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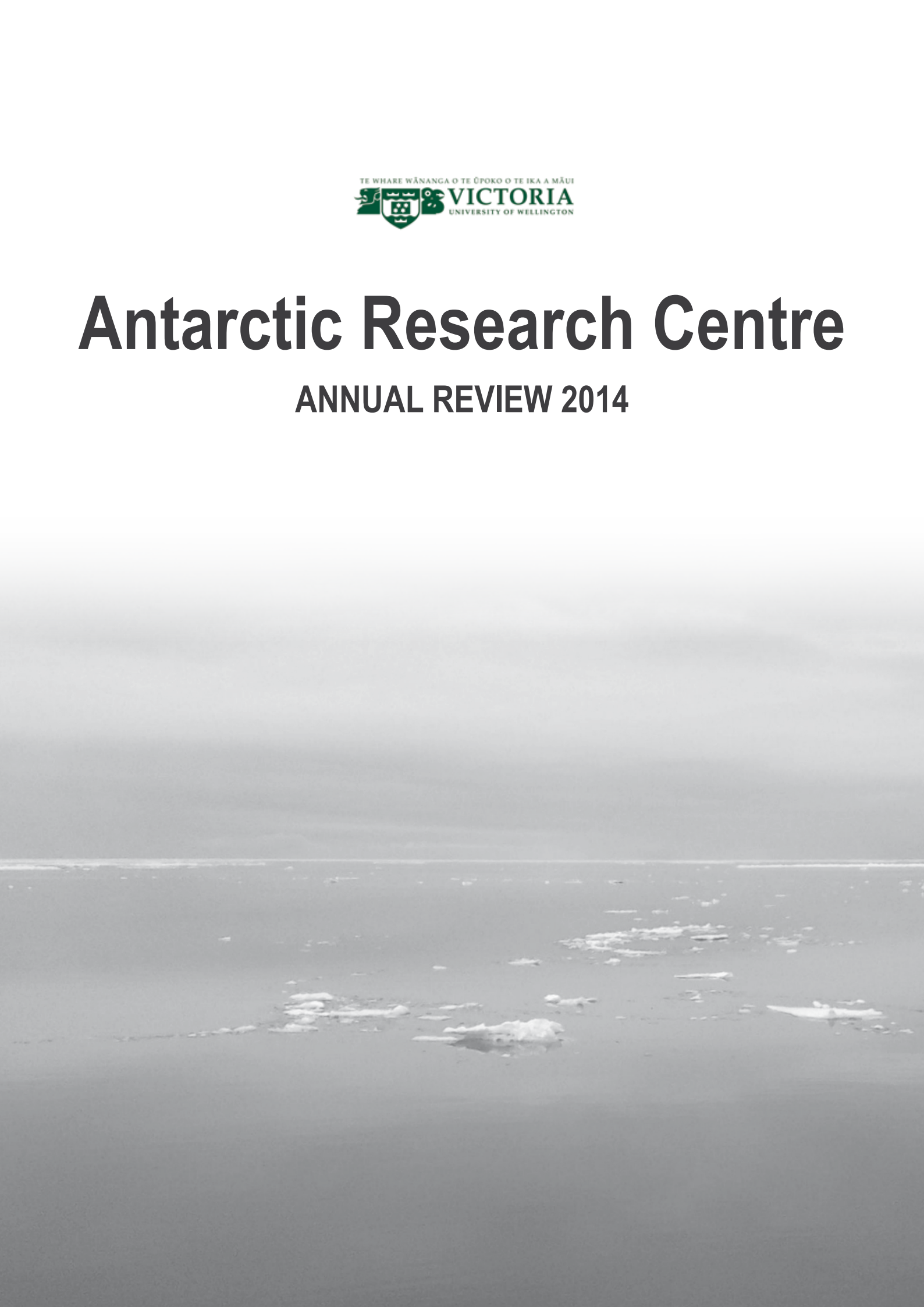

DIRECTOR'S SUMMARY

One of the most rewarding parts of my job is writing this Summary each year for the Annual Review, where I get to reflect on the many activities and achievements of the Antarctic Research Centre (ARC). Despite being dislocated from our Science Faculty colleagues on the Kelburn campus, while the top floor of the Cotton Building was renovated, 2014 was another stellar year for the ARC team. From our temporary digs in the Wellington Railway Station our staff and students contributed to an impressive range of research activities, outreach and engagement events, and were recognized by awards, appointments to international panels and committees and invitations to present at leading conferences and workshops.

Our commitment to world-leading Antarctic and climate change research that makes a difference both internationally and in New Zealand is grounded in scholarly research published in leading scientific journals. This year we profile six papers in *Nature* and *Science* journals co-authored by our staff and students – a record for the ARC! But the commitment to communicating the relevance of this research to the public and stakeholders is equally impressive, and is a hallmark of the ARC research philosophy and approach.

Although it's always so hard to pick scientific highlights, two publications stand out and are reported in more detail in this review. I want to acknowledge the team led by Nick Golledge who published a remarkable result in *Nature Communications* from Nick's ice sheet model that captures the Antarctic contribution to a major global melt-water event 14,500 years ago and indicates Antarctic ice is capable of contributing rates equivalent to 1 m per century to global sea-level rise. The second paper published in *Nature Geoscience* was led by recently completed PhD student, Molly Patterson, supervised by Rob McKay and myself, and is the key output from Rob's participation in the International Ocean Discovery Program expedition to drill the Wilkes Land margin of Antarctica. The paper provides the first direct evidence of an unstable East Antarctic Ice Sheet during natural climate cycles in the past when global climate was 2-3°C warmer than today.

So while some projects were at the publication stage, a number of new projects kicked off involving fieldwork in Antarctica and New Zealand, which kept our scientific drilling technologists busy. My Marsden-funded sea-level change project in Whanganui Basin successfully recovered 735 m of drill core through ancient continental shelf sediments recording higher than present day global sea-levels 3 million years ago. Warren Dickinson and collaborators from GNS Science and the University of Otago trialed a new permafrost drill in the Friis Hills (Dry Valleys) of Antarctica to recover glacial and lake sediments rich in 15 million year old beech leaf fossils from the last time Antarctica's climate could support trees. Back in New Zealand our engineer Darcy Mandeno and the Science Drilling Office are gearing up a new barge-mounted drill rig to recover sediment cores from the bottom of Lake Ohau, scheduled for early 2016. Finally, while not an Antarctic project, Alex Pyne spent much of the later half of 2014 consulting in Whataroa on the GNS Science, Victoria and Otago university consortium attempting to drill through the Alpine Fault.

Gavin Dunbar and postgraduate student Olya Albot sailed with colleagues from the Korean Polar Research Institute (KOPRI) in the Ross Sea on the well-equipped Korean ice breaker, *RV Araon*, as part of an ongoing collaboration with the KOPRI scientists to understand how ice retreated from the Ross Sea following the last ice age 20,000 years ago. Lionel Carter and students are documenting the remarkable pattern of ocean warming around New Zealand as the tropical and Antarctic climate influences expand and contract, respectively.

Our glaciologists, Brian Anderson, Huw Horgan, Ruzica Dadic and Andrew Mackintosh have had their hands full monitoring and understanding the processes that are leading to the rapid demise of New Zealand's alpine glaciers, specifically the Tasman, Fox and Franz Josef. In this review we report some alarming observations about the "slippery slope" our glaciers are on.

Nancy Bertler and the international RICE ice core team had a very busy year melting and sampling the final 200 m of the core and undertaking real-time continuous measurements at the GNS ice core facility. The highly successful first results are emerging along with a "brace" of PhD theses near completion.

While yet again we report a truly impressive range of outreach and engagement activities, I want to acknowledge the "Antarctic Time Travel (ATT) Exhibition" at this year's "New Zealand IceFest". ATT was a GNS Science – Victoria University led initiative supported by the Christchurch City Council and the brainchild of our close collaborator, Richard Levy. I also want to recognize the success of an online crowd-funding campaign organized by Peter Barrett and VicLink which raised $35,000 on the internet site Kickstarter to produce a one hour version for US Public TV of the *Thin Ice: Inside Story of Climate Change* film. A big thank-you to all who donated!

A major event this year was the completion and official opening of the S.T. Lee Antarctic Reading Room in the University's newly renovated central library opened by Vice Chancellor, Professor Grant Guilford in October. The reading room was generously supported by our Singapore-based philanthropist, Dr Lee Seng Tee, and will allow a selection of the Colin Bull Polar Book Collection, as well as other Antarctic items to be displayed. It was an honour to have Colin's wife Gillian, and two of their children, Nicholas and Rachel, speak at the event.

All this research and outreach requires funding, and it was a busy year on the funding front, with our substantive MBIE-funded Past Antarctic Climate Programme under mid-term strategic review, the Hillary Centre of Research Excellence on Antarctic Ice Sheet and Sea-level Rise proposal resubmitted into the latest round and the National Science Challenges being developed. While our research has been considered "out of scope" for the Deep South National Science Challenge, which has been refocused on New Zealand climate change risks consequences, we await the outcome of the other funding proposals. The financial summary for 2014 makes for pleasant reading, with record external revenue of almost $2M reported, largely underpinned by Marsden and MBIE contracts. Nevertheless total revenue of $2.6M, was matched by costs for 2014, and while the budget for 2015 remains tight the prognosis looks good, providing the MBIE Past Antarctic Climates Programme is continued at current levels.

Professor Tim Naish
Director, Antarctic Research Centre

As always I wish to finish up, last but not least, by acknowledging the outstanding effort of our staff and students, who together with our partners and collaborators continue to produce high-quality, world-class research that matters and makes a difference.

Contents

Surface of blue ice - Photo: Ruzica Dadic

OUR MISSION AND RESEARCH APPROACH

Whanganui coastline, New Zealand - Photo: Juliet Sefton

The Antarctic Research Centre mission is to:

"improve understanding of Antarctic climate history and processes and their influence on New Zealand and the global climate system."

We believe our field of research provides exciting opportunities and challenges attractive to young researchers, and is needed to provide a sound basis for international debate, predicting impacts and developing adaptation for New Zealand, as well as policy development on global change issues.

The Antarctic Research Centre (ARC) is one of a number of centres of research excellence within the Faculty of Science at Victoria University of Wellington and reports directly to the newly appointed Dean of Science. It is co-located with the School of Geography, Environment and Earth Sciences, with which it shares academic staff and facilities. It also contributes to both undergraduate and graduate teaching and supervision in the fields of sedimentology, glaciology, paleoclimatology and Antarctic affairs.

Our research

The warming trend observed over the past century and models of its future trajectory suggest that we are rapidly heading towards a climate last experienced more than 3 million years ago. In order to assess model-based climate projections, scientists are increasingly looking back to the future to gain insights into the likely response of Earth's climate. Ice sheets and oceans are some of the slowest responding elements of the climate system to an atmospheric CO_2 perturbation - taking centuries to millennia to play out, and are therefore potentially irreversible on human timescales. Paleoclimate reconstructions provide the only possible way to assess the long term "endgame" (equilibrium response), that we will commit our planet to this century based on the current warming scenarios - which virtually guarantee +2-3°C increase in global surface temperature. Paleoclimate records also allow the role anthropogenic influences to be determined in the context of natural variability of the climate system on human timescales.

This is why at the ARC we focus on reconstructing the response of the Antarctic cryosphere and Southern Ocean to past climates that are similar to future projections and we study their influence on the global climate system, especially the Southwest Pacific region and New Zealand. Our research is leveraged by strong national and international collaborations and partnerships and world leading in-house polar drilling technology provided by the Science Drilling Office, which is funded and supported through a range of MBIE and Marsden programmes, Antarctica New Zealand and private donations.

Our approach involves:

a. The acquisition of past (paleo) observations of surface temperature, atmospheric circulation and composition (greenhouse gases and aerosols), ice sheet, glacier, and sea-ice variability, and oceanic conditions from geological and ice core archives.

b. Undertaking process studies of modern glaciers and glacial and marine systems.

c. Integrating the observations and processes with numerical modelling to understand sensitivity and response of the Antarctic ice sheet and climate system to the type of forcings and feedbacks projected for the future.

d. Then use those same models to improve future projections of ice sheet contribution to sea-level rise and other changes in the Earth System.

e. Comparison and correlation with equivalent "far-field" observations and reconstructions, of global extent, and within the SW Pacific and New Zealand (e.g. records of global sea-level and local New Zealand ocean and climate change).

f. We disseminate our research findings through publications in the world's leading scientific journals, and through education, communication and outreach to the public, practitioners and policy makers.

SECRETS BENEATH THE ICE

View from the base of the Friis Hills across Taylor Glacier, Antarctica - Photo: Chris Kraus

The drivers of ice age cycles and global glaciology 2.5 million years ago remain two of the most enigmatic mysteries in Earth Sciences. Geological research led by the ARC is starting to reveal some icy secrets relevant to our climate future.

Modern and ancient sedimentary systems from Antarctica and the Southern Ocean provide important archives of changes in the behaviour of the ice sheets and their influence on global climate and sea-level. The following provides research highlights from the ARC's geology group.

Riding the ice age cycle

Recent PhD graduate Molly Patterson led the publication of a paper in *Nature Geoscience* with Rob McKay, Tim Naish and IODP Expedition 318 Scientists that identified periodic pulses of icebergs offshore of East Antarctica. Each pulse was related to a melting event of the East Antarctic Ice Sheet driven by long-term changes in Earth's orbit - the so-called Milankovitch cycles. The paper resolved a key part of the long-standing "mystery of the ice ages" problem as to why the response of ice sheets to the various orbital cycles has changed in the geological past.

In the warm Early Pliocene (5-3 million years ago), when carbon dioxide levels were 400 parts per million, as they are today, there was less sea ice, and the East Antarctic Ice Sheet was retreating and advancing every 40 thousand years. They attributed this to changing winds driving warmer ocean water south helping to melt the marine margins of the ice sheets. The location of these winds is thought to be mostly controlled by the tilt of the Earth's axis, which changes every 40 thousand years.

Between 3.5 to 2.5 million years ago, naturally declining carbon dioxide levels (to 280 ppm) resulted in climate cooling and expansion of Southern Ocean sea ice. This restricted the wind-driven warm water currents from penetrating far enough south to melt the ice sheets, and thus the 40 thousand year cycle disappeared. Iceberg discharge decreased significantly at this time, indicating the East Antarctic Ice Sheet was protected by its fringing sea ice belt. However, the sea ice belt periodically melted at times when Earth's orbit results in particularly warm polar summers every 20 thousand years, and pulses of icebergs only occurred at these times. This allowed the oceans to again start to periodically melt the parts of the ice sheet that were in contact with the ocean.

Antarctica's role in Northern Hemisphere glaciation

Molly's results, along with earlier results from the ANDRILL cores highlight an intensification of Antarctic glaciation between 3.5 and 2.5 million years ago. This Antarctic cooling event appears to have just preceded one of Earth's largest ever global climatic events when large ice sheets began periodically appearing in Europe and North America, with over 100 "ice age cycles" occurring since this time. Writing a perspective article in *Science*, Rob highlighted the largely overlooked role that the carbon cycle and oceanic feedbacks associated with Antarctic ice sheet and Southern Ocean sea ice expansion may have had in this global cooling event.

High tides in the Pliocene

Tim also led a group of ARC researchers, including new PhD student Georgia Grant, in a Marsden-funded drilling project in the Whanganui region, North Island. The drilling seeks to obtain a sea-level record during the warm Pliocene when Antarctic ice sheets were known to have been much more variable in size compared to today. Recent results from the ANDRILL and Wilkes Land Antarctic drilling projects suggest that the West Antarctic and marine margins of the East Antarctic ice sheets melted and contributed to global sea-levels 20 m higher than today. Evidence for these past high sea-levels are preserved in the sedimentary rocks under the sheep farms of central North Island west of Taihape. Drilling took two months and was managed by the Science Drilling Office (see pg 14). Two drill sites collected a combined total of 735 m of core that will allow for a backstripping approach to remove the local effects of tectonism and loading on the sea-level record preserved in the Pliocene sediments of the Whanganui Basin – arguably the best such record in the world.

