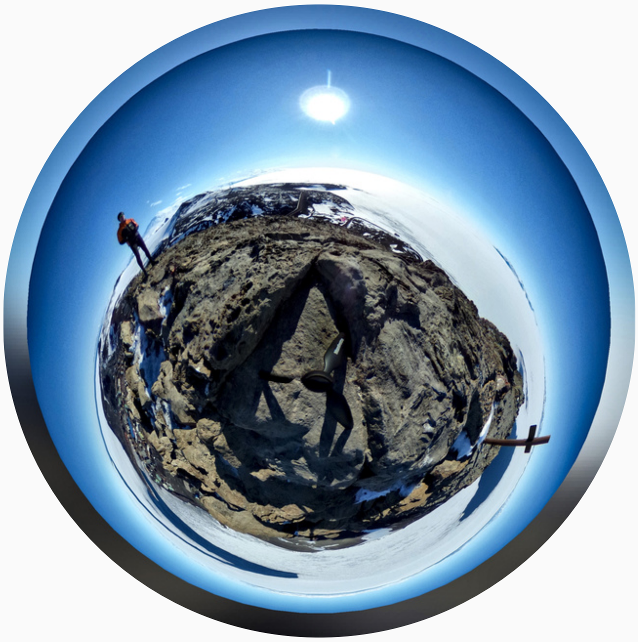
BYTES
THE NEWSLETTER OF THE NATIONAL MODELLING HUB

An update from the National Modelling Hub in Wellington, a multi-institute partnership supporting the Antarctic Science Platform and NZ Searise programmes
October '23 Edition

In a nutshell...

Welcome to the Modelling Hub's latest newsletter! In this edition, we explore the Hub's updates in the world of climate research and innovation. Read on to explore the collaborative efforts of climate modellers, both within the Hub and with external stakeholders, as well as the intricacies of coastal resilience planning. A unique spotlight on the work of a Hub PhD student showcases a new understanding of climate patterns. Enjoy the evolving landscape of climate science, as well as relevant modelling community updates, in this edition of Bytes.



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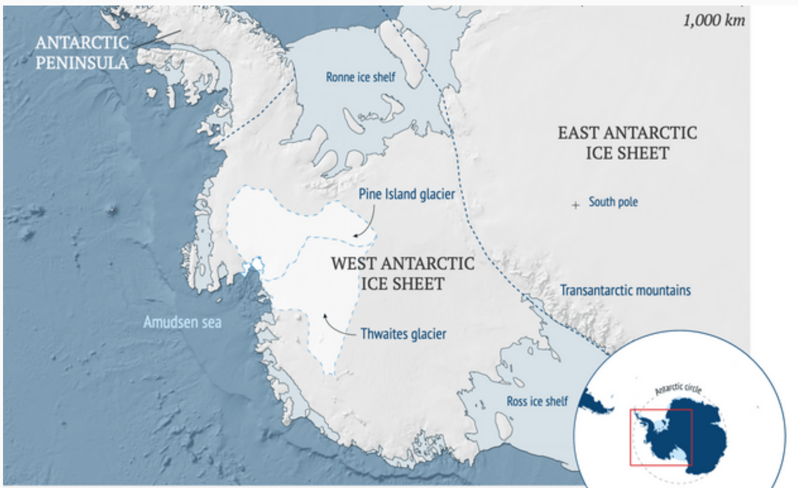
How Modellers Work Together, Relay-Style

Large-scale, complex models often involve various researchers working together. But how? In some cases, the modellers work in relay race, with the model outputs being the baton. Climate, ice, atmosphere and ocean modellers may independently develop stand-alone models for their respective areas of expertise, and then combine the results by passing one model's outputs as input to another. That's how Nick Golledge, Liz Keller, and Stefan Jendersie work together to estimate the potential future consequences of increasing CO_2 levels. By modelling the world under different scenarios (for example, times when the amount of ice in Antarctica or its prevailing climate were different), they can explore how the atmosphere, ocean and ice interact, and determine the real-world consequences of these interactions.

