VICTORIA UNIVERSITY OF WELLINGTON
TE HERENGA WAKA

Te Puna Pātiotio
Antarctic
Research Centre

Te Puna Pātiotio—Antarctic Research Centre

Annual Review 2022

celebrating

CAPITAL
THINKING.
GLOBALLY
MINDED.
MAI I TE IHO KI TE PAE

Contents

Te Puna Pātiotio—Antarctic Research Centre
Annual Review 2022

Designed and edited by: Michelle Dow
Contributions from: Peter Barrett, Lionel Carter, Ruzica Dadic, Michelle Dow, Bella Duncan, Shaun Eaves, Nick Golledge, Huw Horgan, Richard Levy, Darcy Mandeno, Rob McKay, Ruby Muir, Tim Naish, Holly Winton, and Lauren Vargo.

IMPROVING UNDERSTANDING OF ANTARCTIC CLIMATE AND ICE SHEET PROCESSES, AND THEIR IMPACT ON NEW ZEALAND AND THE EARTH SYSTEM

Research

Every 2 km
of Aotearoa New Zealand coastline given specific sea-level rise projections by 2300
(page 15)

45 million years
of Antarctic temperature changes shows direct response to changing carbon dioxide levels
(page 16)

Coupling models
creates robust estimates of Antarctic ice sheet contribution to sea level
(page 17)

Snow and sea ice
Researchers investigate the role of snow cover on the evolution of Antarctic sea ice
(page 18)

500 metres
below the Antarctic ice sheet liquid water flows
(page 19)

Funding

$2.4M Funding
currently received from an international consortium to support the SWAIS 2C project
(page 14)

$13M Endeavour
grant awarded to improve understanding of the impacts of sea-level rise on coastal communities
(page 38)

$800K Rutherford
Discovery Fellowship to understand the role of phytoplankton in a warmer world
(page 38)

$929K Marsden
awarded to research Antarctic ice sheet melt events
(page 39)

$360K Marsden
Fast-Start for research into melting of New Zealand glaciers
(page 39)

Awards

Francis P. Shepard Medal
awarded to Lionel Carter in recognition of his “Excellence in Marine Geology”
(page 26)

Blake Leader Award
Richard Levy received one of four Blake Leader Awards, recognising people who have contributed to a more sustainable future for New Zealand
(page 27)

S.T. Lee Exchange
recipient Ian Blixt travelled to Alaska while Eric Petersen came to Wellington as part of the S.T. Lee Exchange programme
(page 30 & 31)

Arnold Heine Award
recipient Ruby Muir wrote a paper presenting the results of her Masters thesis in which she applied a glacial model to recreate past temperatures during the Antarctic Cold Reversal
(page 41)

Engagement

9 theses
completed by ARC supervised PhD and MSc students
(page 23)

34 publications
in 2022 with ARC staff and student authorship
(page 42)

66 media interviews
given by ARC staff and students on Antarctic and climate related issues
(page 45)

24 talks
given to scientists, politicians, stakeholders, schools and community groups by ARC staff and students
(page 44 & 47)

Icons from smahicon and www.flaticon.com

DIRECTOR'S SUMMARY

In 2022, Te Puna Pātiotio—Antarctic Research Centre reached a significant milestone, celebrating its 50th anniversary. With a milestone like this, we felt it was a valuable exercise in this annual review to pause and reflect on our journey to where we are now. This brief summary of our history, was attempted by myself and three ARC staff members who have been instrumental in our evolution: former directors Peter Barrett and Tim Naish and our long-standing Centre Manager Michelle Dow — who said farewell after a remarkable 16 years with us. Together, we found it impossible to condense this history into one or two pages, and consequentially the first part of this document represents a semicentennial review, albeit in a still very abridged form. It clearly does not do full justice to the many broad contributions that ARC researchers have made to understanding the impact of Antarctic change on the globe, as well as the many national and international collaborators that have supported us in this journey — we know it is not one we have undertaken alone.

Our history is clearly built on a legacy of student-led projects, beginning with undergraduate geology students Peter Webb and Barrie McKelvey in 1957, through to current students Julia Martin and Emma de Jong visiting the icy continent for the first time in 2022. In between, a total of approximately 200 students have undertaken research on our field campaigns, including myself as an MSc student in 1998. It was impossible to tell all of their stories in the history we provide in this report, but I am sure there are many similar to mine.

I had no intention to continue my studies, but an unexpected doorknock from Peter Barrett during my 4th year Honours project, resulted in an offer to do a Masters undertaking seven weeks mapping and sampling rocks in the Transantarctic Mountains. I had never even been on an airplane before, let alone overseas — so I didn't hesitant to say yes to go to one of the most remote regions on Earth. It was truly a trip that changed my life's direction and I am forever grateful I was given this remarkable opportunity. It also awoke an acute awareness about the vulnerability of our planet to the threat of climate change that was clearly emerging at that time.

In my role now, I know almost all of our students view their field experiences in Antarctica in remarkably similar ways. Seeing a high proportion of our students go onto successful research careers across the globe is testament to this — and seeing their passion and successes is one of the most rewarding parts of our job. With the reopening of our borders, we are delighted to see the next generation of students arrive from all around the world. This increased student body has resulted in a renewed vibrancy in the Centre, and I can see a true collective mindset to work on some of the most critical questions. These questions not only address the impact Antarctic climate change will physically have on the earth in our future, but also how society may adapt to such change.

In reviewing the highlights of 2022, it is the increasing diversity of our research portfolio and team that stands out to me. We continue our scientific leadership of Antarctic drilling with the SWAIS 2C project into its final year of preparation. Alex Pyne, Darcy Mandeno and our new engineer James MacPhail are busily constructing the final components of our new sub ice shelf drill system. We also continue our legacy of paleoclimate research with a *Nature Geoscience* paper led by Bella Duncan reconstructing a 45 million year history of Antarctica temperature change, examining a range of legacy cores, including one collected during the ARC's first year in 1972. We undertook a highly successful field season collecting oceanographic, geophysical and sediment core studies beneath the Ross Ice Shelf, and undertook sea ice research in McMurdo Sound. The National Modelling Hub continues to benefit from its multidisciplinary, and multi-institutional, collaborations to develop cutting edge ice sheet and ocean models. We had another year of remarkable funding success, with the awarding of an MBIE Endeavour Fund award for the Our Changing Coast programme led by Tim Naish and Richard Levy, a fifth ARC Rutherford Discovery Fellowship awarded to Holly Winton, a Marsden Fast-Start awarded to Lauren Vargo, and I was also fortunate to be awarded a Marsden Standard Grant. However, for me the highlight of the year was the publishing of an online tool for location specific sea-level rise projections out to the year 2300 for every 2 km of the coast of Aotearoa New Zealand. This work by the ARC-led NZ SeaRise programme exemplifies the impact and relevance that our current research has, and its release captured the attention of the entire nation, providing critical toolsets for local and central governments and coastal communities to enable robust adaption and coastal resilience planning.

Reviewing our past 50 year history has felt like a more important exercise than ever as we head into 2023. We currently face existential questions regarding the purpose of a modern university in a world that has fundamentally changed following the COVID pandemic, and the proposed revisioning of the New Zealand research sector that is currently under way. While we have had so many successes in 2022, these will undoubtably led to many challenges as well as new opportunities. The lessons we have learnt by navigating past challenges is that by clearly identifying our purpose and relevance to Aotearoa New Zealand and global society, we are well placed to continue providing critical, world-leading science for another 50 years.

Professor Rob McKay
Director, Te Puna Pātiotio—Antarctic Research Centre

ARC HISTORY — THE FIRST 50 YEARS

In the beginning

The Antarctic Research Centre (ARC) was established in 1972 as part of the Department of Geology at Victoria University of Wellington, but its origins were created over a decade earlier. Victoria University of Wellington's first Antarctic expeditions began during the International Geophysical Year (IGY), when two third-year geology students, Peter Webb and Barrie McKelvey, stepped off the *HMNZS Endeavour* on 30 December, 1957. Equipped with Professor Bob Clark's WWII field gear to keep them warm, they hitched a helicopter ride with biologist Ron Balham to the unexplored McMurdo Dry Valleys. Initially described by Trevor Hatherton, the head of IGY science team as "uninvited, unheralded, and unwanted", their endeavour, pioneering mapping and precise reporting ultimately left a highly favourable impression, and the success of these two intrepid students paved the way for the annual Victoria University of Wellington Antarctic Expeditions (VUWAE) that continue to this day.

Peter Webb and Barrie McKelvey

In 1970, after four Antarctic expeditions, one with New Zealand and three with the US, including the discovery of the first tetrapod remains in Antarctica, Peter Barrett returned to New Zealand to take up a two-year postdoctoral fellowship at the University to continue the annual Antarctic expeditions (VUWAE 15 & 16). The following year he was appointed Senior Lecturer in Geology and inaugural Director of the ARC. During that time, Peter undertook and led many Antarctic field parties involving both staff and graduate students and built international partnerships that enabled ARC leadership of numerous ambitious drilling projects, beginning with his participation on Deep Sea Drilling Project Leg 28 (1972/73). This was the first deep drilling project in Antarctica that made a startling and fundamental discovery regarding the antiquity of Antarctica's ice sheets — they were 10s of millions years old rather than the previously assumed two million.

A critical event in the evolution of the ARC occurred in 1975, when Alex Pyne enrolled at the University, conducting his first trip to Antarctica as a third year BSc student with VUWAE 22 in 1977/78. He began as a geological assistant, but quickly took a broader interest in all aspects of Antarctic field operations, including sea ice traverses, site surveys and offshore drilling, and in later years, deep ice coring on land. In 1983, he obtained a permanent position with the ARC, and for the next 20 years the ARC consisted of a two-man team with help from colleagues and graduate students (including several who are now staff members), leading expeditions to the ice. These projects further cemented the ARC's international reputation as global leaders in past climates of Antarctica, but also as leaders in innovative polar drilling science and operations.

The first NZ-led drilling was the joint US-NZ-Japan Dry Valley Drilling Project (DVDP, 1970-74), with the final hole being the first attempt to core offshore strata from floating sea ice, off Marble Point (DVDP-15). The ambition was to recover more continuous climate records than could be obtained on land. It was a high-risk plan, and was terminated after the sea ice platform started to crack after coring 51 metres. However, despite many drilling challenges, this project showed enough promise to make a second attempt, and New Zealand was allowed to borrow the rig from the US and run its own project in 1979, with US and Japanese colleagues, for the McMurdo Sound Sediment and Tectonic Studies (MSSTS-1) project. This was more successful, recovering strata back to ~30 million years ago, until coring reached 229 metres and the sea riser bent at the sea floor preventing further drilling.

The lessons learnt during MSSTS-1 to core deeper in offshore settings provided the stimulus for another collaborative drilling project with the US and Japan — Cenozoic Investigations in the western ROss Sea (CIROS, 1984-87). CIROS-2 was drilled first, in 1984 in the safety of Ferrar Fiord, with success in coring to basement at 165 metres, but only after overcoming technical problems that almost terminated the operation. This led Alex to upgrade the drilling system to better deal with tidal rise/fall and sub ice currents, leading to the spectacular success of CIROS-1 in 1986. It was drilled 15 km offshore in 200 metres of water with coring planned to a depth of 500 metres below the sea floor into the warm pre-glacial Eocene strata, providing the first insights into the true antiquity of the Antarctic ice sheets. They drilled to a depth of 702 metres below the sea floor with a remarkable 98% core recovery — a tribute to Alex and the drill team. Remarkably, this core and those from DSDP Leg 28, are still producing new insights into Antarctica's climate, forming a core component of the 45 million year temperature records published by Bella Duncan in 2022.

Peter's leadership of drilling projects culminated with the Cape Roberts Project (CRP, 1997-2000), which was designed to core thicker, more complete, and older sequences than CIROS-1. It had a more sophisticated tide compensation and flotation system and also attracted wider international interest. Italy became a welcome partner with New Zealand and the US as the big three, as well as German, UK and Australian scientists. The project was more complex with an International Steering Committee for the science, and an Operations Management Group for logistics and drilling, as well as a Project Manager for overseeing the spending of large sums of money. Still a lot of operational decision-making came down to Alex with his then 20 years of experience in working and monitoring the sea ice and working closely with our drilling partners at Webster Drilling and Exploration Ltd., through five years of planning, and three successive years of drilling. The result was the successful coring of 1500 metres of strata from 34 to 17 million years ago (over 900 metres in the third season). A key outcome came from the pattern and dating of the advance and retreat of the early ice sheets from the core. This work, led by Tim Naish (then at GNS Science) on his first trip to the ice, paved the way for the ANDRILL programme to capture the younger story. The use of these geological archives showed that Antarctica's ice sheet had been highly dynamic and variable in Antarctica's deep geological time, and helped validate ice sheet computer models that demonstrated Antarctic's ice sheets were incredibly sensitive to past higher greenhouse gas concentrations, and relatively small changes in Earth's temperature. We had now a very serious and societally relevant question to answer – just how sensitive where these ice sheets to climates that were similar to those projected for the end of the century?

While this relevance of understanding Antarctica's climatic past was becoming starkly apparent, internal situations in the University were to play a dramatic role in the evolution of the ARC. In 2000, the University faced some financial difficulties and the expensive nature of Antarctic research seemed an attractive target to cut costs. Peter and Alex, still the only staff in the ARC, were to be made redundant. Our postgraduate students led a series of protests, meetings with managers, and a march to parliament to meet MPs. Peter solicited letters of support from alumni and friends, and responses to the University's leadership flooded in from around the world, leading to discussions with the Vice Chancellor. Peter and Alex's international reputation as leaders in understanding the emerging threat of climate change on Antarctica's ice sheets helped save the ARC. The rescue package set up the Antarctic Research Centre as an independent cost centre with a Director reporting to the Dean of Science, and an Advisory Board of key stakeholders. The ARC was now entirely dependent on obtaining revenue through external research funding to sustain itself, although still contributed to teaching. While painful at the time, this new model of "sink or swim" rapidly pushed the ARC towards developing a more diverse research portfolio with direct relevance to the impacts on Antarctic change on Aotearoa New Zealand and the globe.

1972-1973

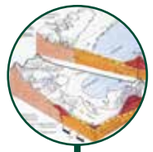
Peter Barrett sails on first international Antarctic drilling project DSDP Leg 28, discovering the Antarctic ice sheets were >27 million years old

1974

Peter Barrett appointed co-chief scientist of DVDP-15, the first attempt at offshore drilling from Antarctic sea ice

1977

BSc student Alex Pyne heads to Antarctica as a geological assistant on VUWAE 22



1979

First NZ-led (with US and Japan) drilling MSSTS-1 off Marble Point provides a glimpse into Antarctica's vegetated past

1983

Alex Pyne permanently appointed as Expedition Manager

Webster Drilling & Exploration Ltd. established, forming enduring partnership with ARC drilling projects

1984-1987

Peter Barrett (chief scientist), Peter Webb (US) and Alex Pyne oversee the CIROS drilling project that provided direct evidence of the onset of major glaciation in Antarctica in the Late Eocene

Philanthropic support

After this near collapse, ARC fortunes rose through a generous donation from the late Singaporean philanthropist, Lee Seng Tee in 2003 launching the inaugural S.T. Lecture in Antarctic Studies and ongoing student exchanges with the University of Alaska Fairbanks. It was during this time Peter also took on administrative support by way of Tamsin Falconer, the first new ARC employee since Alex. Warren Dickinson also joined at this time to undertake field-based geochemistry studies in the Dry Valleys.

Peter also worked with the Victoria University of Wellington Foundation to launch the ARC Endowed Development Fund in 2004, with Barrie McKelvey and Peter Webb as patrons, to support postgraduate students. Generous donations by alumni and donors over the years and $400,000 from the Prime Minster's Science Prize has seen the capital value of the fund rise to $1.5 million, generating $75,000 per year for student grants and PhD scholarships to develop the next generation of leaders in Antarctic research.

Of note were donations from the Morgan Family Charitable Foundation, glaciologist Arnold Heine (creating the Arnold Heine Antarctic Research Award), highly distinguished VUW alumni Professor James Kennett (providing support for the Roger Cooper Masters Scholarship), as well as recent bequests from Ray Dibble and John Nankervis. Webster Drilling and Exploration Ltd., and in particular their Directors, Bain Webster and Jeff Ashby, have also been large supporters, alongside their long association with Alex, the ARC and our Antarctic endeavours. However, the most substantial donation was a $1 million gift from alumnus Alan Eggers in 2007, divided between developing the Centre's drilling capability, a new research direction in ice sheet modelling with the recruitment of Nick Golledge, strengthening marine research, and the ARC Endowed Development Fund.

Building a stable foundation

The first step towards sustaining our future was in 2002, when the ARC got its first external grant via a subcontract from Tim Naish at GNS Science. This grant was then 'upgraded', to the Foundation for Research Science and Technology (FRST) $5M Antarctic Drilling (ANDRILL) programme in 2005. This enabled, the permanent employment of Tim Naish as Deputy Director, Gavin Dunbar as a sedimentologist for the project and Tamsin as Centre Manager. As Tamsin was instrumental in the operational support of ANDRILL the ARC hired a second administrator, Michelle Dow — who would eventually be promoted to Centre Manager in 2011, and continue providing critical support in this role for another 11 years, alongside administrator and Projects Coordinator Dao Polsiri who joined in 2016.

The US, Italy, Germany and New Zealand collaboration ANDRILL programme, represented a major technological drilling challenge, with the two sites not only in water deeper than 800 metres, but also through a floating ice shelf that was 100-150 metres thick. Work to develop the drilling system, which required coupling of a hot water drill system to minerals-industry drill rig, was begun by Alex in 2001. A series of site surveys were then supported by GNS Science, University of Otago, and the ARC, and the first drilling season at the ANDRILL McMurdo Ice Shelf (MIS) drill site was completed in 2006, followed by the ANDRILL Southern McMurdo Sound (SMS) drilling in 2007. These two drilling projects include the two deepest drillholes on the Antarctic continent, at 1284.87 and 1138.54 metres below sea floor, respectively (both with 98% recovery). This achievement was a true world first and its success captured the global attention of media and politicians, not only for its technological innovations but also its societal implications. The sediments obtained provide unequivocal evidence that the marine-based West Antarctic Ice Sheet had collapsed in climates that were similar to those projected for the end of the century. This provided critical "ground-truthing" for ice sheet models being developed for projections under future anthropogenic emission scenarios, including those by Nick Golledge.