The hills were alive – with the sound of hammers

Warren Dickinson, Nick Golledge, Tim and MSc student Chris Kraus, along with ARC adjunct Richard Levy (GNS Science), spent three weeks in the Friis Hills region of the Antarctic Dry Valleys. This location is notable for stunning preservation of fossilized flora and fauna that lived during the Middle Miocene Climatic Optimum, a critical period of past warmth in the context of a past analogue for future climate change. Fieldwork included stratigraphic mapping of the deposits, and a seismic survey to determine the potential for geological drilling of this outcrop to obtain a continuous and more easily datable record. The latter proved a logistical challenge due to the restriction placed on using explosives in the Dry Valleys. With the help of Andrew Gorman (Otago University), the team took turns using the old fashioned method of striking a metal plate with a sledge hammer to provide a seismic source – good honest fieldwork for the Director!

Keep on drilling

As always, much of our focus has been on proposal writing to push forward with future drilling plans. The proposed ANDRILL Coulman High project experienced a significant set back with difficulties in obtaining full funding across our international partnerships. However, the proposal reviewed strongly so we have not given up and will continue to work to bring this project to fruition. Rob continues to led an IODP proposal to drill a transect of cores in the Ross Sea that was rated excellent by IODP Scientific Evaluation Panel and is currently in the "holding bin" pending additional data to be submitted. To obtain these data, our collaborators from the Korean Polar Research Institute (JongKuk Hong, Sookwan Kim) worked hard in a difficult sea ice season in the Ross Sea to obtain new seismic data from the *RV Araon*.

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EVERY DROP COUNTS

Pressure ridges on Ross Ice Shelf, Antarctica - Photo: Darcy Mandeno

Now that processing of the RICE ice core is complete, a picture is forming of a highly dynamic Ross Sea region sensitive to climate change.

The potential for rapid deglaciation of West Antarctica remains a primary uncertainty in the Intergovernmental Panel on Climate Change (IPCC) predictions for 21st Century sea-level rise. The recent, unpredicted collapse of multiple ice shelves and rapid acceleration of Antarctic ice discharge suggests that dynamical responses to warming play a more significant role than is currently understood and captured in coupled climate-ice sheet models. Such models can be improved and validated by replicating known past changes. The Roosevelt Island Climate Evolution (RICE) project led by Nancy Bertler is an international partnership seeking to understand past, present, and future changes of the Ross Ice Shelf, a major drainage pathway of the West Antarctic Ice Sheet. Roosevelt Island is a small ice dome, situated at the northern edge of the Ross Ice Shelf. The ice is grounded about 200 m below sea-level with Ross Ice Shelf ice flowing around the dome. Its location, low elevation and high snow precipitation make the RICE core a sensitive recorder of conditions in the Ross Sea region and West Antarctic ice dynamics.

Melting campaign successfully completed

In 2013, the core processing campaign unexpectantly halted as brittle ice below 500 m started to explode when cut. To enable us to take advantage of the excellent core quality provided by the drilling team, we decided to let the ice 'relax'. As a consequence, from July 2013 to April 2014, the cores were stored at much warmer temperatures (raised from -35°C to -18°C). In April, the team tried again to cut the ice. Our Danish colleagues from the Centre of Climate and Ice of the Niels Bohr Institute at the University of Copenhagen, sent their horizontal saw, and the freezer team nervously touched the precious ice. The relaxation worked! The ice cut beautifully, and hardly any fractures were induced during the processing. As a consequence, the core melting campaign scheduled for June to mid-August was able to proceed.

As in the previous year, international collaborators, staff and students descended on the National Ice Core Research Facility in Wellington with a vibrant and dynamic mix of cultures originating from Australia, Canada, Denmark, Germany, India, New Zealand, People's Republic of China, Russia, and the USA. The teams again worked 12 hour shifts and the processing of the core was completed in early August. The team in Wellington and elsewhere could follow the progress through a video camera in the lab and the data from the continuous flow instruments, which included the New Zealand stable isotope ($\delta^{18}O$, $\delta^{17}O$, δD) LGR laser instrument, and Australian black carbon SP2, and the Danish methane/carbon monoxide laser instrument, particle detector, pH and conductivity cells, and the Ca analyser.

The records showed a dramatic response during the deglaciation, and that the bottom of the ice is well over 60,000 years old. In addition to real time data, the team also collected a total of over 100,000 discrete vials for geochemical analysis and cut over 3,000 ice samples for discrete measurements of greenhouse gas, dust, and tephra analysis. Additional samples are scheduled to be cut for biological, radioactive isotope and physical properties analyses.

First results emerge

The first results from the RICE Science Team are starting to emerge with three papers published in 2014 and seven papers currently in review. First interpretations were also presented at international conferences with six contributions at the SCAR Open Science Conference, and eight contributions at the AGU Fall Meeting. In addition, two international RICE workshops held in Seattle in April and San Francisco in December facilitated excellent discussions and the amalgamation of diverse data sets.

The dating team has made excellent progress and established a high resolution, annual layer count back to 200 years, and developed a tightly constrained age model back to ~30,000 years based on the continuous flow methane correlation with the West Antarctic Ice Sheet ice core record and first identified volcanic events. The initial data show that the Ross Sea region was highly dynamic during the deglaciation and experienced remarkable variability during the Holocene. This has important implications on how quickly this region might respond to and enhance global change. The focus for the coming year will be in finalising the first age scale for the past ~30,000 years and the interpretation of the Holocene and Deglaciation records.

Trace element concentration data were produced by ARC PhD students, Andrea Tuohy and Peter Neff, in collaboration with University of Curtin and University of Maine. The team achieved extremely sensitive measurements to femtogram (parts per quadrillion) levels. The RICE data exhibit a superb record of anthropogenic pollution history and the effect of recent successful policy initiatives for global reduction in heavy metal pollution. In addition, the team vastly increased the number of Rare Earth Element data for the Antarctic continent with an additional ~700 measurements. These data are used to identify major source regions for dust reaching Antarctica and the Southern Ocean, which has important implications for efficiency of the Southern Ocean as a carbon source. The stable isotope record was characterised by ARC PhD student Daniel Emanuelsson, who created the first stacked isotope record, developing a robust snow accumulation and temperature history for the Ross Sea Region and West Antarctica. Over the next 12 months we expect a number of exciting publications to outline some of the key findings RICE has produced.

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University of Waikato
University of Washington (USA)
U.S. Geological Survey

FROM THE MURKY DEPTHS

Edge of Nansen ice shelf from onboard the *IBRV Araon* icebreaker - Photo: Gavin Dunbar

Our ability to predict New Zealand's climate of the future is enhanced by our knowledge of what has gone before.

The climate we live with is changing, reflecting shifts in ocean and atmospheric circulation. The small period of time over which instrumental records exist help us observe and begin to understand the present and recent past. Prior to that we are dependent on sediments that accumulate in the quiet depths of our lakes and oceans over millennia. They provide a unique insight into how our climate system works on timescales that are otherwise inaccessible to us - if we can interpret them correctly. A tenet of a founder of modern Earth Science, Charles Lyell, is that 'The present is the key to the past is the key to the future'. The ARC's lake-ocean group and collaborators continue to work hard on the present and past in order to provide insight into the future.

Recent ocean change

Given the marked ocean warming off eastern Australia, where subantarctic ecosystems have been replaced by their subtropical counterparts, it is highly pertinent to ask how is the ocean off New Zealand faring? Former MSc student Denise Fernandez, now undertaking her PhD at Auckland University, published results from her Masters thesis. The paper in the *Journal of Geophysical Research* shows that the ocean east of central New Zealand is also experiencing a strengthening inflow of subtropical water. On the basis of satellite measurements of the surface ocean height and temperature, Denise demonstrates a rapid warming at a rate of 0.4°C per decade, far higher than the global rate. Furthermore, the ocean fronts in that region are becoming more turbulent in response to increased winds.

Further south on the Campbell Plateau, ARC PhD student Aitana Forcen Vasquez also used satellite data, but this time supported by direct oceanographic measurements made available by the fishing industry. Aitana confirmed the recent increase in wind-induced turbulence similar to that recorded by Denise. However, ocean warming averaged over the Plateau has been modest since the 1980s. Aitana also provides the first detailed analysis of the modern Plateau oceanography and how it has evolved over the last few decades. She is currently preparing her first paper for publication supported by an ARC Endowed Development grant.

A research group led by Chris Turney (University of New South Wales) and including ARC's Lionel Carter is investigating a pronounced warming in the region of New Zealand's subantarctic islands. This step change occurred in the early 1970s and marked the onset of longer and warmer summers. The change was observed in historical ocean and air temperature records including those collected by the polar explorer Douglas Mawson. Temperatures derived from tree ring analyses provided additional evidence. The change is interpreted to reflect an abrupt shift in the regional oceanography.

Breaking ice

Gavin Dunbar and MSc student Olya Albot departed Lyttelton on the 29 December bound for Terra Nova Bay on board the Korean icebreaker research vessel *Araon*. This cruise represents the first collaborative shipboard research between the ARC and the Korean Polar Research Institute (KOPRI). The *Araon* was built in 2009 and has state-of-the-art multi-beam and 3.5 kHz sonar that map the sea floor bathymetry and sub-surface stratigraphy in great detail. It also has the ability to collect piston and gravity cores in water up to 7 km deep and up to 39 m below the sea floor. We hoped to take advantage of this capability to collect long sediment cores from the Southern Ocean for paleoceanographic studies during the transit to Antarctica. However, those latitudes are not known as the "furious fifties" and "screaming sixties" for nothing! Large swells and poorly known sea floor geology made life especially difficult. As it turned out, the sea was too rough for safe operation of the coring gear in the target region and the ship schedule meant that we could not wait around for sea conditions to improve. However, looking beyond this cruise, the sonar mapped out some superb not-seen-before sediment drifts that will be targeted for sampling in the future.

As we got closer to Antarctica the weather improved and the presence of sea ice dampened the waves making science operations easier. We collected a gravity core (a core tube with 1 tonne of lead attached to drive it into the sea floor) from just south of the Drygalski ice tongue. This core will be used to help us build a picture of how ice retreated from the Ross Sea at the end of the last ice age some 20,000 years ago.

Layers of time

In 2014 much of the Lake Ohau Climate History Project has focused on further developing the paleoclimate record from the finely laminated sediments deposited on the floor of Lake Ohau. ARC PhD student Heidi Roop's first paper on the causes of the mm-scale laminations was published in *Sedimentology*. She now has another manuscript in review in the *Journal of Paleolimnology* documenting the strong seasonal control on sedimentation in Lake Ohau. This outcome means that we can relate sedimentation on the lake floor to variability in lake inflow and regional climate back in time. To date our cores capture about 1,400 years worth of sediment layers. For technical and resource consent reasons we have had to delay our deep drilling effort until 2016 when we hope to recover the full 17,000 year record we believe exists under the lake.

In collaboration with the Australian Maritime College (AMC), Hobart, Gavin Dunbar and the Lake Ohau Science Team are making inroads into understanding the large volume of water column data (temperature, turbidity, velocity) collected over the past three years. We have also mapped out lake floor sediments using the sonar system on board a autonomous underwater vehicle (AUV - see image pg 32) operated by AMC to understand how they are distributed. The lake delta is extremely active with large slump features present. Thankfully our core sites are in much more stable settings which will enable us to extract the best possible paleoclimate record.

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GLACIERS - ON THE SLIPPERY SLOPE?

Aoraki Mt Cook National Park, New Zealand - Photo: Huw Horgan

New insights into the key processes driving glacier and ice sheets are revealing some alarming changes.

Predicting the future contribution of glaciers and ice sheets to sea-level rise requires advances to be made in several key areas. We have recently shifted our focus from the ice surface to the bed, where sliding and sediment deformation affects the response of glaciers and ice sheets to climate change. We have also broadened our work on reconstrucing past climate, where we have traditionally focussed on glacier modelling. We are now also turning to ice core records, where an improved understanding of snow deposition and metamorphism will lead to more robust interpretatons of past climate.

Beneath the West Antarctic Ice Sheet

The final Antarctic field season of the Whillans Ice Stream Subglacial Access Drilling (WISSARD) project was carried out during the 2014/2015 austral summer. This culminated in ~760 m of ice drilling at the grounding line (transition between grounded and floating ice) of Whillans Ice Stream.

Previous seismic surveys carried out by Huw Horgan and others suggested that this site was a zone of ongoing sedimentation. Initial results from the new drilling at the grounding line show that sedimentation is indeed occurring, with basal debris and a water column containing previously unknown fish and crustaceans, imaged by remote camera with some of these recovered to the surface.

Biological results from previous drilling at Subglacial Lake Whillans were reported in *Nature*, where a diverse range of bacteria were discovered. Overall the WISSARD project is an exciting prelude to the Ross Ice Shelf Programme that is in advanced planning stages, supported by NZARI. The Ross Ice Shelf Programme, which includes PIs from the ARC, University of Otago, NIWA, and the University of Canterbury, will target the grounding line of Kamb Ice Stream and the centre of the Ross Ice Shelf with ice shelf drilling providing access to the little-explored ocean cavity below.

New Zealand glaciers 'slip sliding away'

The dramatic retreat of New Zealand glaciers in recent years has caused a shift in focus from direct measurement (e.g. Anderson *et al*. 2014) to automatic monitoring as access to some glaciers has become challenging. Consequently, Brian Anderson and Huw have installed new automatic cameras and survey-grade GPS on several glaciers to observe their extrordinary behaviour. A one-year timelapse of the Fox Glacier terminus (www.vimeo.com/glacier/fox2014) shows that as the glacier retreats, it removes support from the adjacent hillside which collapses onto the glacier at such high speed that you can see it move from day to day. This illustrates the very real hazard that retreating glaciers pose. In a related study, PhD student Pablo Irribarren Anacona along with Andrew Mackintosh and Kevin Norton (SGEES) have recently demonstrated in a paper in *Natural Hazards Earth Systems Sciences* how glacier retreat has increased the risk of damaging outburst floods from perched lakes in the Patagonian Andes.

GPS data are providing new insight into processes occuring at the base of New Zealand glaciers. A publication in review in *Journal of Glaciology* led by former MSc student Laura Kerhl and including Huw, Brian, Andrew and Ruzica Dadic demonstrates how rainfall and melt variability causes Franz Josef Glacier to periodically speed up due to enhanced sliding at the glacier/bedrock interface. This effect is even more pronounced at Tasman Glacier; when rainfall rates exceed ~100 mm per day, GPS data show that the glacier tongue lifts by almost up to a metre and speeds up by a factor of 36. This behaviour makes the glacier an ideal target for in-depth studies of basal sliding. This is the focus of a new Marsden bid led by Brian, with the overall goal of narrowing uncertainty in future assessments of sea-level rise.

Climate is the ultimate driver of mountain glacier fluctuations, but distinguishing between natural and human influences on New Zealand glaciers is challenging because natural modes of climate variability such as the El Niño Southern Oscillation strongly influence our climate. In recent decades, climate variability has forced phases of both glacier advance and retreat, as documented in a publication led by former PhD student Heather Purdie and including Brian and Andrew (*Global and Planetary Change*). By using a glacier mass balance model and climate reanalysis data, we have disentangled some of these effects, demonstrating that glacier growth was driven by sequences of unusually cool summers in the Southern Alps during the 1980s and 1990s. This pattern has now reversed and strong summer warming has been responsible for the unprecedented retreat observed since 2009.

Improved understanding of ice core records

Ice cores provide us with one of the finest proxy records of past climate change. But do we really understand the processes that control snow accumulation and densification at ice core sites during ice ages, during which low accumulation and high winds are the norm? Driven by this question, Ruzica has been studying the physical and chemical processes of snow accumulation and firnification in the Allan Hills, a low accumulation area in the Transantarctic Mountains, by investigating the properties of a 5 m firn core using computer tomography, stable isotope ratios δD and $\delta^{18}O$. ^{210}Pb data show that most of this short core is older than 100 years, implying very low rates of snow accumulation. The core shows a remarkably stable structure suggesting a high degree of metamorphism, but it also contains erosion features. These clues suggest that the snow was initially very dense and was deposited under strong wind. Following deposition, decades of moisture transport and temperature-gradient driven metamorphic growth occurred, homogenizing the record. Together, the new data from Allan Hills provides a unique opportunity to investigate the processes that affected ice core records during glacial periods.

