

Marking 150 years of systematic Norwegian oceanographic data collection



The Nordic Seas play a key role in the large-scale ocean circulation connecting the Atlantic and Arctic ocean, and strongly influence global ocean dynamics and regional climate. Key physical processes in this region revolve around the northward transport of warm water from the Atlantic, local dense water formation, and the southward transport of this dense water along with fresh water and sea ice. 2026 marks 150 years since the Norwegian Vøring Expedition, which is considered the beginning of modern systematic oceanographic data collection and exploration. This year's ASOF Workshop (see p15) includes a special session of talks to celebrate the 150th anniversary of the Vøring Expedition, charting the progress of oceanographic research in the region.

Photo courtesy Tim Kalvelage

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EPOC results show Ice Age Atlantic circulation stayed active despite extreme cold

By Jack Wharton, University College London

As part of EPOC's efforts to develop a more holistic understanding of the Atlantic Meridional Overturning Circulation and its influence on weather and climate, researchers have been investigating ocean conditions during one of the most extreme periods in Earth's recent history: the Last Glacial Maximum, around 20,000 years ago.



Although much of EPOC's paleoceanographic work focuses on the instrumental era, new results published in *Nature* show that data from the last ice age provide important context for understanding Atlantic Meridional Overturning Circulation (AMOC) functioning under a fundamentally different climate state.

The Last Glacial Maximum (LGM), some 20,000 years ago, was characterised by global temperatures around 6°C colder than today, extensive ice sheets across much of the Northern Hemisphere – major cities such as Toronto would have been buried beneath some 3 km of ice – and sea levels approximately 120 m lower (Fig. 1). Previous paleoceanographic studies have generally suggested that

the AMOC was weaker during the LGM, accompanied by a shoaling of the boundary between northern-sourced (North Atlantic Deep Water, NADW) and southern-sourced waters to around 2 km depth. As a result, much of the deep North Atlantic is thought to have been filled with southern-sourced waters that were close to freezing, although reconstructions of past hydrographic properties, such as temperature, have been limited to a handful of spot measurements.

Using new geochemical measurements from fossil shells preserved in North Atlantic sediments, EPOC researchers at University College London found that NADW during the LGM was surprisingly warm and salty. Across sites spanning depths from ~1.5 to 4 km, reconstructed deep-



THICKNESS OF THE ICE SHEETS AT VARIOUS LOCATIONS 21,000 YEARS AGO COMPARED WITH MODERN SKYLINES

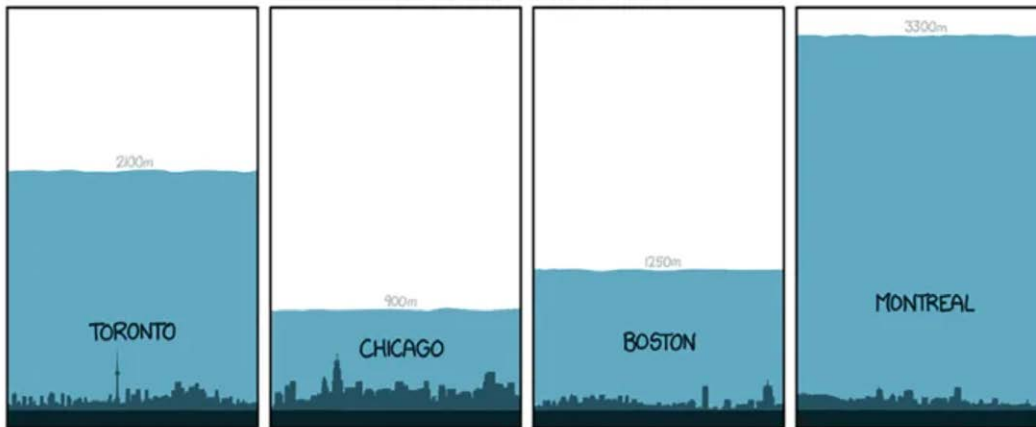


Figure 1: The height of the Laurentide Ice Sheet 21,000 years ago (blue) compared to modern skylines (black) in Toronto, Chicago, Boston, and Montreal. In each city, the Laurentide Ice Sheet wins the height contest. Image courtesy XKCD, sourced from [nsidc.org/learn/ask-scientist/where-will-sea-level-rise-most-ice-sheet-melt](https://www.nsidc.org/learn/ask-scientist/where-will-sea-level-rise-most-ice-sheet-melt)

ocean temperatures were on average only about 1.8° C colder than today – far from the near-freezing conditions previously assumed.

The study analysed benthic foraminifera – tiny organisms whose shells record the temperature and chemical composition of the seawater in which they lived – from marine sediment cores recovered across the North Atlantic (Fig. 2). By combining temperature-sensitive geochemical proxies with stable oxygen isotope data, the researchers were able to constrain both temperature and salinity, revealing a clear chemical fingerprint linking glacial deep waters to surface waters originating western subtropical Atlantic. Taken together, these results indicate that the AMOC remained active during the ice age, continuing to transport warm salty waters into the North Atlantic.

Another important implication of this work is its role in helping reconcile climate model simulations of the LGM

– which typically simulate a relatively strong AMOC and limited shoaling of NADW – with paleoceanographic proxy evidence that has suggested a weaker and more shoaled glacial circulation. Our new proxy data show that during the LGM, NADW extended to depths similar to today, bringing proxy evidence into closer agreement with climate models and increasing confidence in their ability to simulate ocean circulation. These findings once again remind us of the strong impact continued global warming will have on ocean circulation, as the same climate models that correctly predicted this past behaviour also warn that these currents are vulnerable to weakening as the planet warms.

Read the full article: Wharton et al. (2026) Relatively warm deep water formation persisted in the Last Glacial Maximum. Published in *Nature*: [nature.com/articles/s41586-025-10012-2](https://www.nature.com/articles/s41586-025-10012-2)

