IceSked

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Victoria University of Wellington

A Word From the Director

We have had tremendous success with research funding in the second half of 2017 with a MBIE Endeavour Fund grant and a new Marsden grant bringing in around $8 million dollars. This new support will improve our understanding of glacier and ice sheet contributions to sea-level change, a topic of increasingly societal relevance as CO_2 emissions hit a new high (see science stories). We also highlight our international leadership including Tim Naish's Past Antarctic Ice Sheet Dynamics conference in Italy, my own role as an IPCC Lead Author, and our student involvement in international summer schools. *Andrew Mackintosh*

Improved, location specific, sea-level rise predictions for New Zealand are on their way

A five year, $7.1M research programme has been funded by the MBIE Endeavour fund to improve sea-level rise (SLR) predictions for New Zealand. The collaborative NZ SeaRise Programme will be led by the ARC's Tim Naish in partnership with NIWA and GNS Science researchers, and world-leading international collaborators. The science leaders include Nick Golledge (ARC), Rob Bell (NIWA) and Richard Levy (GNS Science).

The motivation for the programme was highlighted by the Parliamentary Commissioner for the Environment who stated in a recent report: "It is certain that the sea is rising and will continue to do so for centuries to come. But much is uncertain – how rapidly it will rise, how different coastal areas will be affected, and how we should prepare." To address this need, the NZ SeaRise Programme will produce accurate estimates of the magnitude and rate of sea-level rise for our coastal regions to 2100 and beyond. We will use these new projections to examine environmental impacts and risks associated with increased coastal flooding due to storm surge and rising groundwater levels and incursion of salt water into coastal aquifers, estuaries, and wetlands. Our programme will improve global- and regional-scale sea-level projections, which currently underestimate the amount of future SLR because they do not include accurate estimates of the contribution from melt of ice sheets in Antarctica and Greenland. With our expertise in modelling future polar ice sheet melt, and capability at NIWA and GNS Science, in estimating changes due to local sea surface height variations and vertical land movements, respectively, our team is uniquely positioned to take on this challenge. We will then establish local sea-level projections that include the effect of land movement. This is important as ground subsidence may cause local sea level to rise by 20 to 30 cm by the end of the century. Finally, we will assess the environmental impact of the new SLR projections in Wellington, Dunedin, Auckland, Hawkes Bay, and New Zealand's Scott Base in Antarctica. These impact studies will be co-designed with stakeholders. Outcomes will include improved decision making, risk management, and adaptation planning based on locally relevant SLR scenarios and vulnerability assessments.

The programme complements and contributes to the aims of both the Deep South and Resilience National Science Challenges, and will provide an application of national benefit for Antarctic ice sheet research to be conducted under the new Antarctic research platform.

Studying past abrupt climate change in New Zealand and Patagonia to better inform our future

Andrew Mackintosh along with ARC/SGEES colleagues Brian Anderson, Shaun Eaves, Lionel Carter and Kevin Norton have been awarded nearly a million dollars by the Marsden Fund to better understand the drivers of the Antarctic Cold Reversal, an abrupt climate change that affected the southern mid to high latitudes around 14,000 years ago. Andrew and his team will be dating and reconstructing glaciers and climate in the Southern Alps and in Patagonia, and working with paleoclimate modellers to understand this societally-relevant period of Earth's recent history. Our team includes international paleoclimate modellers and data experts based in Chile (Maisa Rojas, Esteban Sagredo), Denmark (Joel Pedro), Australia (Laurie Menviel) and the USA (Feng He).

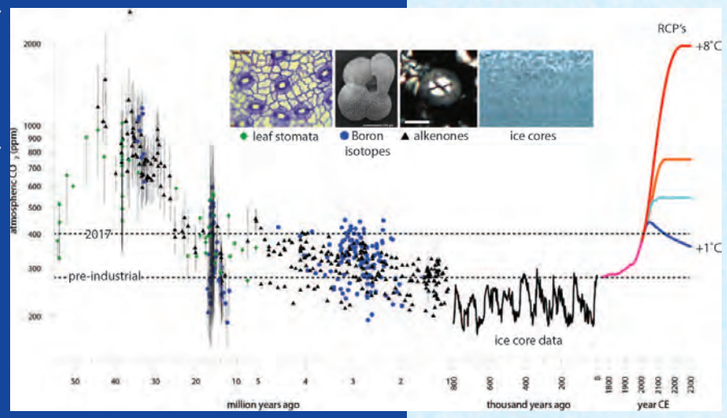
Science Stories
CO_2 emissions reach new record high