In addition to our sediment drilling programme, Nancy Bertler was establishing Antarctic ice coring, where she led small ice coring projects, specialising in investigating high resolution coastal ice cores using borrowed equipment. These provided a unique insight into how well-known low-latitude climate process such as El Niño affect the Ross Sea. However, to build a viable long-term New Zealand capability in this field, a large group of supporters created a pathway for a VUW/GNS Science collaboration as part of the new Joint Antarctic Research Institute (JARI) in 2006. This formalized the highly successful and long standing collaboration between VUW and GNS Science (later joined by NIWA in 2009) and allowed staff and students to move seamlessly between organisations, aligning excellent and important science. GNS Science constructed the ~$1.2M National Ice Core Facility at their Gracefield site, which was formally opened in 2007, while the ARC developed the ~$1.4M drilling technology, and Nancy Bertler was co-employed by both GNS Science and VUW.

In the early 2000s, we also started looking towards transferring our expertise and capability to New Zealand climate change concerns, and in 2004 Brian Anderson joined the ARC, who along with Andrew Mackintosh (then employed by the School of Earth Sciences, leading to a joint appointment with the ARC in 2008) helped develop the ARC's New Zealand glacier research programme, that today forms one of the key pillars of our research. Key contributions in this field include long term monitoring of Southern Alp glaciers and modelling their potential future loss, as well as attributing recent extreme glacier loss to anthropogenic warming. This team investigating modern glaciological processes was joined in 2010 by Huw Horgan, who also brought skill in subglacial Antarctic geophysical exploration, and Ruzica Dadic who investigated snow and sea ice processes.

Also instrumental in ARC's success was the recruitment of Lionel Carter in 2006, as Professor of Marine Geology, who led the $1.2M three-year Antarctica-New Zealand Interglacial Climate Extremes (ANZICE) research programme funded by FRST. This aimed to understand the likely response of the New Zealand-Antarctic region to a warmer world. In this programme, ARC researchers and collaborators examined ice and sediment cores in Antarctica, measured glaciers in New Zealand, oceanography in the Southern Ocean, and workstreams were designed to align our science directly with the needs of policymakers.

ANDRILL MIS drill site (credit: Tamsin Falconer)

1997-2000

NZ-led Cape Roberts Project (NZ-US-Italy-Germany-UK-Australia) collecting 1500 metres of strata that show highly dynamic ice sheets between 34 to 17 million years ago

1999

PhD student Nancy Bertler begins the development of an ice coring programme at the ARC

2000

ARC's only staff, Peter Barrett and Alex Pyne, proposed to be made redundant in restructure of the School of Earth Sciences. Student protests, national and international community lobbying results in a rethink

2001

First VUW intermediate depth ice core recovered from Evans Piedmont Glacier highlights influence of El Niño on Antarctica

ARC established as an independent research institute at VUW and given three years to become self sustainable

2002

ARC receives first Marsden funding via a subcontract with PI Tim Naish (GNS Science)

ARC leds its first external FRST-funded programme for the ANDRILL drilling project

2003

Lee Seng Tee donates $150K for the annual S.T. Lee Lecture in Antarctic Studies (Rob Dunbar presents the inaugural lecture)

Tamsin Falconer employed as ARC Administrator (later Centre Manager) — the first new staff member since 1983

ARC releases first issue of ARC newsletter *IceSked* for alumni and friends

First hot water drilling project on Ross Ice Shelf completed

Onwards and upwards

In 2007, Peter Barrett stood down as Director of the ARC after 35 years and was succeeded in 2008 by Tim Naish, who had been instrumental in shifting our focus towards societal relevance, and after the success of ANDRILL, decided to formally recognize the drilling expertise in the ARC as the Science Drilling Office (SDO) in 2008. That same year, the ARC recruited Darcy Mandeno to join the SDO to provide engineering technical support and provide a succession plan for Alex Pyne — who at the time provided a global capability that was truly unique. Darcy's first job with Alex was to help engineer the New Zealand built intermediate depth ice core drill based on a Danish Hans Tausen drill, modified to be suitable for our needs. The drill was tested in Greenland at the NEEM project before drilling the 784-metre-deep Roosevelt Island Climate Evolution (RICE) ice cores in 2011/12 and 2012/13 field seasons, as part of a nine-nation collaboration led by ARC's Nancy Bertler. Nancy's impressive leadership in this programme led to her becoming a Rutherford Discovery Fellow (RDF) in its inaugural year in 2011, a prestigious programme that recognizes New Zealand's most talented early-to mid-career researchers and in particular their leadership abilities. She led the way, for four subsequent ARC Rutherford fellows (Rob McKay, Nick Golledge, Huw Horgan and Holly Winton), and ARC researchers now make up an impressive 5% of the Rutherford Discovery Fellowships awarded.

RICE drill site (credit: Nancy Bertler)

The policy relevance of our past climate and ice sheet programme was becoming globally recognized, with Tim Naish receiving the international Tinker Muse Prize, and invited to be a lead author on the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment report that highlighted that the risks related to marine ice sheet instability in West Antarctica remain the greatest uncertainty in future sea-level projections. This was followed by Andrew Mackintosh's involvement as lead author on the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate. Nick Golledge's world-leading integration of geological archives with future modelled projections of sea-level rise resulting from Antarctic ice sheet loss were critical components of the sixth assessment for the IPCC. This science now helps underpin governments and communities plans for adaptation strategies to our changing climates, especially anticipating managing the impacts of sea-level rise.

By 2015, we had rapidly expanded with nearly $2M of external revenue and 17 staff. However, the nature of our external funding model meant that the loss of any one of our major programmes presented risk. Indeed, speed wobbles associated with this expansion arose when the proposed third phase of the ANDRILL programme was unable to secure a full international consortium. This meant the New Zealand based funding, and more importantly the capability that had been developed over several decades, was at risk of being lost. Compounding this, the ANZICE programme had come to an end and was not renewed. At this time, we pivoted quickly and developed a broader applied research programme of field-based Antarctic studies, as well as examination of legacy cores, and ice sheet modelling that fed into the new Past Antarctic Climate (PAC) programme funded by the Ministry for Business, Innovation and Employment (MBIE), and led by Richard Levy at GNS Science — who took up a joint appointment with the ARC in 2018 to help develop our applied sea level programme, further deepening the close research partnership with GNS Science.

We also set our sights to developing lighter weight drill systems that could be transported deep into the interior of the Antarctic, with the aim to identify the sensitivity of the West Antarctic Ice Sheet during the most recent warm periods in Earth's past — climates 1.5-2°C warmer than preindustrial values, the limit that the Paris climate agreement seeks to maintain global warming below. The first phase in this drill system was development of the VUW hot water drilling system that proved a critical asset for the successful Ross Ice Shelf Project (RIS, 2015-20), providing access holes to sample and image sea floor, and provide critical measurement of ocean heat and meltwater in the cavity beneath the Ross Ice Shelf.

In 2016, a light-weight helicopter transportable drill system, developed by the ARC and Webster Drilling, was used to recover cores high in the Transantarctic Mountains at Friis Hills. This was yet another innovative technological breakthrough that used cold compressed air instead of drilling mud, so the cores didn't melt. These permafrost-cemented Middle-Late Miocene (16-14 million years ago) glacial and fluvial sediments produced, add to a policy-relevant picture of an ice-free almost temperate environment with mountain glaciers, lakes and tundra vegetation when atmospheric CO_2 levels were last 500 parts per million.

In 2017, Tim Naish resigned from the ARC Directorship to take on a Royal Society of New Zealand James Cook Fellowship, and was replaced by Andrew Mackintosh. This fellowship allowed Tim the space to change research direction and develop an applied sea-level programme for New Zealand, and ultimately led to the MBIE funded $7M NZ SeaRise programme, which resulted in location specific sea-level rise projections out to the year 2300 for every 2 km of coast of Aotearoa New Zealand. This work, alongside the past decade of understanding of Antarctic ice sheet dynamics through geological drilling and modelling was recognised when the ARC-led "Melting Ice & Rising Sea's" Team were awarded the 2019 NZ Prime Minister's Science Prize.

The data acquired by the Ross Ice Shelf programme also provided valuable site survey, for the new intermediate drilling initiative called SWAIS 2C to understand the "Sensitivity of the West Antarctic Ice Sheet in a world that is 2 degrees warmer". This nine-nation ~$9M project led by Richard Levy and Molly Patterson (US-based former-ARC PhD student) plans to recover cores from the grounding line of the Kamb Ice Stream in 2023/24, with a second season planned in the Crary Ice Rise region and co-led by Huw Horgan and Tina Van de Flierdt (Imperial College London). To undertake this challenge we had to hire a third member in the SDO, with Field and Operations Engineer James MacPhail coming onboard in 2022.

Current ARC Director Rob McKay was appointed in 2019, following Andrew's departure to take on a leadership role at Monash University.

2004

First S.T. Lee Exchange with the University of Alaska Fairbanks

ARC Endowed Development Fund launched

Brian Anderson joins the ARC and with Andrew Mackintosh develops the ARC's NZ glacier research programme

2005

ARC is a major partner in FRST $5M ANDRILL programme

Tim Naish appointed as ARC Deputy Director

2006

Joint Antarctic Research Institute (JARI) established with GNS Science (NIWA joins in 2009)

Lionel Carter appointed to led ANZICE programme, investigating the impacts of Antarctic change in NZ and SW Pacific

2006-2008

NZ-co-led (Tim Naish) multi-national ANDRILL programme, the first ever drill core from beneath an ice shelf — revolutionised our understanding of the vulnerability of the West Antarctic Ice Sheet during past warmer-than-present climates

2007

External research revenue breaks $1M mark

National Ice Core Facility officially opened at GNS Science

Alan Eggers donates $1M to the ARC

2008

Tim Naish becomes new ARC Director, replacing Peter Barrett who stepped down after 35 years at the helm

ARC establishes the Science Drilling Office with Darcy Mandeno appointed to provide engineering support

Rob began his career as an ARC MSc student in 1999, and returned as a PhD student in 2005 to work on the ANDRILL McMurdo Ice Shelf project. His research contributed to the fundamental discoveries concerning the instability of the West Antarctic Ice Sheet for which he was awarded the New Zealand Prime Minister's MacDiarmid Emerging Scientist prize in 2011. Rob's role in ANDRILL provided a platform for him to take on leadership within the International Ocean Drilling Project, that has leveraged tens of millions of dollars of international funding over the last decade. His participation in Expedition 318 to the Wilkes Margin led to fundamental discoveries about the sensitivity of subglacial basins of the East Antarctic Ice Sheet, previously considered stable. He subsequently co-led Expedition 374, which saw ocean-based drilling return to the Ross Sea, 46 years after Peter Barrett's Expedition 28 there. The ARC's involvement in this programme has provided support for student research, as well as numerous international collaborations from Asia, Europe, and the Americas, many of whom have joined the SWAIS 2C consortium.

In 2018, Nancy Bertler was appointed as Director of the $49M Antarctic Science Platform, and in 2020 new funding established the National Antarctic Modelling Hub, a joint collaboration between GNS Science, VUW and NIWA, hosted by the ARC. Co-led by Nick Golledge and Liz Keller (ARC/GNS Science), the 'Hub' now hosts six research fellows, each bringing complementary capability in climate modelling (Alexandra Gossart), ice sheet processes (Alanna Alevropoulos-Borrill and Dan Lowry (GNS Science)), oceanographic modelling (Stefan Jendersie and Alena Malyarenko (NIWA)), and data science (Mario Krapp (GNS Science)). This has further developed world class climate and ice modelling and projection capability in New Zealand, and has greatly enhanced inter-institutional collaboration between the three JARI institutes.

In 2022, a collaborative team led by Tim Naish and Richard Levy received more MBIE funding ($13M over 5 years) to continue vital work improving sea-level projections and the understanding of coastal risk for Aotearoa New Zealand.

Modelling Hub (credit: VUW Image Services)

Over the past 15 years, the ARC has evolved by integrating paleoclimate knowledge with an understanding of modern process, and is now making numerical reconstructions and projections of climate, Antarctica, and sea-level working alongside social scientists, users/stakeholders, iwi, and communities to better predict the impacts of climate change, to further incentivise mitigation action, and to ensure that we adequately adapt.

By the end of 2022, the ARC external revenue reached $6.9M, and the ARC had gone from two staff in the 1972 to 27 academic, research, technical and administrative staff.

While, we know we can never relax in a constantly evolving science sector, the ARC has established a niche in Aotearoa New Zealand and is recognised internationally for the quality and importance of its research. Our research streams are more diversified and stable. This was emphasized during the 2020/21 season when for the first time in our history we had no Antarctic field campaign due to the COVID-19 pandemic — although Ruzica Dadic did managed to negotiate closed borders to visit the North Pole on the world's largest ever polar expedition, the MOSAiC Project.

Throughout this challenge, our research has remained more active than ever, and is relevant and world-leading. We have an incredibly exciting batch of new researchers who are breaking new ground in cosmogenic nuclide research and alpine glacial geology (Shaun Eaves and Jamey Stutz), glaciology (Lauren Vargo), biological chemistry (Holly Winton and Bella Duncan), remote sensing and hydrology (Oliver Wigmore) and oceanography (Stefan Jendersie); and like Peter Webb and Barrie McKelvey's first expedition, postgraduate students remain the backbone of much of our reputation and success. Our outcomes are a curated mix of fundamental underpinning research excellence, based on our pioneering beginning, international collaborations and reputation, and applied research co-produced with stakeholders delivering policy-relevant impact for the benefit of Aotearoa New Zealand.

Franz Josef Glacier (credit: Brian Anderson)

As we look forward to the next 50 years we remain cognizant that none of this is possible without national and international partnerships, support to do excellent science that addresses key national and international priorities, but most of all its...

he tangata, he tangata,
he tangata.

2009

Nick Golledge appointed to feed our paleoclimate data into ice sheet and climate models

Morgan Family Charitable Foundation donates $250K following ARC collaboration on the book *Poles Apart*

2010

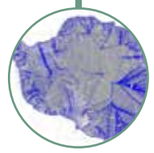
Peter Barrett, Tim Naish and Alex Pyne honoured with NZ Antarctic Medals

Huw Horgan and Ruzica Dadic appointed providing new capability in geophysics and modern ice sheet/snow processes

Postdoctoral Fellow Rob McKay sails on IODP Expedition 318, discovering past East Antarctic Ice Sheet loss in warmer-than present Pliocene

2010-2018

Past Antarctic Climates (PAC) programme integrated geological data with numerical models to reconstruct how Antarctica's ice sheets responded to warmer-than-present climate



2011

Nancy Bertler receives prestigious Rutherford Discovery Fellowship, the first of five to be awarded to ARC researchers (Rob McKay, Nick Golledge, Huw Horgan, Holly Winton)

2011-2013

NZ-led (Nancy Bertler) nine nation ice coring collaboration, Roosevelt Island Climate Evolution (RICE) Project, aims to improve understanding of the stability of the Ross Ice Shelf and West Antarctic Ice Sheet in a warming world

2013

ARC's research becomes policy-relevant. Tim Naish first to become an IPCC lead Author (AR5), followed by Andrew Mackintosh (SROCC), and Nick Golledge (AR6)

VUW, the University of Oxford and DOX Productions film initiative, *Thin Ice — The Inside Story of Climate Science* launched globally

RESEARCH OUTCOMES

Getting ready to drill

2022 was a big year for the SWAIS 2C team as we pushed hard to get ready to drill in December 2023.

The SWAIS 2C drilling project seeks to determine just how sensitive the Ross Ice Shelf and West Antarctic Ice Sheet are to an increase in global surface temperature of 1.5 to 2 °C above pre-industrial values. Our planet has already warmed by over a degree due to anthropogenic greenhouse gas emissions and we are are on track to exceed 1.5 °C by the early 2030's. Sedimentary records that lie below the sea floor beneath Antarctica's ice shelves offer insight into ice sheet response to previous warm intervals that were like our near future world. These geological archives allow us to 'see' if we are approaching a tipping point in the system so that we can work harder to avoid crossing it or quantify and adapt to the consequences if we fail.

This year saw the SWAIS 2C project reach numerous major milestones as we pushed ahead to get ready to drill at Kamb Ice Stream in late 2023 and Crary Ice Rise during the following Antarctic field season. We established a Memorandum of Understanding that creates the international partnership between New Zealand (through the Antarctic Science Platform), Japan, Italy, UK, Germany, South Korea, USA, Australia, and the International Continental Drilling Programme. New Zealand is playing a key role in running this complex multi-million-dollar programme. GNS Science is the Project Manager, the ARC leads drilling operations and manages the operations funds, and Antarctica New Zealand is running the Antarctic operations and logistics with support from the United States Antarctic Program.

Staff from the ARC's Science Drilling Office and a team from Webster Drilling and Exploration Ltd., completed the all-important Antarctic Intermediate Depth Drill. The system is now at Scott Base for over-winter storage. Once integrated with our hot water drill, this one-of-a-kind system will allow our drillers to melt through the Ross Ice Shelf and recover a sedimentary record from the seafloor. The lightweight design of this system will allow our team to do what no one has done before - drill deep into the Antarctic seabed in a region far from a major base, where models indicate the West Antarctic Ice Sheet may have retreated in the Earth's recent geological past.

Members of the Science Leadership Team met at Binghamton University (New York) in December to review science proposals from institutions across the world and establish the SWAIS 2C Science Team. Several members of this team will join our drillers and engineers at the Kamb Ice Stream drill site this coming December. However, the majority will meet for the first time when they descend upon Dunedin in 2024 to study the core in detail at the Otago Repository for Core Analysis. Finally, the long-awaited SWAIS 2C web site went live. This site will evolve and develop as the drilling effort progresses and as science results come in. But for now, check it out at: www.swais2c.aq

Contact: R.Levy@gns.cri.nz

Sea level is rising faster than we thought

In May, the NZ SeaRise: Te Tai Pari O Aotearoa programme released location specific sea-level rise projections out to the year 2300 for every 2 km of the coast of Aotearoa New Zealand.

These projections can be accessed through a new online tool at https://www.searise.nz/maps developed by Takiwā, a data management and analytics platform. For the first time, New Zealanders can see how much and how fast sea level will rise along 'their own' stretch of coast.

Climate change and warming temperatures are causing sea level to rise, on average, by 3.5 mm per year. However, local sea-level rise around the coast of Aotearoa is also affected by up and down movements of our land. In areas that are going down (subsiding) the annual rate of sea-level rise can double. We have connected this vertical land movement (VLM) data with climate driven sea-level rise to provide locally relevant sea-level projections.