nature

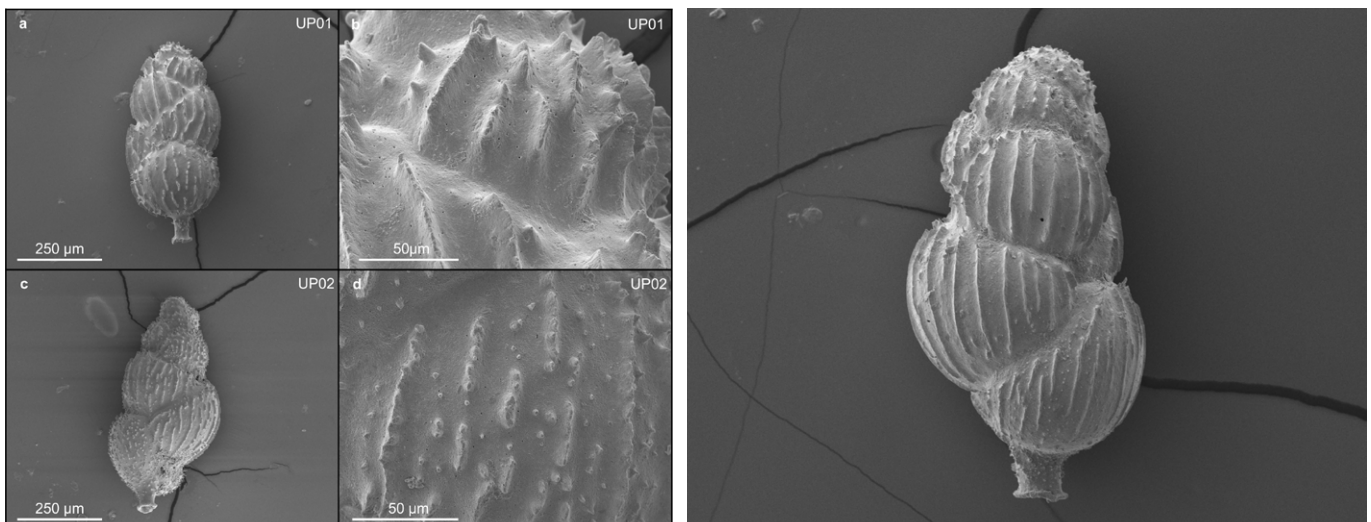


Figure 2: Scanning electron microscope (SEM) images at different magnifications of the benthic foraminifer *Uvigerina peregrina*, one of the species used in this study. The specimen was recovered from sediments deposited around 21,000 years ago at a water depth of approximately 3 km off the coast of North Carolina and Florida. Images courtesy Mark Stanley, Department of Earth Sciences, UCL.

Bridging the gap: Bringing ocean biogeochemistry to AMOC mooring arrays

A landmark workshop in Edinburgh brought marine biogeochemists, physical oceanographers and mooring engineers together to discuss how to increase collaboration

On 20 February 2026, EPOC convened a cross-disciplinary workshop to explore how the mooring arrays that monitor the Atlantic Meridional Overturning Circulation (AMOC) could also serve as platforms for measuring the ocean's chemistry. Forty-eight physical oceanographers, marine biogeochemists and mooring engineers from 22 institutions gathered at the National Museum of Scotland in Edinburgh and online to share knowledge and identify opportunities to build on each other's work.

AMOC has been measured by purpose-built mooring arrays for more than two decades. The RAPID array at 26°N has operated continuously since 2004; the OSNAP array, which monitors the overturning in the subpolar North Atlantic, has been running since 2014. These systems have measured the physics of AMOC with exceptional precision: temperature, salinity and water velocity, from which the strength of the circulation can be calculated. What they have measured far less consistently are biogeochemical properties such as carbon uptake, oxygen and nutrient concentrations – parameters that determine the ocean's role as a carbon sink and a driver of marine productivity. As the AMOC changes under a warming climate, understanding how those changes affect the ocean's ability to absorb carbon and sustain marine ecosystems requires the physics and the biogeochemistry to be measured concurrently, in the same place.

What the science already tells us

The morning sessions made a compelling scientific case for adding biogeochemical (BGC) sensors to mooring arrays. EPOC project coordinator Eleanor Frajka-Williams (U. Hamburg) opened proceedings by setting out the project's rationale for instrumenting mooring frames with BGC sensors alongside their physical counterparts, establishing the context for the day's discussions. To complement this, Pete Brown (NOC) presented a pan-Atlantic overview of where BGC sensors have already been deployed on mooring arrays, from Davis Strait in the north to the subtropical 26°N RAPID array. He highlighted that estimates of carbon transport

derived from temperature and salinity measurements alone carry a systematic bias of approximately 15% in the overturning component. Direct measurements of nitrate and pH removes that bias – indicating that without BGC sensors, ocean carbon transport cannot be accurately calculated.

Clare Johnson (SAMS) presented timeseries data that demonstrate the variability of nutrient and carbon transport by the North Atlantic Current through the eastern boundary of the OSNAP array, whilst Jannes Koelling (U. Washington) showed that a single oxygen sensor, positioned at the right depth on the western OSNAP boundary mooring, is sufficient to track the seasonal export of oxygen-rich Labrador Sea Water – the dense, ventilated water mass formed by winter convection in the Labrador Sea and a key component of the overturning. Wilken-Jon von Appen (AWI) provided a striking example of why physics and chemistry should be measured together, using data from the long-running mooring array in Fram Strait to show that year-to-year variability in sea-ice export creates order-of-magnitude differences in surface ocean stratification.

From sensor to science: the practical challenges

The workshop's afternoon agenda turned to the practical realities of integrating BGC sensors into mooring array programmes and highlighted why bringing engineers and scientists together in the same room matters.

Sara Fowell (NOC) explained how lab-on-chip sensors developed for measuring nutrients, pH and total alkalinity at depth have been successfully deployed on the RAPID eastern boundary mooring, producing the first autonomous, high-frequency pH and alkalinity time series from a transport array. Darren Rayner (NOC) offered a practical guide to integrating oxygen, pH, pCO₂ and nitrate sensors into mooring designs, drawing on deployments across RAPID, the OSNAP/Ellett Array and the C-STREAMS programme. He offered two key messages: the simplest approach is often the most reliable, and planning for failure rather than assuming success is a realistic engineering approach!



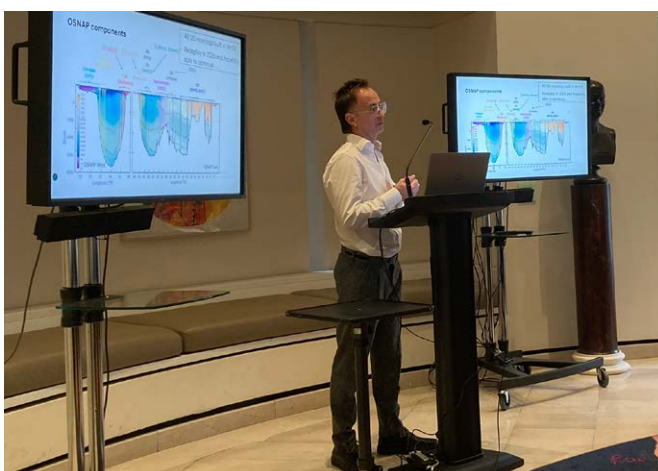
Hilary Palevsky (Boston College) described two programmes that have set benchmarks for BGC sensing on mooring arrays: the Ocean Observatories Initiative (OOI) Irminger Sea array, which has carried oxygen, pCO₂, pH, bio-optics and nitrate sensors since 2014, and GOHSNAP (Gases in the Overturning and Horizontal circulation of the Subpolar North Atlantic Program), which added 65 oxygen optodes to the OSNAP array from 2020. She concluded that moving from raw sensor data to calibrated, science-ready time series requires sustained expert effort and genuine collaboration across disciplines, and highlighted the [OOI BGC Sensor Data Best Practices and User Guide](#) as a useful starting point for any programme embarking on this work.

