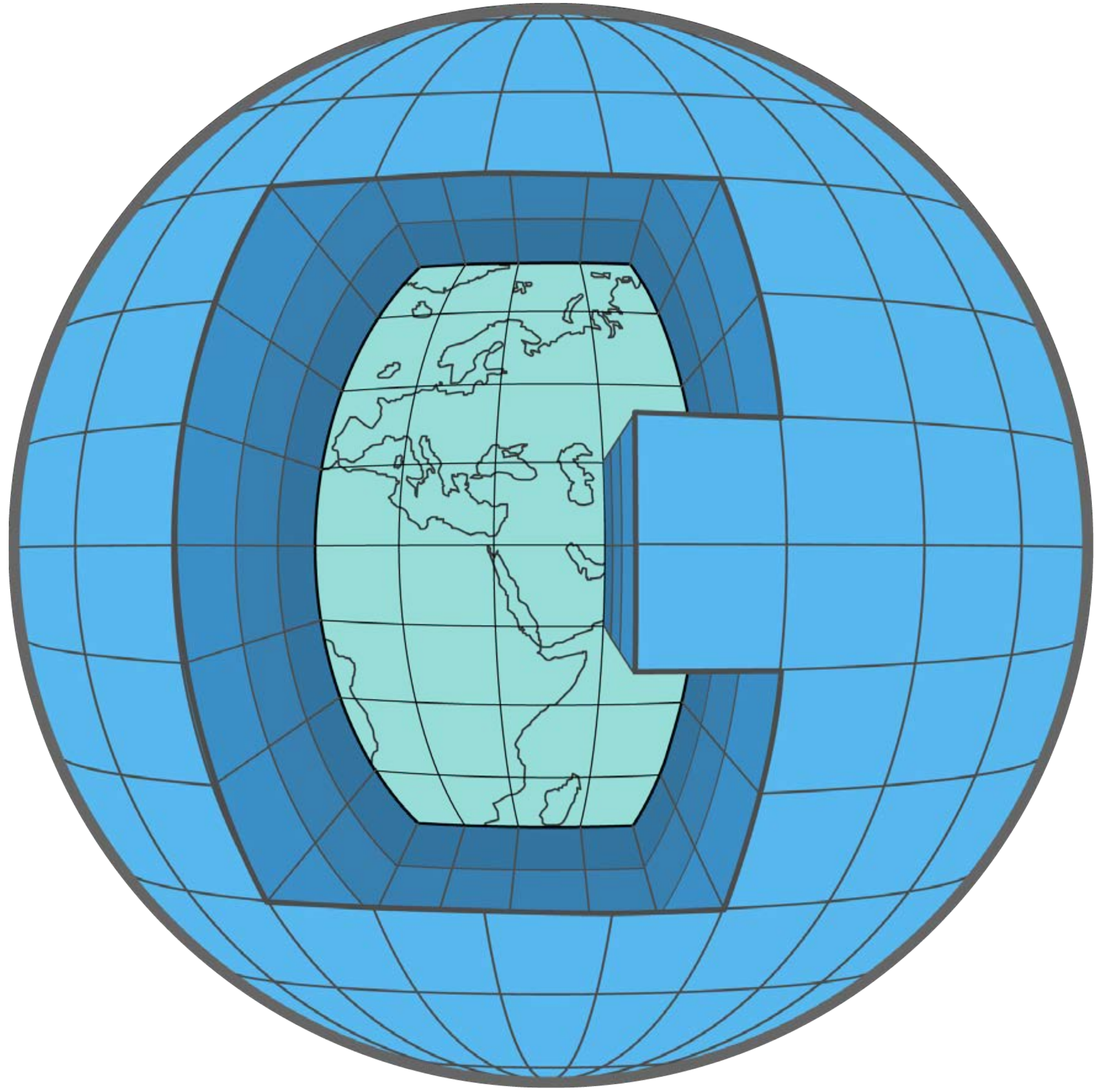
Bolin Centre researchers also use more detailed models than climate models to better understand different processes and interactions within the climate system; for example, models covering only a column of the atmosphere and ocean, ice sheet models, hydrological models, and large eddy simulations.

Modelling support activities at the centre

The modelling coordination team hosted the annual EC-Earth general assembly at Stockholm University in March. More than 70 on-site participants and 40 online guests from all over Europe presented and discussed scientific results and technical developments of this Earth System model. In particular, the development of a model version that will be used for the next phase of the Coupled Model Intercomparison Projects (CMIP) was a primary focus of discussion.

