Antarctic Research Centre

ANNUAL REVIEW 2009

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

CONTENTS

FROM THE DIRECTOR

The 2009 year presented a number of challenges, but was ultimately another very successful year for the Antarctic Research Centre. The ARC continued to grow with the appointment of new staff: Darcy Mandeno as Operations and Field Engineer (1.0FTE), Nick Golledge as a Post-Doctoral Fellow (1.0FTE), Gigi Woods as a Sedimentology Technician (0.4FTE) shared with the School of Geography, Environment and Earth Sciences (SGEES), Melissa Bowen as a Senior Research Fellow in physical oceanography (0.2FTE), and Dan Zwartz and Huw Horgan as Research Fellows in Antarctic ice sheets and sea-level (both 1.0FTE). Dan started in February 2010 and Huw joins us in May 2010. Our burgeoning staff numbers were accommodated in new offices created within the existing footprint of the ARC. At the end of 2009 we had 7.1FTE Academic/ Research Staff (3 Professors, 1 Senior Lecturer, 4 Senior Research Fellows, 1 Research Fellow, and 2 Post-Doctoral Fellows), 1.0FTE Projects Manager, 1.0FTE Engineer, 0.3FTE Science Communication Fellow, 0.4FTE Sedimentology Technician, 1.8FTE Centre Manager and Administrator, 8 PhD and 10 MSc students. Our 2009 budget was $2M.

In 2009 ARC staff led the delivery of new science results at several international meetings (eg. American Geophysical Union, European Geosciences Union, West Antarctic Ice Sheet Initiative, Scientific Committee on Antarctic Research – Antarctic Climate Evolution Symposium, Chapman Conference, Past Climates, and Climate and Biota of the Paleogene), and the publication of 32 high-profile publications in leading international journals (eg. *Nature*, *Bulletin of the Geological Society of America*, *Science*, *Geology*, *Journal of Geophysical Research*, *Journal of Climate*).

More than 60 international scientists attended the ANDRILL McMurdo Ice Shelf Science Integration Workshop held here at Victoria University from 10-13 February. George Denton, Libra Professor of Earth Sciences, University of Maine, presented this year's S.T. Lee Lecture "*Antarctica and the Ice Age Puzzle*", to a capacity audience on 15 May. The S.T. Lee Lecture was held in conjunction with the very successful Past Climates Meeting, which included a one-day symposium, a two-day INTegration of Ice-core, MArine and TErrestrial records (INTIMATE) workshop, and a public lecture by Prof. Wally Broecker (Lamont Doherty Earth Observatory, Columbia University). Ana Aguilar-Islas was this year's recipient of the S.T. Lee Young Researcher Travel Award, an exchange visit between the ARC and the International Arctic Research Center (IARC), University of Alaska Fairbanks. Ana's research at IARC has involved the study of sea ice-derived iron in the Bering Sea and its influence on the spring phytoplankton bloom. ARC was also represented at the first Antarctic Climate Evolution (ACE) Symposium held in Granada, in September aimed at integrating climate proxy data with climate models. The symposium included a workshop on Antarctic Landscape Evolution, and a two-day workshop for planning future strategic drilling campaigns for the next 20 years.

The partners in the Joint Antarctic Research Institute (NIWA, GNS Science and Victoria University of Wellington) formalized their partnership with the signing of the re-stated agreement at the International Polar Year Function in Wellington in July. The JARI sponsored two workshops: (1) This year's Ice Core Symposium was held on 8 October at GNS Science's National Isotope Centre, and (2) on 2 November, Victoria University hosted the first Glacier and Climate Modelling Workshop.

Successful re-bidding of the ANDRILL Programme as the PACAFI (Past Antarctic Climates and Future Implications) Programme in recent FRST Antarctic contestable funding round will result in a $500K p.a. subcontract to the ARC from contract holders GNS Science beginning in November 2010 for up to eight years. A new $770K Marsden Funded project titled "*How does Antarctica Ride the Milankovitch cycle*?" will help support analysis of Integrated Ocean Drilling Program cores being recovered from the Wilkes Land Margin of the Antarctic in early 2010. The Morgan Family Charitable Foundation donated $250,000 to the Antarctic Research Centre for "Antarctic climate research", reflecting Gareth Morgan's appreciation of the value of this work for today's world, which will help support our new research fellow appointments.

We continue to build on our close relationship with Antarctica New Zealand, through a more integrated approach towards support of our large field initiatives such as ANDRILL/PACAFI and ice coring. This support, together with that of our substantive collaborator GNS Science, and close working relationships with NIWA, Otago and Canterbury universities, is maintaining a world class Antarctic paleoclimate research capability in New Zealand.

Prof. Tim Naish, Antarctic Research Centre Director

Mission Statement

The ARC 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.

Antarctic Research Centre Advisory Board

Board Members:

David Bibby (convener), Dean of Science, Victoria University of Wellington
Mike Hannah, Head of School of Geography, Environment and Earth Sciences
Ruth Berry, FRST representative
Trevor Hughes, MFAT Antarctic Policy Unit
Wendy Lawson, Gateway Antarctica representative
Alex Malahoff, CEO, GNS Science
Ian McIntosh, Manager, Research & Commercial, Victoria University of Wellington
Rob Murdoch, Research Manager, NIWA
Tony Robinson, MoRST representative
Lou Sanson, CEO, Antarctica New Zealand

Antarctic Research Centre People

The Antarctic Research Centre was set up in the early 1970's, centering its research in the field of earth sciences. The staff, associated researchers, adjuncts, and students of the ARC along with their main research interests, are listed below:

Staff:

Tim Naish, Professor and Director (0.8)	Sedimentology and paleoclimatology
Brian Anderson, Research Fellow (0.67)	Glacial modelling
Peter Barrett, Professor of Geology (0.5)	Stratigraphy and Antarctic climate history
Nancy Bertler, Senior Research Fellow (0.5)	Ice core climatology
Melissa Bowen, Senior Research Fellow (0.2)	Physical oceanography
Lionel Carter, Professor in Marine Geology (0.7)	Marine geology
Warren Dickinson, Senior Research Fellow (0.2)	Sedimentary petrology and permafrost
Michelle Dow, Administrator (0.8)	Paleontology and climate change
Gavin Dunbar, Senior Research Fellow (1.0)	Marine geology
Tamsin Falconer, Centre Manager (1.0)	Sea ice, drilling, Antarctic history and art
Nick Golledge, Post-Doctoral Fellow (1.0)	Glacial modelling and paleoclimatology
Simon Lamb, Senior Fellow in Science Communication (0.3)	Climate change and science communication
Andrew Mackintosh, Senior Lecturer (0.5)	Glacial geology and glacial modelling
Darcy Mandeno, Operations & Field Engineer (1.0)	Antarctic drilling
Rob McKay, Post-Doctoral Fellow (1.0)	Sedimentology
Alex Pyne, Projects Manager (1.0)	Antarctic logistics and drilling technology
Gigi Woods, Technician (0.4)	Environmental science and estuarine pollution

Associated Researchers:

Cliff Atkins, Lecturer in Geology	Sedimentary processes and environments
Joel Baker, Professor of Geochemistry	Paleoceanography and paleoclimatology
Mike Hannah, Associate Professor in Geology	Marine palynology and biostratigraphy

Adjuncts:

Stuart Henrys, Adjunct Professor	Structural geology and seismic stratigraphy
Dave Lowe, Adjunct Professor	Atmospheric chemistry
Barrie McKelvey, Adjunct Professor	Antarctic ice sheet history
Ross Powell, Adjunct Professor	Sedimentology and climate change
Peter Webb, Adjunct Professor	Micropaleontology and biostratigraphy
Terry Wilson, Adjunct Professor	Structural geology and geotectonics
Richard Levy, Adjunct Associate Professor	Micropaleontology and biostratigraphy
Helen Neil, Adjunct Associate Professor	Oceanography and geochemistry
Mike Williams, Adjunct Associate Professor	Ocean circulation and sea ice formation
Helen Bostock, Adjunct Research Associate	Paleoceanography and geochemistry

Students:

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
Jeremy Fyke, PhD candidate	Ice/ocean modelling
Joe Prebble, PhD candidate	Palynology
Heather Purdie, PhD candidate	Glaciology and climatology
Rachael Rhodes, PhD candidate	Ice core climatology
Julia Bull, MSc candidate	Ice core climatology
Lawrence Kees, MSc candidate	Glaciology and meteorology
Julene Marr, MSc candidate	Marine geochemistry
Rory Mearns, MSc candidate	Palynology
Rebecca O'Donnell, MSc candidate	Glacial modelling
Matt Ryan, MSc candidate	Quaternary climatology
Matt Stevens, MSc candidate	Marine geology
Stephen Stuart, MSc candidate	Glacial modelling
Evelien van de Ven, MSc candidate	Antarctic crustal evolution
Holly Winton, MSc candidate	Ice core climatology

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:

Paul Callaghan, Professor of Physics	Properties of sea ice
Margaret Harper, Research Associate in Geology	Freshwater algae
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 School of 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

ANDRILL MIS delegates on a field-trip in the Wairarapa

Antarctic Climate History from Sediment Cores (ANDRILL Programme and IODP Wilkes Land Margin)

The 2009 year was another productive and successful year for the ANDRILL Programme. In March, new results from the ANDRILL Program, published in *Nature* (Naish *et al.*; Pollard and DeConto), provided an example of how paleoclimate records integrated with climate and ice sheet modelling can reveal past behaviour of the West Antarctic Ice Sheet as well as providing insights into future changes. Rob McKay led a publication of a landmark paper in the *Bulletin of the Geological Society of America* (McKay *et al.*). The paper provides detailed sedimentological interpretations of the AND-1B drill-core that document the history of ice sheet dynamics and the thermal evolution of the ice sheet in Ross Embayment using a range of modern glacimarine settings to interpret the glacial history. More than 60 of the international science team attended the highly successful ANDRILL McMurdo Ice Shelf Science Integration Workshop hosted at Victoria University in February. This workshop resulted in the development of two thematic special issues (*Global Planetary Change* and *Geochemistry, Geophysics and Geosystems*) to be published in 2010. These papers represent the bulk of the funded scientific analysis of the core. Mike Hannah (SGEES) was a co-author on a paper in *Geology* (Warny *et al.*) which documented a period of extreme warmth approximately 15 million years ago known as the Middle Miocene Climatic Optimum which was recovered by the ANDRILL-2A drilling.

Much of 2009 was focussed around developing a strategic plan for future Antarctic margin paleoclimate drilling based on international science imperatives from SCAR, the Antarctic Treaty System, and IPCC regarding high-priority questions surrounding the interactions between Antarctic ice sheets and global climate. This culminated in a two-day workshop led by Tim Naish, Richard Levy (GNS Science), Frank Rack (USA) and Laura DeSantis (Italy) held after the Antarctic Climate Evolution Symposium in September. The outcome was a draft strategic plan identifying high priority science questions and drilling platforms with the endorsement of the international community. A 'White Paper' on Antarctic paleoclimate drilling was also developed for the future plan of the Integrated Ocean Drilling Program. Peter Barrett was selected to participate as one of 12 international scientists writing this plan. Much of this thinking was incorporated from a New Zealand perspective into a 'White Paper' strategy document for FRST, to help guide future investment in Antarctic paleoclimate research prepared by Richard, Tim and Gary Wilson (UOtago). This strategy formed the basis of a successful, multi-institute (GNS Science, VUW, NIWA, UOtago, UCanterbury) collaborative research proposal in FRST-AntNZ's contestable funding round to support the new PACAFI (Past Antarctic Climate and Future Implications) Programme led by Richard. Victoria University and GNS Science will have equal contracts of $500K p.a. out of a total $1.36M p.a. for up to eight years.

This funding will cover site survey and drilling of the ANDRILL Coulman High Project. Presently New Zealand and the United States have committed funds to the site survey field work and significant international discussion is going on around forming a research consortium. The ARC's Science Drilling Office has been funded by Antarctica New Zealand and the ANDRILL Science Committee to develop a project plan and budget for the Coulman High Project.

A three-year Marsden Fund grant was awarded to the Victoria University team of Tim Naish, Rob McKay, Lionel Carter, and Joel Baker (SGEES) for a project titled "*How does Antarctica ride the Milankovitch cycle?*" In simple terms, the team is interested in how the cycles in Earth's orbit (the Milankovitch cycles) that drove repeated oscillations of the great Northern Hemisphere ice sheets, influence fluctuations in the size of Antarctica's ice sheets. The project will support Rob's participation as a member of the shipboard sedimentology team on the Integrated Ocean Drilling Program's expedition to drill marine sediments on the continental margin off Wilkes Land between January and March 2010. It is hoped that the cores will provide a 40 million year history of one of the most vulnerable sectors of Antarctica's sleeping giant - the East Antarctic Ice Sheet.

