How Antarctic Ice and Southern Ocean Changes Are Affecting Climate, Sea Level, and Biodiversity

Ukrainian Research Insights

POLICY BRIEFING

About us

OCEAN ICE stands for "Ocean Cryosphere Exchanges in Antarctica: Impacts on Climate and the Earth System"; it is a Horizon Europe project, funded by the European Commission and UKRI. The project started on 1 November 2022 and will run until 31 October 2026.

Read more about the project: https://ocean-ice.eu

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The work of NASC scientists in Antarctica relies heavily on the Ukrainian Armed Forces, who defend Ukraine against the ongoing russian invasion. 32 Ukrainian polar scientists have joined the military, pausing their research commitments. NASC expresses its deepest gratitude to those who protect Ukraine and ensure our ability to continue scientific endeavors.

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OCEAN ICE in a nutshell

The OCEAN ICE project, **Ocean Cryosphere Exchanges in Antarctica: Impacts on Climate and the Earth System**, is a European research initiative focused on improving our understanding of the critical interactions between the warming Southern Ocean and the Antarctic Ice Sheet.

The project examines how key processes linking the Antarctic Ice Sheet and the Southern Ocean affect the Earth system, including sea-level rise, deep-water formation, ocean circulation, and climate.

Its **main objectives** are to:

01. Improve ocean observations around Antarctica.

02. Develop more accurate models of ocean – ice interactions and ice-shelf basal melting.

03. Improve simulations of Antarctic Ice Sheet change and freshwater discharge.

04. Reduce uncertainty in projections of future ice loss and sea-level rise through 2300.

05. Assess how Antarctic meltwater influences global ocean circulation and climate.

06. Investigate feedbacks among ice-sheet loss, sea-level rise, temperature, and potential climate tipping points.

07. Make project data openly available to support climate research, international assessments, and evidence-based policymaking.

Ukraine's Contribution

The National Antarctic Scientific Center of Ukraine (NASC) is a partner in the OCEAN ICE project. NASC researchers investigated how precipitation, including both snowfall and rainfall, affects the mass balance of Antarctic ice shelves. They used a high-resolution regional atmospheric model for this work. The findings are presented in this policy brief.

NASC also helped address important gaps in field observations by deploying additional autonomous monitoring instruments, such as profiling, or Argo floats, in the Southern Ocean. These unmanned oceanographic platforms operate and collect measurements beneath the ocean surface without requiring continuous support from vessels or personnel.

The floats provide detailed observations of the ocean's physical properties, including surface current direction and speed, temperature, and salinity at different depths. Analysis of these data has improved understanding of the seasonal exchange between the cold waters of the Weddell Sea and the relatively warmer waters surrounding the central and western Antarctic Peninsula.

Why It Matters

The stability of the Antarctic Ice Sheet is a major factor in climate projections of future sea-level rise. When ice shelves thin or collapse due to calving and melting, they accelerate glacier flow into the ocean and contribute to rising sea levels.

By quantifying these processes, the OCEAN ICE project provides essential evidence to assess the risks Antarctic ice loss poses to coastal communities worldwide. The project combines direct observations with advanced numerical modelling, helping to connect oceanographic processes in the Southern Ocean with the long-term evolution of the Antarctic cryosphere.

Summary of Key Findings and Recommendations

In the framework of the OCEAN ICE project, the National Antarctic Scientific Center of Ukraine (NASC) contributes expertise in atmospheric modelling and Southern Ocean observations. Ukrainian researchers investigated how atmospheric rivers and extreme precipitation affect Antarctic snow accumulation and snowmelt, and deployed six ice-capable Argo floats in the Bransfield Strait to obtain year-round oceanographic observations. Together, these studies improve understanding of how interacting changes in the atmosphere, ocean and cryosphere influence Antarctic ice stability, ecosystems and future sea-level rise.

Key Scientific Findings

Atmospheric rivers produce contrasting impact across the Antarctic Peninsula

Atmospheric rivers, narrow corridors transporting large amounts of water vapor, are primary drivers of extreme Antarctic precipitation. When accompanied by warm air, atmospheric rivers can also bring rainfall or rain-on-snow events, particularly in West Antarctica and the Antarctic Peninsula, triggering self-reinforcing retreat of parts of the Antarctic Ice Sheet, contributing to long-term global sea-level rise and affecting coastal communities, infrastructure, ecosystems, and economies worldwide.

