Our Future In Focus

New Zealand Antarctic Science Conference 2019

17-19
JUNE 2019
CHRISTCHURCH TOWN HALL
www.antarcticanz.govt.nz
#FutureinFocus19
ROSS ICE SHELF

PROCESSES, TRENDS AND VARIABILITY IN ANTARCTIC SYSTEMS

ANTARCTIC BIODIVERSITY AND RESILIENCE OF ECOSYSTEM FUNCTION

CRYOSPHERE DYNAMICS

ANTARCTIC PEOPLE AND PLACES

ROSS SEA REGION MARINE PROTECTED AREA

Our Future In Focus

New Zealand Antarctic Science Conference 2019
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FOREWORD

Tautimai Koutou to the 2019 New Zealand Antarctic Science Conference, *Our Future in Focus*.

Please join me in a warm welcome to our new Chief Executive, Sarah Williamson, who joins us from Air New Zealand and aptly starts this week!

Since the last conference, we have safely completed two successful field seasons, supporting research teams in various locations between Cape Adare and the Siple Coast. We are all looking forward to hearing some of the latest findings from those research expeditions.

Antarctica New Zealand is now the proud host of the Antarctic Science Platform, the purpose of which is to conduct excellent science to understand Antarctica’s impact on the global earth system and how this might change in a +2°C world. This long-term investment, from a 2017 Budget initiative, provides much-needed certainty in Antarctic research funding. In just a few months, some of the Platform-funded projects will undertake their first field season, initiating a series of field campaigns that complement the New Zealand Antarctic research programme as a whole.

The Scott Base Redevelopment project has reached a major milestone with $18.5 million announced in Budget 2019. This will fund the next phase of the project which will enable us to support world-leading science for many years to come.

The research conducted in Antarctica and the Southern Ocean is critical for understanding the impact of change on Antarctica and to improve future projections. I am looking forward to seeing you all at this week’s showcase of New Zealand’s Antarctic research.

Peter Smith
Antarctica New Zealand General Manager, Corporate Services and Strategy
Our Future in Focus

Tēnā Koutou, haere mai ki Ōtautahi. Antarctica New Zealand warmly welcomes you to the 2019 New Zealand Antarctic Science Conference, Our Future in Focus.

Ma te rongo ka mohio, ma te mohio ka marama, ma te marama ka matau, ma te matau ka ora. This whakatauki speaks to the heart of New Zealand’s Antarctic research efforts – through perception comes awareness, through awareness comes understanding, through understanding comes knowledge, through knowledge comes well-being.

As atmospheric CO$_2$ concentrations continue to rise and populations around the world consider options for mitigation of and adaptation to change, it is timely to focus on our future and what we can learn from Antarctica. The integration of the Antarctic Science Platform within New Zealand’s Antarctic research programme and the redevelopment of Scott Base provide further opportunities to consider our focus.

This conference is a biennial highlight, and provides an important opportunity to share findings, meet friends and colleagues and discuss collaborative research and outreach opportunities.

Through a series of talks and posters, Our Future in Focus will provide insight into the latest findings from New Zealand’s Antarctic research programme. We acknowledge the significant contributions made by all presenters, and encourage you to engage in discussions.

On behalf of the team at Antarctica New Zealand, we wish you a stimulating and enjoyable conference.

Fiona Shanhun
Antarctica New Zealand Acting Chief Scientific Advisor
CONFERENCE ORGANISATION

Conference Host
Antarctica New Zealand

Conference Committee
Rebecca Macneil, Antarctica New Zealand (Chair)
Fiona Shanhun, Antarctica New Zealand
Marg Craig, The Conference Team
Bailey Jeffery-Butler, Antarctica New Zealand
Michelle LaRue, University of Canterbury
Georgia Nelson, Antarctica New Zealand
Simone Kent, Antarctica New Zealand
Esme Robinson, Antarctica New Zealand
Megan Nicholl, Antarctica New Zealand
With support from Gateway Antarctica local committee

Event Management
The Conference Team

Science Programme
Royal Society National Committee on Antarctic Sciences
GENERAL INFORMATION

CONFERENCE VENUE
The conference is being held at the Christchurch Town Hall, 86 Kilmore Street.

Registration: Ground floor, Avon foyer (Monday 12:00-12:45 pm)
Level one, Limes foyer (Tuesday & Wednesday 08:00-08:30 am)

Monday workshops: Victoria Room
Plenary sessions: Victoria Room
Icebreaker function: Avon Room
Catering: Limes Room
Poster sessions: Limes Room

Antarctica After Dark – Public Talks: Monday 17 June 19:30. The Great Hall, Christchurch Arts Centre, 2 Worcester Boulevard

Conference Dinner: Tuesday 18 June 19:00. Novotel Hotel, 52 Cathedral Square

The Christchurch Town Hall Health and Safety policies apply to all delegates. Delegates are asked to follow any instructions provided by the venue / event staff.

Smoking is not permitted inside the venue.

CODE OF CONDUCT

Our conference is dedicated to providing a harassment-free conference experience for everyone, regardless of gender, gender identity and expression, age, sexual orientation, disability, physical appearance, body size, race, ethnicity, religion, or technology choices.

We do not tolerate harassment of conference participants in any form. We expect conference participants to:

• be considerate and respectful to all community members.
• refrain from demeaning, discriminatory, or harassing behaviour, materials, and speech.
• speak up if they observe anything at an event that conflicts with this Code of Conduct.

If you are being harassed, notice that someone else is being harassed, or have any other concerns, please contact Marg Craig, Becky Macneil, or Michelle LaRue immediately. Do not report harassment via social media.
Conference participants whose behaviour is unacceptable may be sanctioned or expelled from the conference without a refund at the discretion of the conference organisers.

**PARKING**

The closest parking is the Christchurch Casino Carpark, Peterborough Street. See back cover for Christchurch Map and additional parking options.

**TAXIS / SHUTTLE**

The airport is a 25 minute drive from the central city. A taxi fare to the city centre is approximately $50 one way, a shuttle bus $25 or airport bus $8.50.

**Taxis**

Blue Star taxis 0800 379 9799
Gold band taxis 03 379 5795
Corporate Cabs 03 379 5888

**Shuttle**

Super shuttle – 0800 748 885

**REGISTRATION AND INFORMATION**

The registration desk will be open throughout the conference. Name badges can be collected from here on arrival and should be worn at all times.

Please contact Marg (0274359578) or Joanne (0273038703) with any queries.

**RECORDING OF SESSIONS**

Recording of presentations is not permitted.

**STREAM.MA**

This year the conference will be using Strea.ma to inspire conversations on social media about the world class research on show. We encourage you to tweet interesting presentations, post photos of the conference and get the public talking about Antarctic science. Use the #FutureinFocus19 in all your posts and not only will it pop up on the conference Strea.ma feed, but it will help #FutureinFocus19 trend online and inform the public about this important work.
POSTERS
All posters will be on display throughout the conference in the Limes Room.

WIFI
Free Wifi is available at the Christchurch Town Hall.
Login: VBase
Password: No password, but you will be asked to accept their terms and conditions.

EMERGENCY CONTACTS
Emergency: Dial 111
Medical Centre: 24 Hr Surgery, 401 Madras Street
Phone: (03) 365 7777

LOST & FOUND / MESSAGES
Please check the notice board located by the registration desk in the Avon/Limes foyer.

ENVIRONMENT
Delegates are asked to minimise the environmental impact of this conference by using the appropriate bins provided for waste and recyclables. Conference satchels are not being offered, so delegates are encouraged to bring their own bag if needed. Handbooks will only be provided to those who have specifically requested one at the time of registration.

LIABILITY
In the event of any disruption or event leading to losses or added expenses being incurred in respect of the Conference, there shall be no liability attached to Antarctica New Zealand, the Organising Committee, V Base or The Conference Team. The programme is correct at time of printing; however, the Organising Committee reserves the right to amend any component as necessary.

CONFERENCE ORGANISERS
The Conference Team
P O Box 20 051
Christchurch
03 359 2600
marg@conferenceteam.co.nz
www.conferenceteam.co.nz
### PROGRAMME

#### Monday 17 June

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<td>Media Training for Scientists</td>
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<td>Facilitators: Megan Nicholl and Georgia Nelson</td>
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<td>1500</td>
<td>Afternoon Tea</td>
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<td>1530</td>
<td>Vision Mātauranga</td>
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<td>Facilitator: Fiona Shanhun</td>
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<tr>
<td>1700</td>
<td>Icebreaker Function</td>
<td>Avon</td>
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<td>1930</td>
<td>Antarctica After Dark - Public Talks</td>
<td>Great Hall, The Arts Centre</td>
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*Blue Ice, Richard Lord, 2018/19*
**Tuesday 18 June**

