TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

Antarctic Research Centre

ANNUAL REVIEW 2013

DIRECTOR'S SUMMARY

Digging out the food storage cave, RICE Camp at Roosevelt Island, Antarctica - Photo: Darcy Mandeno

Although 2013 began with a budgetary challenge – which was to find new revenue to offset the loss of the Ministry of Business Innovation and Employment (MBIE) ANZICE Programme – it stands out as one of the Antarctic Research Centre's (ARC) most successful years, especially in terms of research outcomes. Peer-reviewed scientific publications reached an all-time record of 47 and included publications in leading journals such as *Nature* (1), *Nature Geoscience* (3), *Proceedings of the National Academy of Sciences*, *Geology*, *Quaternary Science Reviews*, *Geophysical Research Letters*, *Journal of Geophysical Research* and *Paleoceanography*.

A major milestone has been the publication of the Intergovernmental Panel on Climate Change's 5th Assessment Report, *Climate Change 213: The Scientific Basis*. The contribution of Victoria University's three lead authors, including myself, to this 5-6 yearly authoritative update of past, present and projected climate change and its relevance to policymakers, is featured in this review. Over the last four years, I contributed to Chapter 5 "Information from Paleoclimate Archives". While time-consuming, it has been a privilege to work and collaborate with some of the world's leading climate researchers. I have been intellectually-stimulated by this opportunity, and gained an enormous appreciation for how our research contributes to "policy-relevant" science questions, and believe this has benefited the research focus of the ARC. On the research funding front, a major achievement was the award of three new Marsden Fund projects to ARC researchers Ruzica Dadic, Huw Horgan, and I. Gavin Dunbar was also successful as co-PI on a proposal led by our close collaborator at GNS Science, Richard Levy. I am extremely proud of the quality of the young and early career researchers we have developed and mentored within the ARC family. Rob McKay was one of three Victoria University researchers to receive a 2013 Rutherford Discovery Fellowship, adding to the Rutherford Discovery success Nancy Bertler celebrated two years ago. Over the last 10 years seven of the ARC's young scientists have received Marsden Fast-Start Awards (Huw Horgan, Ruzica Dadic, Nick Golledge, Brian Anderson, Andrew Mackintosh, Gavin Dunbar, and Nancy Bertler). Some are not so young anymore, but all have gone onto permanent research positions in New Zealand.

On that note I would like to recognise and welcome the following new staff positions. Andrew Mackintosh brings valuable support to the leadership as newly-appointed Deputy Director. Nancy Bertler was promoted to Associate Professor, Rob McKay was promoted to Senior Lecturer, Nick Golledge and Ruzica Dadic take up permanent positions as Senior Research Fellow and Research Fellow, respectively. Half of Nick's time is shared with GNS Science. Our 21 postgraduate students are the heart and soul of the ARC, providing vitality, intellectual stimulation and horsepower to our research. It's great to see that a large number of our postgraduate students are from overseas and most of our students are co-supervised by staff at NIWA, GNS Science and the School of Geography, Environment and Earth Sciences (SGEES). This leads to a wonderful cross-fertilisation of cultures, resources and ideas. We acknowledge in this review submission of three research theses and welcome new research students.

We outline how our integrated paleoclimate, modern process and numerical modelling approach has provided some fundamental insights into the response of ice sheets, glaciers, oceans and the climate system to global warming, and how that knowledge is transferred to practitioners, the public and policymakers. Like last year we describe some highlights from the Antarctic Geology, Ice Core, Oceans and Lakes, and Glaciology and Modelling teams who all utilize this research approach.

The ARC group remains very committed to science communication through public outreach and advice to government officials and policymakers as well as the delivery of relevant outcomes for end-users, such as other science providers, local authorities, government agencies, industry, and international Antarctic and climate change stakeholders. I am always impressed by the skill and enthusiasm, not to mention the time and energy, our researchers put into communication and outreach. In this review we outline an impressive array of TV, print and radio media, public lectures, school visits and outreach events undertaken by ARC staff and students this year.

A highlight of public outreach was the global launch on Earth Day (22 April) of the film, *Thin Ice: The Inside Story of Climate Science*, in at least 120 countries and on all seven continents, with over 200 organised screenings and 19,000 online views. This initiative, championed by Peter Barrett, involves a collaboration between Victoria University of Wellington, the University of Oxford and DOX Productions, London, was over six years in the making, and takes a fresh look at the changes taking place in the Earth's atmosphere, oceans and ice sheets. The documentary gives the public a rare opportunity to see climate scientists at work, talking about what they do, and their hopes and fears. The film has already received international acclaim being accepted and winning awards at documentary film competitions. The films Victoria University based director, Simon Lamb (SGEES), was recognised with the 2013 Science Communicators Award, by the New Zealand Association of Scientists.

The Antarctic research funding space in New Zealand has been dynamic and constantly evolving throughout 2013 with the newly-formed, New Zealand Antarctic Research Institute (NZARI) running two funding rounds to allocate much-needed new support from philanthropic sources. The ARC was also heavily involved in developing proposals for the "Deep South" National Science Challenge, led by NZARI, and the "Ed Hillary Centre of Research Excellence (CoRE) in Antarctic and Southern Hemisphere Change". While in early 2014 we found out we were unsuccessful in making the CoRE short-list, the plan developed by the ARC and its national (Joint Antarctic Research Institute; JARI) and international partners was a valuable exercise, and will be a template for future research prioritisation and collaboration. The shape of the Deep South Challenge will continue to evolve in 2014.

With the loss of ~$400,000 p.a. from the end of the MBIE (predecessor) ANZICE Programme to be absorbed into our Centre budget, the University generously approved a $170,000 deficit budget target. Through tight fiscal management and new revenue during the year (e.g. NZARI funding success and extension of the MBIE Past Antarctic Climates Programme) our end of year result was a creditable $92,000 deficit – representing a claw-back of $78,000. The 2014 budget remains tight, but with the addition of new Marsden and Rutherford funding the short-term prognosis remains good. A major wild-card for our future sustainability remains the future of the MBIE Past Antarctic Climates Programme, which faces a strategic review in 2014.

So finally, with the latest IPCC Report highlighting the large uncertainties that still exist in the response of the southern high-latitudes and the Antarctic ice sheets to projected global climate change, our mission is as vital as ever. I wish to acknowledge the outstanding effort of our staff and students, who together with our partners and collaborators, continue to produce high-quality, world-class excellent research within a challenging and constantly evolving New Zealand science and innovation sector.

Professor Tim Naish
Director, Antarctic Research Centre

OUR MISSION AND RESEARCH APPROACH

Contents

Upper Tasman Glacier, New Zealand - Photo: Huw Horgan

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 this field 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 Pro-Vice-Chancellor of the Faculty. It is co-located within 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. 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).

e. 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.

ICE SHEETS HATE WATER

An iceberg viewed during IODP Expedition 318 - Photo: Rob McKay

Confirmation that major parts of the Antarctic ice sheet, equivalent to 22 m of global sea-level rise, lie below sea-level and are vulnerable to a warming ocean is focussing ARC research efforts on past East Antarctic Ice Sheet–ocean interactions.

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

The Sleeping Giant

Much of the ARC's geological research over the past decade has focussed on the West Antarctic Ice Sheet in the Ross Embayment, in particular the results from the ANDRILL Program. In the last couple of years our attention has turned to the much larger East Antarctic Ice Sheet (EAIS), equivalent to ~53 m of sea level if it were all to melt. While such a scenario is unlikely in the foreseeable future, approximately 19 m of this is grounded below sea-level, making it potentially sensitive to melting as ocean temperatures warm.

The Integrated Ocean Drilling Program (IODP) Expedition 318 to Wilkes Land in East Antarctica in 2010 was the first visit by IODP to the Antarctic for a decade, and drilled offshore of the largest sector of the EAIS that is grounded below sea level. One of the longest running debates in Antarctic geosciences concerns the relative stablity of the EAIS during the Pliocene epoch, 5-3 million years ago, a debate that the ARC's Peter Barrett has been at the centre of for much of his career. During this time, global temperatures were 2-3°C higher than today and atmospheric carbon dioxide was ~400 ppm, thus providing an insight into ice sheet response to similar climates predicted for the future.

Rob McKay, PhD student Molly Patterson, and a team led by Cary Cook (Imperial College London) published a study in *Nature Geoscience* investigating marine mud deposited offshore of East Antarctica during the Pliocene. Geochemical fingerprinting indicated that this mud was eroded from rocks currently hidden under the ice sheet and could only be eroded by an ice sheet that had retreated inland. They concluded that combined with the loss of the smaller West Antarctic and Greenland ice sheets this retreat resulted in sea-level rises of ~20 m above present-day levels.

Rob was also involved in another IODP Expedition 318 study published in *Proceedings of the National Academy of Sciences*, led by Peter Bijl (Utrecht University), examining the causes of global cooling and ice sheet development in Antarctica following a period of extreme greenhouse gas concentrations in the atmosphere (600-1000 ppm). Following this extreme greenhouse world in the mid Eocene, at about 48 million years ago, a period of cooling was reconstructed from the analyses on fossil algae and organic biomarker proxies. These showed that surface waters and Antarctic air temperatures began to cool as the southern margin of Australia began a major phase of separation from the Antarctic, and this event helped terminate global warmth during the early-mid Eocene hothouse, and ultimately this cooling gave rise to the development of continental-scale glaciations on Antarctica by the end of the Eocene.

Community-Based Review of the Antarctic Ice Sheet Since the Last Great Ice Age

Several ARC staff and students have played a key role in a series of review papers in the journal *Quaternary Science Reviews* as part of a collective effort by the Antarctic Climate Evolution (ACE) Programme of the Scientific Committee for Antarctic Research. These papers outlined the present state of knowledge from the Antarctic geological community regarding the extent and retreat of the Antarctic ice sheets since the last ice age. The retreat of these ice sheets is the largest climatic event the earth has experienced in the past 18,000 years, yet identifying the key mechanisms that led to this event, that saw sea-levels rise by 120 m at an average rate of 1 m per century, is hampered by a lack of good chronological data of ice sheet extent and retreat.

Andrew Mackintosh led a group of 23 international researchers (including four other ARC staff and students) in a review of the East Antarctic Ice Sheet retreat since this ice age. This evidence suggested the majority of ice sheet retreat at the marine margin of this ice sheet occurred after 12,000 years ago, coinciding with warming of the Southern Ocean adjacent to the ice sheet. Despite this conclusion, there remain large uncertainties on these ages, and Andrew's review emphasized the sparse nature of these key datasets, and the complete lack of data from large regions of East Antarctica. Rob was also involved in a similar review of the Ross Sea sector of the West Antarctic Ice Sheet, led by John Anderson (Rice University).

An Eye to the Future

On average it takes a decade to get a new drilling project from the planning phase to have drill core in hand. This year has been busy one for proposal writing, as we attempt to start an ambitious new wave of drilling projects in the Ross Sea and beyond. Proposals for the next phase of ANDRILL drilling at Coulman High have been submitted by adjunct researcher Richard Levy (GNS Science) and Tim Naish to recover a geological history of Eocene greenhouse climates, and the transition to the first ice sheets in Antarctica.

Meanwhile, Rob led a IODP proposal to drill a transect of cores in the Eastern Ross Sea, following on from the Deep Sea Drilling Project Leg 28 in 1973 in this region - Peter Barrett's first involvement in geological drilling in Antarctica.

Finally, Tim had Marsden Fund success with his proposal to drill two sediment cores from the Wanganui Basin, with the aim to identify the amplitude of sea-level variability associated with Antarctic ice sheet retreat during the warm Pliocene ~3 million years ago, with drilling scheduled for mid-2014.