In February 2022, such an event contributed to record temperatures of +12.7°C near the Akademik Vernadsky Research Base and widespread snowmelt.

NASC modelling of 11 extreme precipitation events around Vernadsky Base in 2025 showed that coastal and inland areas respond very differently. All precipitation over land fell as snow, with more than 140 mm of snowfall recorded in windward mountain areas. Nevertheless, near-freezing coastal temperatures generated 2–30 mm of snowmelt and runoff. These findings demonstrate that significant meltwater production does not require rainfall and highlight the particular vulnerability of Antarctic coastal zones and ecosystems.

Year-round observations reveal changing conditions in the Bransfield Strait

From March 2025, Ukrainian scientists established the first float-based observations of the full seasonal cycle of the Bransfield Front with deployment of six ice-capable Argo floats from the ice-class research vessel Noosfera. The floats were configured using a novel “quasi-mooring” approach: they drift at approximately 1,500 m while profiling to 2,000 m, allowing them to remain within the Bransfield Front year-round. Till April 2026, the system produced 273 profiles, including the first sustained under-ice winter observations of the Bransfield Front. More than 428 reports were received from the floats overall, with data collection continuing.

The observations revealed that the Bransfield Strait is warmer, fresher, and more dynamically mobile than historical climatologies suggest:

- Summer surface temperatures reached around +2°C, compared with approximately +1.7°C in historical data.
- Deep western waters were about 0.5°C warmer than climatological averages.
- Water at around 400 m depth was fresher, with salinity differences of up to ±0.1 PSU.
- The Bransfield Front shifts seasonally from its historically established position, potentially affecting nutrient distribution, ecosystems, and heat transport.

These measurements provide a unique dataset establishing a full seasonal cycle of data against which to compare historically summer biased observations. The measurements reveal that the ocean conditions.. that ocean conditions around the Antarctic Peninsula are changing more rapidly than historical climatologies suggest, with implications for heat transport, marine ecosystems and ice – ocean interactions.

Main recommendations coming out of the findings

- Strengthen Antarctic observations and high-resolution modelling of atmospheric rivers, extreme precipitation, and snowmelt.
- Broaden application of the quasi-mooring concept in the Southern Ocean as well as continue monitoring the variability of the Bransfield Front using moorings deployed in areas of the largest seasonal shifts in front position.
- Prepare for rapid changes in vulnerable Antarctic ecosystems through monitoring, communication, and adaptive management.
- Maintain and expand international scientific cooperation by sharing data,expertise, and infrastructure.
- Improve communication of Antarctic climate risks. Communicate how changes in Antarctica influence global sea-level rise, climate and biodiversity to support informed decision-making and public awareness.

The findings show that Antarctica's atmosphere, ocean, ice and ecosystems form a tightly interconnected Earth climate system. Warming is already driving measurable changes in extreme precipitation, snowmelt, ocean temperature, salinity and circulation, with cascading effects on ice-sheet stability, biodiversity and future global sea-level rise. These changes arise from interactions between the atmosphere, ocean and cryosphere and can only be fully understood through integrated observations and coupled modelling. Sustained year-round observations — particularly during the data-sparse winter season — are essential to detect emerging changes, reduce uncertainties in future projections, and provide the scientific evidence needed for effective climate adaptation and environmental policy.

A Challenging Context

Challenge 1:

Atmospheric Rivers Amplify Climate Risks in West Antarctica and the Antarctic Peninsula

The polar regions are at **the heart of Earth's cryosphere**, the frozen component of the climate system, including snow, glaciers, ice sheets, sea ice, and permafrost. The cryosphere plays a critical role in regulating the Earth's climate by reflecting solar radiation, storing freshwater, influencing ocean circulation, and affecting weather and climate worldwide. As the climate warms, changes across the Antarctic are not uniform. While some regions may experience increased snowfall, West Antarctica and the Antarctic Peninsula are among the fastest-changing parts of the continent. These regions are particularly vulnerable because continued warming can trigger self-reinforcing retreat of parts of the Antarctic Ice Sheet, contributing to long-term global sea-level rise and affecting coastal communities, infrastructure, ecosystems, and economies worldwide.