Logistics, access, and the next frontier

Shane Elipot (U. Miami) addressed logistical questions around sensor deployments on mooring arrays. He outlined the processes, timelines and practical challenges involved in planning fieldwork, whilst Laura de Steur (NPI) outlined the annual cruise cycle for the Fram Strait Arctic Outflow Observatory, which has monitored Arctic freshwater and sea-ice export since 1991. Pete Brown (NOC) described the Davis Strait array's two-year turnaround cycle and recent progress adding water samplers to the existing instrument suite. The message from all presenters highlighted that the arrays are open to new participants, the lead times are manageable, and the first step is simply making contact.



An open science session comprised six further presentations on priority questions at the frontier of BGC and AMOC research: carbon and nutrient dynamics at the equatorial Atlantic mooring (Franz-Philip Tuchen, U. Miami); nutrient export through Fram Strait and the wider Arctic gateway budget (Sinhue Torres-Valdés, AWI); the role of mooring arrays within a global carbon observing architecture (Ajit Subramaniam, LDEO); particle flux and the deep biological carbon pump (Rainer Kiko, GEOMAR); AMOC's biogeochemical connectivity across latitudes (Tillys Petit, NOC); and the complementarity of moorings with gliders, Argo floats and ships (Rebecca McPherson, AWI).



Workshop conclusions

The final session of the afternoon revolved around breakout discussions that allowed participants to discuss thoughts and key issues that had come up as a result of the presentations. Key points arising included:

- *Oxygen as standard*: Oxygen sensors are now sufficiently mature, reliable and affordable to be treated as standard

Left: Presenters at the workshop included (from top) Pete Brown (NOC), Eleanor Frajka-Williams (U.Hamburg) and Shane Elipot (U. Miami).

equipment on all transport mooring arrays. The calibration effort does not scale linearly with sensor numbers: once a trained analyst is on a research ship, adding more sensors costs relatively little in time or money. Adopting this recommendation across the community would be a significant step forward for the availability of biogeochemical information from the AMOC observing network.

- *Wait before cutting:* Several AMOC mooring arrays have been scaled back in recent years, reducing the number of instruments deployed. Workshop participants agreed that further reductions should be deferred until Observing System Simulation Experiments (OSSEs — computer-based studies that model what scientific information would be lost if specific sensors were removed) have assessed the biogeochemical consequences. Without this assessment, there is a real risk of removing sensors that are critical for resolving BGC variability but whose value is not visible to a purely physical oceanography appraisal.
- *The bottleneck is organisational, not technical:* For most of the parameters the community wants to measure, sensors now exist and have been demonstrated on long-term deep deployments. Their wider adoption is hindered not by a technology gap but a structural one: physical

oceanography and biogeochemistry groups rarely plan deployments together, share shiptime or pool calibration expertise. Breaking down those silos was identified as the single most important step the community could take.

- *Open the door:* Participants identified an information gap: no shared resource currently exists to explain how to get involved in mooring array programmes, including timelines, permit requirements and contacts. Pete Brown and Eleanor Frajka-Williams endorsed a move to change this in their closing remarks, with the caveat that any such resource should be designed to remain useful as personnel and programmes evolve over time. The EPOC community will consider how best to take this forward.

Next steps

A full report documenting the workshop's presentations and discussions is in preparation, and outputs will feed directly into an assessment of BGC observing on transport mooring arrays – a key EPOC deliverable that will be shared with the wider ocean observing community. Opportunities will be sought to continue the discussions started at this workshop at future events.





AMOC in the media spotlight

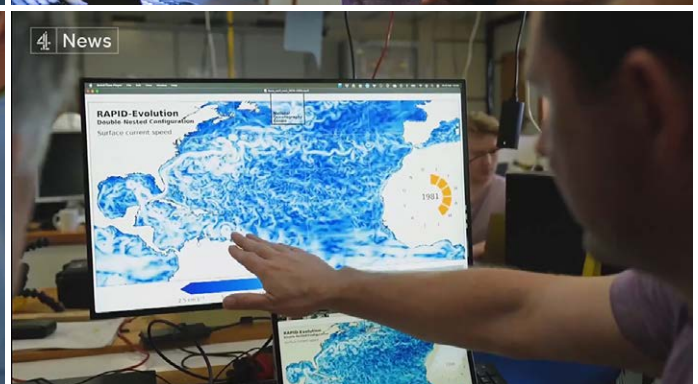
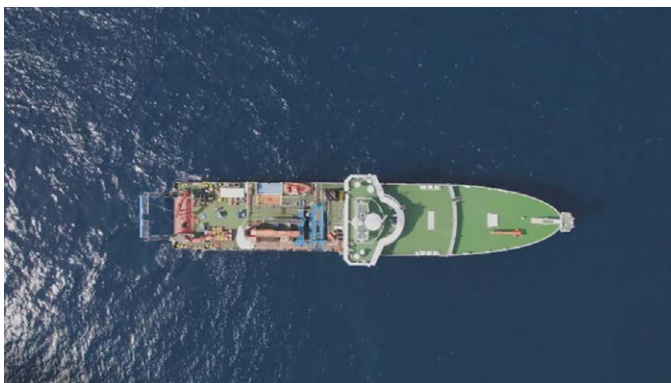
Atlantic Ocean circulation research reached millions when the UK's Channel 4 News featured an extended segment on the National Oceanography Centre's recent research expedition to the RAPID array monitoring system. This timely focus on the Atlantic meridional overturning circulation (AMOC) came just as the world's ocean scientists gathered in Scotland for the Ocean Sciences Meeting in Glasgow (22-27 February 2026; see p8). The convergence of prime-time TV coverage and the OSM conference reflects growing recognition that AMOC variability matters for climate, weather and ecosystems.

The Channel 4 News feature, [The key Atlantic current that could change Europe's climate forever](#), documented RAPID array operations off Tenerife in a broadcast that went out on primetime UK TV on 10 February. Viewers watched oceanographers recover instrumentation from 3000 m depth and download data from sensors encrusted with marine life. The tension of redeploying a RAPID array deep-sea mooring was also captured.

NOC Principal Scientist Dr Ben Moat walked audiences through 20 years of AMOC variability, focusing on the 2009-2010 "perfect storm" when AMOC strength plummeted and heat flow toward Europe dropped by 30%. This dip was accompanied by the coldest December experienced by the UK in a century, while New York City simultaneously experienced 13 cm of sea level rise.