Gavin Dunbar inspects the ANDRILL MIS cores

Southwest Pacific and Southern Ocean Paleoceanography (including ANZICE Programme)

ARC paleoceanographic research includes our FRST-funded ANZICE (Antarctica-New Zealand Interglacial Climate Extremes) programme, which aims to integrate marine, terrestrial and ice core records, focussing on past warm phases. ANZICE includes ARC research in Ice Core Climatology and Glaciers and Climate Change in New Zealand and East Antarctica (following sections).

The year began with the publication of two papers in the journal *Global and Planetary Change* examining the spatial distribution of windblown dust on sea ice in McMurdo Sound and the temporal record of dust variability in the McMurdo Ice Shelf, Antarctica (Atkins and Dunbar, Dunbar *et al.*). In November a much more comprehensive sampling of dust accumulating on sea ice was carried out by Holly Winton. Holly will use this material for her MSc project, which examines the role of aeolian sediment as a source of the iron thought to fertilize the western Ross Sea and thus stimulate the vast plankton blooms recorded there each year as the ice breaks up.

In September Melissa Bowen was welcomed to the team as a Senior Research Fellow. Melissa will be working with Lionel Carter on studying processes in the modern ocean that can lead to better predictions of future ocean conditions and inform our understanding of past ocean circulation.

The 2009 year was a also a busy year for ANZICE paleoclimatology with Julene Marr completing her MSc thesis entitled "*Ecological, oceanographic and temperature controls on the incorporation of trace elements into* Globigerina bulloides *and* Globoconella inflata *in the southwest Pacific Ocean*". Julene used a novel analytical technique (laser ablation inductively coupled plasma mass spectrometry) to measure trace element abundance in the shells of microscopic foraminifera recovered from the modern seafloor sediment around New Zealand. Her research shows that the ratio Mg/Ca in *G. bulloides* correlates strongly with observed water temperatures and yields a new Mg/Ca vs temperature calibration that can be used to estimate changes in sea surface temperature over time from foraminifera extracted from sediment cores. A research paper based on this work is now in review in the journal *Paleoceanography*.

Annette Bolton is continuing her geochemical analysis of the foraminifera *Globigerniodes ruber* as part of her PhD. She spent a week conducting analyses at The Australian National University, Canberra, and has measured both a core top 'calibration' suite of modern sea floor samples from the SW Pacific as well as samples from a drill core east of New Zealand (ODP 1123) which contains sediment deposited during the super-warm interglacial marine isotope stage (MIS) 31. Annette has submitted a paper outlining her geochemical analysis of modern *G. ruber* entitled "*Environmental and ecological controls on Mg/Ca and trace element variability in* Globigerinoides ruber *(white) from tropical and subtropical waters of the Southwest Pacific Ocean*" for publication in *Paleoceanography* and continues to work on a reconstruction of ocean conditions during MIS 31.

Jeremy Fyke has been modelling the environmental conditions necessary for the collapse of the large ice shelves and their progenitor ice sheets. His results suggest continued addition of anthropogenic CO_2 into the atmosphere could result in substantial melting in the Northern Hemisphere, the Antarctic Peninsula and the initiation of high summer melt over the large Antarctic ice shelves and West Antarctic Ice Sheet (WAIS) by year 2500. Capping CO_2 concentrations at present day levels avoided significant summer melt over the large Antarctic shelves, the WAIS and much of Greenland. Jeremy's work has been accepted for publication in the *Journal of Climate* in a paper entitled "*Surface Melting over Ice Shelves and Ice Sheets as Assessed from Modelled Surface Air Temperatures*".

Matt Ryan is near completion of his MSc thesis on reconstruction of West Coast South Island vegetation and terrestrial climate over the last 210 Ky based on pollen extracted from a marine sediment core. His preliminary results, including evidence for a "super-warm" MIS 5e 125,000 years ago, were presented at the Geological Society of New Zealand Conference in Oamaru in November.

Although decadal climate variability in New Zealand is often attributed to the El Nino-Southern Oscillation, a climate phenomenon with its origins in the tropics, three research papers in *Marine Geology* (Brackley *et al.*, Carter, Orpin and Kuehl, and Orpin *et al.*) on the paleoclimate record recovered from Lake Tutira (Hawke's Bay) shows that the Southern Annular Mode driven from Antarctica is also an important driver of climate in New Zealand.

Lionel Carter also contributed to studies on the impact of climate change on the security of undersea telecommunications which was published jointly with the UN Environment Programme and the International Cable Protection Committee (Carter *et al.*).

SCIENTIFIC ACTIVITY

Ice Core Climatology (also an ANZICE objective)

2009 was dominated with preparations for the Roosevelt Island Climate Evolution (RICE) project. The aim of the New Zealand-led RICE project is to recover a high resolution record for the past 40,000 years to improve our understanding of Ross Ice Shelf stability in a warming world. Antarctica New Zealand will support drilling of the 780 m deep core during the 2010/11 and 2011/12 field seasons. Nancy Bertler is the principle investigator of the project and will lead the field seasons and ice core analyses together with collaborators from the United States, Denmark, Germany, and Great Britain in the New Zealand Ice Core Research Facility at GNS Science, Lower Hutt. A critical component of this programme is the newly built New Zealand ice core drilling system. Alex Pyne and Darcy Mandeno will test the equipment in Greenland in July 2010, as part of the NEEM (North Greenland Eemian Ice Drilling) project.

The Ice Core Climatology group is jointly staffed between the ARC and GNS Science. 2009 saw this highly successful relationship develop further with new students and staff at both organisations. Firstly, there was the recruitment of Dr Kate Sinclair at GNS Science, who obtained a FRST Post-Doctoral Fellowship for three years. Kate's interests lie in modelling past atmospheric circulation pattern on the basis of ice core data and has completed processing over 6,000 samples for isotopic and geochemical analysis from a 100 m deep ice core from Whitehall Glacier. In addition a new PhD student, Lana Cohen, recipient of the Sir Robin Irvine Antarctica New Zealand PhD Scholarship, who is focusing on "*What warms or cools the Ross Sea Region?*" using climate models and snow pit data from Roosevelt Island joined the team. Lana's project is supervised by Nancy and Sam Dean (NIWA). Furthermore, Holly Winton, recipient of the Kathleen Stewart Scholarship began her MSc thesis on "*Aeolian iron variability and its contribution to phytoplankton productivity in McMurdo Sound*". Holly is supervised by Nancy and Gavin Dunbar. In addition, government subsidised scholarships were provided for two outstanding undergraduate students, Gemma Wihare and Jess Dallas, to work in the ice core facility to gain work experience in a scientific career. This has been very successful and it is hoped to repeat the initiative next year. Dan Dixon, PhD candidate from the University of Maine, visited for two months for a collaborative project on trace elements in ice cores. His visit was funded by the US National Science Foundation through the East Asia Pacific Summer Institutes Program (EAPSI) programme. As part of this visit a highly successful inter-laboratory comparison between Prof. Paul Mayewski's laboratory

at the Climate Change Institute, University of Maine and the New Zealand Ice Core Facility was conducted. Finally, two MSc students, Julia Bull and Isabel Schuck, successfully completed their thesis work.

Also in 2009 Rachael Rhodes, PhD student, developed the first quantitative proxy for sea-ice extent and primary productivity in the Ross Sea in *Geophysical Research Letters* (Rhodes *et al.*) and Gavin, Nancy and Rob McKay published a manuscript in *Global and Planetary Change* on dust flux in the Ross Sea (Dunbar *et al.*). In addition, Peter Barrett and Nancy contributed to two major review publications: "*State of the Antarctic and Southern Ocean Climate System*" in *Reviews of Geophysics* (Mayewski *et al.*) and three chapters in *Antarctica Climate Change and the Environment*.

Finally, a number of distinguished scientists, ambassadors, and policy makers visited the ice core research group and facilities in 2009. It was a particular pleasure to welcome Prof. Dorthe Dahl-Jensen, Director of the Centre for Ice and Climate at the University of Copenhagen and Chief Scientist of the NEEM ice core programme.

Glaciers and Climate Change in New Zealand and East Antarctica (also an ANZICE objective)

During 2009 there was significant growth in the glacial modelling group. Dr Nick Golledge joined as a Post-Doctoral Fellow in glacial modelling. Nick had previously worked at the British Geological Survey and had recently completed a PhD at the University of Edinburgh supervised by Prof. David Sugden. Alice Doughty joined from the University of Maine to work on a PhD concerning the modelling of Holocene valley glaciers in the Southern Alps. Lawrence Kees began his MSc on glacial snow accumulation in the Southern Alps, and Stephen Stuart an MSc on precipitation downscaling in the Southern Alps, co-supervised by Dr Sam Dean (NIWA).

Jeremy Fyke at the head of Brewster Glacier (Photo: Alice Doughty)

During the first half of 2009, Brian Anderson and Lawrence helped identify potential ice core sites in the Southern Alps using a combination of modelling and onsite radar survey, as part of a FRST subcontract. This culminated in the drilling of three ice core sites by Uwe Morgenstern (GNS Science), Paul Mayewski (University of Maine) and a Chinese team.

Brian and Andrew Mackintosh, with NIWA colleagues Jordy Hendrix, Sam Dean, Abha Sood and Martyn Clark devised ways to downscale climate information from a regional climate model to enable a simulation of future glacier changes in the Southern Alps as part of a FRST subcontract. Brian presented the first results of this work at the International Glaciological Conference "*Ice and Climate Change; a view from the South*" in Valdivia, Chile in Febrary 2010. Brian, Andrew and others also had a paper accepted in *Journal of Glaciology* titled '*Climate sensitivity of a high precipitation glacier in New Zealand*', the first energy balance modelling study of a glacier in the mid latitudes of the Southern Hemisphere. This paper shows that the Brewster Glacier has an unusually high sensitivity to temperature change and that it will melt away entirely with modest warming.

There has been a significant increase in the ice sheet modelling capability this year. Nick has started running the Parallel Ice Sheet Model (PISM) on the New Zealand Southern Alps. He is now able to simulate the glaciers that existed at the end of the last glacial cycle (around 20,000 years ago) on a 1-km grid. The first model output was recently discussed with collaborator Prof. George Denton (University of Maine).

Furthermore, Jeremy Fyke, a PhD student supervised by Andrew, Lionel Carter and Prof. Andrew Weaver (University of Victoria, British Columbia) has developed a coupled atmosphere-ocean-ice sheet model for Greenland and Antarctica. The model is unique in that the ice part (written by Dr David Pollard, Pennsylvania State University) is capable of simulating grounding line processes. Jeremy is now applying his model to future climate simulations. As a first attempt, he calculated the sensitivity of ice shelves to increasing CO_2. This work is now in press in *Journal of Climate* (Fyke *et al.*).

Andrew, Nick and a group of US (Prof. Eugene Domack, Prof. Rob Dunbar, Assoc. Prof. Amy Leventer, Dr. David Pollard, Assoc. Prof. Rob DeConto) and Australian (Dr Duanne White, Assoc. Prof. Damian Gore, Dr David Fink) colleagues have a paper currently in second review in *Nature*. In this work, several lines of evidence (onshore and offshore geological and ice sheet modelling) are used to argue that the last major retreat of the East Antarctic Ice Sheet was driven by sea level rise and ocean warming. Andrew presented this work at the First Antarctic Climate Evolution symposium in Granada, Spain during September. The year concluded with a further increase in the size of the group, with the appointment of Dr Dan Zwartz (Australian National University) and Huw Horgan (Pennsylvania State University).

Finally, Warren Dickinson's research into ancient ice in Antarctica involved the preparation of a manuscript from Gretchen Williams' Honours project (2006), which has now been accepted for publication in *Quaternary Research*. The work uses geochemical fingerprinting to help understand the origin of granite clasts in till on the floor of Beacon Valley. These clasts appear to be emplaced by a large ice sheet, which flowed from the direction of the current Ross Ice Shelf in Middle Miocene time. This work is significant because it provides hard evidence for a ice sheet that stemmed from the early growth of the West Antarctic Ice Sheet. This work will be linked to data from the ANDRILL Southern McMurdo Sound core.

SCIENTIFIC ACTIVITY

Science Drilling Office

The major highlight for 2009 in the Science Drilling Office (SDO) was the employment of Darcy Mandeno as Operations and Field Engineer. Since he started in March, Darcy has been fully engaged with Alex Pyne in designing components of the Ice Core Drilling system. Darcy's skills in three-dimensional computer aided design have enabled us to send full models of components to our fabricators in Nelson, Pro Machining, where they have been made into tangible pieces of the Ice Core Drill, and tent manufacturers, WekaStitch on the West Coast. Late in the year, Darcy was able to go to Antarctica with Nancy Bertler to assist in maintaining weather stations at past drilling sites, and gain an appreciation of the Antarctic environment.