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<tr>
<td>0800</td>
<td>Registration desk open</td>
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<td>0800</td>
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| 0830  | Welcome – Fiona Shanhun  
**Opening Keynote: Professor Juliet Gerrard**  
*One year on – some reflections on the role of PM’s Chief Science Advisor* | Victoria  |
| 0915  | **ROSS ICE SHELF**  
Chair: Gavin Dunbar  
What controls ice stream flow? Using active source seismology to study the basal boundary of ice streams  
*Huw Horgan (Victoria University of Wellington)*  
Anatomy of the grounding line of the West Antarctic Ice Sheet at the Kamb Ice Stream  
*Gary Wilson (University of Otago, GNS)*  
What is this ice: geophysical investigations of a thick accreted basal ice layer at HWD-2, Ross Ice Shelf, Antarctica  
*Kelly Gragg (University of Otago)*  
A closer look: New observations of the marine environment and sea floor sediments below the central Ross Ice Shelf  
*Christina Hulbe (University of Otago)*  
A Wedge Mechanism for Summer Surface Water Inflow into the Ross Ice Shelf Cavity  
*Alena Malyarenko (University of Otago, NIWA)*  
Basal melting of Ross Ice Shelf from solar heat absorption in an ice-front polynya  
*Craig Stewart (NIWA)* | Victoria  |
<p>| 1045  | Morning Tea                                                          | Limes     |</p>
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<th>Time</th>
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<tr>
<td>1115</td>
<td><strong>PROCESSES, TRENDS AND VARIABILITY IN ANTARCTIC SYSTEMS</strong></td>
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<td>Chair: Richard Levy</td>
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<td><strong>There and Back Again: Oceanic Connections between the Grounding Line and the Southern Ocean</strong></td>
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<td><em>Craig Stevens (NIWA and University of Auckland)</em></td>
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<td><strong>Zooplankton community and environmental relationships in an era of climate change: who wins and who loses?</strong></td>
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<td><em>Matt Pinkerton (NIWA)</em></td>
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<td><strong>Effects of environmental conditions on diatom communities and the $\delta^{13}C$ of particulate organic matter in Terra Nova Bay</strong></td>
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<td><em>Michael Bollen (University of Otago)</em></td>
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<td><strong>Building GeoMAP ‘on the sniff of an oily rag’</strong></td>
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<td><em>Simon Cox (GNS Science)</em></td>
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<td><strong>On the role of fossil emissions in past and present atmospheric methane levels</strong></td>
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<td><em>Hinrich Schaefer (NIWA)</em></td>
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<td>1230</td>
<td>Lunch</td>
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<td>1230</td>
<td><strong>Students and early career researchers lunch</strong></td>
<td>Avon</td>
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<td>Proudly sponsored by <a href="#">GATEWAY ANTARCTICA</a></td>
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<td>1330</td>
<td><strong>ANTARCTIC BIODIVERSITY AND RESILIENCE OF ECOSYSTEM FUNCTION</strong></td>
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<td>Chair: Vonda Cummings</td>
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<td><strong>Biotic interactions in Antarctic terrestrial ecosystems: They ARE a factor</strong></td>
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<td><em>Charles Lee (University of Waikato)</em></td>
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<td><strong>Functional resilience of Antarctic microbiomes to climate-induced changes</strong></td>
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<td><em>Maria Monteiro (University of Waikato)</em></td>
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<tr>
<td>1500</td>
<td>Antarctic Society - Linda Kestle</td>
<td>Victoria</td>
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<td>1505</td>
<td>Poster Session and Afternoon Tea</td>
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<tr>
<td>1630</td>
<td>Antarctica New Zealand Update</td>
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<tr>
<td>1730</td>
<td>Antarctic Science Platform - Nancy Bertler</td>
<td>Avon</td>
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<td>1815</td>
<td>Close</td>
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<tr>
<td>1900</td>
<td>Conference Dinner</td>
<td>Novotel Hotel</td>
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### Wednesday 19 June

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<tr>
<td>0800</td>
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<td>0830</td>
<td>Welcome&lt;br&gt;&lt;br&gt;<strong>Keynote:</strong> Associate Professor Nicholas Golledge - <em>The Antarctic Ice Sheet in our rapidly warming world</em>&lt;br&gt;&lt;br&gt;Victoria</td>
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<td>0915</td>
<td><strong>CRYOSPHERE DYNAMICS</strong>&lt;br&gt;&lt;br&gt;Chair: David Prior&lt;br&gt;&lt;br&gt;How does Antarctica cool itself? Exploring the far-infrared outgoing radiation&lt;br&gt;<em>Greg Bodeker (Bodeker Scientific)</em>&lt;br&gt;&lt;br&gt;The distribution and evolution of supercooled water in McMurdo Sound&lt;br&gt;<em>Natalie Robinson (NIWA)</em>&lt;br&gt;&lt;br&gt;Airborne measurements of land-fast sea ice thickness in the SW Ross Sea&lt;br&gt;<em>Pat Langhorne (University of Otago)</em>&lt;br&gt;&lt;br&gt;How do increased Southern Ocean freshwater fluxes affect sea ice over a 150-year period?&lt;br&gt;<em>Inga Smith (University of Otago)</em>&lt;br&gt;&lt;br&gt;Rapid, Dynamic Mid-Holocene Thinning of David Glacier, Antarctica&lt;br&gt;<em>Jamey Stutz (Victoria University of Wellington)</em>&lt;br&gt;&lt;br&gt;Rapid Ross Sea deglaciation as captured in the RICE ice cores&lt;br&gt;<em>Nancy Bertler (Victoria University of Wellington and GNS Science)</em>&lt;br&gt;&lt;br&gt;Victoria</td>
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<td>1045</td>
<td>Morning Tea</td>
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<td>1115</td>
<td><strong>ANTARCTIC PEOPLE AND PLACES</strong>&lt;br&gt;&lt;br&gt;Chair: Megan Nicholl&lt;br&gt;&lt;br&gt;Inclusive Antarctic Engagement: The artist as disrupter in Antarctic Science Communication, Education and Research&lt;br&gt;<em>Gabby O'Connor (NIWA)</em>&lt;br&gt;&lt;br&gt;Media and public perceptions of sea level rise in Aotearoa New Zealand&lt;br&gt;<em>Rebecca Priestley (Victoria University of Wellington)</em>&lt;br&gt;&lt;br&gt;Victoria</td>
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### Antarctic access, boundaries and security
*Germana Nicklin (Massey University)*

### Antarctic ambassadorship: An elusive concept?
*Daniela Liggett (University of Canterbury)*

### Strengthening the Antarctic science-policy interface: an empirical approach
*Natasha Gardiner (University of Canterbury)*

### Antarctic Data Analysis - A visualisation tool to support Antarctic policy
*Fraser Morgan (Manaaki Whenua Landcare Research)*

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<td>1245</td>
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<td>Our Future Focus panel discussion</td>
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<td>Afternoon Tea</td>
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<td><strong>ROSS SEA REGION MARINE PROTECTED AREA</strong></td>
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<td>Chair: Esme Robinson</td>
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<td>Ross Sea Environment and Ecosystem Voyage</td>
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<td><em>Richard O’Driscoll (NIWA)</em></td>
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<td>Phytoplankton community composition, primary production and grazing consumption in the Ross Sea Marine Environment and Ecosystem Voyage 2018</td>
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<td><em>Andres Gutierrez-Rodriguez (NIWA)</em></td>
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<td>Mapping long-term environmental change in the Southern Ocean to underpin monitoring of the Ross Sea region Marine Protected Area</td>
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<td><em>Matt Pinkerton (NIWA)</em></td>
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<td>Sharing the Southern Ocean: Ecophysiology of Diving Ability in Marine Mammal Predators</td>
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<td><em>Regina Eisert (University of Canterbury)</em></td>
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<td>Ross Sea ice-obligate predators: a review of technology and population status update</td>
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<td><em>Michelle LaRue (University of Canterbury)</em></td>
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<tr>
<td>1630</td>
<td>Conference wrap-up and awards</td>
<td>Victoria</td>
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<td>1700</td>
<td>Conference Close</td>
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WORKSHOPS

Monday 17 June

1330  Media Training for Scientists  Victoria

Want to help start environmental conversations and share your research with everyday New Zealanders, but don’t know where to start? Do you want to polish your public image? Or simply learn more about the media? The media training for scientists workshop will include interview tips and tricks, real life examples, mock interviews and social media secrets.

Facilitators: Megan Nicholl and Georgia Nelson

1530  Vision Mātauranga  Victoria

Exploring diverse perspectives on kaitiakitanga

Facilitator: Fiona Shanhun
SOCIAL FUNCTIONS

ICEBREAKER FUNCTION
Join us to get together ahead of the conference for presentation of the 2019 Antarctica New Zealand Postgraduate Scholarships and to experience life under the ice with Boxfish.

When: Monday 17 June
Where: Avon Room, Christchurch Town Hall
Time: 1700 - 1830
Inclusions: Complimentary drink and canapés followed by cash bar

STUDENT AND EARLY CAREER RESEARCHER LUNCH
An opportunity for researchers early in their career or new to Antarctic science a chance to chat, share stories, and meet with our keynote speakers and leaders in the Antarctic science community.

When: Tuesday 18 June
Where: Avon Room, Christchurch Town Hall
Time: 1230 - 1330

CONFERENCE DINNER
The conference dinner is being held at the Cathedral Square Novotel Hotel, and will be a great opportunity to socialise with your fellow conference attendees. The dinner will be buffet style, and includes a welcome drink on arrival. If you haven’t registered for the dinner and would like to attend, please check at the registration desk for availability.

When: Tuesday 18 June
Where: Novotel Hotel, 52 Cathedral Square
Time: 1900 - 2200
AWARDS

2019 Antarctica New Zealand Postgraduate Scholarships

These scholarships will be awarded during the Icebreaker function on Monday evening:

Antarctica New Zealand Sir Robin Irvine Scholarship
New Zealand Post Antarctic Scholarship

Conference Awards

A number of awards are up for grabs this year, recognising excellent talks and posters. Awards will be presented at the prize-giving on Wednesday afternoon.

Open to all:

People’s Choice Award - best talk (Tuesday)
People’s Choice Award - best talk (Wednesday)
People’s Choice Award - best poster
People’s Choice Award - highly commended poster

Just for students / early career:

Best talk
Highly commended talk
Best poster
Highly commended poster

Pressure Ridges, Harry Seagar, 2018/19
ANTARCTICA AFTER DARK

PUBLIC TALKS

When:  Monday 17 June
Where:  The Great Hall, Arts Centre
        2 Worcester Street Boulevard
Time:  1930 - 2130

The evening will showcase a range of Antarctic topics – from historic exploration and discovery to cutting-edge research, Antarctica’s influence on our future, and an Antarctic inspired performance by Warren Maxwell (Trinity Roots). Te Radar will headline this series of exciting short talks to celebrate Christchurch as the gateway city to Antarctica.