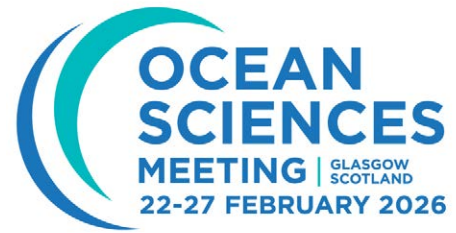
NOC's Dr Adam Blaker – who currently coordinates EPOC's work on quantifying past AMOC change – demonstrated climate models tracking AMOC from the 1970s to present, explaining how models are validated against decades of RAPID observations.

Despite being only 6 minutes in length, this news feature allowed audiences to link the importance of AMOC to their everyday lives whilst also showcasing the need for sustained ocean monitoring.



Clockwise from top left: Aerial shot of RRS Discovery in the Atlantic; EPOC's Adam Blaker (NOC) demonstrates how ocean data contributes to climate models; outputs from the RAPID dataset show variations in AMOC behaviour over time; NOC scientist Ben Moat explains recent trends in AMOC strength. All images courtesy Channel 4 News.

OSM2026: a week at the heart of global ocean science



The AGU Ocean Sciences Meeting 2026, held in Glasgow on 22-27 February, brought together more than 6000 researchers from across the global ocean science community. For EPOC, the week provided a platform to present advancing science to an international audience and to contribute to the wider conversations shaping the future of AMOC research, from observing system design to the question of what the community should be demanding of funders and governments. And an ideal opportunity for EPOC to bring ocean science into the public eye too...

A busy week at the Ocean Sciences Meeting

EPOC's week at OSM kicked off with a Town Hall meeting on *AMOC Observations in Transition: Metrics, Technologies, and Strategies*. Co-hosted by Eleanor Frajka-Williams (U. Hamburg), Adam Blaker (NOC), Pete Brown (NOC) and Sjoerd Groeskamp (NIOZ), the session comprised short presentations, including from across the EPOC community, on proposed metrics for AMOC monitoring and updates on emerging technologies – including drift-free bottom pressure sensors and lab-on-a-chip biogeochemical sensors. The discussion that followed was wide-ranging, with funding security forming a major theme. A comparison was made with the astrophysics community, which secures public funding for space telescope programmes costing billions; an ocean observing programme that could deliver tangible benefits for monitoring European climate could be implemented for a fraction of that cost. A question put to the room was whether the AMOC community has argued its case with sufficient ambition.

The following day, Eleanor Frajka-Williams (U. Hamburg) delivered one of the two OSM26 science plenaries to approximately 3,000 delegates. Her presentation surveyed the current state of knowledge on the AMOC: what sustained observations have established about the AMOC structure and variability, where the key uncertainties remain, and what the community requires to address them.

From the deep past to future projections

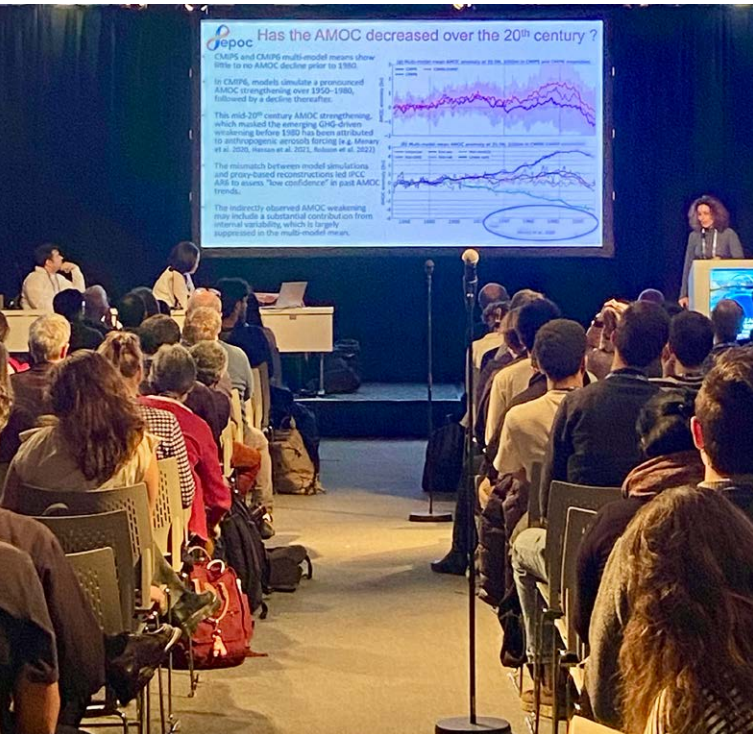
Beyond the plenary and the Town Hall, EPOC researchers contributed oral presentations and posters that covered the full breadth of the project's science. A few themes stood out:

Palaeoclimatology presentations offered two complementary windows onto past AMOC behaviour, each with direct implications for how the circulation and its variability are currently understood. David Thornalley (UCL) used sediment core data from the eastern North American continental margin to reconstruct changes in the Deep Western Boundary Current (the southward-flowing lower limb of the AMOC) across the past 90,000 years, with results challenging the traditional 3-mode view (warm, cold, off) of AMOC state.

Zarina Hewitt (NOC) examined the 8.2 ka BP event – the most prominent abrupt climate event of the Holocene, associated with a pulse of freshwater from the collapse of the Laurentide Ice Sheet and widely used as a test case for understanding how freshwater anomalies affect the AMOC and wider climate. Hewitt's results point to only a moderate AMOC weakening of up to approximately 20% at this time – substantially less than some earlier estimates – indicating that other mechanisms are needed to explain the full pattern of cooling and drying observed during the event.

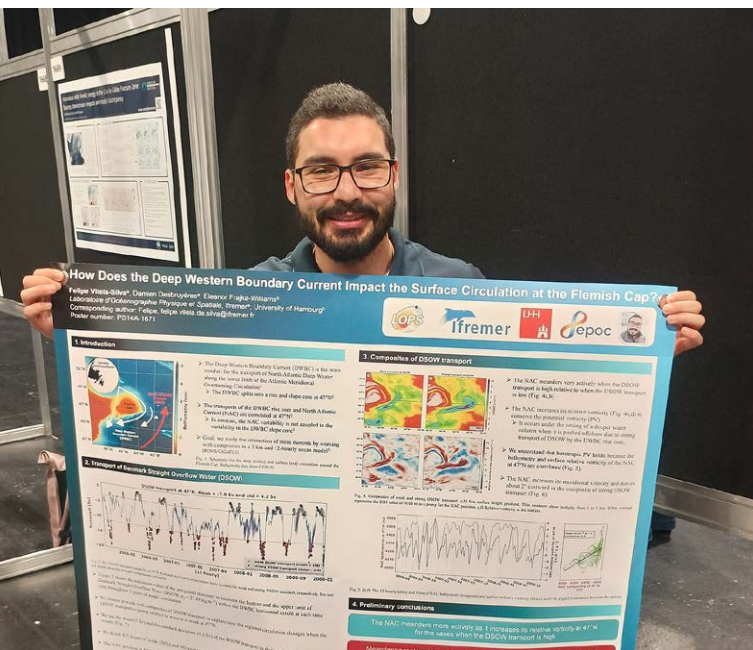
Left: AMOC Town Hall co-hosts Adam Blaker, Pete Brown, Sjoerd Groeskamp and Eleanor Frajka-Williams.