The starting points for this group's most recent experiments were Nick's ice sheet simulations, representing three different configurations: one where the West Antarctic ice sheet (WAIS) is fully intact, another where a part of WAIS has collapsed, and a third scenario where it's fully melted.



Graphic: Carbon Brief. Credit: Quantarctica/Norwegian Polar Institute.

Why WAIS?

For this project, Hub researchers play around with different scenarios for the West Antarctic Ice Sheet (WAIS): fully intact, partially melted, and fully collapsed.

Why? Because the last time CO_2 levels on Earth were at their current levels was approximately 3 million years ago, during the Pliocene era. Geological evidence suggests that, at least during Pliocene interglacials, WAIS was largely absent. So, by exploring how different WAIS configurations impact atmospheric conditions and ocean circulation, we may better understand the future impacts of our currently warming climate.

Nick hands off his three ice-sheet configurations as inputs to the global Earth-system model, run by Liz. She incorporates these ice sheet geometries with other factors that we already know about the Earth's state from 3 million years ago, like greenhouse gas concentrations and the amount of incoming solar radiation. From this, she creates a realistic estimate of the entire global climate. But, Liz doesn't stop there. She does the same thing for three other periods in Earth's history, for each ice sheet scenario, totalling 12 relevant scenarios.

The results of these 12 models are then handed off to Stefan, who uses Liz's global climate estimates as **boundary conditions** for his much higher-resolution models of the Southern Ocean and the continental shelf seas around Antarctica.

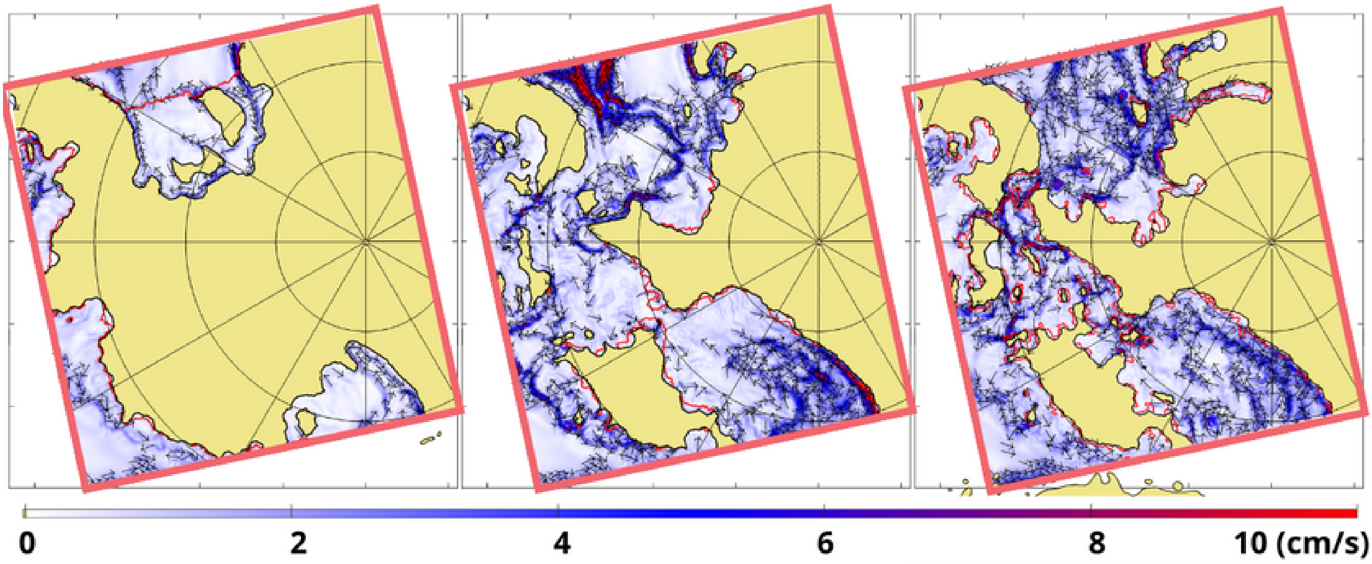
Stefan focuses on the ocean, exploring what the waters around West Antarctica might look like under the three different ice sheet conditions in today's climate, among other scenarios. The image on the next page demonstrates how different the seas act under the three different ice sheet scenarios for today's climate (fully intact, partially collapsed, or fully melted WAIS, from left to right).

