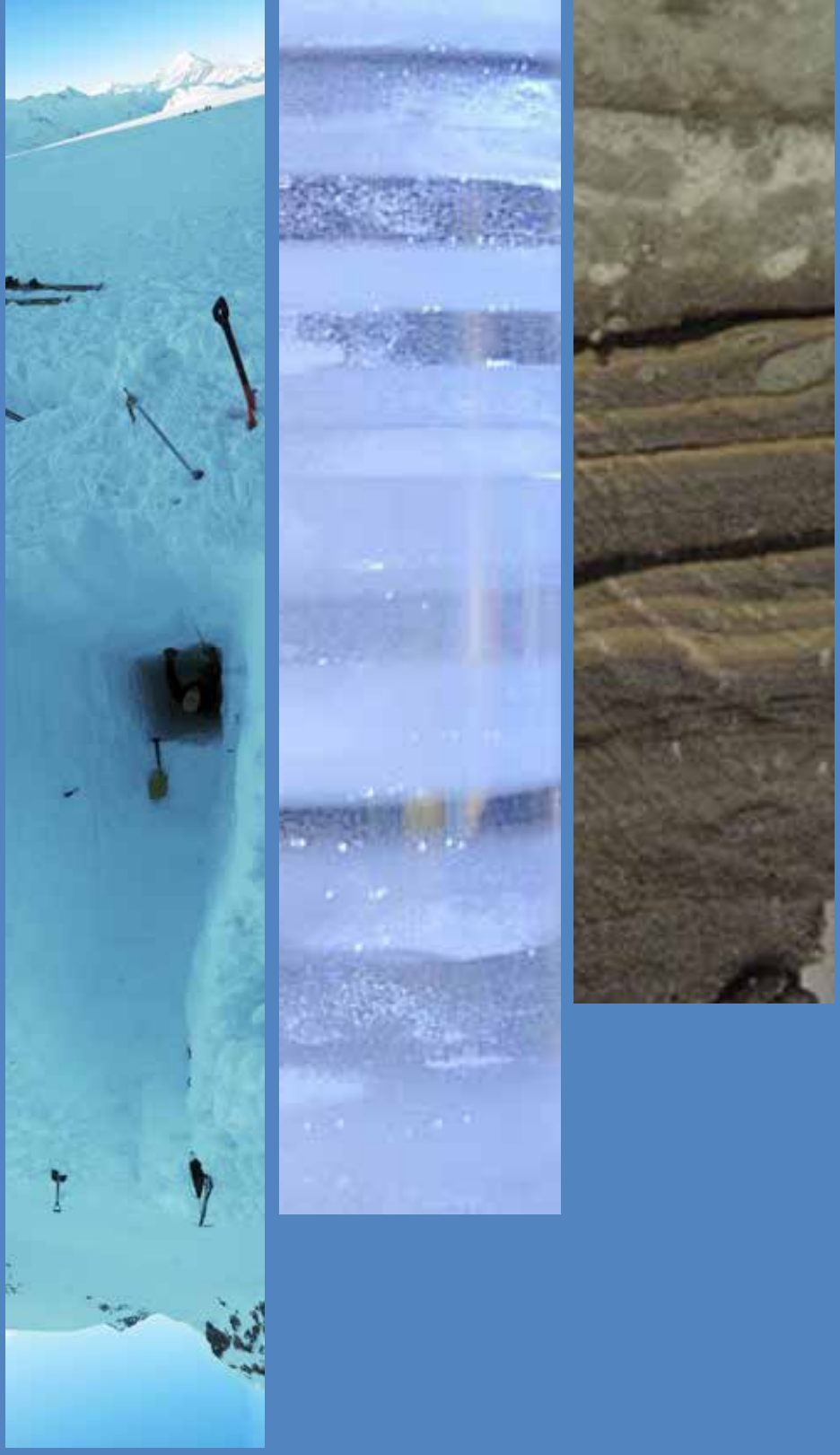


TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

Antarctic Research Centre
ANNUAL REVIEW 2011

Our mission is to improve understanding of Antarctic climate history and processes and their influence on the global climate system, especially on New Zealand and the southwest Pacific region. This is needed to provide a sound basis for national and international policy development on global change issues. The field also provides exciting opportunities and challenges for young researchers.

CONTENTS

DIRECTOR'S SUMMARY

2011 has been another exciting and productive year for ARC staff and students. This year's Annual Review emphasises the importance of our greatest asset, ARC staff , and highlights the contributions of our research teams. Firstly, I want to make special mention of Nancy Bertler's Roosevelt Island Climate Evolution (RICE) ice coring team, who achieved a major milestone in the project by successfully deploying the newly developed ice drill and recovering 130 m of ice core. This achievement represents the culmination of three years of technical development involving testing of the prototype drill system in Greenland by Alex Pyne and Darcy Mandeno, and was made possible by the ongoing support of key partners GNS Science, Antarctica New Zealand and NIWA. I also want to acknowledge Nancy's outstanding leadership of the project, and particularly the co-ordination of national and international partners. The stage is now set for the recovery of a globally unique ice core climate archive later in 2012.

The glaciology and modelling group led by Andrew Mackintosh had a stellar year with results reported in leading scientific journals such as *Nature Geoscience* and the *Journal of Geophysical Research*, their 11 papers accounted for almost half of the ARC publication output in 2011. The ANDRILL Programme has made good progress building towards the next drilling project at Coulman High on the Ross Ice Shelf under the leadership of Richard Levy (GNS Science). A key milestone was the submission of the International Science Proposal to the National Science Foundation. Meanwhile a range of field investigations, involving Nick Golledge, Gavin Dunbar, Dan Zwartz and Cliff Atkins (SGEES) combined with glacial modelling also by Nick is providing important insights into the interpretation of Ross Sea Antarctic geological drill core records.

While picking a single stand-out performance is always tough within such a talented group, the research highlight for me comes from Lionel Carter's ANZICE Programme, which is into its final year of funding from the former MSI. This collaborative programme has taken a holistic approach to assessing the impact of climate changes in Antarctica and the Southern Ocean on the Southwest Pacific and New Zealand. This has been achieved through the integration of ice, marine and lake sediment records of past warm climate analogues, together with an understanding of glacial, ocean and atmospheric processes from numerical modelling. ANZICE addresses a fundamentally important issue - that future climate projections indicate a range of climate changes not experienced during the instrumental period (since ~1850), and can only be properly assessed from past "warmer-than-present climates" recorded in geological and ice core records. On any metric, such as research outcomes, stakeholder/end user benefits or education and outreach, the ANZICE Programme has delivered outstanding value on a budget of $400K pa. Over five years the ANZICE team of Gavin Dunbar, Nancy Bertler, Tim Naish, Peter Barrett, Brian Anderson and Andrew Mackintosh have produced 32 peer-reviewed papers, 60 conference presentations, supervised 17 PhD and MSc students, and has delivered more than 50 public outreach and stakeholder products (reports, talks, media interviews, briefings etc.). In addition the programme has leveraged another ~$400K pa through scholarships, fellowships and other external funding. The loss of the core funding for the ANZICE Programme at the end of September 2012 will put at risk this world-class research capability.

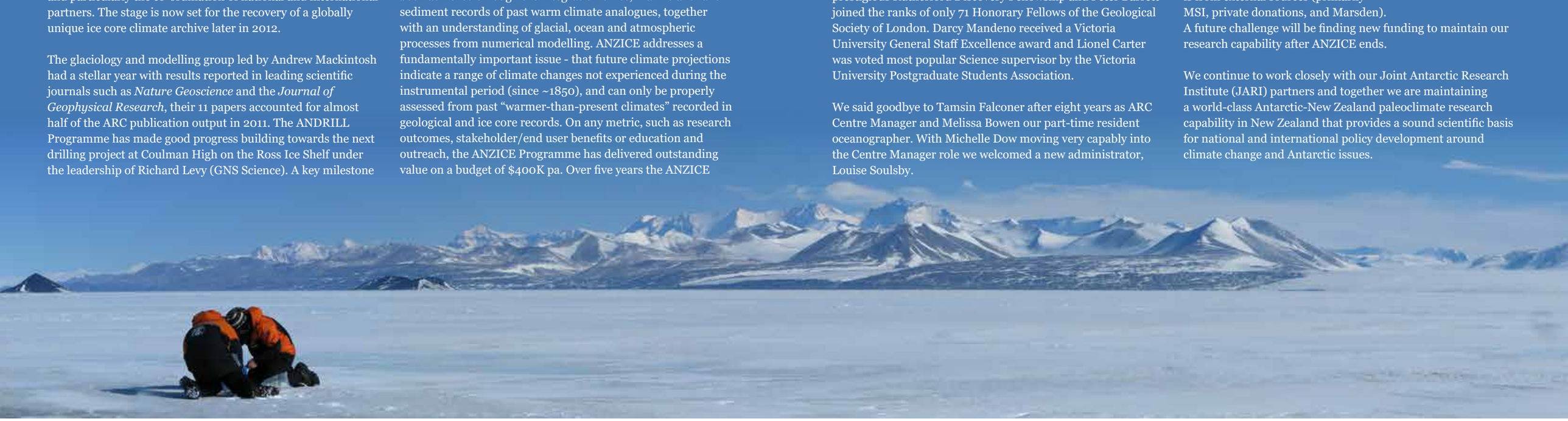
The individual achievements of some ARC staff are also recognised. Rob McKay was awarded the Prime Minister's MacDiarmid Emerging Scientist Prize, Nancy Bertler received a prestigious Rutherford Discovery Fellowship and Peter Barrett joined the ranks of only 71 Honorary Fellows of the Geological Society of London. Darcy Mandeno received a Victoria University General Staff Excellence award and Lionel Carter was voted most popular Science supervisor by the Victoria University Postgraduate Students Association.

We said goodbye to Tamsin Falconer after eight years as ARC Centre Manager and Melissa Bowen our part-time resident oceanographer. With Michelle Dow moving very capably into the Centre Manager role we welcomed a new administrator, Louise Soulsby.

During 2011 ARC had 19 staff and 31 graduate students. It was pleasing to see nine students complete and go onto institutions overseas for postdoctoral studies, or into the work force. It remains a concern that our brightest and best are highly sought after overseas, but struggle to find a bridge to research careers in New Zealand. The ARC received $2.22M in revenue and had an expenditure of $2.09M. Our contribution to University overheads increased to $253K higher than previous years. 75% of our revenue is from external sources (primarily MSI, private donations, and Marsden).
A future challenge will be finding new funding to maintain our research capability after ANZICE ends.

Professor Tim Naish, Director
Antarctic Research Centre

We continue to work closely with our Joint Antarctic Research Institute (JARI) partners and together we are maintaining a world-class Antarctic-New Zealand paleoclimate research capability in New Zealand that provides a sound scientific basis for national and international policy development around climate change and Antarctic issues.