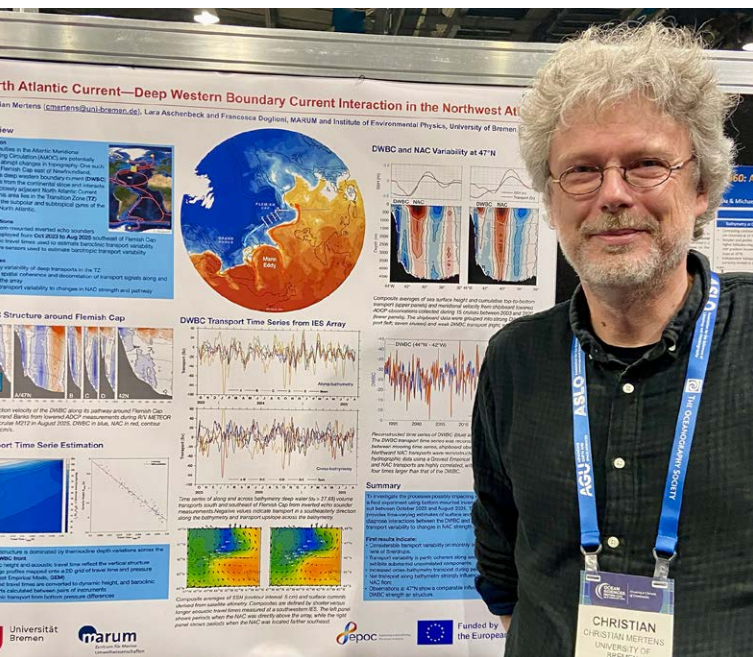
In **modelling**, Rym Msadek (CNRS/CERFACS) examined the respective contributions of greenhouse gas forcing and atmospheric aerosols to AMOC evolution between 1950 and 2014. Both historical simulations and fixed greenhouse gas experiments show a stable AMOC from 1950 to 1980. After 1980, the historical simulations show AMOC weakening driven by greenhouse gas forcing, while the Fixed-GHG runs show a persistent AMOC increase – a delayed response to the Mount Pinatubo volcanic eruption and the effects of anthropogenic aerosols.

Hongdou Fan (MPIM) presented results from 35-year global ICON coupled model simulations at a resolution sufficient to resolve individual ocean eddies and storm-scale atmospheric processes. These reveal that the maximum overturning occurs at a relatively shallow depth, and whilst the eddies themselves contribute only modestly to the overturning transport directly, they play an important indirect role by flattening steep density surfaces and shallowing the mixed layer. The results help reconcile two frameworks, density-based and depth-based, that have historically produced different pictures of where and how the AMOC's downward transport occurs.



Laura de Steur (NPI) presented more than three decades of **observations** of Arctic freshwater and sea ice export through the East Greenland Current in Fram Strait using year-round subsurface mooring data. The record reveals a significant decline in the proportion of the sea-ice component, as well as a dramatic increase in oceanic freshwater transport between 2020-2024, attributed to changes in large-scale atmospheric and ocean circulation patterns in the Arctic. Excess freshwater export through Fram Strait has the potential to affect stratification and water mass formation in the North Atlantic and subsequently influence the AMOC, making continued monitoring of this gateway a scientific priority.

Many other EPOC scientists contributed to the programme at OSM2026 - a full list of EPOC contributions is online at epoc-eu.org/our-work/epoc-osm2026.



Left, from top: Rym Msadek (CERFACS) presenting modelling results that show the impact of increasing anthropogenic aerosols on the AMOC; Felipe Vilela-Silva (Ifremer) preparing to share results from the Flemish Cap at a poster session; Christian Mertens (U. Bremen) presents his work on North Atlantic Current - Deep Western Boundary Current interaction.

Eye on the Ocean

EPOC brings the the delights of oceanography to the public at the Glasgow Science Centre with a day of fun, debate and education

On Saturday 21 February, Glasgow Science Centre hosted *Eye on the Ocean* – a public ocean science showcase organised by the EPOC stakeholder engagement team to coincide with the arrival of OSM26 delegates in the city. Nine marine science organisations provided interactive ocean fun and activities to almost 2000 visitors. At the EPOC stand, Vikki Gunn and Russell Arnott (Seascope Consultants) and Hongdou Fan (MPIM) introduced visitors to the AMOC using recent Channel 4 media coverage of the recent RAPID array expedition alongside high-resolution AMOC ocean-climate simulations. Adam Blaker and Parvathi Vallivattathillam (NOC) projected ocean data visualisations of currents, carbon uptake and heat transfer using a Puffersphere 3D touch globe on loan from Pufferfish Displays Ltd, based in nearby Edinburgh.