Boundary conditions

Boundary conditions inform a model what the world looks like beyond the edge of a simulation. In the images below, the borders are still part of the model's outputs, and are only possible because information about what extends beyond them is provided by the global model via these boundary conditions.

One of the most remarkable takeaways of the project is the outsized impact small changes have on the global scale. The coarseness of the global model used in this project means that the difference between a fully intact WAIS and fully melted WAIS is just a single handful of pixels. However, the consequences of such a change can be seen in temperatures and ocean circulation throughout the globe in the model simulation. This is yet another example of the global impact that relatively small-scale features in Antarctica can have, such as how polynyas (discussed in our last newsletter) have a significant impact on global ocean circulation.

With each of the very different models used in this project requiring weeks or longer to run, the team will continue to explore their experimental outputs in the coming months.



Sea currents under three different ice sheet scenarios for today's climate (fully intact, partially collapsed, or fully melted WAIS, from left to right). Yellow corresponds to land and arrows indicate the direction of ocean currents. The colouring (white to blue to red, measured in cm/s) corresponds to the speed the currents travel. Not only are the currents stronger under the collapsed WAIS model, but they also change direction. In the Ross Sea, the currents run counter-clockwise in the central image versus clockwise in the right image (fully collapsed WAIS).

Changing Coasts: Risks, Roads and Sea-Level Rise

Understanding how climate and ocean changes impact coastal roads and transportation systems is critical when making accurate risk assessments and decisions. However, just building models to describe these systems isn't enough. It's equally important to communicate the modelling processes and outputs, and to adapt them for specific use-cases. That's the work of Mario Krapp, who collaborates with Waka Kotahi New Zealand Transport Agency under the MBIE-funded 'Our Changing Coast' programme, the latest work package of the NZ SeaRise initiative, to help prioritise and mark high-risk zones.