In July and August, Alex Pyne was in Greenland to participate in the NEEM (North Greenland Eemian Ice Drilling) project. This international project is organised by the Centre for Ice and Climate at the Niels Bohr Institute in Denmark and involves scientists from 14 countries. As the drill that Darcy and Alex have been working on in New Zealand is based on the Danish designs, Alex's participation as a driller was a valuable opportunity to gain first hand experience and check some fine design details.

In September, Tamsin Falconer travelled to the Antarctic Climate Evolution (ACE) workshop in Granada, Spain as the SDO representative to a workshop on future

3-D image of ice drill tent operation

Antarctic Margin drilling, where she presented some brief background information on the ANDRILL system. She also participated in a workshop to develop science plans for the ANDRILL Coulman High drill sites. She was able to present a summary of the Scoping Document for logistics for ANDRILL Coulman High that she and Alex had completed earlier in the year.

The last few days of 2009 finished at full pace, with ice core drilling equipment being packed into a container for shipping to Antarctica in January 2010 to be ready for use at Roosevelt Island next summer. Alex and Darcy were assisted by Nancy Bertler and a team of summer research assistants from the Ice Core Facility at GNS Science.

(Back, L-R) Donna Anderson (Pro Machining), Marcus Heigenhauser (WekaStitch), Greg Anderson (Pro Machining), Alex Pyne, Darcy Mandeno and (Front) Bert Newcome (Pro Machining) erecting the ice core drilling tent in Nelson

Morgan Family Charitable Foundation Donation

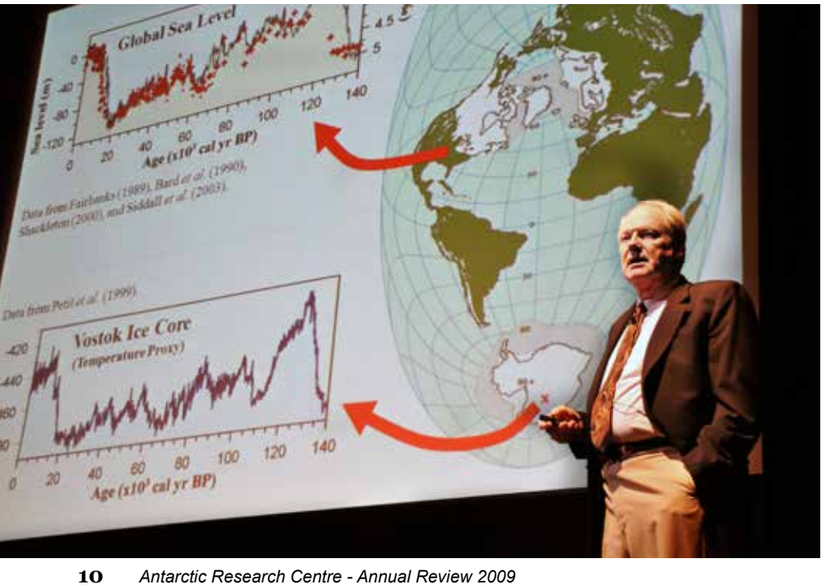
A donation of $250,000 to the Antarctic Research Centre for "Antarctic climate research" was made following assistance given by ARC's Peter Barrett, Lionel Carter and Dave Lowe to economist, adventurer and philanthropist, Gareth Morgan, for his book *Poles Apart*. The book sought views from all sides on the soundness of the science around climate change. The donation reflected Gareth's appreciation of the importance of understanding the behaviour of the Antarctic ice sheet. The donation has been used to provide support for Melissa Bowen's research into the dynamical behaviour of the Southern Ocean, a significant influence on Antarctic ice sheet behaviour and for a research fellowship on ice sheets and sea level appointed to Dan Zwartz who started in February 2010. The donation was made to the ARC through the Victoria University Foundation, and is to be spread over two years.

Jo and Gareth Morgan in Antarctica

Annual S.T. Lee Lecture in Antarctic Studies

George Denton, Libra Professor of Earth Sciences, University of Maine, presented this year's S.T. Lee Lecture "*Antarctica and the Ice Age Puzzle*", to a capacity audience on the 15 May. The lecture discussed the role of Antarctica in recent global ice ages, with a particular focus on determining the origin of a warming event between 18,000 and 11,700 years ago, when the southern part of the planet switched from a glacial climate to the interglacial conditions of today. George is a world expert in the geological history of large ice sheets and smaller mountain glaciers and has over 30 years of field experience in Antarctica, New Zealand, and Patagonia. He has a long-standing interest in the timing and mechanisms of abrupt climate change and climatic interaction between the Northern and Southern hemispheres and over the last few years, has collaborated with New Zealand scientists based at GNS Science to produce a series of maps of the South Island, showing a visual representation of the advance and retreat of ice in the area.

Prof. George Denton presenting his lecture at Te Papa, Wellington (Photo:Margaret Lowe, GNS Science)



The S.T. Lee Lecture was held in conjunction with the very successful Past Climates Meeting organised by Marcus Vandergoes (GNS Science), Giuseppe Cortese (GNS Science) and Helen Bostock (NIWA). The meeting included a one-day symposium, a two-day INTegration of Ice-core, MArine and TErrestrial records (INTIMATE) workshop, and a public lecture by Prof Wally Broecker (Lamont Doherty Earth Observatory, Columbia University). National and international participants discussed the latest advances in understanding Quaternary past climates in New Zealand and Australia, the causes and effects of climate change in the Southern Hemisphere and the relationships with global climate change.

ANDRILL MIS Science Integration Workshop participants at Victoria University

ANDRILL Workshop

More than 60 international scientists attended the ANDRILL McMurdo Ice Shelf Science Integration Workshop held at Victoria University from 10-13 February. The Workshop involved talks and discussions on the latest results and developed collaborative multidisciplinary teams to address key questions arising from analysis of the core. Two one-day field trips to examine local Pliocene to Recent sedimentary sequences were offered immediately following the workshop on Saturday 14th.

JARI Ice Core Symposium

This year's Ice Core Symposium was held on 8 October at GNS Science's National Isotope Centre. The symposium was well attended by scientists and policymakers from across New Zealand, and several ARC staff and students presented during the one-day event. The keynote speaker was Prof. Dorthe Dahl-Jensen, Chief Scientist of the multinational Greenland Ice Coring Project (NEEM project) and Director of the Centre for Ice and Climate, University of Copenhagen. Dorthe also gave a number of stimulating and well attended public talks during her stay, including a presentation at the National Museum Te Papa. Dorthe and her team are an important collaborator of the New Zealand-led Roosevelt Island Ice Core Project. This project is supported by the International Partnerships in Ice Core Sciences and seeks to improve our understanding of the stability of the Ross Ice Shelf, Antarctica in a warming world.

Prof. Dorthe Dahl-Jensen presenting at Te Papa, Wellington

JARI Glacier and Climate Modelling Workshop

On 2 November, Victoria University hosted the first Glacier and Climate Modelling Workshop in association with JARI. The one-day event brought together New Zealand's glacier and climate modelling community and included talks from researchers from NIWA, Otago, Canterbury and Victoria universities. The aim of the workshop was to discuss recent progress and future research directions in three areas: modelling of Southern Hemisphere paleoclimate; simulating future glacier response and water impacts in New Zealand; and predicting the future response of Antarctic ice sheets. The keynote lecture by Olga Sergienko, Princeton University, concerned this last theme, modelling of the physical processes controlling ice sheet behaviour in Antarctica.

Antarctic Climate Evolution Symposium

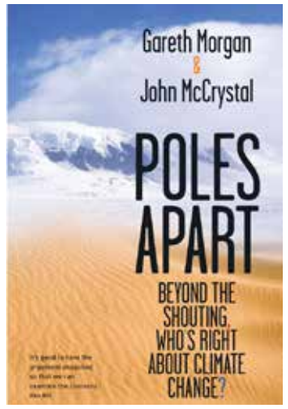
Granada, Spain was host to the First Antarctic Climate Evolution (ACE) Symposium from 7-13 September (www.acegranada2009.com). ACE was established by SCAR in 2004 as one of its five scientific research programmes, with the aim of integrating geoscience data and ice-climate-ocean modelling to establish past Antarctic climate and ice sheet behaviour and so project future behaviour. The 160 attendees from 16 countries included a good representation from the Antarctic paleoclimate community.

ARC was also well represented with two talks on ANDRILL MIS results from Tim Naish and Rob McKay, a talk by Andrew Mackintosh on the ocean and sea level influence of the last Antarctic ice sheet retreat and one by Peter Barrett on the contribution ACE might have to the 5th Assessment Report of the Intergovernmental Panel on Climate Change now being planned.

The symposium included a workshop on Antarctic Landscape Evolution, led by Peter Barrett (ARC), Jane Francis and Alan Hayward (University of Leeds), Christine Siddoway (University of Colorado) and Karsten Gohl (Alfred Wegener Institute). After the meeting Tim Naish (ARC), Richard Levy (GNS Science), Laura De Santis (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale) and Frank Rack (University of Nebraska-Lincoln) ran a well-timed and productive two-day workshop for planning future drilling campaigns for the next 20 years using a range of platforms, including ANDRILL, SHALDRILL and IODP. The outcome of the workshop was a 20 page "white paper" summarising an Antarctic-wide drilling strategy for understanding past Antarctic ice and climate behaviour.

Book Release: Poles Apart

Gareth Morgan couldn't determine who was right on climate change issues from media reports and talking with friends, so he decided to sort it out himself. With writer John McCrystal he sought the views from both sides of the debate - established climate scientists reflecting the IPCC view, and skeptics who believed that present climate change was natural. The former included ARC's Peter Barrett, Lionel Carter, and ARC Adjunct Prof. David Lowe. Although they believe Gareth did a great job on balance,they didn't agree with everything he said. See their view at: www.sciencemediacentre.co.nz/2009/05/19/



S.T. Lee Young Researcher Exchange

Ana Aguilar-Islas was this year's recipient of the S.T. Lee Young Researcher Travel Award, an exchange visit between the ARC and the International Arctic Research Center (IARC), University of Alaska Fairbanks. Ana's research at IARC involves the study of sea ice-derived iron in the Bering Sea and its influence on the spring phytoplankton bloom. While conducting this research, she became interested in Antarctic pack ice zones characterized by high macronutrients and low iron concentrations. The award gave Ana the chance to come to Wellington and develop collaborative projects with Ken Ryan (School of Biological Sciences), Gavin Dunbar (ARC) and Cliff Atkins (SGEES).

Endowed Development Fund

More than $450,000 has been committed to the Endowed Development Fund Appeal. This year's recipients included Rosie Cody, Jeremy Fyke, and Rachael Rhodes from the ARC, as well as Lisa Bryant, Rebecca Cowie, Eileen Koh, and Meghana Rajanahally from the School of Biological Sciences. The funding helped cover costs of attendance at the Urbino summer school (Italy), the Portland modelling school (USA), a research course on atmospheres (France), the SCAR International Biology Symposium (Japan), and the Symposium of Aquatic Microbial Ecology (Slovenia).

SIGNIFICANT EVENTS

Funding Success

- $500K p.a. FRST funded subcontract from GNS Science for up to eight years for the PACAFI project;
- $773K Marsden grant to Tim Naish, Rob McKay, Lionel Carter and Joel Baker (SGEES) for their project titled "*How does Antarctica ride the Milankovitch cycle?*";
- $6, 800 grant from the UK High Commission to Simon Lamb for supporting his work on the climate change film, *The Last Trillion Tonnes*.

Thesis Completions

Julia Bull was awarded an MSc in Geology with First Class Honours for her thesis titled "*Stable isotope, major and trace element chemistry of modern snow from Evans Piedmont Glacier, Antarctica: Insights into potential source regions and relationship of glaciochemistry to atmospheric circulation and vigour*". Supervised by Dr Nancy Bertler and Prof. Joel Baker.

Julene Marr was awarded an MSc in Geology with First Class Honours for "*Ecological, oceanographic and temperature controls on the incorporation of trace elements into* Globigerina bulloides *and* Globoconella inflata *in the southwest Pacific Ocean*". Supervised by Prof. Joel Baker, Prof. Lionel Carter and Dr Gavin Dunbar.

Isabel Schuck was awarded an MSc for her thesis titled "*Mineralogical characterisation and geographic province of atmospheric particles in coastal Antarctic ice cores – indicator of past climate variability*". A joint project between University of Karlsruhe, Germany, Victoria University of Wellington, and GNS Science. Supervisors, Prof. Thomas Neumann, Dr Nancy Bertler and Dr Gavin Dunbar.

JARI signing

GNS Science, Victoria University and NIWA signed the amended JARI agreement in July at the International Polar Year Function in Wellington, formalising the collaboration between the three organizations.

Signing of the JARI agreement (L-R) John Morgan (NIWA), Hon. Wayne Mapp (Minister of Research Science & Technology), David Bibby (VUW) and Alex Malahoff (GNS Science) (Photo:Margaret Lowe, GNS Science)

Awards & Appointments

Tim Naish - New Zealand Science and Technology Medal by the Royal Society of New Zealand. The award is in recognition of Tim's scientific leadership and contribution to the knowledge on Antarctic ice sheets and their influence on global sea-level change and climate in a warming world.

