IceSked

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Newsletter of Te Puna Pātiotio—Antarctic Research Centre
Te Herenga Waka—Victoria University of Wellington

A word from our Director

A core aspect of the Antarctic Research Centre's focus has always been understanding the sensitivity of the Antarctic Ice Sheets to climate change. In this issue, we highlight our increasing focus on Antarctic oceanic change. This includes our leadership in a major new multi-national programme to understand the drivers and implications of the dramatic Antarctic sea ice decline that has occurred over the past few years. We also summarise two high profile papers that address the implications of rapid ocean change on ice sheet stability, and we welcome Natalie Robinson – our new Associate Professor in Sea Ice Science and Oceanography.

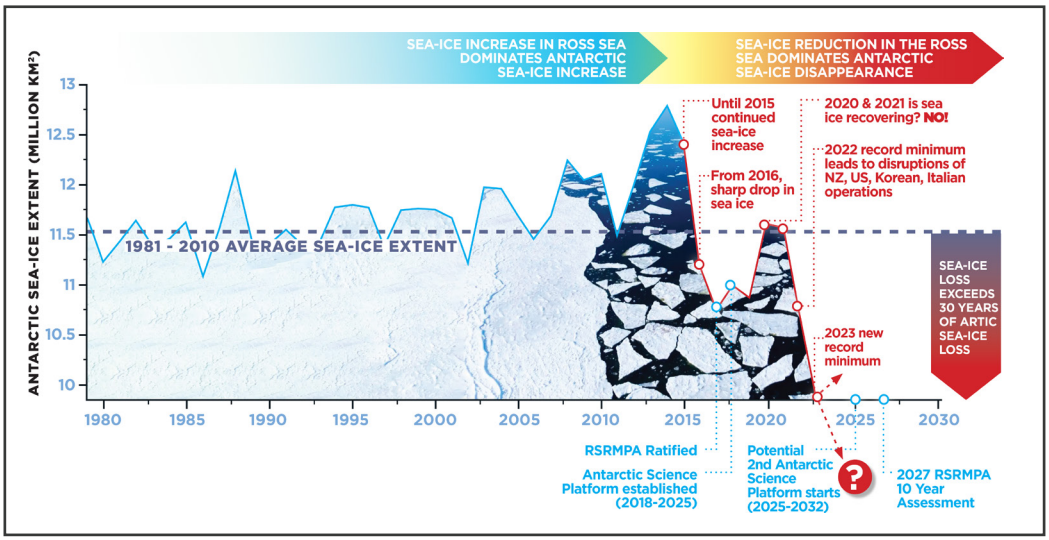
Rob McKay

ARC leads ambitious new Endeavour Fund project

The ARC has received $13.6m funding from the Ministry of Business, Innovation and Employment's Endeavour Fund to support an urgent investigation into the drivers of the unexpected and sharp decline in Antarctic sea ice and its regional and global consequences. As sea ice around Antarctica recedes, heat absorption accelerates surface warming with the potential to destabilise ice shelves that could lead to rapid and potentially unstoppable loss of up to one-third of Antarctica's ice sheets, and result in multi-meter, global sea-level rise over centuries to come. Moreover, sea-ice loss weakens global ocean circulation, impacting heat distribution, decreasing ocean carbon storage, and reducing nutrient supplies that currently support 75% of global ocean primary production. As the Antarctic contracts, the tropics expand with increased heatwaves, atmospheric rivers, and ex-tropical cyclones - impacting Aotearoa.

Led by Prof. Nancy Bertler (ARC and GNS Science), *Antarctic Sea-Ice Switch - Preparing for New Threats* is a five-year research programme, bringing together leading experts from New Zealand, Australia, Canada, France, Italy, Korea, Switzerland, UK, and USA to improve forecasts of future sea-ice trends on global climate, the carbon cycle and sea level rise. The programme also has a strong marine biology focus, investigating the effects of sea-ice decline on the structure and function of ecosystems in the Ross Sea region Marine Protected Area.

Antarctic Sea-Ice Switch will provide critical insights to facilitate adaptation to unavoidable change and identify additional impacts to expect if we cannot curb carbon emissions. Timely knowledge of the most harmful but avoidable impacts will incentivise the drive to net zero 2050, while helping to provide tangible solutions. Guided by the principles of Te Tiriti o Waitangi, we build on established partnerships with Māori to grow resilience for Aotearoa and Antarctica.