"We know that global sea-level rise of 25-30 cm by 2060 is unavoidable regardless of our future emissions pathway. But what may be a real surprise to people is that for many of our most populated regions, such as Auckland and Wellington, this unavoidable rise is happening faster than we thought. Vertical land movements mean that these changes in sea level may happen 20 to 30 years sooner than previously expected," said project co-leader Richard Levy.

"For many parts of New Zealand's coast 30 cm of sea-level rise is a threshold for extreme flooding, above which the 100-year coastal storm becomes an annual event."

Sea-level rise can be kept to a minimum by enacting policies to meet Paris Agreement targets to limit global warming by 2100 to between 1.5 to 2 °C.

"To be forewarned is to be forearmed, and this new science gives us the time and opportunity to put in place equitable and effective adaptation measures, that will limit the impact of unavoidable sea-level rise for the people of Aotearoa," said project co-leader Tim Naish.

Contact: R.Levy@gns.cri.nz
Timothy.Naish@vuw.ac.nz

Sea-level rise projections for the Auckland/ Coromandel region

Lake Ōhau Climate History (LOCH) project (Gavin Dunbar with GNS Science, University of Otago, SDO and Webster Drilling) recovers a 17,000 year record of NZ glacial and climate history

2013-2016

2014

Tim Naish receives international Martha T. Muse Prize for Science and Policy in Antarctica

External research revenue $1.9M

ARC builds a state of the art hot water drill system — a critical international asset for sub ice exploration and drilling

2015-2020

2016

Friis Hills international drilling project (led by Richard Levy and Alex Pyne) uses a new innovative permafrost air drilling system designed by SDO

International Ocean Discovery Program (IODP) Expedition 374, co-led by Rob McKay, makes fundamental discovery about the age and origin of the West Antarctic Ice Sheet

2016-2018

2017

Andrew Mackintosh appointed as third ARC Director

ARC becomes the first certified carbon neutral institute at VUW

Scientists chart 45 million years of Antarctic temperature change

New study shows 'very clear and direct response' of Antarctic temperatures to changing carbon dioxide levels.

Molecular fossils and computer modelling have enabled scientists to build the first catalogue of Antarctic ocean temperatures over the past 45 million years, offering new insights into future sea level changes.

The team, led by scientists from the ARC, GNS Science, and Birmingham University (UK), published their results in *Nature Geoscience* (Duncan *et al*., 2022).

In the study, researchers used molecular fossils from core samples taken during ocean drilling projects. These fossil remains are single lipid (insoluble in water) molecules produced by archaea — single-celled organisms that are similar to bacteria. The archaea adjust the composition of their outer membrane lipids in response to changing sea temperatures. By studying these changes, scientists can draw conclusions about the ancient sea temperature at the time a particular sample died. The researchers then used 'machine learning' — computer systems employing algorithms and statistical models to analyse patterns in data.

The result of this work was the first record of changing Antarctic sea temperatures throughout much of the Cenozoic period, covering the past 45 million years. This record meant the team was able to identify with much more precision the historic temperatures that have caused ice sheets to grow and shrink in the past.

The study's lead author, Bella Duncan, says there is a clear link between carbon dioxide (CO_2), sea-surface temperatures, and the amount of ice on Antarctica throughout the past 45 million years. One surprising finding was that ocean cooling did not always correspond with increases in Antarctic ice. This was observed in a one-million-year period of ocean cooling 24 to 25 million years ago.

"This paradox is likely related to a gradual subsidence event where a once mountainous West Antarctic started to lower below sea level. This enabled a direct oceanic connection with the ice sheets, and because oceans melt ice sheets far more efficiently than the atmosphere, less ice was able to persist," said Bella.

"Once West Antarctica lowered below sea level, colder oceans were needed to grow the marine ice sheet. In our computer simulations, this only occurred when CO_2 lowered below 400 parts per million (ppm). This indicates marine ice sheets can't persist when atmospheric CO_2 exceeds 400 ppm, a threshold we passed in 2013."

The future loss of ice sheets and the retreat of glaciers in the Antarctic is critically important as melting ice in the region could cause sea levels to rise by several metres. Ice in Antarctica is currently responding to warming seas with the loss of some ice shelves leading to accelerated retreat of one of the largest glaciers in the region, the Thwaites Glacier.

"The key challenge now is to slow emissions to prevent further acceleration of this ice loss and limit the impact of sea-level rise as much as possible."

Contact: Bella.Duncan@vuw.ac.nz

A model couple

To many of us, the word 'coupling' brings up images of quiet getaways, romantic dinners, perhaps even long-term commitment to 'the one'. But if you're a scientist, and particularly one who works with computer models, 'coupling' is a word that is both laden with reverence in the research community, but which also strikes fear into the heart of anyone who's ever tried it.

Making two or more computer models work together, so that they exchange information both correctly and efficiently in a way that allows them both to evolve in a coordinated way, is hard. So why do it? In short, realism. The Earth and all its intrinsic processes are intimately linked with one another. Yet in the world of computer modelling, we often break the coupled Earth system down into individual components — the ice sheets, the atmosphere, the ocean. This makes the calculations simpler, our simulations faster, and the results easier to interpret.

But by coupling these different components we have a better chance of capturing 'real-world' behaviour, including emergent phenomena that arise organically from feedbacks between interacting elements.

Over the last three years, researchers in the ARC-hosted Antarctic Science Platform National Modelling Hub have tackled two separate coupling projects. In one, Alex Gossart (ARC) and Alena Malyarenko (NIWA) have brought together the PolarWRF climate model with the MITgcm ocean model. Focusing on the Ross Sea, this project can now simulate the fully-coupled behaviour of the climate system in a way that allows, for example, simulated winds to affect sea ice, which in turn changes modelled ocean circulation and the flow of heat and salt into the cavity beneath the Ross Ice Shelf.

Ocean-driven melting in the ice shelf cavity then affects the flow of the grounded ice upstream, and to understand how exactly those processes might play out over coming decades to centuries, Stefan Jendersie (ARC) and Dan Lowry (GNS Science) have developed a separate coupled ocean–ice sheet model, using ROMS and PISM. This framework will allow us to make more physically robust estimates of the future contribution of the Antarctic ice sheet to sea level.

"These advances have already shown that coupling our models better captures more of the physical processes taking place in Antarctica."

And as we begin to apply these models to other research questions, it looks increasingly likely that we'll come to rely more and more on these tools and the benefits they offer.

Contact: Nicholas.Golledge@vuw.ac.nz

$7M NZ SeaRise MBIE Endeavour programme — a new research direction for ARC into sea-level rise projections and coastal impacts

2017-2022

2019

Rob McKay appointed ARC Director

Alex Pyne retires after 42 years with the ARC

"Melting Ice Rising Seas" team led by the ARC wins Prime Minister's Science Prize for understanding the nature and origin of Antarctic driven sea-level change and improving sea-level projections for Aotearoa

ARC co-leds Antarctic Science Platform Project 1: Antarctic Ice Dynamics

2019-2025

2020

Ruzica Dadic participates in MOSAiC, the world's largest polar expedition

Antarctic Science Platform National Modelling Hub established between GNS Science, NIWA, and VUW, hosted in the ARC

ARC founding member of a worldwide movement to press governments to reduce greenhouse gas emissions to 50% by 2030

2021

2022-2025

NZ-led multi-national SWAIS 2C project — new innovative intermediate sediment coring system designed by SDO

Can snow cover reduce sea ice melt?

Marsden project investigates the role of snow cover on the evolution of Antarctic sea ice.

This Marsden project tests the hypothesis that persistent snow cover can prevent or slow a decline in Antarctic sea ice in response to a warming climate.

"Snow cover dominates the variability of the thermal and optical properties of sea ice and the energy fluxes between the ocean and the atmosphere. Yet data on the physical properties of snow and its effects on sea ice are extremely limited, especially in Antarctica."

This leads to large uncertainties in the coupling of climate feedback and results in significant biases in model representations of the sea ice cover.

Led by Ruzica Dadic and including PhD candidate Julia Martin and Roberta Pirazzini (Finnish Meteorological Institute), the all-women team headed to McMurdo Sound, Antarctica from October to December 2022 to quantitatively investigate the physical properties of snow on the surface of Antarctic sea ice and how it affects sea ice.

The season's unique sea ice conditions, with the relatively late formation of a persistent sea ice cover, provided the ideal laboratory to study a range of snow conditions and to differentiate between sea ice and snow drivers for the atmosphere-sea ice-ocean system. Our set of snow measurements on sea ice, unprecedented in Antarctica, included ground snow/ice measurements, automatic weather and radiation stations, and drone-based measurements. These extensive measurements made it possible to capture the physical properties of snow and their spatial variability, and at the same time, to measure the different components of the energy balance at varying spatial scales. We will use this dataset to improve our understanding of the role that snow plays for the Antarctic sea ice system.

Contact: Ruzica.Dadic@vuw.ac.nz

PhD candidate Julia Martin prepares the drone (credit: Ruzica Dadic)

Beneath Antarctica's ice sheets, liquid water flows

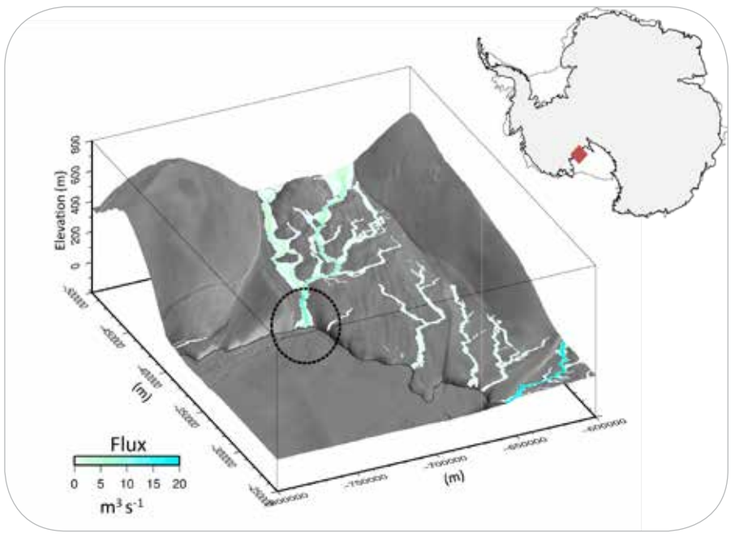
The 2021/22 season saw the Antarctic Science Platform's Antarctic Ice Dynamics project drill into a sub-ice river approximately 1000 km from Scott Base.

The liquid water that flows beneath Antarctica's ice sheets fills sub-ice lakes, allows the overriding ice to slide, and eventually drains into the ocean. Despite the cold surface temperatures, water is possible thanks to heat from the Earth, heat from ice deformation, and the insulation provided by the blanketing ice sheets. However, in spite of the significance of sub-ice water, its quantity and distribution remain poorly known due to the scarcity of direct observations.

A field camp of 22 was led by the ARC's Huw Horgan. The team included NIWA oceanographers, the Icefin team from Georgia Tech and Cornell University, along with students and staff from the University of Otago and Victoria University of Wellington. Using the ARC's hot water drill, the team melted through 500 metres of ice to access a spectacular sub-ice channel 240 metres high and hundreds of metres deep. This channel represents an estuarine-type situation where sub-ice shelf river water draining from beneath the ice sheets mixes with ocean water circulating under the Ross Ice Shelf. Over two weeks of borehole access to this unique environment allowed a range of observations to be made. The ARC's Gavin Dunbar and VUW student Linda Balfoort acquired multiple short cores from the riverbed. Craig Stevens and Craig Stewart (NIWA) collected a vast amount of oceanographic data, and the Icefin remotely operated vehicle imaged the river environment away from the borehole.

The project's sub-ice river access owes huge thanks to ARC's Science Drilling Office, led by Darcy Mandeno, and the commitment of Antarctica New Zealand. With more sub ice-shelf access to come, the ARC and the Antarctic Science Platform look forward to making more significant insights into the past, present, and future of Antarctica's ice sheets.

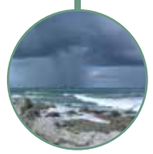
Contact: Huw.Horgan@vuw.ac.nz



Kamb Ice Stream study site (ellipse). Modelled subglacial water flux (ie Brocq et al., 2009) overlain on MODIS Mosaic of Antarctica (MOA, Harran et al., 2005). Black line shows the grounding zone transition between the West Antarctic Ice Sheet and the Ross Ice Shelf

ARC-led (Tim Naish and Richard Levy) $13M Our Changing Coast MBIE Endeavour programme on policy-facing research on sea-level rise impacts

2022-2027



2022

External research revenue reaches $6.9M

22 researchers and 5 professional staff

Winds of change determine past and present glacier retreat

In collaboration with national and international partners, research by ARC glaciologists has shown that longer-term movements of the westerly winds may also have an important role in determining the health of mid-latitude mountain glaciers — both today and in the recent geological past.

The weather and climate of Southern Hemisphere mid-latitudes are dominated by variability of the westerly wind belt. This effect is most obvious in weekly-monthly weather patterns: When the winds push northwards they bring increased storminess, whereas a southward shift generally promotes finer weather.

Vital to establishing this glacier-climate relationship is the long-term dataset afforded by the annual end-of-summer snowline survey. These observations provide a regional overview of how much winter snow has survived the summer melt season — a key determinant of glacier health. Utilising this rare, multi-decade dataset, a paper co-authored by Brian Anderson (Audet *et al*., 2022) demonstrates that the elevation of the snowline exhibits positive correlation local westerly wind strength, suggesting the winds modulate the relative influence of subtropical and subpolar air masses in the mid latitudes.

Evidence that this correlation has persisted over much longer timescales is also emerging in geological records of glacier change. Field-based research led by ARC masters and PhD students has documented the wholesale retreat of New Zealand glaciers, from northern Canterbury to southern Fiordland that began 17,000-18,000 years ago (Moore *et al*., 2022; Stuthridge, 2022; Tielidze *et al*., 2022). Meanwhile MSc student Ruby Muir completed her thesis in which she used numerical glacier modelling to demonstrate that temperatures in Patagonia mirrored those in New Zealand during the deglaciation. In both cases these changes correspond with evidence from wider geological archives (e.g. ice cores) for key shifts in the southern westerlies.

These results are significant as observations and modelling suggest sustained poleward contraction of the westerlies, in response to atmospheric greenhouse gas emissions.

Huw Horgan photographing for snowline survey (credit: Dave Allen, NIWA)

"This positive feedback effect may amplify the impact of global warming in this part of the world."

Contact: Brian.Anderson@vuw.ac.nz
Shaun.Eaves@vuw.ac.nz
Lauren.Vargo@vuw.ac.nz

Science Drilling Office welcome new staff

The ARC's Science Drilling Office (SDO) now has two full time engineers, with James MacPhail joining Darcy Mandeno and the ARC team in September.

Darcy's year started where December 2021 left-off, at Kamb Ice Stream (KIS) with the KIS-2 hot water drilling project well underway. Darcy, with drillers from both VUW and GNS Science, Hedley Berge, Stephen Stretch, Katelyn Johnson (then GNS Science), Stefan Jendersie, and Sean Heaphy successfully completing the season of drilling through the Ross Ice Shelf close to the grounding line enabling the science community with direct observations, installation of an oceangraphic observatory, seafloor sediment sampling, ROV operations, and biological sampling of seafloor sediments and water. On going, excellent support from Antarctica New Zealand also provided a valuable contribution to this successful outcome for the science community.

On return to New Zealand, a very busy 2022 for both Darcy and Antarctic Drilling Advisor, Alex Pyne, saw the continuing preparation for the upcoming SWAIS 2C drilling project, also within the Kamb region, in late 2023. This work includes continuation of the modification of the Antarctic Intermediate Depth Drill (AIDD), a Multipower MP1000 diamond core wireline rig, with the existing 1000 metre hot water drill and ancillary equipment for drilling operations that Alex and industry partner, Webster Drilling and Exploration Ltd., started in 2021. The rig, generators and coring tools where completed, tested and packed, departing Wellington via Christchurch in December 2022 to make the January 2023 cargo ship to McMurdo and Scott Base.

With the SDO workload involving continued drilling operations for the next few years, including potential future ice core drilling, the hiring of James MacPhail was a welcome addition to the ARC team who joined us in September. James, hailing from the UK, had previously worked as a mechanical design engineer in fields ranging from Scottish salmon farms to high specification turbine machinery gas seals. James, freshly arriving in New Zealand with barely time to recover from jet lag was able to join the team in time for the end of year workload, traditionally a busy time for the SDO to get equipment completed, tested and packed for shipping to Antarctica.

The focus for 2023 will continue to be tide compensation and hot water reaming equipment for the AIDD seariser, and maintenance on existing hot water drilling systems, with these items to be sent for winter fly (WINFLY) air movement in August 2023.

Contact: Darcy.Mandeno@vuw.ac.nz

James MacPhail testing equipment ahead of shipping to Antarctica (credit: Darcy Mandeno)

TEACHING AND SUPERVISION

Our staff support a wide range of courses being taught within the School of Geography, Environment and Earth Sciences, as well as providing graduate student supervision. In 2022, our staff supervised 18 PhD and 5 MSc students.

Courses ARC staff taught in

ESCI111	The Earth System: An Introduction to Physical Geography and Earth Sciences
ESCI132	Antarctica: Unfreezing the Continent
ESCI201*	Climate Change and New Zealand's Future
ESCI204	Petrology and Microscopy
GEOG220	Hydrology and Climate
ESCI241	Introductory Field Geology
ENSC301	Topics in Environmental Science
ESCI301*	Global Change: Earth Processes and History
GEOG318	Quaternary Environmental Change
ENSC402	Perspectives in Environmental Science in Aotearoa New Zealand
ESCI412*	Paleoclimatology
ESCI452*	Earth History
ENVI520	Environmental Management

* An ARC staff member was the course co-ordinator

Graduate completions

Kevin Henson (MSc)
Atmospheric dust transport to high-elevation Dronning Maud Land, Antarctica, over the satellite era and implications for centennial scale ice core records of dust deposition.
Supervised by Holly Winton (ARC) and Kyle Clem (SGEES).

Natasha Lelieveld (MSc)
Antarctic paleoenvironment and vegetation reconstruction during the early and middle Miocene using biomarkers from Ross Sea sediment drill cores.
Supervised by Rob McKay (ARC) and Bella Duncan (ARC).