Nancy Bertler along with colleagues from GNS Science, Richard Levy and Jocelyn Turnbull, contributed a paleo-perspective to the 2017 WMO Greenhouse Gas Bulletin – State of the Greenhouse Gases in the Atmosphere Based on Global Observations. Ice core records reveal that over the last eight swings between glacials and interglacials atmospheric CO_2 varied between 180 and 280 ppm. In comparison in 2016, anthropogenic greenhouse gas emissions raised atmospheric concentrations of carbon dioxide (CO_2) to a new record level of 403.3 parts per million (ppm) globally.

We have to look back 3-5 million years ago to find a time in Earth's history with similarly high CO_2 concentrations. Then, global mean surface temperatures were 2-3 degC warmer than today, the Greenland and West Antarctic ice sheets had vanished and low lying basins of East Antarctic ice had retreated causing global sea level to be 10-20 m higher than today. But how quickly did greenhouse gas concentrations change in the past? High resolution ice core records from high snow accumulation regions in West Antarctica and a new generation of ice cores – horizontal ice cores where old ice lays close the surface – along with new analytical techniques provide exciting insights into how quickly atmospheric CO_2 concentrations can change.

When Earth melted out from the grip of the last ice ages, between 23,000 and 9,000 years ago, global CO_2 concentrations increased by 80 ppm. Almost half of that increase occurred in three separate abrupt increases of 10-15 ppm in just 100-200 years caused by changes in ocean circulation patterns between the Southern Ocean and North Atlantic currents. However, today's decadal rate of about 2.2 ppm per year is 20 times faster than the most abrupt natural increase observed. Travelling further back in time, using geological records of alkenones, fossil leave stomata and boron isotopes, we can observe examples of things to come. 15-17 million years ago, CO_2 concentrations were between 400-650 ppm, with global mean temperatures 3-4 degC higher than today and global sea level up to 40 m higher during the warmest periods. Even further back in time, 34 million years ago, CO_2 concentrations were above 1,000 ppm and no ice sheets existed in Antarctica. With the world aiming to reduce greenhouse gas emissions in accord with the UNCCC Paris Agreement, these treasurable windows into the past caution us to double our efforts. *Nancy Bertler*

https://library.wmo.int/opac/doc_num.php?explnum_id=4022

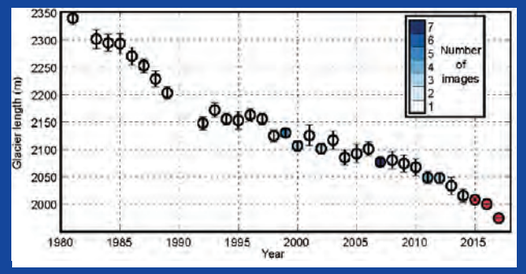


Reconstructions of atmospheric CO_2 over the past 55 million years are generated from proxy data that include boron isotopes (blue circles), alkenones (black triangles) and leaf stomata (green diamonds). Direct measurements from the past 800 000 years are acquired from Antarctic ice cores and modern instruments (pink). Future estimates include representative concentration pathways (RCPs) 8.5 (red), 6 (orange), 4.5 (light blue) and 2.6 (blue)

Measuring New Zealand glacier changes from historic photographs

Since 1977, Trevor Chinn has been photographing the end of summer snowline of 50 New Zealand glaciers along the Southern Alps from a small aircraft. The snowline on a glacier is the boundary between snow and ice, and when monitored annually at the end of summer, it can tell us about the health of a glacier - whether a glacier has likely gained or lost ice since the previous year.

We revisited this photo archive and developed a method to quantitatively measure the snowline elevation and glacier length from these historic images of New Zealand glaciers. The method, which uses structure from motion photogrammetry, was developed with initial application to Brewster Glacier, Mount Aspiring National Park. The snowline elevation record derived for Brewster Glacier shows pronounced interannual variability, but also shows the highest snowlines (corresponding to years the glacier likely lost the most mass) in the past decade. The length record shows 365 ± 12 m of almost continuous terminus retreat since 1981. A large part of the development of this method has included quantifying the associated uncertainties, which are on the order of ~10 m, and validating our records with field measurements.