Royal Society Range, Antarctica (Photo: Dan Zwartz)

OUR PEOPLE

Antarctic Research Centre Advisory Board Members

David Bibby (Convener)	Dean of Science, Architecture & Design, and Engineering, Victoria University of Wellington
Ian Graham	General Manager-Research, GNS Science
Mike Hannah	Head of School of Geography, Environment and Earth Sciences, Victoria University of Wellington
Wendy Lawson	Gateway Antarctica and Geography Department, University of Canterbury
Alex Malahoff	CEO, GNS Science
Ian McIntosh	Manager, Research & Commercial, Victoria University
Rob Murdoch	General Manager-Research, NIWA
Lou Sanson	CEO, Antarctica New Zealand
Caroline Schwalger	Antarctic Policy Unit, Ministry of Foreign Affairs & Trade
under appointment	MSI representative

Staff (* left the ARC in 2011)

Tim Naish (Director)	Professor (0.8 FTE)	Sedimentology and paleoclimatology
Brian Anderson	Research Fellow (0.67 FTE)	Glacial modelling
Peter Barrett	Professor of Geology (0.65/0.7 FTE)	Stratigraphy and Antarctic climate history
Nancy Bertler	Senior Research Fellow (0.5 FTE)	Ice core climatology
Melissa Bowen*	Senior Research Fellow (0.2 FTE)	Physical oceanography
Lionel Carter	Professor in Marine Geology (0.8 FTE)	Marine geology
Warren Dickinson	Senior Research Fellow (0.2 FTE)	Sedimentary petrology and permafrost
Michelle Dow	Administrator/Centre Manager (0.8 FTE)	Paleontology and climate change
Gavin Dunbar	Senior Research Fellow (1.0 FTE)	Marine geology
Tamsin Falconer*	Centre Manager (1.0 FTE)	Sea ice, drilling, Antarctic history and art
Nick Golledge	Postdoctoral Fellow (1.0 FTE)	Glacial modelling and paleoclimatology
Catherine Hines*	Administrator (0.8 FTE)	Art
Huw Horgan	Research Fellow (1.0 FTE)	Ice sheet dynamics
Andrew Mackintosh	Senior Lecturer (0.5 FTE)	Glacial geology and glacial modelling
Darcy Mandeno	Operations and Field Engineer (1.0 FTE)	Antarctic drilling
Rob McKay	Postdoctoral Fellow (1.0 FTE)	Sedimentology
Alex Pyne	Projects Manager (1.0 FTE)	Antarctic logistics and drilling technology
Louise Soulsby	Administrator (0.5 FTE)	Art history and philosophy
Dan Zwartz	Research Fellow (1.0 FTE)	Antarctic ice sheets and sea-level

Associated Researchers

Cliff Atkins	Lecturer in Geology	Sedimentary processes and environments
Joel Baker	Professor of Geochemistry	Paleoceanography and paleoclimatology
Ruzica Dadic	Visiting Research Fellow	Snow and ice processes
Mike Hannah	Associate Professor in Geology	Marine palynology and biostratigraphy
Simon Lamb	Associate Professor	Science communication

Postgraduate Students (* thesis completed in 2011)

Annette Bolton*	PhD candidate	Paleoceanography
Rosie Cody	PhD candidate	Paleoecology and biostratigraphy
Lana Cohen	PhD candidate	Ice core climatology
Alice Doughty	PhD candidate	Glacial modelling
Shaun Eaves	PhD candidate	Glacial geology
Daniel Emanuelsson	PhD candidate	Ice core climatology
Aitana Forcen Vasquez	PhD candidate	Physical oceanography
Jeremy Fyke*	PhD candidate	Ice/ocean modelling
Rachel Gavey*#	PhD candidate	Marine geology
Richard Jones	PhD candidate	Glacial geology
Andrea Logan	PhD candidate	Ice core climatology
Julene Marr	PhD candidate	Marine geochemistry
Molly Patterson	PhD candidate	Sedimentology and paleoclimatology
Joe Prebble	PhD candidate	Palynology
Rachael Rhodes*	PhD candidate	Ice core climatology
Matt Ryan	PhD candidate	Quaternary climatology
Katrin Sattler	PhD candidate	Geomorphology
Jane Chewings	MSc candidate	Sedimentology
Kylie Christiansen	MSc candidate	Paleoceanography
Bella Duncan	MSc candidate	Paleoceanography
Denise Fernandez	MSc candidate	Physical oceanography
Georgia Grant	MSc candidate	Paleoclimatology
Lawrence Kees*	MSc candidate	Glaciology and meteorology
Laura Kehrl	MSc candidate	Glaciology
Sanne Maas	MSc candidate	Sedimentology and paleoclimatology
Bradley Markle*	MSc candidate	Ice core climatology
Karen McKinnon*	MSc candidate	Glacial modelling
Ame Plant	MSc candidate	Paleoceanography
Kolja Schaller	MSc candidate	Glaciology
Stephen Stuart*	MSc candidate	Glacial modelling
Holly Winton*	MSc candidate	Ice core climatology

University of Southhampton student supervised by Lionel Carter

Arriving in Antarctica (Photo: Nancy Bertler)

Adjuncts

Helen Bostock	Adjunct Research Associate	Paleoceanography and geochemistry
James Crampton	Adjunct Professor	Paleontology
Robert DeConto	Adjunct Professor	Earth systems modelling and paleoclimatology
Robert Dunbar	Adjunct Professor	Climate dynamics and oceanography
Stuart Henrys	Adjunct Professor	Structural geology and seismic stratigraphy
Chris Hollis	Adjunct Professor	Micropaleontology
Richard Levy	Adjunct Associate Professor	Micropaleontology and biostratigraphy
Dave Lowe	Adjunct Professor	Atmospheric chemistry
Barrie McKelvey	Adjunct Professor	Antarctic ice sheet history
Helen Neil	Adjunct Associate Professor	Oceanography and geochemistry
Alan Orpin	Adjunct Research Associate	Marine geology
Ross Powell	Adjunct Professor	Sedimentology and climate change
Kate Sinclair	Adjunct Research Associate	Ice core climatology
Alexandra Thompson	Adjunct Research Associate	Atmospheric chemistry
Peter Webb	Adjunct Professor	Micropaleontology and biostratigraphy
Mike Williams	Adjunct Associate Professor	Ocean circulation and sea ice formation
Terry Wilson	Adjunct Professor	Structural geology and geotectonics

Other Academics with Antarctic Interests

Academics at Victoria University also represent a wide range of interests in the Antarctic region from tourism and law to literature and politics, with significant research in Antarctic biology and the properties of ice. Current University staff outside the ARC with Antarctic interests and expertise are listed below:

Sir Paul Callaghan*	Professor of Physics	Properties of sea ice
Margaret Harper	Research Associate in Geology	Freshwater algae
Malcolm Ingham	Senior Lecturer in Physics	Properties of sea ice
Bill Manhire	Professor of English	Antarctic literature
Mark McGuinness	Associate Professor of Mathematics	Modelling
Joanna Mossop	Senior Lecturer in Law	International law
Ronan O'Toole	Senior Lecturer in Microbiology	Environmental microbiology
Nigel Roberts	Professor of Political Science	Antarctic politics and history
Ken Ryan	Senior Lecturer in Antarctic Biology	Marine algae
Tim Stern	Professor in Geophysics	Solid earth geophysics and Transantarctic Mts
Ross Stevens	Senior Lecturer in Design	Design of remote field camps
Joe Trodahl	Emeritus Professor in Physics	Temperature conduction in ice and rock
Cath Wallace	Senior Lecturer in Business and Public Management	Antarctic environmental issues

* deceased

MSc student Rory Hart, WISSARD fieldwork, Antarctica (Photo: Huw Horgan)

ANTARCTIC CLIMATE HISTORY FROM SEDIMENTS

The 2011 year was another productive and successful year for the ANDRILL Programme where the focus continued on writing up results, and undertaking contextual studies for interpreting the drill core records and site survey work for future drilling. Planning with international partners for the ANDRILL Coulman High Project continued with key meetings of the ANDRILL Science Committee at the International Symposium on Antarctic Earth Sciences (ISAES) meeting in Edinburgh and American Geophysical Meeting (AGU) in San Francisco. This resulted in the development of an international science proposal representing USA, NZ, Germany, Korea, Italy, Brazil, and UK and submitted to the US National Science Foundation. The ANDRILL Coulman High Project will recover physical evidence for the response of the Antarctic ice sheets to high levels of atmospheric CO_2 experienced more than 34 million years ago and is scheduled for drilling in 2014-2015. MSc candidate, Sanne Maas, is continung analysis of sediment cores recovered from the Ross Ice Shelf in 2010 as part of the Coulman High Project site surveys.

Nick Golledge, with GNS Science colleague Richard Levy, published a new flow-line model for the Ferrar Glacier in the *Journal of Geophysical Research*, which provides insights into the response of the East Antarctic Ice Sheet during the warmer-than-present Early Pliocene (5-3 million years ago), confirming inferences from the ANDRILL drill cores in Western Ross Sea. Another major contribution from the ANDRILL Programme was a paper led by Andrew Mackintosh and involving Nick and Dan Zwartz, published in *Nature Geoscience*. The research reports a retreat history of the East Antarctic Ice Sheet since the Last Glacial Maximum (~18,000 years ago) based on an integration of onshore and offshore geological observations from the Amery outlet region and numerical ice sheet modelling, and sheds light on the role that marine drivers, such as ocean temperature and sea-level play on ice sheet retreat.

The "Dust Devils" were back in action again this year in Antarctica, with Dan, Cliff Atkins (SGEES), and Gavin Dunbar continuing their array of sampling on the sea-ice in McMurdo Sound and extending their range up into Terra Nova Bay where they received the support and hospitality of the Italian Antarctic Programme. In order to understand the origin, amount and distribution of wind-blown (aeolian) sediment in sea-ice that ultimately ends up on the seabed in western Ross Sea, they are developing numerical model simulations with the help of Nick. This work is an important part of Jane Chewing's MSc project which will integrate her field measurements of dust dispersal with a computer model to help investigate changes in sediment flux to the ocean under perturbed environmental conditions.

Nick was back in action this Antarctic field season with his collaborator, Canterbury PhD student Oliver Marsh, conducting GPS surveys on the Skelton Glacier as part of ongoing efforts to establish the dynamics and mass-balance controls of the present day Transantarctic Mountain Glacier system. With Richard Levy, they are using this data to develop numerical models, that are being applied to past boundary conditions relevant to warming climate scenarios.

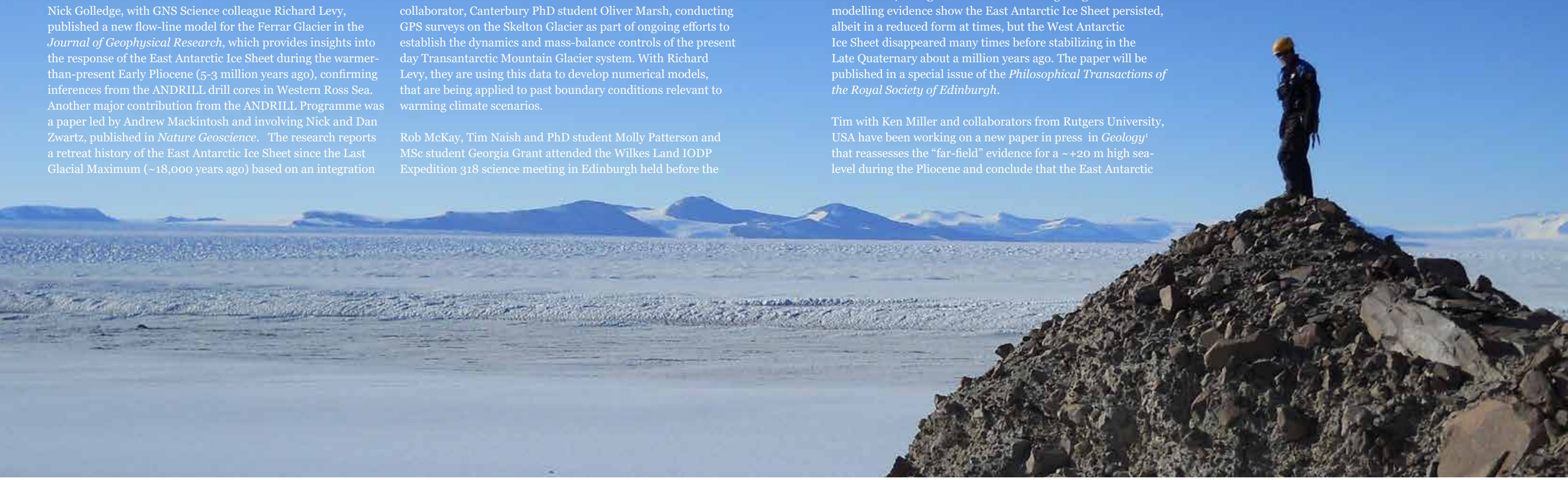
Rob McKay, Tim Naish and PhD student Molly Patterson and MSc student Georgia Grant attended the Wilkes Land IODP Expedition 318 science meeting in Edinburgh held before the ISAES Conference. Rob's team, supported by Tim's Marsden project which aims to understand the Antarctic ice sheets response to orbital (Milanovitch) cycles, are well under way analyzing the Pliocene-Pleistocene cores. While it is early days this work is making some exciting new discoveries about the response of the marine-based part of the East Antarctic Ice Sheet in Wilkes sub-basin during past warm interglacials and a period of sustained warmth in the Pliocene.