The openly available CMIP data archive contains a wealth of data, but can be a challenge to navigate for new users. A workshop series was held in spring 2025, aimed at PhD students and other scientists who would like to get started using these datasets. Invited speakers as well as scientists from the Bolin Centre shared their knowledge and experience of contributing data to CMIP, and workshop participants were offered an opportunity to gain practical experience working with the data.

Since the start of the National Academic Infrastructure for Supercomputing in Sweden (NAISS), Bolin Centre representatives have been part of the NAISS User Support Advisory Committee. A user meeting was organised at Stockholm University by the modelling coordination team to give local users of NAISS services from the whole university a chance to share their experiences and suggestions for improving these services.



A climate model is a three-dimensional representation of the atmosphere that is coupled with the Earth's surface and the seas. In short, the atmosphere and the seas are divided into a series of boxes, or grid cells. In each cell of the grid, values of the temperature, humidity, air pressure, wind speed, sea ice and vegetation are calculated. After the climate's condition in each cell has been calculated, a step forward in time is taken, and all values are calculated again. Illustration: SMHI

Communication and coordination

The Communication and Coordination team at the Bolin Centre works to facilitate effective communication and coordination throughout the organisation. Their responsibilities include creating content for diverse channels, organising outreach events, and coordinating both internal and external meetings and gatherings, such as the annual Bert Bolin Climate Lecture and Bolin Days. Additionally, they manage and produce engaging content for the Bolin Centre website and social media channels, along with providing regular newsletters to its members.

ECR Workshop: Your Science Story

On the 27th of January, the Bolin Centre and the SU Press Office co-organised a workshop on science communication with author and former researcher Jonas Enander. The workshop, titled *Your Science Story* was aimed towards our Early Career Researchers, with about 15 of them in attendance.

Jonas Enander has a PhD in physics and has worked as a post-doctoral researcher in cosmology. Today he devotes his energy to science writing and communication. He has worked as a science communicator at the European Southern Observatory and the Oskar Klein Centre, and regularly writes for different popular science magazines. In August 2024, he published the book *Mörkret & Människan: Om svarta hål och vår plats på jorden* on Albert Bonniers.

During the workshop, Jonas covered effective storytelling techniques that can be applied to different audience; from people with no technical background to funding committees. With the help of writing exercises, attendees left the workshop with the foundation needed to perfect their own science story.

Swedish Climate Symposium 2024
Climate science for society in an interdisciplinary conference

The second Swedish Climate Symposium was held in Norrköping on 15–17 May 2024.The Bolin Centre acted as co-organiser, together with SMHI and the strategic research areas BECC and MERGE at Lund University. Nearly 400 researchers, experts, and societal stakeholders took part in the event, where they each had the opportunity to share and discuss both social science and natural science perspectives on climate issues.

The overarching theme of the conference – climate science for society – encompassed three parts: understanding the climate system, examining societal and environmental challenges, and exploring possible pathways for society to address climate change.

The conference was first held in 2022, and this year it represented an even wider range of scientific disciplines. Over the course of the conference, topics such as the physical effects of climate change, urban planning, climate targets, modelling and observational tools, biodiversity, atmospheric science, agriculture, water resources, and climate justice were presented and discussed. More than 20 scientific sessions were held, and around 100 scientific posters were displayed and presented by researchers.

ForskarFredag 2024
The hunt for new knowledge about the Arctic

During the last week of September, over 25,000 students and members of the general public participated in ForskarFredag as a part of European Researchers' Night. Several Bolin Centre members participated in the exhibition *The hunt for new knowledge about the Arctic*, organised by the Geo- and Environmental Science Section at the university.

Highschool students and members of the general public had the chance to deepen their understanding of climate science through various interactive activities, such as enjoying a nice "spa treatment" in the Mini Geospa; getting a face mask made from clay from the North Pole along with some fresh glacial water to wash it off. Other elements of the exhibit included multiple instruments from the ARTofMELT expedition, a mailbox where visitors could send climate-related questions to researchers, Erasmus+ GeoVT project showing Earth Science through virtual reality, and lots of free profile products.

High school students visiting one of our activity booths during ForskarFredag, seen from above. Photo: Laila Islamovic

The Bolin Days 2024

The 16th edition of the Bolin Days took place on 13–14 November in Aula Magna at Stockholm University. The two-day internal conference started off with a session chaired by the directors together with the chair of the Bolin Centre Board, who gave an overview of current activities as well as updates from the various support groups at the centre. Before the poster competition commenced, Daniel Ospina from Future Earth presented the 10 New Insights in Climate Science.