Tamsin Falconer and Michelle Dow – Victoria University General Staff Excellence Award for their outstanding commitment and performance.

Rachael Rhodes - Victoria University Post-Graduate Research Excellence Award for her recent publication in *Geophysical Research Letters*.

Rosemary Cody - Student Poster award at the Paleoclimatology Summer School in Urbino, Italy in July 2009.

Julene Marr - Royal Society Beanland-Thornley Prize at the Royal Society Beanland-Thornley Student Talks Competition, September 2009.

Rosemary Cody - Hornibrook Prize from the Geological Society of New Zealand for outstanding research contribution by a graduate student in the fields of paleontology and biostratigraphy, presented in November 2009.

Rachael Rhodes - Winner of Foundation for Research, Science and Technology Outstanding Oral Presentation at the Post-Graduate Student Association Conference, Victoria University of Wellington, 20-21 November, 2009.

Tim Naish - Appointed to the Marsden Fund Council for a period of three years and chair of the Earth Science and Astronomy Assessment Panel.

Peter Barrett - Appointed to international committee to write the Science Plan for the Integrated Ocean Drilling Program for the decade beyond 2013.

The Antarctic Research Centre supports a significant proportion of the research 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 our graduate students at MSc and PhD levels.

Staff of the ARC contributed to teaching in SGEES in the following courses in 2009:

ESCI 111	Earth Systems & Global Change: An Introduction to Earth Sciences
ESCI 112	Fundamentals of Geology
ESCI 132	Antarctica: Unfreezing the Continent
ESCI 201	Climate Change and NZ's Future
ESCI 204	Petrology and Microscopy
GEOG 220	Hydrology and Climate
ESCI 241	Introductory Field Geology
ESCI 301	Global Change: Earth Processes and History
ESCI 403	Stratigraphy and Palaeontology
ESCI 404	Special Topics
ESCI 412	Quaternary Geology

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 undersand and interpret evidence from the geological record of environmental change and how this knowledge can be used to help predict future variablility 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.

ESCI 201 students on the Raukawa Marae, Otaki

Joint Antarctic Research Institute (JARI)

There were several changes to the structure of the JARI in 2009. Prof. Tim Naish took over the Directorship from Prof. Peter Barrett as he stepped-down in July, and Dr Richard Levy became the new Deputy Director from Tim. With the formal inclusion of NIWA, new Board and Management teams were also set-up. Prof. Alex Malahoff (CEO, GNS Science) became the Chair of the JARI Board, taking over from Prof. David Bibby. The other board members include: Dr Ian Graham (GNS Science); Dr Rob Murdoch and Dr David Wratt (NIWA); Prof. David Bibby and Assoc. Prof. Michael Hannah (VUW). The revised management team includes: Prof. Tim Naish, JARI Director (VUW) and Dr Richard Levy (GNS Science) as Deputy Director; Dr Frank Bruhn (GNS Science); Prof. Peter Barrett (VUW); Dr Murray Poulter and Sam Dean (NIWA).

Visitors

The ARC had a number of visiting academics during 2009, including:

- Prof. Jaap van der Meer, Professor of Geology at Queen Mary, University of London, UK;
- Dr Poul Christoffersen, Scott Polar Research Institute, University of Cambridge, UK;
- Assoc. Prof. Terry Wilson, Ohio State University, USA;
- Betty Trummel, US ANDRILL Educator;
- Prof. Dorthe Dahl-Jensen, Director of the Centre for Ice and Climate, University of Copenhagen, Denmark;
- Dr Olga Sergienko, Princeton University, USA;
- Dr Frank Niessen, Alfred Wegener Institute, Germany.

Climate Change Research Institute (CCRI)

The year 2009, the first full year for the Climate Change Research Institute, was dominated by the run-up to the United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties in Copenhagen. The Institute ran a series of seminars and workshops, some in conjunction with the Institute of Policy Studies, on issues around the impending agreement. The Institute also provided an assessment of the Emissions Trading Scheme to the Parliamentary Select Committee on this topic. CCRI's FRST-funded research programme on Community Vulnerability, Resilience and Adaptation to Climate Change made good progress on case studies in Auckland and Lower Hutt. Work for the Ministry of Agriculture and Fisheries made progress on setting up a framework for comparing greenhouse gases in a way that is more consistent with keeping to pathways that achieve climate stabilisation.

It was pleasing to see the publication of Andy Reisinger's book *Climate Change 101: An Educational Resource*. Andy and Martin Manning gave a number of public and workshop presentations on the current status of climate science and policy implications. Martin in particular was in demand for advice to both local governments and the IPCC. Peter Barrett is providing a paleoclimate perspective through his ongoing research and attendance at the 31st IPCC Plenary meeting in Bali during October, where the outlines for the 5th Assessment Report were discussed and approved.

New Adjunct staff include Judy Lawrence (local expression of climate change), Geoff Bertram (economics of climate change), Eric Martinot (alternative energy) and Greg Bodeker (atmospheric chemistry). Work began on developing a Masters Programme in Climate Science and Policy with plans to implement in 2011-12.

National Research Collaborators

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

Industry Partners

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

National Stakeholders and End-users

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

International Collaborators

- Alfred Wegener Institute, Germany;
- ANDRILL Science Management Office, University of Nebraska-Lincoln, USA;
- Australian Nuclear Science and Technology Organisation;
- Cambridge University, UK;
- Centre for Climate and Ice, Niels Bohr Institute, University of Copenhagen, Denmark;
- Climate Change Institute, University of Maine, USA;
- Colgate University, USA;
- ETH (Swiss Federal Institute of Technology), Switzerland;
- Hamilton College, USA;
- IDDO (Ice Drilling Design & Operations), University of Wisconsin, USA;
- INGV (National Institute of Geophysics and Volcanology), Italy;
- James Cook University, Australia;
- Macquarie University, Australia;
- Northern Ilinois University, USA;
- Oregon State University, USA;
- Pennsylvania State University, USA;
- Squire, Sanders and Dempsey Legal Counsel, USA;
- Stanford University, USA;
- The Australian National University;
- University of California-Santa Barbara, USA;
- University of Leeds, UK;
- University of Massachusetts, USA;
- University of Sienna, Italy;
- University of Victoria, British Columbia, Canada;
- University of Wales, UK;
- University of Washington, USA;
- Virginia Institute of Marine Sciences, USA.

Contribution to International Programmes

- ANDRILL (Antarctic geological Drilling Program);
- IODP (Integrated Ocean Drilling Program);
- 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).

Public Talks, Visits, and Media

Staff, students and visitors at the ARC were involved in a variety of outreach activities during the year. These activities include talks to community groups, interviews (newspapers, radio and television), and school visits and allow us to present our research and knowledge to the wider community both here and overseas. The following examples indicate the breadth of activity in 2009:

Public Talks & Visits:

- Geography Teachers Conference: Lionel Carter, 27 November;
- Hutt Valley High School: Tamsin Falconer and Cliff Atkins (SGEES), 16 November;
- Waikanae Probus Group: Tim Naish, Rob McKay, and Lionel Carter – Presentation on behalf of ARC, 24 July and 2 September;
- Malaghan Institute Science Faculty Tour: Tim Naish, 20 August;
- Boffa Miskell Landscape Architects, Wellington: Andrew Mackintosh, 14 August;
- Royal Society, Napier Branch: Nancy Bertler, 13 August;
- The New Zealand Antarctic Society: Rachael Rhodes and Kate Sinclair (GNS Science), 13 August;
- Careers Advisor Update Day, Auckland: Andrew Mackintosh, 31 July;
- Redwood School, Tawa: Tamsin Falconer with Betty Trummel (USA), 28 July;
- Maidstone Intermediate: Rob McKay, 23 July;
- Inaugural Professorial Lecture: Tim Naish, 7 July;
- Gus Fisher Gallery, University of Auckland, Tamsin Falconer, 13 June;
- Wellington College: Tamsin Falconer, 5 and 10 June;
- *Poles Apart* book by Gareth Morgan and John McCrystal: Major contributors Dave Lowe, Peter Barrett and Lionel Carter, May;
- S.T. Lee Lecture in Antarctic Studies: invited presenter Prof. George Denton (University of Maine), 15 May;
- Antarctic and climate change Stakeholders, Treaty Nation Ambassadors, Science Minister, and Hon. Wayne Mapp: Tim Naish, 23 April;
- Careers Advisors Tour: Gavin Dunbar, 26 March;
- Phil Goff (Leader of the Opposition) and Grant Robertson (Wellington MP) visit: Tim Naish, Peter Barrett, and Lionel Carter, 12 March;
- The Rotary Club of Port Nicholson: Peter Barrett, February;
- Public Panel Discussion on Climate Change: Nancy Bertler, Peter Barrett, and Lionel Carter, 30 January;
- Presentation to MoRST, FRST, policymakers, and ESCI 201 students: Lionel Carter, Nancy Bertler, and Andrew Mackintosh, 30 January.

Betty Trummel (US ANDRILL Educator) visiting Korokoro School, Wellington during her New Zealand visit

Events:

- New Zealand-German Science Day, Victoria University: Tim Naish, 19 November;
- NatureSpace Family Day-Antarctic Scientists Living in the Freezer, Te Papa: ARC loan of Antarctic gear, 7 October;
- Study at Vic Day: Andrew Mackintosh, 28 August;
- Victoria University of Wellington 2009 Science Careers Expo: Michelle Dow, 13 August;
- 6th Quaternary Techniques Short Course: Nancy Bertler, Lionel Carter, Andrew Mackintosh, 18-19 May.

Media (Newspapers, Radio, and Television):

- *New Zealand Herald*: Tim Naish on latest science in advance of COP15, 5 December;
- *Listener*: Tim Naish, 28 November;
- *TV3 Nightline*: Tim Naish on latest sea level rise projections and Copenhagen, 12 November;
- *Dominion Post*: Tim Naish, 13 & 14 November;
- *Otago Daily Times*: Lionel Carter and upcoming IODP excursions, 6 November;
- *TV Hawkes Bay, Chatroom*: Nancy Bertler, 28 August;
- NewsTalk ZB: Tim Naish, 4 July;
- *"bFM", Auckland University Student Radio*: Tim Naish on Antarctic ice sheets and sea-level rise, 4 July;
- *New Zealand Herald*: Peter Barrett and Tim Naish on big melt in Antarctica, 4 July;
- Radio New Zealand National (Our Changing World): Tim Naish and others give a New Zealand perspective on International Polar Year, 2 July;
- *Otago Daily Times*: Tim Naish inaugural lecture, 2 July;
- *Chicago Tribune*: article on ANDRILL, 25 June;
- *New Zealand Herald*: Tim Naish and Peter Barrett on signing of JARI with NIWA, 24 June;
- *NZPA*: Gareth Morgan donation to the ARC, 2 June;
- *New Zealand Herald*: Alex Pyne on ANDRILL drilling technology, 15 May;
- National and international newspaper publicity on the Schaefer *et al.* (incl Mackintosh) *Science* paper, 1 May;
- *NewScientist*: Tim Naish on ANDRILL, 11 April;
- Newsletter of the German Embassy: Nancy Bertler and the New Zealand Ice Core Programme, April;
- *Dominion Post/Timaru Herald/Gisborne Herald*: Tim Naish on the ice shelf break-up, 6 April;
- National and international television, newspaper and radio publicity (over 300 articles) on release of Naish *et al.* and Pollard and DeConto *Nature* papers, 19 March;
- *NewsTalk ZB*: Tim Naish on stability of the Wilkins Ice Shelf, 27 January;
- *Radio New Zealand National*: Nancy Bertler, 21 January;
- *Dominion Post*: Tim Naish on sea-level threat from melting ice, 21 January.

ARC Newsletter – IceSked

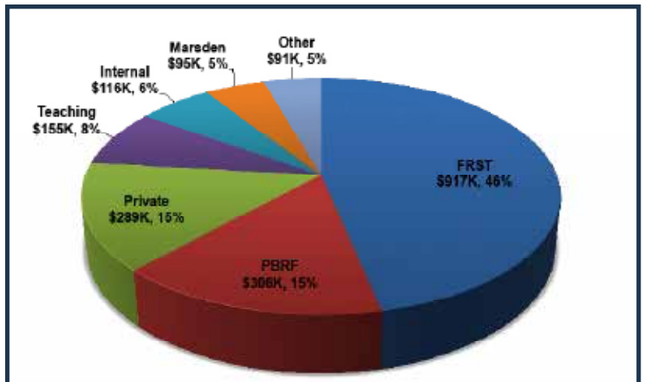
The ARC newsletter *IceSked* is sent out to over 400 alumni, associates and institutions. Issue 12, in June, highlighted the achievements of the ANDRILL Program and the release of the *Nature* papers. It also introduced the Science Drilling Office and its work within the Antarctic Research Centre and welcomed new staff members. The following issue in December acknowledged the donation by the Morgan Family Charitable Foundation, and focused on recent events involving ARC staff and students.