The ice sheet reponse to Pliocene warming has been the subject of considerable controversy over the last three years, often referred to as the "Sirius debate" on account of the glacial tills of the Sirius Group preserved along the Transantarctic Mountains and dated as Pliocene because of Pliocene marine microfossils extracted from them. Peter Barrett, who has been on both sides of the debate, presented a plenary paper at the recent ISAES Conference, in which he concluded that the Sirius Group deposits most likely formed before the Transantarctic Mountains rose to their present height prior to the middle Miocene ~14 Ma ago. Since that time both geological and modelling evidence show the East Antarctic Ice Sheet persisted, albeit in a reduced form at times, but the West Antarctic Ice Sheet disappeared many times before stabilizing in the Late Quaternary about a million years ago. The paper will be published in a special issue of the *Philosophical Transactions of the Royal Society of Edinburgh*.

Tim with Ken Miller and collaborators from Rutgers University, USA have been working on a new paper in press in *Geology*[1] that reassesses the "far-field" evidence for a ~+20 m high sea-level during the Pliocene and conclude that the East Antarctic Ice Sheet may have contributed up to +8 m of the global sea-level rise. These findings are significant as this was the last time Earth had an atmosphere with ~400 ppm carbon dioxide – today's levels. Peter, also working with the Rutgers group, produced a new compilation of deep sea oxygen isotope data to provide a deep sea temperature curve for the last 100 million years, that they published in the *Journal of Geophysical Research*.

Finally, after much effort Rob is very pleased to have confirmation that the paper he has led documenting major cooling of Antarctica in the Late Pliocene (~3 million years ago) and the role this may have played in the onset of Northern Hemisphere glaciations will be published in the *Proceedings of the National Academies*[2] in 2012.

1. Reported as 'in review' in *Science* in the 2010 Annual Review
2. Reported as 'in review' in *Nature* in the 2010 Annual Review



Tim Naish, Oliver Bluffs, Antarctica (Photo: Richard Levy, GNS Science)

SOUTHWEST PACIFIC AND SOUTHERN OCEAN HISTORY

The ocean change group, which includes the ANZICE (Antarctica-New Zealand Interglacial Climate Extremes) Programme, enjoyed another highly successful year marked by major research findings. Such achievement reflects the combined efforts of postgraduate students and ARC staff. The glacial modelling and ice core climatology objectives within ANZICE are reported in more depth in the following two separate sections, however the highlights of 2011 include:

Analysis of sediment cores from Lake Tutira, Hawkes Bay by Lionel Carter, Basil Gomez (UHawaii), Alan Orpin (NIWA), and others, shows that New Zealand's climate is strongly influenced by climate cycles from the Equator (El Niño-La Niña) and Antarctica (Southern Annular Mode). The 7000 year-old lake record suggests that the interaction of these climate forces affects storminess. Under the present phase of warming, the positive phase of the Southern Annular Mode has prevailed over Antarctica for the last ~50 years – a situation that appears to favour La Niña weather patterns. This was the case in 2011 when Southern Hemisphere nations received major floods under enhanced La Niña conditions.

Matt Ryan, PhD candidate supervised by Rewi Newnham (SGEES), Gavin Dunbar and Marcus Vandergoes (GNS Science), is continuing to expand the New Zealand vegetation history of the "superwarm" interglacial periods at 125 000 yrs and 440 000 years ago as recorded by fossil pollen from long sediment cores collected off the West Coast of South Island. As part of Matt's project he has received support from the Australian Institute of Nuclear Science and Engineering (AINSE) for radiocarbon ages to improve identification of offshore pollen transport and accumulation.

Joe Prebble is in the final stages of his PhD project, which uses dinoflagellate assemblages as palaeoenviromental indicators of climate/ocean change in the SW Pacific. This novel research has provided new paleo-proxies of ocean temperature and productivity, and is being used to unravel the response of the Tasman Sea and SW Pacific to warming under super-interglacial periods.

Techniques and calibrations were developed at Victoria University through research by ARC students Annette Bolton, Julene Marr and Kylie Christiansen. They used the ratio of calcium/magnesium in the shells of foraminiferal plankton, to determine the surface temperature in the SW Pacific Ocean. Two plankton species, dwelling at different depths, were found to be good thermometers of the ocean at ~50 m and ~150 m water depth. This allows us to determine (i) the thermal layering of the ocean surface, which is important for the production of marine plankton, (ii) the changing nature of water masses and (iii) the climatic factors that bring about such temperature changes. Annette Bolton was awarded her PhD in 2011 and is now working as a Postdoctoral Fellow at the University of Hong Kong. Bella Duncan is nearing completion of her MSc that examines the factors responsible for rapid changes in the base of the marine food chain which appears to switch from one dominated by animal plankton to one dominated by plant plankton – a switch that qualitatively appears to be occurring off central and southern New Zealand today.

A detailed study by MSc student Denise Fernandez, supervised by Melissa Bowen, uses satellite data on sea surface height and temperatures, to examine the response of wind-forcing on the confluence of subtropical and subantarctic ocean fronts and currents, east of New Zealand. The results show that the ocean has responded to increased windiness that is consistent with changing winds under the latest phase of global warming. The winds have intensified the local ocean fronts, which has implications for the distribution of surface heat and the production of plankton. Melissa's own research on the wind forcing of the Antarctic Circumpolar Current was presented at the International Union of Geodesy and Geophysics (IUGG) General Assembly. Regrettably, Melissa left the ARC at the end of 2011 to take up a full-time position at the University of Auckland (see article in "Significant Events" section pg. 18). One of Melissa's other sudents, Aitana Forcen Vasquez, now co-supervised by Mike Williams (NIWA) and Lionel Carter, is continuing her PhD work on the subantarctic oceanography of the New Zealand region.

Ame Plant is approaching completion of her MSc thesis which deals with the history of the Southern Ocean over the past 14 million years as revealed by trace element signatures preserved in the layers of a slow-growing polymetallic nodule from east of Campbell Plateau.

The study of modern sedimentary processes in the Ross Sea resulted in one completed MSc thesis "*Aeolian iron and its contribution to phytoplankton production in McMurdo Sound, southwestern Ross Sea, Antarctica*" by Holly Winton (awarded with distinction). Holly is writing a manuscript based on her thesis and will take up a PhD scholarship at Curtin University, Perth, Australia in May 2012.

PhD student, Jeremy Fyke helped develop a new coupled ice sheet/climate model that is capable of simulating the dynamic response of the Greenland and Antarctic ice sheets to climate change. The model consists of high resolution ice sheet models that are 'nested' within a global climate model. The resulting 'coupled' model captures the main interactions between ice sheets and climates, and successfully reproduces the modern surface conditions and geometry of the Antarctic and Greenland ice sheets. This new coupled ice sheet/climate model is a highly significant contribution to assessing past and future ice sheet/shelf behaviour, and their potential impacts on the oceans. Jeremy was awarded his PhD in 2011 and secured a Postdoctoral position at the prestigious Los Alamos Laboratory, USA.

Making scientific advances more accessible to policy makers and the wider public continued with a series of "user friendly" documents on the ANZICE webpages (www.victoria.ac.nz/antarctic/research/research-prog/anzice). These articles take the research results and 'translate' them for the non-specialist. In that vein, Dan Zwartz, Lionel Carter and Rhian Salmon (SGEES) have also collaborated with Dr Gareth Morgan and the Morgan Foundation to promote environmental change science and its significance. Lionel worked with Gareth on the oceangraphic science component of his 2011 book "Hook Line and Blinkers" and all three took part in the 2012 "Our Far South" expedition to make the public aware of the issues associated with environmental change in the Southern Ocean and Antarctica (www.ourfarsouth.org).

Drygalski glacier tongue from the air, Terra Nova Bay, Antarctica (Photo: Dan Zwartz)

GLACIOLOGY AND MODELLING

In 2011 the glaciology group included Andrew Mackintosh, Brian Anderson, Nick Golledge, Dan Zwartz, Huw Horgan, visiting Research Fellow Ruzica Dadic, and several students. Alice Doughty (PhD) and Laura Kehrl (MSc) are due to complete their studies in 2012, and they have been joined by new students, Shaun Eaves (PhD), Richard Jones (PhD), Kolija Schaller (MSc) and Rory Hart (MSc). A number of students submitted and successfully defended their theses, including Jeremy Fyke (PhD awarded in 2011), Karen McKinnon (MSc awarded in 2011) and Lawrence Kees (PhD submitted in 2011).

Laura Kehrl carried out a detailed study of ice dynamics at Franz Josef Glacier, which is the first of its kind in New Zealand. Huw Horgan was instrumental in arranging the loan of six high precision Trimble GPS units from Pennsylvania State University, which allowed us to accurately track the motion of the glacier. Laura followed this up with a model simulation of the glacier, which demonstrated that short-term velocity resulted from increased meltwater at the glacier bed.

Huw also led a geophysical expedition at the grounding line of Whillans Ice Stream as part of preparations for the WISSARD (Whillans Ice Stream Subglacial Access Research Drilling) Project. WISSARD is an interdisciplinary programme addressing the subglacial environment beneath this fast flowing ice stream. The project targets water, subglacial sediments, and biological communities at a subglacial lake and at the transition to the floating Ross Ice Shelf. Huw, along with seven others including Rory Hart, conducted seismic surveying, radar profiling, and distributed a network of GPS units across the ice stream.

Karen McKinnon completed her MSc modelling project studying the response of the Tasman Glacier to climate forcing, and in particular, the role of evolving bed topography on this response. She has also produced a draft manuscript.

Kolija Schaller and Brian Anderson carried out a ground penetrating radar study of the Annette Plateau Glacier near Mount Cook, which is a focus of the New Zealand Ice Core Project, led by Uwe Morgenstern (GNS Science). They are attempting to map the detailed three-dimensional structure of the glacier to improve ice core recovery in the future.

Ruzica Dadic submitted a manuscript on the sensitivity of glacier mass balance models to assumptions about turbulent heat fluxes, working with her Swiss colleagues as well as Brian and Andrew Mackintosh.

Nick Golledge headed to Antarctica to undertake glaciological fieldwork on Skelton Glacier, Transantarctic Mountains. Building on work carried out in 2010-11 on Beardmore Glacier, Nick and Oliver Marsh, a University of Canterbury PhD student, aimed to acquire high precision global positioning data along the centreline of the northern arm of the glacier, in order to calculate flow velocities and vertical movements arising from tides. They were able to deploy eight GPS receivers placed at increasing intervals between the floating portion of the glacier where it joins the Ross Ice Shelf, and the Skelton Neve at 1800 m above sea level. Data from this work will be used to constrain numerical models of the flow of the glacier, and together with data from Beardmore Glacier, will help to improve understanding of the behaviour of these large Transantarctic Mountain glaciers.

The group has been highly productive in 2011, both in publications and conference presentations. Andrew, Nick and Dan Zwartz wrote a paper about Antarctic deglaciation which was published in *Nature Geoscience*. Nick and Jeremy Fyke published separate articles detailing the development of new glacier/ice sheet models, published in *Journal of Geophysical Research* and *Geoscientific Model Development*, respectively. Victoria University graduate, Heather Purdie, published several papers from her PhD on snow accumulation processes in the Southern Alps of New Zealand, including one in *Global and Planetary Change*. Huw also published a paper about Ross Ice Shelf melting rates in *Journal of Geophysical Research*.

