BYTES

THE NEWSLETTER OF THE NATIONAL MODELLING HUB

In a nutshell...

It always feels at this time of year as if we're careering towards Christmas, slightly out-of-control, and desperately in need of a break. It's been another busy year, and as we wrap things up for 2024 we bring you just a few short updates in this edition of BYTES.

This month we report on two overseas collaborative trips, the establishment of a new 'Ice Sheets and Artificial Intelligence' research group, and provide a look-ahead for modelling work within the next phase of the Antarctic Science Platform.

We hope you've enjoyed hearing from us throughout 2024, and look forward to sharing more of our research with you in 2025.

Christmas on the Beardmore Glacier, December 2010. Photo: Nick Golledge

Issue 7
December 2024

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Ice Sheets and Artificial InTelligence (ISAIT)

NATIONAL MODELLING HUB

AN UPDATE FROM THE NATIONAL MODELLING HUB IN WELLINGTON, A MULTI-INSTITUTE PARTNERSHIP SUPPORTING THE ANTARCTIC SCIENCE PLATFORM AND NZ SEARISE PROGRAMMES

Looking ahead to Phase 2 of the Antarctic Science Platform

The first phase of the Antarctic Science Platform (ASP) is nearly complete, and the National Modelling Hub has made important scientific contributions with developments of new coupled atmosphere-ocean, ice-ocean, and ice-Earth deformation models that have informed about how the Antarctic Ice Sheet and Southern Ocean will change in a warming world. Planning for Phase 2 of the ASP (2025-2032) is currently underway and will build on these valuable research outcomes. “Tiaki Whenua” will be one of the two main programmes of this new phase, focused on the question: What are the critical vulnerabilities of Antarctica’s ice sheets and glaciers, and what are the implications of likely melt? The newly developed coupled models will be key tools for addressing this important question through informing where observational data is most critical and identifying the early warning signs and timescales for regime shift and irreversible change.

Tiaki Whenua will aim to better predict how climate changes will impact Antarctic ice melt rates and dynamic response under both short (seasons to decades) and long (centuries to millennia) timescales. Models will be applied to determine how extreme weather events in Antarctica may change in frequency or severity and what this means for atmospheric heat and moisture flux and surface mass balance. We will also use models to investigate how the ice sheet system will respond to changes in ocean heat flux and identify early warning signs of ice flow regime shift and irreversible grounding line retreat. These models will be informed from newly obtained geological records, a geophysical traverse across the Ross Ice Shelf, and an observational monitoring network for ice mass balance and velocity. Lastly, we are planning cross-programme initiatives to explore novel modelling approaches and Earth system feedbacks related to ice sheet retreat and melt. Our goal is to improve the understanding of Antarctica’s critical vulnerabilities to enable adaptive planning for future climate, sea level, and ecosystem change.

In addition to the two core projects, Tiaki Whenua and Tiaki Moana, phase two of the Antarctic Science Platform will also support a smaller, cross-cutting, 'Modelling Capability and Development' project. This Hoe aims to provide directed resourcing in three key areas: development of coupled models, integration of artificial intelligence approaches, and the adoption of dynamical systems

(continued...)

modelling. Whilst the budget for this Hoe is tight, it will hopefully be sufficient to support a limited number of researchers whose work is either novel or high-risk, and which is primarily concerned with capability and code development. 'Production'-type simulations using existing and established models will now be funded by each of the two Tiaki, allowing model experiments to be more closely integrated with observational research in a way that should allow for a more coherent and joined-up delivery of outputs.

Woods Hole Oceanographic Institution

In November Nick was invited to Massachusetts to visit Woods Hole Oceanographic Institution. Primarily collaborating with Dr. Alan Condron, an ocean modeller, Nick also spent time with a wide range of WHOI scientists spanning the full breadth of career stages and scientific disciplines. Many of the discussions revolved around the impact of Antarctic (and Greenland) ice sheet melt on the global ocean, particularly in terms of the bistability of the Atlantic Meridional Overturning Circulation and its sensitivity to freshwater fluxes. Whilst at WHOI Nick also gave the Fowler seminar, focusing on Antarctica and its role in the global climate system.

Taking the opportunity of being close to Boston, Nick later caught up with Prof. Jerry Mitrovica (Harvard University), a solid Earth geophysicist who has worked extensively on modelling global isostatic adjustment (GIA) and sea-level change related to ice sheet evolution. Many of Jerry's former students have gone on to be GIA experts in their own right (Natalya Gomez, Evelyn Powell, Holly Han), and have collaborated with Modelling Hub members on various projects over recent years.

Downtown Woods Hole. Photo: Nick Golledge

Despite the distance and carbon cost, the trip was an extremely worthwhile way to reconnect with some of the international community, from whom we have been somewhat isolated in recent years.

Measuring ice crystals in an Antarctic polynya

From September to November, Stefan visited the Institute for Baltic Sea Research (IOW) in Rostock Warnemuende, Germany. In a collaboration between the ARC and the IOW Stefan is developing a project proposal on direct measurement of ice crystals in an Antarctic polynya.

Polynyas, small ice free ocean regions, occur seaward of large outlet glaciers in Antarctica that guide very strong and very cold winds (50m/s, -20C) from the 3000m high Antarctic Plateau to the coast. By mechanical force these winds drive existing sea ice away, while at the same time extracting more heat from the -2C warm ocean. By wind-induced mixing, the heat extraction extends beyond the surface and cools the upper 10-50m of the ocean below its actual freezing temperature. Only in polynyas ice formation is therefore not limited to the surface but extends vertically to depths of tens of meters.

