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Newsletter of the Antarctic Research Centre
Victoria University of Wellington

A word from our Director

As we head into another busy summer field season, this issue profiles research published during the winter months by our recently completed PhD students. We highlight a *Nature* paper led by Georgia Grant that examined a unique record of past sea-level change preserved in drill cores from the aptly named Siberia Station in the Whanganui backcountry; while Dan Lowry led a paper in *Science Advances* examining how model experiments and geological data can be combined to determine how oceanic and atmospheric change may lead to ice sheet loss in the future. At the other end of the career spectrum, we pay tribute to retiring ARC stalwart Professor Lionel Carter who has been instrumental in demonstrating the relevance of Antarctica for New Zealand's climate and oceans. We are very happy that Lionel will continue to contribute to his impressive legacy in the ARC as an Emeritus Professor.

Rob McKay

New research on past sea levels reveals potential for widespread Antarctic melting

Antarctic ice sheets are capable of widespread melting, raising sea-levels up to 20 metres under current atmospheric carbon dioxide levels, according to a new ARC-led study published in *Nature* (Grant, G., *et al., Nature* 574: 237-241). The research shows up to one third of Antarctica's ice sheets melted during the Pliocene epoch around three million years ago, causing sea levels to rise as much as 25 metres above present levels. Levels of carbon dioxide in the Earth's atmosphere were similar to today's levels and in response, temperature was 2-3°C warmer.

The study was led by Georgia Grant, a recent ARC PhD graduate now at GNS Science, and used a new method of analysing marine geological sediments to construct a global sea-level record. Georgia developed the method of determining the magnitude of sea-level change through analysing the size of particles moved by waves, as part of her PhD research on geological cores from Whanganui Basin on the west coast of North Island. Georgia was able to show that during the past warm period of the Pliocene about three million years ago, global sea levels regularly fluctuated between 5 to 25 metres.

The study, which was funded by the Royal Society Te Apārangi's Marsden Fund, also involved the ARC's Tim Naish, Gavin Dunbar, Rob McKay and Richard Levy, as well as other scientists from GNS Science, Waikato University, the Netherlands, the United States and Chile.

Georgia says of critical concern is that over 90% of the heat from global warming to date has gone into the ocean, and much of it into the Southern Ocean which surrounds the Antarctic ice sheet. One third of Antarctica's ice sheet—equivalent to up to 20 metres sea-level rise—sits below sea-level and is vulnerable to widespread and catastrophic collapse from ocean heating. It melted in the past when atmospheric carbon dioxide levels were 400 parts per million (ppm), as they are today.

"Our new study supports the idea that a tipping point may be crossed, if global temperatures are allowed to rise more than two degrees, which could result in large parts of the Antarctic ice sheet being committed to melt-down over the coming centuries. It reinforces the importance of the Paris target," says Georgia.

She says the study also has implications for computer-based ice sheet modelling.

"Our new sea-level estimates provide a target for testing the results from computer models and improving their ability to make accurate projections of the Antarctic contribution to global sea-level rise," she says.

"This new research is consistent with model results that show long-term ice sheet retreat under current carbon dioxide levels," says ARC modeller Nick Golledge.

"The rate of sea-level change estimated from this study is also in line with our understanding of climate sensitivity and supports future predictions of one metre of sea-level rise by 2100."

Georgia Grant (in front) and then MSc student Juliet Sefton at Siberia Station drill site in 2014