The group also made a strong showing at international conferences, including the International Union of Geophysics and Geodesy (IUGG) Congress in Melbourne (talks by Brian, Andrew and Jeremy), the International Symposium on Antarctic Earth Sciences (ISAES) in Edinburgh (talks by Andrew and Nick) and the International Union for Quaternary Research (INQUA) Congress in Bern, Switzerland (talks by Nick, Andrew, and students Alice and Karen).

Lawrence Kees conducting GPR measurements, Davis Snowfield, Franz Josef Glacier, New Zealand (Photo: Lawrence Kees)

ICE CORE CLIMATOLOGY

Nancy Bertler and Dr Sepp Kipfstuhl (Alfred Wegener Institute) measuring the electric conductivity of an ice core (Photo: Nancy Bertler)

Over the past year, the ice core group celebrated a major milestone by successfully beginning drilling of the 750 m deep ice core at Roosevelt Island. This record lies at the heart of the international, New Zealand-led Roosevelt Island Climate Evolution (RICE) Project. Over 50 scientists and 20 graduate students from New Zealand, Australia, Denmark, Germany, Italy, Republic of China, United Kingdom, and the United States are members of the RICE team who are eagerly awaiting for the processing and analysis of the first core material. The project aims to improve our understanding of the stability of the Ross Ice Shelf and the West Antarctic Ice Sheet (WAIS) in a warming world.

During the past Antarctic field season, the team deployed to Roosevelt Island for three and a half months. Upon arrival at Roosevelt Island, the group was greeted by brisk temperatures of well below -30°C. The field party of 11 people from New Zealand, United States, Germany, Australia, and Sweden first set-up camp, excavated the ~20 m x 4 m deep drill trench, that is between 3.5 and 8 m deep (see photos in "Science Drilling Office" section pg. 14). The new intermediate depth ice core drill was set-up and the core processing lines installed. The new drill performed well and produced between 1 and 2 m long cores of excellent quality. The core was drilled to a 130 m depth, and then the drill hole was reamed, cased and filled with a drilling fluid that balances the pressure and prevents the drill hole from closing. In addition, a number of shallow 10 m deep cores were recovered and hundreds of high resolution samples from snow pits and snow surface samples were taken. Professor Howard Conway (University of Washington) joined the team for two weeks to resurvey the 200 km^2 array of mass balance poles across the island and to conduct additional ground penetrating radar surveys. At the end of the field season the drill and generator tent were sealed against the winter weather and the remaining cargo, fuel and equipment for next year's season was stored away. The ice cores and snow samples were shipped with the US supply vessel, *Greenwave II*, to New Zealand and are now stored at -35°C in the National Ice Core Research Facility at GNS Science.

Results from previous ice core work, as part of the ANZICE Programme, showed that the chemistry and dust content in ice cores from coastal Antarctica helped identify air masses and their pathways. This identification of weather patterns and activity allows the extension of climate records back in time with high precision, providing a foundation for more accurate climate projections. Nancy Bertler, Paul Mayewski (University of Maine) and Lionel Carter also published a paper in *Earth and Planetary Science Letters* revealing the presence of the Little Ice Age (LIA), previously thought to be a Northern Hemisphere event, thus throwing into question the classical "see-saw" hypothesis. Its presence in Antarctica reveals the strong climatic links between hemispheres. While also evident in New Zealand, the LIA is less distinct suggesting its amelioration by subtropical climate and ocean.

Two new PhD students joined the field work this year. Andrea Logan, is studying the geochemical record of the RICE ice core, while Daniel Emanuelsson, from Sweden, will be studying the stable isotope record. Andrea and Daniel were selected as the 2011 recipients of the GNS Science Ice Core PhD Scholarships from over 60 applicants. In addition, Tom Beer (University of Maine) joined the team for his MSc on geochemical analysis of snow surface samples.

Back in New Zealand, students also celebrated significant successes. Rachael Rhodes defended her PhD thesis "*Insights into Late Holocene climate of the Ross Sea region, Antarctica, from high resolution ice core chemistry*" in which she presented and interpreted a huge body of data from the Mt Erebus ice core record. Rachael also published a paper on her work in *Chemical Geology* and accepted a Postdoctoral Fellowship with Professor Ed Brook at Oregon State University to work on continuous flow analysis of $\delta^{18}O$. Bradley Markle submitted his MSc thesis "*Dominant synoptic controls and influence of decadal climate oscillations in the Ross Sea region, Antarctica*" which interpreted the Gawn Ice Piedmont ice core. He has since accepted a PhD Scholarship to work with Professor Eric Steig (University of Washington) to study aspects of the WAIS ice core and has a paper accepted in the *Journal of Geophysical Research*. Holly Winton, submitted her MSc thesis on iron fertilisation in the Ross Sea from snow and sea ice samples, and has accepted a PhD scholarship with Associate Professor Ross Edwards to continue her exciting work on iron fertilisation at the University of Curtin, Perth, Australia. Lana Cohen, who had been previously awarded a two-year PhD scholarship - the Antarctica New Zealand Sir Robin Irvine PhD Scholarship - was awarded a one year Victoria University PhD Scholarship to finish her study on modelling snow precipitation characteristics at Roosevelt Island.

Nancy Bertler, was awarded one of ten prestigious Rutherford Discovery Fellowships (see article in "Significant Events" section pg 16). The award allows Nancy to focus on the scientific leadership of RICE and provides an additional PhD scholarship which has been awarded to Peter Neff who commences his PhD studies in 2012. Furthermore, Nancy accepted to serve as Chair for AntarcticClimate21. This new initiative is one of six research programmes currently submitted to the Scientific Council of Antarctic Research. The six year programme will assess climate predictions for Antarctica with a focus for the next 100 to 200 years and aims to quantify impacts on Antarctica's climate and environment and follow-on effects on the global climate system.

SCIENCE DRILLING OFFICE

The members of the Science Drilling Office were reduced to Alex Pyne and Darcy Mandeno when Business Manager, Tamsin Falconer left in April to work for Museums Wellington. The main focus of 2011 was the completion of the Victoria University ice coring drill and its first deployment at Roosevelt Island for the RICE (Roosevelt Island Climate Evolution) Project.

The testing of the prototype drill in Greenland in 2010 identified several improvements needed for the 2011-12 Antarctic field season. Darcy once again spent several weeks working with Pro Machining in Nelson to refine the drill parts and build a second outer barrel and new dry barrel. Darcy's unique core barrel flighting jig was also refined and this has made core barrel construction much faster and precise than the technique employed to make similar core barrels in Europe. This jig design has been shared with Danish and American ice coring colleagues. Other parts of the ice drill system were modified by Alex and the mechanical workshop at GNS Science supervised by Steve Mawdesley including the building of a portable core processing track that was set up at Roosevelt Island for the Antarctic field operation.

Darcy was again invited to participate in the NEEM (North Greenland Eemian Ice Drilling) Program in Greenland during 2011 spending six weeks as a drill mechanic/driller for the 400 m hole, wet drilling using the Hans Tausen drill which the Victoria University drill is copied from. The various drilling and mechanical issues encountered and resolved during the course of drilling this core provided invaluable experience for this seasons RICE ice drilling operation.

For field operations at the Roosevelt Island camp and in partnership with Antarctica New Zealand new power generators were developed to support the drilling operation with waste heat recovery used to melt snow for the water supply in the RAC tent kitchen and showering at the camp. This has certainly improved the functionality of the camp and morale for the team members who had a three month season camping in the snow.

The drilling operation at Roosevelt Island, from October to January, was very successful and achieved most of the goals planned. Once the camp was established the construction of the 14 m long drilling trench under the new 22 m long drill tent was the first major work with most of the team members taking part in cutting snow blocks with chainsaws and hauling them away. The drill was set up in the trench and worked well, dry coring to 130 metres below the surface (m.b.s.) with only minor commissioning and tuning problems. The upper hole was reamed to 206 mm using the reamer set borrowed (and modified) from Danish colleagues to install a 150 mm bore fibreglass casing to 62 m.b.s. The lower part of the hole was then reamed and filled with drill fluid ready for the start of wet drilling next season.

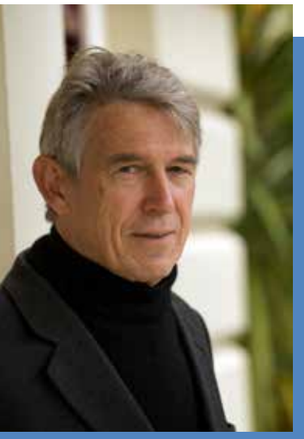
Alex once again attended the annual US ice core community IDDO (Ice Drilling Design and Operations) Technical Advisory Panel meeting in Madison, Wisconsin, where US ice coring technology was discussed in addition presentations of the technology planned for penetration of Lake Vostok (Russian) and Lake Ellsworth (British Antarctic Survey).

Alex and Frank Rack (ANDRILL Science Management Office at UNebraska-Lincoln) convened the second ANDRILL Engineering Task Force meeting in Houston hosted by Stress Engineering Services (SES). The taskforce's primary mission is the technical planning for drilling on the Ross Ice Shelf at Coulman High. The meeting reviewed new riser modelling for the Coulman High site, which had been carried out by SES with Alex's oversight, and also analysis of coring constraints by Marshal Pardey (QD Tech). The results of water column current measurements taken from under the ice shelf at Coulman High the previous 2010-11 Antarctic summer were also reviewed. The task force has confirmed a viable concept for drilling at this site where the ice shelf (drill platform) is moving in excess of 2 m per day.

Excavating the RICE Project drilling trench (Photos: Nancy Bertler)

SIGNIFICANT EVENTS

Honorary Fellow of The Geological Society



Peter Barrett
(Photo: Image Services, VUW)

Peter Barrett, Professor of Geology and founding Director of the ARC has been appointed an Honorary Fellow of The Geological Society of London.

Honorary Fellowships have been an important part of the Geological Society ever since it was founded in 1807. Honorary members brought the Society prestige, and as the Society began to extend its reach further, 'foreign members' began to be appointed. Today, the 71 Honorary Fellows fulfil this role and are recognised for their achievements, not only in science, but in acting as ambassadors for geological science and promoting its aims to the wider public.

"The Fellowship is a truly significant honour. I am particularly pleased to be associated with the society for its recent statement on climate change. I certainly share their view that it is…a defining issue of our time, whose full understanding needs geology's long perspective," says Peter.

Jim Kennett, a friend of the ARC and VUW alumni, and a Fellow of the US National Academies of Science, was visiting when Peter's latest honour was announced. "The list of honorary fellows is short and very distinguished, and it is befitting that Peter be recognised in this way for his enormous contribution", Jim said.

Peter has had a long and distinguished career in unravelling Antarctic geological history. A paper, published in *Science* in 1968 and reported in *Time* magazine, recorded his discovery of the first tetrapod remains in Antarctica, supporting the theory of continental drift. In 1972 Peter joined the first DSDP leg to the Antarctic, coring the Antarctic continental shelf for its geological history and went on to led over 20 expeditions to Antarctica. With this new Fellowship he is now one of only two New Zealanders to have received such a distinguished title.

Rutherford Discovery Fellowship

Nancy Bertler, who is jointly appointed by the ARC and GNS Science, was awarded a 2011 Rutherford Discovery Fellowship. Administered by the Royal Society of New Zealand, the Fellowships support New Zealand's most talented early-to mid-career researchers providing financial support of up to $200,000 per year over a five-year period to investigate a particular research topic, and help them further their career in New Zealand.

"It is a huge privilege and I'm excited about the research the Rutherford Discovery Fellowship will support," Nancy said.

Victoria University Vice-Chancellor Professor Pat Walsh says the Fellowship awards were a significant achievement. "These awards, set up by the Government last year [2010], will allow some of our best and brightest researchers achieve their potential to make an enormous contribution to New Zealand. We are pleased and proud that three of the ten Fellowships were awarded to Victoria University researchers. I am delighted to see those who have dedicated their career to discovery and world-leading research being supported and recognised in this way."