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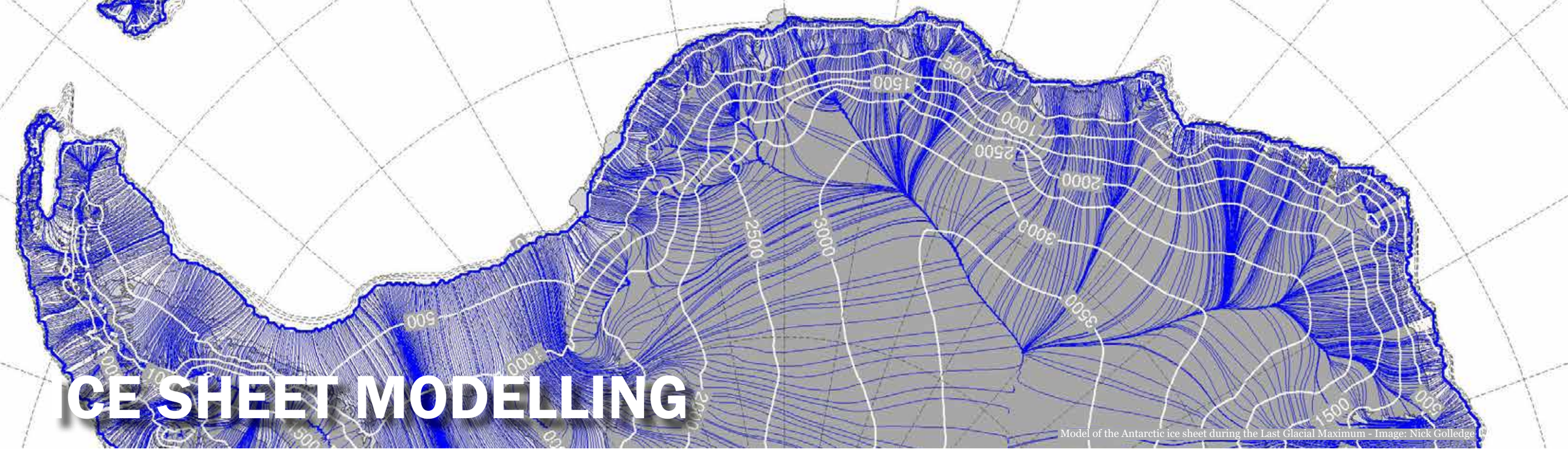
NIWA
St. Olaf College (USA)
The Pennsylvania State University (USA)
University of Alaska, Fairbanks (USA)
University of California (USA)
University of Canterbury
University of Maine (USA)
University of New South Wales (Australia)
University of Otago
University of Tasmania (Australia)
Utrecht University
WSL Institute for Snow and Avalanche Research (Switzerland)

ICE SHEET MODELLING



Model of the Antarctic ice sheet during the Last Glacial Maximum - Image: Nick Golledge

Ice-sheet modelling is becoming an increasingly important tool in Antarctic research, both for the interpretation of records of past ice-sheet and climate change, and for the prediction of changes that will occur over coming centuries.

At the Antarctic Research Centre our ice-sheet modelling expertise continues to grow, and 2014 saw the publication of a wealth of new data, much of it in high-profile journals.

Improving predictions

Nick Golledge, alongside a team of scientists from Victoria University, GNS Science and the University of New South Wales, published new simulations that tried to better predict the way that the Antarctic ice sheet responds to ocean warming. Using sophisticated ice sheet and climate models to recreate the Antarctic ice sheet as it came out of the last ice age, the results, published in *Nature Communications*, showed that abrupt oceanic changes during the last glacial termination triggered a significant shift in the stability of the Antarctic ice sheet and led to a rapid increase in global sea-level.

Using geological data to verify their model results, they found that the ice sheet melted fastest when the ocean around Antarctica became more stratified, or layered, with warm water at depth trapped beneath cold, less saline, surface water. Modern oceanographic observations around Antarctica show the ocean is once again becoming more stratified, with warming of the deeper ocean already accelerating the decline of glaciers such as Pine Island and Totten.

Glacier recession likely to accelerate

Another study used modelling techniques to investigate a small glacier on James Ross Island, near the northern Antarctic Peninsula. The international team, led by Bethan Davies (Royal Holloway, University of London), used a glacier model developed by Nick to simulate the present-day extent and flow speed of the glacier, based on climatic conditions interpreted from the nearby Mt. Haddington ice core record. The model was then applied to the last ten thousand years, guided by geological data, and then into the future, using outputs from a regional climate model.

Published in *Nature Climate Change*, the study used a combination of glacial geology, ice core data and numerical glacier and climate modelling. The team found that glaciers in this region are far more sensitive to changes in air temperature than they are to changes in precipitation amounts. As a result, surface melting in this region is likely to increase greatly under even a slight warming, and will outweigh any gains from increased snowfall. The currently observed glacier recession in this region is therefore likely to continue, and even accelerate, under the presently warming climate.

Past and present response of Antarctic ice sheets

Nick and collaborators at the University of Canterbury and the Centre for Remote Sensing of Ice Sheets published a new study of Skelton and Beardmore glaciers. They used field measurements of glacier velocity and ice thickness, together with local climate data, satellite-derived velocity interpretations, continental-scale interpolations of bed topography, ice thickness and geothermal heat flux, to parameterize and constrain a diagnostic model of these two outlets of the East Antarctic Ice Sheet to investigate how they might respond to future climate forcing.

Working with colleagues at the University of New South Wales, Nick contributed to two new studies that focussed on periods of the recent past. Both studies were led by Chris Fogwill. In one, the team used climate and ice-sheet models to show that East Antarctica may have contributed to the higher global sea-levels recorded during the Last Interglacial (c. 125 ka BP). In the second study, surface exposure dating and ice sheet modelling were combined to show that neighbouring ice streams in the Weddell Sea sector of Antarctica responded independently during the last glacial termination, thinning at different speeds and at different times. Modelling revealed that this behaviour was controlled by spatial variability in the amount of ice discharge taking place at the oceanic margin, which caused abrupt switching of flow direction inland.

Working further north

PhD student, Richard Jones, has been using a combination of glacier flowline modelling and surface exposure dating to investigate the behaviour of Mackay Glacier, an outlet of the East Antarctic Ice Sheet that flows directly into the Ross Sea. Richard collected rock samples from mountain summits along the length of the glacier and analysed them to obtain dates of when they were deposited. What he found was surprising - around 7,000 years ago the glacier thinned by around 200 m in only a few centuries. Using these data to constrain his modelling experiments, Richard was able to demonstrate that this period of rapid thinning was the consequence of glacier instability as it retreated through a deep submarine trough.

Future of the Greenland ice sheet

The future of the Greenland ice sheet and its contribution to sea-level rise will depend critically on two factors; the sensitivity of Earth's atmospheric temperature to the radiative forcing resulting from human carbon dioxide input (climate sensitivity) and the degree to which high latitude warming exceeds the global mean (polar amplification). These dependencies were recently investigated in a *Climate Dynamics* paper led by former PhD student Jeremy Fyke, (now Los Alamos National Laboratory, USA) and Andrew Mackintosh. By starting with observed initial ice sheet conditions in Greenland, the team used David Pollard's (The Pennsylvania State University) ice sheet model coupled to the UVic Earth System Climate Model to calculate future ice sheet response under a climate resulting from a threefold increase in preindustrial carbon dioxide levels. The modelling experiments show that the Greenland ice sheet looses 5-40% of its initial volume after 500 years, with the large range of ice sheet responses depending on the parameter values of climate sensitivity and polar amplification used. This shows how important it is to reduce uncertainty in our understanding of these two parameters that describe key aspects of the climate system.

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University of Canterbury
University of Massachusetts (USA)
University of New South Wales (Australia)
Utrecht University
Worcester State University (USA)

DRILLING SERVICES IN HIGH DEMAND

Siberia Station drill site, Whanganui - Photo: Darcy Mandeno

Whanganui, Whataroa, Lake Ohau and Antarctica. You name it, we drill it! The Science Drilling Office is providing critical support to a range of new projects.

The Science Drilling Office (SDO) is hosted in the Antarctic Research Centre and led by Alex Pyne, the Projects Manager, and Darcy Mandeno, Operations and Field Engineer.

Drilling for past sea-levels

The SDO together with Porirua-based drilling company, Webster Drilling and Exploration Ltd, co-ordinated the drilling of two, stratigraphic drill holes in the back blocks of Whanganui Basin. The Marsden-funded project, led by Tim Naish and involving Gavin Dunbar and Rob McKay, as well as Brent Alloway (SGEES), Diane Seward (SGEES), Hugh Morgans (GNS Science) and Gillian Turner (SCPS), aims to reconstruct past higher-than-present day sea-levels during the warm climate of the Pliocene around 3 million years ago (see pg 5). Darcy, Gavin and PhD student Georgia Grant, collectively spent six weeks at the drill sites recovering and describing the sediment cores, with regular visits from Tim to check on progress.

The first hole, Siberia Station in the Turakina Valley, was started on 14 July and presented some drilling difficulties in winter weather with snow, rain and mud. The main difficulty was in being able to consistently catch the core, with other issues resulting in several drill pipe trips in and out of the hole. Despite this the drillers managed to get the rig dialled in and made good progress during the latter part of the hole.

The second hole at Tiriraukawa on Watershed Road started after a two week hiatus on 18 August, proving to be a more consistent operation and with mostly stunning late winter sun. Lessons from the Siberia operation proved invaluable in achieving good core quality. Drilling was completed on the 10 September and achieved very close to perfect recovery, a credit to the skill of the drillers.

Deep fault drilling

ARC Project Engineer Alex Pyne was working as a technical advisor for the Deep Fault Drilling Project (DFDP-2) with an international team of scientists from twelve countries co-led by Rupert Sutherland (GNS Science/SGEES), John Townend (SGEES) and Virginia Toy (University of Otago). The proposed 1.3 km-deep bore-hole into the Alpine Fault near Whataroa, north of Franz Josef Glacier, South Island started in late August to find out more about the nature of the fault and the earthquakes it produces. The goal was to enable scientists to install monitoring equipment deep inside the fault to record small earthquakes and measure temperature, pressure and chemical conditions close to where earthquakes are generated. Other major faults around the world have been drilled in this way, but it has always been after a big earthquake. This is the first time a major fault has been drilled before it ruptures.

This highly technical drilling project had many challenges, with basement rock being deeper than expected and major drilling component failures resulting in the drilling being prematurely ended on 16 December at 893 m. Although the project did not achieve its goals of making observations and installing instruments within and below the fault zone the team obtained important data and samples.

Drilling design

Darcy's main designing effort in 2014 was around the Friis Hills drill design and the engineering and logistical planning for the Lake Ohau Project.

A small portable shallow coring drill was developed for frozen "soft" lacustrine sediments that are preserved in isolated pockets at Friis Hills. Our previous experience has shown that these frozen "soft" sediments are notoriously difficult to core successfully so we designed a new style core barrel with a replaceable tungsten tooth cutter ring. The first use of this system was not as successful as hoped and we will improve this in the future.

In Lake Ohau the lake floor sediments will be cored with soft sediment tools from a barge using a self-supporting (buoyant) riser casing based on the concepts we have developed for drilling from sea ice in Antarctica. The riser system can be deployed in water depths up to 100 m and will enable the barge to be disconnected from the riser if weather conditions and the wave state become too extreme to operate. Over the 2014-15 summer Darcy has spent a considerable part of his time refining the design of the new barge under construction in Wellington as a collaboration with Webster Drilling. The drilling operation has been delayed and is now scheduled for early 2016 to allow time for the completion of design and fabrication of the new drilling equipment that will be required.

Overseas

In February, Alex made a short journey to Washington DC to sit on a NSF technical panel review that was considering a major new ice drilling initiative in Antarctica. Then in June, Alex was invited to visit MARUM Centre for Marine Environmental Sciences, University of Bremen to discuss the operation of MeBo, a sea floor coring drill, scheduled for operations in 2015/16 in the Amundsen Sea. MeBo is a remotely operated drill system that for the first time would be used in Antarctic waters from the German research vessel *Polarstern*. The Amundsen Sea shallow sea floor sedimentary sequences were expected to be similar lithologies to those that Cape Roberts and ANDRILL have successfully cored in the Ross Sea region so the visit centered on how this drilling experience and techniques could be applied to MeBo.

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COLLABORATORS:
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TEACHING AND SUPERVISION

PhD student, Georgia Grant, with her supervisor, Tim Naish on fieldwork in Whanganui
Photo: Darcy Mandeno

Our staff support a wide range of teaching being carried out within the School of Geography Environment and Earth Sciences.

There is also close interaction between ARC staff and projects with other research programmes in geophysics, geology, physical geography, and the environmental studies programme. ARC staff contributed to the following courses in 2014:

Undergraduate Courses	
ESCI 111	Earth Systems and Global Change
ESCI 132	Antarctica: Unfreezing the Continent
ESCI 201	Climate Change and NZ's Future
ESCI 204	Petrology and Microscopy
ESCI 241	Introductory Field Geology
ENSC 301	Topics in Environmental Science
ESCI 301	Global Change: Earth Processes and History
GEOG 318	Quaternary Environmental Change

Graduate Courses	
ESCI 403	Stratigraphy and Palaeontology
ESCI 404	Special Topics
ESCI 412	Quaternary Geology
PHYG414	Climate Change: Lessons from the Past
ESCI 580	Research Preparation

Our teaching contribution also includes supervision of graduate students from the School of Geography, Environment and Earth Sciences (SGEES). In 2014 our staff supervised 15 PhD and 3 MSc students. The ARC congratulates the following students who completed their theses in 2014:

Lana Cohen (PhD) *"Atmospheric variability and precipitation in the Ross Sea Region, Antarctica"*, Supervised by Sam Dean (NIWA) and Nancy Bertler (ARC).

Molly Patterson (PhD) *"The response of Antarctic ice volume, global sea-level and southwest Pacific Ocean circulation to orbital variations during the Pliocene to Early Pleistocene"* Supervised by Tim Naish and Rob McKay (ARC).

Katrin Sattler (PhD) "*Periglacial preconditioning of debris flows in the Southern Alps, New Zealand"* Supervised by Andrew Mackintosh (ARC/SGEES), and Mairead de Roiste (SGEES).

Rory Hart (MSc) *"The ice thickness distribution of a debris-covered glacier: Tasman Glacier, New Zealand"* Supervised by Andrew Mackintosh (ARC/SGEES), Huw Horgan (ARC/SGEES).

Amy Plant (MSc) *"Abyssal Archives : Unravelling the Late Neogene evolution of the Pacific Deep Western Boundary Current from the New Zealand sector of the Southern Ocean"* Supervised by Lionel Carter (ARC) and Monika Handler (SGEES).

A new online course about Antarctica is being developed at Victoria University, with support from the Antarctic Research Centre and Antarctica New Zealand.

In December 2014, Cliff Atkins from the School of Geography, Environment and Earth Sciences and Rebecca Priestley from the Science in Society group joined the K001 team at their field camp in Friis Hills, Antarctica. Their mission – to film a series of field lectures for the new online course.

Friis Hills is a 1300-metre-high ice-free plateau, in the Dry Valleys region of the Transantarctic Mountains, about 100 km from Scott Base. The site is a great location to investigate the history of the Antarctic ice sheets and, with a team of geologists working there in December, a great opportunity to document the process of Antarctic fieldwork. The Friis Hills ground surface includes moraines, ventifact pavements, and ancient lake sediments, some containing fossil plants, insects, seeds and pollens. Views of the Taylor Glacier and Transantarctic Mountains show ancient granites, dolerite sills and Beacon Supergroup sandstones that record Antarctica's history as part of the supercontinent Gondwana.