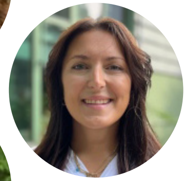
The traditional Bolin Days Dinner was held at the National Museum of Science and Technology, on the night of 14 November 2024. Photo: Laila Islamovic

Around 60 scientific posters were presented in the foyer of Aula Magna as part of the poster competition and exhibition. Thomas Hocking was awarded first place for his poster *Investigating the effect of reflected sunlight on satellite measurements of the Earth's energy imbalance*. Second place was awarded to Julia Asplund, for the poster *What we can learn from aerosol size distribution measurements over the spring Arctic pack ice*, and third place went to Abigail Robinson and the poster *The hydrological archetypes of wetlands*. You can read more about the competition and find examples of some of the posters on the website.

The scientific programme that formed the remainder of the conference included sessions designed to highlight the inter- and cross-disciplinary work between members and Research Themes, as well as the synergies that arise from these interactions. The sessions were titled *Polar Variability and Interactions*, *Biosphere–Atmosphere Interactions*, *From Small to Large Scales of Climate*, and *Hydroclimate Variability and Extremes: Past, Present, and Future*, nicely showcasing the diversity of research topics and the integration of knowledge across disciplines.

In keeping with tradition, the conference ended with a dinner, held this year at the National Museum of Science and Technology. Members had the opportunity to explore the museum, embark on a journey further out into space than any human has ever been through the 3D experience "VAST", and finally, enjoy a nice dinner together.

Maria Basova joined the Bolin Centre in September 2022 as coordinator. Photo: Uly Konstantinow



Laila Islamovic joined the Bolin Centre again in September 2023. Photo: Maria Basova

Sara Gershagen joined the Bolin Centre again in November 2024. Photo: Luliana Domina

The Bert Bolin Climate Lecture

Professor Bert Bolin was not only a leader in climate research, but also one of the founders of the IPCC, which received the Nobel Peace Prize in 2007. To commemorate his contributions, the Faculty of Science at Stockholm University established the annual Bert Bolin Climate Lecture.

Every year, the Faculty of Science selects a prominent scientist in the field of climate research to give the lecture, which is held at Stockholm University. The Bolin Climate Lecturer is appointed by the Dean of the Faculty of Science, and nominations can be made by all Bolin Centre members in response to a call. The lecture provides an opportunity for the distinguished scientist to give both a popular science lecture and a science seminar, sharing their knowledge and insights with the wider community.

The Bert Bolin Climate Lecturer for 2024 was Professor Ricarda Winkelmann from the Potsdam Institute for Climate Impact, University of Potsdam. Prof. Winkelmann, a professor at the University of Potsdam and PIK, leads research on Earth System dynamics, focusing on ice dynamics, ecosystem resilience, and tipping elements. She co-developed the Parallel Ice Sheet Model (PISM) and has received several awards for her work, including Young Scientist of the Year and the Karl Scheel Prize.

This year's lecture was titled *When giants falter: Tipping points in Greenland and Antarctica*, and was aimed at high school students and the general public. Storing ice volumes of more than 65 meters' sea-level equivalent, the ice sheets on Greenland and Antarctica are by far the largest potential source of future sea-level rise. Their stability therefore determines the long-term fate of coastal cities and cultural heritage sites around the world.

While massive in size, the ice sheets also belong to the most vulnerable parts of the Earth system: Feedbacks between ice, atmosphere, ocean, and solid earth give rise to nonlinearities in their response to progressing global warming. Once a critical temperature threshold is crossed, this could lead to self-sustained and potentially irreversible ice loss from Greenland and Antarctica.

Professor Winkelmann covered the processes behind these dynamic instabilities, discussing the risk of crossing ice-sheet tipping points in the near future, and explored the resulting impacts on sea-level rise and our global climate – not just for this century, but for the next millennia and beyond.

The results illustrate how near-term greenhouse-gas emissions will lead to long-term impacts that change the face of our planet. This calls for the need to redefine inter-generational climate responsibility; from near-term human impacts to long-term commitments that determine liveability on Earth.

The annual Bert Bolin Climate Lecture invites high school-students from around Stockholm, this time to the Beijer Hall at the Royal Swedish Academy of Sciences. Photo: Laila Islamovic

Director of the centre Ilona Riipinen (to the left) together with the 2024 Bert Bolin Climate Lecturer Professor Ricarda Winkelmann. Photo: Laila Islamovic

Lecturers

2024 | Professor Ricarda Winkelmann
When giants falter: Tipping points in Greenland and Antarctica

2023 | Professor Trude Storelvmo
The big unknown in future Climate projections

2022 | Professor Hans Joosten
The Great Rewetting: Why we must stop draining peatlands worldwide and as fast as possible

2021 | Professor Emeritus William F Ruddiman
For how long have humans affected the climate?