Emerging evidence: The role of atmospheric rivers

Recent research (1) has identified **atmospheric rivers** — long, narrow corridors that transport large amounts of water vapor from lower latitudes — as one of the primary drivers of Antarctic extreme precipitation. However, when accompanied by warm air, atmospheric rivers can also trigger rainfall and rain-on-snow events, particularly in West Antarctica and the Antarctic Peninsula. Of particular concern are events in which warming shifts precipitation from snow to rain. Rainwater can percolate into the snowpack, enhance surface melting, promote hydrofracturing of ice shelves, and increase the risk of ice-shelf destabilisation, with potential consequences for future sea-level rise. These events illustrate the close coupling between the atmosphere, Antarctic ice, and the Southern Ocean.

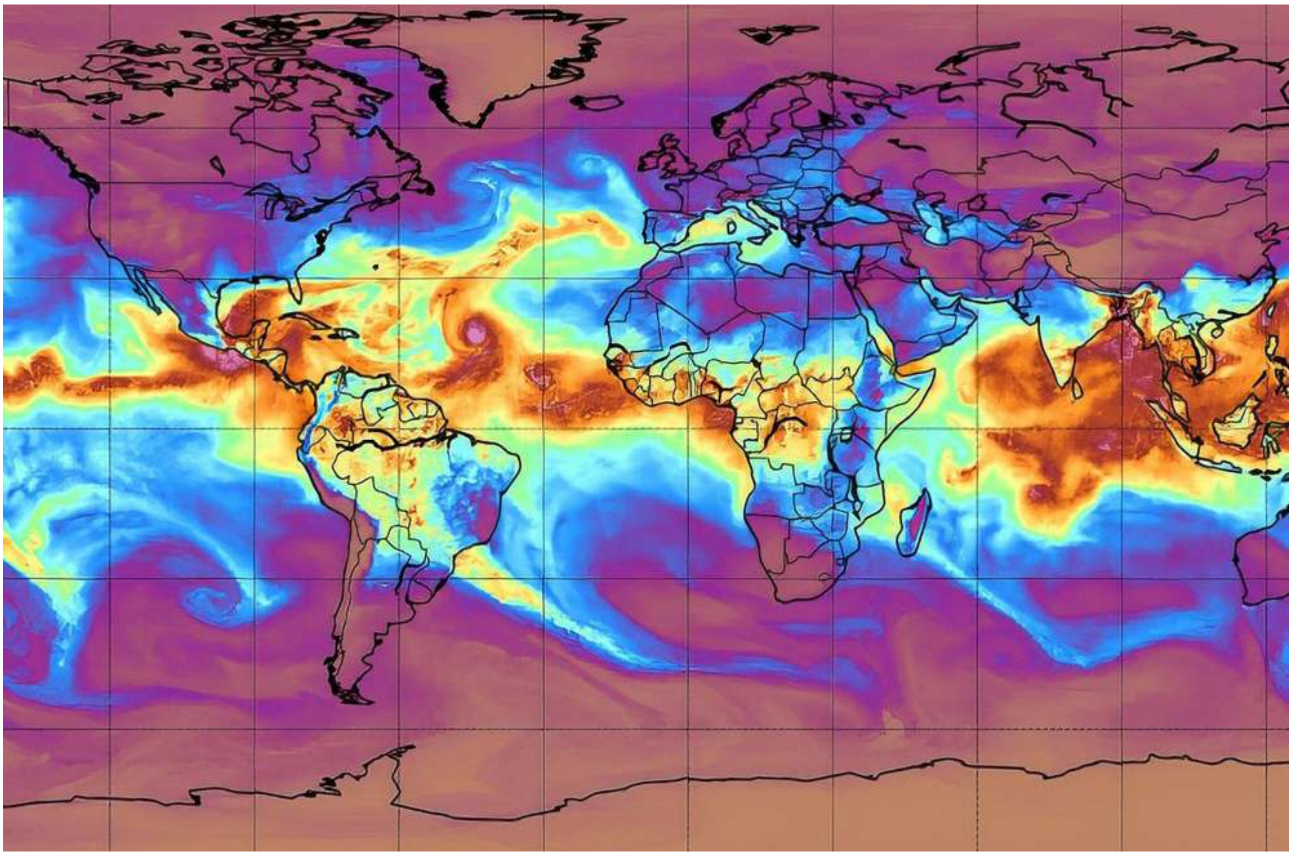

Figure 1. Amospheric rivers

Source: https://uk.meteorologiaenred.com/que-son-los-rios-atmosfericos.html

OCEAN ICE analysed **extreme precipitation events**, episodes of unusually high snowfall or rainfall compared with what is typical for a given location and season, between 1986 and 2015, and showed that the influence of atmospheric rivers extends across Antarctica. Although affecting a given location for only about three days each year, they account **for 50–70% of extreme snowfall events in East Antarctica.** In contrast, over West Antarctica and the Antarctic Peninsula, atmospheric rivers accompanied by warm air intrusions are more likely to trigger widespread melting and rainfall. The same processes have also been associated with major surface melting episodes, including those preceding the collapse of the Larsen A (1995) and Larsen B (2002) ice shelves (1, 4).