With Rebecca behind the camera, Cliff, a geologist with 10 previous Antarctic field seasons, recorded material for his lectures. As well as interviewing Tim Naish, Nick Golledge, and Warren Dickinson from the ARC, Richard Levy from GNS Science, and Adam Lewis from North Dakota State University, he gathered spectacular video footage from a helicopter trip through the Ferrar and Taylor valleys.

Atkins' video lectures will be part of a module on Antarctic geology and paleoclimate research. While in Antarctica, Rebecca – a science historian – recorded lectures for a module on Antarctic science history, and the pair also gathered footage for a module about the role of Antarctica, globally and culturally, that will be led by Rhian Salmon, also from the Science in Society group. Material filmed at the SCAR conference in Auckland in 2014, and additional footage from around New Zealand, will complement the field lectures.

The fully online, interactive course will be available to a wide range of students, especially targeting lifelong learners with an interest in Antarctica. Like all the Science in Society group's online courses, it utilises the latest learning management systems to allow participants to watch pre-recorded videos, access reading material, and engage in asynchronous dialogue via technologies such as discussion boards, blogs, and wikis. Given the severely limited opportunities to physically take students to Antarctica, offering lectures filmed in Antarctica provides a virtual fieldtrip experience giving university students – and the wider public - insight into the unique environment and reality of researchers working in remote locations.

Antarctica online will be launched by the Science in Society group later in 2015. For more information visit: http://www.victoria.ac.nz/science/research/research-groups/science-in-society

Cliff Atkins (right) discusses glaciology with ARC senior research fellow Nick Golledge (left), while Rebecca Priestley films it for a Victoria University of Wellington online course about Antarctic science - Photo: Rebecca Priestley

DOUBLE ACCOLADE FOR LEADING ANTARCTIC RESEARCHER

Windless Bight, Antarctica
Photo: Nick Golledge

Tim Naish received two prestigeous awards; the Martha T. Muse prize and elected as a Fellow of the Royal Society of New Zealand.

In July, ARC Director Tim Naish, became the first New Zealand recipient of the prestigious Martha T. Muse Prize for Science and Policy in Antarctica for his outstanding research into understanding Antarctica's response to past and present climate change and the role of Antarctica's ice sheets in global sea-level change through time.

This leading international award for Antarctic science is funded by the Tinker Foundation and administered by the Scientific Committee on Antarctic Research (SCAR). The award recognises significant and sustained contribution to Antarctic scientific research and policy. Tim received US$100,000 in prize money with the award which was presented in Auckland during the SCAR Open Science Conference. To find out more about the Martha T. Muse Prize, visit www.museprize.org/index.html

To find out more about the Tinker Foundation visit www.tinker.org

Then in October, Tim was elected as Fellow of the Royal Society of New Zealand, an honour given to top researchers for showing exceptional distinction in research or in the advancement of science, technology or the humanities. Tim was thrilled to receive the award saying,

"I'm very humbled to receive this recognition; it is a huge honour as a scientist in New Zealand.

"It's more than a personal thing—research has and always will be collaborative and this award reflects a whole group both nationally and internationally".

The honours state Tim "has advanced our knowledge of Antarctica's response to past and present climate changes and their effects on the Earth system. He has shown that Antarctica is highly sensitive to small increases in temperatures that can cause marked responses such as rises in global sea level and loss of the vast Ross Ice Shelf. He has been a key contributor to the Intergovernmental Panel on Climate Change".

Tim was honoured along with eleven others at this year's Annual General Meeting of the Academy and joins a prestigious group of 399 Fellows who are involved in promoting best practice and providing expert advice. Pro Vice-Chancellor Mike Wilson says very many congratulations are due to Tim on receiving this award.

Tim Naish - Photo: VUW Image Services

"Tim is an outstanding academic, and a truly worthy recipient of this award, which is a reflection of the hard work and passion he has shown as Director of the Antarctic Research Centre."

OTHER AWARDS AND APPOINTMENTS

In 2014 ARC staff and students were awarded the following:

Ruzica Dadic — Permanent appointment as Research Fellow, Antarctic Research Centre.

Shannon Digby — Permanent appointment as Administrator, Antarctic Research Centre.

Nick Golledge — Permanent appointment as Senior Research Fellow, Antarctic Research Centre.

Huw Horgan — Promoted to Senior Lecturer in the 2014 Academic Promotion Round.

Peter Barrett — Member, Martha T. Muse Prize For Science and Policy in Antarctica Selection Committee.

Nancy Bertler — Member of the Steering Committee of the International Polar to Tropical Connections Institute.

Nancy Bertler —Member to Taki Ao, Scientific Advisory Board of young and mid career researchers to MBIE.

Lionel Carter — Patron of the McGuinness Institute.

Bella Duncan and Chris Kraus — Members of Executive Committee for the New Zealand Antarctic Youth Council.

Andrew Mackintosh — Member of the Visioning and Strategy Committee, International Union of Geodesy and Geophysics.

Rob McKay — Chair of ANZIC (Australia New Zealand Implementation Committee) Science Committee for the International Ocean Discovery Program (IODP).

Rob McKay — Member of the Steering Committee of the Scientific Committee on Antarctic Research (SCAR) "Past Antarctic Ice sheets" (PAIS) Project.

Tim Naish — ANZIC representation on the Science Evaluation Panel of the International Ocean Discovery Program.

Alex Pyne — Member of the Steering Committee of the Scientific Committee on Antarctic Research (SCAR) "Past Antarctic Ice sheets" (PAIS) Project (for Technological Development).

Heidi Roop — Member of PAGES Aus2k Steering Committee.

Shaun Eaves — S.T. Lee Travel Award 2014: visit to University of Alaska, Fairbanks.

Shaun Eaves — Best student presentation at the Australasian Quaternary Association Meeting.

Kristina Pascher — Young Researcher Travel Grant by the Geosciences Society of New Zealand to attend an international conference.

Heidi Roop — 'Best Poster' award for her presentation of her Lake Ohau research at the SCAR Open Science Conference.

Heidi Roop — VUW Post Graduate Research Excellence Award.

Juliet Sefton — 'Best Student Presentation' award at the NZ Geosciences Conference.

S.T. LEE YOUNG SCIENTIST EXCHANGE PROGRAMME

Shaun Eaves camping at the foot of Denali (Mt. McKinley) - Photo: Shaun Eaves

The S.T. Lee Young Scientist exchange programme offered two researchers the opportunity to travel between the University of Alaska Fairbanks and Victoria University.

Shaun Eaves

In July, ARC PhD student, Shaun Eaves, headed to Alaska for two weeks with the glaciology research group at the University of Alaska Fairbanks. As part of his PhD research, he has been simulating past glacier fluctuations on New Zealand's volcanoes, Tongariro and Ruapehu, during a period known as the Antarctic Cold Reversal (approx. 13,000 years ago). The 'Land of the Midnight Sun' has its fair share of glaciers, volcanoes and glaciers on volcanoes. So this visit gave him an excellent opportunity to interact with senior scientists, postdoctorates and graduate students, all of whom specialise in cryospheric research.

After an extra-curricular jaunt to the stunning Denali National Park, it was into the wild, literally, as he participated in the International Glaciology Summer School. This biennial course for postgraduate glaciologists takes place in the 'town' of McCarthy (population: 28), at the foot of the gigantic Wrangell and St. Elias mountain ranges in south east Alaska. Living out of a tent and bathing amongst the salmon in the glacial river for 10 days, they were schooled in the physics of glaciers by an international cast of glaciologists. This also included excursions onto (and underneath) nearby Kennicott and Root glaciers, where we encountered grizzly bears, black bears and even more oddly, a porcupine.

"All in all, it was an exhilarating, educational and exhausting trip, to a part of the world that rivals Antarctica and New Zealand for its sheer beauty and isolation."

Christina Carr

Earlier in the year, University of Alaska Fairbanks PhD student, Christina Carr, arrived fresh from Antarctic fieldwork to spend about three weeks working with Huw Horgan. Christina was part of a field team that collected geophysical data focusing on the areas around the Blood Falls feature of Taylor Glacier. The geophysical campaign included collecting GPS, ground-penetrating radar (GPR), interferometric radar, seismic, and time-lapse and thermal imagery data. While at the ARC, Christina focused on the initial preparation and processing of the GPR dataset under the guidance of Huw, and developed code to georeference the GPR data. At the end of her visit in Wellington, the newly georeferenced GPR transects could be topographically corrected.

A highlight of Christina's visit was a weekend trip to the Tongariro area with a group of (mostly) geology Victoria University graduate students. While completing the Tongariro crossing, climbing Ngauruhoe, and hiking around Ruapehu, they spent a good deal of time "geologizing". Christina thoroughly enjoyed the weekend learning the volcanic and glacial history of the area through observation and discussion of landforms and deposits with these knowledgeable young scientists.

Christina Carr enjoying the views from the top of Mt Ngauruhoe - Photo: Christina Carr

"I'm honoured to have had the opportunity to visit the Antarctic Research Centre at Victoria University of Wellington through the S.T. Lee Travel Award. I look forward to welcoming the next recipient of the S.T. Lee Travel Award to Fairbanks!"

SCAR IN NZ

In April seventy-four Antarctic scientists and policy makers from twenty-two countries came together in Queenstown, New Zealand for the 1st Scientific Committee on Antarctic Research (SCAR) Antarctic and Southern Ocean Science HorizonScan. The task was to identify the most compelling scientific questions that Antarctic researchers should address in two decades time. These questions span the breadth and depth of modern Antarctic science, and were grouped into the following themes: (i) The Global Reach of Antarctica and the Southern Ocean; (ii) The Ice Sheet and Sea-Level; (iii) The Dynamic Earth beneath Antarctic Ice; (iv) Evolution and Undiscovered Life; (v) Near-Earth Space and the Universe Beyond.

Tim Naish, Peter Barrett and Nancy Bertler were amongst the New Zealand contingent, which also included representatives from other Universities, Antarctica New Zealand and Ministry of Foreign Affairs and Trade. We were asked to find the key issues that will define the priorities for funders, research providers and stakeholders for the next two decades, think outside the box, not to be constrained by resources, and while some issues were of immediate importance, to also anticipate emerging issues. The criteria were broad, ranging from critical fundamental knowledge gaps, exciting blue-sky discoveries, and issues of immediate societal relevance, technological challenges and the need for resources. The outcome of the HorizonScan and the questions were published in articles in *Nature* and *Antarctic Science*.

HorizonScan was the brainchild of ex-SCAR President, Chuck Kennickutt, who with financial support from the Tinker Foundation and Antarctica New Zealand, worked tirelessly to pull off what was a highly successful process.

Then from the 23 August to 3 September, about 1,000 scientists from around the world converged on Auckland for the 2014 SCAR Open Science Conference. ARC staff and students were there enforce and delivered a range of excellent talks and posters, networked with new and old collaborators and friends, and enjoyed the associated public and outreach events. Highlights included an ANTCLIM21 Project session convened by Nancy Bertler and the presentation of new results from the RICE Project, the PAIS project session where both Nick Golledge and Molly Patterson presented summaries of their newly published *Nature* papers, Heidi Roop receiving a best poster award for the presentation of her Lake Ohau PhD research, and Tim Naish receiving the Martha T. Muse Prize for Antarctic Science and Policy at the conference dinner. This highly successful conference was well-organized by Convener Bryan Storey, Director of Gateway Antarctica, University of Canterbury.

Attendees of the 1st SCAR HorizonScan, Queenstown, New Zealand - Photo: SCAR

ANTARCTIC AND ARTIC PHOTO EXHIBITION

The photo exhibition in 'The Hub'
Photo: Colin McDiarmid, VUW Image Services

The visually stunning *From Pole to Pole* photo exhibition contrasting the Antarctic and Arctic was held in Victoria's University's 'Hub' space.

The High Commission of Canada approached the ARC with the idea of a photographic exhibition contrasting changes between the Arctic and the Antarctic. This collaboration led to the highly successful and visually stunning *From Pole to Pole* exhibition displayed between the 11 August and 5 September in Victoria University's 'Hub' space, a main thoroughfare and hang-out space for staff and students. The exhibition contrasted changes particularly in terms of human influence and climate change.

For ARC staff and students it was a great opportunity for friendly competition as photo collections were scoured for images to make the final cut. The exhibition was officially opened by Christian DesRoches, then Acting Canadian High Commissioner and Professor Mike Wilson, Victoria University Pro Vice-Chancellor at a function attended by staff, students, friends, colleagues and members of the diplomatic corps, many thanks to Chantal Hickey (Canadian High Commission) and then ARC Administrator Robyn McFarlane for their organization of the event.

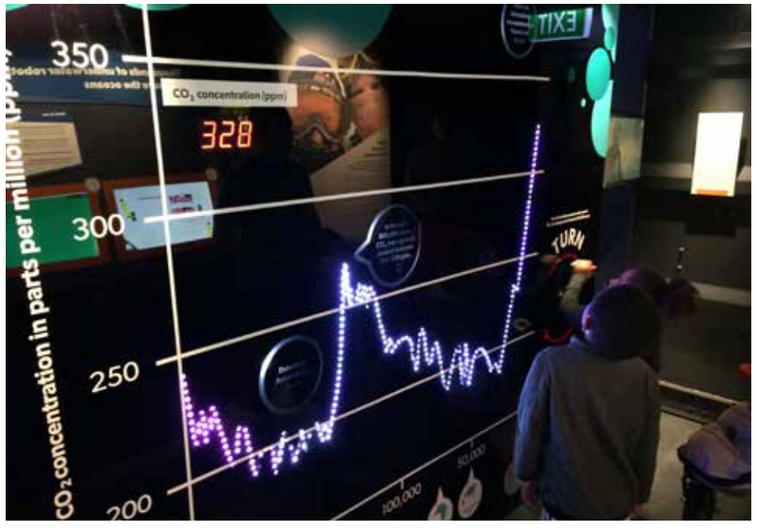
Mike Wilson (Pro Vice-Chancellor), Jonathan Sinclair (British High Commissioner), Tim Naish (ARC Director) and Christian DesRoches (Canadian High Commission Councellor)
Photo: Colin McDiarmid, VUW Image Services

ANTARCTIC TIME TRAVEL

The ARC contributed to the development of the Antarctic Time Travel exhibit at the 2014 NZ IceFest.

Victoria University participated as a sponsoring partner in the 2014 New Zealand IceFest held in Christchurch from 27 September through to 12 October. The festival celebrates New Zealand's activities and interests in Antarctica from science to art to environmental protection, tourism and exploration with a series of public events spread out over the two week period. A major highlight was the Antarctic Time Travel (ATT) exhibition, which was the brainchild of our close colleague Richard Levy (GNS Science), who worked closely with exhibit project manager, Bec McMaster (Christchurch City Council), to create a truly world class science exhibition. The primary sponsors were Victoria University and GNS Science with Tim Naish and PhD student Heidi Roop serving on the Advisory Committee and contributing to content. The ATT comprised nine interconnected shipping containers taking the visitor on a trip through time from the greenhouse world 50 million years ago, when Antarctica had a warm temperate climate with rain forest to the cold glacial environment of today, and then into three possible futures depending on how we choose to deal with climate change. It was a very popular attraction with 10,000 visitors. Victoria is in discussion on how to bring the exhibition to Wellington's waterfront next year.

ARC PhD student Peter Neff contributed to a public climate change panel discussion and Victoria University's Rhian Salmon co-ordinated a science meets art symposium with renowned NZ photographer Anne Noble from Massey University. Victoria University psychologist, Marc Wilson and Tim also did their double act evening talk on, "Climate science: If it's so obvious why don't we believe that the climate is changing?"



Kids checking out the Antarctic Time Travel exhibits - Photo: Tim Naish

ANTARCTIC THEMED READING ROOM

The glass wall defining the room - Photo: Colin McDiarmid, VUW Image Services

The S.T. Lee Antarctic Reading Room in Victoria's Kelburn Library, was formally opened by Vice-Chancellor Grant Guilford in a ribbon-cutting ceremony.

Funded by Singapore philanthropist Dr Lee Seng Tee, the quiet study space, open to all Victoria University students, features displays, photographs and rock collections highlighting the Antarctic Research Centre's history and research in the Antarctic, as well as a selection of the newly acquired Colin Bull Polar Book Collection, covering both Antarctic and Arctic polar regions.

