BYTES

THE NEWSLETTER OF THE NATIONAL MODELLING HUB

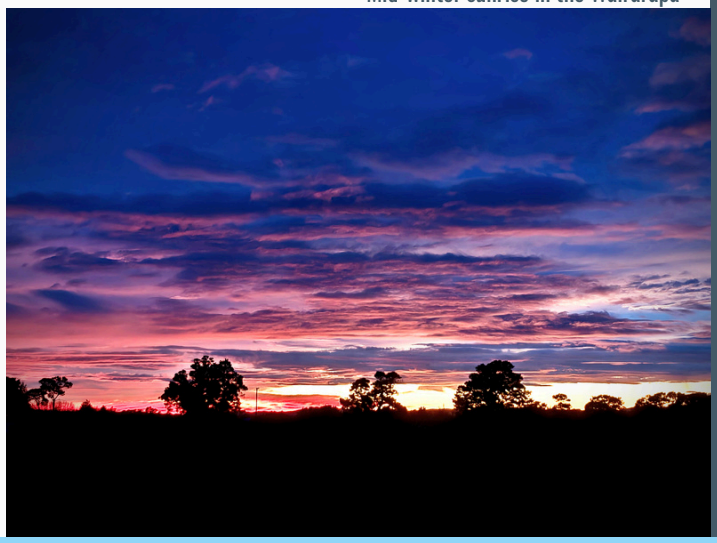
Issue 9
July 2025

In a nutshell...

We have turned a corner in Earth's orbit around the sun, and the days are getting longer again (phew!). And so too have we turned a corner with the Antarctic Science Platform (ASP), coming to the end of Phase 1 (2018-2025) and looking ahead now to the new work programme being developed for Phase 2 (2025-2032). The ASP Modelling Hub has changed a lot since its inception in 2020, and as we go forward from here our modelling group is more diversified and more widely distributed than ever before.

In this issue of BYTES we report on some of the changes taking place, as well as some of our ongoing research. In particular we highlight two projects using artificial intelligence methods to tackle different areas of climate science, as well as a recently published paper that takes a new perspective on a long-standing debate.

Mid-winter sunrise in the Wairarapa



Dan moves to University of South Florida

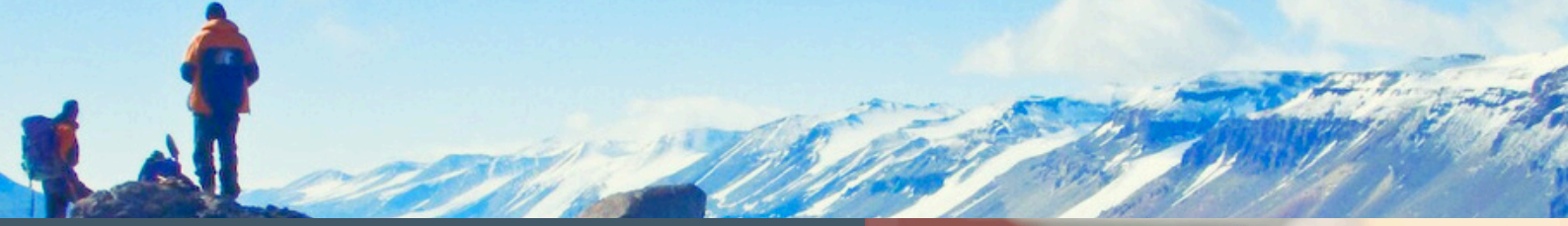
Data reconstruction using artificial intelligence

Palaeoclimate from iceberg-rafted debris

Global climate as a dynamical system

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



Dan moves to University of South Florida

After nearly a decade in New Zealand, Dan Lowry is now set to take up a new position back home in the USA. Dan joined the Antarctic Research Centre in 2016 to work on a Ph.D with Nick Golledge and Nancy Bertler. Using ice sheet and climate models, Dan worked to improve our understanding of Antarctic Ice Sheet change in the Ross Sea during the last deglaciation. After completing an excellent thesis, Dan took up a position with GNS Science and continued working on Antarctic ice sheet modelling. Over the subsequent 6 years, Dan's work also brought him into the field of future projections, contributing to several strands of the Ice Sheet Model Intercomparison Project (ISMIP) for CMIP6.