Ruby Muir (MSc)
The magnitude of regional cooling across Southern Patagonia during the Antarctic Cold Reversal and Younger Dryas determined by glacier modelling.
Supervised by Shaun Eaves (ARC/SGEES), Lauren Vargo (ARC), and Brian Anderson (ARC).

Greta Stuthridge (MSc)
The glacial history of the Upper Clarence Valley, North Canterbury, New Zealand.
Supervised by Shaun Eaves (ARC/SGEES) and Kevin Norton (SGEES).

Hayden Young (MSc)
Investigating the applications of Co:Co2ff Emission ratio to develop a greater understanding of Co_2 fossil sources in Auckland, New Zealand.
Supervised by Liz Keller (ARC) and Jocelyn Turnbull (GNS Science).

Alanna Alevropoulos-Borrill (PhD)
Future evolution of the Amundsen Sea Embayment, West Antarctica: Exploring the modelled ice stream sensitivity to numerical representation.
Supervised by Nick Golledge (ARC) and Stephen Cornford (Swansea)

Francesca Baldacchino (PhD)
Present and future Antarctic ice sheet dynamics from observations and modelling.
Supervised by Nick Golledge (ARC) and Huw Horgan (ARC/SGEES)

Levan Tielidze (PhD)
Late Quaternary glacier-climate reconstructions from the Southern Alps, New Zealand.
Supervised by Shaun Eaves (ARC/SGEES) and Kevin Norton (SGEES).

Arran Whiteford (PhD)
Ice and ocean dynamics at a subglacial river mouth on the Siple Coast, Antarctica.
Supervised by Huw Horgan (ARC/SGEES) and Brian Anderson (ARC).

1972-2022
Graduate Completions

28 Honours Students
74 MSc Students
65 PhD Students

SIGNIFICANT EVENTS

ARC pays tribute to philanthropic supporter Lee Seng Tee

Long-time supporter of the ARC Lee Seng Tee passed away in July aged 99 years. We pay tribute to Dr Lee and thank him for his enduring legacy.

Dr Lee's significant financial support over 20 years has recognised and bolstered the University's strong contribution to Antarctic research. It established the annual S.T. Lee Lecture in Antarctic Studies and the S.T. Lee Antarctic Reading Room in the University's library. Many early career researchers and students, both in New Zealand and Alaska, have benefited from the S.T. Lee Young Scientist Travel award — an exchange programme with the University of Alaska Fairbanks.

Dr Lee was the second son of visionary businessman Lee Kong Chian, who made a name in the rubber, pineapple, coconut oil, and sawmill trades. In 1952, Lee Kong Chian created the Lee Foundation, one of Singapore's largest charitable organisations that supports education, healthcare, welfare, and disaster relief. A bibliophile, Dr Lee liked to support libraries, reading rooms, and public lecture series believing that for disseminating information these gifts produced the most "bang for buck". While Chinese convention is to display the family name first, Dr Lee recognised the European convention by naming his projects 'S.T. Lee.'

Dr Lee's connection with Te Herenga Waka—Victoria University of Wellington was through Emeritus Professor Don Trow of the School of Accounting and Commercial Law. Professor Trow was introduced to Dr Lee during a visit to Singapore in 1999. Professor Trow explains how the relationship came about:

"Dr Lee's connection with our University commenced in the late 1990s at the time of a reunion in Singapore of commerce graduates from Victoria University of Wellington. One of those graduates was a personal friend of Dr Lee, and had arranged a lunch for those at the reunion to meet Dr Lee."

"Dr Lee was a most impressive host for the occasion. A perfect gentleman, he was proud of his Chinese heritage and the remarkable growth and success of the Singapore nation. He was quietly spoken but engaging, and remarkably well versed on international affairs and the role of New Zealanders in worldwide activities."

From this beginning, Professor Trow developed a close personal friendship with Dr Lee that continued with several meetings in Singapore in succeeding years.

Having established lectures in the Northern Hemisphere, Dr Lee was keen to develop projects in the Southern Hemisphere. He noted the closeness of New Zealand to Antarctica and was drawn to supporting research activities there, but with a proviso. He had to be convinced that the activity had world class ranking and that Victoria University of Wellington could stand as a quality institution alongside the other universities he supported, notably Oxford, Cambridge, and Harvard.

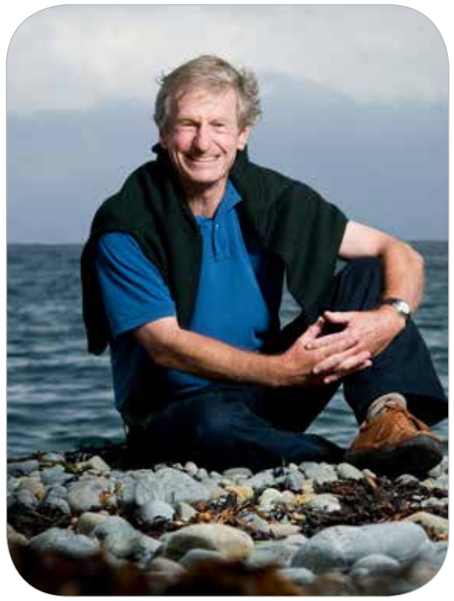
A meeting was arranged between Dr Lee and Emeritus Professor Peter Barrett, Director of the Antarctic Research Centre at the time and one of New Zealand's foremost Antarctic scientists. This proved to be most successful. Peter was a good fit with Dr Lee's quiet, thoughtful, and polite personality and was also greatly admired for his leadership and high-quality research activity, much of it at the coal face—or rather ice face.

"In 2003, Dr Lee made an endowed gift to establish the annual S.T. Lee Lecture in Antarctic Studies. This was his first gift to an educational institution in the Southern Hemisphere."

Lee Seng Tee by Wang Qing Yu, Wolfson College, University of Cambridge collection

While Dr Lee was never able to visit New Zealand, Peter and another former ARC Director, Professor Tim Naish, enjoyed visiting him at his offices in Singapore. We are very grateful for his endowments, which will continue to develop Antarctic science and climate change research for years to come.

View the full story here: https://125.wgtn.ac.nz/dr-lee-seng-tee/



Lionel Carter (credit: VUW Image Services)

Lionel Carter wins Francis P. Shepard Medal

Emeritus Professor, Lionel Carter, has been awarded the Francis P. Shepard Medal for Marine Geology in recognition of his "Excellence in Marine Geology."

The Medal commemorates the professional life of American geologist Francis Parker Shepard, whom in many eyes is regarded as the father of marine geology. His publications extended from 1927 to 1984 during which period he observed, measured, and sampled the ocean floor — a research effort that redefined basic concepts of how the ocean functioned. Those changes were captured in the book, *Submarine Geology*, published in 1948 and first on the subject. Against such a backdrop it is a tremendous honour for Lionel to receive this award.

The first Medal was awarded in 1967 by the Society of Sedimentary Geology which although based in the USA, has a strong international outlook. The list of past awardees reads like a who's who of marine geology and includes researchers from Europe, North America and Oceania. There are now two New Zealanders on the roll of honour. In 2002, the medal also went to Emeritus Professor James Kennett of the University of California who is also a VUW alumni and long-term friend and benefactor to the ARC.

When asked about his presence on the list, Lionel replied,

"There is no doubt in my mind that I have been very fortunate to work with some exceptional and generous researchers from New Zealand and overseas."

"Those collaborations, together with institutional support, have been made possible by the remarkable nature of our vast marine environment. Under international law New Zealand has some level of jurisdiction over nearly 6 million square kilometres of ocean. Because of its size and location, it encompasses a wide range of natural phenomena that include an active tectonic plate boundary, tropical to polar climate and ocean waters, the largest ocean current namely the Antarctic Circumpolar Current, and the highly active Taupo Volcanic Zone. In essence, it is one of nature's great dynamic laboratories that provides insights into how our planet ticks. Who wouldn't want to research here?"

Paleoclimatologist receives Blake Leader Award

Joint ARC and GNS Science researcher, Professor Richard Levy, received one of four prestigious Blake Leader Awards.

Richard Levy at the Blake Awards ceremony (credit: BLAKE)

In an awards ceremony held on 10 November, Richard was honoured for his commitment to helping us understand climate change issues and lead the necessary changes. Blake awards recognise and celebrate people whose leadership has contributed to a more sustainable future for New Zealand.

Richard's 23 years of scientific research includes more than a decade leading the Past Antarctic Climates and Future Implications programme at GNS Science. This work explored the distant past to help understand how warming temperatures will affect our planet in the future. It has taught us that Antarctic ice sheets are even more dynamic and vulnerable than we previously believed. He is currently co-leading the new SWAIS 2C drilling project, which is designed to reveal the sensitivity of the Ross Ice Shelf and West Antarctic Ice Sheet to past warming.

Closer to home, Richard also co-led the NZ SeaRise: Te Tai Pari O Aotearoa programme over the last five-years and now he is coleading, Te Ao Hurihuri: Te Ao Hou—Our Changing Coast, programme learning how climate change and sea-level rise will affect different parts of New Zealand's coastline. This project is geared towards practical solutions. Richard has personally connected with iwi, councils, and many other people to help them understand the risks of sea-level rise and plan more resilient infrastructure. "Action and leadership are needed right now if we are to meet the challenges of climate change and build a sustainable future for our planet," says Richard.

The message is starting to get through, and more governments around the world are agreeing to cut the amount of carbon dioxide going into the atmosphere. A certain amount of warming is inevitable, but there is still time to keep this to manageable levels by focusing on mitigation and adaptation. Richard says,

"I'm much more confident that we as humans are trying to get on top of this problem. We've acknowledged it at last — and we're actually coming up with solutions."

The comic strip (credit: Simone Giovanardi)

Returning to a green Antarctica

Bella Duncan and illustrator Simone Giovanardi collaborate on a history of Antarctic climate and vegetation comic.

Antarctica conjures up images of a frozen, white continent, devoid of vegetation. This has been our narrative of Antarctica since the earliest voyagers came across the vast frozen ocean. As more explorers and geologists started to study the rocks of the continent they discovered clues that Antarctica hasn't always been an icy expanse. Rock samples of glossopteris leaf fossils, an ancient tree that lived 250 million years ago, were found alongside the bodies of Robert Falcon Scott and his companions, and told the story of a much greener, warmer past.

"Antarctica wasn't always covered in ice. But a return to a green continent would be bad news for us."

The comic by Simone and accompanying article by Bella tell the story of Antarctica's warmer history, showing illustrations of Antarctica during periods of higher temperatures and atmospheric CO_2 in the geological past. As CO_2 levels continue to relentlessly creep up, the world of our future becomes more and more like worlds further back in our past. So what image of Antarctica will we commit to? A lower CO_2 version where impacts of temperature and sea-level rise are reduced? Or the version that will play out if we don't act fast enough, the "greenhouse" world of vast ice loss, grave environmental change, and eventually, a return to a green Antarctica.

This collaboration began at the Drawing Science workshop, hosted by The Spinoff and the Science Media Centre. The workshop, also attended by the ARC's Lauren Vargo, brought together researchers and illustrators to discuss how we can better communicate our science through art.

Checkout the full comic strip at: https://thespinoff.co.nz/science/27-01-2022/returning-to-a-green-antarctica

S.T. Lee Lecture in Antarctic Studies

Our annual lecture was given by a leading international researcher who sailed across the Pacific to get here!

The 19th annual S.T. Lee Lecture 'Antarctic Ice: Ancient, Beautiful and Unforgiving' held on 15 November, was presented by Professor Robin Bell, Lamont-Doherty Earth Observatory, Columbia University, USA.

Robin's research accomplishments emerge from her approach of looking holistically at Earth's large ice sheets on our planet with the goal of understanding how they work and how they will change in the future.

Robin's presentation focussed on the Antarctic ice sheet which is over 4 km thick and has persisted for 34 million years. She has spent much of her career uncovering the secrets within and beneath Antarctica's featureless surface, including hidden mountains, volcanoes, and giant lakes. Robin discovered an active volcano beneath the vulnerable West Antarctic Ice Sheet, studied Lake Vostok, a large lake beneath more than 3 km of ice, and led an international expedition to the Gamburtsev Mountains. During the lecture the audience was shown inside the ice, revealing folds, bends and bulbous structures that record its history including subglacial water flows — which apparently run uphill!

Robin Bell presenting her lecture in the Hunter Council Chamber (credit: VUW Image Services)

"Robin is motivated by the goal of enabling coastal communities around the globe to develop scientifically informed strategies to respond to changing sea levels, creating a future that is thriving and sustainable for all."

While in Wellington, Robin attended a round table discussion at the Parliamentary Commission for the Environment on some of the emerging science around the Antarctic ice sheet and sea-level rise, and implications for mitigation and adaptation.

PhD candidate takes his research to the ends of the Earth

Ian Blixt from Te Kura Mātauranga Koiora—School of Biological Sciences headed to the University of Alaska Fairbanks (UAF) as part of the S.T. Lee Young Scientist Exchange Programme.

Ian Blixt in Alaska (credit: Ian Blixt)

Ian was one of three Te Herenga Waka—Victoria University of Wellington young researcher recipents in 2022 to promote polar, glaciological, and climatological research with the International Arctic Research Center (IARC). Awarded by the ARC, Ian was chosen for the exchange due to his research focus on Antarctic sea ice bacteria.

"We have recently discovered that these bacteria can use sunlight as an alternative source of energy, similar to plants. My research focuses on the effect this new form of bacterial phototrophy (ability to use light as an energy source) has on the wider sea ice and marine ecosystems," Ian said.

"This unique form of light-harvesting was only discovered in 2000, but it now appears that these 'energiser microbes' convert sunlight into chemical energy at a rate that is approximately equal to the energy consumption of fossil fuels by the human population. What is this supplementary energy used for? Will these microbes buffer the increased environmental stress in a rapidly changing world?"

During his exchange, Ian had the opportunity to present his research at the IARC, the Microbial Ecology Seminar, and to the Sea-Ice Persons working group, alongside meeting with subject matter experts. Ian also attended the opening night of Arctic Fest 2022, an opportunity which he describes as "the most memorable" part of his trip.

"This festival is all about the combination of Indigenous knowledge, art, and science. It was a pretty unique event; I haven't really heard of anything like it before."
The Young Scientist Exchange which alternates between the two universities, is usually awarded to one researcher per year however, due to travel restrictions in the years prior, there were five recipients in 2022 (including two from the University of Alaska Fairbanks).

"I can't thank the late Dr Lee and the Antarctic Research Centre enough for this opportunity."

Alaskan researcher heads downunder

Eric Petersen arrived in New Zealand in December as part of the S.T. Lee Young Scientist Exchange Programme.

Eric Petersen is a research associate at the Geophysical Institute, University of Alaska Fairbanks, researching debris-covered glaciers and relict ice in rock glaciers and other landforms. He is currently working on an extensive field project on the Kennicott Glacier, a large debris-covered valley glacier in the Wrangell-St. Elias National Park, Alaska, investigating the melt of ice buried beneath a surface debris layer, as well as exposed in steep "ice cliffs" commonly found on debris-covered glaciers.

Eric is also a participant in Subsurface Water Ice Mapping (SWIM) on Mars, a collaborative project with the aim of comprehensively mapping martian mid-latitude ice deposits as a service for future crewed missions to Mars.

Eric was one of five recipients of the S.T. Lee Young Scientist Exchange and spent two weeks in Wellington. While here, Eric had many discussions with ARC staff and students and also gave a seminar on his research.

"The S.T. Lee Exchange Programme allowed me to interact with a number of researchers at the Antarctic Research Centre that pursue common interests."

With Warren Dickinson, Eric discussed the logistics of working in the Antarctic Dry Valleys as well as Warren's geochemical and geomorphic work on buried ice. With Brian Anderson, discussions were on the retreat of debris-covered glaciers and Brian's recent work on the lake-terminating terminus of Tasman Glacier. With recently completed PhD student Levan Tielidze, discussions involved rock glacier geomorphology and mapping in the context of landform origins; and working together on manuscripts and proposals in the future. While Lauren Vargo discussed her involvement in the Girls on Ice programme and mentoring strategies/ pedagogies.

Eric Petersen in front of the proglacial lake of the Kennicott Glacier, Wrangell Mountains, Alaska (credit: Ryland West)

Farewell to our long-standing Centre Manager

After 16 years supporting the ARC, the team say goodbye to one of our most important team members, Michelle Dow.

Michelle joined the ARC in 2006 as ARC Administrator, a fixed-term position for just two days per week, to assist then Centre Manager, Tamsin Falconer. Michelle was a science technician for GNS Science at the time and co-worker Tim Naish (who had a joint position with GNS and the ARC) encouraged her to apply for the role. At that time, the ARC comprised only nine staff. By 2008, the role had become permanent and increased to 0.8 FTE. Together, Michelle and Tamsin won a joint Staff Excellence Award in 2010 for their administration support of the ARC. In 2011, Tamsin resigned, and Michelle stepped-up into the Centre Manager role at 0.7 FTE, which she held for the remaining 11 years. Throughout her time the Centre tripled in staff, and Michelle was a crucial part of the ARC's growth and success, providing a high level of support for the team.

During her time, Michelle has worked with all four ARC Directors: Peter Barrett, Tim Naish, Andrew Mackintosh and now Rob McKay (who was a PhD student when she began). Her institutional knowledge, reliability, attention to detail, and strong sense of fairness and equitability was greatly valued by all of the Directors over the years.

Michelle's role primarily involved managing the ARC's finances including the Centre's budget and monitoring research contracts, which became increasingly more prolific and complicated as we grew. However, she was also central to promoting the ARC through the production of the ARC's Annual Review and bi-annual newsletter, IceSked, sent out to stakeholders and researchers worldwide.

In January 2016, Michelle felt privileged to be given the opportunity to head to Antarctica as a Field Assistant with Tim Naish and Richard Levy, setting up camps at the base of Mt Discovery and Brown Peninsula.

Michelle also initiated changing the ARC's te reo name, working with the Deputy Vice-Chancellor (Māori) to change it from an outdated literal translation to Te Puna Pātiotio, with Te Puna referring to 'the spring', that wells up or flows, and Pātiotio relating to being 'frozen over', which captured perfectly both the energy and output of knowledge that flows from the Centre.

Michelle was also part of the team that won the 2019 Prime Minister's Science Prize. Although this prize is often associated with academic

Michelle in Antarctica in 2016 (credit: Michelle Dow)

Michelle Dow (credit: VUW Image Services)

staff, we genuinely felt we couldn't accept this prize without recognising the leadership of our professional staff, most notably Michelle who had been central to this success for over a decade.