The room was planned and developed as a collaborative effort between the ARC and its Director Tim Naish and Noelle Nelson and her team in the Kelburn library. Emeritus Professor Peter Barrett and ARC Centre Manager Michelle Dow developed the displays for the room, while science librarian Rohini Biradavolu catalogued the Colin Bull Polar Book collection.

The opening ceremony was held on the 22 October and began with a karakia by Professor Piri Sciascia to bless the new room and ended with Vice Chancellor Professor Grant Guilford cutting the ribbon and inviting everyone to view the completed room for the first time. Peter also honored ARC benefactors at the event, particularly Dr Lee, Alan Eggers, Gareth Morgan and Colin Bull for their generous donations to the ARC.

Colin Bull was an Emeritus Professor and Physics lecturer at the University from 1956 to 1961, and played a key role in the early development of Victoria's Antarctic research programme, including leading the 1958-59 expedition to the Dry Valleys. The Colin Bull Polar Book Collection was donated to the library by his family so that library users could benefit from access to its 1800 titles. A feature of the opening was the address by Colin's wife Gillian, who attended with two of their children, Nicholas and Rebecca. She said that the donation would mean a great deal to the polar scientist who passed away in 2010.

"He would be so pleased to know that his books are available to all people from all walks of life".

For more information on Colin Bull and his collection, visit the Library website: http://library.victoria.ac.nz/library-v2/collections/colin-bull-collection

A two day symposium was also held around the room's opening, featuring 16 talks on past discoveries, including the exploration of the Antarctic Dry Valleys 57 years ago by Barrie McKelvey, one of the first two Victoria University students to work on the continent. Barrie and fellow student Peter Webb along with Peter Barrett, ARC's Founding Director, have their images emblazoned on the glass wall of the new S.T. Lee Antarctic Reading Room (see above photo). Past and present staff and students presented research from subsequent expeditions, highlighting Victoria Universities history on the ice as well as plans for future research.

(top) Piri Sciascia blessing the room;
(middle left) Gillian Bull with Rebecca and Nicholas Bull in the background; (middle right) Vice-Chancellor Grant Guilford cutting the ribbon;
(bottom) West end of reading room showing the rock display and Colin Bull collection - Photos: Colin McDiarmid, VUW Image Services

S.T. LEE LECTURE IN ANTARCTIC STUDIES

Edge of an ice shelf, Antarctica
Photo: Christina Riesselman, University of Otago

Rob DeConto presenting his lecture
Photo: Gerry Keating, Image Services, VUW

Professor Rob DeConto presented the 2014 S.T. Lee Lecture, established by Singapore philanthropist Dr Lee Seng Tee, to an audience overflowing into a second room, he presented the latest model predictions of how fast the Antarctic ice sheet may melt and contribute to future sea-level rise.

The 14th annual S.T. Lee Lecture in Antarctic Studies "*The Fate of the Antarctic Ice Sheet: Lessons from the geological past and how they are informing future predictions*" was presented by Professor Rob DeConto on the 3 September.

Rob is Professor of Geosciences at the University of Massachusetts-Amherst, where he is a senior scientist in the Climate System Research Center. Rob's background spans geophysics, oceanography, and atmospheric science. In the last decade, his focus has been on the polar regions, including fieldwork in Antarctica, the development of numerical climate-ice sheet models, and the application of those models to a wide range of past and future climate scenarios.

With the Antarctic ice sheet containing more than 50 m of equivalent sea-level it poses the single greatest threat to global shorelines and coastal cities. Emerging geological records imply surprising sensitivity of the ice sheet during past periods of global warmth, with serious implications for its future response to climate and ocean warming. Recent observations show accelerating retreat of some major outlet glaciers, especially in West Antarctica where the bed of the icesheet lies hundreds of metres below sea-level hinting that a massive runaway ice-retreat is already underway. Rob's lecture explored what geological records tell us about the past history of the ice sheet, the attempts to develop numerical models to simulate those past changes, and what the models say about the ice sheet's long-term future over coming decades and centuries.

Rob presented his lecture again the following night at the University of Otago hosted by Professor Gary Wilson, and visited GNS Science and NIWA. The week-long visit also included a trip to the Wairapapa to visit geological sites in the area.

The computerised Antarctic ice sheet model developed by Rob and his close collaborator, David Pollard (The Pennsylvania State University), is one of the most sophisticated dynamic ice sheet models currently available and incorporates a regional climate model that simulates changes in response to atmospheric and ocean temperatures typical of past and future warming. Our in-house ice sheet model developed by Nick Golledge is rapidly gaining a reputation as the other key Antarctic ice sheet model (see page 12). Nick will soon be publishing modelled Antarctic ice sheet contributions to future sea-level rise from his model for the IPCC climate scenarios.

Rob and his team published, the results he presented in the 2014 S.T. Lee Lecture in *Earth and Planetary Science Letters*, and these are having a major impact on the scientific community. The figure below shows the model results for climate conditions under which atmospheric CO_2 forcing of 400 ppm has warmed the global ocean by 2°C. These are climate conditions we are likely to experience in the coming decades. Under these conditions floating ice shelves are drastically reduced or removed completely by increased oceanic melting, and by hydrofracturing due to surface melt draining into crevasses. Ice at deep grounding lines is weakened and fails structurally, producing rapid and unstoppable retreat in all the regions of Antarctica where ice is grounded below sea-level, ultimately contributing 17 m of global sea-level over the next few thousand years. What is most alarming is that the meltwater contribution over the first millennium rises global sea-level at a rate of 2 m per century. This is significantly higher than the current predictions by the IPCC, and suggests that Antarctica may be more vulnerable to warm climates than in most previous studies.

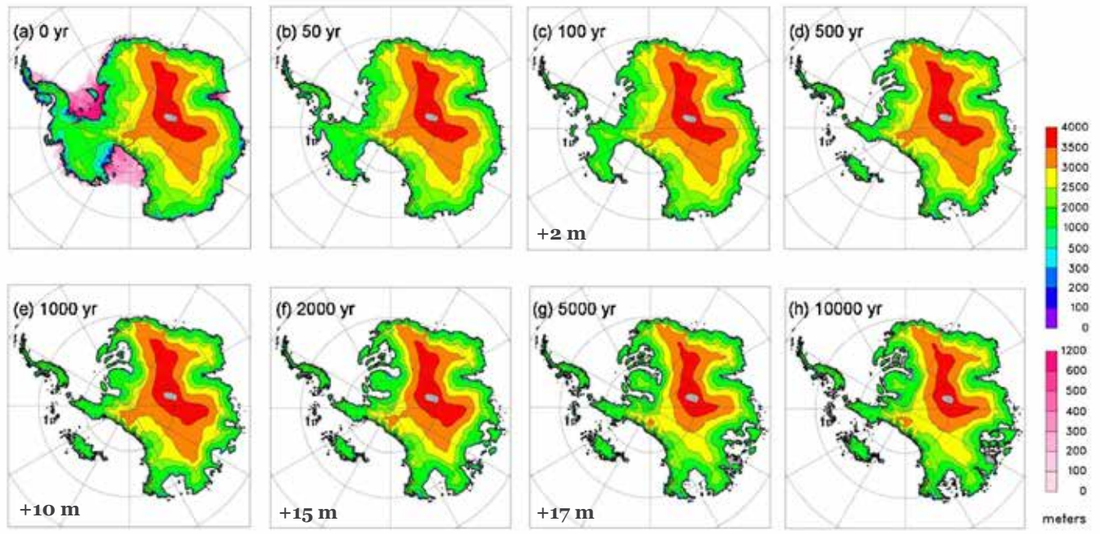


Figure shows the latest coupled ice sheet-climate model of Antarctic contribution to future sea-level rise presented by Rob DeConto at the 2014 S.T. Lee Lecture. The models starting point is a world where the Antarctic surface ocean has warmed by 2oC and the atmosphere has 400 ppm CO2 concentration. As the Antarctic ice sheets melt it contributes to +17 m of sea-level rise by 5000 yrs (Pollard *et al.*, (2015), Earth and Planetary Science Letters 412: 112–121)

THIN ICE GETS A KICKSTART

left-right: Suze Keith, Simon Lamb, Peter Barrett, Gary Ward
Photo: Peter Barrett

Thin Ice: The Inside Story of Climate Science - saw the launch of a campaign to get the film to a US distributor and funding a one hour version for US Public TV.

The film *Thin Ice; The Inside Story of Climate Science* was an initiative between Victoria University of Wellington, the University of Oxford and DOX Productions, London. The documentary gives the public a rare opportunity to see climate scientists at work, talking about what they do, and their hopes and fears.

In 2013 we reported the successful global launch of the film, the production of a DVD and some film festival awards, all very satisfying after six years in production. In 2014 the goal was to increase its reach, especially with young people through educational networks.

By December 2013 *Thin Ice* Executive Producer, Peter Barrett had enlisted the help of Victoria University's commercial arm VicLink, who funded a summer research assistant, Suze Keith, to develop a marketing and operations strategy, and provided their management accountant Gary Ward to help Suze and Peter, review and assess offers for becoming educational distributor for *Thin Ice*. The successful company was Green Planet Films (GPF), a California-based company with ten years' experience.

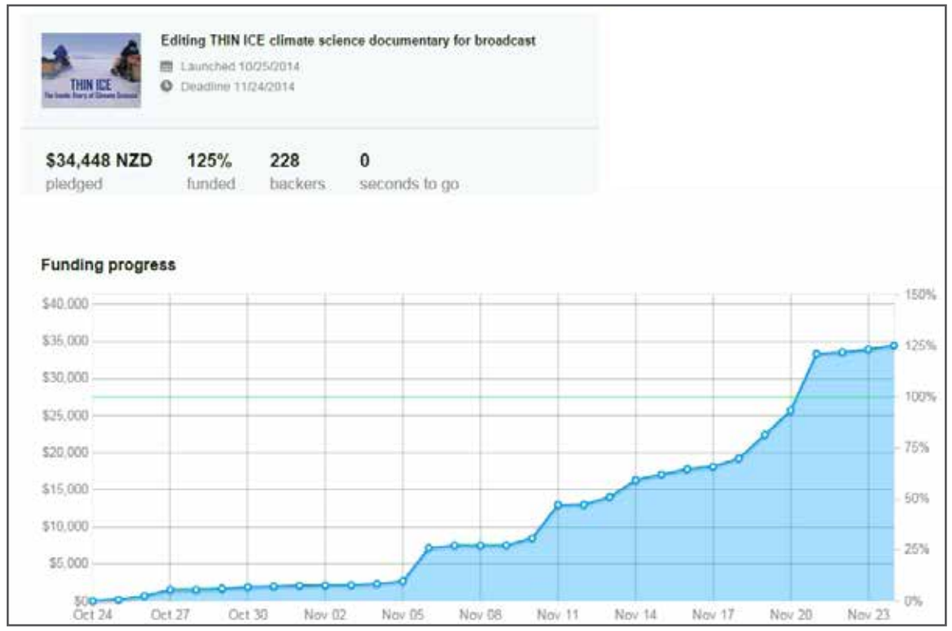
GPF Chief Executive Suzanne Harle has been active through the year in promoting *Thin Ice* to a wide range of institutions, and providing access through streaming, downloads or DVDs. Through her efforts we had screenings by invitation at environmental film festivals in San Francisco in June, Santo Domingo in September, and the world's oldest in Barcelona in October, and a small but rising stream of sales to schools, colleges and universities is developing.

The most challenging opportunity to date came from a discussion Suzanne had with a Californian TV station manager, Stan Marvin, who thought the film would appeal to American public TV audiences if it were trimmed to their standard 57 minute length (down from its original 73 minutes). He suggested submitting it for screening, but first the film had to get re-edited down to length at our own expense ($US23,000), and find around $US10,000 for promoting its screening throughout the network if selected. *Thin Ice* Director/Narrator, Simon Lamb, talked with David Sington (DOX Productions) and produced a 57 minute rough cut, sufficient to show that the removal of several non-critical sections left a film that still worked well, sufficient to convince the networks that they wanted it for broadcast, in Stan's view. The barrier was the $31,000 for the re-edit and promotion.

Then Suzanne told us about Kickstarter, an organisation that ran crowd-funding campaigns that she had seen work for funding TV versions of films like ours. But it involved developing a convincing story and providing "rewards" that related in some way to the project as incentives to donate. Peter put it to Gary, Suze and Simon, and they became the Wellington Thin Ice Kickstarter Team. Shortly after, Christchurch-based Earth Sea & Sky came on board as our primary reward partner and the campaign was underway. The team decided early on it would be extremely risky to rely solely on individual donors so sought some initial institutional support and fortunately got help from the Tindall Foundation (NZ) and the Climate Change Institute (University of Maine). This allowed us to set a more achievable goal of $US22,000, that had to raise in 30 days, or the pledges would be returned.

The campaign itself began on 24 October with numerous e-mails to various networks, friends, and alumni. Pledging was worryingly slow for the first 20 days, by which time we had just passed the 50% mark with help from Tim's Martha Muse Prize on 5 November and the New Zealand Antarctic Institute on 10 November. About this time Simon was interviewed on Radio NZ, and after a few more days the pledge rate took off and we reached 93% with four days to go. While this was happening, we also attracted a significant pledge from the ANDRILL Science Committee on 20 November that took us to the 120% mark. We completed the campaign with 125% of the original target. The appeal itself can be seen at http://kck.st/1u90mFC and the 30 days of stress can be gauged from the graph below. We have now dispatched all the rewards and are enormously grateful to all those who supported the campaign (see https://www.facebook.com/ThinIceClimate).

Our goal for 2015 is to conclude arrangements for editing and delivery of the TV version for broadcast mid-year in the US, and perhaps other parts of the world. We hope it will help American viewers see the direct link between rising greenhouse gas emissions and changing climate, and strengthen their support for a global emissions reduction agreement in Paris in December.



The Thin Ice funding progress chart generated by Kickstarter

NEW ZEALAND'S ANTARCTIC RESEARCH ENVIRONMENT

An igloo, Antarctica - Photo: Nancy Bertler

An update on NZARI, JARI, National Science Challenges & CoREs.

The complex Antarctic research funding environment continued to evolve through 2014 as the scope of the Deep South National Science Challenge was clarified and the role of New Zealand Antarctic Research Institute (NZARI) was consolidated. A further round of Centre of Research Excellence proposals was offered to unsuccessful proponents in the 2013 round, and the eight-year Ministry of Business Innovation and Employment (MBIE) funded Past Antarctic Climate (PAC) Programme, which faced a mid-term review because the US proposal for the international ANDRILL Coulman High Project was unsuccessful in raising the required operational funding.

NZARI awarded a new collaborative grant of ~$750k over three years for the Ross Ice Shelf Project to the University of Otago. Victoria University along with GNS Science, NIWA and the University of Canterbury have co-principal investigators and subcontractors. ARC will receive ~$80k per annum to support ice sheet modelling, glacial geophysics and sub-ice shelf sediment coring. It is anticipated that this project will be co-funded through continuation of the MBIE-PAC Programme. Due to logistical challenges faced by Antarctica New Zealand, the Ross Ice Shelf Project and its funding has been delayed by a year. ARC researchers applied for an additional $100k of NZARI grants in 2014, but these were unsuccessful. The 2014 NZARI Annual Report is available at http://nzari.aq/whats-new.

The scope of the Deep South National Science Challenge is evolving and an implementation plan is being negotiated with MBIE. In early 2014 it became clear that the original proposal and business plan led by NZARI Director, Gary Wilson, was unacceptable to MBIE and a major change in emphasis towards climate change consequences and impacts for New Zealand was requested. The leadership of the challenge was handed over to NIWA, and while Victoria's Climate Change Research Institute will be a significant partner in the Science Challenge, Antarctic ice sheet and sea-level rise research was deemed "out of scope". Consequently the Antarctic Research Centre is no longer involved in the Challenge.