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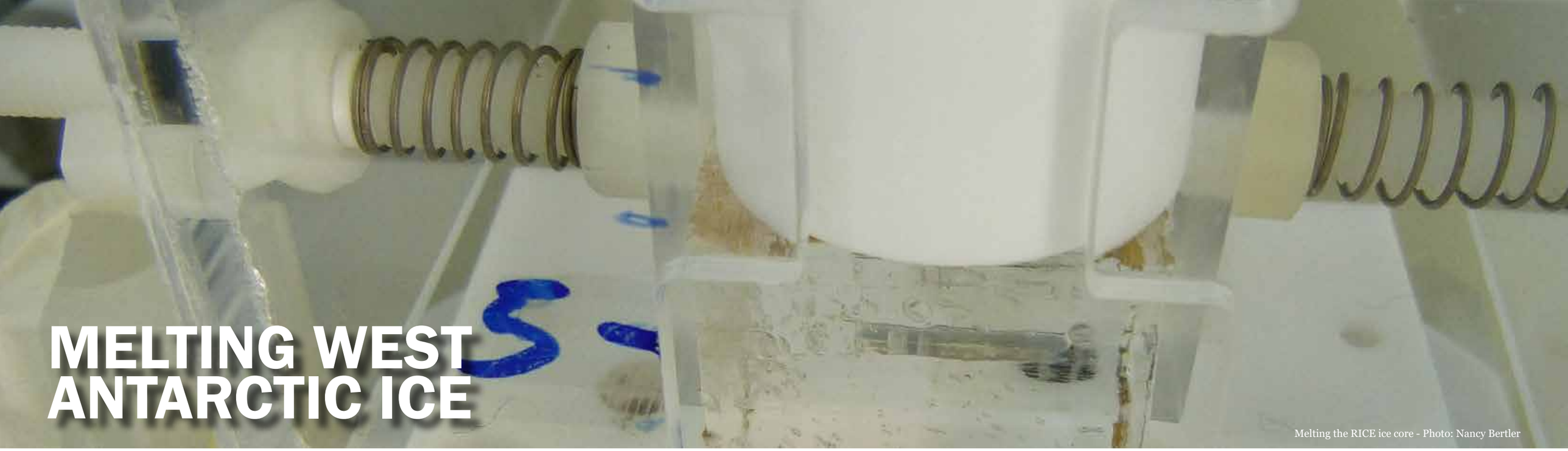
MELTING WEST ANTARCTIC ICE



Melting the RICE ice core - Photo: Nancy Bertler

After the successful recovery of the 763 m deep Roosevelt Island Climate Evolution (RICE) ice core during the 2012/13 Antarctic field season, 2013 was dedicated to processing and analysing the precious ice.

From May to August, the ice core group's international collaborators descended on the New Zealand National Ice Core Facility at GNS Science. The 27 staff and students from 12 nations participated in the core processing campaign. Using a new combination of Danish, New Zealand, Australian and US components, the RICE continuous melt system was set-up, including seven continuous flow instruments analysing the RICE core in real time as the core melted. The exceptionally high-resolution, continuous flow records include measurements from; the melted water of the ice (water isotope ratios, black carbon and calcium concentrations, pH and conductivity variations), the gas bubbles (methane and carbon monoxide concentrations) and dust (quantity and grain size characteristics). In addition, over 30,000 discrete samples were collected in ultra clean vials for geochemical analyses, and the first 1,000 discrete ice samples were also cut.

Reaching Breaking Point

The teams processed the ice with great success and ahead of schedule, feeling optimistic that the core processing would be completed. However, this was not to be. In every ice sheet exists a zone of brittle ice. Here the gas bubble pressure and the ice crystal characteristics create highly stressed ice which fractures easily when drilled or processed and can disintegrate into mere rubble when handled. The New Zealand ice core drilling system achieved exceptionally high core quality through the brittle ice zone, however, as the core processing teams cut the ice from 500 m depth, the ice started to explode. The team tried various approaches with limited success, watching on as precious ice cracked and fractured, rendering core sections unsuitable for high resolution, continuous flow analysis. At 512 m, Nancy Bertler, RICE Chief Scientist, decided to stop the processing to allow the ice to relax. The consensus was that this would be best achieved by resting the ice for one year at warmer temperatures of -18°C. From April to July 2014, the international core processing teams will convene again in New Zealand to complete the core processing.

Diary of an Ice Core Processor

Our PhD students were critical to the success of this operation and took on important responsibilities. Peter Neff, who has extensive prior experience with ice core processing led the core cutting team in the freezer, spending 8-10 hours/day at -18°C with a team of 3-5 staff. Here, each metre was cut into seven parallel, 1 m long sections – allocations for nine nations and over 50 planned measurements. The cleanly cut planes provided an ideal surface to measure electric conductivity, which provided the first glimpse at the age of the ice by detecting past volcanic eruptions and large climatic transitions. The core stratigraphy was logged at the same time and the team found five ash layers, providing valuable, independent age benchmarks.

Daniel Emanuelsson together with Troy Baisden (GNS Science) developed the continuous flow Los Gatos laser absorption spectroscopy analyzer for measuring stable water isotopes and achieving the fastest published response time of any such instruments. This is important as a fast response time permits a higher resolution analysis. During the core processing campaign, Daniel led the night shift team operating the seven continuous flow instruments and collecting large numbers of discrete samples.

Andrea Tuohy set-up the Element II ICP-MS instrument at the Victoria University Geochemistry Laboratory for ultra low concentration measurements pushing the limits of analytical chemistry and spending many hours searching for higher sensitivity to detect ever lower contaminant levels. It was essential to monitor contamination levels before and during the core processing to guarantee ultra clean conditions were maintained, as some elements are measured at concentration levels of parts per quadrillion. In addition, Andrea and Rebecca Pyne (GNS Science) led the discrete sampling logistics of collecting and registering over 30,000 samples and ensuring their integrity for geochemical analysis.

Peeking into the Treasure Chest

The RICE records will provide food for thought for many years to come. However, first emerging records already excite the RICE team. At the conclusion of the processing campaign, the RICE Science team met at GNS Science for the Third International RICE Workshop to share first data and discuss future steps. Because of its location at the northern edge of the Ross Ice Shelf, the ice is expected to be a sensitive recorder of the Ross Ice Shelf retreat history when Antarctica warmed after the last ice age. This record will allow us to determine the sensitivity of the ice shelf to ocean warming along with changes in atmospheric circulation and sea ice cover, which will help to improve future projections of the potential collapse of the Ross Ice Shelf and thus West Antarctica. An initial annual layer count of geochemical tracers as well as a first interpretation of volcanic markers in the record provided a means to constrain the age model developed by T.J. Fudge (University of Washington) and others. The refined age model suggests that the entire RICE core provides a high resolution record of the deglaciation history in the Ross Sea region and a lower resolution record extending back to >60,000 years and perhaps beyond.

RICE Team: B.Alloway, T.Baisden, T.Beers, H.Berge, N.Bertler, T.Blunier, D.Bowden, E.Brook, S.Canessa, C.Cary, G.Ciobanu, D.Clemens-Sewall, H.Conway, C.Cunde, R.Dadic, D.Dahl-Jensen, N.Dunbar, B.Delmonte, R.Edwards, A.Ellis, D.Emanuelsson, W.Feitang, J.Fitzpatrick, TJ.Fudge, A.Giese, V.Gkinis, I.Goodwin, M.Grant, S.Haines, M.Hansson, B.Hawley, M.Hendley, R.Hindmarsh, Y.Jiao, J.Kaiser, D.Kalteyer, L.Keller, S.Kipfstuhl, H.Kjaer, E.Korotkikh, A.Kurbatov, L.Lanci, J.Lee, V.Maggi, D.Mandeno, S.Mawdesley, P.Mayewski, R.McKay, A.Menking, U.Morgenstern, P.Neff, S.Phipps, B.Proemse, A.Pyne, R.Pyne, J.Rawson, E.Saltzmann, R.Scherer, S.Semper, J.Severinghaus, W.Shimeng, S.Sneed, E.Steig, A.Tuohy, F.Valero-Delgado, P.Vallalonga, E.Waddington, J.West, H.Winton, D.Zhang

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

BENEATH THE WAVES

Seas and passing squall off Riversdale, Wairarapa, New Zealand - Photo: Lionel Carter

Considering that water covers more than 70% of Earth's surface, the roles played by lakes and oceans are pivotal to determining how the planet will respond to future change.

Studies of lake and marine sediments identify how environments behaved under past warm periods and hence reveal the natural cycles of change as well as the long-term effects of warming. That information, coupled with knowledge of the physical and biological processes that affect the modern world, greatly enhance our ability to predict the future. In that light, the ARC's lake-ocean group, in close collaboration with New Zealand and international colleagues, is making marked progress in determining how the New Zealand environment "ticks" under polar to subtropical climatic influences.

Fertilising the Antarctic Ocean

An outstanding natural feature of the Ross Sea is the seasonal blooming of plankton. For a few weeks over summer this region is one of the most biologically productive in the world. A possible trigger for these blooms is the introduction of iron-rich dust deposited in the ocean as sea ice melts. MSc student Jane Chewings completed a research paper in *Sedimentology* (2014) on the quantities of dust blown onto the sea ice each year. Former MSc student Holly Winton extended that analysis, by assessing the potential of this dust to "fertilize" the Ross Sea with iron (in review in *Global Biogeochemical Cycles*). While the sea ice appears dust-strewn, there was not enough material to be the main source of iron fertiliser. The answer must be elsewhere – perhaps in the upwelling of deep, nutrient-rich ocean waters across the Antarctic margin.

Polar and Tropical Forcing of New Zealand

New Zealand's highly variable climate and ocean reflect the interaction of Antarctic and tropical forces, which vary markedly in time and space. A study of the SW Pacific Ocean involving Gavin Dunbar and Lionel Carter (Cortese *et al.*, *Paleoceanography*) revealed that during the last major warm period, 125,000 years ago, the tropics expanded south to bring about major changes in ocean currents and the production of plankton. Subtropical currents strengthened to Tasmania and caused the existing trans-Tasman flow to transport more warm water to southernmost New Zealand. This raised ocean surface temperatures on Campbell Plateau by 2°C and more. Bella Duncan's MSc research on the plateau sediments reveals a shift in plankton; from animal-dominant to plant-dominant communities. That shift has potential implications for the marine food chain and the biological influences on the uptake/release of carbon dioxide.

Using pollen preserved in cores from the Tasman Sea, PhD student Matt Ryan is assessing patterns of vegetation during another warm period 440,000 years ago. At that time, dominant forest trees like rimu seem to have exceeded their optimum growth temperature and thus the forest was quite different to today. Former PhD student Joe Prebble assessed past warm periods using the organic remains of minute marine plankton called dinoflagellates. This research required considerable development to determine if these plankton could be used as proxies for past environmental conditions. The results, published as two papers in *Marine Micropaleontology*, confirm that dinoflagellate remains can provide information on ocean surface temperatures, plankton productivity and water masses - findings that are now being applied to earlier warm periods. Another development and application of proxies for past ocean change are the trace element signatures preserved in the calcium carbonate shells of planktonic foraminifera. Julene Marr used elements such as magnesium, manganese and zinc to identify variations in ocean surface temperatures and water mass characteristics off Hawke Bay since the last ice age, ~20,000 years ago. Results from her PhD, published in *Paleoceanography* and *Chemical Geology*, identify dominant sub-Antarctic influences in cold periods and strong subtropical influences in warm phases.