In his leaving speech, Rob acknowledged Michelle's quick and decisive actions throughout the pandemic in 2020, helping guide our business continuity plans, implementing procedures for managing the lock outs, and helping manage the transition to work from home.

While there are the key parts of the role where Michelle has been indispensable, it is also the subtle and proactive things that will be equally missed — Michelle has been instrumental in refurbishing and refreshing the spaces within the Centre including the S.T. Lee Antarctic Reading Room opened in 2014, decorating the new 5th floor offices in 2015, and assisting with the planning and design of the National Modelling Hub office in 2020.

The team presented Michelle with a "korowai", a stunning stylised wooden art work inspired by a traditional Māori cloak of feathers, as a reflection of the esteem in which she was held.

A double goodbye for two key researchers

After a year away on sabbatical Ruzica Dadic and Huw Horgan decide to make Davos, Switzerland their home with exciting new opportunities.

Ruzica Dadic

Ruzica arrived in New Zealand in 2010 with fractional employment from ETH (Switzerland) and the University of Washington. She joined the ARC's glacier modelling group conducting research on the role of snow drift on alpine glaciers in the Southern Alps.

In 2012, Ruzica received the NASA Group Achievement Award for outstanding contributions to the NASA mission ICESCAPE, and the EGU Young Scientist Travel Award. In 2013, she won a Marsden Fast-Start award titled, "Improving ice core records — Understanding the link between rapid changes of greenhouse gases and temperature." Ruzica was made a permanent Research Fellow in 2014, and promoted to Senior Research Fellow in 2017. In 2019, she was part of the team that won the Prime Minister's Science Prize and in 2021, Ruzica had more success with Marsden receiving $913K for her project asking "Can snow change the fate of Antarctic sea ice?" During her time with the ARC, she was also an AI on several other Marsden and Deep South projects.

In 2020, Ruzica was the only New Zealand researcher to join the €140 million MOSAiC project, the largest polar expedition in history. The MOSAiC expedition involved experts from 20 countries, from more than 70 scientific institutions, who spent a combined year in the Arctic, on the research vessel *RV Polarstern*. Ruzica and her colleagues were interested in how the physical properties of snow affect the amount of heat and light that goes into the ocean instead of being reflected back into the atmosphere.

Ruzica also conceived the idea of creating a Girls* on Ice programme in Aotearoa New Zealand established through Inspiring Girls Expeditions which has been running since 1999 (see article on next page).

As part of the current Marsden, she will continue to work with a Māori children's book writer, to publish a picture book that combines Māori world views and Antarctic/snow/ice science as a stepping stone to creating educational resources for primary schools in the future, making cryospheric science more accessible to everyone.

Ruzica's research and emerging leadership at the ARC was exceptional and will be greatly missed. This excellence was clearly noted by our Swiss colleagues, who offered her the role as Head of the Snow and Atmosphere research unit, at Swiss Federal Research Institute (WSL) in Davos, which is part of ETH — one of the world's leading research organisations.

Huw Horgan

Huw Horgan is an alumni of Te Herenga Waka—Victoria University of Wellington completing his BSc in 2003 and then an MSc in 2004. He went on to pursue his PhD at Pennsylvania State University, completing in 2009, looking at Antarctic ice sheet dynamics. Through the generous donation by Alan Eggers, Huw joined the ARC in 2010 as a Research Fellow. During this time he continued to work on ice dynamics in West Antarctica as part of the National Science Foundation funded WISSARD Program. He used geophysical imaging of the ice sheet and underlying geology with a view to studying the role that subglacial water and sediments play in regulating ice sheet dynamics. In 2012, in was made a permanent Lecturer with a joint position between the ARC and the School of Geography, Environment and Earth Sciences. In this role, Huw provided research and teaching in a huge range of subjects from remote sensing of the ice sheet grounding line, and sub ice sheet (including identifying estuaries beneath ice sheets) and New Zealand glaciology. He has also been a great mentor, supervising seven MSc and seven PhD candidates during his time here. In 2014, he was promoted to Senior Lecturer and then Associate Professor in 2021.

In 2013, Huw was awarded a Marsden titled "Can ice sheets help themselves? Investigating self-stabilisation and instability in Antarctica." He was also a leading member of the NZARI Ross Ice Shelf Project, the NIWA funded End-of-Summer Snowline project and AI on several other Marsden funds. Huw was also a key member of the "Melting Ice and Rising Seas" team that won the 2019 Prime Minister's Science Prize. Huw is currently co-leader of the Antarctic Science Platform (ASP): Antarctic Ice Dynamics Project, a five year project which begun in 2019. Although leaving New Zealand to join ETH, we are very happy that Huw will stay on with the ARC in a 0.2 FTE role to continue his ASP commitments particularly for the upcoming SWAIS 2C project.

Ruzica Dadic and Huw Horgan in Aoraki Mt Cook (credit: Ruzica Dadic)

Introducing Girls* on Ice Aotearoa

The ARC is excited to host this newly established Inspiring Girls Expedition promoting diversity in science, art and outdoor professions.

Girls* on Ice Aotearoa (GOIA) offers an experience of glaciological science and mātauranga Māori (Māori knowledge), established through Inspiring Girls Expeditions and hosted by Te Puna Pātiotio—Antarctic Research Centre at Te Herenga Waka—Victoria University Wellington. We hope that this experience will inspire passion, participation and empowerment for girls* in professions of science, art and wilderness exploration.

Ruzica Dadic initiated the concept of creating a New Zealand expedition, and along with fellow ARC researchers, Lauren Vargo, Holly Winton and a growing team, they have developed the programme. With support from the Victoria University of Wellington Foundation, they are seeking philanthropic funding to finance the expeditions. One such supporter, Beverley McCombs, whom kickstarted the fundraising with her generous donation said she was looking to contribute to a cause close to her heart,

"I've been there myself. I was a country girl with local schooling and missed the possibilities that this programme offers. I'm very keen to encourage girls towards all that this delivers."

The first Inspiring Girls Expedition in 1999 was in the rugged North Cascades mountains of Washington state, USA. Since then, they have grown into an international community with branches and expeditions in the United States, Canada, Switzerland, Austria, Central Asia, and now Aotearoa New Zealand.

Their history began as an organization seeking to create space for girls and women to grow and thrive in historically male-dominated fields. While they acknowledge their name is imperfect, Inspiring Girls* Expeditions welcomes female-identifying, nonbinary, and intersex students. GOIA also especially welcomes youth of Māori and Pasifika descent.

Te Hauhunga is the reo Māori name of GOIA. Te means 'the', while 'hauhunga' can mean 'frost' or 'frosty', a reference to the large role ice plays in the expeditions, but it can also be translated as 'a pale green variety of greenstone.' Just like greenstone, our students are considered taonga or a treasure. Additionally, 'hauhunga' can be broken down into two component words: 'hau' (vitality, vital essence) and 'hunga' (a group)' — together these words suggest 'a vibrant group', a great description for our expedition teams. Overall, the name Te Hauhunga conveys how valued our students are as they grow in confidence and vitality exploring Aotearoa's icy environments. The name Te Hauhunga was created by Dr Meegan Hall and Professor Rawinia Higgins at Te Herenga Waka—Victoria University of Wellington.

During the expedition they will venture into the North Island's Central Plateau and explore the unique glaciers of Mount Ruapehu, New Zealand's highest active volcanic peak. A team of around ten girls will learn about the ever-changing nature of glaciers on Mount Ruapehu, engage in practical field work, and navigate a unique Māori cultural partnership. They work together to create a positive and educational experience for the leaders and participants alike, developing our knowledge of the land, and forming life-long friendships. From sketching the patterns of a melting glacier to climbing a rock wall for the first time, they will empower our participants to lead and succeed through science, art, and outdoor exploration.

In 2022, Lauren participated in the Girls* on Ice Alaska expedition as one of two scientists in the team which also included an artist and mountain guide. On the first day, instructors taught the students how to put their crampons on, how to walk around safely with their ice axes, how to self arrest (so if you slip and fall, you know how to dig your ice axe into the snow to stop). For the next week, each day included morning yoga, followed by art and science lessons, before heading onto the glacier in the afternoons. For some students, this was very far from anything they had done before. The instructors wanted to get the students to the point where they were pushing themselves and broadening their horizons!

The first GOIA expedition is planned for 2024. If you would like to support this expedition, please go to:

https://www.wgtn.ac.nz/engage/giving/priorities/environment-sustainability/support-young-women-to-explore-the-sciences

Awards and appointments

In 2022 ARC staff and students received the following:

Awards

Lionel Carter — Awarded Francis P. Shepard Medal for "Excellence in Marine Geology".

Emma de Jong — Won "Most Creative Poster Prize" at the Surface Ocean Lower Atmosphere Summer School.

Nick Golledge — IPCC WGI co-awarded 2022 Gulbenkian Prize for Humanity.

Aileen Gordon — Won "Best Poster Prize" at the NZ Geosciences Conference.

Richard Levy — Awarded Blake Leader Award.

Appointments

Nancy Bertler — Promoted to Professor scale in 2022 Academic Promotion Round.

Shaun Eaves — Promoted to Senior Lecturer scale in 2022 Academic Promotion Round.

Huw Horgan — Promoted within Associate Professor scale in 2022 Academic Promotion Round.

Liz Keller — Promoted to Senior Research Fellow scale in 2022 Special Promotion Round.

Richard Levy — Promoted to Professor scale in 2022 Academic Promotion Round.

Rob McKay — Promoted to Professor scale in 2022 Academic Promotion Round.

Tim Naish — Appointed a Member Joint Scientific Committee, World Climate Research Programme (WCRP).

Lauren Vargo — Climate and Cryosphere (CliC) Scientific Steering Group Member, World Climate Research Programme (WCRP).

Lauren Vargo — New Zealand National Delegate to the WCRP, Royal Society Te Apārangi.

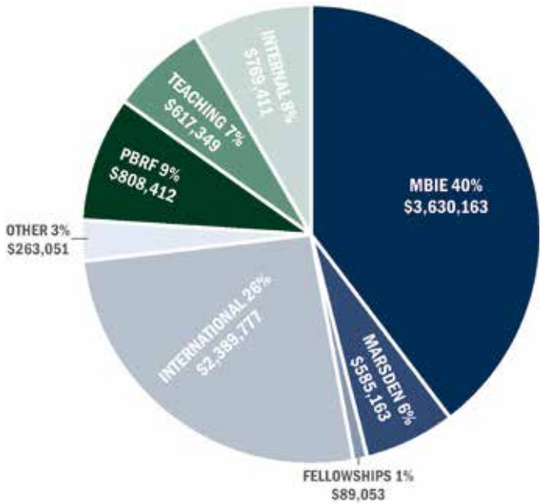
1972-2022 Staff Awards

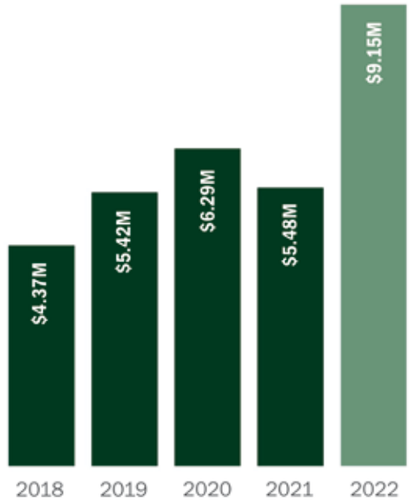
3	Antarctic place names
1	Asahiko Taira Ocean Drilling Prize
2	Blake Leadership Awards
2	Endeavour Fund grants
3	Fellows of the Royal Society of New Zealand
1	Francis P. Shepard Medal
1	Hill Tinsley Medal
1	Honorary Fellow of the Geological Society of London
1	Hamilton Award
1	Hatherton Award
1	Hutton Medal
3	IPCC Lead Authors
1	James Cook Fellowship
1	James Lee Wilson Award
17	Marsden Fund grants
2	Marsden Medals
1	Martha T. Muse Prize
2	McKay Hammer Awards
3	New Zealand Antarctic Medals
2	New Zealand Science and Technology Medals
1	Premio Internazionale Felice Ippolito
1	Prime Minister's MacDiarmid Emerging Scientist
1	Prime Minister's Science Prize
2	Polar Medals
5	Rutherford Discovery Fellowships
3	Rutherford Postdoctoral Fellowships
1	Scientific Committee on Antarctic Research President's Medal
2	Wellingtonian of the Year Awards

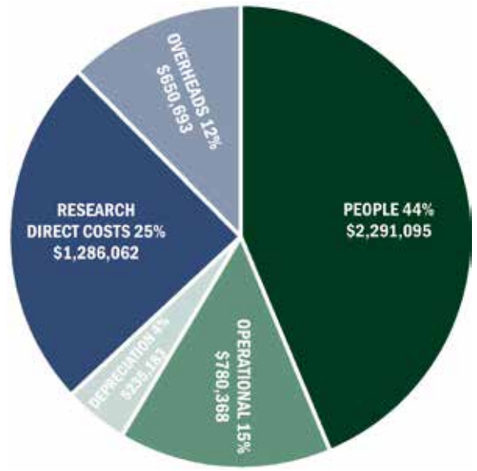
FINANCIAL SUMMARY

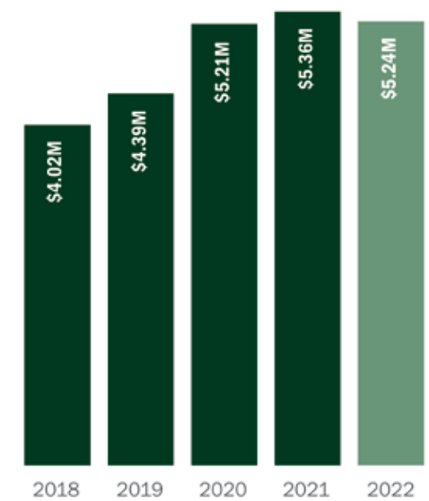
The ARC finances include both a Centre budget and 44 grants held by the Research Trust of Victoria University of Wellington (RTV). Our consolidated revenue sources and expenditure areas as well as five year summaries are summarized in the charts below (all figures are exclusive of GST). These charts combine the Centre budget that operates over the University financial year (January-December) and RTV budgets which operate over the life of the projects, as such, the year-end balances for revenue versus expenditure are often out-of-phase.

In 2022, the ARC generated $9.15M in total revenue, with a corresponding expenditure of $5.24M, we contributed $651K of overheads to the University from grants, and generated a $132K surplus for the University from the Centre.









Revenue

Overall 73% of ARC's revenue was from external funding sources. With funding from the Ministry of Business, Innovation and Employment (MBIE) making up 40% of this.

The ARC had a large increase in revenue in 2022 due to the $2.4M of funding from an international consortium for the SWAIS 2C project which is held in the Research Trust of Victoria University of Wellington. We had four active Marsden grants and two Rutherford Fellowships which ended in 2022. Our $263K of 'Other' external funding came from national funding sources such as the Department of Conservation, as well as reimbursement of costs from other institutes and private donations held by the Victoria University of Wellington Foundation, and transferred to the Centre for the ARC Endowed Development Fund and Arnold Heine Antarctic Research awards.

The remaining sources of revenue are from internal sources. The $808K PBRF (Performance-Based Research Fund) accounted for 9% and has continued to increase every year over the last six years. Our teaching revenue of $617K was from EFTS (Equivalent Full-time Student) for teaching and co-ordinating School of Geography, Environment and Earth Sciences courses and tuition fees for supervising postgraduate students. This has decreased from the previous year due to a decline in University enrolments. The 8% of internal grant funding included the $740K 2020 surplus transferred to a RTV grant for use on ARC strategic projects and the $29K Mātauranga Māori Research Fund grant.

Expenditure

Overall, our expenditure was slightly down on the previous year. ARC expenditure is divided between costs incurred directly within grants held in the Research Trust of Victoria University of Wellington, and those directly from the Centre's budget.

Our 'People' costs accounted for 44% ($2.3M) and covered salaries, annual leave and superannuation for permanent and fixed term staff including research assistants paid from grants.

The Centre's 'Operational' costs include $223K for occupancy charges for office and workshop space, $218K to support students through scholarships and grants, $77K for consultancy fees, $46K for IT related charges, $45K for IODP/ICDP membership, and $23K for equipment maintenance and consumables. The remaining $148K covered general operational costs such as office supplies, catering, printing, and domestic and international travel costs.

The Centre budget also included $235K of expenditure for the depreciation of CAPEX equipment.

The almost $1.3M of Research Direct Costs includes $486K of subcontracts to our research partners, $196K for student stipends and fees, and $24K for analytical costs. The remaining $580K supported costs such as fieldwork, consumables and travel costs.

The ARC's $651K overhead contribution included $416K to the Research Office and $235K to the University.

$13M project to focus on predicting impacts of sea-level rise

A major research programme led by the ARC will improve understanding of the impacts of sea-level rise on coastal communities.

Funding for the programme, Te Ao Hurihuri: Te Ao Hou—Our Changing Coast, is being provided by the 2022 Endeavour Fund administered by the Ministry of Business, Innovation and Employment.

Programme co-leader Professor Tim Naish, said the research will improve the ability to predict sea-level rise and the impacts it will have around the country.

"We know the sea around Aotearoa is rising but we don't yet know enough about how coastal regions will be affected to ensure our adaptation measures will be effective and appropriate," he says.

A key focus of the project is on improving the models currently used to understand the effects of sea-level rise, such as coastal flooding and groundwater salination, and risks to key infrastructure and cultural sites.

Tim said the research will produce a new, publicly-available online tool showing sea-level projections, at 100 metre spacing, along the New Zealand coastline. Risk assessment will be possible at the scale of individual houses and buildings.

Estimates provided by the new tool will also include the probability of major earthquakes causing changes in land elevation along the coast. We know that 50 cm of sea-level rise is unavoidable by 2100 and we could see up to 2.5 metres in some parts of the country.

"The aim of this project is to help ensure coastal impacts are well-understood so decisions about how we manage coastal areas and adapt to sea-level rise are based on the very best research."

Co-leader Professor Richard Levy said the programme involves a multi-disciplinary team including researchers from GNS Science, University of Auckland, University of Canterbury, University of Waikato, Oceanum Ltd., Takiwā Ltd., and Te Whare Wananga o Awanuiarangi.

The research team will also work with central and local government agencies, iwi, and community organisations, he says. The project began in October and runs until 2027.