Nancy arrived in New Zealand from Germany in 1999 completing her PhD at Victoria University in 2004. She developed ice core research as a new discipline in New Zealand and now leads the National Ice Core programme. Nancy also manages the New Zealand Ice Core Research Laboratory and has led 11 expeditions to Antarctica to investigate the climate history of the Ross Sea region, including this past season as Chief Scientist of the international Roosevelt Island Climate Evolution (RICE) Project.

Nancy Bertler
(Photo: Image Services, VUW)

Prime Minister's MacDiarmid Emerging Scientist

Post-doctoral Fellow, Rob McKay received the 2011 Prime Minister's MacDiarmid Emerging Scientist prize presented in December. The prize, worth $200,000, was awarded for his research into past environmental change in Antarctica and its implications for the current phase of global warming.

Antarctic Research Centre Director, Tim Naish, describes Rob as the kind of talented, emerging scientist that New Zealand needs to maintain its world-class Antarctic and climate research capability. "This is a big honour for Rob and recognition of the importance of his contribution to understanding the behaviour of Antarctic Ice Sheets in a warmer world. Rob is an articulate communicator and has demonstrated leadership and scholarship on the international stage developing strong networks of international collaborators, bringing him and the group at the Antarctic Research Centre some exciting new opportunities."

Rob's winning science uses marine sedimentary records and glacial deposits to reconstruct episodes of melting and cooling in Antarctica over the past 13 million years and show how they influenced global sea levels and climate. "Uncertainty about how Antarctic ice sheets will respond to global warming remains one of the most important issues facing climate change scientists," Rob says. "Better knowledge in this area has particular relevance for New Zealand because we sit at a major gateway where water from Antarctica enters the world's oceans." To study this Antarctic link to New Zealand, he is also developing a five million year ocean-climate history from records collected from offshore eastern New Zealand.

Vice-Chancellor Professor Pat Walsh says he is very proud of Dr McKay's success. "He is an excellent and dedicated researcher, and it is wonderful to see our scientists being recognised at the highest level".

Rob first travelled to Antarctica in 1998 and has since taken part in two further scientific missions - the ANDRILL McMurdo Ice Shelf Project in 2005 and the Integrated Ocean Drilling Programme Expedition to Wilkes Land in 2010. Rob receives $50,000 of the prize money and is able to use the remaining $150,000 to support his on-going research.

Rob McKay (left) receiving his award from New Zealand Prime Minister, Hon. John Key (right)

Rob McKay on board the *JOIDES Resolution,* IODP Wilkes Land Cruise
(Photo: Rob McKay)

Fond Farewells

Tamsin Falconer (Photos: various)

The ARC's Centre Manager, Tamsin Falconer, resigned in April after almost eight years of service. During this time, Tamsin was instrumental in steering the ARC through rapid growth and setting-up the Science Drilling Office (SDO). She worked closely with SDO's Director, Alex Pyne, as Project and Business Development Manager. Her many achievements include coordinating the development of a Project Plan for the next phase of the ANDRILL Program's drilling on the Ross Ice Shelf at Coulman High, which she presented to international partners in Buenos Aries last August. She was also Project Coordinator of the successful Coulman High drill site surveys this season, overseeing an international team making hot-water access holes through the ice shelf to deploy oceanographic moorings and recover sea-floor sediment cores.

At her leaving function attended by friends, colleagues and stakeholders, both Peter Barrett and Tim Naish remarked on the incredible evolution of Tamsin in her time at the ARC. When Tamsin joined in 2003 the ARC was small consisting of Peter Barrett, Alex Pyne, and a couple of postdocs and students. She had returned from her OE holding a bachelors degree in architecture, having a penchant for museums and wondering where life might take her. Admittedly Antarctica was already in the Falconer family blood with her father Robin visiting by ship many years earlier. Then Tamsin headed there herself with Gateway Antarctica, and all became involved in the New Zealand Antarctic Society, where Tamsin held a committee position for many years. Tamsin witnessed and contributed to the growth of the ARC from those small beginnings to the large family it is today. This quietly-spoken efficient organiser not only became an aficionado with University finances handling many complicated research contracts, but she oversaw the shift and refurbishment of our current premises on the 5th floor of Cotton building, became adept at managing stakeholder relationships and functions, contributed to outreach and education in schools, and also developed an interest and expertise in scientific drilling and engineering! In 2010 Tamsin's outstanding contribution was recognised through a University General Staff Team Excellence Award.

Under Alex's expert guidance Tamsin provided critical support for the drilling operations during ANDRILL's first drilling seasons, spending three long summers in Antarctica between 2005-2008 as assistant to the Drill Site Manager, and just like her role back here she provided the "glue" that kept the operation running smoothly and successfully. The only blemish on her otherwise spotless record was when she directed Alex to drive the Hagglunds vehicle out of the field centre at Scott Base. Unfortunately the garage door was not all the way up and Alex tore it off! Late that night there was a special request on Scott Base radio for "The Doors" song "Break on through to the other side"!

Tamsin developed considerable skills in project management which she now combines with her interests in museums in her position at Museums Wellington.

Melissa Bowen (Photo: Image Services, VUW)

Melissa Bowen left the ARC at the year-end to take up a position in the School of Environment, University of Auckland. This is a significant loss because Melissa has made a substantial contribution to ARC science through her physical oceanographic expertise and the generous way she helped students and staff.

A PhD graduate from the prestigious Woods Hole Oceanographic Institute, she returned to New Zealand to take up a position at NIWA where she focused on the surface circulation of the Tasman Sea that was a combination of fundamental and applied research, the latter relating to the dispersal of fish larvae. Melissa joined the ARC in September, 2009, as a Senior Research Fellow, and although a part-time position, her contribution was major. She undertook supervision of MSc and PhD students, taught a 4th year ESCI course, joined a Marsden project as an investigator, conducted a course on wavelet analysis, published two papers and unfailingly provided much needed wisdom on a host of physical oceanographic matters. Such expertise is much needed considering we live on an ocean-dominated planet that is undergoing rapid environmental change. The ARC will greatly miss Melissa but we wish her every success in the new job and look forward to collaborative projects in the future.

S.T. Lee Lecture in Antarctic Studies

'Untroubled times are those we yearn most for'. The opening statement of the synopsis of this year's S.T. Lee Lecture presented by Professor Steven Chown, Director of the DST-NRF Centre of Excellence for Invasion Biology and Professor of Zoology at Stellenbosch University, South Africa. Professor Chown's highly engaging talk, *Lion Griefs in the Shade: Global Change Biology in the Antarctic* highlighted the rapid environmental changes occurring in apparently pristine biological systems, such as those of the terrestrial Antarctic. Across the region the signs of impact from the major environmental change drivers and their synergies are becoming more noticeable. Climate change is making many terrestrial areas more hospitable for indigenous organisms and for species from temperate areas. Distributions are changing rapidly, with the greening of areas that were previously free of closed vegetation making habitat change a significant consideration for the region. Warming in many areas is also benefitting non-indigenous over indigenous species. Although conservation management is feasible in many instances, the consequences thereof are frequently unanticipated. Professor Chown's talk can be downloaded from our website (www.victoria.ac.nz/antarctic/about/news/s-t-lee-lecture/lecture-2011).

(L-R) VUW Vice-Chancellor, Professor Pat Walsh, Professor Steven Chown, and Singapore High Commissioner, His Excellency M.P.H. Rubin (Photo: Image Services, VUW)

S.T. Lee Young Researcher

Marijke Habermann on Fox Glacier (Photo: Andrew Mackintosh)

In February, Marijke Habermann, a PhD student from the University of Alaska, Fairbanks (UAF), visited the ARC under the S.T. Lee Young Researcher Travel Award. Marijke's research in the Geophysical Institute at UAF focuses on numerical ice sheet modelling, specifically the use of inverse methods to infer bed properties beneath large outlet glaciers of the Greenland Ice Sheet from observed velocities. These glaciers are currently some of the fastest flowing glaciers on Earth, and so a better understanding of the physical controls that govern their behaviour is a goal that has potentially far-reaching significance.

During her time at Victoria University, Marijke worked with Nick Golledge to gain familiarity with the Parallel Ice Sheet Model - a UAF development that Nick has been using extensively since 2009. She gave an informative and detailed presentation of her work to ARC staff and students, and led a discussion in the glaciology group on her forthcoming *Journal of Glaciology* paper. In addition to office-based modelling work, Marijke participated in the Snow and Ice Research Group (SIRG) field meeting that took place in Fox Glacier township, presenting her research to other postgraduate students and academic researchers, and setting foot on New Zealand ice for the first time.

The ongoing collaboration between Victoria University and UAF continues to prove valuable in facilitating the exchange of ideas between the two institutions, and in a mutual benefit of exposure to novel and relevant expertise. This may be further enhanced in the coming year, with the 'International Symposium on Glaciers and Ice Sheets in a Warming Climate' taking place in Fairbanks in June 2012.

SIRG Meeting

The New Zealand Branch of the International Glaciological Society, known locally as the Snow and Ice Research Group (SIRG - www.sirg.org.nz), held its annual meeting in Fox Glacier between 9-11 February. The conference was organised by ARC PhD student Alice Doughty with assistance from Katrin Sattler (SGEES) and Karen McKinnon (ARC). Along with sessions on "Glacier behaviour and dynamics", "Fox and Franz Josef Glaciers", "Antarctica, Modelling and Climate and Permafrost", there was also a public lecture *Glaciers in our backyard* which featured the perspectives of three West Coast people; Cornelia Vernoorn from the Department of Conservation who manages ~7,000 visitors to the glacier each day; Graham Wilcox, who guides tourists on the glacier and assists scientists in monitoring ablation, and Brian Anderson, an ARC glaciologist, who monitors mass balance on the Fox and Franz Josef Glaciers with an interest in modelling the interactions between glaciers and climate.

The meeting was attended by 50 participants from five countries representing 13 institutions: NIWA, Victoria, Otago, Canterbury, and Massey universities from New Zealand and international scientists from the University of Fribourg (Switzerland), Swiss Federal Institute for Snow and Avalanche Research (Switzerland), Bristol Glaciology Centre (UK), University of Victoria (Canada), University of Washington (USA), University of Alaska, Fairbanks (USA), University of Queensland (Australia), and Curtin University (Australia). The majority of participants walked on the glacier, with some walking on a glacier for the first time, as they inspected and debated the origin of surface features such as ice pressure arches, conduits, crevasses, entrained debris and ice foliation.

JARI Workshop

The Joint Antarctic Research Institute (JARI) and GNS Science hosted a two-day workshop *Past Antarctic Climates* on the 6-7 April, which saw Antarctic paleoclimate researchers from NIWA, GNS Science, Otago, Canterbury, and Victoria universities, come together to present latest results and discuss future research directions and priorities. The workshop was ably convened by Richard Levy (GNS Science) with the support of Lionel Carter and Nancy Bertler (ARC). It provided an opportunity for the larger multi-institutional MSI-funded programmes such as ANDRILL, ANZICE, Ice Coring (Global Change through Time), and Sea Ice to highlight achievements. It also enabled other more independent researchers to show how their research is aligned to some of the high-priority goals outlined in the new Antarctic-Southern Ocean research strategy. A successful evening session for stakeholders (funders and end-users) was held profiling some of the research outcomes and their importance for the Intergovernmental Panel on Climate Change's 5th Assessment Report. Lionel, Nancy, Tim Naish, Andrew Mackintosh, Peter Barrett, Warren Dickinson, Gavin Dunbar, and Rob McKay presented to the workshop and representatives from the Ministry of Foreign Affairs and Trade, Ministry of Science and Innovation, Ministry for the Environment, and the Climate Change Research Institute. An exciting planning session for future research directions focussed on the need for more data to validate models of past "warmer-than-present" climates and the impact of polar temperature amplification on the Antarctic ice sheets and climate system as the Earth continues to warm.