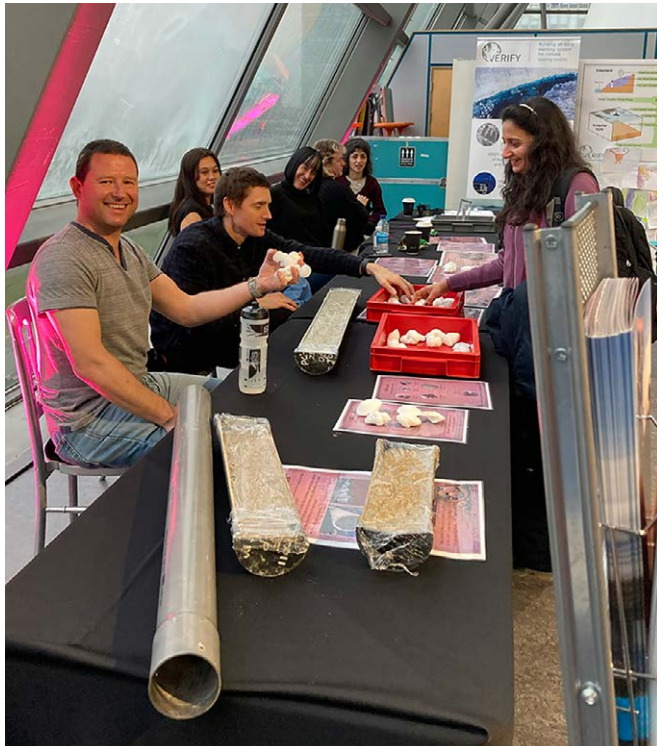
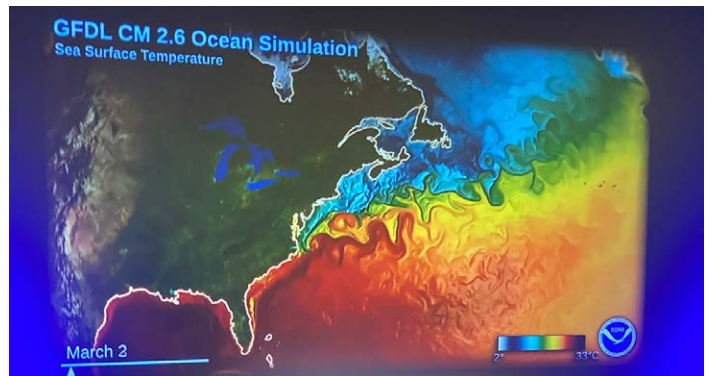
David Thornalley, Jack Wharton and colleagues (UCL) took over a corner of the exhibition hall to introduce elements of palaeoclimatology, including a foraminifera-sorting activity in which visitors inferred past climate conditions from two contrasting fossil assemblages, a marble-fed tipper game that illustrated how incremental changes in a physical system can trigger rapid and irreversible transitions, and a very popular palaeo-themed colouring corner. Other exhibits included a demonstration of the physics of ocean temperature and salinity (SAMS), an introduction to the AMOC and how it transports heat around the ocean (NOC), a journey to the roots of physical oceanography (Greenwich Museums Trust), and a look at how ocean conditions affect marine life in the deep ocean and along the shoreline (U. Glasgow).

At lunchtime, a special ticketed event in the Centre's IMAX theatre saw Helen Czerski (UCL) deliver a public talk on why physical oceanography matters, drawing on her new book *Blue Machine*. Following her talk, a strongly-contested and at times heated but fun public debate saw David Thornalley, Kristin Burmeister (SAMS), Lea-Anne Henry (U. Edinburgh) and Russell Arnott championing their favourite pieces of scientific equipment in the hope of preventing them from being cast overboard to save their sinking research ship. With the assistance of ocean modeller Gaurav Madan (U. Reading), the 120-strong audience quizzed the panellists on the size, weight, cost and scientific merits of their equipment and then cast their votes on which piece of kit should be jettisoned to save the ship. Up against a sediment corer, a CTD rosette and a robotic glider, Lea-Anne made an impassioned case for her ROV and won the overall audience vote. To calm everyone's excitement at having saved the ship, the debate was followed by a 3D screening of the film *Ocean Odyssey*, which follows the fate of a juvenile humpback whale as it navigates the ocean currents... but the robotic glider attracted a small backstage fanclub as it made its way from the theatre back up to the exhibition hall – accompanied by some big science questions from some of the youngest audience members!

Our sincere thanks go to all the exhibitors and volunteers who gave up their weekend to make the day a success, and also to the team at Glasgow Science Centre for their excellent support in the run up to and during the event.



Early visitors to the Eye on the Ocean public exhibition shortly after opening at the Glasgow Science Centre



Clockwise from top left: The EPOC stand at the entrance to Eye on the Ocean; Helen Czerski (UCL) explaining why ocean physics matters to a public audience; David Thornalley (UCL) making the case for deep-sea mud during the 'Save our Ship' science debate; NOC's Adam Blaker and Parvathi Vallivattathillam take a break from demonstrating ocean data on the Puffersphere to be enlightened about forams at the 'palaeo corner' of the Eye on the Ocean exhibition.

A new recruit to EPOC's outreach team

EPOC's outreach and stakeholder engagement team is delighted to welcome a new recruit! Dr Russell Arnott is a marine scientist trained in physical oceanography and ocean ecology, with a PhD from the University of Bath. His research examined how turbulent mixing shapes phytoplankton communities, combining mesocosm experiments with fieldwork in the Baltic Sea and the Southern Ocean.

Russell has worked across academic research, applied science and education, teaching oceanography, climate processes, and science communication. He previously worked as a survey oceanographer, contributing to coastal and offshore environmental monitoring programmes and supporting data collection for environmental impact assessments. Alongside his oceanography background, Russell brings experience in

science communication and engagement, having delivered training and engagement activities for international research programmes, with a focus on communicating complex ocean and climate science to non-specialist audiences.



Russell joined Seascope Consultants in February and will support the EPOC partnership by translating complex research outputs into clear, digestible material for stakeholders and policymakers. Contact him at russell.arnott@seascopeconsultants.co.uk

Probing the ocean's memory

By Hongdou Fan, Max Planck Institute for Meteorology



My journey into understanding the ocean's role in Earth's climate began during my Master's studies, where I applied information theory to investigate how ocean surface conditions, sea ice, and snow cover shape the predictability of winter temperatures. Fascinated by the ocean's long memory, I developed an ECMWF-based calibration algorithm to predict midlatitude Eurasian winter temperatures. This system has been running operationally since 2021 and now supports China's National Winter Forecast Annual Consultation. During my PhD, my research shifted toward ocean dynamics and predictability. I demonstrated that subdecadal salinity predictability in the Nordic Seas originates from the North Atlantic subpolar gyre, whereas temperature predictability is much weaker—likely damped by strong air-sea fluxes along the North Atlantic and Norwegian Atlantic Currents. These findings sharpened my scientific focus on the AMOC and its underlying physical mechanisms.

Since December 2025, I have been co-leading EPOC work packages 2 and 4, running storm- and eddy-resolving global coupled ICON (ICOsahedral Non-hydrostatic atmosphere model) simulations to investigate the downward limb of the

AMOC. My current focus is on understanding why Eulerian diagnostics and isopycnal (water mass-based) perspectives yield markedly different estimates of downward volume transport – a question that goes to the heart of how we conceptualise and quantify ocean overturning. The past year has been both challenging and deeply rewarding: working at these unprecedented resolutions has been exciting, intellectually stimulating, and has further deepened my fascination with the complexity of the AMOC.

Looking ahead, my next major research focus will be the meridional connectivity of the AMOC, with particular emphasis on the role of mesoscale eddies in meridional transport. We will leverage global coupled ICON simulations with resolution down to 1.8 km around the Flemish Cap and directly compare them with targeted observational field experiments conducted within the project. While the ocean's rich mesoscale eddy field is visible at every moment, their contribution to large-scale meridional transport remains poorly understood. I am excited to tackle this challenge and to explore the mechanisms governing the meridional coherence of the AMOC.