Rutherford funding to understand the role of phytoplankton in a warmer world

Dr Holly Winton has been awarded an $800K Rutherford Discovery Fellowship.

Holly's research is titled, "Southern Ocean phytoplankton and climate: Understanding the ability of phytoplankton to modulate climate in a warmer world." Southern Ocean phytoplankton (tiny marine plants) interact with the Earth's climate by using sunlight to convert carbon dioxide into organic carbon. They also produce aerosols which help form clouds and regulate the Earth's energy balance. Phytoplankton blooms are seasonal and altered by sea ice conditions, temperature, wind, and nutrient availability. Given our current warming climate, it's important to understand how seasonal phytoplankton blooms have responded to Earth's previous warm periods.

With this Fellowship, Holly will measure and compare the expanded suite of biomarkers found in ice cores and present-day aerosols for a more complete picture of how and why Southern Ocean phytoplankton have changed in the past and what we might expect in the future.

"Another aspect of this Fellowship partners with mātauranga Māori experts to explore connections and co-create a maramataka—a Māori environmental and lunar calendar of Antarctica, providing a Māori worldview and holistic perspective of environmental change in the region."

Two successful Marsden awards looking at ice sheet and glacier melt

Professor Rob McKay has been awarded a $929K Marsden while early career Research Fellow Lauren Vargo was awarded a Marsden Fast-Start.

Rob McKay's Marsden project, "Past abrupt Antarctic ice sheet melt events and impacts on sea level and climate", will investigate past millennial-scale (1,000-10,000 years) climate events that can produce abrupt global changes over decadal timescales.

While proxy data and models indicate the Antarctic ice sheets may have contributed to such events, it is widely considered that collapse of past marine-based Northern Hemisphere ice sheets played a dominant role. Most of these Northern Hemisphere ice sheets are now gone, so these ocean-ice feedbacks will likely not play out in the same manner during future ice sheet collapses. Models indicate the marine-based Antarctic ice sheets may display instabilities and associated meltwater release will widely impact global sea level, precipitation and wind fields. Rob will use sediment cores to assess if the Antarctic ice sheets experienced "millennial-scale" melt events during warmer than present climates in the deeper geological past when Northern Hemisphere ice sheets were absent.

Lauren Vargo, was awarded a $360K Marsden Fast-Start grant for her project titled, "How much are glaciers melting due to climate change?"

"Billions of people will be impacted by melting glaciers. Scientific consensus is high that human influence is the main driver of glacier retreat."

However, methods to quantify how much of annual glacier melt is due to anthropogenic climate change do not exist. Lauren's project will develop and apply an innovative framework to 230 glaciers worldwide, to determine how much melting in individual years is due to anthropogenic climate change by using computer models to simulate glacier mass change 'without climate change' (greenhouse gases are ~1/3 of modern) and 'with climate change' (greenhouse gases at modern levels). Lauren will also project future changes in extreme glacier melt as temperatures continue to rise. The results will inform climate change assessments and decision-makers as the impacts of glacier melt, including declining water availability and increases in natural hazards, continue to intensify.

An iceberg during IODP-374
(credit: William Crawford, IODP JRSO)

John Nankervis checking the aerial photos after the descent of Mt Morning, Antarctica, during VUWAE 21, 1976 (credit: Harry Keys)

John Nankervis's generous bequest

The ARC is very grateful to the late John "Nank" Nankervis (1946-2022) who bequeathed a cash gift to the Victoria University of Wellington Foundation for research into Antarctic geology, tectonics and geophysics.

The gift has been added to the ARC Endowed Development Fund to provide support for future Antarctic research.

Over a 50-year climbing career, John made a tremendous contribution to mountaineering both in Aotearoa and around the world. Those contributions included ascents of all New Zealand's 3000 metre peaks, 50 of which were first ascents in the Southern Alps. He climbed extensively in South America, and his first expedition to the Himalayas was in 1981. He also climbed in Africa, Antarctica, Australia, Canada, China, Pakistan, Kyrgyzstan and Europe during his many expeditions.

John was President of the New Zealand Alpine Club, and lead author of many submissions on National Park management plans and proposals. He served three terms on the Tongariro-Taupo Conservation Board, ten years on the New Zealand Conservation Authority, a decade as New Zealand delegate to the International Federation for Climbing and Mountaineering (UIAA), and many other roles. In 2010, he was made a member of the New Zealand Order of Merit for services to mountaineering.

In the summer of 1976, John was a field assistant on a Victoria University of Wellington Antarctic Expedition (VUWAE 21) with Field Leader, and friend, John "Harry" Keys, who said,

"Nanks' experience on the upper Taylor Glacier was reassuring as we crossed through a crevasse field and our trip from Mt Morning via Mt Discovery summit to its base was a real highlight."

"His wicked sense of humour certainly came out that summer! He is much missed by many."

John was a supporter of the ARC Endowed Development Fund since its inception in 2004, and most recently attended the ARC's S.T. Lee Lecture in Antarctic Studies in April 2021.

Arnold Heine Antarctic Research Award

The 2022 Arnold Heine Antarctic Research Award recipient was recent MSc graduate Ruby Muir.

Ruby Muir received the award to write a paper presenting the results of her Masters thesis in which she applied a glacial model to recreate past temperatures during the Antarctic Cold Reversal.

The research built on New Zealand glacier modelling, which established the magnitude of mid to high latitude expression of the Antarctic Cold Reversal extending this record across the Pacific to Southern Patagonia. Using glacier modelling, Ruby reconstructed Antarctic Cold Reversal temperature anomalies from two mountain glaciers in Patagonia between 44–46°S. The anomalies compare well with the New Zealand records, and extend the latitude range of Southern Hemisphere climate reconstructions.

Combining the results with those from New Zealand provides insight into the previously unclear, larger-scale climate re-organisation that occurred during the Antarctic Cold Reversal. These glacier-based, paleoclimate anomalies are best explained by a northward migration of southern westerly winds.

The research results are valuable for several reasons. Firstly, these are the first glacier-based Antarctic Cold Reversal temperature reconstructions from the Southern Patagonia, expanding the spatial extent of Southern Hemisphere quantitative paleoclimate proxies that encompass this period. Secondly, they align with the New Zealand reconstructions of Antarctic Cold Reversal glacier advance driven by temperature anomalies of -2.2 to -3°C, which supports the proposed theory of southern westerly wind advance during the Antarctic Cold Reversal. These findings can be used to assess hypotheses regarding the drivers of millennial scale climate fluctuations, and the Antarctic Cold Reversal in particular.

Additionally, the research is an example of glacier modelling conducted entirely using globally-available and remotely-developed glacier and climate datasets. Thus, it represents a methodology that could potentially be expanded and applied to existing moraine datasets throughout New Zealand and globally.

Ruby Muir in the field (credit: Ruby Muir)

ARC Endowed Development Fund Awards

The Endowed Development Fund awards small grants of up to $4,500 to postgraduate students with research links to Antarctica.

The awards provide students with opportunities that would not have otherwise been possible. Examples include; participation in international summer schools, the opportunity to work with collaborators in world-class analytical facilities, and the ability to travel to international conferences and workshops to present their scientific discoveries on a world-stage.

The 2022 recipients were:

Kevin Henson (MSc, ARC/SGEES), to write-up a paper on his research for submission to a journal.

Claudia Moore (SGEES), to contract as an research assistant to work on cosmo laboratory samples.

Matthew Tankersley (ARC), to travel to U.S. Interdisciplinary Antarctic Earth Science meeting & West Antarctic Ice Sheet (WAIS) Conference: Denver.

PUBLICATIONS

Peer-reviewed publications

Audet, A.C., Putnam, A.E., Russell, J.L. Lorrey, A., Mackintosh, A., **Anderson**, B., Denton, G.H. (2022). Correspondence among mid-latitude glacier equilibrium line altitudes, atmospheric temperatures, and westerly wind fields. *Geophysical Research Letters* 49: e2022GL099897. https://doi.org/10.1029/2022GL099897

Baldacchino, F., Morlighem, M., **Golledge**, N.R., **Horgan**, H., Malyarenko, A. (2022). Sensitivity of the Ross Ice Shelf to environmental and glaciological controls. *The Cryosphere* 16(9): 3723-3738. https://doi.org/10.5194/tc-2022-50

Behrens, B.C., Yokoyama, Y., Miyairi Y., Sproson, A.D., Yamane, M., Jimenez-Espejo, F.J., **McKay**, R.M., Johnson, K.M., Escutia, C., Dunbar, R.B. (2022). Beryllium isotope variations recorded in the Adélie Basin, East Antarctica reflect Holocene changes in ice dynamics, productivity, and scavenging efficiency. *Quaternary Science Advances* 7: 100054. https://doi.org/10.1016/j.qsa.2022.100054

Bisset, R., Nienow, P., Goldberg, D., **Wigmore**, O., Loayza-Muro, R., Wadham, J., Macdonald, M., Bingham, R. (2022). Using thermal UAV imagery to model distributed debris thicknesses and sub-debris melt rates on debris-covered glaciers. *Journal of Glaciology* 1-16. https://doi.org/10.1017/jog.2022.116.

Bollen, M., Riesselman, C.R., Ohneiser, C., **Albot**, O., **McKay**, R., Lee, M.K., Yoo, K.C., Kim, S., Lee, J. **Levy**, R. (2022). Pleistocene oceanographic variability in the Ross Sea: A multiproxy approach to age model development and paleoenvironmental analyses. *Global and Planetary Change* 216: 103901. https://doi.org/10.1016/j.gloplacha.2022.103901

Chorley, H., **Levy**, R., **Naish**, T., Lewis, A., Cox, S., Hemming, S., Ohneiser, C., Gorman, A., Harper, M., Homes, A., Hopkins, J., Prebble, J., **Verret**, M., **Dickinson**, W., Florindo, F., **Golledge**, N., Halberstadt, A.R., Kowalewski, D., **McKay**, R., Meyers, S., Anderson, J., Dagg, B., Lurcock, P. (2022). East Antarctic Ice Sheet variability during the middle Miocene Climate Transition captured in drill cores from the Friis Hills, Transantarctic Mountains. *GSA Bulletin* https://doi.org/10.1130/B36531.1

Clem, K.R., Bozkurt, D., **Kennett**, D., King, J.C., Turner, J. (2022). Central tropical Pacific convection drives extreme high temperatures and surface melt on the Larsen C Ice Shelf, Antarctic Peninsula. *Nature Communications* 13: 3906. https://doi.org/10.1038/s41467-022-31119-4

Colleoni, F., **Naish**, T., DeConto, R., De Santis, L., Whitehouse, P. (2022). The uncertain future of Antarctica's melting ice. *Eos* 103. https://doi.org/10.1029/2022EO220014

Duncan, B., **McKay**, R., **Levy**, R., **Naish**, T., Prebble, J.G., Sangiorgi, F., Krishnan, S., Hoem, F., Clowes, C., Dunkley Jones, T., Gasson, E., Kraus, C., Kulhanek, D. K., Meyers, S.R., Moossen, H., Warren, C., Willmott, V., Ventura, G.T., Bendle, J. (2022). Climatic and tectonic drivers of late Oligocene Antarctic ice volume. *Nature Geoscience* 15: 819-825. https://doi.org/10.1038/s41561-022-01025-x

Gagan, M.K., Halide, H., Permana, R.C.E., Lebe, R., **Dunbar**, G.B., Kimbrough, A.K., Scott-Gagan, H., Zwartz, D., Hantoro, W.S. (2022). The historical impact of anthropogenic airborne sulphur on the Pleistocene rock art of Sulawesi. *Scientific Reports* 12: 21512. https://www.nature.com/articles/s41598-022-25810-1

Garnett, J., Halsall, C., **Winton**, H., Joerss, H., Mulvaney, R., Ebinghaus, R., Frey, M., Jones, A., Leeson, A., Wynn, P. (2022). Increasing accumulation of perfluorocarboxylate contaminants revealed in an Antarctic firn core (1958-2017). *Environmental Science and Technology* 56(16): 11246-11255. https://doi.org/10.1021/acs.est.2c02592

Hogan, K.A., Arnold, N.S., Larter, R.D., Kirkham, J.D., Noormets, R., Ó Cofaigh, C., **Golledge**, N.R., Dowdeswell, J.A. (2022). Subglacial water flow over an Antarctic palaeo-ice stream bed. *Journal of Geophysical Research: Earth Surface* 127(2): e2021JF006442. https://doi.org/10.1029/2021JF006442

Jones, J., Kohfeld, K.E., Bostock, H., Crosta, X., Liston, M., **Dunbar**, G., Chase, Z., Leventer, A., Anderson, H., Jacobsen, G. (2022). Sea ice changes in the southwest Pacific sector of the Southern Ocean during the last 140 000 years. *Climate of the Past* 18(3): 465-483. https://doi.org/10.5194/cp-18-465-2022

Keller, E.D., Hilton, T.W., Benson, A., Karalliyadda, S., Xie, S., Gurney, K.R., Turnbull, J.C. (2022). Mahuika-Auckland: A spatially and temporally resolved fossil fuel CO_2 emissions data product for Auckland, New Zealand. *Geoscience Data Journal* 00, 1–21. https://doi.org/10.1002/gdj3.181

Kim, S., **McKay**, R.M., Lee, J., Yoo, K.C., Lee, M.K., Moon, H.S. (2022). Bioturbation supplying young carbon into West Antarctic continental margin sediment. *Palaeogeography, Palaeoclimatology, Palaeoecology* 602: 111161 https://doi.org/10.1016/j.palaeo.2022.111161

King, M.V., Gales, J.A., Laberg, J.S., **McKay**, R.M., De Santis, L., Kulhanek, D.K., Hosegood, P.J., Morris, A. (2022). Pleistocene depositional environments and links to cryosphere-ocean interactions on the eastern Ross Sea continental slope, Antarctica (IODP Hole U1525A). *Marine Geology* 443: 106674. https://doi.org/10.1016/j.margeo.2021.106674

Lacelle, D., Fisher, D.A., **Verret**, M., Pollard, W., (2022). Improved prediction of the vertical distribution of ground ice in Arctic-Antarctic permafrost sediments. *Communications Earth & Environment* 3: 31. https://doi.org/10.1038/s43247-022-00367-z

Lorrey, A.M., **Vargo**, L., Purdie, H., **Anderson**, B., Cullen, N.J., Sirguey, P., Mackintosh, A., Willsman, A., Macara, G., Chinn, W. (2022). Southern Alps equilibrium line altitudes: Four decades of observations show coherent glacier-climate responses and a rising snowline trend. *Journal of Glaciology* 68(272): 1127-1140. https://doi.org/10.1017/jog.2022.27

McKay, R., **Albot**, O., **Dunbar**, G.B., Lee, J.I., Lee, M.K., Yoo, K.C., Kim, S., Turton, N., Kulhanek, D., Patterson, M., **Levy**, R. (2022). A comparison of methods for identifying and quantifying ice rafted debris on the Antarctic margin. *Paleoceanography and Paleoclimatology* 37(4): e2021PA004404. https://doi.org/10.1029/2021PA004404

Moore, E.M.M., **Eaves**, S.R., Norton, K.P., Mackintosh, A.N., **Anderson**, B.M., Dowling, L.H., Hidy, A.J. (2022). Climate reconstructions for the Last Glacial Maximum from a simple cirque glacier in Fiordland, New Zealand. *Quaternary Science Reviews* 275: 107281. https://doi.org/10.1016/j.quascirev.2021.107281

Nicolaus, M., Perovich, D.K., Spreen, G., Granskog, M.A., von Albedyll, L., Angelopoulos, M., Anhaus, P., Arndt, S., Belter, H.J., Bessonov, V., Birnbaum, G., Brauchle, J., Calmer, R., Cardellach, E., Cheng, B., Clemens-Sewall, D., **Dadic**, R., *et al*. (2022). Overview of the MOSAiC expedition: Snow and sea ice. *Elementa: Science of the Anthropocene* 10(1): 000046. https://doi.org/10.1525/elementa.2021.000046

Patterson, M.O., **Levy**, R.H., Kulhanek, D.K., Van De Flierdt, T., **Horgan**, H., **Dunbar**, G.B., **Naish**, T.R., Ash, J., **Pyne**, A., **Mandeno**, D., Winberry, P., Harwood, D.M., Florindo, F., Jimenez-Espejo, F.J., Läufer, A., Yoo, K.C., Seki, O., Stocchi, P., Klages, J.P., Lee, J.I., Colleoni, F., Suganuma, Y., Gasson, E., Ohneiser, C., Flores, J.A., Try, D., Kirkman, R., Koch, D. (2022). Sensitivity of the West Antarctic Ice Sheet to +2 °C (SWAIS 2C). *Scientific Drilling* 30: 101-112. https://doi.org/10.5194/sd-30-101-2022

Pérez, L.F., de Santis, L., **McKay**, R.M., Larter, R.D., Ash, J., Bart, P.J., Böhm, G., Brancatelli, G., Browne, I., Colleoni, F., Dodd, J.P., Geletti, R., Harwood, D.M., Kuhn, G., Laberg, J.S., Leckie, R.M., **Levy**, R.H., Marschalek, J., Mateo, Z., **Naish**, T.R., Sangiorgi, F., Shevenell, A.E., Sorlien, C.C., van de Flierdt, T. (2022). Early and middle Miocene ice sheet dynamics in the Ross Sea: Results from integrated core-log-seismic interpretation. *Bulletin of the Geological Society of America* 134(1-2): 348-370. https://doi.org/10.1130/B35814.1

Pérez, L.F., **McKay**, R.M., De, Santis, L., Larter, R.D., **Levy**, R.H., **Naish**, T.R., Anderson, J.B., Bart, P.J., Busetti, M., **Dunbar**, G., Sauli, C., Sorlien, C.C., Speece, M. (2022). Early to middle Miocene ice sheet dynamics in the westernmost Ross Sea (Antarctica): Regional correlations. *Global and Planetary Change* 216: 103891. https://doi.org/10.1016/j.gloplacha.2022.103891

Petherick, L.M., Knight, J., Shulmeister, J., Bostock, H., Lorrey, A., Fitchett, J., **Eaves**, S., Vandergoes, M.J., Barrows, T.T., Barrell, D.J.A., Eze, P.N., Hesse, P., Jara, I.A., Mills, S., Newnham, R., Pedro, J., Ryan, M., Saunders, K.M., White, D., Rojas, M., Turney, C. (2022). An extended last glacial maximum in the Southern Hemisphere: A contribution to the SHeMax project. *Earth Science Reviews* 231: 104090. https://doi.org/10.1016/j.earscirev.2022.104090

Prebble, J.G., **Dunbar**, G., van den Bos, V., Li, X., Vandergoes, M., Richardson, S., **Horgan**, H., Holt, K.A., Howarth, J., **Levy**, R. (2022). Toward a novel multi-century archive of tree mast using pollen from lake sediments. *The Holocene* 32(11): 1184-1192. https://doi.org/10.1177/0959683622111429

Stroeve, J., Nandan, V., Willatt, R., **Dadic**, R., Rotosky, P., Gallagher, M., Mallett, R., Barrett, A., Hendricks, S., Tonboe, R., Serreze, M., Thielke, L., Spreen, G., Newman, T., Yackel, J., Ricker, R., Tsamados, M., Macfarlane, A., Hannula, H-R., Schneebeli, M. (2022). Rain-on-Snow (ROS) understudied in sea ice remote sensing: A multi-sensor analysis of ROS during MOSAiC. *The Cryosphere* https://doi.org/10.5194/tc-2021-383

Tankersley, M.D., **Horgan**, H.J., Siddoway, C.S., Caratori Tontini, F., Tinto, K.J. (2022). Basement topography and sediment thickness beneath Antarctica's Ross Ice Shelf. *Geophysical Research Letters* 49(10): e2021GL097371. https://doi.org/10.1002/essoar.10509277.2

Tielidze, L.G., **Eaves**, S.R., Norton, K.P., Mackintosh, A.N., Hidy, A.J. (2022). Cosmogenic 10Be constraints on deglacial snowline rise in the Southern Alps, New Zealand. *Quaternary Science Reviews* 286: 107548. https://doi.org/10.1016/j.quascirev.2022.107548

Tielidze, L.G., Jomelli, V., and Nosenko, G.A. (2022). Analysis of regional changes in geodetic mass balance for all Caucasus glaciers over the past two decades. *Atmosphere* 13(2): 256. https://doi.org/10.3390/atmos13020256.