Exploring Fox Glacier, SIRG Meeting (Photo: Andrew Mackintosh)

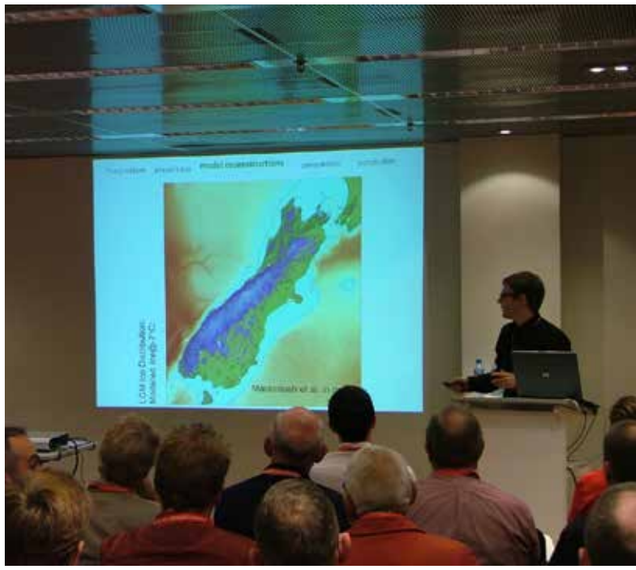
ISAES Symposium

The four-yearly International Symposium on Antarctic Earth Sciences (ISAES) was held this year in Edinburgh, Scotland from 10-16 July. It was ably convened by Professor Martin Siegert and his talented team in pink tee-shirts, and hosted at the historic University of Edinburgh beneath Arthur's Seat and Salisbury Crags where the geologist James Hutton developed some of his most famous theories on the formation of geological sequences. With this and a pre-conference fieldtrip by Alex Pyne, Rob McKay and Tim Naish to Isla and Arran to inspect the local peat, the scene was set for yet another very enjoyable and successful conference. There was a good turnout from ARC staff and students with Cliff Atkins (SGEES) and Warren Dickinson convening a vibrant session on cold-based glaciation. Andrew Mackintosh spoke on his recently published research in *Nature Geoscience* receiving a lot of interest, and Rob McKay and the rest of the Wilkes Land IODP Expedition members were presenting their initial results. This was also an opportunity for Rob's students Molly Patterson and Georgia Grant to interact with the rest of the Wilkes Land Team and the broader Antarctic community. Both presented posters and said they got tremendous value from the opportunity to participate (thanks to support from the ARC Endowed Development Fund). ANDRILL Program results were in the thick of it again with Nick Golledge, Rob McKay, Alex Pyne, Richard Levy (GNS Science) and Gary Wilson (UOtago) all presenting talks. Peter Barrett gave a fascinating historical overview of the progress in understanding the Late Neogene glacial history of Antarctica and the vexed Sirius Group debate in his Plenary, putting some old bones to rest (but not all). Tim Naish espoused the value of Antarctic paleoclimate research in the context of climate change and the IPCC in his Plenary Lecture. All in all it was a great gathering of old and new friends and colleagues, and great to see Antarctic geological research addressing some of the leading questions in global change research.

INQUA Congress

The International Union for Quaternary Research (INQUA) Congress is held every four years. In 2011, four members of the ARC glacial modelling group attended this event between the 21 and 27 July in Bern, Switzerland. INQUA is attended by several thousand scientists, and is the premier scientific event for discussing Earth's climate record over the last 2.6 million years. In particular, it is an exciting place to present cutting-edge science in the field of climate change.

One of the aims of the ARC's glacial modelling group is to use models to help understand the paleoclimate significance of New Zealand moraine records. The group showcased our newest findings in four oral presentations delivered by Andrew Mackintosh, Nick Golledge, Alice Doughty and Karen McKinnon in the sessions 'Glacier-climate sensitivities and paleoclimate implications', 'Pleistocene Glacial Chronologies and Paleoclimate Implications', 'Glacial overdeepening: processes, forms and significance' and 'Linking Southern Hemisphere multiproxy records and past circulation patterns'. Andrew commented how pleased he was to see both the students (Alice and Karen) deliver outstanding talks in front of their international peers.



Andrew Mackintosh presenting at INQUA Congress (Photo: David Lowe, Waikato University)

ARC Endowed Development Fund

The Victoria University Foundation holds approximately $450,000 in the ARC Endowed Development Fund. This substantial fund enables us to give grants to students for conference travel, workshops or writing papers on their research. This year's recipients included Kylie Christiansen and Sanne Maas (ARC) who attended the Geosciences Conference in Nelson, Georgia Grant (ARC) who attended the IODP Wilkes Land Meeting in Edinburgh, Julene Marr (ARC) particpated in the Goldschmit Conference in Prague, Molly Patterson (ARC) to attend the Urbino Paleoclimatology Summer School, Matt Ryan (ARC) attended the INQUA Congress in Bern, while Rebecca Cowie, Meghana Rajanahally (School of Biological Sciences), and Holly Winton (ARC), received funding to write-up papers following the completion of their theses.

Molly Patterson (right) discussing her research during Urbino Summer School poster session (Photo: Molly Patterson)

Matt Ryan during INQUA Congress fieldtrip to Rhone Glacier, Switzerland (Photo: Matt Ryan)

Awards & Appointments

- **Peter Barrett** appointed an Honorary Fellow of The Geological Society of London;
- **Darcy Mandeno** won a 2011 Victoria University General Staff Excellence Award;
- **Michelle Dow** appointed ARC Centre Manager in July;
- **Louise Soulsby** appointed ARC Administrator in September;
- **Lionel Carter** was voted 'Most Popular Supervisor - Science' for the Postgraduate Student Association's 2011 Victorias Awards;
- **Georgia Grant** won 'Best Talk' at the Wellington Geological Society Annual Beanland-Thornley student presentation night;
- **Joe Prebble** won the third place award for 'Student Oral Presentation' at the Geosciences Conference in Nelson;
- **Sanne Maas** awarded third place for best 'Student Poster Presentation' at the Geosciences Conference in Nelson.

Funding Success

- $1M over five years for **Nancy Bertler** - Rutherford Discovery Fellowship (shared with GNS Science);
- $300K over three years for **Brian Anderson** - FastStart Marsden grant;
- $150K for **Rob McKay** - Prime Minister's MacDiarmid Emerging Scientist prize;
- $50K from the Research Office for support of RICE Project (**Nancy Bertler**);
- $45K from NIWA for extending - Regional Modelling Project (**Andrew Mackintosh**).

Nick Golledge installing a GPS receiver on Skelton Glacier, Antarctica (Photo: Stu Arnold, Antarctica New Zealand)

TEACHING PROGRAMME

The Antarctic Research Centre supports a significant proportion of the teaching being carried out in the paleoclimatology research theme in SGEES. There is also close interaction between ARC staff and projects with other research programmes in geophysics, geology, physical geography, and the environmental studies programme. The teaching programme also includes supervision of graduate students at MSc and PhD levels. ARC staff contribute to the following courses:

Courses

Undergraduate Courses		Graduate Courses	
ESCI 111	Earth Systems & Global Change	ESCI 403	Stratigraphy and Palaeontology
ESCI 112	Fundamentals of Geology	ESCI 404	Special Topics
ESCI 132	Antarctica: Unfreezing the Continent	ESCI 412	Quaternary Geology
ESCI 201	Climate Change and NZ's Future	PHYG 414	Climate Change: Lessons from the Past
ESCI 204	Petrology and Microscopy	PHYG 416	Special Topic B
GEOG 220	Hydrology and Climate	ESCI440	Directed Individual Study
ESCI 241	Introductory Field Geology	PHYG580	Research Preparation
ESCI 301	Global Change: Earth Processes and History		
GEOG 323	Advanced Physical Environmental Processes		

ARC staff are particularly involved in ESCI 132 as it relates to Antarctica specifically and are the course co-ordinators for ESCI 201 and ESCI 301. The following outlines in more detail these three courses:

ESCI 132 - Antarctica: Unfreezing the Continent

Although primarily an introduction to the natural history of the Antarctic continent many other diverse topics are covered including:

- History of exploration of the continent;
- Antarctica's role as a recorder of past climate change;
- Its importance in any future change in climate;
- The geological history of Antarctica and the development of the ice sheets;
- The history of life on the continent;
- The human experience in Antarctica.

ESCI 201 - Climate Change and NZ's Future

Victoria University's involvement with research in climate history provides the background to this course. The course covers climate change from a variety of perspectives including:

- The causes and effects of climate change;
- Human-caused vs natural climate variability;
- Greenhouse gases and the role of fossil fuels;
- Climate scenarios for the future and their implications;
- Matauranga Maori ideas and its relevance;
- How government policy is responding to climate change;
- The Kyoto protocol and its implications for New Zealand.

ESCI 301 - Global Change: Earth Processes and History

This course aims to better understand and interpret evidence from the geological record of environmental change and how this knowledge can be used to help predict future variability through observational and numerical models. The main topics are:

- The dynamics and effects of polar and mountain ice systems;
- The processes controlling the modern ocean;
- Proxies of past environmental change in the world's oceans;
- Cenozoic evolution and variability of global climate and oceans.

ESCI301 Whanganui Basin fieldtrip (Photo: Sanne Maas)

Graduate Completions

Annette Bolton (PhD) "*LA-ICP-MS trace element analysis of planktonic foraminifera: An application for Marine Isotope Stage 31 in the southwest Pacific Ocean*". Supervised by Joel Baker (SGEES) and Lionel Carter.

Jeremy Fyke (PhD) "*Simulation of the global coupled climate/ice sheet system over millennial timescales*". Supervised by Lionel Carter, Andrew Mackintosh, and Andrew Weaver (UVictoria, Canada).

Rachael Rhodes (PhD) "*Insights into Late Holocene climate of the Ross Sea region, Antarctica, from high resolution ice core chemistry*". Supervised by Nancy Bertler and Joel Baker (SGEES).

Lawrence Kees (MSc) "*Assessment of a snow storage gradient across a maritime mountain environment; a Ground Penetrating Radar investigation*". Supervised by Brian Anderson and Andrew Mackintosh.

Bradley Markle (MSc) "*Dominant synoptic controls and influence of decadal climate oscillations in the Ross Sea region, Antarctica*". Supervised by Nancy Bertler and Joel Baker (SGEES).

Karen McKinnon (MSc) "*The role of climate and bed topography on the evolution of the Tasman Glacier since the Last Glacial Maximum*". Supervised by Andrew Mackintosh and Brian Anderson.

Stephen Stuart (MSc) "*Observations and modelling of precipitation in the Southern Alps of New Zealand*". Supervised by Andrew Mackintosh and Sam Dean (NIWA).

Holly Winton (MSc) "*Aeolian iron variability and its contribution to primary production in McMurdo Sound, SW Ross Sea, Antarctica*". Supervised by Nancy Bertler and Gavin Dunbar.

COLLABORATIONS

Joint Antarctic Research Institute (JARI)

In 2011, JARI continued to foster communication and collaboration on joint Antarctic paleoclimate research and saw Otago and Canterbury universities join established partners NIWA, GNS Science and Victoria University. Tim Naish continued into his third and final year as Director. Much of the JARI focus was on the development of the New Zealand Antarctic Research Institute (NZARI), being led by Antarctica New Zealand, who have set-up a private-public research partnership, that will strategically align MSI funded Antarctic research alongside new private funding from the US-based Julian Robertson Foundation. A potential "research grand challenges" developed by JARI partners focussed on Antarctic and Ross Sea environmental change in a warmer world and the downstream impacts on New Zealand were outlined at the NZARI science planning meeting, convened by Gary Wilson (UOtago) and hosted by the Cawthron Institute in Nelson. These concepts were developed further at the JARI Past Antarctic Climates workshop, convened by Richard Levy (GNS Science) (see article in "Significant Events" section). The JARI Board have endorsed the NZARI concept and it is envisaged that the JARI will ultimately evolve into the climate/paleoclimate research capability of the NZARI.