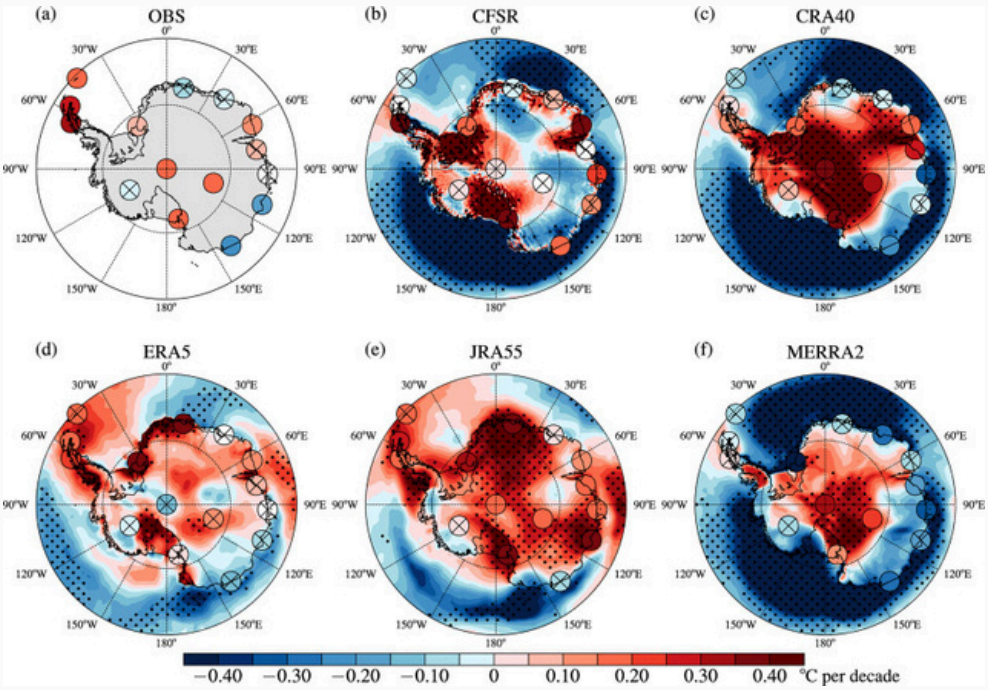
Dan storming home to win the 2017 Wellington Marathon in a course-record time of 2:22:43, a record that remains unbeaten to this day. Photo from https://wellingtonmarathon.co.nz/storage/app/media/History/2017PostRace.pdf

As an early career researcher Dan made has a huge contribution, leading papers in Science Advances, and Nature Communications, as well as co-authoring articles in Nature and Science and being a contributing author on the 'Ocean, Cryosphere, and Sea Level Change' chapter of the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6). Now very much an emerging researcher of international standing, Dan's expertise is more-and-more sought-after, and his new position at USF is a huge opportunity for him to build his own research group with postgraduate students and postdoctoral researchers of his own. We're really sad to see him go, but wish Dan all the best for an exciting and successful future!

Data reconstruction using artificial intelligence

Reanalysis products are a common tool for climate scientists to evaluate how global warming has influenced our climate over the recent past, including the warming rate in the Antarctic. We also use these products to infer how much Antarctic sea ice and the ice sheet have melted over recent decades. However, different reanalysis products show significantly different warming trends over the Antarctic (see Figure below). This urges us to create a temperature dataset that better matches ground-truth observations. Given the increasing number of weather stations that collect temperature, humidity, and pressure data across the Antarctic, it is possible to reconstruct a climate dataset closer to ground-truth observations that fully covers the Antarctic, including its interior and the Southern Ocean, where direct measurements are absent. This reconstruction can be advanced by the latest AI algorithms. New AI algorithms have been developed to fill in missing information in photos, a process similar to the climate data reconstruction we aim to achieve here.

Peter Siew (ARC) and Bach Nguyen (Engineering and Computer Science Department) are collaborating on this reconstruction project, aiming to create a daily, gridded surface air temperature and precipitation dataset covering the entire Antarctic since the 1980s. This dataset will be useful for understanding extreme sea and land ice melting events in the Antarctic.



Annual SAT trends (K/deace) over 1980–2023 from (a) in-situ observations and various reanalysis datasets, including (b) CFSR, (c) CRA40, (d) ERA5, (e) JRA55, and (f) MERRA2. Taken from Wang et al. 2025: https://doi.org/10.1016/j.accre.2025.03.003

Palaeoclimate from iceberg-rafted debris

ISAIT
ice sheets and artificial intelligence

Julianne Burns, a Ph.D student in the Antarctic Research Centre supervised by ARC Director Rob McKay and Nick Golledge is studying sediment cores from around Antarctica to determine how the ice sheet changed with climate during the Miocene (approximately 5 to 23 million years ago). She is using iceberg rafted debris (IRD) fluxes as a proxy for past ice sheet instability. As an ice sheet moves over an underlying rock, some of the rock will be eroded and entrained into the overlying ice. When that ice is then discharged into the ocean as icebergs, the icebergs gradually melt, and the incorporated rocks drop out and are deposited on the seafloor as IRD (Figure 1). While IRD could include particles of all grain sizes, shifts in IRD abundance are commonly characterized by isolating the “outsized” coarse grain fraction, typically above 2mm (Figure 2). By measuring changes in IRD quantity down core, iceberg fluxes through time can be reconstructed. (Continued...)