Feature film on Climate Change

Over the past three years, the ARC, with the help of the VUW Research Office, has been supporting Simon Lamb to make a feature film on climate change. Simon, lead producer, cameraman and director of the film, secured a further series of interviews with scientists and technologists in 2009. This has allowed the film to include new research that indicates a practical limit for the amount of carbon the atmosphere can absorb without unacceptable risk, indicated in the title, *The Last Trillion Tonnes*. The last three months of the year were spent in editing and another three months of work should see the film through to completion. Those involved are very pleased with the way it is shaping up and hope to begin screenings in New Zealand early in 2010, with wider distribution to follow.

The Antarctic Research Centre received its $1.97M revenue from three major sources: Research Grants (primarily from FRST, Marsden, Internal grants and private funds); PBRF; and Teaching and Supervision within SGEES. Just over half of that income covers the costs associated with staff salaries (salaries, annual leave, etc). The ARC actual revenue and expenditure for 2009 are summarized below (all figures are exclusive of GST).

Revenue



2009 Revenue Sources

Revenue is derived from the following sources:

FRST:
- ANDRILL Programme, VUW part of major grant to GNS Science, UOtago and VUW, which runs through to 2010;
- ANZICE Programme, started October 2007 and runs through to mid-2011;
- Regional Modelling, NIWA sub-contract until December 2011;
- Tasman Alps Glacier project, a GNS Science subcontract from April 2009 until September 2011;
- McKay Post-Doctoral Fellowship, from June 2009 to May 2012.

Private Donations (managed by VUW Foundation):
- Golledge Post-Doctoral Fellowship, funded from Alan Eggers donation until February 2011;
- Morgan Family Charitable Foundation, support for Melissa Bowen from September 2009 until December 2011;
- Science Drilling Office, supported in part from the Alan Eggers Donation;
- ARC Endowed Development Fund, supported seven students travel to conferences and courses in 2009.

PBRF:
- Calculated by VUW based on external research funding that meets the PBRF criteria, plus the quality rating of staff in the ARC. The ARC did not get funding for research degree completions, which are recorded within SGEES.

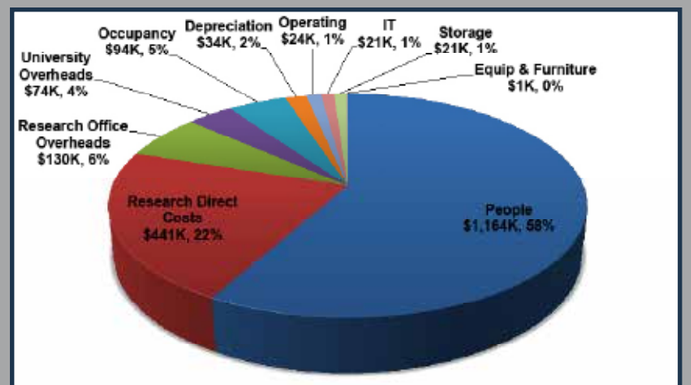
Teaching:
- From SGEES for teaching services by ARC staff.

Internal:
- Lamb Deputy Vice-Chancellor Research Sponsorship, to support the production of the climate change film;
- Office of DVC-Research, $50K contribution to the New Zealand membership to the Integrated Ocean Drilling Program;
- Science Faculty Research Grants, supported a Summer Research Assistant for Gavin Dunbar, Rachael Rhodes' attendance at the Atmosphere course in France, and Alice Doughty's PhD field work.

Marsden:
- Dunbar FastStart, through to March 2010;
- Mackintosh FastStart, for Southern Hemisphere glacier work ended in February 2009;
- Townend Marsden, supports work by Lionel Carter on this project.

Other:
- International Cables Protection Committee, contract with Lionel Carter;
- Coulman High Project, funding from Antarctica New Zealand in support of work on scoping this new project;
- Biochar Project, to support a Research Assistant for Warren Dickinson;
- Science Drilling Office, funding from US to cover SDO consultancy activities.

Expenditure



2009 Expenditure

Expenditure covers the following costs:

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.

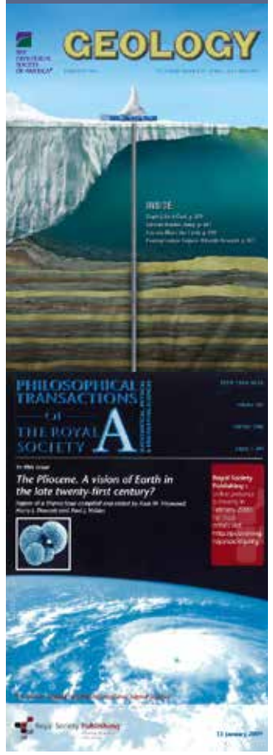
Research Office and University Overheads:
- Used by the University for administrative purposes and to cover services provided by the Research Office and central University.

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 and copying, catering, training, and kitchen supplies.

Storage:
- Occupancy costs for storage spaces shared with SGEES.



Scientific Journals (23)

Acton G., Crampton J., Di Vincenzo G., Fielding C.R.,. Florindo F., **Hannah M.**, Harwood D.M., Ishman S., Johnson K., Jovane L., Levy R.A., Lum B., Marcano M.C., Mukasa S., Ohneiser, C., Olney M., Riesselman C., Sagnotti L., Stefano C., Strada E., Taviani M., Tuzzi E., Verosub K.L., Wilson G.S., Zattin M., and the ANDRILL-SMS Science Team, (in press). Preliminary integrated chronostratigraphy of the AND-2A Core, ANDRILL Southern McMurdo Sound Project, Antarctica. *Terra Antartica.*

Atkins, C.B. and **Dunbar, G.B.**, 2009. Aeolian sediment flux from sea ice into Southern McMurdo Sound, Antarctica. *Global and Planetary Change* 69: 133-141. [doi:10.1016/j.gloplacha.2009.04.006].

Brackley, H.L., Blair, N.E., Trustrum, N.A., **Carter, L.**, Leithold, E.L., Canuel, E.A., Johnston, J., Tate K.R., (in press). Dispersal and transformation of organic carbon across an episodic, high discharge continental margin; Waipaoa Sedimentary System, New Zealand. *Marine Geology* [doi: 10.1016/j.margeo.2009.11.001].

Brooks, L.A., Townend, J., Gerstoft, P., Bannister, S., **Carter, L.**, 2009. Fundamental and higher-mode Rayleigh wave characteristics of ambient seismic noise in New Zealand. *Geophysical Research Letters* 36: L23303 [doi:10.1029/2009GL040434].

Carter, L., Orpin, A., and Kuehl, S., (in press). From mountain source to ocean sink – the passage of sediment across an active margin, Waipaoa sedimentary system, New Zealand. *Marine Geology* [doi: 10.1016/j.margeo.2009.12.010].

Dunbar, G.B., **Bertler, N.A.N.**, and **McKay, R.M.**, 2009. Sediment flux through the McMurdo Ice Shelf in Windless Bight, Antarctica. *Global and Planetary Change* 69(3): 87-93. [doi:10.1016/j.gloplacha.2009.05.007].

Fyke, J.G., **Carter, L.**, **Mackintosh, A.**, Weaver, A.J., Meissner, K.J., (in press). Surface melting over ice shelves and ice sheets as assessed from modelled surface air temperatures. *Journal of Climate* [doi: 10.1175/2009JCLI3122.1].

Golledge, N., Hubbard, A., and Bradwell, T., 2009. Influence of seasonality on glacier mass balance, and implications for palaeoclimate reconstructions. *Climate Dynamics* [doi: 10.1007/s00382-009-0616-6].

Golledge, N.R., Hubbard, A., and Sugden, D.E., 2009. Mass balance, flow, and subglacial processes of a modelled Younger Dryas ice cap in Scotland. *Journal of Glaciology* 55: 32-42.

Hubbard, A.L., Bradwell, T., **Golledge, N.R.**, Hall, A., Patton, H., Sugden, D.E., Cooper, R.M., Stoker, M.S., 2009. Dynamic binge-purge cycles, ice streams and their impact on the extent and chronology of the last British-Irish Ice Sheet. *Quaternary Science Reviews* 28: 759-777.

Jellyman, D.J. and **Bowen, M.M.**, 2009. Modelling larval migration routes and spawning areas of Anguillid eels of New Zealand and Australia. *American Fisheries Science Symposium* 69: 255-274.

Mayewski, P.A., Meredith, M.P., Summerhayes, C.P., Turner, J., Worby, A., **Barrett, P.J.**, Casassa, G., **Bertler, N.A.N.**, Bracegirdle, T., Naveira-Garabato, A.C., Bromwich, D., Campbell, H., Hamilton, G. H., Lyons, W.B., Maasch, K.A., Aoki, S., Xiao, C., van Ommen, T., 2009. State of the Antarctic and Southern Ocean climate system (SASOCS). *Reviews of Geophysics* doi:10.1029/2007RG000231.

McKay, R., Browne, G., **Carter, L.**, Cowan, E., **Dunbar, G.**, Krissek, L., **Naish, T.**, Powell, R., Reed, J., Talarico, F., Wilch, T., 2009. The stratigraphic signature of the late Cenozoic Antarctic Ice Sheets in the Ross Embayment. *Geological Society of America Bulletin* 121: 1537-1561. [doi: 10.1130/B26540.1].

Naish, T.R. and Wilson, G.S., 2009. Constraints on the amplitude of Mid-Pliocene (3.6–2.4 Ma) eustatic sea-level fluctuations from the New Zealand shallow-marine sediment record. *Philosophical Transactions of the Royal Society A*: 169-188 [doi:10.1098/rsta.2008.0223].

Naish, T., Powell, R., Levy, R., Wilson, G., Scherer, R., Talarico, F., Krissek, L., Niessen, F., Pompilio, M., Wilson, T., **Carter, L.**, DeConto, R., Huybers, P., **McKay, R.**, Pollard, D., Ross, J., Winter, D., **Barrett, P.**, Browne, G., **Cody, R.**, Cowan, E., Crampton, J., **Dunbar, G.**, Dunbar, N., Florindo, F., Gebhardt, C., Graham, I., Hannah, M., Hansaraj, D., Harwood, D., Helling, D., Henrys, S., Hinnov, L., Kuhn, G., Kyle, P., Läufer, A., Maffioli, P., Magens, D., Mandernack, K., McIntosh, W., Millan, C., Morin, R., Ohneiser, C., Paulsen, T., Persico, D., Raine, I., Reed, J., Riesselman, C., Sagnotti, L., Schmitt, D., Sjunneskog, C., Strong, P., Taviani, M., Vogel, S., Wilch, T., Williams, T., 2009. Obliquity-paced Pliocene West Antarctic ice Sheet oscillations. *Nature* 458: 322-328.

Orpin, A.R., **Carter, L.**, Page, M.J., Cochran, U.A., Trustrum, N.A., Gomez, B., Palmer, A.S., Mildenhall., D.C., Brackley, H.L., Northcote, L., (in press). Holocene sedimentary record from Lake Tutira as a template for upland watershed erosion proximal to the Waipaoa sedimentary system, North-eastern New Zealand. *Marine Geology* [doi: 10.1016/j.margeo.2009.10.022].

Page, M.J., Trustrum, N.A., Orpin, A.R., **Carter, L.**, Gomez, B., Cochran, U.A., Mildenhall, D.C., Rogers, K.M., Brackley, H.L., Palmer, A.S., Northcote, L., (in press). Storm frequency and magnitude in response to Holocene climate variability, Lake Tutira, north-eastern New Zealand. *Marine Geology* [doi:10.1016/j.margeo.2009.10.019].

Rhodes, R.H., **Bertler, N.A.N.**, Baker, J.A., Sneed, S.B., Oerter, H., Arrigo, K.R., 2009. Sea ice variability and primary productivity in the Ross Sea, Antarctica, from methylsulphonate snow record. *Geophysical Research Letters* 36(10), L10704 [doi:10.1029/2009GL037311, 2009].

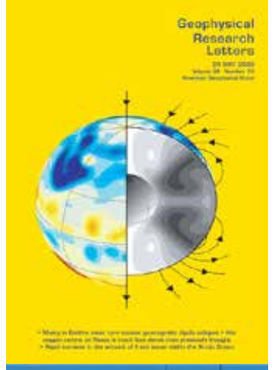
Schaefer, J.M., Denton, G.H., Kaplan, M., Putnam, A., Finkel, R.C., Barrell, D.J.A., Andersen, B.G., Schwartz, R., **Mackintosh, A.**, Chinn, T., Schlüchter, C., 2009. High-frequency Holocene glacier fluctuations in New Zealand differ from the Northern signature. *Science* 324: 622-625.