Knowledge of the climate and oceanographic mechanisms that bring about past change is underpinned by studies of modern ocean and climate as undertaken by former MSc student Denise Fernandez. Her thesis-derived paper in the *Journal of Geophysical Research* (2014), confirms a strengthening of the subtropics in a warmer world - in this case the present phase of warming. Observations spanning two decades reveal a more vigorous and warmer inflow of subtropical water off eastern New Zealand that is consistent with an observed intensification of regional winds.

Lakes - A View of Past Weather and Climate

Lake Ohau, in the South Island, has thousands of years worth of finely layered sediments with each layer probably representing one year of sedimentation. This was confirmed by PhD student Heidi Roop, who further revealed the layers vary in response to seasonal variations in climate (paper in review in *Sedimentology*). The present sediment record extends back ~2000-1200 years and enables detection of hydrologic change at sub-decadal and possibly annual scales that currently indicate a strong relationship between sedimentation, decreasing precipitation and persistent change in the flow of westerly winds.

The recent award of a Marsden grant to project leaders, Richard Levy (GNS Science), and Gavin will extend the investigation back to the last ~17,000 years. This will be achieved by coring through the 70-100 m-thick sediment cover to the underlying lake floor. This sediment has accumulated since glaciers last occupied the lake. Because of the detail in this record, it will provide a much-needed insight into the interactions of the polar-sourced Southern Annular Mode (SAM) and tropical-sourced El-Niño-Southern Oscillation (ENSO) - both major drivers of New Zealand's winds, rainfall, and air temperature.

Lake Tutira, North Island is also providing detailed insights into polar-tropical forcing and their impact on climate, but this time from a central North Island perspective (Gomez *et al.*, *The Holocene*). Despite its northerly position, Lake Tutira still feels the influence of Antarctica via SAM, which interacts with ENSO to regulate rainfall and storminess - the intensity of which depends on whether SAM and ENSO are in or out of phase. That phasing has varied with time and appears to be superimposed on a long-term intensification of the Southern Hemisphere westerly winds.

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ICE SHEETS AND MOUNTAIN GLACIERS IN A WARMING WORLD

Calving of the Tasman Glacier, New Zealand - Photo: Brian Anderson

Understanding the present, modelling the past and predicting the future of glaciers and ice sheets: the ARC glaciology group has come of age.

2013 was an important year for the glaciology group. The award of Marsden Fast-Start grants to Ruzica Dadic and Huw Horgan means that every member (Andrew Mackinstosh, Brian Anderson, Nick Golledge, and Ruzica and Huw) has now secured a Marsden grant. This provides the autonomy to follow our own intellectual paths – while remaining part of a group with the purpose of understanding the response of glaciers and ice sheets to changing climate.

Dramatic Retreat of New Zealand Glaciers

Thousands of tourists used to walk directly onto Franz Josef Glacier each year. Dramatic glacier retreat in the last 18 months has now made this impractical. As a consequence, Brian Anderson has switched from direct mass balance measurement to monitoring of these changes by remote camera and GPS. There are now five cameras at Franz Josef, Tasman and Fox glaciers, which have collected around 25,000 images, while GPS stations provide insight into ice dynamics including basal lubrication and iceberg calving. Using this data, and the results of a new gravity survey of Tasman Glacier by MSc student Rory Hart, Brian's computer modelling indicates that the effect of warming is so pervasive that iconic New Zealand glaciers will be unrecognisable remnants high in the mountains by the end of this century – see 'Keeping it Pure' (http://www.primetv.co.nz/Default.aspx?tabid=362).

Modelling Antarctic Ice-Ocean Interactions

Over the last year Nick Golledge has continued to refine his simulations of the Antarctic ice sheet, focusing on the time period from the Last Glacial Maximum (~20,000 years ago) through to the present-day. Nick uses a sophisticated ice sheet model jointly developed by a NASA-funded team in Fairbanks, Alaska, and the Potsdam Institute for Climate Impact Research. By comparing high-resolution simulations with geological data his experiments have shown that transient changes in the ice sheet might be responsible for many of the details seen in the geological record, findings that were recently published in *Quaternary Science Reviews*. More recently, he has been running this model with outputs from palaeoclimate model simulations from researchers at University of New South Wales, Australia, and has found that a threshold may exist in the way that the Antarctic ice sheet interacts with its surrounding ocean. If Antarctic ice melts fast enough, it has the potential to disrupt circulation patterns in the Southern Ocean, which we know from paleo-proxy records has significant ramifications for New Zealand's climate.

Discovery of an Estuary Beneath the West Antarctic Ice Sheet

In September, Huw Horgan published the results of an active-source seismic survey on Whillans Ice Stream in West Antarctica, in the journal *Geology*. This survey, carried out as part of the WISSARD programme (http://www.wissard.org), provided the first observational evidence that estuaries occur at the grounding lines of modern ice sheets. Estuaries are important as they provide a pathway for warm ocean water to migrate up-glacier, and concentrate the drainage of subglacial melt water emptying into the sub ice-shelf cavity. Estuaries may be widespread beneath ice sheets, especially in regions with low surface gradients and abundant subglacial melting. Huw's Marsden Fast-Start grant will continue this work.

Antarctic Blue Ice Provides Insight into 'Snowball Earth'

According to the 'Snowball Earth' hypothesis, most of the oceans were repeatedly covered by ice during Earth's early history (2.45–2.22 billion and 580-730 million years ago). Tropical glaciation must have been facilitated by a run-away albedo feedback, where the growth of thick ice covering the sea (known as 'sea glaciers') reflected progressively more incoming solar radiation to space, encouraging further ice build-up. The problem is that tropical sea glaciers were unlikely to have been snow covered, and most Earth analogues (e.g. the ablation zones of temperate glaciers) are too dark, and couldn't have caused this feedback. Ruzica Dadic used very cold, sublimating blue ice in the Transantarctic Mountains, Antarctica as an analogue for explaining how ancient ice may have formed at the Equator, publishing her results in *Journal of Geophysical Research*. Ruzica will now switch to air bubbles within ice cores in her new Marsden Fast-Start project, in collaboration with Nancy Bertler and Richard Alley (The Pennsylvania State University).

The Last Deglaciation in Antarctica and New Zealand

Two PhD students are making exciting progress in understanding how glaciers responded to the last great warming event on Earth – between the Last Glacial Maximum and the present day. Richard Jones has been working on the Mackay Glacier, at the northern end of the McMurdo Dry Valleys. Richard's new 10Be ages have the promise of being one of the finest datasets from Antarctica, showing how the enormous East Antarctic Ice Sheet and adjacent grounded ice in the Ross Sea responded.

Meanwhile, Shaun Eaves has provided the first chronology of past glacier fluctuations on the volcanoes of the central North Island. By working with Gisela Winkler and Joerg Schaefer (Lamont Doherty Earth Observatory), Shaun has shown that Mt Ruapehu and Tongariro were last covered by extensive glaciers during Marine Isotope Stage 4 (~65,000 years ago), the Last Glacial Maximum and around the time of the Antarctic Cold Reversal (~13,000 years ago). Along with the glacier model that he has developed with Brian, Shaun's work has potential to significantly advance our understanding of ice ages in the Southern Hemisphere.

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Lamont-Doherty Observatory (USA)
Los Alamos National Laboratory (USA)
Memorial University of Newfoundland (Canada)
NIWA
Potsdam Institute for Climate Impact Research (Germany)
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)

DRILL BABY, DRILL

Loading the Basler, Roosevelt Island, Antarctica - Photo: Jodie Curtis (Antarctica New Zealand)

Drill baby, drill!... seems to be the catchphrase for the ever in demand duo at the Science Drilling Office as new scientific drilling projects are funded.

The Science Drilling Office (SDO) is hosted in the Antarctic Research Centre and comprises Alex Pyne as the Projects Manager and Darcy Mandeno as the Operations and Field Engineer. The duo provide a technical focus and support for drilling related research undertaken by ARC members.

Taking care of business in Antarctica

A significant part of Darcy Mandeno's 2013 year involved the detailed planning then leadership of the field team for the recovery of all the Victoria University RICE drill system and Antarctica New Zealand camp infrastructure from Roosevelt Island. This was a major logistic effort supported by Antarctica New Zealand and the US Antarctic Program (USAP), with planning that involved the air assets of the 109th New York Air National Guard's LC 130s and Kenn Borek's Basler BT-67s.

The season start and deployment to Scott Base was delayed two weeks due to the U.S. Government shutdown in September and early October then further delays deploying to Roosevelt Island from Scott Base due to bad weather. Ultimately the silver lining to the U.S. Government shutdown was the increased availability of aircraft assets due to the unfortunate cancellation and reduction of several high profile USAP field operations in Antarctica, resulting in all the equipment removed from Roosevelt Island in two and a half weeks. Excellent field support from staff from Antarctica New Zealand and the Christchurch based Harewood air movements operations air cargo handlers of the Royal New Zealand Air Force, contributed to the ultimately successful season.

In total approximately 30 tonnes of equipment was returned to Scott Base, much of which was scheduled to return to Wellington in containers on the 2014 resupply ship operations. However, a storm at McMurdo in mid February 2014 damaged the ice pier during ship on-load operations, requiring the ship to leave early and consequently the equipment will now be delayed until main body flights in October 2014 and the next ship operations in February 2015.

RICE field science objectives were also successfully achieved by our USAP RICE collaborators including borehole logging, with assistance from the New Zealand engineering/logistics team, when required.

Alex Pyne also went to Antarctica for nearly three weeks and was based at Scott Base, receiving equipment from Roosevelt Island and preparing this for return to New Zealand. In addition while at Scott Base an assessment of ANDRILL equipment stored at Williams Field was made for the future planning of Coulman High as well as supervising the re-berming of this equipment by Scott Base's Army heavy plant operators. The final job was to prepare Scott Base staff led by Kate McKenzie (Antarctica New Zealand) to recover the Evans Piedmont Automatic Weather Station which hadn't been serviced for three seasons.

Business Abroad

Alex was invited to speak at the Fourth International Symposium on Polar Earth Sciences and exploration in Changchun China in May and presented a paper on ANDRILL Drilling Technology. He also presented a technical presentation on ice coring at Roosevelt Island to the Strategic Science in Antarctica Conference held in Hobart in June.

Alex, Darcy, and PhD student Peter Neff also attended the 7th International Symposium on Ice Drilling in Madison, USA presenting papers on Roosevelt Drilling and Logistics and Peter presented posters on both brittle ice core processing and also drilling at Mt Waddington (British Columbia) which he previously worked on as a student at Washington State University in Seattle.

Minding the Home Front

Several other projects continued to keep the Science Drilling Office team busy in New Zealand. The Roosevelt Island ice core processing was a major science effort in Wellington and Darcy was involved in the design of new equipment and the processing of the ice core at the New Zealand National Ice Core Facility at GNS Science during May-July.

ANDRILL drilling at Coulman High remains on our radar and in preparation for a further science proposal planned for submission in early 2014 Alex provided updated technical budgets for incorporation into a US National Science Fund bid.

Drilling the Alpine Fault on New Zealand's West Coast will be a major scientific effort in 2014 and Alex has been assisting Rupert Sutherland (GNS Science) to develop the technical drilling requirements, drilling contractor assessments and the tender process to engage a drilling contractor.

While in Antarctica, Alex also checked the ANDRILL soft sediment equipment requested for coring Lake Ohau in New Zealand's South Island. This new Marsden funded project is likely to be drilled in early 2015 and a new job for the Science Drilling Office. These projects plus Marsden funded drilling in the Wanganui Basin promises to make 2014-15 another busy year for the Science Drilling Office.