Figure 1

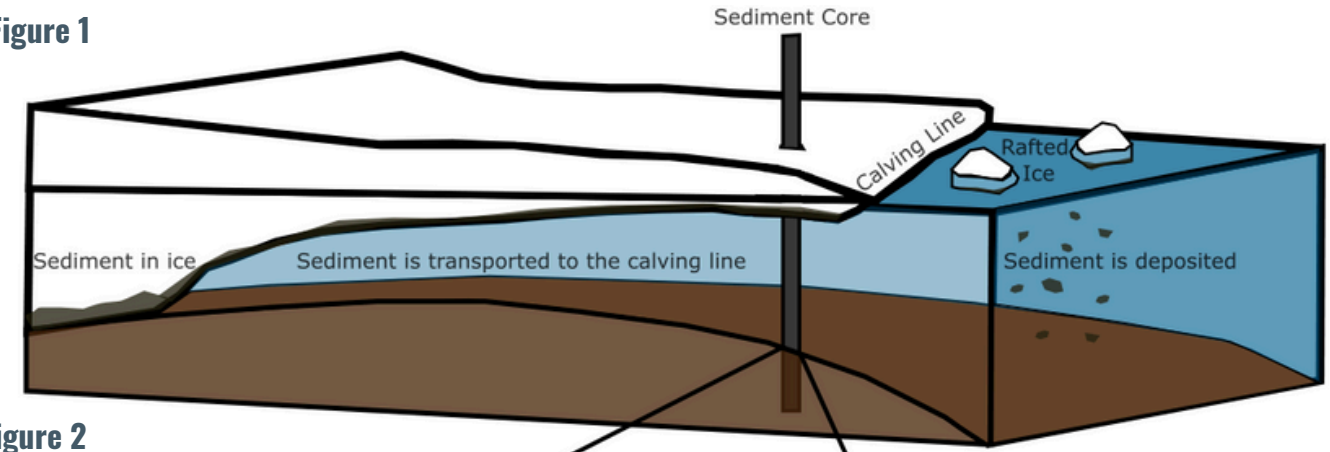
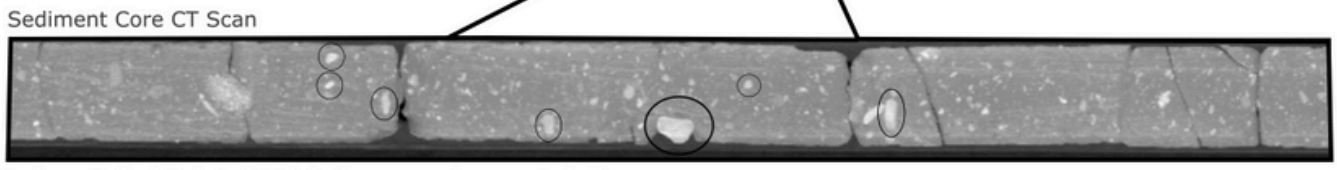


Figure 2



Iceberg Rafted Debris (IRD) (a few examples are circled).

Figure 1 : Ice Sheet diagram dictating the mechanisms in which Ice rafted debris (IRD) are deposited.

Figure 2 : Compiled CT scan example with some of the IRD.

(Continued from page 4...)
Counting the debris manually is time-consuming, so as part of her research project Julianne also hopes to work with AI researchers in the school of Engineering and Computer Sciences (ECS) to develop and validate an automated machine learning technique. This approach would identify and quantify IRD in CT scans of several hundred sediment cores. Ideally the computational method will accurately count IRD particles, measure their maximum dimensions, and record their depth positions within the cores. The automated results can then be compared against existing manual counting datasets to assess method reliability and potential for broader paleoclimatic applications.

At the moment a fully operational system is still some way off, but other groups around the world are working on similar approaches, and the potential is enormous. For VUW, this collaboration between the ARC and ECS is part of the 'Ice Sheets and Artificial InTelligence' (ISAIT) working group, which aims to bring the two fields closer together to tackle important climate-related research problems.