Tim Naish co-ordinated a resubmission of the Hillary Institute Centre of Research Excellence (CoRE) proposal. The new-look proposal focused specifically on Antarctic ice sheet contribution to global sea-level rise and improved predictions of sea-level rise for New Zealand and better governance around anticipating and managing the impacts. This is presently a notable research gap in New Zealand, which is inadequately-funded and lacks effective co-ordination. The proposal combined elements of Victoria's climate change CoRE as will as the original Hillary Core proposal, linked up with a range of research providers and stakeholders.

The Joint Antarctic Research Institute (JARI) Directed by Richard Levy (GNS Science) continues in its role as a highly successful research alliance between GNS Science, VUW, NIWA, University of Canterbury and University of Otago. JARI partners align resources (staff and facilities), support joint appointments, and links with international collaborators. The JARI has proved critical in developing effective collaborations and providing the capability for delivering outcomes for a number of major collaborative Antarctic research programmes such as RICE, ANDRILL, and PAC.

ARC ENDOWED DEVELOPMENT FUND

The ARC Endowed Development Fund has now reached $500,000, with 62 grants having been awarded since its inception in 2004.

This substantial fund enables the ARC to give small grants of up to $4000 to postgraduate students with research links to Antarctica and enables some amazing opportunities to be taken up, that would not have otherwise been possible. Examples include; participation in international summer schools in glaciology, modelling and paleoclimatology, the opportunity to work with collaborators in world-class analytical facilities, and the ability to travel to international conferences and workshops to present their scientific discoveries on a world-stage.

The 2014 recipients were:

Kristina Pascher who attended the Climatic and Biotic Events of the Paleogene (CBEP) meeting and Urbino Summer School in July.

Recently completed PhD student Molly Patterson flew back to New Zealand in August to present her research at the SCAR Meeting in Auckland.

Cassandra Trinh-Le travelled to the University of Ottawa and NASA Ames in November to collect samples for her Masters research.

Andrea Tuohy, Daniel Emanuelsson, Heidi Roop, and Peter Neff all presented their PhD research at the American Geophysical Union Meeting in San Francisco in December.

Finally Aitana Forcen Vasquez is writing a paper on her PhD research to be submitted in 2015.

Discussions are underway with the Victoria University Foundation on a new fund raising campaign to increase the size of the Endowed Development Fund. Details will be announced in 2015.

Cassandra Trinh-Le using a vacuum chamber to impregnate sediment samples with epoxy; NASA Ames Research Center - Photo: Cassandra Trinh-Le

OUTREACH

Pupils from Omarama School check out the AUV on Lake Ohau
Photo: Remo Cossu, University of Tasmania

Our staff and students were involved in a variety of outreach activities during the year, presenting our research and knowledge to the wider community.

Media interviews

3 News 'Firstline': 31 March, "Scientists warn New Zealand not ready for climate change" Tim Naish on IPCC WG2 AR5 Report. http://www.3news.co.nz/environmentsci/scientists-warn-nz-not-ready-for-climate-change-2014033109.

3 News: 30 July, "Southern Alps melt accelerating - study" Andrew Mackintosh. http://www.3news.co.nz/environmentsci/southern-alps-melt-accelerating--study-2014073017#axzz3U7mpawqH

3 News 'Firstline': 28 November, "Sea-level rise and implications for New Zealand" Nancy Bertler. http://www.3news.co.nz/nznews/sea-level-rise-incredibly-certain---scientist-2014112810#axzz3OvkIwOpE

Campbell Live: 19 May, "What's happening to Franz Josef Glacier?" Brian Anderson.

Prime TV: 16 January, "Keeping it Pure - climate change documentary" Brian Anderson.

TVNZ 'One News': 5 August, Tim Naish, Nancy Bertler and Gary Wilson (UOtago) on Auckland SCAR Conference.

TVNZ 'One News': 28 August, "Abrupt sea level rise with footage from RICE" Nancy Bertler and Tim Naish.

TVNZ 'One News': 3 November, Tim Naish on IPCC synthesis report.

TVNZ 'Breakfast Show': 27 August, Tim Naish on the SCAR Auckland Conference. http://tvnz.co.nz/breakfast-news/auckland-hosts-major-antarctic-conference-video-6065177.

Radio NZ 'Our Changing World': 14 March, "The state of the West Antarctic Ice Sheet" Huw Horgan. http://www.radionz.co.nz/national/programmes/ourchangingworld/audio/2596600/melting-glaciers-in-west-antarctica.

Radio NZ 'Our Changing World/ Eureka': 22 May, "Melting glaciers in West Antarctica" Tim Naish and Huw Horgan.

Radio NZ 'Our Changing World/ Eureka': 7 August, "Drilling into the past" Tim Naish on Marsden fieldwork in Whanganui Basin also featuring Gavin Dunbar.

Radio NZ 'Our Changing World/ Eureka': 21 August, "Antarctic Time Travel and Past Climates" Tim Naish.

Radio NZ 'Our Changing World/ Eureka': 28 August, "Melting Ice. Rising Sea" Tim Naish.

Radio NZ 'Morning Report': 3 November, "IPCC Synthesis Report" Tim Naish.

Dominion Post: 6 September, "Who will head up Our Place?" Lionel Carter.

Grey Star: 27 December "Wet spring not enough to replenish glaciers" Brian Anderson.

Huffington Post: 16 May, Tim Naish on irreversible loss of West Antarctic glaciers. http://live.huffingtonpost.com/r/segment/west-antarctica-melting-ice-climate-change-/53725e5c78c90a2285000004c.

New Zealand Geographic: May-June issue, "The cold hard truth" Brian Anderson and Nancy Bertler on changes in New Zealand glaciers and Antarctic ice sheets.

New Zealand Listener: 19 September, "Feature article on climate change and Antarctic research" Tim Naish.

NZ Herald: 31 March, "NZ unprepared for rising sea levels – report" Tim Naish http://www.nzherald.co.nz/world/news/article.cfm?c_id=2&objectid=11229566.

NZ Herald: 1 April, "Wake up call for New Zealand to act on climate change" Tim Naish in repsonse to launch of IPCC WG2 AR5 release. And all syndicated local dailys.

NZ Herald: 3 April, "Editorial: Climate report a wake-up call for global action" Tim Naish. http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11231090.

NZ Herald: 17 May, "El Niño could help glaciers" Brian Anderson.

NZ Herald: 30 July, "Southern Alps snow, ice vanishing" Andrew Mackintosh. http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11301095

NZ Herald: 13 August, "Wanganui reveals prehistoric climate" Tim Naish. http://www.nzherald.co.nz/wanganui-chronicle/news/article.cfm?c_id=1503426&objectid=11308075.

NZ Herald: 18 August, "Kiwis in Antarctica: Secrets of the ice world". Tim Naish. http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11310259.

NZ Herald: 28 August, "Antarctic sea level rise could be more dramatic than earlier thought – expert". Tim Naish http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11315512

Sciblogs: 18 June, "How mixed-age air bubbles 'smear' the climate record" Ruzica Dadic.

The National Business Review: 28 November "Private sector to the rescue? Climate change needs industry, not government" Lionel Carter.

The Press: 8 September, "Award reflects NZ's Antarctic role". http://www.stuff.co.nz/the-press/christchurch-life/freeze-out/10419211/Award-reflects-NZs-Antarctic-role.

Talks to the public and policymakers

AUT Public Presentation: "Ice sheets and sea-level rise" during World Science week, Tim Naish, Auckland, 26 August.

BBC/RSNZ 'Naked Scientist': Live radio panel discussion including Tim Naish, Wellington, 12 August. http://www.royalsociety.org.nz/events/the-naked-scientists-live/

Consulation for the Parliamentary Commission for the Environment: "New Zealand sea-level rise and review comments", Tim Naish, Wellington, July-October.

New Zealand IceFest: "Fresh faced Antarcticans" and "Climate change is generation Y's issue?", Peter Neff, Christchurch, 10 October.

New Zealand IceFest: "Psychology of climate change", Tim Naish and Marc Wilson (Psychology), Christchurch, 11 October.

PolarTREC Teacher Orientation: Heidi Roop.

Royal Society of New Zealand Speakers Science Forum: "Potential collapse of the West Antarctic Ice Sheet – Implications for global sea-level rise", Nancy Bertler, New Zealand Parliament, Wellington, 19 March.

SCAR HorizonScan: Tim Naish, Peter Barrett and Nancy Bertler 3 of 70 invited international Antarctic researchers to set the direction of Antarctic science for the next 20 years, Queenstown, 21-24 April.

School Fest Antarctic Student Day: "Ice cores – What they tell us about the future", Nancy Bertler, TePapa, Wellington, 7 March.

Tri-University Presentation: "Southern Ocean in a warming world", Lionel Carter, Wellington, 7 May.

VUW Public Lecture Series: "9 billion people, global warming and climate change", Tim Naish, Blenheim, 6 August.

VUW Public Lecture Series: "Southern Ocean - Linking Antarctica and NZ", Lionel Carter, Christchurch, 10 September.

VUW Science Lecture Series for the Regions: "Sea-level rise – Implications for New Zealand", Christchurch, 10 September.

VUW Young Alumni: "Thin Ice – Climate change implications for New Zealand", Lionel Carter and Nancy Bertler, Victoria University of Wellington, New Zealand, 1 December.

School & community groups

Aoraki/Mt Cook Public Talk: "What's happening to our glaciers?", Brian Anderson, Aoraki/Mt Cook, 4 July.

Flagstaff, Arizona: "Science in classroom mentor, Student in Classroom Program" Heidi Roop.

Masterton South Rotary: "Paleoclimate in Antarctica", Bella Duncan, Masterton, 28 October.

New Plymouth Boys High School: "Collision NZ how the land and ocean tick", Lionel Carter, New Plymouth, 9 June.

Ngaio School: "Antarctica", Tim Naish, Wellington, 26 June.

Papanui Junction School: "Wanganui drilling project" Gavin Dunbar and Tim Naish, Siberia Station, 24 July.

St Barnabas Church: "South", Lionel Carter, Wellington, 7 October.

Totara Park Primary School: "Backyard treasure; searching for fossils in New Zealand rocks" Matt Ryan, Upper Hutt, 5 December.

Omarama School: "Lake Ohau project" Gavin Dunbar, Lake Ohau 5 December.

Other activities

Science Communication Workshop: Jointly run by Richard Jones (Climatica) and EGU, May.

Island of Ice Educational iPad App: Joint project with NASA and the Joint Committee including Heidi Roop, launched at AGU, December.

PUBLICATIONS AND CONFERENCES

Peer-reviewed publications (34)

Anderson, B.M., Willis, I., Goodsell, B., Banwell, A., Owens, I., **Mackintosh**, A., Lawson, W., (2014). Annual to daily ice velocity and water pressure variations on Ka Roimata o Hine Hukatere/Franz Josef Glacier, New Zealand. *Arctic, Antarctic and Alpine Research* 46(4): 919-932. doi:10.1657/1938-4246-46.4.919.

Anderson, J.B., Conway, H., Bart, P.J., Witus, A.E., Greenwood, S.L., **McKay**, R.M., Hall, B.L., Ackert, R.P., Licht, K., Jakobsson, M., Stone, J.O., (2014). Ross Sea paleo-ice sheet drainage and deglacial history during and since the LGM. *Quaternary Science Reviews* 100: 31-54.

Carter, L., Gavey, R., Talling, P.J., and Liu J.T., (2014). Insights into submarine geohazards from breaks in subsea telecommunication cables. *Oceanography* 27(2): 58-67. doi:10.5670/oceanog.2014.40.

Chewings, J.M., **Atkins**, C.B., **Dunbar**, G.B. and **Golledge**, N.R. (2014). Aeolian sediment transport and deposition in a modern high latitude glacial marine environment. *Sedimentology* 61: 1535-1557. http://dx.doi.org/10.1111/sed.12108.

Christner, B.C., Priscu, J.C., Achberger, A.M., Barbante, C., Carter, S.P., Christianson, K., Michaud, A.B., Mikucki, J.A., Mitchell, A.C., Skidmore, M.L., Vick-Majors, T.J., and the WISSARD Science Team (including **Horgan**, H.), (2014). A microbial ecosystem beneath the West Antarctic Ice Sheet. *Nature* 512: 310-313.

Davies, B.D., **Golledge**, N.R., Glasser, N., Carrivick, J., Ligtenberg, S., Barrand, N., van den Broeke, M., Hambrey, M., Smellie, J., (2014). Modelled glacier response to centennial temperature and precipitation trends on the Antarctic Peninsula. *Nature Climate Change* 4: 993-998. http://dx.doi.org/10.1038/nclimate2369.

Emanuelsson, B.D., Baisden, W.T., **Bertler**, N.A.N., Keller, E.D., Gkinis, V., (2014). High-resolution continuous flow analysis setup for water isotopic measurement from ice cores using laser spectroscopy. *Atmospheric Measurement Techniques* 7: 12081-12124. doi:10.5194/amtd-7-12081-2014, 2014.

Fernandez, D., Bowen, M., and **Carter**, L., (2014). Intensification and variability of the confluence of subtropical and subantarctic boundary currents east of New Zealand. *Journal of Geophysical Research: Oceans* 119(2): 1146-1160. doi:10.1002/2013JC009153.

Fogwill, C., Bingham, R., **Mackintosh**, A., Marchant, D., (2014). Standing on the shoulders of giants. *Antarctic Science* 26(6): 601-602. doi:10.1017/S095410201400073X.

Fogwill, C.J., Turney, C.S.M., **Golledge**, N.R., Rood, D.H., Hippe, K., Wacker, L., Wieler, R., Rainsley, E.B., **Jones**, R.S., (2014). Drivers of abrupt Holocene shifts in West Antarctic ice stream direction from combined ice sheet modelling and geologic signatures. *Antarctic Science* 26: 674-686.

Fogwill, C.J., Turney, C.S.M., Meissner, K.J., **Golledge**, N.R., Spence, P., Roberts, J.I., England, M.H., Jones, R.T., **Carter**, L., (2014). Testing the sensitivity of the East Antarctic Ice Sheet to Southern Ocean dynamics: Past changes and future implications. *Journal of Quaternary Science* 29(1): 91-98. ISSN: 0267-8179. doi:10.1002/jqs.2683.

Fyke, J., Eby, M., **Mackintosh**, A., Weaver, A. (2014). Impact of climate sensitivity and polar amplification on projections of Greenland Ice Sheet loss. *Climate Dynamics* 43(7-8): 2249-2260. doi:10.1007/s00382-014-2050-7.

Gallagher, S.J., Exon, N., Seton, M., Ikehara, M., Hollis, C.J., Arculus, R., D'Hondt, S., Foster, C., Gurnis, M., Kennett, J.P., **McKay**, R., Malakoff, A., Mori, J., Takai, K., Wallace, L., (2014). Exploring new drilling prospects in the southwest Pacific. *Scientific Drilling* 17: 45-50.

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Reports

Bache, F., Sutherland, R., Mortimer, N., Browne, G., Lawrence, M.J.F., Black, J., Flowers, M., Rouillard, P., Pallentin, A., Woelz, S., Wilcox, S., Hines, B., Jury, S., **Roop**, H., (2014). *Tangaroa* TAN 1312 Voyage Report: Dredging Reinga and Aotea basins to constrain seismic Stratigraphy and Petroleum systems (DRASP), NW New Zealand. *GNS Science Report 2014/05.*

Workshops

Barrett, P., **Bertler**, N., and **Naish**, T., (2014). 1st Antarctic & Southern Ocean Science Horizon Scan – A View beyond the Horizon: Future Directions in Antarctic Science, Queenstown, New Zealand, 20-24 April.

Bertler, N. (2014). CliC SSG-X, SCAR and Clic Workshop – Common and Complementary Interests, Geneva, Switzerland, 17-20 February.

Bertler, N., (2014). 5th International RICE Science Workshop, University of Washington, Seattle, USA, 2-5 February.

Bertler, N., (2014). 2nd Antarctic Climate 21 Workshop, San Francisco, USA, 11-12 December.

Bertler, N. , (2014). 6th International RICE Science Workshop, San Francisco, USA, 13-14 December.