OUR FUTURE FOCUS

PANEL DISCUSSION AND Q & A

Wednesday 19 June

1345 - 1445  Victoria

This session will include short presentations from a panel of representatives to provide a variety of perspectives on the New Zealand Antarctic Research Programme, and to collectively consider our future focus.
Professor Juliet Gerrard trained at Oxford University, where she completed a First Class Honours degree in Chemistry and a DPhil in Biological Chemistry. In 1993, she moved to Aotearoa New Zealand, as a research scientist at Crop & Food Research. She was appointed as a Lecturer in Biochemistry at the University of Canterbury in 1998, where she became Professor and Co-Director of the Biomolecular Interaction Centre.

In 2014, she moved to the University of Auckland as a Professor in the School of Biological Sciences and the School of Chemical Sciences and later the Associate Dean for Research in the Faculty of Science.

Juliet’s research covers a broad base and is interdisciplinary, cutting across biochemistry, chemistry, health, agricultural and food science and biomaterial design. It also incorporates a full spectrum of fundamental and applied research. She has held an Industry and Outreach Fellowship with Callaghan Innovation and founded a start-up company.

Juliet has over 150 publications, as well as three books. She won a National Teaching Award for Sustained Excellence in Tertiary Teaching in 2004 and played an increasingly governance role in the research sector, including as Chair of the Marsden Council and a Director for Plant & Food Research, prior to her appointment in 2018 as the Prime Minister’s Chief Science Advisor.
Nicholas Golledge is an Associate Professor in the Antarctic Research Centre, Victoria University of Wellington, specialising in the numerical simulation of the Greenland and Antarctic ice sheets, and particularly, their response to changing external forcings over time.

Recent work has focused largely on policy-relevant timescales and societally-relevant questions such as the future ice-sheet contribution to global mean sea level. Entwined with this is the role that systemic feedbacks between ice sheets, ocean, and climate, might play in influencing future ice sheet evolution and the manifestation of future climatic changes.

Nick currently holds a Royal Society Te Aparangi Discovery Fellowship, is a Lead Author on the Sixth Assessment Report of the IPCC, and leads the ‘Future Projections’ Expert Group of the Antarctic Science Platform. He likes running long distances and drinking strong coffee, not necessarily at the same time.

**Keynote Abstract**

Ice sheet models provide a mechanism with which to explore scenarios that might play out under different climate states, and to gain insights into the dominant processes that drive ice sheet evolution. But they also allow for more abstract experimentation that seeks primarily to better identify and quantify the uncertainties inherent in those simulated scenarios. With our future climate trajectory and associated impacts coming ever more clearly into focus, the ice sheet modelling community are grappling with how to quickly and accurately characterise the extant ice sheets of Greenland and Antarctica, in order to make robust predictions of how these bodies will respond to greenhouse gas emissions over the coming century. This pressing need comes with enormous responsibility and with challenges that are both technical as well as philosophical. In this talk I will present an overview of the state of the science, and highlight some of the areas where future efforts are being focused. I will attempt to summarise what we think we know so far, and what still needs to be better understood to answer society’s most urgent questions.
What controls ice stream flow? Using active source seismology to study the basal boundary of ice streams.

Huw Horgan¹
Laurene van Haastrecht²

¹ Antarctic Research Centre, Victoria University of Wellington
² Victoria University of Wellington

Most of the ice that leaves the interior of Antarctica and enters the world’s oceans does so by way of fast-flowing ice streams. These ice streams can flow at hundreds of metres per year, but also show remarkable variability, switching on and off, and decelerating and accelerating at decadal and centennial timescales. Both the rapid flow of ice streams, and their variability is often attributed to the properties of the underlying material that itself deforms in response to the overlying ice. Here we present the results of active source seismic surveying from both the active Whillans Ice Stream and the currently inactive Kamb Ice Stream. By measuring the energy returned to the surface after bouncing off the base of the ice we are able to determine the acoustic properties of the underlying sediment. We calibrate our method using the known properties of the proximal floating ice shelf. Our results indicate that the substrate beneath these two ice streams consists of low porosity, easily deformable material. We conclude that either non-local properties, or subtle differences below the resolution of geophysical methods, are likely responsible for the flow differences of these two ice streams.
Anatomy of the grounding line of the West Antarctic Ice Sheet at the Kamb Ice Stream

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The response of the marine-based West Antarctic Ice Sheet to warmer than present conditions is a key focus of the NZARI Ross Ice Shelf Programme and the new Antarctic Science Platform project Antarctic Ice Dynamics Past, Present, and Future. What happens at the grounding line where the ice sheet begins to float and form the Ross Ice Shelf is thought to be a critical part of how the entire system responds to changing climate. The factors and processes affecting the flux of ice across the grounding line are a fundamental but little observed part of the system. Here we present findings from the 2018 expedition to the Kamb Ice Stream (KIS) region of the Siple Coast along with evidence from earlier visits to the region. Today, ice at the KIS grounding line is stationary despite flowing at hundreds of meters per year several centuries ago. A more detailed picture of a dynamic grounding line is emerging and sediment accumulating in a basin in front of the grounding line has the potential to reveal previous response to warmer interglacial periods. Plans are underway to recover sediment cores from the newly identified sedimentary basin.
What is this ice: geophysical investigations of a thick accreted basal ice layer at HWD-2, Ross Ice Shelf, Antarctica?

Kelly Gragg
Martin Forbes, Christina Hulbe and Gavin Dunbar

1 University of Otago
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In the austral summer of 2017, the Aotearoa New Zealand Ross Ice Shelf programme drilled two boreholes through the ice shelf at ~8039 S, 17428 E, approximately 450 km downstream of the grounding zone. The ice originates in the glacier-left margin of the flow band from Liv Glacier. Both boreholes encountered a ~60 m layer of bubble-poor ice containing unevenly distributed sediment. We used low frequency radar imaging both across and along the flow band together with borehole video observation and sediment analysis to conclude that the basal ice is terrestrial in origin.

This conclusion is unexpected. Elsewhere, remotely imaged accreted basal ice (bright reflector in the ice column; or appearing as a base shallower than predicted by surface elevation) has been interpreted to be of marine origin. Our discovery suggests that the same signal may arise from different conditions and reminds us that ice shelves are composites of flow bands with different origins and properties.

Hot water drilling was undertaken by the Victoria University of Wellington Hot Water Drilling initiative. We thank the drilling team led by A. Pyne and D. Mandeno.
A closer look: New observations of the marine environment and sea floor sediments below the central Ross Ice Shelf

Christina Hulbe¹
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Direct observations of present-day conditions and sea-floor sediments in the central region of the Ross Ice Shelf (RIS) indicate a system characterised by long quiescent periods but capable of rapid change. Our evidence comes from two boreholes drilled using hot water at a site ~320 km upstream of the present-day calving front (~8039 S, 17428 E). Over 2 weeks in early December 2017, we made repeated temperature, salinity, current, and turbulence measurements through the ~428 m water column, collected 11 sea-floor sediment cores and collected sediments from within the ice shelf. The oceanic boundary layer at the base of the ice shelf is cold, relatively fresh and a few 10s of m thick. This layer is separated from a benthic ~50m high salinity layer by a more variable intermediate layer. There is no evidence of persistent basal freezing along the ice flow trajectory. Sea-floor sediment cores contained a highly compacted diamict overlain by 47cm of granule-sized mud pellets and capped by 7cm of mud with infrequent dropstones, indicating minor Holocene basal melting. The emerging picture is of one persistent post-LGM ice cover in the RIS embayment although the transition from near-grounding line to distal-grounding line appears to have been rapid.
A Wedge Mechanism for Summer Surface Water Inflow into the Ross Ice Shelf Cavity

Alena Malyarenko¹,²
Natalie Robinson², Mike Williams² and Pat Langhorne¹
¹ University of Otago
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Recent observations from the Ross Ice Shelf cavity show basal melt rates higher than previously observed. The data demonstrate high seasonal variability, associated with surface water inflow into the cavity, which is in contact with the ice shelf base. This inflow of such warm surface waters has not been observed for other ice shelf cavities and is not explained by existing mechanisms. We have found that ablation of the ice shelf itself creates a density structure, a wedge, in the ocean in front of the Ross Ice Shelf that allows warm summer surface water to slip easily to 230 m depth and enter the cavity. In support of the new mechanism, we present the new observations from the RIS cavity, historical observations next to the Ross Ice Shelf front and seal-borne observations from the Ross Sea. By this mechanism, the Ross Ice Shelf basal melting in the frontal zone is directly connected to surface waters in the Ross Sea. Hence, changes in sea ice cover and solar heating in the Ross Sea will have an immediate effect on the Ross Ice Shelf stability.
Ice-ocean interactions at the base of Antarctic ice shelves are rarely observed, yet strongly influence ice sheet evolution and stability. Here we present radar derived basal melt rates, and observations from instruments moored beneath Ross Ice Shelf to examine the oceanographic processes that drive basal melting of the world’s largest ice shelf. We show that basal melt rates near a critical pinning point of the shelf are an order of magnitude higher than the shelf-wide average, strongly influenced by a seasonal inflow of warm surface water that nearly triples basal melt rates during summer. The findings suggest that solar heat absorbed in ice front polynyas can make an important contribution to the net mass balance of ice shelves, and potentially impact their stability.
1. Ice shelf breaker upperers

**Martin Forbes**¹
Christina Hulbe¹

1 School of Surveying, University of Otago

Long through-cutting rifts are characteristic features of ice shelves. They affect stress transmission across the ice they split and can further affect stresses of the remaining ice shelf when they cause the detachment of tabular icebergs. We use a linear elastic fracture mechanics (LEFM) approach to investigate the conditions of propagation and spatial limits of rifts. We apply LEFM, with the extended finite element method, to determine stress intensity factors and (therefore) stresses at rift tips in an elastic subdomain. The subdomain is made representative of ice shelf conditions by imposing deviatoric stresses from an ice flow model.