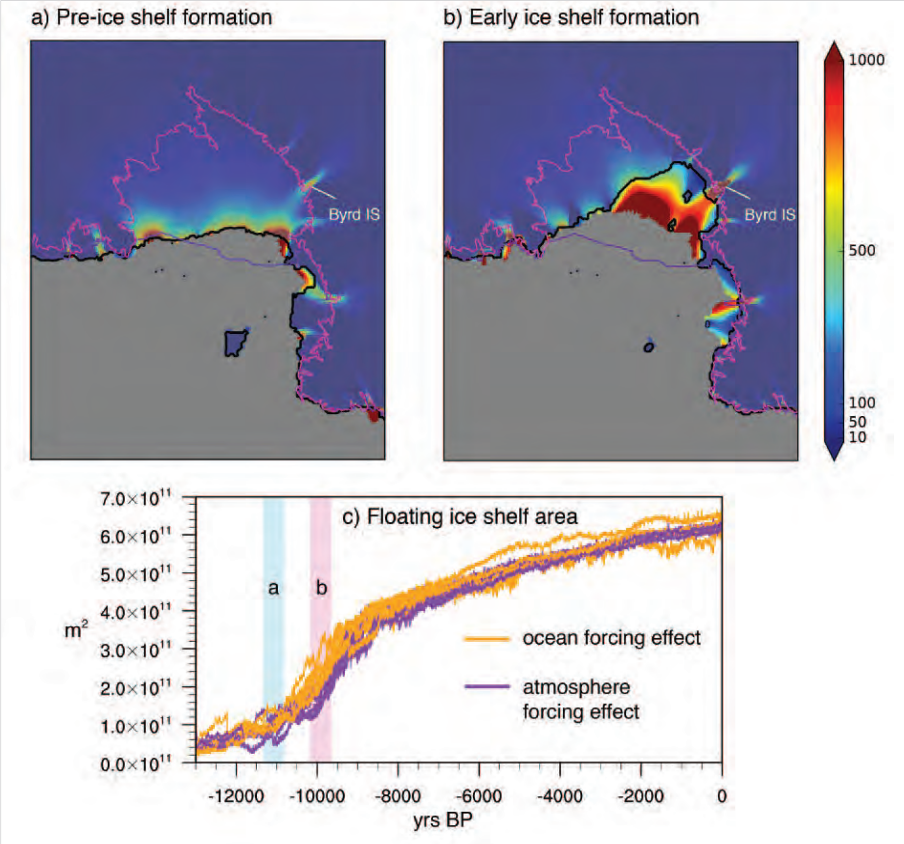
Accurately predicting Antarctica's ice sheet response

A new model, developed by recently completed ARC PhD student, Dan Lowry, could help to more accurately predict how Antarctica's ice sheets will respond to a warming world and impact global sea-level rise. Dan developed the model and has recently published an article about it in the well-respected *Science* journal *Science Advances* (Lowry, D., *et al., Science Advances* 5: eaav8754). Dan says the purpose of his research is to determine how stable the West Antarctic Ice Sheet is in a warming world to help project future sea-level rise.

"Our main findings are that ocean and atmosphere warming are the primary controls on the major glacial retreat that took place in the Ross Embayment since the last ice age. But significantly, our modelling showed that the dominance of these two controls in influencing the ice sheet was different at different times, with melting from underneath the Ross Ice Shelf due to ocean warming becoming the main driver of ice sheet retreat over time," he says.

The model works by simulating the physics of the ice sheet and its response to changes in ocean and atmosphere temperatures. The simulations are then compared to geological records and tested against past scenarios to check its accuracy.

"This all goes back to the question of sea-level rise and how the processes, that have affected the Antarctic ice sheet through its history, will continue to affect global sea level. The past really is the key to the future," he says.



Simulated formation of the Ross Ice Shelf. As the ice sheet retreats toward Byrd Glacier, ice velocity increases (indicated by colour in panel a and b), and the ice sheet begins to float. The black line represents the ice sheet grounding line, which is the transition between grounded ice and floating ice. With development of the ice shelf, simulations that use different ocean forcings (orange lines in panel c) show greater variation than model simulations that use different atmosphere forcings (purple lines in panel c), suggesting the importance of sub-ice shelf melting in past ice sheet retreat over the past 10,000 years

Dan's supervisor and co-author Nick Golledge says this modelling work is critical to help policy makers and communities develop adaptation and mitigation strategies for sea-level rise.

"It fundamentally supports sea level projections for cities and infrastructure in New Zealand and elsewhere," he says.