Invited keynote/plenary presentations

Bertler, N., (2014). Potential collapse of the West Antarctic Ice Sheet – Implications for global sea level rise. *31st General Assembly of the International Council for Science (ICSU)*, Auckland, New Zealand, 31 August-3 September.

Bertler, N., Conway, H., Dahl-Jensen, D., and the RICE Team, (2014). RICE - Roosevelt Island Climate Evolution project - a new, intermediate depth ice core record from coastal Antarctica. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Bertler, N.A.N, and others (including **Dadic**, R., **Emanuelsson**, D.B., **Golledge**, N., **Naish**, T., **Neff**, P.D., **Tuohy**, A.), (2014). The Roosevelt Island Climate Evolution (RICE) ice core – A coastal record of West Antarctic deglaciation. *WAIS Divide Science Meeting*, La Jolla, USA 22-24 September.

Carter, L., (2014). Submarine cables and the ocean environment. *Submarine Cables in the Sargasso Sea-Legal and Environmental Issues in Areas Beyond National Jurisdiction*, George Washington University, Washington DC, USA, 23 October.

Naish, T., (2014). Martha T. Muse Lecture: Paleoclimate perspectives on Antarctic ice sheet sensitivity. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Oral presentations

Anderson, B., (2014). Measuring ground deformation from time-lapse photography – examples from Franz Josef and Fox glaciers. *SIRG NZ 2014 Workshop*, Aoraki Mt Cook Village, New Zealand, 2-4 July.

Bache, F., Sutherland, R., Stagpoole, V., Browne, G., Lawrence, M.J.F., Mortimer, N., Herzer, R., Black, J., Hines, B., **Roop**, H.A., Flowers, M., Rouillard, P., Collots, J., Patriat, M., (2014). Geological overview of the Reinga Basin, NW New Zealand: Key observations and new constraints. *Advantages Conference*, Wellington, New Zealand, 1-3 April.

Barrett, P.J., and the Thin Ice Team, (2014). Communicating science the "Thin Ice" experience. GeoSciences Conference, New Plymouth, New Zealand, 24-27 November, *Geoscience Society of New Zealand Miscellaneous Publication 139A*. p. 5.

Barrett, P., Lamb, S., Sington, D., England, P. Fairhead, D., Sheppard, P. Fitzgerald, C., Franklin, J., **Roop**, H., Keith, S., Harle, S., (2014). Communicating science - the "Thin Ice" experience. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Bertler, N., and the RICE Team, (2014). RICE - Roosevelt Island Climate Evolution Project - A new intermediate depth ice core record from coastal Antarctica. GeoSciences Conference, New Plymouth, New Zealand, 24-27 November, *Geoscience Society of New Zealand Miscellaneous Publication 139A*. p. 10.

Bertler, N. and others (incl. **Dadic**, R., **Emanuelsson**, D., **Naish**, T., **Neff**, P. and **Tuohy**, A.). The Roosevelt Island Climate Evolution (RICE) Project – Did the Ross Ice Shelf Collapse During MIS 5e? *AGU Fall 2014 Meeting*, San Francisco, California, USA, 15-19 December.

Carter, L., (2014). Polar-equatorial interactions off New Zealand from Last Glacial Maximum to 2014. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Carter, L., (2014). Improving environmental reconstructions - A case study from postglacial SW Pacific Ocean. GeoSciences Conference, New Plymouth, New Zealand, 24-27 November, *Geoscience Society of New Zealand Miscellaneous Publication 139A*. p. 18

Carter, L., Talling, P.J., and Gavey, R., (2014). Insights into natural hazards affecting submarine telecommunication cables. ICPC Plenary Meeting, Dubai, United Arab Emirates, 17-19 March.

Chinn, T.J., Purdie, H., and **Anderson**, B., (2014).When dead ice is not stagnant. *SIRG NZ 2014 Workshop*, Aoraki Mt Cook Village, New Zealand, 2-4 July.

Collins, J., Norton, K., and **Mackintosh**, A., (2014). In situ cosmogenic ^{10}Be in Pyroxenes. GeoSciences Conference, New Plymouth, New Zealand, 24-27 November, *Geoscience Society of New Zealand Miscellaneous Publication 139A*. p. 24.

Cossu, R., Forrest A.L., Stumpner, P., **Roop**, H.A., **Dunbar**, G., Levy, R.H., Vandergoes, M.J., Schladow, S.G., (2014). Observations of turbidity currents and internal waves in glacial Lake Ohau, South Island, New Zealand. *17th Workshop on Physical Processes in Natural Waters*, Trento, Italy, 1-4 July.

Cortese, G., Panitz, S., **Golledge**, N., Neil, H., Diekmann, B., (2014). A Radiolarian-based paleoclimate history of Core Y9 (Northeast of Campbell Plateau, New Zealand) for the last 160 kyr. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Dadic, R., (2014). High degree snow metamorphism in the Alan Hills, Antarctica. *SIRG NZ 2014 Workshop*, Mt Cook Village, New Zealand, 2-4 July.

Dadic, R., Schneebeli, M., **Bertler**, N., Schwikowski, M., Matzl, M., (2014). High-degree snow metamorphism in the Allan Hills, Antarctica. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Dickinson, W. and **Atkins**, C., (2014). The origin of buried ice and permafrost sediments in Victoria Valley, Antarctica. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Dunbar, G.B., Levy, R., Vandergoes, M.J., **Roop**, H.A., Phipps, S.J., Fitzsimons, S.J., Howarth, J.D., and the Lake Ohau Science Team, (2014). Lake Ohau: A 17,000 year seasonally resolved record of climate change. GeoSciences Conference, New Plymouth, New Zealand, 24-27 November, *Geoscience Society of New Zealand Miscellaneous Publication 139A*. p. 35.

Eaves, S.R., (2014). Cosmogenic 3-helium. *NZ Cosmogenic Nuclide Workshop*, Wellington, New Zealand, May.

Eaves, S.R., **Mackintosh**, A., Winckler, G., Schaefer, J.M., **Anderson**, B., Townsend, D., (2014). Uniform summertime cooling across New Zealand drove glacier readvance during the late-glacial. *Australasian Quaternary Association Meeting*, Mildura, Australia, 29 June-4 July.

Emanuelsson, D., **Bertler**, N., Baisden, T., Keller, E., (2014). Interpretation of a 2,000 year, high resolution water stable isotope record from the RICE ice core Roosevelt Island, Antarctica. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Fogwill, C., Turney, C., **Golledge**, N., Rood, D., Hippe, K., Wacker, L., Wieler, R., Rainsley E., (2014). Mechanisms driving abrupt shifts in West Antarctic ice stream direction during the Holocene. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Golledge, N.R., Menviel, L., **Carter**, L., Fogwill, C.J., England, M.H., Cortese, G., Levy, R.H., and others (including **Bertler**, N.A.N.), (2014). Insights into continental-scale ice-ocean feedbacks from palaeo-ice sheet modelling. *Ice-ocean interactions Workshop*, Hobart, Australia, 10-11 November.

Golledge, N., Menviel, L., Denton, G., **Carter**, L., Fogwill, C., England, M., Cortese, G. (2014). Antarctic meltwater pulses from a positive ice-ocean feedback mechanism. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Golledge, N., Menviel, L., Denton, G., **Carter**, L., Fogwill, C., England, M., Cortese, G., (2014). Antarctic meltwater pulses from a positive ice-ocean feedback mechanism. GeoSciences Conference, New Plymouth, New Zealand, 24-27 November, *Geoscience Society of New Zealand Miscellaneous Publication 139A*. p. 43.

Golledge, N.R., Menviel, L., Denton, G.H., Fogwill, C.J., (2014). Data-constrained modelling of Antarctic ice sheets at the Last Glacial Maximum, and implications for their deglacial sea level contribution *Joint Model-Data Workshop for the Late Pleistocene Evolution of the Greenland and Antarctic Ice Sheets*, Grenoble, France, 22-24 May.

Hollis, C.J., **Pascher**, K.M., Hines, B.R., Littler, K., Kulhanek, D.K., Strong, C.P., Zachos, J.C., Eggins, S.M., Phillips, A., (2014). Was the Early Eocene ocean unbearably warm or are the proxies unbelievably wrong? *Rendiconti Online della Società Geologica Italiana* 31: 33-34. doi: 10.3301/ROL.2014.31. Climatic and Biotic Events of the Paleogene 2014: Selected short notes and abstracts, Ferrara, Italy, 1-6 July.

Hollis, C., **Pascher**, K., Shepherd, C., Hines, B., Cortese, G., Morgans, H., Kulhanek D., **McKay** R., Crampton, J., (2014). Reconciling proxies and fossils with Southern Ocean circulation models for the Paleogene. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Horgan, H.J., **Anderson**, B., and Dykes, R.C., (2014). Rain-induced unstable sliding – Tasman Glacier. *SIRG NZ 2014 Workshop*, Aoraki Mt Cook Village, New Zealand, 2-4 July.

Horgan, H.J., **Anderson**, B., Dykes, R., Chamberlain, C., Townend, J., (2014). Rain induced unstable sliding - Tasman Glacier. GeoSciences Conference, New Plymouth, New Zealand, 24-27 November, *Geoscience Society of New Zealand Miscellaneous Publication 139A*. p. 53.

Jones, R.S., **Mackintosh**, A.N., Norton, K.P., **Golledge**, N.R., Fogwill, C., (2014). Rapid thinning of an East Antarctic outlet glacier during Holocene climate stability. *SIRG NZ 2014 Workshop*, Aoraki Mt Cook Village, New Zealand, 2-4 July.

McKay, R., Maas, S., **Naish**, T., Levy, R., **Golledge**, N., **Dunbar**, G., Kuhn, G., (2014). Early Holocene retreat of the marine-based ice sheet in the central Ross Sea. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Mckinnon, T., McKinnon, K., and **Anderson**, B., (2014). UAVs for glacier mapping: Lessons learned. *AGU Fall 2014 Meeting*, San Francisco, California, USA, 15-19 December.

Naish, T., and the CH 5 IPCC WG1 AR5 Author Team, (2014). Paleoclimate perspectives on present and future polar amplification. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Neff, P., **Bertler**, N., Edwards, R., **Tuohy**, A., (2014). Lanthanide element studies of aerosol particles in an ice core from Roosevelt Island, Antarctica. *SIRG NZ 2014 Workshop*, Aoraki Mt Cook Village, New Zealand, 2-4 July.

Neff, P., **Bertler**, N., Edwards, R., **Tuohy**, A., (2014). Exploring extra-Antarctic air transport pathways using Rare Earth Element concentrations in dust from the RICE ice core, Roosevelt Island, Ross Sea Sector. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Neff, P., Fudge, T.J., and Medley, B., (2014). Amundsen Sea coastal domes: high resolution Holocene ice core sites. *IDPO Community Workshop on Ice Coring*, Irvine, California, USA, 26-27 February.

Neff, P., Fudge, T.J., and Medley, B., (2014). Amundsen Sea coastal domes: high-resolution Holocene ice core sites. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Patterson, M., **Naish**, T., **McKay**, R., Escutia, C., Jimenez-Espejo, F., Raymo, M., Meyers S., Tauxe, L., Brinkhuis, H., (2014). Orbital forcing of the East Antarctic Ice Sheet during the Pliocene-Early Pleistocene. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Roop, H., Bartholow, S., Huffman, L., Herrmann, N., Wilkening, B., Wesche, G., (2014). Researcher-educator collaborations inspiring global engagement in polar science through the Polar Educators International Master Class Program. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Roop, H., Bartholow, S., Warburton, J., Larson, A., (2014). Researcher involvement in teacher-research experiences: A case study of the PolarTREC program. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Roop, H., Levy, R., **Dunbar**, G., Vandergoes M., (2014). High-resolution records of Southern Hemisphere mid-latitude change over the last 2,000 years: A perspective from a New Zealand varve sequence. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Salmon, R. and **Roop**, H., (2014). Scientist engagement in public outreach events: Motivations, experience, and evaluation. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Salmon, R. and Roop, H.A., (2014). Why do scientists do outreach, what do we achieve, and how can we better learn from each other, and from research in this field? *AGU Fall 2014 Meeting*, San Francisco, California, USA, 15-19 December.

Schneebeli, M., Chappellaz, J., **Dadic**, R., Matzl, M., Proksch, M., Weissbach, S., (2014). Review and new results on snow metamorphism in Eastern Antarctica. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Sefton, J., **Naish**, T., and **McKay**, R., (2014). Testing the role of Milankovitch forcing on global sea-level change using a continuous Late Pliocene shallow-marine sedimentary record from the Wanganui Basin, New Zealand. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Sefton, J., **Naish**, T., **McKay**, R., Turner, G., Seward, D., Alloway, B., Morgans, H., (2014). Milanovitch in mud: Testing the influence of orbital forcing on global sea-level change using a late Pliocene marine sedimentary record from the Wanganui Basin, New Zealand. GeoSciences Conference, New Plymouth, New Zealand, 24-27 November, *Geoscience Society of New Zealand Miscellaneous Publication 139A*. p. 96.

Tuohy, A., **Bertler**, N., and Edwards, R., (2014). Tracing anthropogenic pollution in Antarctica from the RICE core. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Vandergoes, M., Levy, R., **Dunbar**, G., **Roop**, H., Fitzsimons, S., Wilson, G., Florindo, F., Howarth, J., Moy, C., Phipps, S., Sood, A., Ditchburn, R., Li, X., Gorman, A., Kaufman, D., Upton, P., Walker, S., Stone, J., **Pyne**, A., Purdie, J., (2014). A new high-resolution record of South Island hydrology from Lake Ohau sediments, South Island, New Zealand. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Welter, J., **Horgan**, H., **Anderson**, B., Lorrey, A., Chinn, T., Willsman, A., **Mackintosh**, A., (2014). Glacier monitoring in 3D using structure from motion (SfM). GeoSciences Conference, New Plymouth, New Zealand, 24-27 November, *Geoscience Society of New Zealand Miscellaneous Publication 139A*. p. 116.

Winton, H., Delmonte, B., Andersson, P., **Atkins**, C., **Bertler**, N., **Dunbar**, G., Edwards, R., (2014). Aeolian dust in the Ross Sea: Local versus distal sources. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Zondervan, A., Ditchburn, B., Norton, K., Vandergoes, M., McDonnell, R., Tremain, R., Barrell, D., **Jones**, R., Schaefer, J., Putnam, A., (2014). Improving capabilities of surface exposure age dating within New Zealand. GeoSciences Conference, New Plymouth, New Zealand, 24-27 November, *Geoscience Society of New Zealand Miscellaneous Publication 139A*. p. 122.

Poster Presentations

Atkins, C., **Dunbar**, G., **Golledge**, N., **Zwartz**, D., (2014). Aeolian dust in Terra Nova Bay Polynya, Antarctica. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Blunier, T., Simonsen, M.F., Brook, E., Lee, J., Vallelonga, P.T., **Bertler**, N.A.N., (2014). Continuous and discrete measurements of atmospheric methane from an ice core from Roosevelt Island, East Ross Sea, Antarctica. *AGU Fall 2014 Meeting*, San Francisco, California, USA, 15-19 December.

Duncan, B., **McKay**, R., **Naish**, T., Bendle, J., Levy, R., Moossen, H., Ventura, T., (2014). Late Oligocene to Pliocene Antarctic climate and oceanographic reconstructions using molecular and isotopic biomarker proxies. GeoSciences Conference, New Plymouth, New Zealand, 24-27 November, *Geoscience Society of New Zealand Miscellaneous Publication 139A*. p.35.

Duncan, B., **McKay**, R., **Naish**, T., Levy, R., Bendle, J., Ventura, T., (2014). Neogene Antarctic climate and oceanographic reconstructions using molecular and isotopic biomarker proxies. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Eaves, S.R., Winckler, G., Schaefer, J.M., Vandergoes, M.J., **Mackintosh**, A., Townsend, D., Alloway, B., **Ryan**, M., (2014). Surface exposure dating in igneous domains: Development and application of a cosmogenic 3He surface exposure dating in the South West Pacific. *Australasian Quaternary Association Meeting*, Mildura, Australia, 29 June- 4 July.