2020 | Professor Roberto Buizza
Climate Change: How can we motivate transformation?

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

For a clomplete list of all the Bert Bolin Climate Lecturers please visit:
www.bolin.su.se/Research/Conferences and seminars

Bolin Climate Lecture 2024

When giants falter: Tipping points in Greenland and Antarctica

Lecture by Professor Ricarda Winkelmann, Potsdam Institute for Climate Impact Research (PIK), University of Potsdam, Germany

With expertise in climate system analysis and ice dynamics, Professor Winkelmann will delve into critical thresholds of ice-sheet stability and will shed light on the potential impacts of Greenland and Antarctica's ice dynamics on global sea-level rise and climate change.

The lecture will be given in English.

Register and learn more by scanning the QR-code.

Welcome!

08 MAY

Time: 14h00–15h00
Place: Beijersalen
The Royal Swedish Academy of Sciences

Stockholm University

The Bolin Centre Board

The Bolin Centre is led by the Bolin Centre Board, which comprises representatives from all of 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.

Professor Regina Lindborg
Chair of the Bolin Centre Board, Department Physical Geography, Stockholm University.

Professor Johan Nilsson
Vice-chair of the Bolin Centre Board, Department of Meteorology, Stockholm University.

Professor Anna Sobek
Department of Environmental Science, Stockholm University.

Professor Annica Ekman
Department of of Meteorology, Stockholm University.

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Professor Helena Martins
Swedish Meteorological and Hydrological Institute.

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PhD student, Department of Physical Geography, Stockholm University.

Daniella Lillieroth Charalambous
Department of Physical Geography, Master's Student.

Professor Ilona Riipinen
Ex Officio, Director of the Bolin Centre, Stockholm University.

Professor Gustaf Hugelius
Ex Officio, Vice-Director at the Bolin Centre, Stockholm University.

Maria Basova
Ex Officio, Coordinator at the Bolin Centre, Stockholm University.

Laila Islamovic
Ex Officio, Communicator at the Bolin Centre, Stockholm University.

Please note that the list of board members is accurate as of December 2024. Later changes to board membership may have occurred. The most up-to-date information can be found on our website: www.su.se/bolin-centre-for-climate-research/about-the-centre/organisation

Photo: Inês Jakobsson

The External Science Advisory Group

The Bolin Centre has appointed an ESAG composed of leading national and international scientists working 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 to increase the Bolin Centre's contacts with international networks and research groups within the climate research area.

Professor Jay Famiglietti (chair)

Arizona State University, School of Sustainability, College of Global Futures.

Professor Karen E. Kohfeld

Director and Professor, School of Environmental Science Professor, School of Resource and Environmental Management at Simon Fraser University, Burnaby, Canada.

Professor Camille Parmesan

National Aquarium Chair in the Public Understanding of Oceans and Human Health at the University of Plymouth U.K., at SETE – Theoretical and Experimental Ecology Station, CNRS *Centre National de la Recherche Scientifique*, France, and is adjunct professor at The University of Texas at Austin, U.S.A.

Professor Victor Brovkin

Max-Planck Institute for Meteorology, Department of Climate Dynamics.

Professor Trude Storelvmo

University of Oslo, Department of Geosciences, Meteorology and Oceanography Section.

Please note that the list of ESAG members is accurate as of December 2024. Later changes to the ESAG membership may have occurred.
You can find the most up-to-date information on: www.su.se/bolin-centre-for-climate-research/about-the-centre/organisation

Photo: Martin Jakobsson

Bert Bolin – a world-leading scientist and science organiser

Bert Bolin joined the newly created Department of Meteorology at [1]Stockholm University in 1948 as an assistant to Professor Carl-Gustaf Rossby. Apart from a few brief absences, 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 a natural leader. He initiated several research programmes focusing on the global environment including the World Climate Research Programme and the International Geosphere-Biosphere Programme.

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 the IPCC has been confirmed by many. The IPCC received the Nobel Peace Prize in 2007.

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

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

Henning Rodhe
Bert Bolin's student, colleague and friend

You can watch a slide show about Bert Bolin and the Bolin Centre for Climate Research at https://www.su.se/english/about-the-university/cultural-heritage-and-history/the-history-of-stockholm-university/bert-bolin-founder-of-the-climate-panel-and-world-leading-scientist-1.531330

Photo: Inês Jakobsson

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, and in 2010 the KTH Royal Institute of Technology and the Swedish Meteorological and Hydrological Institute joined the centre.

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.

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