Changes in the length of Brewster Glacier from 1981-2017, calculated from historic photographs (blue-white) and recent images (red)

Going forward, we will use this method to calculate snowline and length changes for the additional 49 New Zealand glaciers with historic photographs. We are also looking into the accuracy of using this method to calculate changes in ice volume over time. The application of this method extends far beyond New Zealand glaciers, as it can be applied to calculate changes in any landscape with historic images. *Lauren Vargo*

Vargo, L.J., Anderson, B.A., Horgan, H.J., Mackintosh. A.N., Lorrey, A.M., Thornton, M., (In Press). Using structure from motion photogrammetry to measure past glacier changes from historic aerial photographs. *Journal of Glaciology* - doi 10.1017/jog.2017.79

Prof Matt King presenting the S.T. Lee Lecture ©Image Services, VUW

S.T. Lee Lecture in Antarctic Studies

The 15th annual S.T. Lee Lecture in Antarctic Studies, "Continental loss: The quest to determine Antarctica's contribution to sea-level rise" was presented by Professor Matt King on 16 October 2017.

For over 50 years scientists have been working to understand Antarctica's contribution to sea level. For much of this time there has been disagreement about whether this massive ice sheet is even growing or shrinking. Recently, advances in data analysis and computer modelling resulted in the first reconciled estimate of change showing that Antarctica is increasingly contributing to sea-level rise. During the lecture Matt explained some of the major advances that led to this reconciled estimate and highlighted some of the fascinating things we can learn about Earth from the vantage-point of Antarctica.

Matt is Professor of Polar Geodesy at University of Tasmania working on observing and modelling the Antarctic ice sheet, sea-level change and the changing shape of Earth. Several of his papers were used to establish the physical basis of climate change within the 5th assessment report of the IPCC. His work has received international recognition most prominently when the Royal Society (London) awarded him the 2015 Kavli Medal and Lecture for his work that contributed to the first reconciled estimate of Antarctica and Greenland's contribution to sea-level change.

During his week here, Matt travelled to the University of Otago to repeat his S.T. Lee Lecture and meet with colleagues, he gave specialist talks at Victoria University and GNS Science, had media interviews with Radio New Zealand, and a reception was held for him and invited guests at the Australian High Commissioner's residence.

Delft Summer School on Sea Level Change

This past August, we joined 32 other PhD students and postdocs from around the world for a summer course on sea-level change, hosted by the TU Delft Climate Institute in the Netherlands. This was a fitting location given that over a quarter of the country actually lies below sea level, and only 50% of land exceeds 1 metre above sea level. Our course focused on the different contributors to global and regional sea-level changes, including the solid earth, glaciers and ice sheets, ocean temperature and dynamics, atmospheric dynamics and land-water storage. We also explored the tools available to look at past and modern sea-level changes, such as the geological record, tide gauges, ice sheet models and satellite altimetry. Given the future implications of sea-level rise, we took a field trip to an artifically-made sand dune on the Dutch coast designed to allow the natural transport of sand to continue to build the beach. On our last day, we brought all of the course elements together for discussions of future projections of global and regional sea-level rise, emphasising the greatest source of uncertainty, the Antarctic ice sheet, and the application of these projections to sea-level allowances, which will allow coastal communities to adapt to these changes. *Dan Lowry and Laurine van Haastrecht*

Karthaus Ice and Climate Summer School

In mid-September, I was one of 34 students gathered in Karthaus, Italy, for a 12-day summer school course titled, "Ice Sheets and Glaciers in the Climate System." The intensive course covered a variety of topics such as numerical modelling of ice sheets and ice shelves, continuum mechanics, geophysics, ice-ocean interactions, and ice cores. Each day consisted of morning lectures, afternoon practicums, and group projects we presented at the end of the course. My group used recently acquired ice-radar data and model outputs to identify potential drill site locations for the Beyond EPICA – Oldest Ice (BE-OI) project which seeks to acquire a 1.5-million-year old ice core record.