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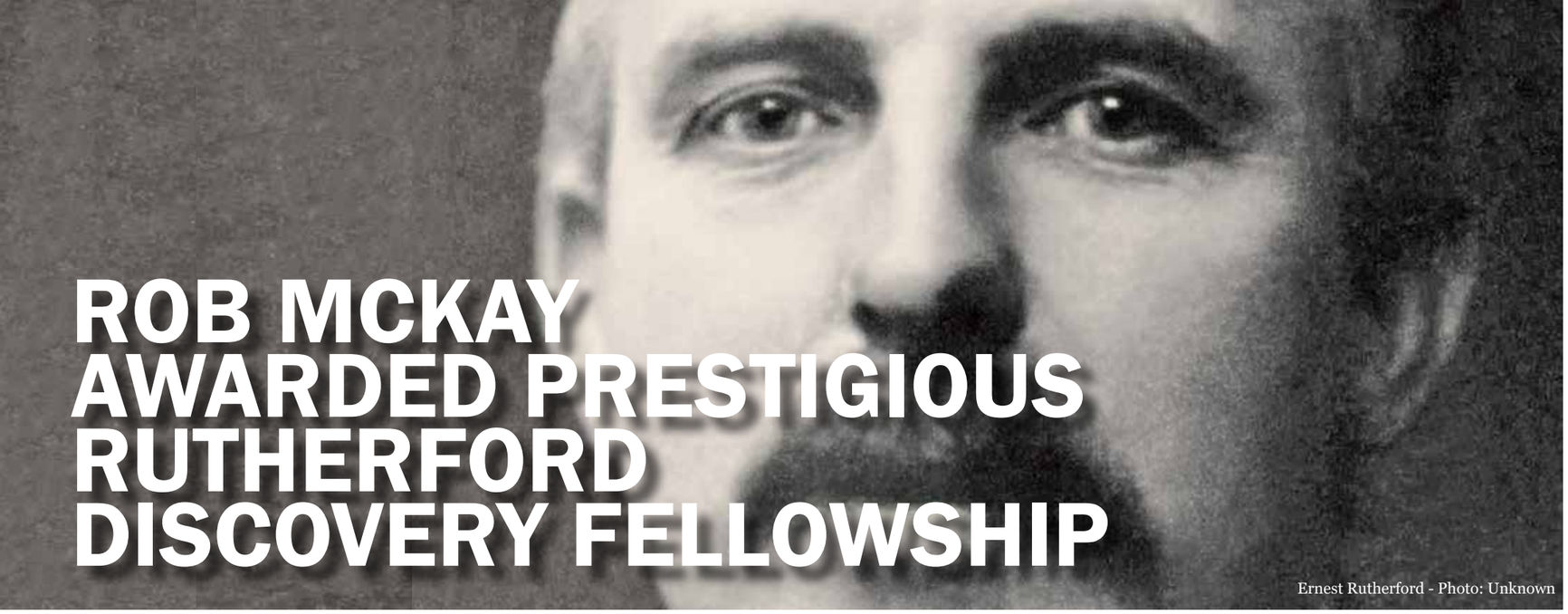
COLLABORATORS:
Antarctica New Zealand
GNS Science
Webster Drilling & Exploration Ltd.



ROB MCKAY AWARDED PRESTIGIOUS RUTHERFORD DISCOVERY FELLOWSHIP

Ernest Rutherford - Photo: Unknown

Rob McKay was one of three Victoria University researchers to receive a 2013 Rutherford Discovery Fellowship. On top of Nancy Bertler's success two years ago the ARC now hosts two Rutherford Discovery Fellows.

Rob McKay, recently promoted to Senior Lecturer in the Antarctic Research Centre, is emerging as one of the world's top glacial sedimentologists, and his research into past environmental change in Antarctica won him the 2011 Prime Minister's MacDiarmid Emerging Scientist Prize. He has made several trips to Antarctica, gathering marine sedimentary records and glacial deposits to reconstruct episodes of melting and cooling in Antarctica over millions of years.

The Rutherford Discovery Fellowship will enable Rob to conduct an in-depth study into how the Antarctic ice sheet and the Southern Ocean has interacted over the past 23 million years, with particular reference to how New Zealand's climate is likely to be affected in the future by greenhouse gas emissions. As Rob points out, the consequences of Antarctic warming are more far-reaching than sea level rise alone: changes in the Southern Ocean sea ice belt around Antarctica would affect the primary plankton productivity in the Southern Ocean.

Just as critical, is that warming of the Antarctic weakens the temperature gradient between the poles and equators, as this changes the location and strength of the westerly winds that pass over the Southern Ocean and New Zealand latitudes. These winds help drive global ocean circulation, and regulate the relative location where Antarctic and tropical-sourced water masses meet. These waters currently meet in the latitude of New Zealand, and as we have a strongly maritime-influenced climate, changes in the Southern Ocean and Antarctica will have a profound impact on our climate.

Rob comments that "there are still numerous first order gaps in our knowledge of how Antarctica and the Southern Ocean have responded during warmer-than-present past climates, so we are not short of ideas for future work. We also have a wealth of archive material from decades of field work in the Antarctic to address these questions, but not enough 'hands on deck' or existing laboratory facilities in New Zealand to get though this work. The Rutherford Fellowship allows us to develop these new lab capabilities, and employ laboratory assistants, so is a fantastic opportunity to say something new about climate history in the Southern Ocean and Antarctica, and how this may have influenced our own climate in New Zealand".

Rob McKay - Photo: Image Services, VUW

The ten fellowships, administered by the Royal Society of New Zealand, support New Zealand's most talented early- to mid-career researchers by providing financial support of $800,000 over a five-years to investigate their research topic, and help them further their career.

ARC SUCCESS IN MARSDEN FUND

In 2013 ARC researchers were awarded $1.5M of new funding over three years from the Marsden Fund.

The Marsden Fund supports research excellence, allowing New Zealand's best researchers to explore ideas at the forefront of their disciplines. The successful ARC researchers will be investigating the following projects, which have been funded over a three-year period:

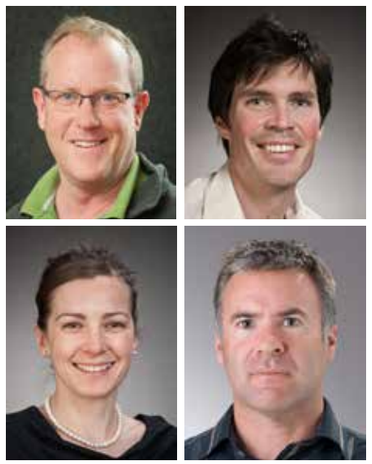
Tim Naish: "Drilling back to the Pliocene in search of Earth's future high-tide."

Huw Horgan: "Can ice sheets help themselves? Investigating self-stabilisation and instability in Antarctica."

Ruzica Dadic: "Improving ice core records-understanding the link between rapid changes of greenhouse gases and temperature."

Richard Levy (GNS Science), and **Gavin Dunbar** (ARC): "New Zealand's stormy Past: Resolving changes in South Island precipitation under varying influence of tropical and polar forcing over the past 17,000 years."

We are extremely proud of our history of success with Marsden, especially with gaining support for early career researchers. Over the last 10 years seven of the ARC's young scientists have received Marsden Fast-Start Awards (Huw Horgan, Ruzica Dadic, Nick Golledge, Brian Anderson, Andrew Mackintosh, Gavin Dunbar, and Nancy Bertler). Some are not so young anymore, but all have gone onto permanent research positions in New Zealand, and higher honours such as Rutherford Discovery Fellowships, and more Marsden success.



The successful ARC Marsden recipients
(Top L-R) Tim Naish, Huw Horgan,
(Bottom L-R) Ruzica Dadic and Gavin Dunbar
Photos: Image Services, VUW

ARC CONTRIBUTES TO INTERNATIONAL CLIMATE CHANGE REPORT

New Jersey shoreline in the aftermath of super storm Sandy
Photo: National Geographic Magazine

Three climate science experts from Victoria University of Wellington played a central role in the latest global report on the state of the world's climate.

Tim Naish (ARC), David Frame (Climate Change Research Institute), and James Renwick (School of Geography, Environment and Earth Sciences) are lead authors on Working Group One of the International Panel for Climate Change's (IPCC) Fifth Assessment Report (AR5), released in Sweden at the end of September. Other contributing authors who made a valuable contribution to the AR5 were Dan Zwartz (ARC) and Chris Hollis (GNS Science). We believe that Victoria University may hold the record for the most lead authors from a single institution.

Climate Change 2013: The Physical Science Basis, confirms and strengthens many of the findings from the Fourth Assessment Report published in 2007 on observed changes in the global climate, their underlying causes and their future projections. 209 lead authors and 50 review editors from 39 countries spent four years comprehensively assessing the published literature and writing the report, which cites more than 9000 scientific publications and received 60,000 individual review comments on its four drafts. The 14,000 word "Summary for Policymakers" was approved line by line in a plenary session in Stockholm between 23-26 September and was signed off by 195 countries.

For Tim Naish who contributed to Chapter 5 - "Information from Paleoclimate Archives", the experience was challenging and time-consuming, but enormously rewarding and a privilege to be working alongside the world's leading climate scientists. The challenge was processing such a large volume of information while remaining objective and reaching a consensus amongst your peers. You really have to be very critical about the quality of evidence and the confidence that you can place on it.

The latest report documents global temperature increases of the atmosphere and oceans, decreases in the volume and cover of snow and ice, as well as an average rise in sea level of 19 centimetres between 1901 and 2010. It also documents the continued increase in concentration of greenhouse gases in the Earth's atmosphere, caused primarily by the burning of fossil fuels and land use changes, and a related trend towards ocean acidification. The report reiterates that "warming of the climate system is unequivocal" and that the "human influence on the climate system is clear".

Ice core evidence shows that carbon dioxide concentrations are now at levels unprecedented in at least the last 800,000 years, and the report outlines four possible future greenhouse gas concentration scenarios to the end of this century and beyond, ranging from one in which emissions are substantially reduced, to one with continuing high emission rates. Corresponding estimates for global surface temperature increases range from between 0.3 and 1.7°C, to between 2.6 and 4.8°C by the year 2100.

As far as the cryosphere goes, the report describes observed changes to Greenland and Antarctic ice sheets. It is very likely the Arctic sea-ice cover will continue to shrink and thin as the region is expected to warm more rapidly than other areas of the world. In addition, the volume of the polar ice sheets and glaciers globally will continue to decrease, contributing to a likely range of global mean sea-level rise between 26-82 centimetres by the end of the century, depending on the greenhouse gas concentration pathway we end up following. The West Antarctic Ice Sheet still remains a wild card, and the report cautions that only the collapse of marine-based sectors of the Antarctic ice sheet, if initiated, could cause sea-level to rise substantially above these 'likely' ranges during the 21st century.

The IPCC AR5 was officially presented in New Zealand on the 11 October at a stakeholder workshop in Wellington, hosted by the Royal Society of New Zealand. The IPCC Working Group One Co-Chair, Thomas Stocker, from Bern Switzerland, joined the New Zealand authors and New Zealand's IPCC Working Group One Bureau Member, David Wratt (NIWA) to present the report and answer questions.
The summary and the final draft of the full Working Group One report is available at: www.climatechange2013.org.

A hard copy will be available in 2014. The remainder of the AR5 report will be released in stages over the coming year.

The IPCC Chapter 5 team at work, Marakesh, Morocco - Photo: Tim Naish

THIN ICE – A GLOBAL LAUNCH FOR A GLOBAL ISSUE

On Earth Day (22 April), the film *Thin Ice: The Inside Story of Climate Science* was launched globally on all seven continents, in at least 120 countries, with over 200 organised screenings and 19,000 online views.