Visitors

The ARC had a number of visiting academics during 2011 including:

Katie Brennan, Victoria University, Canada;
Professor John Chappell, retired;
Professor Steven Chown, Stellenbosch University, South Africa;
Professor Paul Fitzgerald, Syracuse University, USA;
Professor Basil Gomez, University of Hawaii, USA;
Professor Robert Jacobel, St. Olaf College, USA;
Associate Professor Brian Jones, University of Wollongong, Australia;
Emiritus Professor James Kennett, University of California, USA;
Dr Maisa Rojas, University of Chile;
Dr Martin Schneebeli, WSL Institute for Snow and Avalanche Research Centre, Switzerland;
Dr Damon Teagle, National Ocean Centre, Southampton, UK;
Associate Professor Terry Wilson, Ohio State University, USA;
Professor Ian Wright, National Ocean Centre, UK.

Visiting academic Professor Steve Chown with Nancy Bertler and Dean Peterson (L-R) on Wairarapa fieldtrip (Photo: Peter Barrett)

Staff and students within the ARC also worked closely with people from the following departments, institutes and organisations:

National Research Collaborators

- Antarctica New Zealand;
- Department of Geography, University of Otago;
- Department of Geology, University of Canterbury;
- Department of Geology, University of Otago;
- Department of Marine Science, University of Otago;
- Department of Physics, University of Otago;
- Gateway Antarctica, University of Canterbury;
- Geomarine Research Ltd.;
- GNS Science;
- NIWA;
- University of Auckland;
- University of Waikato.

National Stakeholders and End-users

- Antarctica New Zealand;
- Department of Conservation;
- Land Information New Zealand;
- Ministry for the Environment;
- Ministry of Fisheries;
- Ministry of Foreign Affairs and Trade;
- Ministry of Science and Innovation;
- Royal Society of New Zealand.

Industry Partners

- Pro Machining;
- Webster Drilling & Exploration Ltd.;
- WekaStitch.

International Collaborators

- Alfred Wegener Institute, Germany;
- ANDRILL Science Management Office, University of Nebraska-Lincoln, USA;
- British Antarctic Survey, UK;
- Cambridge University, UK;
- Climate Change Institute, University of Maine, USA;
- Colgate University, USA;
- Curtin University of Technology, Australia;
- Desert Research Institute, USA;
- ETH (Swiss Federal Institute of Technology), Switzerland;
- Harvard University, USA;
- Hamilton College, USA;
- IDDO (Ice Drilling Design & Operations), University of Wisconsin, USA;
- INGV (National Institute of Geophysics and Volcanology), Italy;
- James Cook University, Australia;
- Lamont Doherty Earth Observatory, Columbia University, USA;
- Macquarie University, Australia;
- Moss Landing Marine Laboratories, USA;
- New Mexico Tech, USA;
- Northern Illinois University, USA;
- Centre for Climate and Ice, Niels Bohr Institute, University of Copenhagen, Denmark;
- Oregon State University, USA;
- Raytheon Polar Services Company, USA;
- Stanford University, USA;
- The Australian National University;
- The Pennsylvania State University, USA;
- University of California-Santa Barbara, USA;
- University of Chicago, USA;
- University of Delaware, USA;
- University of Kansas, USA;
- University of Leeds, UK;
- University of Massachusetts, USA;
- University of Milan, Italy;
- University of Oslo, Norway;
- University of Sienna, Italy;
- University of Tokyo, Japan;
- University of Victoria, British Columbia, Canada;
- University of Wales, UK;
- University of Washington, USA;
- Virginia Institute of Marine Sciences, USA;
- Woods Hole Oceanographic Institution, USA.

Contribution to International Programmes

- ANDRILL (Antarctic geological Drilling Program);
- ATHENA (Advancing Technological and Environmental Stewardship for Subglacial Exploration in Antarctica);
- IODP (Integrated Ocean Drilling Program);
- IPCC (Intergovernmental Panel on Climate Change;
- IPICS (International Partnership on Ice Coring Sciences);
- ITASE (International Trans-Antarctic Scientific Expedition);
- LGP (Latitudinal Gradient Programme);
- SCAR-ACE (Antarctic Climate Evolution);
- SCAR-AGCS (Antarctica in the Global Climate System).

OUTREACH

Staff and students at the ARC were involved in a variety of outreach activities during the year. These activities include interviews (newspapers, radio and television), talks to community groups, school visits and newsletters, and allow us to present our research and knowledge to the wider community both here and overseas.

Media (Newspapers, Radio, and Television)

- **Radio New Zealand**: "Climate research reveals role of ocean warming", Andrew Mackintosh on *Nature Geoscience* paper, 17 January;
- **Science Media Centre**: "NZ-led research sheds light on historic ice sheet retreat", *Nature Geoscience* paper, 17 January;
- **Scoop**: "New findings on why Antarctic ice sheets melt", Andrew Mackintosh on *Nature Geoscience* paper, 17 January;
- **Antarctica New Zealand Media Release**: Matt Vance on Roosevelt Island Climate Evolution Project, Nancy Bertler (www.antarcticanz.govt.nz), 2 February;
- **Radio New Zealand "Our Changing World"**: Cliff Atkins and Jane Chewings feature on "Antarctic aeolian dust, sedimentation and phytoplankton blooms", 19 May;
- **Science Media Centre**: "Climate change and extreme weather in the News", Lionel Carter (www.sciencemediacentre.co.nz/2011/07/15/climate-change-and-extreme-weather-in-the-news/), 15 July;
- **Stuff**: "Climate change evidence undeniable", Lionel Carter (www.stuff.co.nz/environment/5287638/Climate-change-evidence-undeniable), 15 July;
- **Dominion Post**: "You have been warned", Lionel Carter, 15 July;
- **Dominion Post**: "Vic Professor wins prestigious award", Peter Barrett's Honorary Fellow, 4 October;
- **Radio New Zealand "Our Changing World"**: "Honor for Antarctic scientist", Peter Barrett's Honorary Fellow, 6 October;
- **Carbon News**: "Change a challenge, says pioneer Professor", Peter Barrett, 7 October;
- **Science News**: "Polar ice sheets are synchronised swimmers", Andrew Mackintosh comments on Weber *et al.* (2011) *Science* paper, 1 December;
- **Dominion Post**: "Antarctic researcher among top science award winners", Rob McKay, 16 December;
- **TV3 National News**: Tim Naish commenting on cracks developing in the Pine Island Glacier, December.

Public Talks, Events and School Visits

- **Auckland U3A**: Tim Naish, presentation on "Antarctica and climate change", 9 March;
- **JARI Symposium, GNS Science**: Tim Naish, Lionel Carter, Andrew Mackintosh, Nancy Bertler, Nick Golledge, Peter Barrett, Warren Dickinson, Gavin Dunbar, Rob McKay, Holly Winton, and Brad Markle presentations to Climate Change and Antarctic Research government stakeholders, 6 April;
- **Tawa College**: Dan Zwartz presentation on Antarctica, 5 May;
- **Royal Society Speakers Forum**: Tim Naish presentation to members of Parliament on "Antarctic big science and international science diplomacy", 10 May;
- **Redwood School**: Dan Zwartz presentation on Antarctica, 16 June;
- **Kiwi Conservation Club**: Cliff Atkins (SGEES) and Dan Zwartz presentation on Antarctica, 30 July;
- **Science Careers Expo**: Dan Zwartz represented the ARC, 11 August;
- **NZ International Polar Year workshop, NIWA**: Tim Naish talk on ANDRILL. Awarded best talk and airfare to the Monteal IPY Meeting, September;
- **NZCCRI seminar series**: Tim Naish talk on "Ice sheets and sea-level", 15 September;
- **AntarcticaNZ Board**: Peter Barrett talk on Antarctic "Big science" projects, 30 September;
- **NZCCRI Seminar Series**: Andrew Mackintosh talk on "Glaciers and ice sheets in a warming world", Andrew Mackintosh, 24 November.

ARC Newsletter - IceSked

The ARC continues to publish a twice-yearly newsletter for alumni, colleagues and stakeholders, which is distributed to over 400 recipients around the world. Issue 16, published in June, profiled the Roosevelt Island Climate Evolution (RICE) Project and farewelled our Centre Manager, Tamsin Falconer as well as highlighting the work by two of our PhD students, and acknowledging the recent student graduations and thesis completions.

Issue 17, published in December, celebrated the recent successes of our staff and students and introduced a new feature, "A Science Story" which profiles a recent ARC research discovery. Once again we also farewelled a member of the ARC, Senior Research Fellow Melissa Bowen.

'Antarctic dress-ups' - kids try on the old Antarctic field gear during a school visit (Photo: Sanne Maas)

FINANCES

The Antarctic Research Centre finances include both a cost centre budget and grant funds held by the Research Trust. In 2011, the ARC received a total of $2.22M in revenue with an expenditure of $2.09M (just over half covered staff salary costs). Although the separate cost centre budget recorded a $144K loss the research funding contribution to the University via overheads was $253K, which is higher than in previous years.

Revenue Sources

MSI

- ANDRILL Programme, VUW portion of GNS Science grant funded until September 2013;
- ANZICE Programme, extended in September 2011 for an additional year until September 2012;
- Regional Modelling, NIWA sub-contract extended in December 2011 until June 2012;
- Tasman Alps Glacier project, a GNS Science subcontract extended (with no further funding) for another year until September 2012;
- McKay Postdoctoral Fellowship, from June 2009 to May 2012.

PBRF

- Calculated by VUW based on external research funding that meets PBRF criteria, and the quality rating of ARC staff. The ARC does not receive funding for research degree completions directly, they are recorded within SGEES budget.

Private Donations (held by VUW Foundation)

- Golledge Postdoctoral Fellowship, funded from Alan Eggers donation until February 2012;
- Horgan Research Fellowship, funded from Alan Eggers donation through to March 2011;
- Morgan Family Charitable Foundation, supports Bowen and Zwartz, extended (with no further funding) until December 2012;
- ARC Endowed Development Fund, supported nine students in 2011 to travel to conferences and write papers.

Marsden

- Dunbar FastStart, extended (with no further funding) through to July 2011;
- Naish Marsden, funded until December 2012;
- Townend Marsden, supports work by Lionel Carter on this project.

Teaching

- From SGEES for teaching services by ARC staff.

Internal

- Office of DVC-Research, sponsorship to support the production of the climate change film;
- Office of DVC-Research, contribution to the New Zealand membership to the Integrated Ocean Drilling Program;
- Office of DVC-Research, contribution to support the RICE field season;
- Internal grants from the Science Faculty to support postgraduate student travel, summer research assistance and time for completed graduate students to write-up papers for publication.

Other

- Coulman High Project, funding from Antarctica New Zealand in support of a project plan and budget, and employment of field staff for the site survey, funding until February 2011;
- Hot Water Drilling, funding from US ANDRILL Science Management Office for site survey activities, no 2011 funding but grant remains open for future use;
- International Cables Protection Committee, contract with Lionel Carter;
- Ocean Drilling Review Committee, funding for Naish to attend meetings;
- IPCC, funding for Naish to attend IPCC authorship meetings;
- Funding from LINZ for support/maintenance of the Cape Roberts Tide Gauge.

Expenditure

People

- Covers all salaries, ACC, annual leave, superannuation and other associated people costs.

Research Direct Costs

- Includes expenditure directly associated with research projects such as field work costs, conference attendance, analyses, and consumables. This category also includes pay for Research Assistants.

Research Office and University Overheads

- Used by the University for administrative purposes and to cover services provided by the Research Office and central University.

Occupancy

- Based on a charge per square metre for office and working spaces within the ARC.