We model groups of rifts in the Ross Ice Shelf to investigate rift propagation and rift tip arrest. We demonstrate how far-field stresses determine gross rift geometries, how near-field stresses govern rift interaction and fine scale features and rift tip interaction with suture zones. Locations along the Shirase Coast, the ice shelf front west Roosevelt Island and downstream of Crary Ice Rise are considered.

2. Initial results of the 2018 Kamb Ice Stream seismic survey on the Siple Coast, Ross Ice Shelf

**Andrew Gorman**¹
Gary Wilson², Laurine van Haastrecht³, Robert Dagg¹, Caitlin Hall¹, Robin Davies⁴ and Huw Horgan⁵

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Seismic data collection during event K001B-1819, undertaken in conjunction with the 2018 Antarctica New Zealand Siple Traverse, expanded on a single 23-km-long seismic line collected in early 2015
(Horgan et al., 2017) that crossed the grounding line of the Kamb Ice Stream at the Siple Coast of the Ross Ice Shelf. This region will be the focus of the Ross Ice Shelf Programmes HWD1 drilling endeavour this coming season. The layout of the lines was designed to provide regional coverage of the sub-ice-shelf ocean and sediments in a region where Rosetta airborne-gravity data identified a gravity low. Detailed surface gravity data (reported elsewhere) were also collected during the campaign. A 20-km long line running parallel to the grounding line tied the 2015 line at one end; an orthogonal 10-km long line tied the long line and ran parallel to the 2015 line. Acquisition parameters were kept the same as the original survey: 2.4 kg explosive shots in 25 m deep hot-water-drilled holes, 96-channel symmetric shot records with 10 m geophone spacing. Processed seismic data show a mostly flat seafloor lying beneath the ocean cavity suggesting that the Rosetta gravity low must have a geological, rather than bathymetric, origin.

3. Initial results of the 2018 Kamb Ice Stream gravity survey on the Siple Coast, Ross Ice Shelf

Caitlin Hall
Gary Wilson, Andrew Gorman, Laurine Van Haastrecht and Bob Dagg

1 University of Otago
2 GNS Science
3 Victoria University of Wellington

A gravity anomaly low on the Siple Coast of the Ross Ice Shelf recently identified by the large-scale Rosetta airborne gravity project became a site of interest for the Ross Ice Shelf Programme, due to its proximity to the grounding line of the Kamb Ice Stream. The specific research objectives for event K001B-1819 were to use gravity and seismic methods to better constrain the three-dimensional structure of the water cavity in the vicinity of the grounding line, which was initially interpreted to be 20 m thick overlying a flat seafloor. Here we present the results of last season’s gravity surveying undertaken with La Coste and Romberg gravimeters, every 480 m along three lines totalling 40 km in length. A field base station was established by repeatedly tying local measurements to those made at Hut Point (Ross Island). Field gravity measurements have been reduced to account for elevation and tides and computationally modelled to
constrain subsurface thicknesses and densities, thereby calibrating larger-scale three-dimensional models of the geometry of the water cavity and sedimentary basins (and providing ground proofing for Rosetta). These models are now being used to optimally position future scientific drilling that will facilitate paleoclimate reconstructions at the Siple Coast.

4. Phase sensitive radar measurements along the Ross Ice Shelf SPOT traverse

Joseph Snodgrass¹
Wolfgang Rack¹, Adrian McDonald², Christina Hulbe⁴, Daniel Price¹, Michelle Ryan², Kelly Gragg³ and Martin Forbes⁴

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Ice shelves are vulnerable to ocean warming and their fate is controlled by oceanic processes in the ice shelf cavity. This study presents the analysis of multiyear ground penetrating radar data from along the South Pole traverse on the Ross Ice Shelf to gain knowledge about melting and freezing at the ice-water interface. Autonomous phase-sensitive radar echo sounding (ApRES) measurements shown here were collected during the 2015 - 2017 Antarctic season. High accuracy single point measurements of 21 locations were processed using MATLAB scripts developed by the British Antarctic Survey to match internal reflection boundaries and the basal reflection return. The coherent radar waveforms and therefore stable basal regimes over the investigation period allow this type of analysis. Strong basal reflections from a defined ocean-ice boundary showed basal melting and fuzzy reflections are interpreted as partial freezing or the existence of debris near the base of the ice shelf. By comparing multiple years of data, ice shelf strain rates and basal melting in the order of 1cm to 70cm were derived. Strong variation in the basal reflection regimes along the traverse are attributed to changes in basal topography, thickness, and ice origin.
5. Modelling the dynamic response of the Ross Ice Shelf to ungrounding from pinning points

Holly Still
Christina Hulbe and Adam Campbell

University of Otago

Pinning points are localised regions of grounding within an ice shelf that generate resistance to ice flow, and in turn, affect grounding line and tributary glacier dynamics. Large ice rises are known to contribute to flow resistance and ice shelf stability but are unlikely to change over the coming decades while smaller-scale ice rumples are more vulnerable to change. The ungrounding of ice rumples may lead to faster flow, thinning, and grounding line retreat. This study focuses on a collection of ice rumples located downstream from the outlets of the MacAyeal and Bindschadler Ice Streams in the Ross Ice Shelf (RIS). Only ~15 m of ice shelf thinning is required for these ice rumples to lose contact with the seafloor. We use the Ice Sheet System Model (ISSM) to conduct two experiments. A steady-state RIS simulation is perturbed by: (1) modifying the bathymetry to simulate unpinning and (2) modifying basal drag to simulate changes in the amount of contact between the ice shelf and seafloor. We project the future evolution of the RIS over 100 years and assess how changes in pinning point configuration modify the force budget, ice flow, ice thickness, grounding line position, and mass flux.
PROCESSES, TRENDS AND VARIABILITY IN ANTARCTIC SYSTEMS
There and Back Again: Oceanic Connections between the Grounding Line and the Southern Ocean

Craig Stevens¹,²
Christina Hulbe³, Mike Brewer¹, Craig Stewart¹, Natalie Robinson¹, Christian Onheiser³, Stefan Jendersie⁴, Melissa Bowen², Won Sang Lee⁵, Seung-Tae Yoon⁵, Denise Fernandez¹, Gary Wilson³, and Christina Riesselman³

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Ninety percent of the heat captured by the planet is stored in the oceans and much of this is in the Southern Ocean. Consequently, understanding ocean transport and connectivity is fundamental to determining Antarctica’s impact on the global earth system, and in predicting how the Antarctic/Southern Ocean system will change in a +2C, or warmer world. A multi-scale approach is required as many of the important energy transfers in the climate system take place at scales smaller than achievable in predictive tools. In this talk we will look at recent observations and upcoming challenges incorporating both process and monitoring time series to answer major questions relating to the ocean’s role in the coupled ice-ocean-atmosphere system in a rapidly changing climate.
Zooplankton community and environmental relationships in an era of climate change: who wins and who loses?

Matt Pinkerton¹
Moira Decima¹, Karen Robinson¹ and Rob Stewart¹

¹ NIWA

Zooplankton are the key trophic link between the microbial community and Antarctic predators such as fish, mammals and seabirds. We used 20 years of Continuous Plankton Recorder zooplankton data to explore spatial and seasonal patterns in zooplankton in the Southern Ocean, and the relationship between zooplankton and environmental drivers. Zooplankton abundances in the Ross Sea region are higher by about a factor of 2, compared to other Antarctic areas, with herbivorous zooplankton especially abundant in this region. Environmental information was generally good at explaining the average spatial patterns in abundances and distributions of key zooplankton groups, and was used to investigate long-term change in zooplankton communities. Environmental conditions for most broad groups of zooplankton in the Southern Ocean over the last 20 years (1997-2018) are associated with positive trends in abundance. Copepods and foraminifera are likely to benefit especially. In contrast, the environmental conditions for pteropods (small marine snails living in the water column) seems to have worsened over the last 20 years over the Ross Sea shelf especially. The negative pressure on pteropod abundance may have implications for the Ross Sea shelf ecosystem where pteropods are a major contributor to the flow of organic matter to the seabed.
Effects of environmental conditions on diatom communities and the $\delta^{13}\text{C}$ of particulate organic matter in Terra Nova Bay

Michael Bollen$^1$
Christina Riesselman$^1$, Robert Dunbar$^2$, David Mucciarone$^2$, Hans DeJong$^2$, Christian Ohneiser$^1$ and Giacomo DiTullio$^3$

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We present a study on the modern diatom ecology and particulate organic carbon $\delta^{13}\text{C}$ from water column samples obtained in Terra Nova Bay (TNB). 100 paired analyses were undertaken, finding a positive correlation between absolute diatom abundance and the $\delta^{13}\text{C}$ of suspended particulate organic matter. Cluster analysis of diatom assemblages grouped the samples into four distinct spatial and temporal groups, with the two most populous groups, separated by a latitudinal boundary at 74.9°S. South of this boundary, sustained katabatic winds interact with surface waters and result in intense mixing and sea ice formation, while north of 74.9°S the embayment is relatively sheltered from such atmospheric forcing. The most positive $\delta^{13}\text{C}$ values (-24 to -21‰) were observed in northern TNB, with high absolute diatom abundance and relative abundance of *Fragilariopsis curta*. The most negative values of $\delta^{13}\text{C}$ (-23 to -29‰) were seen in southern TNB, coinciding with relatively high relative abundances of *Chaetoceros* resting spores, and low *F. curta* and absolute diatom abundances. We suggest the $\delta^{13}\text{C}$ of particulate organic matter is driven by primary productivity, with regional enrichment and depletion due to water column stratification driven by sea-ice melt, and wind-induced deep mixing limiting productivity respectively.
Building GeoMAP ‘on the sniff of an oily rag’