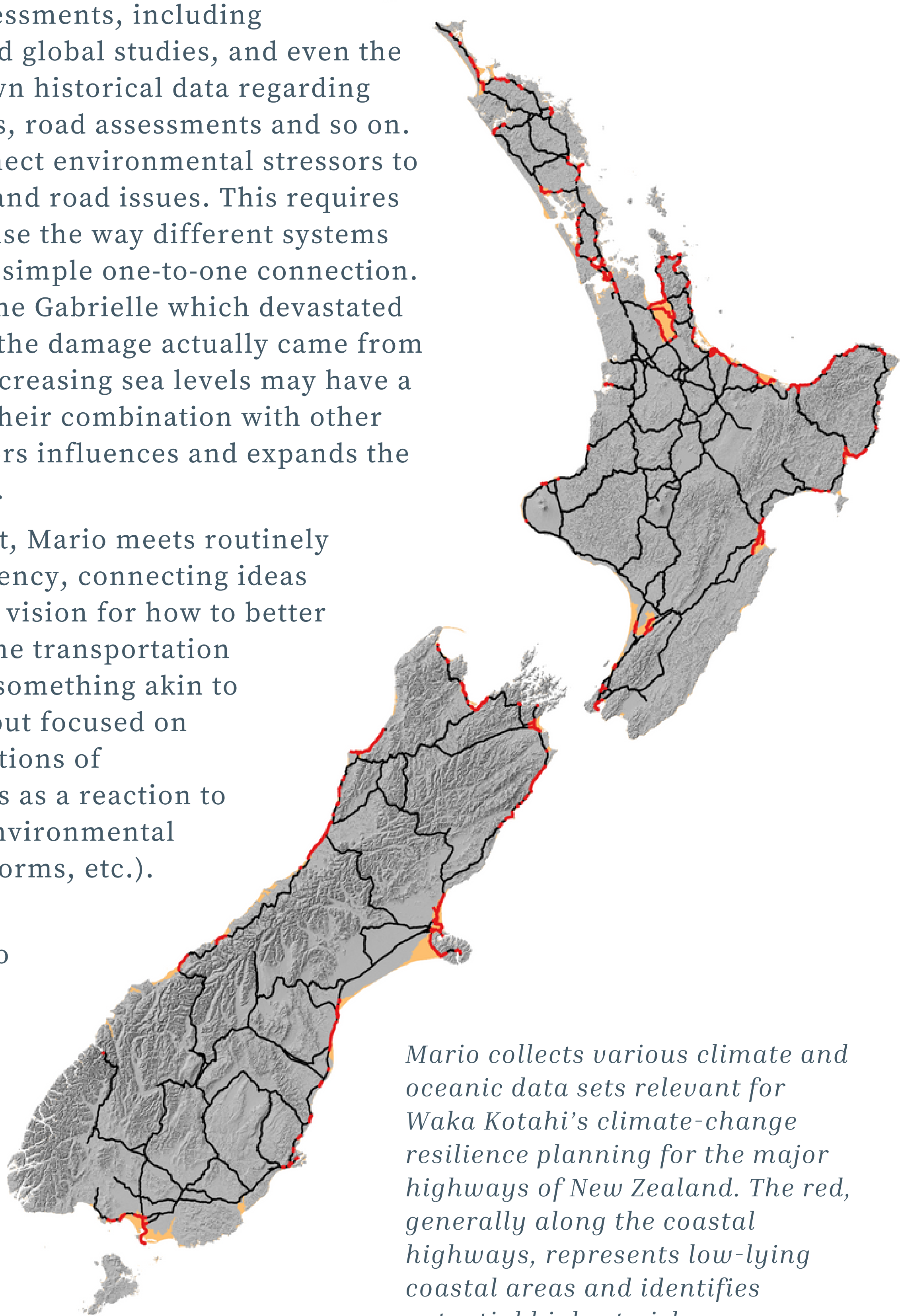
Currently, the team is conducting a historic assessment of road damages, trying to (in retrospect) predict the impact of various weather and environmental stressors. This allows them to develop an effective strategy that can then be applied to future contexts. Mario's role involves estimating the risk factors across the country, as is shown in the second image below. There, the red lines indicate roads that are at higher risk, particularly when it comes to storms.

As oceans rise and land subsides, it's important to evaluate how the coasts will be affected. Mario's project focuses on transportation, but the issue is equally important in other disciplines. NZ SeaRise also offers publicly available sea-level projections for the entire coast of New Zealand, so anyone can look up how their home or city will be affected in the next 100 years. Image from NZ SeaRise site.

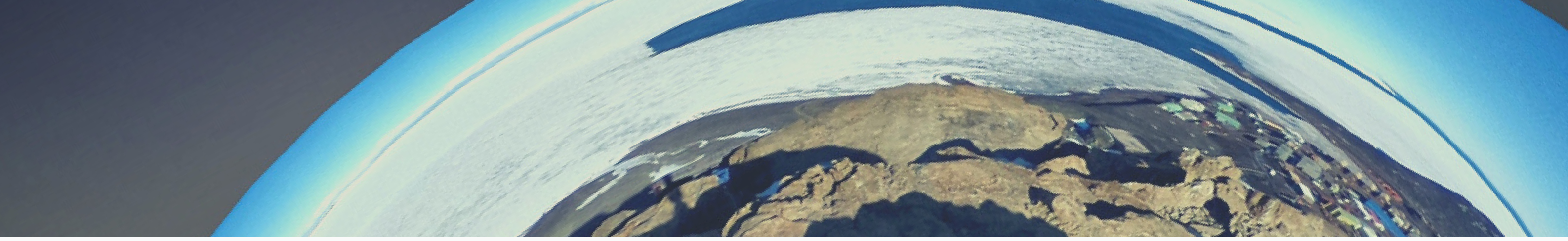
Mario and his collaborators use a variety of sources to develop their risk assessments, including observations, local and global studies, and even the Transport Agency's own historical data regarding previous road closures, road assessments and so on. The team tries to connect environmental stressors to the different outages and road issues. This requires careful scrutiny because the way different systems interact isn't always a simple one-to-one connection. Take the recent Cyclone Gabrielle which devastated Hawke's Bay. Most of the damage actually came from rivers that flooded. Increasing sea levels may have a similar story, in that their combination with other environmental stressors influences and expands the impact they may have.