This initiative between Victoria University of Wellington, the University of Oxford and DOX Productions, London, was over six years in the making, and takes a fresh look at the changes taking place in the Earth's atmosphere, oceans and ice sheets. The 73-minute-long documentary gives the public a rare opportunity to see climate scientists at work, talking about what they do, and their hopes and fears.

The Thin Ice project was conceived over a cup of coffee at a climate change conference in March 2006, when the ARC's Peter Barrett, suggested to fellow geologist Simon Lamb, then at Oxford University, that he make a film about climate science and scientists with his friend David Sington from DOX Productions. Support from Oxford came through Philip England, then Head of Earth Sciences, with coproduction and website development in New Zealand from Catherine Fitzgerald (Blueskin Films) and James Franklin (Pixeco), respectively. Using the website as a platform for the global launch was the work of ARC student, Heidi Roop, and Rhian Salmon (then Climate Change Research Institute).

The resulting film takes viewers on Simon's personal journey of discovery as he meets and interviews 40 scientists working at the front line of climate research in the Arctic, Antarctic, Southern Ocean, New Zealand, Europe and the United States. Simon says "I was motivated to make the film by a determination that people should hear from climate researchers themselves". Perhaps the most significant achievement is reflected in a blog post by Chicago physicist Ray Pierrehumbert's, where he says "One of the many things I like about this film is that it puts a human face on climate science". One of the 44 comments following says "It's like having a chat with a knowledgeable mate down at the pub".

A feature of the project is the Thin Ice website (www.thiniceclimate.org). This hosts close on 40 video clips taken from the 120 hours of interviews that expand on key aspects of the film for educators and others with specific interests. The website also includes biographies of the scientists and film makers. The website shop provides for purchasing a DVD of the film with options to view the film in sections and with subtitles in Chinese, English, French, German, Russian and Spanish, and a less expensive download option.

The DVD was produced by the Dubshop, Wellington, through a grant from the Tindall Foundation to distribute DVD's to leading New Zealand companies with the help of Enviromark CEO Ann Smith. It came out just in time to present the first copies to Thomas Stocker, co-chair, International Panel for Climate Change (IPCC) Working Group One, and the four Victoria University IPCC lead authors, at the New Zealand Outreach Workshop for the release of the IPCC 5th Assessment Report on 11 October. Several of the report's lead authors feature in the film, which makes some of the key points in the report itself.

Other significant achievements have been invitations to submit in a number of film festivals; Sheffield in June, Siberia and Indonesia in September and Norway in October, with several more in 2014. The film was also screened in Warsaw (with Polish subtitles) at the Palace of Culture and Science in November during the United Nations Framework Convention on Climate Change meeting there. We were especially pleased to win the best popular science film award at the 12th Baikal International Film Festival. We were also delighted that Simon received the NZ Science Communicators Award for 2013.

Another highlight was the invitation to screen in December at the American Geophysical Union (AGU) Fall Meeting in San Francisco. The film attracted an appreciative audience, and was followed by a lively panel discussion led by producer - director - writer Geoff Haines-Stiles (*Earth - An Operator's Manual*, released in 2011). A review in the AGU newsletter EOS (4 February, 2014) quoted audience member Michael Mottl, chair of Oceanography at the University of Hawai'i as saying Thin Ice "brought tears to my eyes," noting its portrayal of climate scientists in the field under modest or difficult circumstances. "It's so clear they're driven. That goes a long way to counter those saying [climate change] is a hoax," he said. "How could anyone possibly believe that when they see a film like this?"

Our goal for 2014 is to increase the reach of the film in education both here and abroad, and we are in discussion with interested film distributors with the help of Victoria University's VicLink.

In addition to funding a summer research assistant, Suze Keith, to assist in the development of a marketing and operations strategy, VicLink management accountant Gary Ward has assisted with the analysis and scrutiny of the licensing offers. Catherine Fitzgerald, has also played a key role in the DVD production, and advising on licensing and distribution issues. We are excited about the range of future opportunities for the film which are being developed with our International Advisory Board.

Relaxing after the Thin Ice panel discussion at the AGU screening are (L-R) Peter Weiss (AGU Public Information Officer), Peter Barrett (Thin Ice Executive Producer), Myles Allen (one of the stars of Thin Ice and IPCC Lead Author), Geoff Haines-Stiles (Producer) and (inset) Simon Lamb (Thin Ice Director - Narrator) - Photo: Peter Barrett

S.T. LEE LECTURE IN ANTARCTIC STUDIES

Artist impression of Mid-Cretaceous Forests in Antarctica based on research by Jodie Howe and Jane Francis, University of Leeds - Image: copyright R. Nichols, Paleocreations.com

Professor Jane Francis presented the 2013 S.T. Lee Lecture established by Singapore philanthropist Lee Seng Tee.

On 15 August, Jane Francis, then Dean of the Faculty of Environment, University of Leeds, and now Director of the British Antarctic Survey in Cambridge, UK, came to Wellington to present the annual S.T. Lee Lecture in Antarctic Studies.

Jane's talk "When Antarctica was green: Fossil plants reveal Antarctica's climate history" outlined her research into ancient climates, particularly of the polar regions where she studies fossil plants from the Arctic and Antarctica to decipher greenhouse climates of the past, when forests, not glaciers, covered the high latitudes.

Millions of years ago at a time when Antarctica had moved to its current geographical position, the presence of many plant fossils show that life was very different near the South Pole: Antarctica was green. Fossil remains of leaves, wood, pollen, seeds and flowers show that the continent was covered in lush green forests that flourished in warm humid climates, despite the extreme polar light regime of continuous summer sunlight and long dark winters. Many of the fossil plants have been identified as ancestors of vegetation that grows in South America and Australasia today, with some additional tropical types that migrated far south during periods of extreme global warmth. As the polar climate cooled and ice sheets developed, small dwarf shrubs of southern beech (Nothofagus) heroically survived close to the pole before the expanding ice sheets wiped all forests from Antarctica.

Jane's presentation was highlighted by her collaborations with artists to produce illustrations showing environmental reconstructions of what Antarctica's forests looked like during different time periods as the fossil record changed. We were left with the question , "Will Antarctica become green again as the climate warms?"

This years 11th S.T. lecture was smoothly co-ordinated and hosted by Peter Barrett, Jane's schedule was a busy mix of accompanying talks, media engagements, meetings with staff and students, social events and field trips, including visits to view the local flora and fauna in the Wairarapa at Mt Bruce and a day walk into the Tararua's with Peter and Tim Naish.

Jane Francis presenting her lecture in the Victoria University Council Chambers Photo: Image Services, VUW

VISITORS TO THE ARC

In 2013 the ARC hosted Bethan Davies (Aberystwyth University) for a six month visiting SCAR Fellowship. During her visit she adapted a glacier flowline model originally written by Nick Golledge to run on a small glacier on James Ross Island, Antarctic Peninsula. By driving this model with high-resolution climate records from the new Mount Haddington ice core, Bethan's experiments showed that Holocene fluctuations in glacier length and ice shelf extent were mostly controlled by atmospheric temperatures. Using climate model projections for the next century, her models also show that changes in precipitation will do little to offset increased melt under a warming climate.

Bethan is also involved with science communication particularly through her website AntarcticGlaciers.org. During her time at the ARC she and PhD student, Heidi Roop developed a session for the AGU Fall Meeting 2013, entitled "The role of scientists as communicators: From the classroom to the pub".

Bethan Davies at AGU, San Francisco Photo: Heidi Roop

We finished the year with two important visitors to the ARC, the first was Lev Tarasov (Memorial University of Newfoundland) and later Regine Hock (University of Alaska, Fairbanks).

Lev came in August with his wife and daughter for six months to concentrate on his ice sheet modelling research. While Regine was here for two months from October-November working on her glacier mass balance modelling. Both shared their expertise with ARC staff and students and presented seminars to the Earth Sciences community in Wellington, while also exploring joint research opportunities.

After waiting seemingly forever for appropriate weather, both Regine and Lev joined Andrew Mackintosh and Nicolas Cullen (University of Otago) at Brewster Glacier, South Island for the annual end of winter glacier mass balance measurements.

(L-R) Regine Hock and Lev Tarasov on Brewster Glacier, New Zealand Photo: Andrew Mackintosh

THE RICH TAPESTRY OF NEW ZEALAND'S ANTARCTIC RESEARCH ENVIRONMENT

Tasman Glacier, New Zealand
Photo: Huw Horgan

NZARI, National Science Challenges, CoREs and JARI.

The Antarctic science funding space remains dynamic and continues to evolve as new funding streams (Government and private) are aligned with existing funding. This presents a number of exciting opportunities, both in terms of science projects and collaborations. The New Zealand Antarctic Research Institute (NZARI) has had a successful first year since its launch at Premier House, by Prime Minister John Key in August 2012. Much of NZARIs activities over the last 12 months are summarised in its inaugural annual report. Initially seven projects were funded from philanthropic sources (Julian Robertson Foundation, Air New Zealand) with support from Antarctica New Zealand through NZARI in 2013. ARC's Rob McKay and Richard Levy (GNS Science) received support for their project "Southern Ocean and Antarctic climate response to high atmospheric CO_2 forcing" investigating Antarctic ice sheet and ocean circulation response during the warm Middle Miocene, and Tim Naish received funding for a review of "Polar amplification: Past, present and future", based on collaborations stemming from the recently released Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report. Tim's project was selected for sponsorship by Air New Zealand and featured in the inflight KiaOra magazine.

NZARI Director, Gary Wilson (University of Otago), led a successful proposal, "The Deep South", which has been selected as one of the ten National Science Challenges. A full proposal and business plan for the "Deep South" was submitted in December for funding, with the lead institutions being NZARI, GNS Science, VUW, NIWA and Antarctica New Zealand.

ARC also led a multi-institutional proposal for a Centre of Research Excellence (CoRE) named the "Ed Hillary Institute for Antarctic and Southern Hemisphere Change" building on the successful collaboration developed through the Joint Antarctic Research Institute (JARI). We were honoured to receive approval to use the Hillary family name. A full proposal led by Tim Naish was submitted in December 2013 and the outcome will be known by April 2014*.

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 Otago and University of Canterbury. JARI partners align resources and international collaborations to address New Zealand's high-priority Antarctic and Southern Ocean research questions, and will play a role in delivering outcomes for the National Science Challenge and NZARI, based on a proven model developed by projects such as ANDRILL and ice coring.

* The Ed Hillary CoRE was not selected for the final short-list

INTERNATIONAL CRYOSPHERIC STEWARDSHIP

In July and August Andrew Mackintosh travelled to Switzerland in his role as Secretary General of the International Association of Cryospheric Sciences (IACS), to organize the DACA-13 'Davos Atmosphere Cryosphere Assembly' which was attended by more than 1000 scientists. He had a very busy week running the conference, giving talks, and attending business meetings.

After Switzerland, Andrew was invited as an IACS observer by his Chinese colleague Professor Xiao Cunde to visit glaciological research stations in Tibet. This involved a visit to Lhasa and surrounding mountains and lakes with a small group of glaciological colleagues including Professors Doug MacAyeal (University of Chicago) and Bob Bindschadler (NASA).

(Left) Tibetan women in traditional dress; (Above) Tibetan Pass (5000 m) - Photos: Andrew Mackintosh

ARC ENDOWED DEVELOPMENT FUND

The ARC Endowed Development Fund has now reached $500,000, with 54 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 2013 recipients included PhD students Christine Bylenga and Francisca Vermeulen from the School of Biological Sciences, who presented their research at the XIth SCAR Biology Symposium held in Barcelona, Spain. The remaining recipients were all from the Antarctic Research Centre. Bella Duncan attended the Urbino Paleoclimatology Summer School in Urbino, Italy in July, Heidi Roop and Molly Patterson both attended the American Geophysical Union Meeting in San Francisco in December. Andrea Tuohy and Peter Neff headed to Curtin University, Perth to collaborate with researchers there on their ice core research. Daniel Emanuelsson travelled to the University of Washington, Jane Chewings completed sample analyses which contributed to the results for a paper she submitted to *Sedimentology*. Finally Richard Jones used his grant to pay for cosmogenic dating of his samples from the Mackay Glacier, Antarctica.