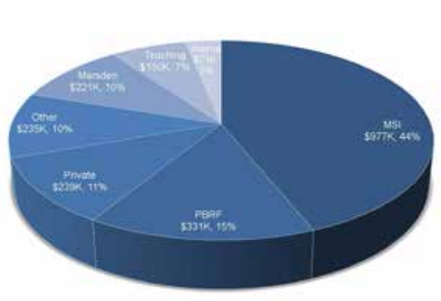
Depreciation

- Covers the costs of CAPEX purchases.

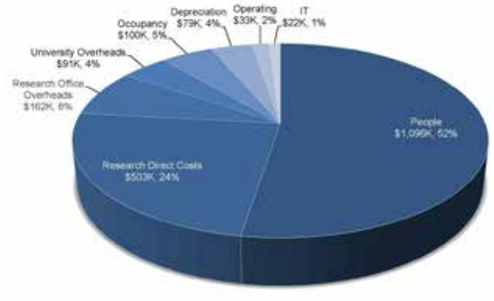
Operating

- Includes costs involved in the daily running of the Centre such as printing, catering, postage, and kitchen supplies.

The ARC actual revenue and expenditure for 2011 are summarized in the charts below (all figures are exclusive of GST), these figures combine the cost centre budget that operates over the VUW financial year (January-December) and Research Trust grant budgets which operate over the life of the project. As such, the year end balances for revenue versus expenditure in Research Trust grants are often out-of-phase.

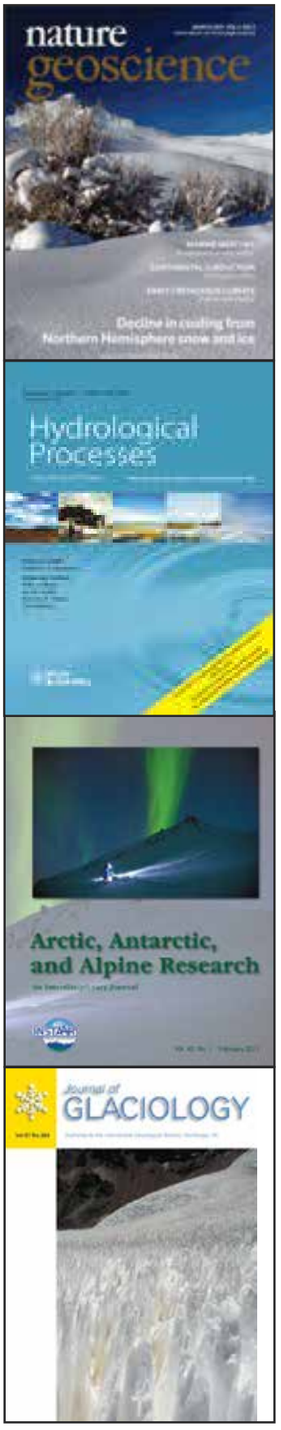


2011 Revenue Sources



2011 Expenditure

PUBLICATIONS AND CONFERENCES



Scientific Journals (24)

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Cramer, B.S., Miller, K.G., **Barrett**, P.J., Wright, J.D., 2011. Late Cretaceous–Neogene trends in deep ocean temperature and continental ice volume: Reconciling records of benthic foraminiferal geochemistry (δ18O and Mg/Ca) with sea level history. *Journal of Geophysical Research–Oceans* 116, C12023. doi:10.1029/2011JC007255.

Finlayson, A.G., **Golledge**, N.R., Bradwell, T., Fabel, D., 2011. Evolution of a Lateglacial mountain ice cap in northern Scotland. *Boreas* 40: 536-554, doi:10.1111/j.1502-3885.2010.00202.x.

Fyke, J., Weaver, A., Pollard, D., Eby, M., **Carter**, L., **Mackintosh**, A., 2011. A new coupled ice sheet-climate model: Description and sensitivity to Eemian, Last Glacial Maximum, late Holocene and modern conditions. *Geoscientific Model Development* 4: 117-136.

Galeotti, S., Lanci, L., Florindo, F., **Naish**, T., Sagnotti, L., Sandroni, S., Talarico, F., (in press). Cyclochronology of the Eocene–Oligocene transition from the Cape Roberts Project-3 core, Victoria Land basin, Antarctica. *Palaeogeography, Palaeoclimatology, Palaeoecology*, doi:10.1016/j.palaeo.2011.08.011 (available online 2011).

Golledge, N.R., and Levy, R.H., 2011. Geometry and dynamics of an East Antarctic Ice Sheet outlet glacier, under past and present climates. *Journal of Geophysical Research* 116, F03025, doi:10.1029/2011JF002028.

Gomez, B., **Carter**, L., Orpin, A., Cobb, K., Page, M., Trustrum, N., Palmer, A., 2011. ENSO / SAM interactions during the middle and late Holocene. *The Holocene* 22(1): 23-30, doi:10.1177/0959683611405241.

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Herman, F., **Anderson**, B.M., and Leprince, S., 2011. Mountain glacier velocity variation during a retreat-advance cycle quantified using high-precision analysis of ASTER images. *Journal of Glaciology* 57(202): 197-207.

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Horgan, H., Walker, R.T., Anandakrishnan, S., Alley, R.B., 2011. Surface elevation changes at the front of the Ross Ice Shelf: Implications for basal melting. *Journal of Geophysical Research* 116, C02005, doi:10.1029/2010JC006192.

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Sutton, P.J.H. and **Bowen**, M.M., 2011. Currents off the west coast of Northland, New Zealand. *New Zealand Journal of Marine and Freshwater Research* 45(4): 609-624.

Talarico, F.M., **McKay**, R.M., Powell, R.M., Sandroni, S., **Naish**, T., (in press), Late Cenozoic oscillations of Antarctic ice sheets revealed by provenance of basement clasts and grain detrital modes in ANDRILL core AND-1B. Global and Planetary Change, 80-81, doi:10.1016/j.gloplacha.2009.12.002. (available online 2011).

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Fyke, J., 2011. Simulation of the global coupled climate/ice sheet system over millennial timescales. Unpublished PhD Thesis, Victoria University of Wellington, Wellington. 175pp.

Kees, L., 2011. Assessment of a snow storage gradient across a maritime mountain environment; a Ground Penetrating Radar investigation" Unpublished MSc Thesis, Victoria University of Wellington, Wellington.

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Rhodes, R., 2011. Insights into Late Holocene climate of the Ross Sea region, Antarctica, from high resolution ice core chemistry. Unpublished PhD Thesis, Victoria University of Wellington, Wellington. 231pp.

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Litchfield, N.J.; Page, M.J.; Upton, P.; Gomez, B.; **Carter**, L., Vandergoes, M., 2011. Last Glacial Maximum to present paleoclimate and paleovegetation records from the North Island East Coast; selection for input into a climate-driven hydrological transport model. *GNS Science Report 2011/20*: 24pp.

National Research Council (**Naish**, T.), 2011. *Scientific Ocean Drilling: Accomplishments and Challenges*. Washington, D. C.: The National Academies Press

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Atkins, C., and **Dickinson**, W., 2011. Glacial geology: Processes and products, with particular emphasis on cold-based glaciers. *11th International Symposium on Antarctic Earth Sciences*, Edinburgh, Scotland, 10-16 July 2011.

Cullen, N., Cogley, G., Jansson, P., **Mackintosh**, A., 2011. Glacier and ice cap fluctuations. *XXVth International Union of Geodesy and Geophysics General Assembly - Earth on the Edge: Science for a Sustainable Planet*, Melbourne, Australia, 28 June – 7 July 2011.

Dickinson, W. and **Carter**, L., 2011. New Zealand coasts and margins. *Geosciences 2011 Conference*, Nelson, New Zealand, 27 November-1 December 2011.

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Conference – Invited Oral Presentations

Barrett, P.J., 2011. Reconciling views on Antarctic Neogene glacial history, 2011. *11th International Symposium on Antarctic Earth Sciences*, Edinburgh, Scotland, 10-16 July 2011.

Carter, L., 2011. Natural causes of cable faults: Hazard occurrence, trends and case studies. *Centre for International Law*, Singapore, 14 April 2011.

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Anderson, B., Goodsell, B., Owens, I.F., Willis, I.C., Lawson, W.J., **Mackintosh**, A.N., 2011. Diurnal to decadal ice velocity variations on Franz Josef Glacier (Ka Roimata o Hine Hukatere), South Westland, New Zealand. *XXVth International Union of Geodesy and Geophysics General Assembly - Earth on the Edge: Science for a Sustainable Planet*, Melbourne, Australia, 28 June – 7 July 2011.

Anderson, B., and **Mackintosh**, A., 2011. Glacier geometry and hydrology changes in the Southern Alps, New Zealand. *XXVth International Union of Geodesy and Geophysics General Assembly - Earth on the Edge: Science for a Sustainable Planet*, Melbourne, Australia, 28 June – 7 July 2011.

Atkins, C., **Dickinson**, W., Joy, K., Storey, B., 2011. Influence of cold-based glaciers on landscape development. *11th International Symposium on Antarctic Earth Sciences*, Edinburgh, Scotland, 10-16 July 2011.

Barrett, P., 2011. A revised understanding of deep ocean temperatures through the Cenozoic. *Joint Antarctic Research Institute Symposium on Past Antarctic Climate*, GNS Science, Lower Hutt, New Zealand, 6-7 April, 2011.

Barrett, P.J.,2011 Global temperature over human, ice age and geological time-scales. In: N.J. Litchfield and K. Clark (Eds.), Abstract volume, Geosciences Conference, Nelson, 27 November-1 December 2011. *Geoscience Society of New Zealand Miscellaneous Publication 130A*: p. 14

Barrett, P.J., 2011. Cenozoic climate: From proxy reconstructions to model assessments IV. *American Geophysical Union Fall Meeting*, San Francisco, USA, 5-9 December 2011.

Bertler, N., 2011. Little ice age. *Joint Antarctic Research Institute Symposium on Past Antarctic Climate*, GNS Science, Lower Hutt, New Zealand, 6-7 April, 2011.

Bowen, M., 2011. Remote Influences of boundary current variability on extra-tropical sea surface temperature. *XXVth International Union of Geodesy and Geophysics General Assembly - Earth on the Edge: Science for a Sustainable Planet*, Melbourne, Australia, 28 June – 7 July 2011.

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LIST OF ACRONYMS

ANDRILL	ANtarctic geological DRILLing
ANZICE	Antarctica-New Zealand Interglacial Climate Extremes (ARC FRST-funded programme)
DSDP	Deep Sea Drilling Project
ESCI	Earth Science (a Victoria University course code)
FTE	Fulltime Equivalent
GEOG	Geography (a Victoria University course code)
GNS Science	Institute of Geological and Nuclear Sciences Ltd.
GPS	Global Positioning System
IDDO	Ice Drilling Design & Operations (University of Wisconsin)
IODP	Integrated Ocean Drilling Program
IPCC	Intergovernmental Panel on Climate Change
ISAES	International Symposium on Antarctic Earth Sciences
JARI	Joint Antarctic Research Institute
JOIDES	Joint Oceanographic Institutions for Deep Earth Sampling
LA-ICP-MS	Laser Ablation Inductively Coupled Plasma Mass Spectrometry
LINZ	Land Information New Zealand
NEEM	North Greenland Eemian Ice Drilling (University of Copenhagen, Denmark project)
NIWA	National Institute of Water and Atmospheric Research
NZCCRI	New Zealand Climate Change Research Institute
PBRF	Performance Based Research Fund
PHYG	Physical Geography (a Victoria University course code)
RICE	Roosevelt Island Climate Evolution (ice coring project)
SDO	Science Drilling Office
SGEES	School of Geography, Environment and Earth Sciences
U3A	University of the Third Age (retired members organisation)
VUW	Victoria University of Wellington
WISSARD	Whillans Ice Stream subglacial Access Research Drilling (a US Program)

Pressure ridges, Ross Ice Shelf, Antarctica (Photo: Nick Golledge)

Gavin Dunbar and Cliff Atkins near New Harbour, Antarctica (Photo: Dan Zwartz)

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