In this ongoing project, Mario meets routinely with the Transport Agency, connecting ideas and sharing a broader vision for how to better build resiliency into the transportation system. He envisions something akin to weather forecasting, but focused on anticipating the conditions of transportation systems as a reaction to various climate and environmental stressors (cyclones, storms, etc.).

Automating the current process, Mario and his colleagues are developing means of embedding resiliency into the country's transportation, to better prepare and react to the changing climate and coasts for years to come.



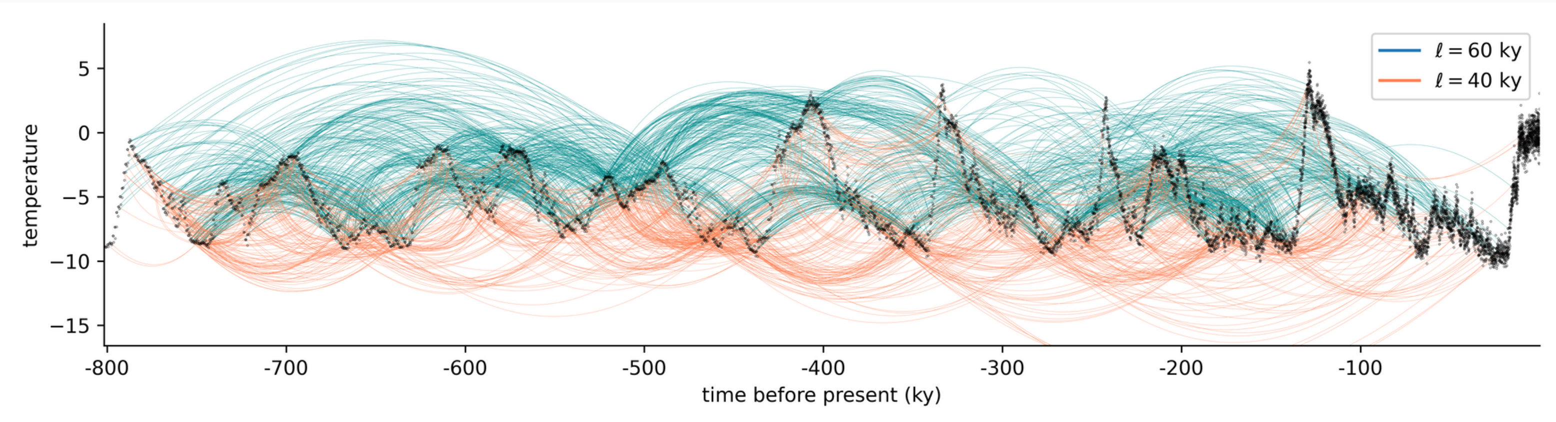
Mario collects various climate and oceanic data sets relevant for Waka Kotahi's climate-change resilience planning for the major highways of New Zealand. The red, generally along the coastal highways, represents low-lying coastal areas and identifies potential highest-risk zones.