AWARDS AND APPOINTMENTS

Andrew Mackintosh — Promoted to Deputy Director of the Antarctic Research Centre.

Gavin Dunbar (with co-PI Richard Levy, GNS Science) – Marsden Grant, "New Zealand's Stormy Past: Resolving changes in South Island precipitation under varying influence of tropical and polar forcing over the past 17,000 years".

Huw Horgan — Marsden Fast-Start Grant, "Can ice sheets help themselves? Investigating self-stabilisation and instability in Antarctica".

Matt Ryan — Geoscience Society of New Zealand Hornibrook Award.

Nancy Bertler — Promoted to Associate Professor.

Peter Barrett — Appointed to the Assessment Committee for Martha Muse Prize.

Rob McKay — Promoted to Senior Lecturer in Sedimentology and Paleoceanography in the 2013 Academic Promotion Round.

— Rutherford Discovery Fellowship, "How the Antarctic ice sheet and the Southern Ocean has interacted over the past 23 million years.

— NZARI Fund, "Southern Ocean and Antarctic climate response to high atmospheric CO_2 forcing"

Ruzica Dadic – Marsden Fast-Start Grant, "Improving ice core records-understanding the link between rapid changes of greenhouse gases and temperature".

Shaun Eaves/Rory Hart – Geological Society Beanland-Thornley Prize for "Best Talk".

Tim Naish — Research Excellence Award, Victoria University of Wellington Staff Excellence Awards

— Marsden Fund, "Drilling back to the Pliocene in search of Earth's future high-tide".

— NZARI Fund, "Polar amplification: Past, present and future"

Thin Ice - was awarded "The best popular science film" at the Biakal Film Festival in Irkutsk, Simon Lamb was there to receive the award in person.

TEACHING AND SUPERVISION

Jane Chewings (right) and her supervisor Cliff Atkins during her graduation - Photo: Jane Chewings

Our staff support the teaching being carried out in the paleoclimatology research theme 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 2013:

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
SCIE 211	Contemporary Issues in Science and Society
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
PHYG 580	Research Preparation

Our teaching contribution also includes supervision of graduate students from the School of Geography, Environment and Earth Sciences (SGEES). In 2013 our staff supervised 16 PhD and 5 MSc students. The Antarctic Research Centre congratulates the following students who completed their theses in 2013:

Julene Marr (PhD) *"Planktic foraminiferal proxy development and application to paleoceanographic change in the Southwest Pacific Ocean"*
Supervised by Lionel Carter (ARC) and Monika Handler (SGEES)

Jane Chewings (MSc) *"Sedimentology and numerical modelling of aeolian sediment dispersal, McMurdo Sound, southwest Ross Sea, Antarctica"*
Supervised by Cliff Atkins (SGEES), Gavin Dunbar (ARC) and Nick Golledge (ARC)

Kolja Schaller (MSc) *"Englacial hydrology of Annette Plateau, a temperate alpine glacier, Southern Alps, New Zealand"*
Supervised by Brian Anderson (ARC), Huw Horgan (ARC/SGEES) and Uwe Morgenstern (GNS Science)

Our staff and students were involved in a variety of outreach activities during the year. These activities include media interviews, public talks, and school visits, allowing us to present our research and knowledge to the wider community both here and overseas.

Media Interviews

Radio NZ 'Our Changing World': "Southern Alps Glaciers" Brian Anderson, 3 January.

NZ Herald: "Antarctica key to tackling New Zealand climate change issues" Tim Naish, 18 January.

The Nelson Mail: "Ancient ice cores begin journey north" Nancy Bertler, 19 January.

Dominion Post: "Core blimey-science drills up answers" Nancy Bertler, 26 January.

Radio NZ 'Checkpoint': "RICE" Nancy Bertler, 26 January.

The Global Mail: "The Snow-Readers" by Finlay Macdonald on Nancy Bertler's RICE project, 5 March.

3 News 'Nightline': "Climate change film gives scientists voice" on Thin Ice film, 11 March.

NZ Herald: "Doco tracks climate science from Arctic to Antarctica" on Thin Ice film, 18 March.

3 News: "Winners and losers as climate change hits Antarctica" Tim Naish, 4 April.

NZ Herald: "Antarctic team digs deep to predict climate future" Nancy Bertler, 6 April.

NZ Herald: "Ice-free past points to daunting future" Rob McKay, 6 June.

NZ Herald: "Research on ice: The seven projects" Tim Naish, Richard Levy (GNS Science) and Rob McKay, 14 June.

NZ Herald: "Rising seas tipped to flood Earth" Tim Naish, 26 June.

The Press: "Ice-Breaking research on global warming" Tim Naish, 9 July.

The Southland Times: "Scientists keen to see what lies beneath" Tim Naish, 9 July.

Hutt News: "Past revealed as ice melts" featuring image of Peter Neff, 23 July.

You Tube: "RICE project" video by Julian Thompson (GNS Science), 1 August.

Radio NZ 'Our Changing World': "Melting ice cores from the RICE Project" Peter Neff and Nancy Bertler, 8 August.

Oamaru Mail: "Project traces climate history" Heidi Roop on Lake Ohau, 30 August.

Kiora Magazine: "Cold comfort" Tim Naish, September issue.

APiS UK 'Bee Keeping Science and News: "Research - Pollen indicates our history" Matt Ryan, September issue.

Radio Ngati Porou Current Affairs: "An island in a changing ocean" Lionel Carter, 10 September.

NZ Herald: "Grim message on climate change" featuring Tim Naish, IPCC report, 28 September.

3 News 'Firstline': "Kiwi scientist warns of climate doom" Tim Naish, 30 September.

Hawkes Bay TV 'Chatroom': "An island in a changing ocean" Lionel Carter, 30 September.

The Dominion Post: "Researchers' efforts to be supported by fellowships" featuring Rob McKay, 1 October.

NZ Herald: "Southern Alps ice levels show sharp decrease" featuring Brian Anderson's research model, 12 October.

Radio NZ 'Our Changing World': "Scientists calculate rates of sea-level rise as ice sheets melt" Tim Naish on IPCC report, 24 October.

Scoop: "Victoria University scoops 21 Marsden grants", featuring Tim Naish, Huw Horgan, Ruzica Dadic, and Gavin Dunbar, 29 October.

NZ Herald: "Solving riddle of giant ice streams" Tim Naish, 30 October.

Radio NZ 'Nine to Noon': "The role of Antarctica in climate change" Tim Naish on ARC Marsden success, 30 October.

Scoop: "Warm reception for cold facts on climate change" Peter Barrett on Thin Ice film, 11 November.

3 News: "Glaciers set to halve in next 100 years" Brian Anderson and Huw Horgan, 23 November.

Scoop: "Southern Alps glaciers in state of rapid change" Brian Anderson, 24 November.

Newstalk ZB: "Glaciers retreating faster" Brian Anderson, 25 November.

RadioLIVE 'The Marcus Lush Breakfast Show with Hilary Barry': "Glacier retreat" Brian Anderson, 25 November.

The Press: "South Island glaciers may retreat by 8 km" Brian Anderson, 25 November.

NZ Herald: "Glaciers set to shrink under climate change" Brian Anderson, 28 November.

Audiovisual Media

Thin Ice – The Inside Story of Climate Science – a David Sington-Simon Lamb film. [DVD]. Peter Barrett (Executive Producer), Retrieved from http:// www.thiniceclimate.org

Talks to the Public and Policymakers

Australian Meteorological and Oceanographic Society '2013 Pearman Lecture': "Ice sheets, mountain glaciers and climate change", Andrew Mackintosh, Melbourne, Australia, 28 June.

VUW Free Public Lecture Series: "9 billion people, global warming and climate change" Tim Naish, Blenheim, 7 August.

VUW Alumni Events: "9 billion people, global, warming and climate change" Tim Naish, NZ House, London; NZ Residence, Berlin; NZ UN Mission, New York, 5-7 September.

VUW Free Public Lecture Series: "An island in a changing ocean - how New Zealand's ocean is responding to modern climate change" Lionel Carter, Napier, 11 September.

VUW Free Public Lecture Series: "Sailing down the Waipaoa to the deep ocean - discovering how climate and earthquakes shape land and ocean" Lionel Carter, Gisborne, 12 September.

VUW Free Public Lecture Series: "9 billion people, global warming and climate change", Tim Naish, New Plymouth, 19 September.

Ambassador of the United States discussion: "Challenges and opportunities in the marine environment" Lionel Carter, Wellington, 19 September.

IPCC 5th Assessment Report Presentation at RSNZ IPCC Stakeholders Workshop: Tim Naish, David Wratt (NIWA), Dave Frame (CCRI), James Renwick (SGEES), Wellington, 11 October.

Briefing to members of NZ Parliament on the outcomes of the IPCC 5th Assessment Report: Tim Naish, Dave Frame (CCRI), James Renwick (SGEES), Wellington, 16 October.

U3A Wellington City: "How stable is the West Antarctic Ice Sheet in a warming world?" Nancy Bertler, Wellington, 25 October.

School & Community Groups

Chalkle Course: "A warming world, how do we know?" Heidi Roop, Wellington 7 May.

NZ Mountain Guides Association: Brian Anderson, 8 June.

Geology of your own back-yard: Hands-on geology with correspondence school kids from the South Island, Heidi Roop and Peter Neff, Lake Ohau, 22-25 July.

NZ Science & Technology Fair: Gavin Dunbar (judge), 28-31 August.

Forest and Bird South Island Gathering: Brian Anderson, 29 September.

Tararua Tramping Club: Brian Anderson, 22 October.

Exploration Station, AGU Meeting: Heidi Roop) "ARC-Polar Educators International booth" Heidi Roop, San Francisco, 8 December.

Virtual Classroom Visits: Heidi Roop and Peter Neff (multiple dates).

Scientists in the Classroom Mentor Program: Heidi Roop and Peter Neff both served as mentors, (multiple dates).

Other Activities

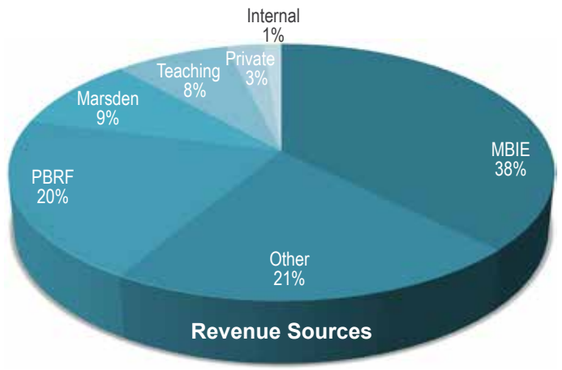
In July, PhD student Richard Jones launched a new climate science-public outreach website, *Climatica*, www.climatica.org.uk The project is supported by the Geological Society (London) and Quaternary Research Association (UK), as well as the World Bank's Connect4Climate initiative. A partnership is also being established with the European Geosciences Union (EGU) to educate scientists about outreach. The website features a range of articles written by scientists, blogs from researchers in the field, video talks and opportunities for questions and discussion. Additionally, summaries of the individual sections of the new the International Panel for Climate Change (IPCC) report will be published. Earlier this year they also discussed the importance and motivation for climate science outreach in the Guardian newspaper (UK) "Shouldn't climate scientists try harder at communicating their findings?". In 2014, we will convene a science communication skills workshop at the EGU international conference in Vienna.