Recent illustrative example: In February 2022, an atmospheric river transported warm, moisture-rich air to the Antarctic Peninsula, contributing **to record temperatures of +12.7°C near Vernadsky Research Base and widespread surface melting** (2). For reference, the Akademik Vernadsky Research Base is located on Galindez Island, off the Argentine Islands in the northern part of the Antarctic Peninsula.

Potential consequences of extreme precipitation in warming Antarctica:

- Accelerated ice-sheet mass loss through enhanced melting and ice-shelf weakening.
- Increased risk of accelerated global sea-level rise through Antarctic ice loss.
- Disruption of Antarctic terrestrial and coastal ecosystems.

Atmospheric rivers are a natural component of Antarctica's climate system, but their impacts are becoming increasingly important as the climate warms. They replenish the ice sheet through heavy snowfall, particularly in East Antarctica, yet under warmer conditions they can also deliver rainfall, trigger widespread surface melting and destabilise ice shelves, especially in West Antarctica and the Antarctic Peninsula. Understanding how these competing effects evolve is essential for improving projections of future Antarctic ice loss and global sea-level rise.

Strengthen Antarctic observations and coupled atmosphere–ocean–ice modelling. Sustained observations, together with high-resolution modelling, are needed to better represent atmospheric rivers, improve projections of Antarctic ice-sheet change and sea-level rise, and provide the evidence base for climate adaptation and coastal risk management.

Challenge 2:

Lack of Year-Round Observations of Water-Mass Properties in the Bransfield Strait, Southern Ocean

The Bransfield Strait is a critical gateway in the Southern Ocean, where relatively warm, modified West Antarctic Peninsula waters and Circumpolar Deep Water interact with colder Weddell Sea waters. Their interaction defines the **Bransfield Front**, a dynamic boundary that regulates the exchange of heat, freshwater, and nutrients in one of Antarctica's most rapidly changing regions.

However, the Bransfield Front has never been regularly observed with the same technology and frequency throughout the full annual cycle, particularly during winter. **Vessel-based surveys** are generally concentrated in summer and early autumn, as severe sea-ice conditions, storms, and limited daylight make operations from late autumn to early spring difficult and costly. Consequently, major seasonal changes in water temperature, salinity, stratification, and mixing remain understudied due to the lack of in situ data.

Figure 2. Examples of deployments on a Weddell sea

Source: https://hal.science/hal-01581890v1/file/ 30-2_ treasure.pdf

An important supplementary source of observations comes from **seal-borne profiles** collected through the International Marine Mammals Exploring the Oceans Pole to Pole (MEOP) program. Instruments attached to marine animals, typically elephant seals, record water temperature, salinity, and pressure, which are used to determine depth during repeated dives. The instruments also transmit the animal's location and diving behaviour via satellite when it surfaces. These measurements generate vertical profiles showing how ocean properties vary from the surface to depths of several hundred metres, and sometimes beyond 1,000 metres.

Seal-borne observations are especially valuable in polar regions because they can provide measurements beneath sea ice and in remote coastal waters that are difficult or hazardous for research vessels and conventional observing platforms to access. They contribute to understanding seasonal ocean circulation, the transport of relatively warm deep water toward Antarctic ice shelves, sea-ice processes, and the oceanic drivers of basal ice-shelf melting.

Nevertheless, seal-borne profiles cannot replace a dedicated, year-round observing system. Their distribution depends on animal movements and behavior, resulting in uneven spatial and temporal coverage. Seals may not sample the locations or depths most important for characterising the Bransfield Front, and measurements are often concentrated along individual foraging routes. Unfortunately, seals do not sample where oceanographers need them most.

As a result, **existing climatologies rely primarily on summer and early-autumn observations, while the coldest and most dynamically important months are represented by sparse and highly interpolated data**. This can smooth out or obscure the very mixing, transformation, and seasonal water-mass exchanges that define the front.