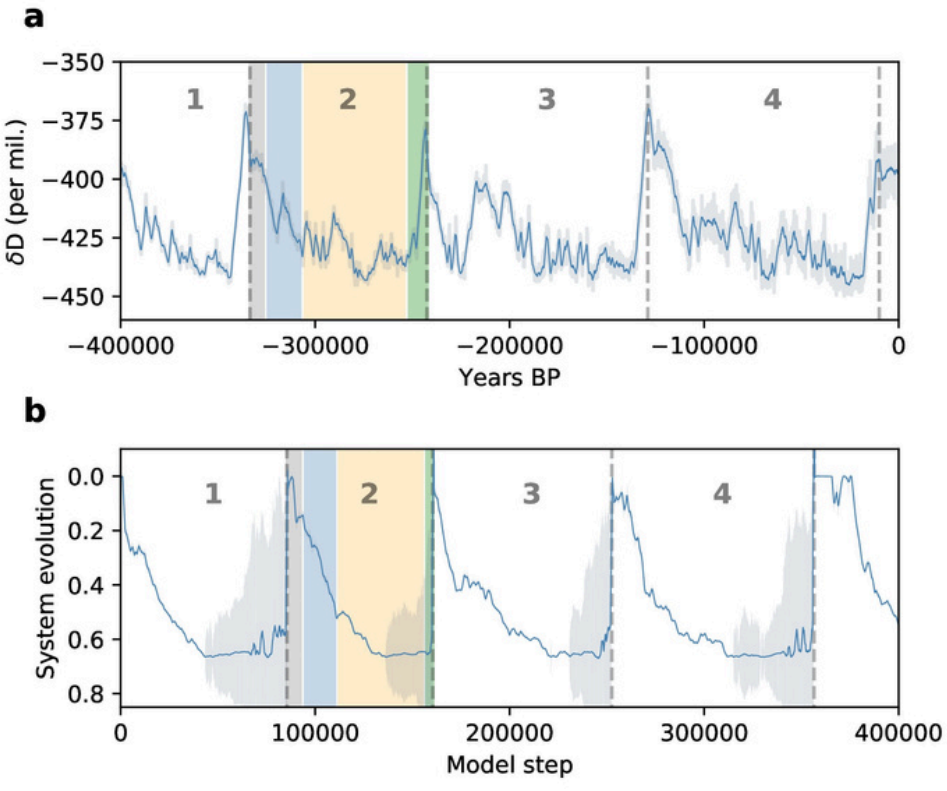
Publication:
Global climate as a dynamical system

The prevailing view of the Earth's climate is that, over timescales longer than a few decades, it is largely a deterministic system in which orbital changes in incoming solar radiation (insolation) lead to warming or cooling of the atmosphere. These orbital changes trigger feedbacks within the Earth system, for example leading to the release or storage of greenhouse gases in the ocean or on land. At shorter timescales, however, it is commonly accepted that the climate system behaves dynamically, and even chaotically, and as a consequence our ability to predict its evolution becomes increasingly diminished the further ahead we try and look.
(Continued...)

(Continued from page 5...)

In a recent paper, Nick Golledge argues that the climate system can actually behave dynamically, rather than purely deterministically, over much longer periods - even perhaps over millions of years. Nick investigated the Plio-Pleistocene, the period spanning the last five million years, and specifically an interval within that period known as the mid-Pleistocene Transition (MPT, 1.4 to 0.75 million years ago). During the MPT, glacial cycles gradually lengthened from around 41,000 years to 100,000 years. These two frequencies reflect known periods of change in, respectively, the obliquity (tilt) of Earth's axis and in the eccentricity of Earth's orbit around the sun. These both represent deterministic forcings. But why our climate switched from one to the other during the MPT has been debated for decades.

Using dynamical systems models, rather than deterministic models, Nick's experiments managed to reproduce key aspects of this major climate transition such as the change in its frequency and in the increasing asymmetry of the glacial cycles. And it did this entirely through internal feedbacks that allowed different climate components to synchronize with one another, not through external changes. The implication is that global climate does operate as a dynamical system over long periods, and as such, might be more prone to long-term unpredictable (or chaotic) changes than we tend to think.



a) Earth's climate over the last 400,000 years, according to the EPICA ice core record from East Antarctica.

b) A simulation using a simple dynamical systems model that captures the same basic shape of the climate oscillations, but without any external forcing.

N. R. Golledge (05 May 2025): A dynamical systems perspective on the Mid-Pleistocene Transition, Journal of the Royal Society of New Zealand DOI: 10.1080/03036758.2025.2495317

NATIONAL MODELLING HUB

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MARIO KRAPP

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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 nine active PhD students: Béatrice Désy, Frank MacKenzie, Huiling Zou, Ihanshu Rane, Prasad Shelke, Vincent Charnay, Timothée Lebrat, Xingyu Wang and Faezeh Bahmani.

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