Schiller, M., **Dickinson, W.W.**, Ditchburn, R.G., Graham, I.J., Zondervan, A., 2009. Atmospheric 10Be in an Antarctic soil: Implications for climate change. *Journal of Geophysical Research* 114: F01033 [doi:10.1029/2008JF001052].

Stoker, M.S., **Golledge, N.R.**, Phillips, E.R., Wilkinson, I.P., Akhurst, M.C., 2009. Lateglacial-Holocene shoreface progradation offshore Eastern Scotland: A response to climatic and coastal hydrographic change. *Boreas* 38(2): 292-314.

Taviani M., **Hannah, M.**, Ishman S., Johnson K., Olney M., Riesselman C., Tuzzi E., and the ANDRILL SMS Science Team, (in press). Palaeontology of the AND-2A Core, ANDRILL Southern McMurdo Sound Project, Antarctica. *Terra Antartica*.

Warny, S., Askin, R.A., **Hannah, M.J.**, Mohr, B.A.R., Raine, J.I., Harwood, D.M., Florindo, F., and the SMS Science Team, 2009. Palynomorphs from a sediment core reveal a sudden remarkably warm Antarctica during the middle Miocene. *Geology* 37: 955-958 [doi:10.1130/G30139A.1].



Books/Book Chapters (9)

Abram, N., Anderson, J., Bargelloni, L., **Barrett, P.J.**, Bentley, M.J., **Bertler, N.A.N.**, and 26 others, 2009. Antarctic climate and environment history in the pre-instrumental period. In Turner, J., Bindschandler, R., Convey, P., di Prisco, G., Fahrbach, E., Gutt, J., Hodgson, D., Mayewski, P.A., and Summerhayes, C.P., (Eds.), *Antarctic Climate Change and the Environment*. Cambridge, UK, Scientific Committee on Antarctic Research, p. 115-182, ISBN 978-0-948277-22-1.

Adams, B., Arthern, R., Atkinson, A., Barbante, C., Bargagli, R., Bergstrom, D., **Bertler, N.A.N.**, and 57 others, 2009, The Instrumental Period. In Turner, J., Bindschandler, R., Convey, P., di Prisco, G., Fahrbach, E., Gutt, J., Hodgson, D., Mayewski, P.A., and Summerhayes, C.P., (Eds.), *Antarctic Climate Change and the Environment*. Cambridge, UK, Scientific Committee on Antarctic Research, p. 183-298, ISBN 978-0-948277-22-1.

Ainley, D., **Barrett, P.**, and 16 others, 2009. The Antarctic Environment in the Global System. In Turner, J., Bindschandler, R., Convey, P., di Prisco, G., Fahrbach, E., Gutt, J., Hodgson, D., Mayewski, P.A., and Summerhayes, C.P., (Eds.), *Antarctic Climate Change and the Environment*. Cambridge, UK, Scientific Committee on Antarctic Research, p. 1-32, ISBN 978-0-948277-22-1.

Arbetter, T., Arthern, R., Barbante, C., Bargagli, R., Bergstrom, D., **Bertler, N.A.N.**, and 51 others, 2009, Observations, Data Accuracy and Tools. In Turner, J., Bindschandler, R., Convey, P., di Prisco, G., Fahrbach, E., Gutt, J., Hodgson, D., Mayewski, P.A., and Summerhayes, C.P., (Eds.), *Antarctic Climate Change and the Environment*. Cambridge, UK, Scientific Committee on Antarctic Research, p. 33-114, ISBN 978-0-948277-22-1.

Barrett, P.J., 2009. A history of Antarctic Cenozoic glaciation – view from the continent. In Florindo, F. and Siegert, M. (eds.), *Antarctic Climate Evolution, Developments in Earth and Environmental Sciences 8*. Elsevier: The Netherlands. p. 33-82.

Carter, L., Burnett, D., Drew, S., Hagadorn, L., Marle, G., Bartlett-McNeil, D., Irvine, N., 2009. *Submarine Cables and the Oceans - Connecting the World*. UNEP-WCMC Biodiversity Series 31. ICPC/UNEP/UNEP-WCMC, 64pp. ISBN 978-0-9563387-2-3.

Carter, L., McCave, I.N., Williams, M., 2009. Circulation and water masses of the Southern Ocean: A review. In Florindo, F. and Siegert, M. (eds.), *Antarctic Climate Evolution, Developments in Earth and Environmental Sciences 8*. Elsevier: The Netherlands. p. 85-114.

Naish, T., **Carter, L.**, Wolff, E., Pollard, D., Powell, R., 2009. Late Pliocene-Pleistocene Antarctic climate variability at orbital and suborbital scale: Ice sheet, ocean and atmospheric interactions. In Florindo, F. and Siegert, M. (eds.), *Antarctic Climate Evolution, Developments in Earth and Environmental Sciences 8*. Elsevier: The Netherlands. p. 465-527.

Wilson, G., Pekar, S., **Naish, T.**, Passchier, S., DeConto, R., 2009. The Oligocene-Miocene boundary – Antarctic climate response to orbital forcing. In Florindo, F. and Seigert, M. (eds.), *Antarctic Climate Evolution, Developments in Earth and Environmental Sciences 8*: Elsevier: The Netherlands. p. 444-465.

Theses

Bull, J.R., 2009. Stable isotope, major and trace element chemistry of modern snow from Evans Piedmont Glacier, Antarctica: Insights into potential source regions and relationship of glaciochemistry to atmospheric circulation and vigour. Unpublished MSc thesis, Victoria University of Wellington: Wellington. 206pp

Marr, J., 2009. Ecological, oceanographic and temperature controls on the incorporation of trace elements into *Globigerina bulloides* and *Globoconella inflata* in the Southwest Pacific Ocean. Unpublished MSc thesis, Victoria University of Wellington: Wellington. 152pp.

Schuck, I., 2009. Mineralogical characterisation and geographic province of atmospheric particles in coastal Antarctic ice cores – indicator of past climate variability. Unpublished MSc thesis, University of Karlsruhe, Germany, Victoria University of Wellington, New Zealand, and GNS Science, New Zealand.

Reports

Burnett, D.R. and **Carter, L.**, 2009. Deep-sea observatories and the law. *Oceans'09 IEEE*, Bremen 11pp.

Conference Proceedings

Dickinson, W.W., Schiller, M., Graham, I.J., Baker, J.A., 2009. A possible long-term record of Mg isotopic composition in seawater from ferromanganese nodules in the South Pacific. *Geochimica et Cosmochimica Acta* 73(13) supplement 1: A291.

Conference – Oral Presentations

Anderson, B.M. and **Mackintosh, A.N.**, 2009. A methodology for ice core site selection. *The 2009 New Zealand Snow and Ice Research Group (SIRG) Annual Workshop*, Albertown, Otago, New Zealand, 16-18 February, 2009.

Barrett, P.J., 2009. NZ Geosciences contribution to 5th IPCC Assessment Report. In Barrell, D.J.A., and Tulloch, A.J. (Eds.), *Programme and Abstracts, Geosciences 09 Conference*. Oamaru, New Zealand. Geological Society of New Zealand Miscellaneous Publication 128A: p. 11.

Barrett, P.J., 2009. ACE contribution to the Intergovernmental Panel on Climate Change Fifth Assessment Report. *First Antarctic Climate Evolution Symposium*, 7-11 September, 2009, Granada, Spain.

Barrett, P.J., 2009. Antarctica and climate change. *Annual Antarctic Conference*, Auckland, 1-3 July 2009.

Barrett, P.J., Cramer, B.S., Crowley, T.J., Miller, K.G., Wright, J.D. 2009. Global temperature over the last 100 million years: From greenhouse to icehouse. In Strong C.P., Crouch E.M., and Hollis C., *Climatic and Biotic Events of the Paleogene*, 12-15 January 2009, Te Papa, Wellington, New Zealand, GNS Science Miscellaneous Series 16, 144p.

Barrett, P.J., Francis, J.E., Hayward, A.M., Gohl, K., Siddoway, C.S., Wilson D.S., 2009. ANTscape: Antarctic paleotopographic maps for the last 100 million years. *First Antarctic Climate Evolution Symposium*, 7-11 September, 2009, Granada, Spain.

Bertler, N.A.N., 2009. Past and Future Climate Variability in the Ross Sea Region. *Ice Core Symposium*, GNS Science, National Isotope Centre, Lower Hutt, 8 October 2009.

Bertler, N.A.N., 2009. The Roosevelt Island Project. *WAIS Ice Core Meeting*, La Jolla, San Diego USA,1-3 October 2009.

Bertler, N.A.N., 2009. Past and future climate variability in the Ross Sea region. *Annual Antarctic Conference*, Auckland, 1-3 July 2009.

Bertler, N.A.N., 2009. Coastal Antarctic ice cores. In. Cortese, G., Vandergoes, M., Bostock, H., 2009. *Past Climates Meeting*, 2009, Te Papa, Wellington, New Zealand, 15-17 May, 2009. GNS Science Miscellaneous Series 23.

Bertler, N.A.N., 2009. Antarctic Climate Change. *Climate of the Past – Transfer of Science to Policy*, Victoria University, Wellington, 30 January 2009.

Bull, J.R., **Bertler, N.A.N.**, and Baker, J.A., 2009. Climatic controls of trace element chemistry at a coastal Antarctic site; Evans Piedmont Glacier. *Joint Antarctic Research Institute Ice Core Research Workshop*. GNS Science, Wellington, 15 December, 2009.

Carter, L., 2009. New Zealand in the world ocean – a tale of two hemispheres. *International Ship Owners [Research] 22nd Meeting*, Wellington, 20 January, 2009.

Carter, L., 2009. Marine Environmental Advisor Report, 2009. *ICPC Plenary 2009*, Florida 20-23 April, 2009.

Carter, L., 2009. Earthquake related failures of submarine cables off Taiwan. *ICPC Plenary 2009*, Florida 20-23 April, 2009.

Carter, L., 2009. Changes in ocean circulation and water masses since the Last Glacial Maximum - the New Zealand record. In. Cortese, G., Vandergoes, M., Bostock, H., 2009. *Past Climates Meeting*, 2009, Te Papa, Wellington, New Zealand, 15-17 May, 2009. GNS Science Miscellaneous Series 23, p9.

Carter, L., 2009. Ocean environment and cables – vulnerabilities and trends. *ROGUCCI Global Summit Reliability of the Global Undersea Cable Communications Infrastructure*, Dubai 27-29 October, 2009.

Carter, L., 2009. Conversation with a taxi driver – views on climate change. Invited Lecture: *NZ Post Graduate Conference*, Wellington, 20-21 November, 2009.

Carter, L., 2009. "The Global cable Network – the need to protect infrastructure" and "Ocean users – now and in the future". Invited Lecture: *Submarine cables and Law of the Sea, Centre International Law*, Singapore, 13-14 December, 2009.

Carter, L. and ICPC, 2009. Submarine Cable Network Security. *APEC Telecommunications Conference*, Singapore, 13-14 April, 2009.

Carter, L. and Wood, M., 2009. Modern sediment dispersal and deposition at the high input, Waipaoa continental margin. *US-NZ Margins Meeting*, 5-9 April, 2009.

Carter, L., **Dunbar, G.**, **Naish, T.**, **McKay, R.**, **Fyke, J.**, Duncan, B. 2009. Southern Ocean in a warming world – insights from the SW Pacific. *Annual Antarctic Conference*, Auckland, 1-3 July 2009.

PUBLICATIONS & CONFERENCES

Carter, L., McCave, N., **McKay, R.**, **Dunbar, G.**, Hall, I., 2009. Southern Ocean response to glacial-interglacial cycles – Insights from the SW Pacific and ANDRILL 001. In **Dow, M.**, Fischbein, S., Levy, R., **Naish, T.**, Powell, R. *ANDRILL McMurdo Ice Shelf Project Science Integration Workshop - Program and Abstracts*. 10-13th February, 2009, Victoria University of Wellington. ANDRILL Contribution 12. Wellington, New Zealand, 65 pp.

Crampton, J., Vandergoes, M., **Carter, L.**, 2009. Modulation of abrupt climate change in the Southwest Pacific during Antarctic Cold Reversal-Younger Dryas time. *Chapman Conference*, 15-19 June, 2009.

Doughty, A.M. and Denton, G.H., 2009. 10Be cosmogenic exposure ages of late Pleistocene moraines near the Mayburn Gap of the Pukaki Basin. *The 2009 New Zealand Snow and Ice Research Group (SIRG) Annual Workshop*, Albertown, Otago, New Zealand, 16-18 February, 2009.

Fyke, J., **Carter, L.**, **Mackintosh, A.**, 2009. Simulating ice shelf stability with a climate model. *The 2009 New Zealand Snow and Ice Research Group (SIRG) Annual Workshop*, Albertown, Otago, New Zealand, 16-18 February, 2009.