Simon Cox

GNS Science

Following publication of a South Victoria Land geological map in 2012, GNS Science launched an ambitious project to build a similar high-quality digital geological dataset covering the entire Antarctic continent. With minimal local funding available in NZ, they sought support and enthusiasm internationally through formation of a SCAR Action Group. Five-years later, the first version of GeoMAP (v.201907) will be released at the ISAES XIII meeting in July 2019. Such rapid work was enabled through a clear vision, a tried and tested methodology from mapping New Zealand (QMAP 1993-2014), and a top down work-stream. Feature classification and description of rock and moraine polygons employed international GeoSciML data protocols to provide attribute-rich and queriable data; including bibliographic links to source maps and literature. The new data are unified for use at 1:250,000 scale but locally have higher spatial precision. GeoMAP has involved ~18 key collaborators (principally from USA, Norway, Italy, UK, Australia, Korea and NZ) with much manual work completed by 11 student volunteers visiting NZ on internships or working remotely. Although it has operated awkwardly across the NZ-Antarctic funding environment, GeoMAP now provides an underpinning dataset describing the Antarctic geosphere that will be ideal for continent-wide perspectives and cross-discipline science.
On the role of fossil emissions in past and present atmospheric methane levels

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Levels of atmospheric methane [CH₄] responded sharply to climate events at various time scales throughout the glacial period. Competing hypotheses hold that either increased wetland production or abrupt release of methane stored in permafrost/marine sediments caused observed [CH₄] increases. The radiocarbon (¹⁴C) content of atmospheric methane provides a definitive test for the rival explanations, but the enormous amount of required ancient sample air is prohibitive for such analyses using ice cores. The ancient ice layers exposed on Taylor Glacier in the McMurdo Dry Valleys were used to examine an abrupt warming event ~11,500 years ago for the sudden input of ¹⁴C-devoid permafrost methane. The records show that the [CH₄] increase must be attributed to wetlands alone and place an important constraint on the rate of natural methane emissions from oil and gas reservoirs. The latter is important to understand the modern methane budget and quantify fugitive emissions from the fossil fuel industry.
6. **Subglacially-precipitated carbonates from Northern Victoria Land, Antarctica: Implications for sub-Ice Sheet paleohydrology?**

Paul Augustinus¹
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Subglacially-precipitated carbonate (SPC) occurs in layers and as fissure-fills on bedrock hummocks in the Helliwell Hills of Northern Victoria Land (NVL), Antarctica. Uranium-series dating of the carbonates demonstrates that most material grew near continuously from 17 to 27 ka, although precipitates in growth position also formed during the last four glacial cycles as demonstrated by weighted mean U-Th ages of 162 ± 1 ka, 215 ± 2 ka, 254 ± 2 ka and 334 ± 4 ka. The combination of SPC micro-facies, high-resolution major and trace element mapping, δ18O and clumped isotope analyses of the SPCs indicate precipitation from sub-Ice Sheet meltwater. The SPCs have depleted δ13C driven by active microbial metabolism in the basal meltwater environment during SPC precipitation. Furthermore, the SPC isotopic and elemental geochemistry, combined with microbial DNA preserved in the SPCs, indicate that subglacial volcanism was active during their precipitation and likely induced melting of the local ice-sheet base. This meltwater was injected into interconnected basal hydrological systems and could have reached the ice sheet margin. The NVL SPC investigations are ongoing and have been expanded onto similar material collected from several locations around the EAIS margin.

7. **Erosional history from landslide deposits in the Central Transantarctic Mountains**

Peter Barrett¹
David Elliot² and Jamey Stutz¹

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The Transantarctic Mountains (TAM) began rising around 55 mya, with their features initially shaped by fluvial erosion. East Antarctic margin strata record dynamic ice sheets from 34 mya, with a few remnant glacial
deposits within the mountains themselves. Cooling around 14 mya resulted in relatively stable cold glaciers and ice sheets eroding only at the base resulting in todays extreme relief. However erosional history of the TAM is largely unconstrained by physical evidence from the mountains themselves. This talk draws attention to a number of large landslide deposits, a consequence of load exceeding rock strength in over-steepened topography. One such landslide event is recorded by Permian-Triassic debris piles on a flat-topped ridge (2000-2300 m asl) from their bedrock sources high on the NW face of Mt Mackellar (4300m). These piles imply the collapse of over a cubic km of rock debris falling up to 1200 m and reaching as far as 16 km from their source. Possible circumstances for and dating of such events will be discussed.

8. **Antarctic and Southern Ocean publications with New Zealand authorship - trends in basic metrics from 1990 to 2018**

Peter Barrett

1 Antarctic Research Centre, Victoria University of Wellington

This publications/citations database was extracted from all Antarctic and Southern Ocean publications in Elseviers SCOPUS database with at least one NZ-based author between 1990 and 2018 (2575 papers and 61355 citations). The whole database was checked to ensure they were indeed from the target region (around 300 were not). The rest were subdivided into 11 subject areas but clustered into just three for graphic display biological science, physical science and humanities and trend lines drawn. Database plots show a rising trend in publication numbers from ~50 in the 1990s and peaking at 200 in 2014-15, but falling to ~150 in the last 3 years. However, a subset from research directly supported by Antarctica NZ (1/4 of the total) has maintained 2015 publication levels. For the whole database, citations averaged over the last six years have risen steadily from 1990 but peaked in 2011 and then declined slightly. Both biological and physical sciences showed similar numbers and trends overall. Factors influencing these trends will be complex, but these observations provide a useful starting point for further analyses to help future science review panels assess the health of NZs Antarctic Research Programme. This work is being carried out in collaboration with AntarcticaNZ.
9. GeoMAP dataset of the Antarctic Peninsula

Simon Cox
Luigi Lelli¹, Nicola Dal Seno¹ and Belinda Smith Lyttle²

¹ DIStAV, University of Genoa
² GNS Science

A new geological dataset has been compiled for the Antarctic Peninsula. Rock and moraine polygons from the ADD (Antarctic Digital Dataset) were reshaped and shifted where necessary (using LIMA landsat imagery), then assigned information on rock type, geological name, age, original mapping author bibliography and source code from published hardcopy maps and regional GIS data. Some early maps left outcrops as unknown, but a recent regional-scale framework (Burton-Johnson & Riley 2015) has been used to infer local geology adding a ? symbol in unit codes that clearly identifies inferred data. Many faults are concealed beneath ice and have been captured with information on accuracy and exposure, as well as source of information. 1569 structural measurements of bedding, foliation and lineation were also captured, located within areas of rock polygon outcrops they represent. Supraglacial features and glacial till, seasonal water and blue ice were newly mapped using LIMA. The work was completed while visiting New Zealand on SCAR-supported student internships. It contributes to the international SCAR GeoMAP initiative to compile a unified geological dataset of Antarctica. Data for the peninsula form one of the larger GeoMAP datasets to be released at the ISAES XIII conference.

10. Southern Ocean Wave Atlas

Peter McComb
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The Southern Ocean is the least observed and understood of any major ocean. Here the persistent westerly winds and extensive fetch produces higher wave heights for longer periods than anywhere else. The RNZN has patrol and SAR responsibilities in this ocean, however the detailed spectral wave characteristics are unknown, meaning critical design factors for new ships are unavailable.
A measurement / modelling campaign was undertaken, including moored buoy deployments at 52.7S, where phenomenal conditions were observed (24.8m waves). Five drifting buoys were also deployed in a trial of a new technology in energetic open ocean states.

The modelling, conducted with WAVEWATCH III, included comprehensive analysis of available forcings including wind/ice from the CFSR and ERA5 reanalyses. The relative importance of large-scale ocean currents was also examined, with currents from CFSR, HYCOM and Glorys considered. ERA5 winds were found to be superior, and Glorys provided the best results for currents, significantly reducing the positive wave height bias in the Southern Ocean. This configuration was used to produce a 25-year hindcast, from which an atlas of the relevant physical surface ocean variables was been produced.

The atlas is a freely available gridded dataset of derived statistics that includes monthly and annual directional values for the surface current speed, wavelength, wave period, significant wave height, return period significant wave height, Douglas sea states, and dangerous seas indices.

11. Initial findings of a 25 wave buoy array in the Southern Ocean and Ross Sea

Sally Garrett¹

¹ New Zealand Defence Force

The waves of the Southern Ocean and Ross Sea are largely unstudied. The New Zealand Defence Force (NZDF) routinely operates in these areas and is currently engaged in a ship building program which requires detailed understanding of the wave climate for ship design. Unlike other areas the Southern Ocean and Ross Sea has limited ship traffic and therefore limited wave observations from volunteer observing ships. Moreover, due to the difficult conditions and remote location limited scientific measurements of waves have been completed.

In 2017, the NZDF deployed a moored wave buoy in open ocean 11 nautical miles south of Campbell Island. In addition, 23 free floating buoys were also deployed between 42 S and 67 S. This array has provided an understanding of wave characteristics across the Southern Ocean and Ross Sea.

The initial findings of the wave climate measured by the array will be compared to similar Northern Hemisphere locations used to develop ship building guidelines. A summary of the implication of the differences for future ship building will be presented.
12. Quantifying Sea Ice Trends in the Southern Ocean: A Path to Tread with Caution

Bryony Freer\textsuperscript{1}
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The passive microwave-derived record of global sea ice cover is often cited as the longest and most reliable climate dataset in existence. Four decades of daily sea ice extent, area and concentration measurements in the Southern Ocean are available from the National Snow and Ice Data Centre (NSIDC).Extent is used to report trends, including the overall increase in Antarctic sea ice cover since 1978.

However, a close examination of these datasets finds that measures of sea ice extent and area in the Southern Ocean are not always consistent with one another. Changes in extent appear to be exaggerated compared to area in extreme months, such as the record September 2014 maxima/December 2016 minima, and are driven largely by changes in the Ross and Weddell Seas. A comparison of the low-resolution passive microwave (SSM/I and AMSR2) and high-resolution SAR imagery in the Weddell Sea reveals a consistent underestimation of the sea ice cover by the algorithms and raises concerns over the suitability of the 15% threshold used to define sea ice extent.