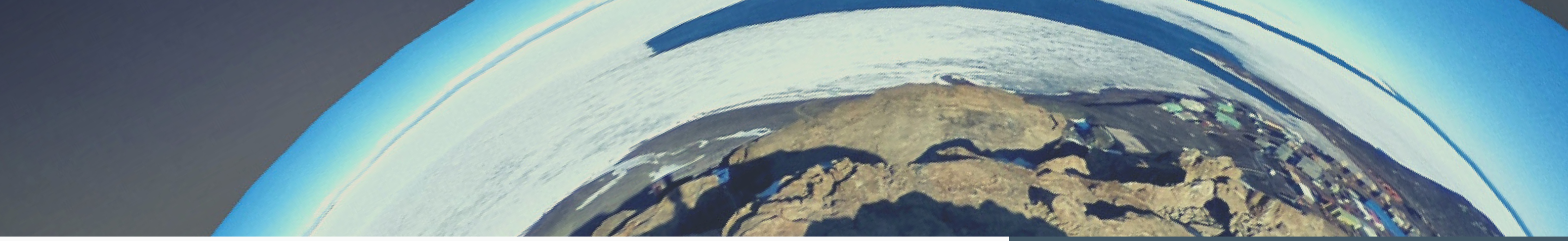
PhD Student Spotlight: Béatrice Désy

Interdisciplinary approaches to climate science often leave one thinking about biology, ecology, or even, as we see in previous stories, transportation and logistics. However, the work of Béatrice, alongside her advisors, goes to show that principles used in network and information sciences can greatly enhance how we study and understand climate.

With a Master's in Complex Systems, Béatrice pursues a unique approach to climate modelling. Her projects involves applying methods originally designed for text and blog post data by her co-advisor, Markus Luczak-Roesch from the School of Information Management, to climate data. Working together with her Hub co-advisor, Nick Golledge, she studies patterns of climate events over the last 800,000 years. What makes this project unique is the non-specificity of the approach. Rather than looking at how certain physical events tend to reoccur, Béatrice and her collaborators look at the problem from a new perspective. Considering the global mean temperature the last 800,000 years, she identifies periods of time which demonstrate similar patterns in climate evolution. The visual below shows how recurrences of similar temperatures take place, with lines connecting repeated patterns seen in 40,000 (red) and 60,000 year periods (blue).



Results from Béatrice's work showing recurring climate events over the last 800,000 years. Lines connect similar events (i.e. repeated patterns in temperature) at 40,000 (red) and 60,000 (blue) year intervals. The black line indicates changes in the mean global temperature. Keep in mind, "climate event" doesn't necessarily mean any real-world event, but just a pattern in how global temperature changes.



Although Béatrice only started the project last year, she has already found some unexpected results. Namely, that these patterns happen at various intervals, and not necessarily the typical 100,000-year cycle that is commonly assumed. That will become clearer as Béatrice dives into the research in the coming months, after having recently arrived back from several months of research-driven travel.

During her travels, she presented her work at the Potsdam Institute for Climate Impact Research, where the longest-standing researchers in the field of modelling climate with networks are located. She also shared her work at the NetSci network science conference in Vienna, as well as with her previous research group at Université Laval, in Québec.

Although presenting early-stage research is challenging, Béatrice finds it extremely valuable. She shares, "I really like receiving early feedback." Béatrice found it both humbling and interesting to present to researchers at Potsdam who have been working on applying network models to climate for over 15 years. No doubt, the early advice and insights garnered from her travels will help shape and contribute to the novelty and impact of her project.

Climate Events

In the context of Béatrice's work, "climate events" refer not to any particular physical event, but rather to the pattern of how global temperature changes over a set period of time (say, 40,000 years). However, by treating all changes in this generic way, this project may better inform actual physical processes behind these patterns of change.

Béatrice travelled across the world this last summer, as she presented her research to various audiences in Europe and North America, including the Potsdam Institute for Climate Impact Research.

Winter School Recap

At the end of September, the Modelling Hub organised and ran our third annual 'Winter School' for numerical modelling and data analysis. The event was a collaboration with New Zealand eScience Infrastructure (NeSI), who support New Zealand research projects through their high performance computing (HPC) infrastructure services.