Addressing this observational gap is essential for determining how the Bransfield Front changes through winter, how it controls the transport of heat toward the Antarctic Peninsula, and how seasonal ocean variability may affect ice-shelf stability and regional climate.

Challenge 3:

Testing and Optimizing Argo Floats for Southern Ocean Observations

Deploying autonomous Argo floats offers a promising way to address the lack of year-round observations in the Bransfield Strait and the adjacent Southern Ocean identified in Challenge 2. After deployment, these free-drifting instruments are transported by ocean currents and repeatedly profile the water column, typically from the surface to depths of approximately 2,000 m. They measure essential physical properties, including temperature, salinity, and pressure in water masses, and monitor changes in ocean stratification, circulation, and heat transport.

However, effectively using Argo floats in this region presents several technical and logistical challenges. The Southern Ocean is a particularly demanding operating environment, characterised by extensive seasonal sea-ice cover, strong currents, severe storms, and limited opportunities for ship-based deployment and recovery. These conditions can reduce float lifetime and lead to uneven spatial and temporal data coverage.

Although **the global Argo observing system comprises approximately 4,000 active floats (Fig. 3), the Southern Ocean is a specialised, high-priority component of this network**. The number and distribution of floats in the region vary with seasonal deployment campaigns, instrument availability, and float survival under harsh environmental conditions.

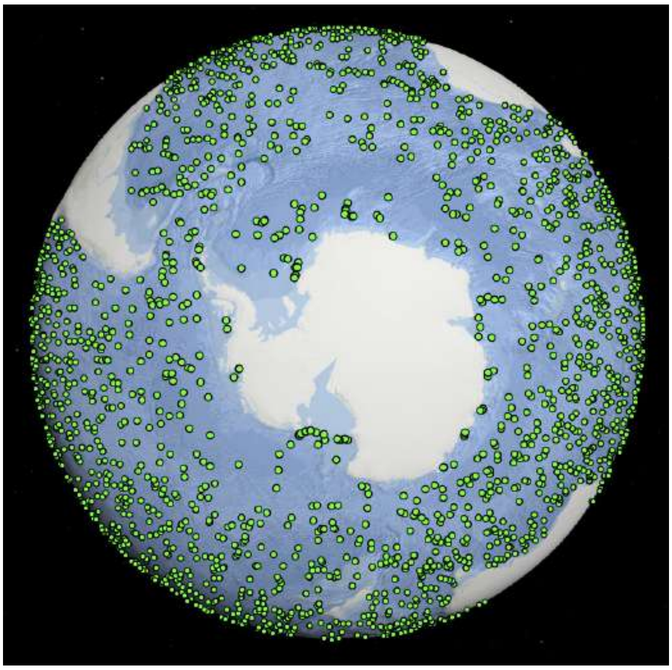

Figure 3. Locations of Argo floats

Source: https://globalocean.noaa.gov/research/argo-program/

Sea ice is one of the main limitations. Conventional Argo floats cannot transmit data while submerged beneath dense sea ice because they require a clear connection with satellites at the ocean surface. This can result in data loss during winter or prevent floats from completing their normal measurement and transmission cycles.

These limitations may be reduced through:

- improved algorithms for detecting and avoiding sea ice;
- careful selection of deployment locations and timing;
- use of ice-capable or under-ice Argo floats;
- delayed data transmission and onboard data storage; and
- integration with satellite observations, seal-borne profiles, ship-based measurements, and moorings.

The challenge, therefore, is not simply to deploy Argo floats but to test and optimise their use under regional Southern Ocean conditions. This includes determining the most suitable deployment sites, assessing float performance and survival, evaluating the quality and continuity of the measurements, and identifying how the resulting data can be integrated into ocean and ice-sheet models.

Developing this operational knowledge would contribute to the objectives of **the OceanEye initiative**, the European Commission's newly launched initiative for strengthening Europe's contribution to global ocean observation. OceanEye places particular emphasis on expanding advanced observing technologies, including the Argo network, and on improving the integration of in situ observations with digital ocean platforms and numerical models. Experience gained from deploying and operating Argo floats in the Bransfield Strait and surrounding Southern Ocean would therefore provide both regional scientific benefits and transferable knowledge for broader ocean observation activities.