Building shared data tools for the AMOC community



The AMOC is monitored across the Atlantic by an international network of observing arrays: RAPID, OSNAP, MOVE, and SAMBA, among others. Each operates independently and generates data products in different formats. As such, comparing results across these systems or building analyses that draw on more than one of these sources requires researchers to spend significant time on data handling before any science can begin.

The [GitHub AMOCcommunity](#) is an open platform established to help change this, by providing a shared space for the international research community to develop and maintain tools, datasets, and standards for AMOC research. It directly addresses expectations set by the CLIVAR AMOC Task Team for improving access to AMOC observational data and is designed as a long-term resource that will continue to serve the community beyond the end of EPOC.

AMOCatlas: one interface for the AMOC observational record



EPOC researchers have developed [AMOCatlas](#) to provide a simple way to access observational data from the different Atlantic monitoring arrays.

The system uses Python to provide unified access to data from 13 AMOC-related sources, handling downloads automatically and caching data locally so that repeat calls do not trigger unnecessary downloads. Once loaded, data from any source are delivered in a standardised format. This is the core of what AMOCatlas does: it removes the variability in how different data producers encode their outputs, so that a researcher accessing AMOC data from multiple sources can work with the same data structure.

Each dataset is accompanied by metadata including processing timestamps and source information to support reproducible workflows. Built-in visualisation tools with consistent styling make it straightforward to plot and compare data across arrays, and example notebooks are available to support new users. The practical outcome is that multiple data-source analysis has become quicker and easier: data handling that previously took days can now be done in minutes.

AMOCatlas is a work in progress and new contributions are welcome. If you work with AMOC observational data and want to add a dataset or help extend the package's capabilities, this community is the place to start.

METRIC: model evaluation against the observational arrays

Evaluating how well an ocean model reproduces the observed AMOC is challenging as the major observing arrays each calculate their transport estimates using methodologies specific to their array design. With these differences in approach, comparing model output with observational calculations can result in model-observation discrepancies that are methodological rather than physical.

[METRIC](#) (Meridional ovErTurning ciRculation diagnostIC) is an open-source Python package that addresses this. It calculates AMOC transports from model output using the same methodology applied at the RAPID, MOVE and SAMBA arrays, producing estimates that are genuinely equivalent to the observed values. This means that differences between model and observations reflect the physics, not the calculation method.

The latest version includes an automated validation feature that generates a report comparing a model's overturning, heat and freshwater transports to available observations. The report is reproducible and can be updated as new data become available, providing a consistent record of model performance against the observational record over time.

Get involved

A community is only as valuable as the people that make it, as a work-in-progress, we welcome contributions from the wider community. If you work with AMOC data or models and want to add a dataset, extend existing functionality, or raise an issue, the AMOCcommunity GitHub is the place to start. New contributors can introduce themselves in the Discussions section and browse existing repositories to find where their expertise fits.

Find out more at github.com/AMOCcommunity

International grant award takes EPOC work to new levels

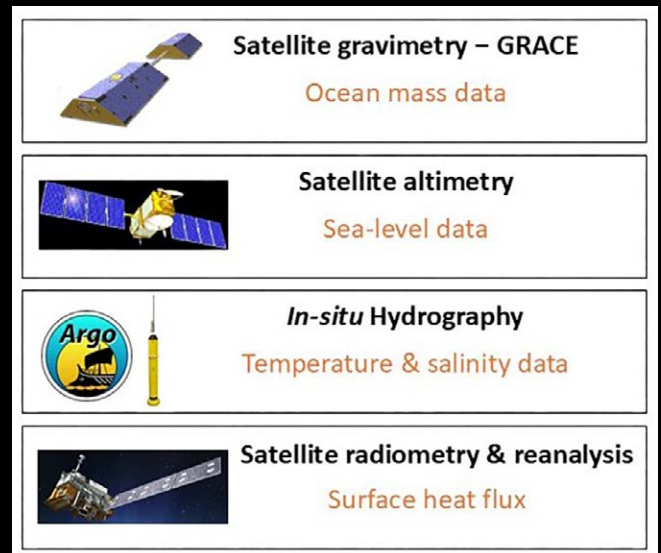
By Francisco M. Calafat, University of Barcelona

Two EPOC researchers, Francisco M. Calafat (University of Barcelona) and Eleanor Frajka-Williams (University of Hamburg) have been awarded a new research grant by EIG CONCERT-Japan* to carry out the UHEAT project – an achievement that directly builds on research developed in WP1 of EPOC.

In particular, a substantial component of UHEAT draws on a novel Bayesian hierarchical framework (Calafat et al., 2025) that combines observations from hydrography, satellite altimetry and gravimetry, and surface heat flux data to estimate Atlantic meridional ocean heat transport and ocean heat content. In UHEAT, this approach will be extended to the Pacific Ocean, expanded back in time to 1993, and further developed to separate upper- and deep-ocean heat content contributions. The Bayesian model outputs will also be used to approximate ocean circulation as a two-layer fluid, enabling new barotropic and baroclinic circulation estimates.

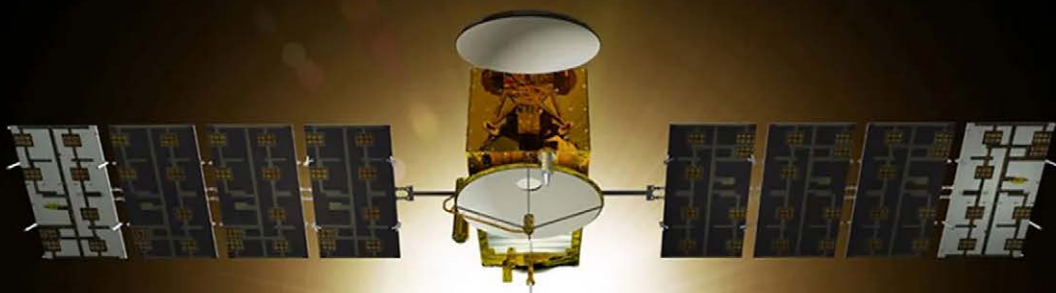
Overall, UHEAT aims to advance our understanding of regional ocean heat content changes and their links to marine heatwaves, and to translate this knowledge into AI-based models for predicting marine heatwaves and their impacts on key fish species. The project brings together a highly complementary international consortium of researchers from leading institutions in Spain, Germany and Japan. This award illustrates how EPOC is contributing transferable tools and insights that enable new international research initiatives.

Reference: Calafat et al. (2025) Estimates of Atlantic meridional heat transport from spatiotemporal fusion of Argo, altimetry, and gravimetry data. *Ocean Science*, DOI [10.5194/os-21-2743-2025](https://doi.org/10.5194/os-21-2743-2025)



Above: the UHEAT approach combines observations from hydrography, satellite altimetry and gravimetry, and surface heat flux data to estimate ocean heat transport and ocean heat content.