The complex dance of ice, ocean, and Earth in West Antarctica

Dan Lowry (GNS Science and ARC Adjunct)

As Antarctic ice melts due to climate change, rising sea levels could displace millions of people by the century's end. A key uncertainty in how quickly the sea level may rise is whether stable regions like West Antarctica's Siple Coast might destabilize. However, recent research reveals that ice sheet stability has fluctuated over millennia in this region of West Antarctica.

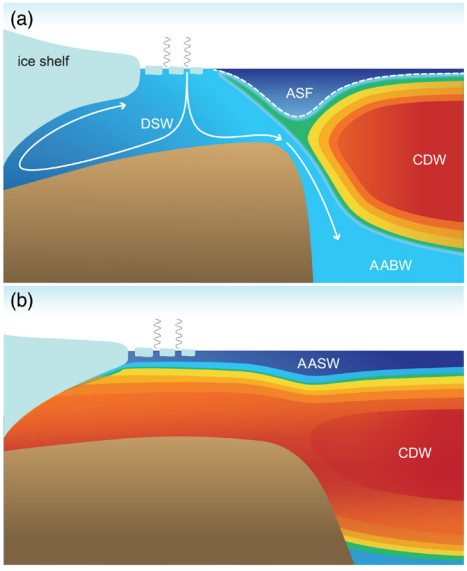
Sediment analysis shows the ice sheet retreated significantly 7,000 years ago, returning to its current position 2,000 years ago. Understanding these shifts is critical for predicting future changes. Two main hypotheses explain this historic behaviour.

The first relates to Earth's crust. As ice sheets shrink, the crust lifts up, and nearby sea levels drop due to reduced gravitational pull between ice and ocean. These changes may have stabilized and advanced the ice sheet.
The second hypothesis focuses on ocean dynamics. Sea ice formation expels salt, creating dense, cold water that sinks and mixes deep into the ocean, blocking warm currents from melting ice shelves. Weaker mixing may have allowed warm waters to melt the Ross Ice Shelf, prompting ice retreat, while stronger mixing coincided with ice advance.

From computer model simulations of ice flow and crustal uplift under varying ocean temperatures and data from marine sediments and ice cores, the team showed that the most likely cause of these past shifts in the ice sheet were due changes in ocean dynamics. However, crustal uplift controls how quickly the ice sheet changes when the ocean warms and cools. This means that the ice sheet, the ocean, and Earth's crust are all interacting.

These findings have significant implications for climate policy. Although some believe West Antarctic melting is irreversible, the study highlights the importance of mitigation. High emissions could recreate historical conditions of a warm ice shelf cavity, leading to extensive ice loss in a currently stable region of the West Antarctic Ice Sheet. By reducing greenhouse gas emissions and preventing ocean warming, humanity can mitigate catastrophic sea-level rise.

Read the full *Nature* paper here.



(a) Cold dense shelf water blocks warm circumpolar deep water from melting the ice.

(b) Warm circumpolar deep water flows under the ice shelf, causing ice melting and retreat.

AGU, CC BY-SA

Can we stop an icesheet collapse?

Alanna Alevropoulos-Borrill

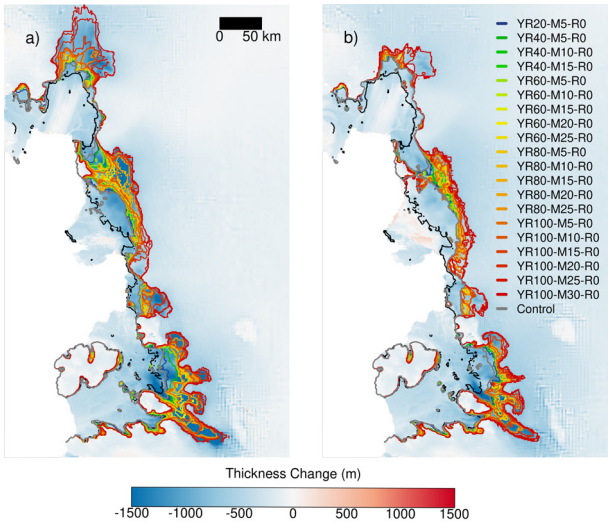
Satellite observations have shown extensive thinning and retreat of glaciers in the Amundsen Sea Embayment (ASE), where warm Circumpolar Deep Water (CDW) drives melting at the base of the region's ice shelves. With the continuing contraction of circumpolar Westerly winds, the volume of CDW on the continental shelf in the ASE in the future is expected to enhance basal melt rates, potentially driving the sector toward instability. Recent publications suggest that regional warming in the ASE is 'unavoidable', even in a low emissions future.