OCEAN ICE has deployed more than a dozen such floats in a pioneering experiment to observe the full seasonal cycle in front of ice shelves in the Weddell Sea, Amundsen-Bellingshausen and Ross/East Antarctic. However, the dynamically novel region of the Antarctic Peninsula and Bransfield Strait was missing prior to NASC deployments, which have filled a notable gap in the regimes resolved by OCEAN ICE float deployments

Key findings: New evidence from NASC

Result 1: Extreme precipitation affects the Antarctic Peninsula's coast and interior differently

To understand how atmospheric rivers affect the Antarctic Peninsula at the local scale, NASC researchers analysed 11 extreme precipitation events around Ukraine's Vernadsky Research Base in 2025 using the high-resolution **Polar Weather Research and Forecasting (Polar WRF) model**. The simulations were evaluated against in situ observations, providing confidence in the analysis of snowfall, snowmelt, and runoff at the local scale (4).

High-resolution Polar WRF simulations revealed that coastal and inland regions respond very differently to the same weather events (5). While the Antarctic interior remains extremely cold and dry, coastal regions can experience heavy snowfall together with rapid snowmelt under near-freezing conditions, making them particularly vulnerable to continued warming. They also show that significant meltwater production can occur even when precipitation falls almost entirely as snow.

Key findings:

- **Mountain barriers shape Antarctic snowfall**: Moist air is forced to rise over coastal mountains, producing heavy snowfall on windward slopes while limiting precipitation farther inland.
- **Extreme precipitation fell entirely as snow over land**: During all analysed events, precipitation fell as snow over land, producing over 140 mm of snowfall on windward mountain slopes, while rainfall was confined to adjacent open ocean.
- **Near-freezing coastal conditions promote rapid snowmelt**: The low-lying coastal zone is highly sensitive to warming. Small increases in ocean and air temperatures along the coast can trigger rapid melting and significant surface runoff. Even when all precipitation falls as snow, near-freezing temperatures along the coast can generate substantial snowmelt and runoff (2–30 mm), demonstrating that rainfall is not required for significant meltwater production.
- **The consequences extend beyond the cryosphere to Antarctic ecosystems**: Antarctic coastal zones occupy only a small fraction of the continent but support much of its terrestrial biodiversity. Increased snowmelt and runoff can alter freshwater availability, soil moisture and breeding habitats, affecting ecosystem functioning and biodiversity.

Together with the continent-wide evidence presented in Challenge 1, these findings demonstrate how atmospheric rivers, local topography and near-freezing coastal conditions interact to control the fate of extreme precipitation. Even when precipitation fell entirely as snow over land around Vernadsky Research Base, substantial snowmelt and runoff occurred, highlighting the vulnerability of Antarctic coastal regions to continued warming. These interacting processes increase risks to ice-sheet stability, Antarctic coastal ecosystems and future global sea-level rise.

Result 2: Ice-capable Argo floats are a breakthrough in oceanographic data collection for Bransfield Strait

As part of the OCEAN: ICE project, Ukrainian scientists successfully deployed **six ice-capable Argo buoys** in the Bransfield Strait to collect unique year-round oceanographic data.

Figure 4. NASC oceanographer Natalia Dikul with the first ARVOR buoy

Why Bransfield Strait?

The Bransfield Strait, situated between the Antarctic Peninsula and the South Shetland Islands, serves as a crucial waterway in the Southern Ocean; it connects the Weddell Sea at the south and the modified West Antarctic Peninsula waters to the north of the Strait. The strait has substantial depth gradients, from shallow areas of about 300 metres to sections exceeding 2750 meters.

In this area, strong mixing events, including upwelling, lead to high nutrient availability that supports diverse marine ecosystems. The area supports a wide range of marine life, including seals, penguins, and various fish species. The ecological health of the strait is vital for maintaining the overall balance of the Southern Ocean ecosystem.

Despite its importance, the Bransfield Strait has been understudied, with no comprehensive year-round data on water mass distribution. Until now.

Agro floats and quasi-mooring concept: The deployed ARVOR buoy models feature **ice-capable technology**. These floats can detect ice cover through temperature changes and strategically avoid becoming trapped by ice by delaying their ascent until conditions improve.

The deployment of these profiling floats, oriented perpendicular to the Bransfield Front, was completed in March 2025 from the Ukrainian ice-class vessel Noosfera. **This initiative represents a significant milestone not just for Ukrainian polar researchers but for Ukraine as a whole, as it was Ukraine's first deployment.**

Scientists aimed to test **a novel quasi-mooring concept**. Instead of allowing the floats to drift freely, they were configured to operate at a drift depth of 1,500 meters and to profile up to 2,000 meters. This caused the floats to sink to the sea bed, because the bathymetry at the deployment locations was shallower than the drift depth. This deliberate choice means that the floats do not drift between profiles, allowing them to operate in a 'quasi-mooring' mode. Furthermore, this strategic placement exploited deep circulation patterns, keeping the floats within a designated corridor for extended periods if they do move into regions of deeper water (6).