Henrys, S., Wilson, T., **Hansaraj, D.**, **Naish, T.**, Powell, R., and the ANDRILL McMurdo Ice Shelf Science Team, 2009. Regional seismic stratigraphic correlations: Using the results of AND-1B. In **Dow, M.**, Fischbein, S., Levy, R., **Naish, T.**, Powell, R. *ANDRILL McMurdo Ice Shelf Project Science Integration Workshop – Program and Abstracts*. 10-13th February, 2009, Victoria University of Wellington. ANDRILL Contribution 12. Wellington, New Zealand, 65 pp.

Levy, R., Luyendyk, B., Fischbein, S., Harwood, D., **Naish, T.**, Rack, F., Sorlien, C., Wilson, D., Wilson, G., **Pyne, A.**, **Falconer, T.**, and the ANDRILL Science Committee. 2009. Drilling to uncover the evolution and behaviour of the West Antarctic Ice Sheet in a high CO2 world. *Annual Antarctic Conference*, Auckland, 1-3 July 2009.

Mackintosh, A., Domack, E., **Golledge, N.**, Dunbar, R., Leventer, A., White, D., Fink, D., Gore, D., Lavoie, C. 2009. Last major retreat of Antarctic ice sheets forced by sea level rise and ocean warming. *Annual Antarctic Conference*, Auckland, 1-3 July 2009.

Mackintosh, A., Domack, E., **Golledge, N.**, Dunbar, R., Leventer, A., White, D., Fink, D., Gore, D., Lavoie, C., Pollard, D., DeConto, R., 2009. Last major retreat of Antarctic ice sheets forced by sea level rise and ocean warming. *First Antarctic Climate Evolution Symposium*, 7-11 September, 2009, Granada, Spain.

Mackintosh, A., Domack, E., Leventer, A., Dunbar, R., Fink, D., White, D., Gore, D., 2009. Last major retreat of Antarctic ice sheets forced by sea level rise and warming. *The 2009 New Zealand Snow and Ice Research Group (SIRG) Annual Workshop*, Albertown, Otago, New Zealand, 16-18 February, 2009.

Marr, J., Baker, J., **Carter, L.**, **Dunbar, G.**, 2009. Mg/Ca-temperature relationship of *Globigerina bulloides*. *Royal Society Beanland-Thornley Student Talks Competition*. Wellington, New Zealand, 4 September 2009.

McKay, R., **Naish, T.**, and Powell, R., 2009. Pleistocene fluctuations of the Antarctic Ice Sheet in the Ross Embayment. In **Dow, M.**, Fischbein, S., Levy, R., **Naish, T.**, Powell, R. *ANDRILL McMurdo Ice Shelf Project Science Integration Workshop - Program and Abstracts*. 10-13th February, 2009, Victoria University of Wellington. ANDRILL Contribution 12. Wellington, New Zealand, 65 pp.

McKay, R., **Naish, T.**, Levy, R., **Carter, L.**, 2009. Did Antarctic cooling ~3.3 million years ago help facilitate Northern Hemisphere glaciations? In Barrell, D.J.A., and Tulloch, A.J. (Eds.), *Programme and Abstracts, Geosciences 09 Conference*. Oamaru, New Zealand. Geological Society of New Zealand Miscellaneous Publication 128A: p. 139.

McKay, R., **Naish, T.**, Levy, R., **Carter, L.**, 2009. Did Antarctic cooling ~3.3 million years ago drive Northern Hemisphere glaciations? *First Antarctic Climate Evolution Symposium*, 7-11 September, 2009, Granada, Spain.

Naish, T. and the ANDRILL McMurdo Ice Shelf Science Team, 2009. Orbital influences on the Pliocene Antarctic ice sheets. *First Antarctic Climate Evolution Symposium*, 7-11 September, 2009, Granada, Spain.

Naish, T. and the ANDRILL McMurdo Ice Shelf Science Team, 2009. The stability of the Antarctic ice sheets during the early Pliocene climatic optimum. In Barrell, D.J.A., and Tulloch, A.J. (Eds.), *Programme and Abstracts, Geosciences 09 Conference*. Oamaru, New Zealand. Geological Society of New Zealand Miscellaneous Publication 128A: p. 150.

Naish, T.R., and the ANDRILL McMurdo Ice Shelf Science Team. 2009. Pliocene variability of the West Antarctic Ice Sheet from the ANDRILL, AND-1B geological record. In **Dow, M.**, Fischbein, S., Levy, R., **Naish, T.**, Powell, R. *ANDRILL McMurdo Ice Shelf Project Science Integration Workshop - Program and Abstracts*. 10-13th February, 2009, Victoria University of Wellington. ANDRILL Contribution 12. Wellington, New Zealand, 65 pp.

Naish, T.R. and the ANDRILL McMurdo Ice Shelf Science Team. 2009. The West Antarctic Ice Sheet in a warmer world. *Annual Antarctic Conference*, Auckland, 1-3 July 2009

Naish, T., Powell, R., Levy, R., DeConto, R., Pollard, D., and ANDRILL MIS Science Team, 2009. Obliquity-paced Pliocene West Antarctic Ice Sheet oscillations. *European Geosciences Union General Assembly*, Vienna, Austria 19-24th April 2009.

Naish, T., Ravelo, C., Triphati, A., Pagani, M., 2009. Reconciling Pliocene warmth: How can ANDRILL contribute? In **Dow, M.**, Fischbein, S., Levy, R., **Naish, T.**, Powell, R. *ANDRILL McMurdo Ice Shelf Project Science Integration Workshop - Program and Abstracts*. 10-13th February, 2009, Victoria University of Wellington. ANDRILL Contribution 12. Wellington, New Zealand, 65 pp.

Purdie, H., **Mackintosh, A.**, Lawson, W, **Anderson, B.**, 2009. Simultaneous measurements of snow accumulation east and west of the Southern Alps, New Zealand. *The 2009 New Zealand Snow and Ice Research Group (SIRG) Annual Workshop*, Albertown, Otago, New Zealand, 16-18 February, 2009.

Rhodes, R.H., **Bertler, N.A.N.**, Baker, J.A., 2009. Trace elements reveal 'Little Ice Age' in an Antarctic ice core. *New Zealand Postgraduate Conference. Victoria University of Wellington*, Wellington, New Zealand, 20-21 November, 2009. (Winner of Foundation for Research, Science and Technology Outstanding Oral Presentation)

Ryan, M.T., **Dunbar, G.B.**, Hannah M.J., Vandergoes, M.J., Neil, H.L., Bostock, H., 2009. A 210 ka terrestrial palynomorph record from a marine sediment core, West Coast, South Island. In Barrell, D.J.A., and Tulloch, A.J. (Eds.), Programme and Abstracts, Geosciences 09 Conference. Oamaru, New Zealand. *Geological Society of New Zealand Miscellaneous Publication* 128A: p. 183.

Stumm, D., Fitzsimons, S.J., Cullen, N.J., Hoelzle, M., Machguth, H., **Anderson, B.**, **Mackintosh, A.**, 2009. Brewster Glacier's mass balance modeled over three decades. *The 2009 New Zealand Snow and Ice Research Group (SIRG) Annual Workshop*, Albertown, Otago, New Zealand, 16-18 February, 2009.

Riger-Kusk, M., Lawson, W., Rack, W., **Anderson, B.**, 2009. Preliminary results from a study of ice dynamics of the Darwin-Hatherton glacial system, Antarctica. *The 2009 New Zealand Snow and Ice Research Group (SIRG) Annual Workshop*, Albertown, Otago, New Zealand, 16-18 February, 2009.

Conference - Poster Presentations

Anderson, B. and **Mackintosh, A.** 2009. Present-day fluctuations of glaciers in the Southern Alps, New Zealand, and their climatic drivers. In. Cortese, G., Vandergoes, M., Bostock, H., 2009. *Past Climates Meeting*, 2009, Te Papa, Wellington, New Zealand, 15-17 May, 2009. GNS Science Miscellaneous Series 23, p4.

Barrell, D.J.A., Denton, G.H., Andersen, B.G., Chinn, T.J.H., **Doughty, A.M.**, Finkel, R.C., Hendy, C.H., Kaplan, M.R., Kelley, S., Lowell, T.V., Putnam, A.E., Schaefer, J.M., Schlüchter, C., Schwartz, R., Vandergoes, M.J. 2009. Records of past climate changes obtained from glacier landforms, central South Island, New Zealand – An overview. In. Cortese, G., Vandergoes, M., Bostock, H., 2009. *Past Climates Meeting*, 2009, Te Papa, Wellington, New Zealand, 15-17 May, 2009. GNS Science Miscellaneous Series 23, p7.

Barrett, P. 2009. Cenozoic paleoclimates: From the greenhouse to the icehouse world (and back?). *Annual Antarctic Conference*, Auckland, 1-3 July 2009.

Bertler, N.A.N. and Wood, S.W. 2009. Report on Antarctic climate change and the environment. *Annual Antarctic Conference*, Auckland, 1-3 July 2009.

Bolton, A., Baker, J., **Carter, L.**, **Dunbar, G.**, 2009. A from the past: What microfossils can tell us about climate change. In **Marr, J.** and Allan, A. (Eds.), *New Zealand Postgraduate Conference, 2009: Programme and Abstracts*. Victoria University of Wellington Postgraduate Students' Association Miscellaneous Publication 1.

Bull, J., **Bertler, N.A.N.**, and Baker, J. 2009. Chemistry of coastal Antarctic snow: Potential ENSO indicator. *Annual Antarctic Conference*, Auckland, 1-3 July 2009.

Bull, J.R., **Bertler, N.A.N.**, and Baker, J.A., 2009. Chemistry of modern Antarctic snow: A potential ENSO indicator. In. Cortese, G., Vandergoes, M., Bostock, H., 2009. *Past Climates Meeting*, 2009, Te Papa, Wellington, New Zealand, 15-17 May, 2009. GNS Science Miscellaneous Series 23.

Cody R., Crampton, J., Levy, R., **Naish, T.**, Wilson, G., Harwood, D. 2009. Application of quantitative biostratigraphic modeling to the AND-1B drill core record: Local chronology and regional correlation. In **Dow, M.**, Fischbein, S., Levy, R., **Naish, T.**, Powell, R. *ANDRILL McMurdo Ice Shelf Project Science Integration Workshop - Program and Abstracts*. 10-13th February, 2009, Victoria University of Wellington. ANDRILL Contribution 12. Wellington, New Zealand, 65 pp.

Denton, G.H., Putnam, A.E., Schaefer, J.M., Barrell, D.J.A., Andersen, B.G., Schwartz, R., Finkel, R.C., Chinn, T.J.H., **Doughty, A.M.**, 2009. Holocene 10Be surface-exposure chronology of moraines deposited by the Cameron Glacier, Arrowsmith Range, Southern Alps, New Zealand. In. Cortese, G., Vandergoes, M., Bostock, H., 2009. *Past Climates Meeting*, 2009, Te Papa, Wellington, New Zealand, 15-17 May, 2009. GNS Science Miscellaneous Series 23, p13.

Denton, G.H., Putnam, A.E., Schaefer, J.M., Barrell, D.J.A., Andersen, B.G., Schwartz, R., Finkel, R.C., Chinn, T.J.H., **Doughty, A.M.** ,2009. 10Be surface-exposure chronology of the Birch Hill moraines, Pukaki Region, Southern Alps, New Zealand. In. Cortese, G., Vandergoes, M., Bostock, H., 2009. *Past Climates Meeting*, 2009, Te Papa, Wellington, New Zealand, 15-17 May, 2009. GNS Science Miscellaneous Series 23, p14.

Doughty, A.M., Denton, G.H., Hall, B.L., Putnam, A.E., Schaefer, J.M., Barrell, D.J.A., Andersen, B.G. 2009. ^{10}Be cosmogenic exposure-ages from Late Pleistocene moraines near Mary Burn, Lake Pukaki, central South Island, New Zealand. In. Cortese, G., Vandergoes, M., Bostock, H., 2009. *Past Climates Meeting*, 2009, Te Papa, Wellington, New Zealand, 15-17 May, 2009. GNS Science Miscellaneous Series 23, p15.

Doughty, A.M., **Mackintosh, A.**, and **Anderson, B.**, 2009. Using computer models to quantify New Zealand glacier fluctuations over the past 13,000 years. . In Barrell, D.J.A., and Tulloch, A.J. (Eds.), *Programme and Abstracts, Geosciences 09 Conference*. Oamaru, New Zealand. Geological Society of New Zealand Miscellaneous Publication 128A: p. 60.

Doughty, A.M., Putnam, A.E., Kelley, S.E., Denton, G.H., Schaefer, J.M., Kaplan, M.R., Barrell, D.J.A., Andersen, B.G., Schwartz, R., Finkel, R.C., Travis, S. 2009. Timing and duration of the Last Glacial Maximum inferred from a ^{10}Be surface-exposure chronology of the Lake Pukaki moraine complex, Mackenzie District, Southern Alps, New Zealand. In. Cortese, G., Vandergoes, M., Bostock, H., 2009. *Past Climates Meeting*, 2009, Te Papa, Wellington, New Zealand, 15-17 May, 2009. GNS Science Miscellaneous Series 23, p16.