This study therefore calls into question the significance of the reported extremes and demands caution to be taken when making interpretations based on just one of these measures.

13. Solar influence: direct and indirect effects on polar stratospheric chemistry from 2005-2017

Emily Gordon\textsuperscript{1}
Annika Seppala\textsuperscript{1}

\textsuperscript{1} University of Otago

It is widely acknowledged that polar ozone influences the chemistry and dynamics of the polar atmosphere. Not only is it important to protect humans from harmful UV radiation but ozone perturbations also affect things like surface temperatures in Antarctica, Brewer-Dobson circulation and stratospheric heating. Here, we investigate how energetic particle precipitation (EPP) influences stratospheric chemistry. EPP is
characterised as energetic particles originating from the Sun penetrating to the Earth’s atmosphere and ionising neutral species. This is both a direct effect, as EPP causes in situ increases in HOx and NOx species which catalytically destroy mesospheric and upper stratospheric ozone, but it is also has an indirect effect. The unique conditions in the Southern Hemisphere winter increase the lifetimes of NOx in the stratosphere, causing it to descend as far as the lower stratosphere, where the ozone hole occurs. This combination of factors potentially allows ozone depletion up to 5 months following the initial precipitation event(s), while the longer lived NOx and NOy species may interact with the ozone hole-forming substances released in the springtime.


Peter Kuma
Sean Hartery\(^1\), Darin Toohey\(^2\), Laura Sellegri\(^1\), Karine Sellegri\(^3\), Mike Harvey\(^4\) and Adrian McDonald\(^1\)

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\(^4\) NIWA

During an austral summer voyage to the Ross Sea aboard the R/V Tangaroa we measured sea-level concentrations of aerosol between 0.33 m. We compared these measurements to calculations of aerosol concentrations from the combination of the following: the parameterization of sea spray aerosol (SSA) flux currently used with the New Zealand Earth System Model (NZESM); source-receptor calculations from the Lagrangian particle dispersion model, FLEXPART-WRF; and, meteorological information from Antarctic Mesoscale Prediction System (AMPS) weather forecasts. We found that our observations were best reproduced using a more conservative estimate of the wind speed dependence of SSA flux than currently modelled within the NZESM. Our methodology also showed that while model-observation mismatch could be partially linked to sea surface temperature, which limits bubble size and subsequent aerosol production, it was more strongly linked to the scavenging of aerosol from low cloud or fog within the MBL. An independent set of aerosol concentration measurements collected on board an aircraft during the SOCRATES campaign confirmed our findings, highlighting the
reproducibility of this study. Finally, we present new parameters for the estimation of SSA flux within the NZESM which correct current biases in aerosol optical depth between the NZESM and satellite observations.

15. Evaluation of Southern Ocean cloud in the HadGEM3 general circulation model and MERRA-2 reanalysis using ship-based observations

Peter Kuma
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Southern Ocean shortwave radiation biases of up to 40 Wm$^{-2}$ in summer are common in general circulation models, with misrepresentation of cloud identified as the major cause. We evaluate the atmospheric component GA7.0 and GA7.1 of the HadGEM3 general circulation model and the MERRA-2 reanalysis, and find that GA7.0 and GA7.1 underestimate the reflected top of atmosphere shortwave radiation, while MERRA-2 overestimates this quantity. Using a dataset of ship ceilometer and radiosonde observations we evaluate cloud cover and link it to the thermodynamic profile. We find low cloud below 2 km and fog predominant and cloud cover exceeding 90% in most regions. We show that this cloud is strongly linked to boundary layer stability and sea surface temperature. Using a ground-based lidar simulator we produce virtual ceilometer measurements along the voyage tracks for a 1:1 comparison with the ceilometer measurements. We find that GA7.0 and MERRA-2 underestimate cloud cover by 18-25%, especially cloud below 1 km and fog. While the boundary layer stability is well represented in GA7.0 and MERRA-2, the link between the boundary layer stability and cloud found in observations is not present in the models, pointing to deficiencies in the subgrid scale parametrisation of cloud.
16. Climatic records in volcanic rocks: Glaciovolcanology from the southwest Ross Sea, Antarctica

Adam Martin¹
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Past ice sheet thickness and thermal regime (ice sheet stability) are best elucidated by examining lava ice interactions (glaciovolcanology). Mason Spur is a Miocene to recent eruptive centre, and Helms Bluff contains a Pliocene-aged eruption record, both in the southwest Ross Sea, Antarctica, where several varieties of lava ice interactions were mapped recently. Early eruptions at Mason Spur were voluminous, occurring immediately after the Mid Miocene Climatic Optimum during descent into a deeper icehouse world - a period that is crucial for comparing how modern global warming and sea-level changes will affect the planet. The rock record here shows environmental conditions at a time when Mason Spur eruptions were potentially continental in their impact. Younger volcanic rocks (< 6 Ma) at Mason Spur also record lava ice interactions, revealing the thickness of the past Antarctic ice sheet and wet- versus dry-based glacial conditions. Nearby, Helms Bluff shows a classic aā lava fed delta sequence erupted at a time when other forms of evidence for ice sheet conditions are conflicting. Our mapping shows minimum ice sheet thickness and the thermal ice-regime present between eruptions. Glaciovolcanology remains critical for understanding past ice sheet behaviour for modelling future climate and sea level changes.

17. Radar measurements of snow depth over sea ice on unmanned aerial vehicle

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¹ Canterbury University
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³ Gateway Antarctica, University of Canterbury

We have developed and trialled an unmanned aerial vehicle (UAV) mounted radar that maps out snow thickness as the UAV autonomously flies over sea ice. In this presentation, we will describe the initial investigations, design, development and field trials of the UAV and
radar. Field trials were conducted on sea ice in McMurdo Sound, Antarctica, during the summer season of 2017/2018. Results of snow depth measurements show that the radar is capable of snow depth measurements of between 10 cm to 100 cm. These results are checked for accuracy with ground truth measurements. From the radar measurements, we could discern additional reflections from the different sub-layers of the snow. Full feature reconstruction of air/snow and snow/ice interfaces is successful. Measurement trials were also conducted at different flight characteristics stationary, flying at constant velocities of 1 to 3 m/s, and at heights of 5 to 15 m. Snow depth results obtained from radar measurements indicate a gradual deterioration of snow depth features as flight velocities are increased from 1 to 3 m/s.

18. Pattern Matching of Synoptic Surface Winds to Identify the Quality of Reanalyses

Adrian McDonald¹
Luke Cairns¹

¹ University of Canterbury

This study compares statistics of surface winds in eight reanalyses, namely, the CERA20C, ERA5, ERA-Interim, ERA20C, JRA55, MERRA2, NCEP/NCAR2 and 20th Century Reanalysis V2c (20CRV2c) datasets. This comparison uses daily scale winds classified against 12 representative patterns derived using the Self Organising Map technique on ERA-Interim output over the Ross Sea/Ross Ice Shelf region. The frequency of the patterns for the eight reanalyses are shown to be very similar over the reference period 1980-1999. Analysis shows that all eight reanalyses display similar time variations relative to the mean occurrence in the satellite era. The CERA20C, ERA20C, JRA55 and 20CRV2c datasets and the ensemble members within those reanalyses display larger variations and some trends previous to 1979. However, the level of divergence is clearly largest previous to the International Geophysical Year (1957). The reanalyses are highly consistent in the satellite era, less consistent between 1979 and the International Geophysical Research (1957), and show very poor consistency before 1957. Strong trends in the frequency of specific regimes in the 20CRV2c before 1957 suggest that this reanalysis is affected by artefacts associated with a relaxation towards the model climatology.
19. Soil climate and active layer depth: monitoring, model development, and relationship to regional climate drivers in the 21st century, Ross Sea Region, Antarctica

Tanya O’Neill

Megan R. Balks, Karin Bryan, Annette G. Carshalton and Cathy Selbold

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The depth of seasonal thaw (active layer depth, ALD) integrates a range of soil and atmospheric climate variables and can provide a clear signal of a changing climate. Nine soil-climate monitoring stations were established between 1999 and 2012 in the McMurdo Dry Valleys; monitoring atmospheric variables and soil temperature at depths to 1.2m, with hourly means recorded.

Between site establishment and 2018 mean ALD was: Mt Fleming-8 cm; Wright Valley: South Wall-38 cm, North Wall-37 cm, Floor-49 cm; Victoria Valley-23 cm; Marble Point-50 cm; Minna Bluff-29 cm; Scott Base-33 cm; and Granite Harbour-86 cm. All sites had between-year variability, but no warming or cooling trends.

A regression-derived model predicted ALD. mean summer air temperature, total summer solar radiation, altitude, and ground surface temperature had the greatest effect on ALD (p <0.0001). Multiple regression analysis was undertaken with differing number variables using both step-wise and restricted maximum likelihood (REML) methods, which gave significant results (Adj R² > 0.5).

There was a strong relationship between the ALD and Amundsen Sea Low (3-4-year cycle); and a weak relationship with the Southern Annular Mode and Southern Oscillation Index (6-8 year cycle).

20. Finding the bottom of the sea ice

Maren Richter

Greg Leonard, Inga Smith, Pat Langhorne and Andrew Mahoney

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A precise knowledge of the thickness of sea ice is important for many different reasons. However, defining the ice-water interface is not as trivial
as it may appear. Sea ice in McMurdo Sound is influenced by supercooled water exported from a nearby ice shelf which allows the formation of a sub-ice platelet layer (SIPL). This friable layer consists of ice platelets of seemingly random orientation under the consolidated sea ice and forms an important habitat for sea ice organisms as well as influencing the sea ice growth rate. The transition from solid ice to water, via a layer of loose or semi-consolidated ice crystals, complicates the definition of sea ice thickness.