This approach prioritises high temporal resolution at the front itself over broad basin-scale coverage, effectively transforming the floats into vertically profiling moorings capable of operating year-round, even under sea ice.

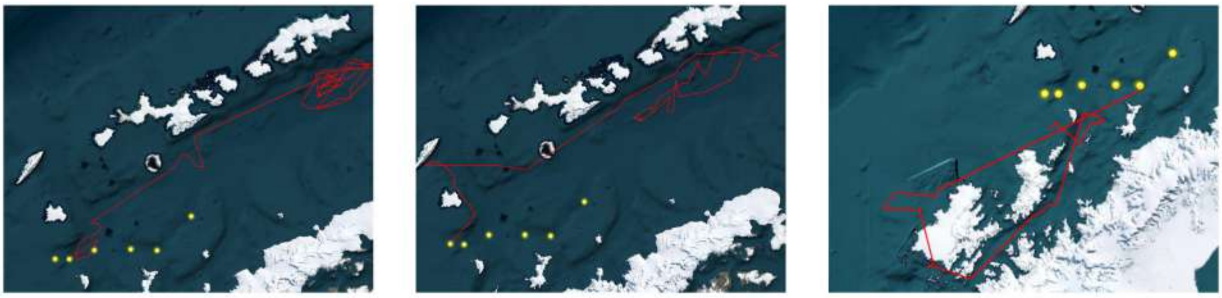

Figure 5. Yearly routes of Argo floats registered in the Bransfield Strait

The initiative proved to be a resounding success. **The floats remain reliably positioned in Bransfield Strait, confirming their strategic deployment for effective study**. From March 2025 to April 2026, the quasi-mooring setup yielded 273 profiles, including the first sustained under-ice winter observations of the Bransfield Front, marking a significant advancement in our understanding of this critical region.

Result 3: New data from Argo floats show that the Southern Ocean in Bransfield Straitbecomes warmer, less salty, and more mobile

Data from Argo floats have enabled the first comprehensive year-round study of the Antarctic region, significantly enriching our understanding of its seasonal dynamics. Notably, the inclusion of regular winter data offers unprecedented insights.

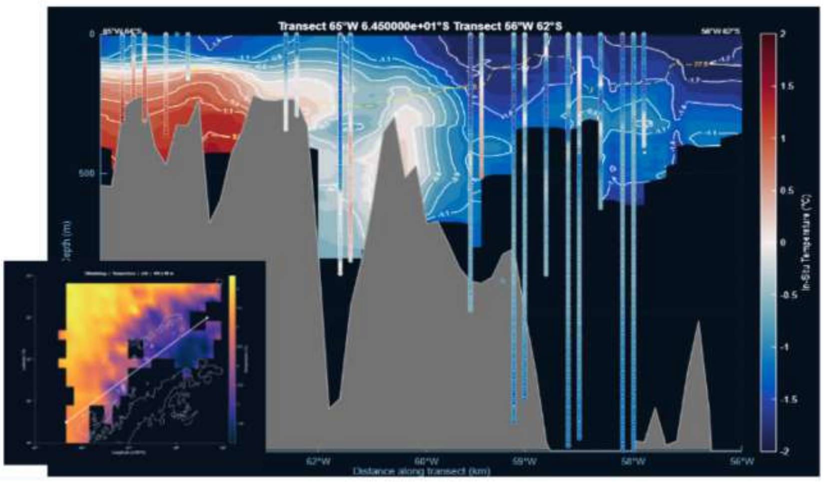

Figure 6. Seasonal variability of in-situ temperature along the transect (63°W, 64.5°S → 56°W, 62°S) and across the 400 m layer (June-August 2025)

Source: Deliverable D10.4

Natalia Dikul, an oceanographer at the NASC, illustrates this progress: *"If we compare water masses to a garden, then, in addition to the vibrant green of summer, we have finally observed the other seasons: the sprouting of leaves from buds, their yellowing, and eventual fall."*

Over more than a year, researchers received 428 reports from the Argo buoys, and data collection is still ongoing. This information has been cross-referenced with two established multi-decadal climatologies (NAPv1.0 and a compilation of Southern Ocean profiles).