One day we left the classroom to check out several glaciers in the Ötztal Alps. Despite the sunny weather on the day, early snowfall made it too dangerous to service the weather station on the Hochjochferner Glacier as classes have done in the past. Nevertheless, we were provided with wonderful vistas and a much needed break from coursework!

In between all things science, a plethora of delicious food and good conversation awaited. In our free time, most students hiked the various trails surrounding the tiny town to counteract the five course dinners. Over these meals and during these hikes we developed friendships and networks that laid the groundwork for future scientific collaborations. *Katelyn Johnson*

Katelyn Johnson enjoying the snow in the Ötztal Alps

OTHER ACTIVITIES

Andrew Mackintosh selected as IPCC Lead Author

ARC Director, Andrew Mackintosh was selected from more than 500 nominations worldwide to serve as a Lead Author on the Intergovernmental Panel on Climate Change (IPCC) Special Report on the Oceans and Cryosphere in a Changing Climate. The Special Report is unique in the body's history, says Andrew. "It reflects the increasing awareness of the changing cryosphere and oceans, and their impact on human civilisation and global ecosystems. The report will span the full range of topics from physical climate science, via changes in terrestrial and marine ecology, to human impacts including legal, economic and social dimensions." The first Lead Author meeting was held in Nadi, Fiji, during early October. Andrew is a Lead Author on Chapter 3 "Polar Regions", which will have core sections dealing with changes in the Antarctic ice sheet and its effects on sea level, ocean circulation and ecology. Please feel free to email Andrew key papers published in this field since the 5th IPCC Assessment Report in 2013 (Andrew.Mackintosh@vuw.ac.nz)

Top: Chris Derkson (Canada), Alexey Ekaykin (Russia), Martin Sommerkorn (Norway), Andrew Mackintosh (NZ). Bottom: Monica Muelbert (Brazil), Sandra Cassotta (Denmark), Mike Meredith (UK), Ted Schuur (USA), Anne Hollowed (USA)

PAIS – An international conference on Antarctica

Latest advances and future research priorities were the focus of the Scientific Committee on Antarctic Research (SCAR) Past Antarctic Ice Sheet Dynamics (PAIS) Conference, Trieste, Italy, 10-15 September 2017. The conference was organized by Laura De Santis and Tim Naish, co-chief officers of SCAR-PAIS Programme, with major support from Istituto Nazionale di Oceanografia e di Geofisica, Antarctic Research Centre at Victoria University, SCAR, Programma Nazionale di Ricerche in Antartide (PNRA), University of Trieste and US National Science Foundation. The conference was attended by 210 scientists and students from 18 countries, 20 from New Zealand. The editors of *Nature Communications, Nature Geoscience* and *Reviews in Geophysics* also attended the meeting - we are in discussion over a number of publications, which will provide state of the art reviews.

The conference show-cased the latest advances in Antarctic ice sheet and sea-level science and identified future research gaps and priorities. Specific emphasis was placed on the research priorities of the IPCC, Antarctic Treaty System (ATS), and the SCAR Horizon Scan. Keynote speakers from outside the PAIS community helped stimulate new multidisciplinary research directions on how Antarctic ice sheet and climate change will impact biological systems, global climate systems, and sea-level change. Richard Levy (GNS Science) gave an invited talk on how paleoclimate research informs future ice sheet projections.

photo by Sterle

The final day was dedicated to a science-policy session. SCAR president, Steven Chown, discussed his vision for how SCAR research can have more impact within both the ATS and UN frameworks. Valérie Masson-Delmotte, co-Chair of IPCC Working group 1, outlined the chapter structure and how the SCAR community could contribute to the next assessment report. Chuck Kennicutt, leader of the SCAR Horizon Scan and Council of Managers of National Antarctic Programs (COMNAP) Antarctic Roadmap Challenges project, talked about how international logistics and operations could be aligned to address the big science questions.

The outcome of the conference will be a white paper that identifies new strategic directions, as the basis for a future interdisciplinary SCAR research programme.

Although the programme was demanding, our Italian hosts provided a stunning water-front venue close to wonderful restaurants, superb logistics and social events, which resulted in a highly productive and memorable meeting. More detail on the conference programme, highlights, side events and workshops can be viewed on the website.

Tim Naish

http://www.scar-pais.org/index.php/conference