Dunbar, G., Baker, J., **Naish, T.**, 2009. *Neogloboquadrina pachyderma* Mg/Ca-based sea surface temperature estimates associated with the retreat of the Ross Ice Shelf at 1.07 Ma. In **Dow, M.**, Fischbein, S., Levy, R., **Naish, T.**, Powell, R. *ANDRILL McMurdo Ice Shelf Project Science Integration Workshop – Program and Abstracts*. 10-13th February, 2009, Victoria University of Wellington. ANDRILL Contribution 12. Wellington, New Zealand, 65 pp.

Falconer, T.R., **Pyne, A.R.**, Cowie, J., Huey, D.P., Leitch, J., Mitchell, M., Webster, B., 2009. ANDRILL drilling from an ice shelf platform: Past achievements and future ideas. In **Dow, M.**, Fischbein, S., Levy, R., **Naish, T.**, Powell, R. *ANDRILL McMurdo Ice Shelf Project Science Integration Workshop -Program and Abstracts*. 10-13th February, 2009, Victoria University of Wellington. ANDRILL Contribution 12. Wellington, New Zealand, 65 pp.

Golledge, N.R., Bradwell, T., Hubbard, A. 2009. Seasonality and glacier mass balance: implications for palaeoclimate reconstructions of northern and southern hemispheres. In. Cortese, G., Vandergoes, M., Bostock, H., 2009. *Past Climates Meeting*, 2009, Te Papa, Wellington, New Zealand, 15-17 May, 2009. GNS Science Miscellaneous Series 23, p21.

Hannah, M. 2009. Initial marine palynology results from ANDRILL AND–1B. In **Dow, M.**, Fischbein, S., Levy, R., **Naish, T.**, Powell, R. *ANDRILL McMurdo Ice Shelf Project Science Integration Workshop - Program and Abstracts*. 10-13th February, 2009, Victoria University of Wellington. ANDRILL Contribution 12. Wellington, New Zealand, 65 pp.

PUBLICATIONS & CONFERENCES

Hannah, M.J., Raine, J.I., Warny, S., Askin, R.A., Mohr, B.A.R., 2009. Palynomorphs recovered from the ANDRILL SMS sediment core provide first proximal environmental characterization of the Middle Miocene climatic optimum. In Barrell, D.J.A., and Tulloch, A.J. (Eds.), *Programme and Abstracts, Geosciences 09 Conference*. Oamaru, New Zealand. Geological Society of New Zealand Miscellaneous Publication 128A.

Kaplan, M.R., Schaeffer, J.M., Putnam, A., Barrell, D.J.A., Denton, G.H., Andersen, B.G., Chinn, T.J.H., **Doughty, A.M.**, Finkel, R.C., Schwartz, R., Kelley, S. 2009. 10Be surface-exposure chronology of Lateglacial moraines in the Ben Ohau Range, South Island, New Zealand. In. Cortese, G., Vandergoes, M., Bostock, H., 2009. *Past Climates Meeting*, 2009, Te Papa, Wellington, New Zealand, 15-17 May, 2009. GNS Science Miscellaneous Series 23, p30.

Kaplan, M.R., Schaeffer, J.M., Barrell, D.J.A., Andersen, B.G., Chinn, T.J.H., Putnam, A., **Doughty, A.M.**, Denton, G.H., Finkel, R.C., Schwartz, R., Kelley, S. 2009. 10Be surface-exposure chronology of moraines deposited in upper Whale Stream, Ben Ohau Range, South Island, New Zealand. In. Cortese, G., Vandergoes, M., Bostock, H., 2009. *Past Climates Meeting*, 2009, Te Papa, Wellington, New Zealand, 15-17 May, 2009. GNS Science Miscellaneous Series 23, p31.

Levy, R., **Cody, R.**, Crampton, J., Fielding, C., Harwood, D., Henrys, S., **McKay, R.**, Riesselman, C., Scherer, R., Sjunneskog, C., Wilson, G., Winter, D., 2009. A chronostratigraphic framework for Neogene drill cores from McMurdo Sound, Antarctica and application to paleoclimatic and tectonic studies. In **Dow, M.**, Fischbein, S., Levy, R., **Naish, T.**, Powell, R. *ANDRILL McMurdo Ice Shelf Project Science Integration Workshop - Program and Abstracts*. 10-13th February, 2009, Victoria University of Wellington. ANDRILL Contribution 12. Wellington, New Zealand, 65 pp.

Mackintosh, A., **Anderson, B.**, Hubbard, **Golledge, N.**, **Purdie, H.**, **Doughty, A.**, Huybers, P., Pierrehumbert, R., Denton, G., Barrell, D., Chinn, T.J.H., Andersen B., Finkel, R.C., Kaplan, M., Putnam, A., Schaefer, J., Schwartz, R. 2009. Drivers of Southern Hemisphere climate variability: A view from modelling of New Zealand glaciers. In. Cortese, G., Vandergoes, M., Bostock, H., 2009. *Past Climates Meeting*, 2009, Te Papa, Wellington, New Zealand, 15-17 May, 2009. GNS Science Miscellaneous Series 23, p37.

Marr, J., Baker, J., **Carter, L.**, **Dunbar, G.**, 2009. Development of a Mg/Ca temperature calibration for the planktonic foraminifera *G. Bulloides* for New Zealand waters. In **Marr, J.** and Allan, A. (Eds.), *New Zealand Postgraduate Conference, 2009: Programme and Abstracts*. Victoria University of Wellington Postgraduate Students' Association Miscellaneous Publication 1.

McKay, R., Browne, G., **Carter, L.**, Cowan, E., **Dunbar, G.**, Krissek, L., **Naish, T.**, Powell, R., Reed, J., Talarico, F., Wilch, T. 2009. The stratigraphic signature of the Late Cenozoic Antarctic ice sheets in the Ross Sea embayment. *Annual Antarctic Conference, Auckland*, 1-3 July 2009.

McKay, R.M., **Naish, T.R.**, and Powell, R.D. 2009. Pleistocene fluctuations of the Antarctic Ice Sheet in the Ross Embayment. *European Geosciences Union General Assembly*, Vienna, Austria 19-24th April 2009.

Putnam, A., Denton, G.H., Schaefer, J.M., Barrell, D.J.A., Andersen, B.G., Kaplan, M.R., Schwartz, R., Finkel, R.C., **Doughty, A.M.**, Travis, S. 2009. Timing and duration of the Last Glacial Maximum inferred from a 10Be surface-exposure chronology of the Lake Ohau terminal moraine complex, Southern Alps, New Zealand. In. Cortese, G., Vandergoes, M., Bostock, H., 2009. *Past Climates Meeting*, 2009, Te Papa, Wellington, New Zealand, 15-17 May, 2009. GNS Science Miscellaneous Series 23, p41.

Rhodes, R.H., **Bertler, N.A.N.**, Baker, J.A., Sneed, S.B., Oerter, H., Arrigo, K.R. 2009. A methylsulphonate snow pit record controlled by Ross Sea Polynya size and productivity. In. Cortese, G., Vandergoes, M., Bostock, H., 2009. *Past Climates Meeting*, 2009, Te Papa, Wellington, New Zealand, 15-17 May, 2009. GNS Science Miscellaneous Series 23, p47.

Ryan, M.T., **Dunbar, G.B.**, Vandergoes, M.J., Hannah., M.J., Neil, H., Bostock, H., 2009. A preliminary 210Ka terrestrial palynomorph record from a marine sediment core, West Coast, South Island. In. Cortese, G., Vandergoes, M., Bostock, H., 2009. *Past Climates Meeting*, 2009, Te Papa, Wellington, New Zealand, 15-17 May, 2009. GNS Science Miscellaneous Series 23, p53.

Ryan, M.T., **Dunbar, G.B.**, Mildenhall, D.C., Hannah, M.J., 2009. Last glacial and Holocene terrestrial pollen records from marine cores, MD06-3002 and 3006, Poverty Bay, North Island, New Zealand. *MARGINS Source-to-Sink Synthesis Meeting*, Gisborne, New Zealand. 5-9 April, 2009.

Schaefer, J.M., Denton, G.H., Finkel, R.C., Kaplan, M.R., Putnam, A., Schwartz, R., Barrell, D.J.A., Andersen, B.G., **Mackintosh, A.**, Schlüchter, C. 2009. High-frequency fluctuations of Mueller, Tasman and Hooker Glacier, New Zealand's Southern Alps, during the last 7,000 years. In. Cortese, G., Vandergoes, M., Bostock, H., 2009. *Past Climates Meeting*, 2009, Te Papa, Wellington, New Zealand, 15-17 May, 2009. GNS Science Miscellaneous Series 23, p51.

Schaefer, J.M., Finkel, R.C., Kaplan, M.R., Putnam, A., **Doughty, A.M.**, Kelley, S., Schwartz, R., Denton, G.H., Barrell, D.J.A., Andersen, B.G., Schlüchter, C. 2009. Precise 10Be dating of glacier fluctuations in the Southern Alps, New Zealand, over the last 70,000 years. In. Cortese, G., Vandergoes, M., Bostock, H., 2009. *Past Climates Meeting*, 2009, Te Papa, Wellington, New Zealand, 15-17 May, 2009. GNS Science Miscellaneous Series 23, p52.

Talarico, F., **McKay, R.**, Powell, R., Sandroni, S., **Naish, T.**, 2009. Provenance signatures of the Antarctic ice sheets in the Ross Embayment during the Late Cenozoic: The ANDRILL core AND-1B record. In **Dow, M.**, Fischbein, S., Levy, R., **Naish, T.**, Powell, R. *ANDRILL McMurdo Ice Shelf Project Science Integration Workshop - Program and Abstracts*. 10-13th February, 2009, Victoria University of Wellington. ANDRILL Contribution 12. Wellington, New Zealand, 65 pp.

LIST OF ACRONYMS

ACE	Antarctic Climate Evolution (SCAR programme)
AGCS	Antarctica in the Global Climate System (SCAR programme)
ANDRILL	ANtarctic geological DRILLing
AntNZ	Antarctica New Zealand
ANZICE	Antarctica-New Zealand Interglacial Climate Extremes (ARC FRST-funded programme)
ARC	Antarctic Research Centre
CCRI	Climate Change Research Institute
DVC	Deputy Vice-Chancellor
EAPSI	East Asia Pacific Summer Institutes Program (NSF and MoRST funded programme)
ETH	Swiss Federal Institute of Technology
FRST	Foundation for Research, Science and Technology
FTE	Fulltime Equivalent
GNS Science	Institute of Geological and Nuclear Sciences Ltd.
IARC	International Arctic Research Center (University of Alaska Fairbanks)
ICDP	Inter-Continental Drilling Programme
ICPC	International Cables Protection Committee
IDDO	Ice Drilling Design & Operations (University of Wisconsin)
INGV	National Institute of Geophysics and Volcanology (Italy)
INQUA	International Union for Quaternary Research
INTIMATE	INTegration of Icecore, Marine and TErrestrial records (INQUA programme)
IODP	Integrated Ocean Drilling Program
IPCC	Intergovernmental Panel on Climate Change
IPICS	International Partnership on Ice Coring Sciences
ITASE	International Trans Antarctic Scientific Expedition (ice coring collaboration)
JARI	Joint Antarctic Research Institute
LGP	Latitudinal Gradient Programme
MFAT	Ministry of Foreign Affairs and Trade
MIS	McMurdo Ice Shelf (ANDRILL drill site)
MoRST	Ministry of Research Science and Technology
NEEM	North Greenland Eemian Ice Drilling (University of Copenhagen, Denmark project)
NIWA	National Institute of Water and Atmospheric Research
NSF	National Science Foundation (US science funder)

LIST OF ACRONYMS

PACAFI	Past Antarctic Climates and Future Implications (ANDRILL programme)
PBRF	Performance Based Research Fund
PISM	Parallel Ice Sheet Model
RICE	Roosevelt Island Climate Evolution (ice coring project)
SCAR	Scientific Committee on Antarctic Research
SDO	Science Drilling Office
SGEES	School of Geography, Environment and Earth Sciences
SHALDRIL	SHALlow DRILling project
SMS	Southern McMurdo Sound (ANDRILL drill site)
UCanterbury	University of Canterbury
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UOtago	University of Otago
VUW	Victoria University of Wellington
WAIS	West Antarctic Ice Sheet

Antarctic Research Centre
Victoria University of Wellington
PO Box 600
Wellington 6140
New Zealand

Phone **+64-4-463 6587**
Email **antarctic-research@vuw.ac.nz**
Website **www.victoria.ac.nz/antarctic**