Here's what the data revealed (5):

01. **Increased Temperature**: During the period of investigation, the area has experienced significant warming compared to historical averages. During summer, Argo data indicate the surface layer reached +2 °C (compared to ~+1.7 °C in climatologies), with peak temperatures up to 2.7 °C. Throughout much of the water column, a warm anomaly persists. Notably, deep temperatures in western areas are approximately 0.5 °C warmer than climatological averages (−1.2 °C vs. −1.7 °C).

02. **Freshening**: At a depth of 400 meters, the Argo data show that water is notably fresher and less salty than historical observations. This change affects a significant portion of the studied area, with a salinity difference of up to ±0.1 practical salinity units, indicating shifts in freshwater input or changes in oceanic circulation.

03. **Enhanced Mobility**: The Bransfield Strait demonstrates seasonal mobility, particularly concerning the boundary (front) between West Antarctic Peninsula waters and Weddell Sea waters. This front is shifting from its climatologically established position season by season. Such changes may have profound implications for nutrient distribution, ecological dynamics, and the overall health of marine ecosystems in the region.

Overall, these findings highlight the critical role of year-round data collection in understanding the complexities and evolving conditions of Antarctic marine environments.

Our Recommendations

The findings from the OCEAN ICE project underscore significant shifts in the Antarctic environment and provide crucial insights for future research and policy-making. The following recommendations are proposed:

01. **Strengthen observations and high-resolution modelling of Antarctic precipitation and snowmelt**: Expand and sustain coordinated atmospheric, oceanic, and cryospheric observations, together with high-resolution modelling of atmospheric rivers, extreme precipitation, and snowmelt, particularly in the Antarctic Peninsula and coastal West Antarctica. These capabilities are essential for the early detection of changes in precipitation and snowmelt processes, thereby improving projections of Antarctic ice-sheet stability and global sea-level rise, while supporting evidence-based climate adaptation and the protection of vulnerable Antarctic coastal ecosystems.

02. **Broaden application of the quasi-mooring concept**: The quasi-mooring approach using the Agro floats showed its effectiveness in studying Southern Ocean dynamics. Future research should expand this application to capture real-time data on water column conditions, movement patterns, and thermal anomalies. By leveraging this innovative methodology, researchers can gain deeper insights into the complex interactions within marine ecosystems, leading to improved climate models and predictions. It is also important to continue monitoring the variability of the Bransfield Front using moorings deployed in areas with the largest seasonal shifts in front position.

03. **Prepare for rapid Changes in vulnerable Antarctic ecosystems**: The accelerating pace of warming in the Antarctic region suggests an urgent need for heightened awareness and preparedness for further rapid changes. Communicating these risks to stakeholders, including policymakers, the scientific community, and the public, is crucial. Establishing adaptive management strategies and action plans can help mitigate impacts on Antarctic ecosystems and global climate dynamics, ensuring both the protection of these vital regions and the sustainability of their contributions to Earth's climate system.

04. **Continue to collaborate internationally for integrated research efforts**: OCEAN ICE became a successful example of international scientific cooperation. Continuing this work can enhance the collective understanding of Antarctic changes. By pooling resources, data, and expertise, the global scientific community can develop more robust climate models and responses to the challenges posed by a rapidly changing environment.

05. **Invest in Public Outreach and Education**: Increasing public awareness about the Antarctic region's critical role in global climate systems is essential. Educational campaigns can foster understanding and support for ongoing research initiatives and conservation efforts, highlighting the interconnectedness of Antarctic ecosystems with global environmental health.

By implementing these recommendations, we can better prepare for and respond to the dynamic changes occurring in the Antarctic, ensuring that we effectively address both local and global climate challenges.

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3. Deliverable D10.4 – Report on seasonal modulation of Bransfield Strait ocean front variability: Contribution to WP1 OCEAN ICE

4. Deliverable D11.1 – Report on analysis of historical extreme precipitation in high-resolution RCMs: Contribution to OCEAN ICE WP3

5. Deliverable D11.2 – Report on effect of extreme weather on ice-shelf processes: Contribution to OCEAN ICE WP3

6. Deliverable D1.1 – Standardisation of pan-Antarctic mooring and profiles

All deliverables available on https://zenodo.org/communities/oceanice by December 2026.