Emanuelsson, D.B., **Bertler**, N.A.N., Baisden W.T., Keller, L.E., (2014). A 100-year reconstruction of regional sea ice extent in the Ross and Amundsen-Bellinghausen Seas as derived from the RICE ice core, coastal West Antarctica. *AGU Fall 2014 Meeting*, San Francisco, California, USA, 15-19 December.

Jones, R., **Mackintosh**, A., Norton, K., **Golledge**, N., Fogwill, C., (2014). Glacial history and behaviour of Mackay Glacier, Transantarctic Mountains. *EGU*, Vienna, Austria, 27 April-2 May.

Jones, R., **Mackintosh**, A., Norton, K., **Golledge**, N., Fogwill, C., (2014). Glacial history and behaviour of Mackay Glacier, Transantarctic Mountains. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

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Kjær, H.A., Vallelonga, P., Simonsen, M., **Neff**, P., **Bertler**, N., Svensson, A., Seierstad, I., Albert, P. and Bourne, A. Re-evaluating the 1257 AD eruption using annually-resolved ice core chemical analyses. *AGU Fall 2014 Meeting*, San Francisco, California, USA, 15-19 December.

Kjær, H.A., Vallelonga, P., Simonsen, M., **Neff**, P., **Bertler**, N., Svensson, Dahl-Jensen, D., (2014). Initial continuous chemistry results from the Roosevelt Island Ice Core (RICE). *AGU Fall 2014 Meeting*, San Francisco, California, USA, 15-19 December.

Lee, J.E., Brook, E., Blunier, T., **Bertler**, N.A.N., Vallelonga, P.T., (2014). A new age constraint on the deglaciation of the Ross Sea from an ice core from Roosevelt Island, East Ross Sea, Antarctica. *AGU Fall 2014 Meeting*, San Francisco, California, USA, 15-19 December.

Neff, P., **Tuohy**, A., **Bertler**, N., Edwards, R., (2014). Antarctic and Southern Ocean mineral dust aerosol transport pathways: Forward-trajectory modeling and source constraints derived from the RICE ice core. *AGU Fall 2014 Meeting*, San Francisco, California, USA, 15-19 December.

Neff, P., **Tuohy**, A., **Bertler**, N., Edwards, R., (2014). Exploring extra-Antarctic air transport pathways using Rare Earth Element concentrations in dust from the RICE ice core, Roosevelt Island, Ross Sea Sector. *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Newnham, R., **Ryan**, M., **Dunbar**, G., Vandergoes, M., Neil, H., Alloway, B., Bostock, H., Quan Hua., (2014). Marine-terrestrial comparisons and ocean ventilation in the east Tasman Sea during the last glacial-interglacial cycle. GeoSciences Conference, New Plymouth, New Zealand, 24-27 November, *Geoscience Society of New Zealand Miscellaneous Publication 139A*. p. 78.

Pascher, K.M., Hollis, C.J., **McKay**, R., Cortese, G., (2014). Southern Ocean endemism evident in Late Eocene radiolarian assemblages, DSDP Site 277, Campbell Plateau (New Zealand). *Rendiconti Online della Società Geologica Italiana* 31: 33-34. doi: 10.3301/ROL.2014.31. Climatic and Biotic Events of the Paleogene 2014: Selected short notes and abstracts, Ferrara, Italy, 1-6 July.

Pascher, K.M., Hollis, C.J., and **McKay**, R., (2014). Southern Ocean endemism evident in Late Eocene radiolarian assemblages, DSDP Site 277, Campbell Plateau (New Zealand). *SCAR Open Science Conference*, Auckland, New Zealand, 25-28 August.

Roop, H.A., **Dunbar**, G.B., Vandergoes, M.J., Levy, R., Howarth, J., Fitzsimons S., Phipps, S., (2014). A 1,200-year record of climate variability reconstructed from a laminated lacustrine sediment sequence from Lake Ohau, South Island, New Zealand. *AGU Fall 2014 Meeting*, San Francisco, California, USA, 15-19 December.

Simonsen, M.F., Kjær, H.A., Vallelonga, T.P., **Neff**, P.D., **Bertler**, N.A.N., Svensson, A., Seierstad, I., Albert, P.G., Bourne, A.J., Kurbatov, A., (2014). Re-evaluating the 1257 AD eruption using annually-resolved ice core chemical analyses. *AGU Fall 2014 Meeting*, San Francisco, California, USA, 15-19 December.

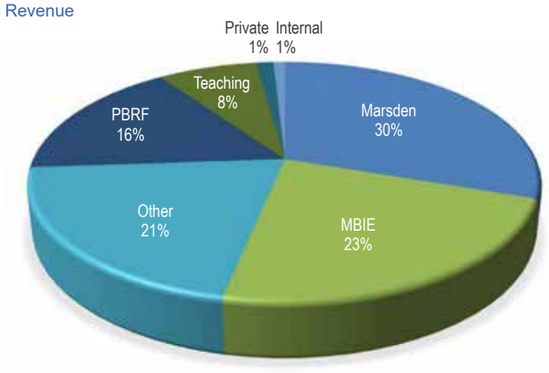
Tuohy, A., **Neff** P., **Bertler**, N. and Edwards, R., (2014). 1000 year record of heavy metal contamination from the RICE ice core, Roosevelt Island, Antarctica. *AGU Fall 2014 Meeting*, San Francisco, California, USA, 15-19 December.

FINANCIAL SUMMARY

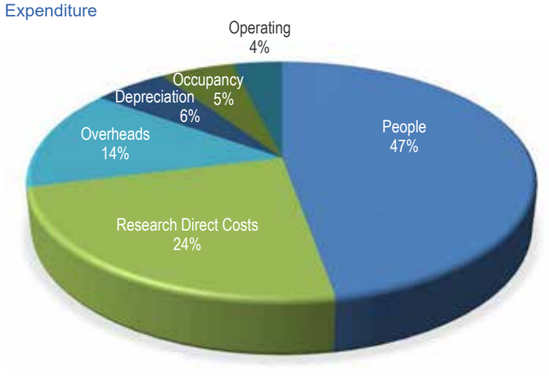
The ARC finances include both a Centre budget and grant funds held by the Research Trust of Victoria University of Wellington. The total ARC revenue and expenditure for 2014 are summarized in the charts below (all figures are exclusive of GST), these figures combine the Centre budget that operates over the Victoria University financial year (January-December) and Research Trust grant budgets which operate over the life of the projects. As such, the year-end balances for revenue versus expenditure in Research Trust grants are often out-of-phase.

2014 Finances

Revenue



Expenditure

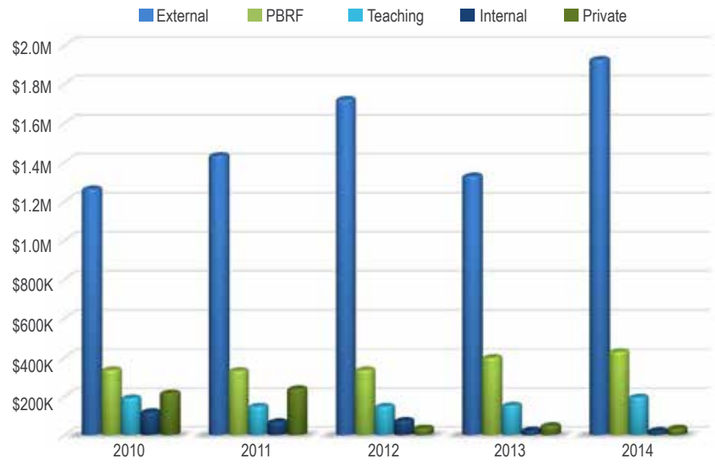


In 2014, the ARC received a total of $2.6M in revenue and a corresponding expenditure of $2.5M. The individual cost centre budget had an approved budget target of $0, however due to additional revenue the Centre made a $28K profit. The ARC's research funding contribution to the University via overheads from Research Trust grants was $344K, thus overall the ARC contributed $372K to the University.

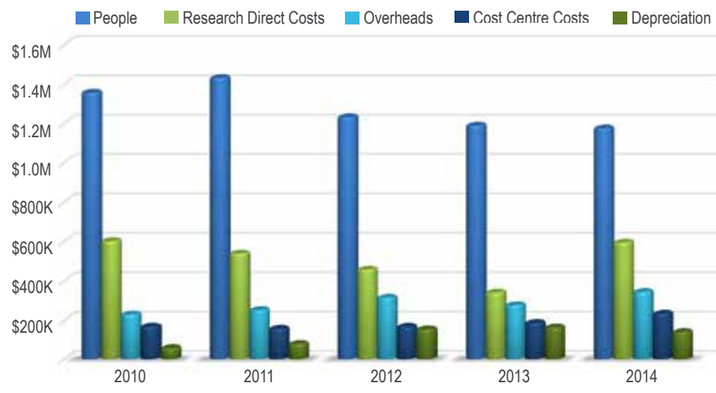
Around 75% of our funding is from external sources. The highest proportion of which came from Marsden funding with the ARC holding six contracts in 2014 generating revenue of $790K. Ministry of Business, Innovation and Employment (MBIE) funding of $600K came directly or via sub-contracts from GNS Science and NIWA. 'Other' includes two Rutherford Fellowships and NZARI funding, as well as funding from other national and international organisations. The remaining 25% of revenue is made up of PBRF, Teaching, Private and Internal grants. PBRF (Performance-Based Research Fund) is calculated by Victoria University based on external research funding that meets 'PBRF' criteria and the quality rating of staff. 'Teaching' is the contribution from SGEES, based on hours, for teaching and supervision by ARC staff, as well as a proportion of PBRF graduate completion income. 'Private' revenue were donations held by the Victoria University Foundation that have been transferred to the Research Trust. Finally, the 'Internal' funding is the $23K of University funded grants for staff and students.

Almost half of the expenditure, $1.2M, is related to staff costs including salaries, annual leave, and superannuation. The 'Research Direct Costs' include $590K expenditure directly associated with research projects such as field work costs, sub-contractors, conference attendance, analyses, and student scholarships. The remaining 29% includes 'Overheads' which are transferred directly from Research Trust grants by the University to cover services provided by the Research Office and central University, 'Depreciation' of CAPEX equipment, 'Occupancy' (office space), and the general 'Operating' costs of the Centre including computers, phones, printing, stationary, and postage.

Five year summary



2010-2014 Revenue Summary



2010-2014 Expenditure Summary

New Funding Success

The ARC successfully secured the following new NZARI funding in 2014:

NZARI "Tidal Flexure of Ice Shelves", $5K over 1 year.

NZARI "Ross Ice Shelf Project", $80K over three years.

'External' revenue, which combines funding from MBIE, Marsden, and 'Other' sources, increased over the period from 2010-2012 with a significant drop in 2013 due to the loss of one of our major programmes. External revenue recovered again in 2014 due to the additonal four Marsdens and a new Rutherford awarded late in 2013. 'PBRF' has increased due to the 2012 review where the quality rating of our staff and research increased. Revenue from 'Teaching and Supervision' also increased slightly due to more PBRF graduate completion funding coming through. 'Internal' funding from University grants has decreased, as has 'Private' funding with no new private donations since 2010. The chart reflects how the donations have been transferred from the Victoria University Foundation to the Research Trust as income to be spent.

On the expenditure side, 'People' related costs are by far our greatest expenditure. The increase from 2010 to 2011 reflect new appointments, while the decrease in 2012 was because two staff were directly supported by the Research Office for six months. The further decline in 2013 and 2014 is a result of a decrease in FTE's of senior staff which have outweighed increases in salaries due to promotions and new appointments during that same period. 'Research Direct Costs' reflect the cycle of research projects with higher costs in the fieldwork and analyses years. Since 2013 scholarships have also been deducted in full in the first year, so for example the increase in 2014 reflects the Marsden-funded drilling fieldwork undertaken that year and a full 3-year PhD scholarship paid to the Scholarships Office. 'Overheads' paid to the University mirror the pattern of external revenue. The basic operational costs for the Centre remained stable over the 2010-2012 period however the increase in 2013 and further in 2014 is primarily a result of increases in the occupancy (space) charges and discretionary spending to support conferences and events such as SCAR and NZ IceFest. 'Depreciation' costs have increased with a marked rise in 2012 due to the captilisation of our $1M Ice Core Drill however in 2014 it decreased again when $290K of this drill was written-off.

DIRECTORY

On top of Friis Hills, Antarctica
Photo: Nick Golledge

DIRECTOR

Tim Naish	Professor	Sedimentology and paleoclimatology

DEPUTY DIRECTOR

Andrew Mackintosh	Associate Professor	Glaciology, climatology, modelling and geomorphology

ACADEMIC STAFF

Brian Anderson	Senior Research Fellow	Glacial modelling
Peter Barrett	Emeritus Professor	Stratigraphy and Antarctic climate history
Nancy Bertler	Associate Professor	Ice core climatology
Lionel Carter	Professor	Ocean history and processes
Ruzica Dadic	Research Fellow	Snow and ice processes
Warren Dickinson	Senior Research Fellow	Sedimentary petrology and geochemistry
Gavin Dunbar	Senior Research Fellow	Sedimentary geology and geochemistry
Nick Golledge	Senior Research Fellow	Ice sheet modelling
Huw Horgan	Senior Lecturer	Glacial geophysics
Rob McKay	Senior Lecturer	Stratigraphy and sedimentology
Dan Zwartz	Research Fellow	Antarctic ice sheets and sea-level

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Darcy Mandeno	Operations and Field Engineer

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Shannon Digby	Administrator

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Mike McWilliams, GNS Science
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Prue Williams, Ministry of Business, Innovation & Employment

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GRADUATE STUDENTS

Lana Cohen *	PhD	Ice core climatology
Jesse-Lee Dimech	PhD	Geophysics
Bella Duncan	PhD	Paleoceanography
Shaun Eaves	PhD	Glacial geology
Daniel Emanuelsson	PhD	Ice core climatology
Aitana Forcen Vasquez	PhD	Physical oceanography
Pablo Iribarren Anacona	PhD	Glaciology
Richard Jones	PhD	Glacial geology
Peter Neff	PhD	Ice core climatology
Kristina Pascher	PhD	Paleoclimatology
Molly Patterson *	PhD	Sedimentology
Heidi Roop	PhD	Sedimentology
Matt Ryan	PhD	Quaternary climatology
Katrin Sattler *	PhD	Geomorphology
Andrea Tuohy	PhD	Ice core climatology
Amy Plant *	MSc	Paleoceanography
Juliet Sefton	MSc	Paleoclimatology
Rory Hart *	MSc	Geophysical glaciology

*thesis submitted in 2014

ASSOCIATED RESEARCHERS

Cliff Atkins	Senior Lecturer in Earth Sciences	Sedimentary processes and environments
Michael Hannah	Associate Professor in Earth Sciences	Marine palynology
Kevin Norton	Senior Lecturer in Geography	Geomorphology and geochemistry
Rebecca Priestley	Senior Lecturer - Science in Context	Antarctic science history
James Renwick	Professor in Physical Geography	Atmospheric circulation
Tim Stern	Professor in Geophysics	Solid earth geophysics and Transantarctic Mts

OTHER VUW ACADEMICS WITH ANTARCTIC INTERESTS

David Frame	Professor of Climate Change	Climate policy and future climate change
Margaret Harper	Research Associate in Geology	Freshwater algae
Malcolm Ingham	Senior Lecturer in Physics	Properties of sea ice
Mark McGuinness	Reader in Mathematics	Modelling
Joanna Mossop	Senior Lecturer in Law	International law
Nigel Roberts	Adjunct Professor of Political Science	Antarctic politics and history
Ken Ryan	Associate Professor in Antarctic Biology	Marine algae
Rhian Salmon	Senior Lecturer - Science in Context	Science communication
Ross Stevens	Senior Lecturer in Industrial Design	Design of remote field camps
Joe Trodahl	Emeritus Professor in Physics	Temperature conduction in ice and rock
Cath Wallace	Teaching Fellow in Environmental Economics	Antarctic environmental issues

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Cover photo: Sea ice in Terra Nova Bay, Antarctica - Photo: Gavin Dunbar

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