While the response of the ASE to more extreme future climatologies are well researched, few studies explore alternative futures where CDW may be blocked from ice shelf cavities. Sustained cool periods induced by climate variability or artificial geoengineering in the region could create such conditions to lower basal melt rates in the ASE. With this in mind, Alanna and the team of modelling hub researchers chose to investigate whether an alternative future could permit stabilisation or recovery of these fast flowing ice streams.

In this study, Alanna ran an ensemble of nearly 200 regional ice sheet future simulations with the model BISICLES, where basal melt rates in each simulation were perturbed over 200 years. The simulations varied the magnitude and durations of periods of increased melting, which were all followed with extended periods of reduced melting to replicate cooler ocean conditions.

The results of the study show that extreme reductions in basal melting promote thickening and re-advance of ice streams however centuries of increased accumulation is required to entirely offset future mass loss from this highly dynamic region.

Read the full *Nature* paper here.



Maps of grounding line positions for each simulation in the initial subset plotted at different time snapshots a) Year 100, b) Year 200. Each line represents a different simulation in the subset which is colour coded with respect to the forcings in Figure 1a. The background of the map shows the thickness change for the snapshot year in the high end simulation (YR100-M30) relative to the control.

ARC PhD candidate updates

In the past few months, ARC PhD candidates have travelled to conferences and workshops around the world to support their research and professional development.

Béatrice Désy - SCAR, Peru

In August I attended the SCAR Open Science Conference 2024 in Pucón, Chile. This was my very first "climate science" conference, which felt like a bit of a baptism by fire, or perhaps by ice. Coming from a background in statistical physics and network science, it was fascinating to engage with such a diverse crowd of Antarctic researchers, and to see differences and similarities across a range of fields. I took the stage twice to present my research on recurring patterns in ice core records - one contributed talk is more than enough, lesson learned. I greatly enjoyed all the keynote presentations and the few posters that I could squeeze next to during the very dense poster session, especially the ones about research that weaves together different approaches and areas of study, mirroring and expanding my own experience.

Julianne Burns - Urbino Summer School, Italy

This past July, I had the privilege of attending the Urbino Summer School for Paleoclimatology in Urbino, Italy. The course combined lectures, practical sessions, and a field day covering all aspects of paleoclimatology, with this year's focus specifically on modelling. I presented a poster on the research I have been doing titled "Investigating the Role of Orbital Forcing on Antarctic Ice Sheet-Ocean Dynamics during the Miocene." The course provided me with a strong foundation in various paleoclimatological methods that generate the data I use, and it was an excellent opportunity to meet researchers whose papers I have frequently read. Many thanks to GeoDiscoveryNZ and ANZIC for their support.

Vincent Charnay - Karthaus, Italy

Thanks to ARC's Endowed Development Fund scholarship, I was able to attend the Karthaus summer school on Ice Sheets and Glaciers in the Climate System in South Tyrol, Italy. Located in a beautiful little town in the middle of the European Alps, the summer school offered courses relevant to my thesis, on ice sheet modelling, paleoclimate modelling, ice-ocean interaction and many more. Lectures, exercises, computer projects, hikes, sauna and a delicious dinner were part of the daily Karthaus programme. One of the highlights of those two weeks was an excursion to nearby glaciers, which generated interesting discussions on glacial geomorphology and how the glaciers and ice sheets have shaped the landscape surrounding us.