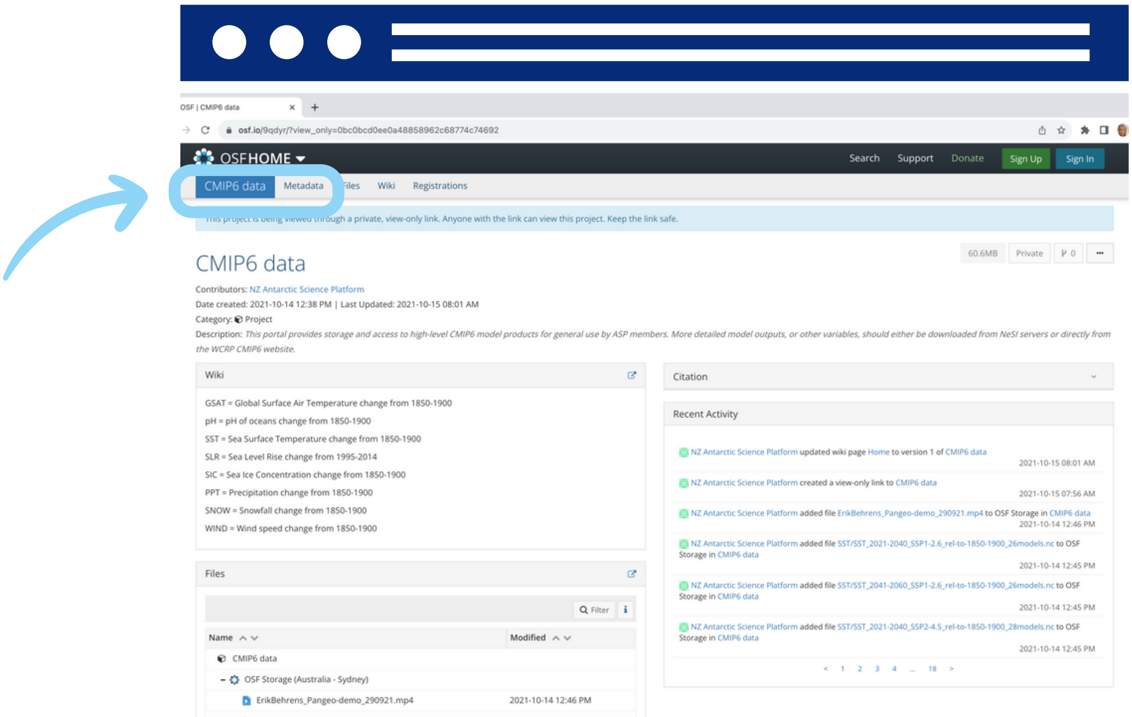
Attended by more than 20 participants from across New Zealand universities and CRIs, the 3-day workshop at Victoria University of Wellington had students learning about climate models and even running their own simulations of Cyclone Gabrielle.

NeSI staff were on hand for all three days helping teach and supervise the interactive sessions together with Hub researchers. With the icebreaker drinks and group dinner, everyone seemed to have had a great time. We even had a suggestion to extend the course to a full week!

Keep an eye on future issues of Bytes to find out more about the 2024 Winter School once planning gets underway.

Data for All ASP Scientists

Researchers in the Antarctic Science Platform working on science projects 1-4 (Ice Dynamics, Ocean Mechanics, Ecosystems, and Feedbacks) may find they need to use components of CMIP6 datasets at some point in their work. The atmosphere-ocean general circulation model simulations coordinated by the Coupled Model Intercomparison Project Phase 6 provide quality-assured and reproducible estimates of ocean and atmospheric changes for the rest of the current century under a range of plausible emissions scenarios.



Given the importance of accessing the CMIP6 datasets, the ASP CMIP6 Working Group was established to serve as a point-of-contact for ASP researchers trying to access CMIP6 data. The data is easily accessible on OSF here. There, scientists can find time-slice data for a range of common parameters downloaded from the IPCC Interactive Atlas, and for convenience have been made available for download in netCDF format.

Find more information, check out the CMIP6 page on the Modelling Hub website here.

NATIONAL MODELLING HUB

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NICK GOLLEDGE

Glaciology, climate change, numerical modelling of Earth systems

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 eight active PhD students: Béatrice Désy, Frank MacKenzie, Huiling Zou, Ihanshu Rane, Nikhil Hale, Prasad Shelke, Vincent Charnay, and Yaowen Zheng.

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
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