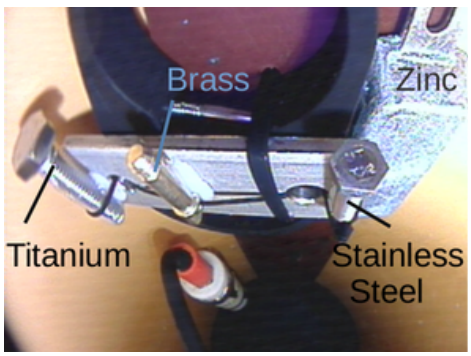
Newly formed sea ice excretes salty brine which is much denser than the ambient ocean water. Eventually this process forms Antarctic Bottom Water which fills the entire planet's deep ocean basins and controls the global transport of heat, nutrients and oxygen.

Insulating the cooled salt water tank

Climate models (GCM) have difficulties simulating this comparably small regional process in Antarctica of global importance. While physically accurate, direct calculation of mm-scale sub-surface ice formation is impossible on global scales, GCMs rely on parametrizing the overall net ice formation. This parametrization is a functional relationship between wind speed and temperature and the resulting polyna ice production rate - a relationship which needs to be derived from long term continuous observation data in winter.

However, no such data set exists currently. Ship access to polynyas is almost impossible in winter and stationary observation platforms are threatened by instrument freezing or collisions with icebergs.

Stefan's project proposes a technological way around these challenges to obtain this critical data set. (continued...)



Preliminary tests of freeze-on to different materials in saltwater below its freezing point. Accretion of frazil ice on stainless steel and zinc surfaces. No accretion on titanium and copper surfaces.

To work out a detailed design of the proposed polynya observation platform Stefan worked with the technicians and engineers from the IOW, who have long term experience with the technology in non-polar environments. The second objective of his visit was to develop a set of laboratory experiments that simulate certain aspects of sub-surface ice formation. The results will supplement the expected observation data and contribute to a robust parametrization of polynyas in GCMs.

Due to a temporary technical issue, our website is currently not accessible via the 'modellinghub.org' domain address. However, it is still online, and can be found at 'modellinghub.ucraft.site'. We hope to restore the domain name in 2025!

Ice Sheets and Artificial InTelligence (ISAIT)

About seven years ago, Modelling Hub co-leader Nick Golledge had a French intern visiting who started work on a neural network model for the Antarctic Ice Sheet. The idea was to build an emulator that could predict four-dimensional (x, y, z, time) ice sheet evolution under a range of future climates, without the computational cost of traditional (process-based) ice sheet simulations. Over subsequent years, this led to an informal collaboration between the Antarctic Research Centre (ARC) and machine learning experts in the Engineering and Computer Science (ECS) department at Victoria University of Wellington. In 2023, ECS founded the Centre for Data Science and Artificial Intelligence (CDSAI). Through co-developed projects, links with the ARC have continued to strengthen, and now we are working together on three MBIE-funded projects: the Antarctic Science Platform (ASP), Our Changing Coast, and a new Smart Ideas project led by Bach Nguyen (CDSAI).

Acknowledging this growth and future intention of cooperation and collaboration, Nick and Bach instigated the 'Ice Sheets and Artificial InTelligence' (ISAIT) group, and in November held a workshop to bring together researchers from both ARC and CDSAI to share their respective research. The meeting was very successful and opened up a number of new avenues for future collaboration. As the Modelling Hub starts planning for the next phase of the ASP, we hope that CDSAI will be an important part of our future work.

ISAIT
ice sheets and artificial intelligence

NATIONAL MODELLING HUB

RESEARCH TEAM

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Ice Shelf cavities, Ross ice sheet, The Terra Nova Bay Polynya

ALANNA ALEVROPOULOS-BORRILL

Ice sheet modelling, Ice-ocean interaction

ALEX GOSSART

Surface mass balance processes, Ross Sea, Terra Novay Bay

DAN LOWRY

Ice sheet dynamics, Ice shelf-ocean interactions, surface mass balance

LIZ KELLER

Carbon cycle dynamics, changes in Antarctica on global climate

MARIO KRAPP

Statistical modelling, dynamical systems, complexity

NICK GOLLEDGE

Glaciology, climate change, numerical modelling of Earth systems

PETER SIEW

Artificial Intelligence and machine learning

STEFAN JENDERSIE

Ocean circulation around Antarctica, ice shelves, polar oceanography

ABOUT THE HUB

The National Modelling Hub was set up as a partnership between NIWA, VUW and GNS, funded by the Antarctic Science Platform (ASP). Now, the Hub incorporates researchers from VUW, GNS Science and University of Canterbury, all of whom are funded through a range of research programmes. The work of the Hub is coordinated by Nick Golledge and Liz Keller, Co-Chairs of the ASP Modelling and Future Projections Working Group.

The Hub has six active PhD students: Béatrice Désy, Frank MacKenzie, Huiling Zou, Ihanshu Rane, Prasad Shelke and Vincent Charnay.

Victoria University of Wellington Te Herenga Waka | Te Puna Pātiotio Antarctic Research Centre | GNS Science Te Pū Ao | NZ SEA RISE Te Tai Pari o Aotearoa | Antarctic Science Platform | Ministry of Business, Innovation & Employment Hīkina Whakatutuki | University of Canterbury Te Whare Wānanga o Waitaha Christchurch New Zealand | NIWA Taihoro Nukurangi

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