Here, we compare different methods of processing temperature string data, collected over the past 20 years, to determine the ice-ocean interface and assess the performance of these methods. The resulting time-series can be used to study interannual variability and existing or emerging trends in sea ice thickness and growth. Although SIPLs are rarely found outside the vicinity of deep drafted ice shelves, our results are of relevance to other situations in which the ice bottom is ill-defined, e.g. very early stages of growth or advanced stages of melt.

21. Developing a nowcasting solar flare capability using Scott Base AARDDVARK data: addressing the needs of global aviation

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Harriet George, Mark Clilverd, Neil Thomson, James Brundell and Kathy Cresswell-Moorcock

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Solar flares are the largest explosions in the modern solar system. Flares blast intense fluxes of X-rays, UV, and radio waves into space - affecting the dayside of the Earth. The energy is primarily deposited into the upper atmosphere increasing ionospheric electrical conductivity. These increases, as well as associated solar radio noise bursts, can directly impact the aviation industry. Solar flares and other space weather events produce degradation or disruption of communications, navigation, and surveillance systems, as well as leading to an elevation in radiation dose levels at flight altitudes. The International Civil Aviation Organization (ICAO) has requested global space weather forecasting to support global aviation. Forecasting of solar flares is possible but is currently very unreliable. We have responded to a UK Met Office request for a nowcasting capability.
We use ~5 years of narrow band VLF radio observations made by the AARDDVARK receiver at Arrival Heights, operated through event K060. Applying linear regression analysis we have shown that the AARDDVARK-observed phase can be used to provide high accuracy estimates of the solar flare X-ray flux impinging the Earth’s atmosphere. Our technique is capable of shaving ~3 minutes or more off existing satellite-provided solar flare warning times.

22. Mechanisms linking solar forcing, polar ozone and regional scale climate variability

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1 University of Otago
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Energy from the Sun is a vital requirement for life on Earth. However, work to understand the role of the Sun as a driver for the climate system has suggested that there are several mechanisms for solar influence on climate, some linking to variability on regional scale. We have investigated the physical mechanisms to climate variability from the least understood of these: energetic particle precipitation. Energetic particle precipitation into the atmosphere is a significant part of geomagnetic activity experienced by the Earth, the aurora (Southern Lights) being a visible manifestation of it. Unlike other types of solar forcing, the initial impact from energetic particles is on the Earth’s polar regions where they lead to significant changes in atmospheric chemical balance, leading to changes in ozone levels. Changes in ozone can further couple into atmospheric dynamics at a level that is comparable to solar UV. This type of solar forcing has previously been linked to stratospheric and tropospheric circulation anomalies and large-scale weather patterns, but we have not understood the physical mechanisms driving these. Here, we report results from new Chemistry-Climate model simulations that have revealed new insights into the chemical-dynamical coupling processes influencing regional variability on solar cycle time scales.
23. Arrival Heights as a GRUAN site

Dan Smale¹
Richard Querel¹

¹ NIWA

The GCOS Reference Upper-Air Network (GRUAN) is a reference network of high-quality harmonised observations with well-documented metadata and fully characterised and traceable uncertainties. This high data quality allows for climate trend studies and satellite validation work to be performed using what would otherwise be routine meteorological parameters. The first essential climate variables targeted by GRUAN are temperature and humidity profiles and will soon include ozone profiles.

However, there are no GRUAN-certified sites in Antarctica (Syowa and Davis are GRUAN-candidate sites currently under assessment). Arrival Heights (AHts) is a premier site for atmospheric composition measurements in Antarctica. It is sister-site of the GRUAN-certified Lauder Atmospheric Research Station in Central Otago, New Zealand (to-date the only GRUAN-certified site in the Southern Hemisphere).

Working in partnership with USAP and LINZ, NIWA is proposing a GRUAN site at Arrival Heights following the model of NIWA’s GRUAN distributed-site that joins Lauder station and the NZ MetServices Invercargill site. The Arrival Heights-based GRUAN site would connect AHts measurements with U.S. radiosonde data from the McMurdo facility and LINZ GNSS data from the receiver installed near Scott Base. Future work would expand AHts upper-air measurements to include ozonesondes and frost-point hygrometer launches.

24. Opportunistic observations of Erebus volcanic plume composition by high resolution solar occultation mid infra-red spectroscopy

Dan Smale¹

¹ NIWA

Twice a year, in the first week of April and September around solar noon, the sun path tracks across the Erebus summit. Under clear conditions during active volcanic degassing direct mid infra-red solar spectra absorption occultation measurements through the plume are possible with the Bruker 125HR Fourier transform interferometer located at Arrival Heights. Such opportunistic measurements (only 5 observations over 22
years) allow us to quantify plume composition. It is also the only such measurements (worldwide) taken at high spectral resolution, allowing us to investigate isotopic composition. In this preliminary study we found that the incumbent spectral analysis procedure used to investigate stratospheric composition (the focus on ozone hole chemistry) could be adapted to explicitly measure plume concentrations. Applying this adapted technique, we calculated Hydrogen Chloride (HCl) and Hydrogen Fluoride (HF) plume concentrations and found HCl/HF mass mixing ratios in accordance with current literature. Other trace gases in the plume (such as SO$_2$, CO$_2$, OCS, CO, H$_2$O and accompanying isotopes) will be analysed later.

25. Holocene paleoceanographic evolution at the Ross Sea-Southern Ocean interface

Olivia Truax$^1$
Christina Riesselman$^1$, Gary Wilson$^1$, Rebecca Parker$^2$, Jae Il Lee$^3$, Kyu-Cheul Yoo$^3$ and Richard Levy$^4$

$^1$ University of Otago
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Reconstructions of Antarctic oceanography from past intervals of warming are a crucial component of estimating the sensitivity of marine-based glaciers and ice shelves to atmospheric and oceanic changes in the twenty first century. We present a high-resolution oceanographic record from a sediment core, RS15-GC57, retrieved from Robertson Bay, a protected embayment west of Cape Adare. By interpreting the properties of RS15-GC57 in the context of modern instrumental datasets we reconstruct Holocene oceanography at the interface between the Ross Sea, East Antarctic Ice Sheet, and the Southern Ocean.

The most prominent feature in proxy records from RS15-GC57 is a rapid (~200 yr) transition dated to 3.2 ka, coincident with the termination of the mid-Holocene climatic optimum and onset of cooler conditions in Adélie Land and the Antarctic Peninsula. Late Holocene cooling may be associated with the stabilization of the Antarctic Ice Sheet in the Ross Embayment. During the late Holocene, CDW upwelling and sea ice duration in Robertson Bay are modulated by centennial trends in the Southern Annular Mode. After 500 cal yr BP increased sea ice duration in Robertson Bay indicates that icier conditions persisted at the northern margin of the East Antarctic Ice Sheet during the Little Ice Age.
Adélie penguins (*Pygoscelis adeliae*) are an indicator species used to detect and monitor the effects of environmental change on Antarctic marine ecosystems. Since the early 1980s, New Zealand has conducted an annual census of Adélie penguins in the Ross Sea region, with data submitted to the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) Ecosystem Monitoring Programme (CEMP). The number of breeding pairs is determined through aerial photography of colonies, and subsequent image processing and penguin counting using semi-autonomous software. Changes in the number of breeding pairs can be considered in relation to environmental factors, allowing hypotheses about population responses due to natural versus anthropogenic changes to be tested.

The long-term data set is valuable for characterising Ross Sea ecosystems, assessing ecosystem resilience under changing environmental conditions, investigating the impacts of fishing and invasive species, and analysis of site-specific environmental relationships and species interactions. Importantly, the data set also provides a baseline for research and monitoring associated with the Ross Sea region Marine Protected Area. This poster presents the latest Ross Island Adélie penguin population data, and highlights the value of long-term records of top predator abundance and distribution.
ANTARCTIC BIODIVERSITY AND RESILIENCE OF ECOSYSTEM FUNCTION
ANTARCTIC BIODIVERSITY AND RESILIENCE OF ECOSYSTEM FUNCTION

Tuesday 18 June 1330
Chair: Vonda Cummings

Biotic interactions in Antarctic terrestrial ecosystems: They ARE a factor

Charles Lee
Tancredi Caruso, Daniel Laughlin, Ian Hogg, Eric Bottos, Uffe Nielsen, Diana Wall, Byron Adams, Allan Green and Craig Cary

1 University of Waikato
2 Queen’s University Belfast
3 University of Wyoming
4 Polar Knowledge Canada
5 Thompson Rivers University
6 Western Sydney University
7 Colorado State University
8 Brigham Young University

Antarctic terrestrial ecosystems are generally viewed as predominantly abiotically-driven that harbour insignificant biotic interactions. Our inability to directly study biotic interactions in Antarctic soils contributes to this view. It is technologically challenging to observe at spatial scales relevant to soil organisms, and even more challenging to make such observations in situ over appropriate temporal scales (e.g., S. lindsayae has a life cycle >200 days). As a result, very little progress has been made since the need for more manipulative field and laboratory experiments was formally identified more than a decade ago.