Tielidze, L.G., Nosenko, G.A., Khromova, T.E., Paul, F. (2022). Strong acceleration of glacier area loss in the Greater Caucasus between 2000 and 2020. *The Cryosphere* 16: 489–504. https://doi.org/10.5194/tc-16-489-2022.

Venugopal, A.U., **Bertler**, N.A.N., Pyne, R.L., Kjær, H.A., **Winton**, V.H.L., Mayewski, P.A., Cortese, G. (2022). Role of mineral dust in the nitrate preservation during the glacial period: Insights from the RICE ice core. *Global and Planetary Change* 209: 103745. https://doi.org/10.1016/j.gloplacha.2022.103745

Whiteford, A., **Horgan**, H.J., Leong, W.J., Forbes, M. (2022). Melting and Refreezing in an Ice Shelf Basal Channel at the Grounding Line of the Kamb Ice Stream, West Antarctica. *Journal of Geophysical Research: Earth Surface* 127(11): e2021JF006532. https://doi.org/10.1029/2021JF006532

Winton, V.H.L., Bowie, A.R., Curran, M.A., Moy, A.D. (2022). Enhanced deposition of atmospheric soluble iron by intrusions of marine air masses to East Antarctica. *Journal of Geophysical Research: Atmospheres* 127(13): e2022JD036586. https://doi.org/10.1029/2022JD036586

Reports

Chown, S.L., Leihy, R.I., **Naish**, T.R., Brooks, C.M., Convey, P., Henley, B.J., Mackintosh, A.N., Phillips, L.M., Kennicutt, M.C. II., Grant, S.M. (Eds.) (2022). *Antarctic Climate Change and the Environment: A Decadal Synopsis and Recommendations for Action*. Scientific Committee on Antarctic Research, Cambridge, United Kingdom. www.scar.org.

Ministry for the Environment. (2022a). *Aotearoa New Zealand's First National Adaptation Plan*. Wellington, Ministry for the Environment. https://environment.govt.nz/publications/aotearoa-new-zealands-first-national-adaptation-plan/. **NZ SeaRise** pg. 69

Ministry for the Environment. (2022b). Interim Guidance on the Use of New Sea-Level Rise Projections. Wellington, Ministry for the Environment. https://environment.govt.nz/publications/interim-guidance-on-the-use-of-new-sea-level-rise-projections/. Compiled by R.G. Bell, Lawrence, J., **Naish**, T., **Levy**, R., Allan, S.

O'Neill, T., Robinson, E., and **Verret**, M. (2022). New Zealand. *International Permafrost Association Country Reports* 2021, p.43-44.

Theses

Alevropoulos-Borrill, A. (2022). Future evolution of the Amundsen Sea Embayment, West Antarctica: Exploring the modelled ice stream sensitivity to numerical representation. PhD thesis, Te Herenga Waka—Victoria University of Wellington. doi: 10.26686/wgtn.21588555

Henson, K. (2022). Atmospheric dust transport to high-elevation Dronning Maud Land, Antarctica, over the satellite era and implications for centennial scale ice core records of dust deposition. MSc thesis, Te Herenga Waka—Victoria University of Wellington. doi: 10.26686/wgtn.20399592

Lelieveld, N. (2022). Antarctic paleoenvironment and vegetation reconstruction during the early and middle Miocene using biomarkers from Ross Sea sediment drill cores. MSc thesis, Te Herenga Waka—Victoria University of Wellington. doi: 10.26686/wgtn.21554862

Muir, R. (2022). The magnitude of regional cooling across Southern Patagonia during the Antarctic Cold Reversal and Younger Dryas determined by glacier modelling. MSc thesis, Te Herenga Waka—Victoria University of Wellington https://doi.org/10.26686/wgtn.21128218

Stuthridge, G. (2022). The glacial history of the Upper Clarence Valley, North Canterbury, New Zealand. MSc thesis, Te Herenga Waka—Victoria University of Wellington.

Tielidze, L. (2022). Late Quaternary glacier-climate reconstructions from the Southern Alps, New Zealand. PhD thesis, Te Herenga Waka—Victoria University of Wellington. doi: 10.26686/wgtn.21708491

Whiteford, A. (2022). Ice and ocean dynamics at a subglacial river mouth on the Siple Coast, Antarctica. PhD thesis, Te Herenga Waka—Victoria University of Wellington. doi: 10.26686/wgtn.21456243

Young, H. (2022). Investigating the applications of Co:Co2ff Emission ratio to develop a greater understanding of Co_2 fossil sources in Auckland, New Zealand. MSc thesis, Te Herenga Waka—Victoria University of Wellington. doi: 10.26686/wgtn.20388474

PRESENTATIONS

Invited presentations

Golledge, N. (2022). Climate-forced changes of the Antarctic ice sheet: Evidence, inference, and speculation. *University of California Santa Cruz*, USA, 9 March, 2022.

Golledge, N. (2022). Processes missing from models: The cryosphere. *World Climate Research Programme*, 22 March, 2022.

Golledge, N. (2022). Climate-forced changes of the Antarctic ice sheet: Evidence, inference, and speculation" *PALSEA*, online, 13 April, 2022.

Golledge, N. (2022). Climate-forced changes of the Antarctic ice sheet: Evidence, inference, and speculation. *COLDEX* 3 May, 2022.

Student oral presentations

Balfoort, L., **Dunbar**, G., Naeher, S., **Horgan**, H. (2022). Environmental conditions of the West Antarctic Ice Sheet during the Miocene: Insights from organic biomarker distributions. In: Zernack A.V., Palmer, J. eds. Geoscience Society of New Zealand Annual Conference 2022: Programme & Abstracts Volume. *Geoscience Society of New Zealand Miscellaneous Publication 161A*. Geoscience Society of New Zealand, Wellington, pp. 123.

de Jong, E., **Winton**, H., Naeher., S., **Duncan**, B., **McKay**, R., Atkins, C., Lee, J., Deppler, S. (2022). Lipid biomarkers of marine phytoplankton variability in modern snow and marine sediments from the southwestern Ross Sea, Antarctica. *SCAR Open Science Conference*, online 1-10 August, 2022.

Gorman, A.R., Hall, C., van Haastrecht, L., Black, J.A., **Horgan**, H., **Dunbar**, G., Wilson, G.S., **Tankserley**, M., Dagg, B. (2022). Seismic and gravity constraints on the stratigraphy of the Siple Coast region underlying the Kamb Ice Stream, Antarctica. In: Zernack A. V., Palmer, J. eds. Geoscience Society of New Zealand Annual Conference 2022: Programme & Abstracts Volume. *Geoscience Society of New Zealand Miscellaneous Publication 161A*. Geoscience Society of New Zealand, Wellington, pp. 123.

Monteiro, V.C., Turnbull, J., Davis, K.J., Miles, N.L., Barkley, Z., Deng, A. (2022). The use of nocturnal observations in urban-scale atmospheric inversions for greenhouse gases. *American Geophysical Union (AGU) Fall Meeting*, Chicago, USA, 12-16 December, 2022.

Tielidze, L., **Eaves**, S., Norton, K., Mackintosh, A., Alan, H. (2022). Late Quaternary glacier-based climate reconstruction from the Southern Alps, New Zealand. *EGU General Assembly*, Vienna, Austria and online, 23-27 May, 2022.

Student poster presentations

de Jong, E., **Winton**, H., **Duncan**, B., Naeher., S. (2022). The unknown future of Ross Sea, Antarctic phytoplankton: A multi-archive biomarker approach to the recent past. *Surface Ocean Lower Atmosphere (SOLAS) Summer School*, online, 13-17 June, 2022.

Gordon, A., Naeher, S., **Winton**, H., Rees, A., Kennedy, L., Raine, I. (2022). Development of a chemotaxonomic classification of New Zealand plants – Implications for using biomarkers to reconstruct our bioheritage. In: Zernack A. V., Palmer, J. eds. Geoscience Society of New Zealand Annual Conference 2022: Programme & Abstracts Volume. *Geoscience Society of New Zealand Miscellaneous Publication 161A*. Geoscience Society of New Zealand, Wellington, pp. 123.

Oliver, W.J., Gorman, A.R., Bowman, M.H., Black, J.A., **Tankersley**, M. (2022). Seismic and gravity surveys characterise Discovery Deep, Antarctica. In: Zernack A. V., Palmer, J. eds. Geoscience Society of New Zealand Annual Conference 2022: Programme & Abstracts Volume. *Geoscience Society of New Zealand Miscellaneous Publication 161A*. Geoscience Society of New Zealand, Wellington, pp. 123.

MEDIA AND COMMUNITY ENGAGEMENT

TV interviews

Newshub — 13 February, Lauren Vargo, "Climate Change Minister James Shaw was warned emission target was too ambitious, too expensive." https://www.newshub.co.nz/home/politics/2022/02/climate-change-minister-james-shaw-was-warned-emissions-target-was-too-ambitious-too-expensive.html

Three's AM Show — 10 March, Rob McKay, "Ernest Shackleton's ship Endurance found preserved underwater."

TVNZ Q&A with Jack Tame — 27 March, Tim Naish, "Why polar temperatures spikes matter for us all." https://www.tvnz.co.nz/shows/q-and-a/clips/why-polar-temperature-spikes-matter-for-us-all

Newshub — 1 May, Richard Levy and Tim Naish, "Alarming new statistics reveal NZ's sea-level could rise 30 cm in next 10 to 20 years." https://www.newshub.co.nz/home/new-zealand/2022/05/alarming-new-statistics-reveal-new-zealand-s-sea-level-could-rise-30cm-in-next-10-to-20-years.html

Newshub — 1 May, Tim Naish, "Tough questions over who will pay for homes and infrastructure affected by sea-level rise." https://www.newshub.co.nz/home/new-zealand/2022/05/tough-questions-over-who-will-pay-for-homes-and-infrastructure-affected-by-sea-level-rise.html

TVNZ Sunday — 1 May, Brian Anderson, "Rivers of Tears." https://www.tvnz.co.nz/shows/sunday/clips/rivers-of-tears

Al Jazeera — 2 May, Tim Naish, "New Zealand faces major sea rise 'much sooner than we thought'." https://www.aljazeera.com/news/2022/5/2/new-zealand-faces-major-sea-rise-much-sooner-than-we-thought

1News Breakfast — 2 May, Tim Naish, "Kiwis can now see how sea-level rise will affect them." https://www.1news.co.nz/2022/05/02/kiwis-can-now-see-how-sea-level-rise-will-affect-them/?fbclid=IwAR3Xd_32SS7p2gh4m2wC7IVseQWsxw1XvGCJLOYYPn9ZIAf9NAeJIdarf4

Newshub — 2 May, Richard Levy and Tim Naish, "How sea-level rise will work invisibly - paralysing towns and cities from underground." https://www.msn.com/en-nz/news/national/how-sea-level-rise-will-work-invisibly-paralysing-towns-and-cities-from-underground/ar-AAWP84W

Newsroom — 2 May, Tim Naish and Richard Levy, "NZ sea-level rising twice as fast." https://www.newsroom.co.nz/nz-sea-level-rising-twice-as-fast

Newshub — 2 May, Richard Levy, "Invisible' effects could paralyse towns if rising sea-levels aren't stopped." https://www.youtube.com/watch?v=t00a854vxTc

Newshub — 2 May, Richard Levy, "What are those in power doing to solve NZ's rapidly rising sea levels?" https://www.youtube.com/watch?v=dQj05MmHHi4

NZ Today — 2 May, NZ SeaRise, "New NZ sea-level rise projections crucial for planning." https://www.newzealandtoday.net/home/2022/5/2/new-nz-sea-level-rise-projections-crucial-for-planning

CNN — 3 May, Tim Naish, "'A bit terrifying': New Zealand sea level rising more quickly than forecast." https://www.news18.com/news/buzz/a-bit-terrifying-new-zealand-sea-level-rising-more-quickly-than-forecast-5100139.html

WION (World is One News – India) — 3 May, NZ SeaRise, "Study: Alarming rise in New Zealand's sea levels." https://www.youtube.com/watch?v=F4Gigp-Mqto

Newshub Late — 4 May, Richard Levy, "Climate expert warns people living in populated coastal areas could lose insurance with just a small sea-level rise." https://www.newshub.co.nz/home/new-zealand/2022/05/climate-expert-warns-people-living-in-populated-coastal-areas-could-lose-insurance-with-just-a-small-sea-level-rise.html

NewsHub — 7 June, Huw Horgan and Richard Levy, "Kiwi scientists make astonishing discovery hundreds of metres under Antarctic ice." https://www.newshub.co.nz/home/new-zealand/2022/06/kiwi-scientists-make-astonishing-discovery-hundreds-of-metres-under-antarctic-ice.html

TV3 AM Show — 20 June, Nick Golledge, "Climate change and Everest base camp."

TVNZ OneNews — 14 July, Nick Golledge, "NZ-linked 'atmospheric rivers' behind record melting of Antarctic ice shelf." https://www.1news.co.nz/2022/07/14/nz-linked-atmospheric-rivers-behind-record-melting-of-antarctic-ice-shelf/

NewsHub — 1 August, Tim Naish, "How can New Zealand adapt to climate change before it's too late?" https://www.newshub.co.nz/home/new-zealand/2022/08/how-can-new-zealand-adapt-to-climate-change-before-it-s-too-late.html

TVNZ OneNews — 18 September, Bella Duncan and Tim Naish, "New Antarctica data reveals 'tipping point' for ice melt." https://www.1news.co.nz/2022/09/18/new-antarctica-data-reveals-tipping-point-for-ice-melt/

BBC Frozen Planet II: Frozen Peaks — 25 September (UK)/13 February 2023 (NZ), Brian Anderson, Timelapse movies of Franz Josef Glacier.

Radio interviews

RadioNZ News — 1 May, Tim Naish and Richard Levy, "Sea-levels rising twice as fast as thought NZ." https://www.rnz.co.nz/news/national/466262/sea-levels-rising-twice-as-fast-as-thought-in-new-zealand

RadioNZ Morning Report — 2 May, Tim Naish, "Sea rising twice as fast as previously thought for some of NZ." https://www.rnz.co.nz/national/programmes/morningreport/audio/2018840200/sea-rising-twice-as-fast-as-previously-thought-for-some-of-nz

RadioNZ 'Afternoons with Jesse Mulligan' — 8 June, Holly Winton, "Microplastics found in Antarctica for the first time." https://www.rnz.co.nz/national/programmes/afternoons/audio/2018845073/microplastics-found-in-antarctica-for-the-first-time

95bFM — 9 June, Holly Winton, "First microplastics found in Antarctica snow."

Print Media

Stuff — 8 January, Tim Naish, "'It totally resonates': Kiwi climate experts react to the number one movie Don't Look Up." https://www.stuff.co.nz/environment/climate-news/127432079/it-totally-resonates-kiwi-climate-experts-react-to-the-number-one-movie-dont-look-up

The Spinoff — 27 January, Bella Duncan, "Returning to a green Antarctica." https://thespinoff.co.nz/science/27-01-2022/returning-to-a-green-antarctica

The Conversation — 11 February, Huw Horgan, "Exploring Antarctica's hidden under-ice rivers and their role in future sea-level rise." https://theconversation.com/exploring-antarcticas-hidden-under-ice-rivers-and-their-role-in-future-sea-level-rise-176456

Ocean News — 8 March, Darcy Mandeno, "Okeanus Winch Completes Antarctic Field Season." https://www.oceannews.com/news/science-and-tech/okeanus-winch-completes-antarctic-field-season

Wairarapa Times Age — 19 March, Bella Duncan, "Antarctica offers big clues."