In December, PhD student Heidi Roop, as a member of the Executive Committee, Heidi helped to launch a new international organisation, Polar Educators International. www.polareducator.org This even launched at the Cyropshere Reception, where Heidi Roop spoke and launched the organization. PEI has over 600 members from scientific and education communities.

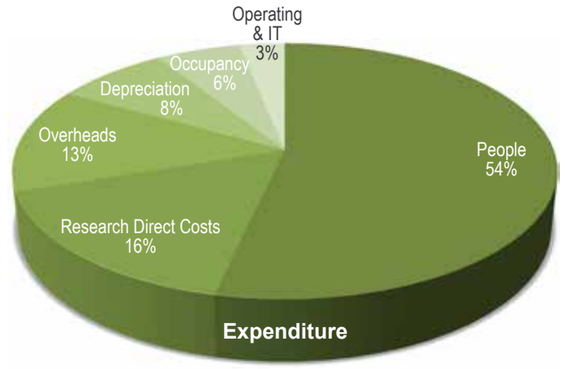
The Antarctic Research Centre had a challenging year due to a reduction in revenue. However new funding awarded late in 2013 means the future is looking bright.

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 2013 are summarized in the charts below (all figures are exclusive of GST), these figures combine the Centre budget that operates over the our 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.
In 2013, the ARC received a total of $1.96M in revenue and had a corresponding expenditure of $2.16M. The individual cost centre budget for 2013 had an approved budget deficit of $170K, however due in part to additional revenue and careful expenditure the overall loss for the Centre at year end was only $92K. The ARC's research funding contribution to the University via overheads from Research Trust grants was $278K, thus overall the ARC contributed $186K to the University.

2013 Finances

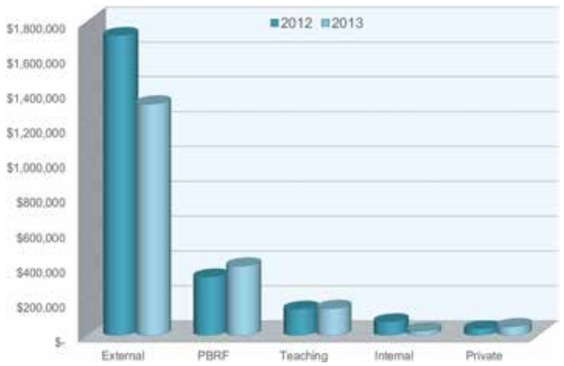


The highest proportion of revenue came from Government (MBIE) funding either directly or through sub-contracts from GNS Science and NIWA. Grants in Other include a Rutherford Fellowship and NZARI funding, as well as funding from international organisations. PBRF is calculated by Victoria University based on external research funding that meets PBRF criteria and the quality rating of staff. Teaching is a contribution, based on hours, from SGEES for teaching and supervision by ARC staff, as well as a proportion of PBRF graduate completion income. Private revenue are donations held by the VUW Foundation and transferred to the Research Trust, and Internal funding is University supported grants.

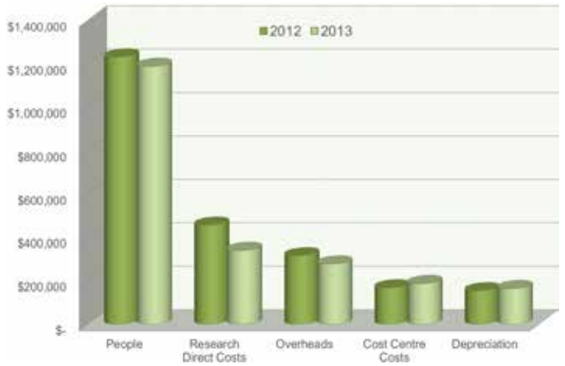


Just over half of the expenditure is related to staff costs including salaries, annual leave, and superannuation. The Research Direct Costs include expenditure directly associated with research projects such as field work costs, conference attendance, analyses, and consumables. The other major expenditure is the Overheads which are transferred out of Research Trust grants by the University to cover services provided by the Research Office and central University. The remaining expenditure items relate to the Depreciation of CAPEX equipment, Occupancy (office space), and the general Operating Costs of the Centre including computers, phones, printing, catering, and postage.

Comparison with Previous Year



2012 vs 2013 Revenue Summary



2012 vs 2013 Expenditure Summary

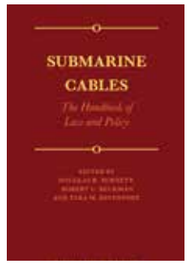
External revenue, which includes funding from the Ministry of Business, Innovation and Employment (MBIE), Marsden, and Other sources, dropped significantly between 2012 and 2013 due to the loss of $400K per year funding for the ANZICE (Antarctica-New Zealand Interglacial Climate Extremes) programme from the predecessor of MBIE. Internal funding from University grants was also down. However following the PBRF (Performance-Based Research Fund) review which took place in 2012, where the quality rating of our staff and research increased, PBRF revenue was higher in 2013. Revenue from Teaching and Supervision for the School (SGEES) increased slightly due to more PBRF graduate completions. There was no new Private funding in 2013 but rather more of the donations already held by the VUW Foundation were transferred to the Research Trust as income to be spent.

New Funding Success

The ARC successfully secured the following new funding in 2013:

NZARI Fund - $90,527 over 1 year
Rutherford Discovery Fellowship - $800,000 over five years
Marsden Fund - $1,546,266 over three years

Efforts were made to reduce our expediture in 2013, primarily the Research Direct Costs in projects. However basic operational costs for the Centre, primarily increased charges from the University for occupancy (space), meant we could not reduce the overall Cost Centre expenditure. Depreciation costs also increased slightly due to the purchase of hydrographic equipment for the Lake Ohau project recently funded by Marsden.



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Sinclair, K.E., **Bertler**, N.A.N., Trompetter, W.J., Baisden, W.T., (2013). Seasonality of airmass pathways to coastal Antarctica: Ramifications for interpreting high-resolution ice core records. *Journal of Climate* 26: 2,065-2,076. doi:10.1175/JCLI-D-12-00167.1

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Steig, E.J., Ding, Q., White, J.C.W., Küttel, M., Rupper, S.B., Neumann, T.A., **Neff**, P.D., Gallant, A., Mayewski, P.A., Taylor, K.C., Hoffmann, G., Dixon, D.A., Schoenemann, S., Markle, B., Fudge, T.J., Schneider, D.P., Schauer, A.J., Teel, R.P., Vaughn, B. H., Burgener, L., Williams, J., Korotkikh, E., (2013). Recent climate and ice-sheet changes in West Antarctic compared with the past 2,000 years. *Nature Geoscience* 6(5): 372-375. http://dx.doi.org/10.1038/NGEO1778

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Reports

Eaves, S.R., (2013). Review of Geomorphological Mapping: Methods and Applications by M.J. Smith, P. Paron, and J.S Griffiths (Eds.), *Geomorphology* 197: 204-205.

Roop, H.A., (2013). International interaction and collaboration: A summary of the Second PAGES Young Scientists Meeting. *Quaternary Australasia* 30(2): 38-39.

CONFERENCES

Invited Keynote/Plenary Presentations

Carter, L., (2013). Environmental regulation and potential impacts on submarine cables. *APEC Workshop – Enhancing Supply Chain Connectivity: Submarine Telecommunications Cable Connectivity in the Asia-Pacific Region*, Indonesia, 15 October.

Golledge, N., (2013). High-resolution modelling of Antarctic ice sheet dynamics using the Parallel Ice Sheet Model. *University of New South Wales*, Sydney, Australia, 22 May.

Golledge, N., (2013). Dynamics of the Antarctic ice sheet: Insights from field observations and high-resolution numerical modelling, *University of Otago*, Dunedin, New Zealand, 15 September.

Mackintosh, A. (2013). Retreat history of the East Antarctic Ice Sheet since the Last Glacial Maximum. *Strategic Science in Antarctica Conference*, Hobart, Australia, 24-28 June.

Naish, T., (2013). Plio-Pleistocene Antarctic ice sheet evolution and implications for global climate and sea-level. *Japan Society for the Promotion of Science Fellowship*, Korean Polar Research Institute, JAMSTEC, University of Kochi, Japan, January-February. (Plenary)

Naish, T., (2013). The importance of paleoclimate – Looking back to the future. *New Zealand Antarctic Research Institute (NZARI) Planning Workshop*, Auckland, New Zealand, 13 March. (Keynote)

Naish, T., (2013). Paleoclimate perspectives on polar ice-sheet and sea level sensitivity to global warming. *Strategic Science in Antarctica Meeting*, Hobart, Australia, Tim Naish, 24-28 June. (Keynote)

Naish, T., (2013). Launch IPCC 5th Assessment Report. *Greenhouse 2013 Conference*, Adelaide, Australia, 9 October. (Keynote)

Naish, T., (2013). ANDRILL Coulman High Project: Resolving Antarctic ice sheet behaviour in a high CO_2 world. *International Continental Drilling Program 10 year Science Planning Workshop*, Potsdam, Germany, 13 November. (Keynote)

Pyne, A., (2013). ANDRILL Drilling Technology. F*ourth International Symposium Polar Earth Sciences and Exploration*, Changchun, China, 14-15 May.

Oral Presentations

Anderson, B., (2013). Towards a network of ground-based cameras for monitoring glacier change. *Snow and Ice Research Group (SIRG) Annual Meeting*, Dunedin, New Zealand, 11-13 February.

Anderson, B., **Mackintosh**, A., Zammit, C., Oerlemans, J., (2013). Past and future glacier change in the Southern Alps, New Zealand. *International Symposium on Changes in Glaciers and Ice Sheets: Observations, Modelling and Environmental Interactions*, Beijing, China, 28 July- 2 August.

Atkins, C.B., **Dunbar**, G.B., **Golledge**, N.R., **Chewings**, J.M., (2013). Aeolian dust research in the SW Ross Sea, Antarctica: Links between dust, biogeochemical cycles and climate change. *Joint Antarctic Research Institute Symposium on Past Antarctic Climate*, Lower Hutt, New Zealand, 25 February.

Cohen, L., Sinclair, K., and **Bertler**, N.A.N., (2013). Modelling the isotopic composition of snow for synoptic storm events at Roosevelt Island, Antarctica. *Strategic Science in Antarctica Conference*, Hobart, Australia, 24-28 June.

Crowley, S., Warburton, J., and **Roop**, H.A., (2013). Cool collaborations: Scientists, educators, and infrastructure in organizational partnerships. *International Teacher-Scientist Partnership Conference*, Boston, USA, 13-14 February.

Eaves, S.R., (2013). The timing of glacier fluctuations in North Island, New Zealand during the last glacial cycle. *Geoscience Society of New Zealand - Wellington Branch*, Wellington, New Zealand, 17 October.

Eaves, S.R., **Mackintosh**, A., Townsend, D., **Anderson,** B., (2013). What can New Zealand's northernmost glaciers tell us about past climate change? *Snow and Ice Research Group (SIRG) Annual Meeting*, Dunedin, New Zealand, 11-13 February.

Golledge, N. (2013). Modelling Antarctic ice sheet fluctuations through the last glacial cycle. *Roosevelt Island Climate Evolution (RICE) Workshop*, Lower Hutt, New Zealand, 22 July.

Golledge, N., Marsh, O., Rack, W., Braaten, D., Jones, R., (2013). Basal conditions of two Transantarctic Mountain outlet glaciers from observation-constrained diagnostic modelling (presented by Richard Levy). *Strategic Science in Antarctica Conference*, Hobart, Australia, 24-28 June.