*The European Interest Group (EIG) CONCERT-Japan is an international joint initiative to support and enhance science, technology and innovation cooperation between the European region and Japan. For more details see concert-japan.eu





Coming up in the calendar...

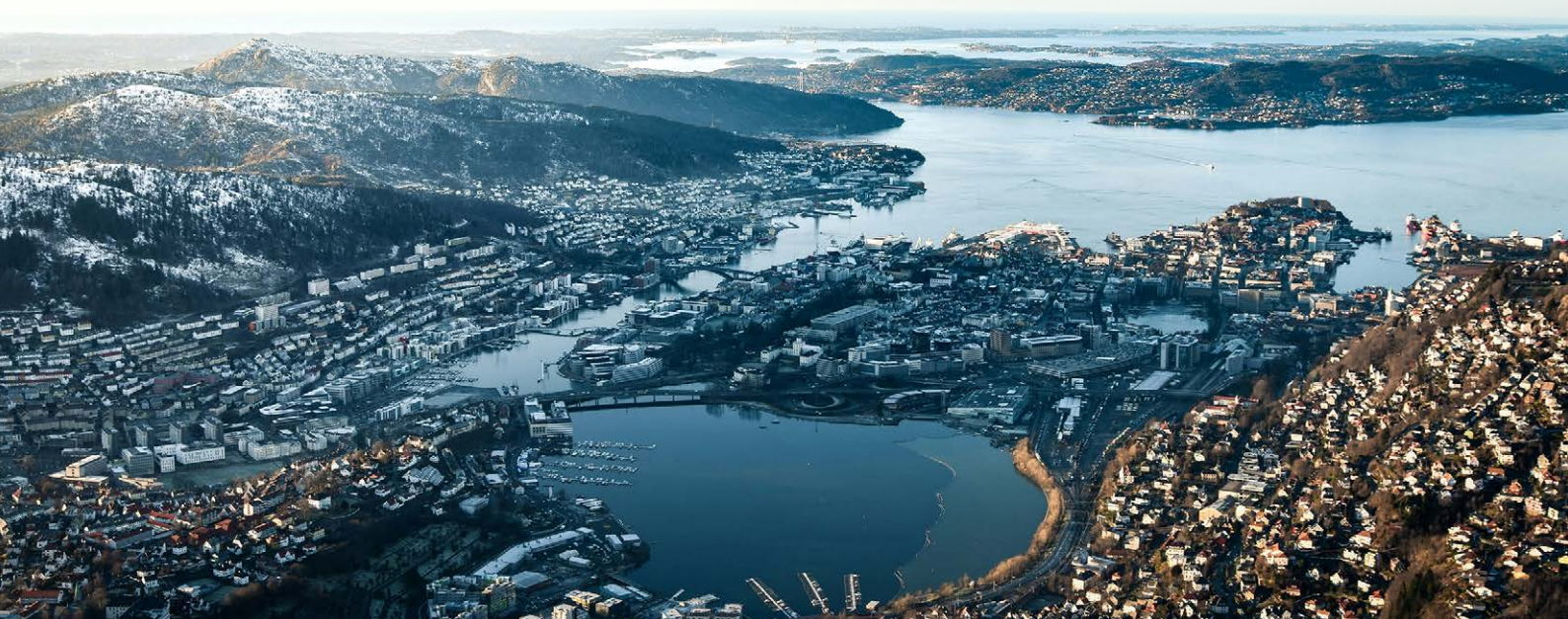
24th ASOF workshop, 21-23 April 2026, Bergen, Norway

Bergen is host to two important workshops this spring: the 24th Arctic-Subarctic Ocean Fluxes (ASOF) workshop takes place on 21-23 April 2026. Hosted by the University of Bergen, this year's meeting includes a special event celebrating [150 years of marine research in the Nordic Seas](#). In-person registration is now closed but online participation is still possible. Full details at asof.awi.de



Greenland-Scotland Ridge workshop, 24 April 2026

Immediately after the ASOF meeting, a 1-day workshop on the Greenland-Scotland Ridge (GSR) will be held at the Havforskninginstituttet (Institute of Marine Research, also in Bergen), with the goal to advance the GSR observing system by identifying key knowledge gaps, and to develop a strategy to deliver a sustained time series of transport across the Ridge. Sessions cover both observational and modeling frameworks, with discussions aimed at identifying ways to increase cross-institutional collaboration. For more information contact James Wyatt: jamesw@hav.fu



EGU 2026: 3–8 May 2026, Vienna, Austria & Online

The 26th meeting of EGU takes place in Vienna in May 2026. EPOC researchers are co-chairing or presenting in a number of sessions, including those listed below. Registration to participate online or in person (including single-day passes) is still open. Full details at www.egu26.eu



CL0.5 AMOC changes and impacts on physical, biogeochemical, and societal systems ([more](#))

OS1.1 The Future Ocean – CMIP and Beyond ([more](#))

OS1.4 The North Atlantic: natural variability and global change ([more](#))

OS1.9 Changes in the Arctic Ocean, sea ice and subarctic seas systems: Observations, models and perspectives ([more](#))

OS1.6 Physical, biological and chemical evolution of high-latitude oceans: from past to future ([more](#))

OS4.1 Machine Learning for Ocean Science ([more](#))

EPOC annual meeting: 25-27 August 2026, CNRS Toulouse, France

The fourth annual meeting of the EPOC consortium will take place in Toulouse, France at the end of August. The first two days are devoted to science presentations and are open to invited experts from outside the EPOC family. The final day is a closed session for EPOC partners only. Details on registration and abstract submission will follow later in the spring.



About EPOC

EPOC (Explaining and Predicting the Ocean Conveyor) is a 5-year research project funded under the European Union's Horizon Europe programme. Involving 21 institutions from France, Germany, Norway, UK, USA and Canada, and led by Universität Hamburg, EPOC aims to generate a new concept of the Atlantic meridional overturning circulation (AMOC), its function in the Earth system and how it impacts weather and climate.

EPOC has five overarching scientific objectives:

- Generate comprehensive records of AMOC transports across the whole Atlantic, to assess the timescales of transport variability and the degree to which the AMOC behaves as a conveyor belt.
- Determine key processes that make or break meridional connectivity of ocean transports, and assess their representation in models, especially in high resolution coupled simulations.
- Identify the processes and drivers of recent change in the AMOC, and infer the likely roles of natural and anthropogenic forcings, and internal variability.
- Assess the key processes of future AMOC changes, and identify indicators of abrupt changes and AMOC-related climate impacts with societal relevance.
- Design, and deploy elements of, a next generation observing system for the entire system of the AMOC.

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