Dan's research was funded by the Royal Society Te Apārangi's Marsden Fund and in 2017, Dan also received an Antarctica New Zealand Sir Robin Irvine Postgraduate Scholarship to support his research. Antarctica New Zealand Acting Chief Scientific Advisor Dr Fiona Shanhun says it is great to see their scholarship recipients contributing to understanding Antarctica's role in the global climate system.

S.T. Lee Exchange – Applying NZ research on a global scale

The last chapter of my dissertation involved finding the influence of humans on the highest melt years of New Zealand

Lauren Vargo measuring mass balance at Brewster Glacier in April 2018

glaciers. I show that the highest melt years were more likely to have occurred with humans, compared to a world without anthropogenic climate change. But this method requires measurements of glacier melt, which we only have for two glaciers in New Zealand.

So, I put in an application for the S.T. Lee Young Scientist Exchange with University of Alaska-Fairbanks with the lofty goal of applying the same analysis used for the New Zealand glaciers, to over 100 glaciers around the world. I hoped that by working with Professor Regine Hock - a leading scientist on simulating global glacier mass balance - we would be able to develop a plan for applying my local New Zealand study to glaciers around the world.

During my time working with Regine, we came up with a plan for this research project. But visiting Fairbanks also led me to meet and talk with other students and scientists. For example, I chatted with ice sheet modellers about how this method of calculating the human influence on glacier melt might be applied to ice sheets, which was especially relevant as the Greenland ice sheet was setting melt records at the time.

Lauren Vargo

Esteemed Professor, Lionel Carter retires

On the 28 June, the ARC celebrated the career of Professor Lionel Carter at his retirement function held at Victoria University of Wellington. Prior to joining the ARC as Professor of Marine Geology in 2006, Lionel spent 32 years at NIWA and its predecessor the New Zealand Oceanographic Institute of the DSIR.

Lionel's research career has centred on investigating basic geological and oceanic processes and applying these discoveries to assess ocean environmental change, natural hazards and resources. Some of his major research achievements include determining the abyssal circulation and its interaction with the ocean floor in the SW Pacific Gateway off eastern New Zealand. This system of currents forms the local component of the Ocean Conveyor, which is one of the major transporters of heat around the planet as well as a regulator of climate change. He discovered the long distance transport (> 2000 km) of sediment and its accumulation as extensive sediment drifts under abyssal currents. And Lionel identified the Eastern New Zealand Oceanic Sedimentary System (ENZOSS), whereby sediment generated at the southern sector of the New Zealand plate boundary is transferred to the deep ocean, transported up to 4500 km by abyssal currents and returned to the northern sector of the plate boundary via the Kermadec subduction zone.

A firm believer in applying research to real-world problems, Lionel applied his expertise to a wide range of marine engineering projects. For over 15 years, he has been working with the International Cable Protection Committee – an international forum for the submarine telecommunication cable industry – to better protect the global fibre-optic cable network from marine hazards. This work has gained significance as this cable network carries over 95% of all international internet and communications traffic.

During his career, he has participated on 36 oceanographic voyages of which 28 were as voyage leader. Lionel has also been the recipient of numerous awards. In 1998, Lionel received the Geological Society of New Zealand's McKay Hammer for the most meritorious research papers between 1996-1998. He was named a Fellow of the Royal Society of New Zealand in 2003, received the Marsden Medal for outstanding services to science in 2012, and in 2015 the Hutton Medal for outstanding scientific research in Earth sciences.

While at the ARC, he led the ~$2M ANZICE (Antarctica-New Zealand Interglacial Climate Extremes) Programme funded by the then New Zealand Foundation for Research Science and Technology. ANZICE was closely aligned with the Global Change Through Time programme at GNS Science and linked with the ice core group at NIWA and aimed to understand the likely response of the New Zealand-Antarctic region to a warmer world. Lionel also embraced teaching whole-heartedly and is a highly popular and respected lecturer at undergraduate level – and has been a dedicated thesis supervisor. His scientific advice is always sensible and his sense of humour absurdly brilliant, something everyone in the ARC has appreciated. The ARC is pleased to continue working with Lionel as an Emeritus Professor.