Linda Balfoort - IODP Core Repository, Texas

This July, GeoDiscoveryNZ and ANZIC supported my travel to the International Ocean Discovery Program (IODP) core repository at Texas A&M for the GLAcial Sediment School (GLASS). Researchers, lab technicians, and tutors presented lectures about their respective fields (Arctic and Antarctic) before we were split into groups and assigned an IODP sediment core from a polar region. The goal was to learn to correctly classify the sediments, interpret the environment in which these sediments were deposited, and understand their significance. The dual approach of lectures and labs was incredibly valuable and allowed me to connect with the many people who attended the course. Getting an insight into everyone's different methods and approaches to research was fascinating. The absolute highlight of the trip was seeing the core repository and seeing the ANDRILL cores in person. I love sediments!

Ihanshu Rane - IUGG-CMG 2024, India

The Mathematical Geophysics 2024 conference (IUGG-CMG 2024) held in Mumbai, focused on "Mathematical Geophysics for Sustainable Development." As a PhD researcher, I am developing a Machine Learning (ML) model to predict Antarctic coastal polynyas, critical regions for sea-ice production with global climate impacts. Current models poorly represent these polynyas, making predictions challenging. My ML model aims to improve understanding of these processes and their climate implications. The conference allowed me to network with peers, learn from ML experts, and gain valuable feedback from senior researchers, which has significantly enhanced my model development and is shaping my thesis.

Bella Duncan receives 2024 Hamilton Award

The ARC's Dr Bella Duncan has received the prestigious Hamilton Award from Royal Society Te Apārangi for her research on Antarctic climate history. Her study, 'Climatic and tectonic drivers of late Oligocene Antarctic ice volume' published in Nature Geoscience, reconstructs a 45-million-year record of ocean temperatures using molecular fossils from single-celled organisms. This research links atmospheric carbon dioxide levels, tectonic shifts, ocean warming, and ice sheet volume, providing critical insights into past and future climate impacts and clear evidence that continued if carbon dioxide emissions continue unabated, humanity can expect major ice loss and sea-level rise over the coming decades and centuries.

The findings reveal that during periods when carbon dioxide levels matched projections for the next century, the West Antarctic Ice Sheet experienced significant melting, with tundra vegetation thriving in the region. This underscores a dire warning: continued carbon emissions will likely lead to substantial ice loss and sea-level rise. Dr Duncan's pioneering use of molecular fossils in Antarctica has transformed understanding of how ocean temperatures influence ice sheet stability, filling gaps in scientific knowledge about past ice melt periods.

Dr Duncan's research has far-reaching implications for understanding climate change in inaccessible areas of Antarctica and the Southern Ocean. The Hamilton Award is the Royal Society Te Apārangi Early Career Research Excellence Award for Science, and is awarded for a single piece of work published within 13 years of receiving a PhD. We wholeheartedly congratulate Bella on this honour.

Dr Bella Duncan with award certificate. Photo by Rebecca McMillan, Royal Society Te Apārangi

New staff spotlight - Natalie Robinson

The ARC is excited to welcome Natalie Robinson as our new Associate Professor in Sea Ice Science and Oceanography. Natalie joins us from NIWA, where she still retains a fractional role helping us to enhance collaboration with their oceanography teams.

Natalie undertook her Master of Science project in the ARC, where she pioneered the application of oceanographic measurements beneath the Ross Ice Shelf in 2003. She has since become a leading global expert in the processes of ice-ocean interactions, leading major initiatives to highlight the increasing importance of catastrophic declines in sea ice in the past 5 years, its potential influence on the Ross Sea Marine Protected Area and New Zealand's climate. She was also successful as Principal Investigator in last year's Marsden Fund, leading a project to understand the oceanographic connections between ice shelf cavities and sea ice. To achieve this, she has returned to the use of our newer Hot Water Drilling system almost 20 years after she first used this technology for her MSc. She is also a Key Researcher in the recently awarded Antarctic Sea Ice Switch Endeavour project lead by Nancy Bertler (see front page). Her interest in understanding the physical processes that control sea ice growth and decay aligns strongly with existing expertise in the National Modelling Hub, and the biological sciences programme at VUW.

Natalie is internationally recognised as a scientific leader in her field, exemplified by her recent secondment (half-time) to Antarctic New Zealand as Deputy Director of the Antarctic Science Platform, and incoming Director for Phase 2 – helping guide the direction of Antarctic science for all of New Zealand over the next 7 years.

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Near Upper Priestley Glacier, Victoria Land. Photo by Holly Winton