NZ Herald — 28 March, Lauren Vargo, "How did our icy wonders fare over fifth hottest summer." https://www.nzherald.co.nz/nz/how-did-our-icy-wonders-fare-over-fifth-hottest-summer/5SXTG6JCGKHVEXODADGN53JNUM/?c_id=1&objectid=12513830&ref=rss

Stuff — 29 March, Lauren Vargo, "Many of New Zealand's 'skeletal' glaciers will be gone in a decade." https://www.stuff.co.nz/environment/128186612/many-of-new-zealands-skeletal-glaciers-will-be-gone-in-a-decade

The Guardian — 31 March, Lauren Vargo, "Many of New Zealand's glaciers could disappear in a decade, scientists warn." https://www.theguardian.com/environment/2022/mar/31/many-of-new-zealands-glaciers-could-disappear-in-a-decade-scientists-warn?utm_term=Autofeed&CMP=twt_gu&utm_medium&utm_source=Twitter#Echobox=1648687530

NZ Herald — 18 April, Huw Horgan, Shaun Eaves, Lauren Vargo, "Special report: The tragic trend making ghosts of our glaciers." https://www.nzherald.co.nz/nz/special-report-the-tragic-trend-making-ghosts-of-our-glaciers/5WON6ZEZZXSQNM3MFP2VIREGGI/

Beehive.co.nz — 1 May, NZ SeaRise, "New sea level data underlines need for action." James Shaw Media Release https://www.beehive.govt.nz/release/new-sea-level-data-underlines-need-action

NZ Herald — 1 May, Tim Naish and Richard Levy, "How our coast will be transformed." https://www.nzherald.co.nz/nz/rising-risk-how-our-coast-will-be-transformed/R24X3UURX7ESXCLKCGDSHFU2EU/

Stuff — 1 May, Tim Naish and Richard Levy, "Sinking cities." https://interactives.stuff.co.nz/2022/04/sinking-cities-sea-level-rise/

NZ Herald — 2 May, Tim Naish, "Rising tides: What's in store for NZ's three biggest cities?" https://www.nzherald.co.nz/nz/rising-tides-whats-in-store-for-nzs-three-biggest-cities/4VUIHQZIIPLF3UA6CCC5MZZW5E/

Otago Daily Times — 2 May, Tim Naish and Richard Levy, "Cyber attack hits website showing projected sea-level rise." https://www.odt.co.nz/news/national/cyber-attack-hits-website-showing-projected-sea-level-rise

The Press — 2 May, Tim Naish and Richard Levy, "Sinking coastlines mean parts of Christchurch will feel impact of sea-level rise earlier than expected." https://www.stuff.co.nz/the-press/news/128505544/sinking-coastlines-mean-parts-of-christchurch-will-feel-impact-of-sealevel-rise-earlier-than-expected

Science Media Centre — 2 May, Tim Naish and Richard Levy, "NZ sea levels may rise twice as fast as thought — Expert reaction." https://www.sciencemediacentre.co.nz/2022/05/02/nz-sea-levels-may-rise-twice-as-fast-as-thought-expert-reaction/

The Spinoff — 2 May, Tim Naish, "Parts of NZ predicted to experience devastating sea-level rise within 20 years." https://thespinoff.co.nz/live-updates/02-05-2022/parts-of-nz-predicted-to-experience-devastating-sea-level-rise-within-20-years

Stuff — 2 May, Tim Naish, "Cyberattack targets sea-level rise website on the day of launch." https://www.stuff.co.nz/environment/climate-news/128517872/cyberattack-targets-sea-level-rise-website-on-the-day-of-launch

AFP — 3 May, Tim Naish, "NZ sea level rising!" https://www.thenews.com.pk/print/955112-nz-sea-level-rising

Climate Adaptation Platform — 3 May, Tim Naish, "NZ's sea levels rising twice the rate?" https://climateadaptationplatform.com/nzs-sea-levels-rising-twice-the-rate/

NZ Geographic — 3 May, Richard Levy and Tim Naish, "A map of the future." https://www.nzgeo.com/stories/a-map-of-the-future/

The Spinoff — 3 May, Tim Naish,"Sea level rise reality hits home." https://thespinoff.co.nz/the-bulletin/03-05-2022/sea-level-rise-reality-hits-home

Xinhua news agency — 3 May, Tim Naish, "Sea levels rising twice as fast in New Zealand." https://www.indiatvnews.com/news/world/sea-levels-rising-twice-as-fast-in-new-zealand-2022-05-02-773763

Stuff (Nelson) — 4 May, Tim Naish, "Fears planned city library will become 'stranded asset' amid faster sea-level rise." https://www.stuff.co.nz/environment/climate-news/128521294/fears-planned-city-library-will-become-stranded-asset-amid-faster-sea-level-rise

Gisborne Herald — 5 May, Tim Naish, "City stable as sea set to rise." https://www.gisborneherald.co.nz/local-news/20220505/city-stable-as-sea-set-to-rise/

Waikato Times — 6 May, Richard Levy, "Thames rising: Warnings over NZ Searise data indicating Coromandel town on the up." https://www.stuff.co.nz/waikato-times/news/300578625/thames-rising-warnings-over-nz-searise-data-indicating-coromandel-town-on-the-up

Stuff — 20 May, Tim Naish, "Nelson Airport reassessing plans in light of climate report." https://www.stuff.co.nz/environment/climate-news/128692254/nelson-airport-reassessing-plans-in-light-of-climate-report

The Guardian — 6 June, Huw Horgan, "'Hidden world' of marine life discovered in Antarctic 'river' under ice." https://www.theguardian.com/world/2022/jun/06/hidden-world-of-marine-life-discovered-in-antarctic-river-under-ice

Science Media Centre — 8 June, Holly Winton, "First microplastics found in Antarctic snow – Expert reaction." https://www.sciencemediacentre.co.nz/2022/06/08/first-microplastics-found-in-antarctic-snow-expert-reaction/

Stuff — 29 June, Richard Levy, "Adapt, defend or retreat: James Shaw's blunt message for coastal homeowners." https://www.stuff.co.nz/dominion-post/news/wellington/129118120/adapt-defend-or-retreat-james-shaws-blunt-message-for-coastal-homeowners

Stuff — 22 July, Tim Naish, "Expanding or developing new coal mines 'totally irresponsible', professor says." https://www.stuff.co.nz/environment/climate-news/129326502/expanding-or-developing-new-coal-mines-totally-irresponsible-professor-says

Stuff — 16 August, Nick Golledge, "An unrealistically hot forecast for 2100 could hurt your property values." https://www.stuff.co.nz/environment/climate-news/129492959/an-unrealistically-hot-forecast-for-2100-could-hurt-your-property-values

Canvas Magazine & New Zealand Herald — 18 September, Lauren Vargo, "Marking 129 years of suffrage: Actors, activists and authors who stand for change." https://www.nzherald.co.nz/lifestyle/womens-suffrage-emma-thompson-zoe-bell-lydia-ko-sporty-spice-tami-neilson-changing-the-world/FKMXG3QRPQTMQKWCLKCLG6OFBM/

Wairarapa Times Age — 4 October, Bella Duncan, "Antarctica's future is detected in its past." https://times-age.co.nz/antarcticas-future-is-detected-in-its-past/

NZ Herald — 3 November, Lauren Vargo, "Vanishing taonga: How climate change is melting our glaciers." https://www.nzherald.co.nz/nz/vanishing-taonga-how-climate-change-is-melting-our-glaciers/DLRKD2W6H5JMV4DOQLNPXMJDCY/

VUW Victorious magazine — 7 November, Nick Golledge, "Glacial pace picks up." https://www.wgtn.ac.nz/victorious/issues/victorious-2022/glacial-pace-picks-up

Stuff & The Forever Project — 7 December, Lauren Vargo, "Top glacier sleuth trying to get more girls on ice." https://www.stuff.co.nz/environment/climate-news/300742550/top-glacier-sleuth-trying-to-get-more-girls-on-ice

Antarctic Magazine — December issue, Nick Golledge, "Antarctic research a major factor in understanding sea rise."

YouTube — December, Ruzica Dadic and Julia Martin, "Using drones in Antarctic sea ice research." https://www.youtube.com/watch?v=Ir1SI7VOwv8

Geopark Group — Levan Tielidze, Shaun Eaves, Gavin Dunbar, geological information signs in Ahuriri River and Lake Ōhau.

Geological information sign at Lake Ōhau (credit: Shaun Eaves)

Talks to community groups

Royal Society Public talk — 4 March, Nick Golledge, "IPCC AR6."

Blake Trust Young Leaders — 19 May, Tim Naish, "Impacts and implications of sea-level rise for Aotearoa New Zealand and the Pacific Islands."

Waitaki Whitestone Geopark — 19 May, Shaun Eaves, "Reconstructing climate from glaciers."

Nelson Climate Action Forum — 7 June, Tim Naish, "Sea level rise: We have less time to act than we thought." https://www.youtube.com/watch?v=6iK9Caazp5Q.

Greytown Rotary Club — 22 June, Nick Golledge, "Climate change: Past, present, future."

Wellington South Coast Community Meeting — 29 June, Tim Naish and Richard Levy, "Sea-level rise" with Climate Change Minister James Shaw and Mayor Andy Foster.

Diplosphere Conference — 4 July, Tim Naish, facilitates session and panel discussion "Destination our planet: How do we become stewards of sustainability & intergenerational wellbeing? | Kaitiaki" at 2022. Navigating a stormy world, Te Ao Maori perspectives, Anchoring Māori Values in Foreign Policy, Te Papa. https://www.diplosphere.org/conference

Kuranui College, Greytown — 4 July, Nick Golledge and Shaun Eaves.

Greytown Primary School, Greytown — 6 July, Nick Golledge.

Blue School, Greytown — 8 July, Nick Golledge.

U3A (Christchurch) — 5 August, Tim Naish, "Antarctica and climate change."

Wakatu Climatorium Youth Climate Conference — 19 August, Tim Naish, ""Forecasting & data – a world full of data." https://klimatorium.dk/en/unges-nationale-klimamoede/

Ross School — 22 September, Brian Anderson, an afternoon of glaciers and experiments.

Antarctic Season Opening Church Service — 10 October, Tim Naish, "Urgency of Antarctic science and climate change." https://www.antarcticanz.govt.nz/media/news/godspeed-with-hope-urgency

Papakaura High and Rangeview Intermediate — 28 October, Tim Naish, to workshop environmental issues with mātauranga Māori and artist/educator Dr Natalie Robertson, and professional photographers Raymond Sagapolutele and Cherrilee Fuller, as part of Auckland Arts Festival and Track Zeros Through the Eye of the Lens - Tamaki-Makuarau. https://trackzero.nz/eye-of-lens/tamaki-makaurau/.

RealSnowPrincess — blog by Julia Martin https://realsnowprincess.weebly.com/blog

EGU Blogs — Tielidze Levan"Cryospheric Sciences - A new glacier chronology from New Zealand." https://blogs.egu.eu/divisions/cr/2022/07/15/new-chronology-nz

Director

Rob McKay
Professor
Stratigraphy & sedimentology

Administration Office

Barbara Fuchs
Operations Manager

Dao Polsiri
Projects Coordinator

Researchers

Alanna Alevropoulos-Borrill
Research Fellow
Ice sheet modelling

Brian Anderson
Associate Professor
Glacial modelling

Nancy Bertler
Professor
Ice core climatology

Warren Dickinson
Senior Research Fellow
Sedimentary petrology

Alexandra Gossart
Research Fellow
Cimate modelling

Huw Horgan
Associate Professor
Glacial geophysics

Stefan Jendersie
Senior Research Fellow
Ocean modelling

Liz Keller
Senior Research Fellow
Modelling Hub Co-Leader

Oliver Wigmore
Research Fellow
Hydrology

Holly Winton
Senior Research Fellow
Antarctic ice core climatology

Science Drilling Office

Darcy Mandeno
Science Drilling Office
Engineering Manager

James MacPhail
Field & Operations
Engineer

Alex Pyne
Antarctic Drilling Advisor

Gavin Dunbar
Senior Lecturer
Sedimentology & geochemistry

Bella Duncan
Research Fellow
Organic geochemistry

Shaun Eaves
Senior Lecturer
Glaciology & paleoclimatology

Nick Golledge
Professor
Ice sheet modelling

Richard Levy
Professor
Stratigraphy

Tim Naish
Professor
Paleoclimatology

Jamey Stutz
Research Fellow
Antarctic geology

Lauren Vargo
Research Fellow
NZ glacier monitoring & modelling

Emeriti

Peter Barrett
Emeritus Professor
Antarctic climate history

Lionel Carter
Emeritus Professor
Ocean history & processes

Postgraduate students

Olya Albot	PhD	Coastal modelling
Alanna Alevropoulos-Borrill*	PhD	Ice sheet modelling
Francesca Baldacchino*	PhD	Remote sensing
Jay Cockrell	PhD	Antarctic paleoclimatology
Zoe Heine	PhD	Sea-level rise
Daemon Kennett	PhD	Atmospheric modelling
Karsten Lorentz	PhD	Erosion mechanics
Frank Mackenzie	PhD	Last interglacial dynamics
Julia Martin	PhD	Sea ice evolution
Alexander Mattin	PhD	Biogeochemical impacts
Vanessa Monteiro	PhD	Environmental studies
Ruby Muir	PhD	New Zealand glaciology
Ihanshu Rane	PhD	Antarctic foehn winds
Prasad Shelke	PhD	Geophysics
Matthew Tankersley	PhD	Geopotential modelling
Levan Tielidze*	PhD	Glaciology
Arran Whiteford*	PhD	Subglacial hydrology
Yaowen Zheng	PhD	Antarctic climatology
Huiling Zou	PhD	Antarctic paleoclimatology
Linda Balfoort	MSc	Sedimentology
Emma de Jong	MSc	Environmental science
Aileen Gordon	MSc	Biomarkers
Kevin Henson*	MSc	Ice core climatology
Natasha Lelieveld*	MSc	Antarctic paleoclimate
Ruby Muir*	MSc	Physical geography
Greta Stuthridge*	MSc	Geochronology
Hayden Young*	MSc	Carbon cycle

*thesis submitted for examination in 2022

Associated VUW researchers

Cliff Atkins	School of Geography, Environment and Earth Sciences	Sedimentary processes
Judy Lawrence	Climate Change Research Institute	Climate change adaptation
Kevin Norton	School of Geography, Environment and Earth Sciences	Geomorphology and geochemistry
Rebecca Priestley	Centre for Science in Society	Antarctic science history
James Renwick	School of Geography, Environment and Earth Sciences	Atmospheric circulation
Tim Stern	School of Geography, Environment and Earth Sciences	Transantarctic Mountains geophysics

ARC adjuncts

Katelyn Johnson	GNS Science	Paleoenvironmental reconstruction
Daleen Koch	GNS Science	Project Management
Karin Kvale	GNS Science	Modelling
Mario Krapp	GNS Science	Data scientist
Dave Lowe	LoweNZ Ltd	Atmospheric chemistry
Dan Lowry	GNS Science	Numerical modeller
Andrew Mackintosh	Monash University	Glaciology and modelling
Alena Malyarenko	NIWA	Process-scale ice shelf modelling
Marjolaine Verret	The University Centre in Svalbard	Permafrost geochemistry
Dan Zwartz	Dept. Industry, Science, Energy & Resources	Climate change

ARC advisory board

Ehsan Mesbahi (Convenor), Pro Vice Chancellor—SHEADI, Victoria University of Wellington
Craig Cary, New Zealand Antarctic Research Institute
Jana Newman, Ministry of Foreign Affairs & Trade
Rob Murdoch, NIWA
Gary Wilson, GNS Science
Monica Handler, School of Geography, Environment and Earth Sciences, Victoria University of Wellington
Prue Williams, Ministry of Business, Innovation & Employment

Collaborators

National collaborators

Antarctica New Zealand
GNS Science
Manaaki Whenua—Landcare Research
Meridian Energy
New Zealand eScience Infrastructure (NESI)
NIWA
Oceanum
University of Auckland
University of Canterbury
University of Otago
University of Waikato
Webster Drilling and Exploration Ltd.

International collaborators

Aberystwyth University (Wales)
Alfred Wegener Institute (Germany)
Australian Antarctic Division
The Australian National University
Australian Nuclear Science and Technology Organisation
Australian Institute of Nuclear Science and Engineering
Berkeley Geochronology Centre (USA)
Binghamton University - State University of New York (USA)
British Antarctic Survey (England)
Central Washington University (USA)
Chinese Academy of Meteorological Sciences
Chinese Academy of Sciences
CSIRO - The Commonwealth Scientific and Industrial Research Organisation (Australia)
Durham University (England)
École polytechnique fédérale de Lausanne (Switzerland)
Finnish Meteorological Institute (Finland)
Hokkaido University (Japan)
Instituto Andaluz de Ciencias de la Tierra (Spain)
Istituto Nazionale di Geofisica e Vulcanologia (Italy)
Imperial College London (England)
Institut de Ciències del Mar (Spain)
Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (Italy)
Japan National Institute for Polar Research (Japan)
Jilin University (China)
Keele University (England)
Korea University (South Korea)
Korean Polar Research Institute (Republic of Korea)
Laboratoire de glaciologie et géophysique de l'environnement (France)
Lamont-Doherty Earth Observatory (USA)
Lawrence Berkeley National Lab (USA)
Lawrence Livermore National Laboratory (USA)
Marche Polytechnic University (Italy)
McGill University (Canada)
Monash University (Australia)
Moss Landing Marine Laboratories (USA)
NIOZ Royal Netherlands Institute for Sea Research (The Netherlands)
National Oceanic and Atmospheric Administration (USA)
National Oceanography Centre (England)
National Research Council (Italy)
Niels Bohr Institute (Denmark)
Northern Arizona University (USA)
Northern Illinois University (USA)
The Ohio State University (USA)
Oregon State University (USA)
The Pennsylvania State University (USA)
Rutgers University (USA)
Scripps Institution of Oceanography (USA)
Southampton University (England)
Standford University (USA)
Swiss Federal Research Institute WSL (Switzerland)
Temple University (USA)
Texas A&M University (USA)
Tulane University (USA)
Università degli Studi di Napoli Parthenope (Italy)
University of Alaska, Fairbanks (USA)
University of Bergen (Norway)
University of Birmingham (England)
University of Bordeaux (France)
University of Bremen (Germany)
University of Bristol (England)
University of California, Irvine (USA)
University of Cambridge (UK)
University of Colorado (USA)
University of Granada (Spain)
University of Maine (USA)
University of Massachusetts Amherst (USA)
University of Melbourne (Australia)
University of Milano-Bicocca (Italy)
University of Nebraska-Lincoln (USA)
University of New Mexico (USA)
University of New South Wales (Australia)
University of Oslo (Norway)
University of Ottawa (USA)
University of Pisa (Italy)
University of Plymouth (England)
The University of Queensland (Australia)
University of South Florida (USA)
The University of Sydney (Australia)
University of Tasmania (Australia)
University of Urbino (Italy)
University of Washington (USA)
University of Waterloo (Canada)
University of Wisconsin-Madison (USA)
Utrecht University (The Netherlands)
Worcester State University (USA)
Yale University (USA)

VICTORIA UNIVERSITY OF WELLINGTON
TE HERENGA WAKA

Te Puna Pātiotio
Antarctic
Research Centre

www.wgtn.ac.nz/antarctic
Antarctic-Research@vuw.ac.nz
+64-4-463 6587