Lionel Carter; in Antarctica for the ANDRILL programme; on board NIWA's *Tangaroa* research vessel

More Marsden success for ARC researchers

One of the first two Marsden Council Awards was awarded to a team led by Professor Vic Arcus (University of Waikato), that includes ARC's Bella Duncan as a Principal Investigator. These new $3 million "super marsden" grants are designed to support innovative trans-disciplinary research. This study aims to define a theory - in fact a single equation - that explains the temperature dependence of all terrestrial biology from the enzyme to biosphere scale, and has fundamental implications for microbial growth rates, plant and soil respiration, photosynthesis and, landscape carbon sequestration. Titled *Macromolecular Rate Theory (MMRT) and the temperature-dependence of the terrestrial biosphere over time and space*, the team of researchers will work across scales and disciplines including chemical physicists, molecular biologists, plant physiologists, soil scientists, climate modellers and paleoclimate experts. The paleoclimate team from the ARC, which also includes Nancy Bertler and Tim Naish, will use geological reconstructions of the evolution of temperature, carbon dioxide, and photosynthetic pathways over the last 40 million years to ground truth models during past warm climates. More specifically, Bella will analyse molecular biomarkers to reconstruct aspects of vegetation evolution and the carbon cycle. We are very excited to see this broadening of our climate research expertise into collaborative, multidisciplinary Earth system science that supports and promotes early career researchers.

A second, $960k standard, Marsden grant was awarded to Nancy Bertler through GNS Science. Titled *Did the West Antarctic Ice Sheet Collapse during the Last Interglacial Warm Period?*, the study aims to develop the first West Antarctic ice core account of the last interglacial, some 115,000 to 130,000 years ago. Then, temperatures were 1-2°C warmer and global sea levels were 6-9 metres higher than today. This makes the last interglacial an important record to test and improve models that assess climate change consequences in a Paris Agreement or warmer world. The ARC's Nick Golledge, Ruzica Dadic and Rob McKay are key partners for this project along with leading international ice core and modelling experts from the US and Europe.

2019 Hill Tinsley Medal awarded to Nick Golledge

Associate Professor Nick Golledge has been awarded the 2019 Hill Tinsley Medal from the New Zealand Association of Scientists (NZAS). The medal is awarded to an early career scientist for outstanding fundamental or applied research in the physical, natural, or social sciences. In 2016, the NZAS awarded the first Beatrice Hill Tinsley Medal, which replaced the Association's Research Medal for early career researchers.

Nick received the award for his work in modelling ice sheet and individual glacier behaviour over a range of time periods. His work has provided valuable insight into past ice sheet behaviour.

Nick joined the ARC in 2009, soon after completing his PhD. While at the Centre, he has focused on modelling Antarctic ice sheets and their contribution to sea-level rise. He has published many high-impact scientific articles, including a recent *Nature* paper which explores the global consequences of 21st century ice-sheet melting, and his findings have made media headlines across the world.

The Hill Tinsley Medal
(photo courtesy of NZAS)

Congratulations to our students on their recent completions

Lisa Dowling MSc *The Holocene glacial history of Dart Glacier, Southern Alps, New Zealand*

Clarrie Macklin MSc *Finite-element modelling of Haupapa/Tasman Glacier's basal sliding events*

Rebecca Pretty MSc *Ice dynamics and ocean productivity during the Late Miocene, offshore Wilkes Land, East Antarctica*

Simon Reeve MSc *Development of an improved ramped pyrolysis method for radiocarbon dating and application to Antarctic sediments*

Nikita Turton MSc *East Antarctic Ice Sheet and Southern Ocean response to orbital forcing from Late Miocene to Early Pliocene, Wilkes Land, East Antarctica*

Lukas Eling PhD *Early Holocene Antarctic climate variability - drivers and consequences as captured by major ions in the Roosevelt Island Climate Evolution (RICE) ice core*

Dan Lowry PhD *Deglacial climate and ice sheet evolution of the Ross Embayment, Antarctica*

Abhijith Ulayottil Venugoapl PhD *Glacial Antarctic warm events as captured by the RICE ice core*

Lauren Vargo PhD *Drivers of modern New Zealand glacier change*

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