Golledge, N., Rack, W., Jones, R., Marsh, O. Braaten, D., (2013). Glaciology of Transantarctic Mountain outlet glaciers from field observations and numerical modelling. *Korean Polar Research Institute (KOPRI) Workshop*, Seoul, Korea, 28 August.

Hart, R.J., **Mackintosh**, A.M., **Horgan**, H.J., **Anderson,** B.M., (2013). Applying geophysical methods to constrain ice thickness: Tasman Glacier, New Zealand, *Snow and Ice Research Group (SIRG) Annual Meeting*, Dunedin, New Zealand, 11-13 February.

Hart, R.J., **Mackintosh**, A.M., **Horgan**, H.J., **Anderson,** B.M., (2013). The ice-thickness distribution of a low-angled, debris-covered glacier: Tasman Glacier, New Zealand. *Geoscience Society of New Zealand - Wellington Branch*, Wellington, New Zealand, 17 October.

Jones, R.S., **Mackintosh**, A.N., Norton, K.P., **Golledge**, N.R., (2013).The glaciology of a Transantarctic Mountains outlet glacier – Implications for cosmogenic nuclide dating. *Snow and Ice Research Group (SIRG) Annual Meeting*, Dunedin, New Zealand, 11-13 February.

Jones, R.S., **Mackintosh**, A.N., Norton, K.P., **Golledge**, N.R., (2013). The glaciology of a Transantarctic Mountains outlet glacier – Implications for cosmogenic nuclide dating. *Joint Antarctic Research Institute Symposium on Past Antarctic Climate*, Lower Hutt, New Zealand, 25 February.

Mackintosh, A., (2013). Understanding the relationship between glaciers and climate change. *University of Melbourne,School of Earth Sciences Seminar Series*, Melbourne, Australia, 30 May.

Mackintosh, A., (2013). Ice sheets, mountain glaciers and their interactions with climate. *Monash University, School of Geography and Environmental Science Seminar Series*, Melbourne, Australia, 13 June.

Mackintosh, A., **Anderson**, B., Dean, S., Renwick, J., Lorrey, A., **Dadic**, R., (2013). Climatic attribution of mountain glacier fluctuations. *Davos Atmosphere and Cryosphere Assembly DACA-13*, Davos, Switzerland, 8-12 July.

Mandeno, D., **Pyne**, A., **Bertler**, N., **Neff**, P., (2013). Ice coring at Roosevelt Island: Drill design, performance and refrigeration solutions at a low altitude "warm coastal" Antarctic location. *7th International Workshop on Ice Drilling Technology*, Madison, Wisconsin, USA. 9-13 September.

Patterson, M.O., **McKay**, R.M., **Naish**, T., Escutia, C., Jimenez-Espejo, F.J., Raymo, M.E., Tauxe, L., Brinkhuis, H., (2013). Pliocene and Early Pleistocene orbital forcing of the East Antarctic Ice Sheet. *AGU (American Geophysical Union) Fall Meeting*, San Francisco, USA, 9-13 December.

Pyne, A., **Mandeno**, D., **Bertler**, N., (2013). Intermediate coring at Roosevelt Island: Logistics and lessons. *7th International Workshop on Ice Drilling Technology*, Madison, Wisconsin, USA, 9-13 September.

Pyne, A., **Mandeno**, D., **Bertler**, N., Conway, H., (2013). Roosevelt Island Climate Evolution (RICE), West Antarctica. *Strategic Science in Antarctica Conference*, Hobart, Australia, 24-28 June.

Roop, H., Bartholow, S., and Huffman, L., (2013). From pole to pole: Experiences educating about the polar regions. *AGU (American Geophysical Union) Fall Meeting*, San Francisco, USA, 9-13 December.

Roop, H. and Davis, B., (2013). The role of scientists as communicators: From the classroom to the pub. *AGU (American Geophysical Union) Fall Meeting*, San Francisco, USA, 9-13 December.

Roop, H.A., **Dunbar**, G., Levy, R., Vandergoes, M., (2013). Exploring climate varve relationships in a sediment sequence from Lake Ohau, South Island, New Zealand. *AGU (American Geophysical Union) Fall Meeting*, San Francisco, USA, 9-13 December.

Ryan, M., Newnham, R., **Dunbar**, G., Vandergoes, M., Neil, H., Alloway, B., Bostock, H., (2013). High-resolution Southern Hemisphere terrestrial vegetation and SST reconstructions from "super-warm" interglacial stages 1, 5e and 11 from the Eastern Tasman Sea. *INQUA (International Union for Quaternary Research) Early Career Researcher Inter-congress Meeting*, Wollongong, Australia, 2-6 December.

Salmon, R., Atkins, C.B., and **Roop**, H., (2013). Communicating our science: Thinking big picture. Workshop session at *Strategic Science in Antarctica Conference*, Hobart, Australia, 24-28 June.

Salmon, R., Goven, J., and **Roop**, H.A., (2013). Why do scientists engage in public science events? Motivations, experiences, and evaluation. *Science Communicators Association of New Zealand*, Christchurch, New Zealand, 22 February.

Salmon, R. and **Roop**, H.A., (2013). Polar outreach and communication: What is the future of this IPY legacy? *Strategic Science in Antarctica Conference*, Hobart, Australia, 24-28 June.

Stumpner, P.R., Forrest, A., **Roop**, H.A., **Dunbar**, G., Levy, R.H., Vandergoes, M.J., Schladow, S.G., (2013). Observations of turbidity currents in glacial Lake Ohau, South Island, New Zealand. *16th International Workshop on Physical Processes in Natural Waters*, Queensland, Australia, 8-11 July.

Poster Presentations

Atkins, C.B, **Dunbar**, G., and **Golledge**, N. (2013). Aeolian dust in Terra Nova Bay Polynya, Antarctica. *Strategic Science in Antarctica Conference,* Hobart, Australia, 24-28 June.

Jones, R.S., **Mackintosh**, A.N., Norton, K.P., **Golledge**, N.R., Fogwill, C., (2013). Glacial history of Mackay Glacier, Transantarctic Mountains: Chronology of thinning to the present day. *Strategic Science in Antarctica Conference*, Hobart, Australia, 24-28 June.

Neff, P., **Bertler**, N., and RICE Community, (2013). Roosevelt Island Climate Evolution (RICE) project update. *WAIS (West Antarctic Ice Sheet) Divide Ice Core Science Meeting*, La Jolla, USA, 24-25 September.

Neff, P., **Bertler**, N., **Pyne**, A., **Mandeno**, D., RICE Community, (2013). Roosevelt Island Climate Evolution (RICE) project: Ice core quality at an intermediate depth site. *7th International Workshop on Ice Drilling Technology*, Madison, Wisconsin, USA, 9-13 September.

Neff, P., Steig, E., Clark, D., Pettit, E., (2013). Ice core drilling at a high-accumulation temperate-glacier site: Combatant Col, Coast Mountains, British Columbia, Canada. *7th International Workshop on Ice Drilling Technology*, Madison, Wisconsin, USA, 9-13 September.

Pascher, K., Hollis, C., and **McKay**, R., (2013). Paleobiogeography of Eocene radiolarians from the Southwest pacific. *Geosciences Society of New Zealand Annual Conference*, Christchurch, New Zealand, 24-27 November.

Roop, H.A. and Salmon, R., (2013). Why do you do outreach? *NZARI (New Zealand Antarctic Research Institute) Planning Workshop*, Auckland, New Zealand, 13 March.

Roop, H.A. and Salmon, R., (2013). Why do you do outreach? *Strategic Science in Antarctica Conference*. Hobart, Australia, 24-28 June.

Roop, H.A., Vandergoes, M., Levy, R., **Dunbar**, G., (2013). Late-Holocene climate variability in southern New Zealand: A multi-proxy study of lake sediments from Lake Ohau to reconstruct regional climate. NZARI (*New Zealand Antarctic Research Institute) Planning Workshop*, Auckland, New Zealand, 13 March.

Roop, H.A., Vandergoes, M., Levy, R., **Dunbar**, G., Fitzsimons, S., Howarth, J., Ditchburn, B., Wilson, G., Purdie, J., (2013). Late-Holocene climate variability in southern New Zealand: A multi-proxy study of lake sediments from Lake Ohau to reconstruct regional climate. *PAGES 2nd Young Scientists Meeting - The Past: A Compass for Future Earth*, Goa, India, 11-12 February.

Salmon, R., Priestley, R., and **Roop**, H.A., (2013). Science communication and public engagement: What are we trying to achieve? *Asia-Pacific Science, Technology and Society Network-Biennial Conference*, Singapore, 15-17 July.

Sugisaki, S., Tauxe, L., Iwai, M., van de Flierdt, T., Cook, C., Jimenez, F.J., Khim, B-K., **Patterson**, M.O., **McKay**, R.M., Passchier, S., Roehl, U., González, J.J., and Escutia, C., (2013). Pliocene and latest Miocene anisotropy of magnetic susceptibility (AMS) from the Wilkes Land margin. *AGU (American Geophysical Union) Fall Meeting*, San Francisco, USA, 9-13 December.

Thierry, A.M., Bourgain, P., Crowley, S., Robineau, C., **Roop**, H.A., Valkonen, T., Warburton, J., (2013). Country-specific actions and international cooperation to better communicate polar science to young students. *XIth SCAR (Scientific Committee on Antarctic Research) Biology Symposium*, Barcelona, Spain, 16-19 July.

OUR PEOPLE

"Who's watching who?" - Photo: Nick Golledge

DIRECTOR

Tim Naish	Professor	Sedimentology and paleoclimatology

DEPUTY DIRECTOR

Andrew Mackintosh	Associate Professor	Glacial geology and glacial modelling

SCIENCE DRILLING OFFICE

Alex Pyne	Projects Manager
Darcy Mandeno	Operations and Field Engineer

ACADEMIC STAFF

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

ADMINISTRATION

Michelle Dow	Centre Manager
Louise Soulsby	Administrator
Robyn McFarlane	Administrator

ASSOCIATED RESEARCHERS

James Renwick	Associate Professor	Atmospheric circulation
Michael Hannah	Associate Professor	Marine palynology
Cliff Atkins	Lecturer	Sedimentary processes and environments

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Helen Bostock	Ross Powell
Helen Neil	Stuart Henrys
James Crampton	Terry Wilson
Kate Sinclair	

GRADUATE STUDENTS *thesis completed in 2013

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

OTHER VUW ACADEMICS WITH ANTARCTIC INTERESTS

Joe Trodahl	Emeritus Professor in Physics	Temperature conduction in ice and rock
David Frame	Professor of Climate Change	Climate policy and future climate change
Tim Stern	Professor in Geophysics	Solid earth geophysics and Transantarctic Mts
Ken Ryan	Associate Professor in Antarctic Biology	Marine algae
Nigel Roberts	Adjunct Professor of Political Science	Antarctic politics and history
Mark McGuinness	Reader in Mathematics	Modelling
Joanna Mossop	Senior Lecturer in Law	International law
Kevin Norton	Senior Lecturer in Geography	Geomorphology and geochemistry
Malcolm Ingham	Senior Lecturer in Physics	Properties of sea ice
Ross Stevens	Senior Lecturer in Industrial Design	Design of remote field camps
Cath Wallace	Teaching Fellow in Environmental Economics	Antarctic environmental issues
Margaret Harper	Research Associate in Geology	Freshwater algae

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Cover photo: Rock wedged in blue ice, Antarctica - Richard Jones

Lake Ohau, New Zealand from the air - Photo: Warren Dickinson


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