Utilising the unprecedented collection of 500+ discrete samples from three Dry Valleys made available through the New Zealand Terrestrial Antarctic Biocomplexity Survey, we undertook modelling-based approaches to characterise the role of biotic interactions in shaping Antarctic terrestrial ecosystems. At the community level, our findings revealed that biotic interactions among functional groups are critical for explaining the structure of extant communities and likely a key driver of community assembly. For nematodes specifically, our results strongly support the existence of negative biotic interactions imposed by the most abundant species on other dominant species. Our results indicate that biotic interactions are an integral part of ecosystem assembly in terrestrial Antarctica.
Functional resilience of Antarctic microbiomes to climate-induced changes

Maria Monteiro¹
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The biological productivity of McMurdo Dry Valley ecosystems is driven primarily by microbial processes, which are limited by the availability of liquid water and extreme climatic conditions. Despite the increasing threats of climate change, the consequences of long-term disturbances on microbial ecological processes in Antarctica and its resilience are unknown, mostly since climatic change takes longer than direct observations would permit. Early signs of ecological change will likely appear as alterations of microbial physiology and ecology since microorganisms respond to physicochemical changes in the environment. Using a space-for-time approach to represent resilience, four wetness transects were sampled from the edges of Lake Brownworth in Wright Valley. We hypothesize that systems without historical hydrological changes (e.g., Lake Brownworth) harbor microbiomes well adapted to wet or dry conditions and are structurally and functionally different to systems subjected to annual hydrological changes where the microbiomes might be functionally heterogeneous and potentially more resilient. Through metagenomic and metatranscriptomic analysis, the levels of functional redundancy within the communities from Lake Brownworth will be assessed, and the capacity of current microbiomes to engage with future environmental change will be evaluated. Work of this type will help us to understand the fragility and resilience of polar ecosystems.
Some like it hot: genomes from an isolated Antarctic geothermal refugium

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Craig Herbold², Matt Stott³, Charles Lee¹ and Ian McDonald¹

¹ University of Waikato
² University of Vienna
³ University of Canterbury

Geothermal systems in Antarctica support a diverse microbiota and may have served as essential refugia for terrestrial organisms during periodic glacial maxima. As the most remote geothermal environments on the planet, they provide a rare opportunity to address questions around microbial biogeography and the interactions between globally distributed and endemic microbes. Despite their biological importance, these extremely remote geothermal locations remain vastly understudied. Tramway Ridge, an Antarctic specially protected geothermal area (elevation 3340m), located near the summit of Mount Erebus, is home to a unique and poorly understood community of micro-organisms. Here we provide the first metagenomic characterization of high-temperature fumarolic sediments, and the first from terrestrial Antarctica. We recovered 17 nearly complete genomes, representing 11 prokaryotic phyla/divisions to infer their role in the environment. Results demonstrate that the subsurface of Tramway Ridge is dominated by novel, possibly endemic deep-branching members of several bacterial phyla, and a single deep branching relative of the Thaumarchaeota. Based on its phylogenetic position and novel functional attributes we propose Candidatus Austellarchaeum erebusii to help infer the defining characteristics of the earliest Thaumarchaeota. A global comparative metagenomic analysis has revealed that the Mt. Erebus microbial community has retained a marine signature reflecting its early origin.
Rapid responses of Antarctic coastal benthic communities to recent sea ice breakouts

Drew Lohrer
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Seafloor organisms in Antarctica are important bellwethers of change, and there is empirical evidence of links between sea ice characteristics and coastal seafloor community structure. A major component of the food that feeds coastal seafloor organisms comes from diatom-dominated under-ice algal communities, which are affected by sea ice characteristics. Here we discuss results from New Harbour in 2009, when the sea ice had not broken out for more than a decade, relative to 2017, after recent sea ice breakouts. The quantity of detrital algal material in the sediment was ten times higher in 2017 than it was in 2009, rates of oxygen consumption measured in our seafloor incubation chambers were roughly three times higher in 2017 than 2009, and photos from 2017 and 2009 show an explosion of life in the intervening period (particularly arborescent bryozoans and Homaxonella sponges). These changes are likely a response to the recent break-outs of sea ice from New Harbour and show the importance of sea ice characteristics to seafloor biota and ecosystem functions. The relatively rapid transformation that was documented runs counter to the existing paradigm that Antarctic seafloor biotic communities are stable, long-lived, and slow growing.
Modelling responses in a key marine sea star to a changing coastal Antarctic environment

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Bruno Danis², Mary Sewell³ and Antonio Garcia Aguera²

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² Université Libre de Bruxelles
³ University of Auckland

Coastal waters of Antarctica are showing new physical conditions that can be linked to climate change, including warming and acidification. Understanding how marine species will respond and adapt to such change is an important question, which we examined experimentally in a model species, the abundant coastal sea star, *Odontaster validus*. For this, ≈600 individuals were flown to New Zealand live, where they were reared in the laboratory under controlled present-day and near-future (2100) conditions for two years. Experimental procedure involved raising the animals in ambient and reduced seawater pHT (8.12 and 7.65) at 5 temperatures ranging between (-1C and 4C). Over the two years, we followed responses in the adults in the form of measuring changes in their metabolism and morphometrics, and modelling their dynamic energy budget, which indicated changes in the allocation of resources to growth and reproduction under future conditions, but not survival. At the end of the experiment we also examined transgenerational responses to future conditions, in terms of the performance of the larval offspring (size and survival) from acclimated parents. Such experiments demonstrate how modelling of complex biological responses can be applied to predicting future outcomes of climate change in a range of Antarctic taxa.
Detecting range shifts in the remote Southern Ocean: First measurements for Oceania humpback whales

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Sufficient understanding of the current distribution of species is required to detect changes. Animal-borne loggers enable us to remotely monitor animal distribution in remote locations. We deployed 25 satellite tags on humpback whales at the Kermadec Islands to study their distribution patterns within their Southern Ocean feeding grounds. We applied a state-space model to identify behavioural states; transit, or search (indicative of foraging), and used statistical modelling and remotely sensed data to correlate whale behaviour with environmental parameters. We identified two important feeding areas, one within Ross Sea and one within the Amundsen and Bellingshausen Seas regions. There were marked differences in the environmental features of the two feeding areas (e.g. oceanic vs. near continental shelf) and consequently the whales ended up utilising these areas very differently. Overall, whale behaviour was most strongly affected by season, time lagged ice-edge dynamics, and sea surface height. The two feeding areas are experiencing different responses to climate change, which may elicit different responses from the whales. The observed behavioural plasticity should enable these animals to adapt to future changes, either by moving or prey switching, and with these first data on their distribution patterns within the Southern Ocean we can detect such changes.
27. Are Antarctic *Deinococcus* species unique?

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Members of the genus *Deinococcus* are known as multi-extremophilic bacteria. They are ubiquitous and found in diverse environments, including the Arctic, hot deserts, high-radiation sites, hot springs, the high atmosphere, and Antarctica. Two studies reported isolation of *Deinococcus* species from Antarctica. Three new isolates have been identified from sandstone, marble rock, and endolithic habitats samples in the McMurdo Dry Valleys (MDV), and one new isolate has been obtained from soils from Grove Mountains, Princess Elizabeth Land. All these isolates exhibited high resistance to ionizing radiation but are also phenotypically heterogeneous. The isolates from MDV are psychrophilic, and one isolate, *D. frignes*, is uniquely facultatively anaerobic among psychrophilic *Deinococcus*. Conversely, the isolate from Grove Mountains is mesophilic and aerobic. It is worth noting that isolates of *Deinococcus* from Antarctica exhibit a high level of resistance to ionizing radiation compared with psychrophilic *Deinococcus* strains isolated from non-Antarctic alpine environments, which exhibit very low capacities for radiation resistance. These observations show that *Deinococcus* are extraordinary bacteria that use diverse mechanisms to survive harsh environments. Comparative analysis of the ecological traits of Antarctic *Deinococcus* species with non-Antarctic strains can potentially shed light on the poorly understood ecology of the *Deinococcus* group.
28. Exploring variability in thermal tolerance capacities among populations of Antarctic springtails

Clare Beet¹
Craig Cary¹, Ian McDonald¹, Brent Sinclair² and Ian Hogg³

¹ University of Waikato
² Western University
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Assessing the resilience of Antarctic biota to climate change is integral to predicting the likely impacts of rising temperatures on the survival, diversity and distribution of Antarctic communities. Springtails are the largest terrestrial Antarctic invertebrates and are also sensitive to environmental disturbances, making them ideal biological indicators of climate change. The limited dispersal capabilities of springtails and consequent low levels of gene flow have created highly structured communities which present opportunities to test whether that diversity confers differential survival capabilities. Previous studies have identified two distinct COI lineages of the springtail *Gomphiocephalus hodgsoni* within Taylor Valley and postulated that the currently dominant upper valley lineage is more cold adapted while the coastal lineage more warm adapted. This project aimed to test this idea through physiological analyses of populations from an upper area of Taylor Valley and a coastal population from Botany Bay. Our preliminary data demonstrate that indeed the coastal population has on average higher upper thermal limits, although there also appears to be diurnal variation in thermal tolerance capacities. These findings highlight the potential that as temperatures rise, warm adapted populations may start to proliferate at the expense of cold adapted groups leading to overall changes in community structure.

29. Fussy feeders or fallacy? Investigating the prevalence of prey preference in killer whales, globally and in the Southern Ocean

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Killer whales (*Orcinus orca*) are a cosmopolitan species, currently represented by ten ecotypes that are differentiated by variations in morphology, hunting techniques, genetics, and prey preference. This
study examined killer whale diet to understand whether there are discrepancies between each ecotypes perceived preference and the species they have been observed consuming. To do so, a meta-analysis was carried out that analysed data from 60 papers published during 1969-2018. I found that killer whales predated on 159 different species overall, with only the Northern Hemispheres Resident ecotype displaying definite specialist traits. The Southern Ocean ecotypes predated on 30 different species in total, with 56% of those lying outside their perceived preferences. This work suggests that while there are some distinct differences between the ecotypes globally, prey preferences of killer whales were often less restrictive than generally presumed within conventional knowledge. As the apex predator in many of the worlds oceans, the species hold significant influence over the health and structure of their surrounding ecosystem. Further research into the prey each ecotype consumes, and how these may be impacted by climate change and anthropogenic threats, is a crucial step in understanding the conservation needs of this keystone species.

30. The use of active acoustics to study and monitor mid-trophic level organisms of the Southern Ocean and Ross Sea pelagic ecosystems

Yoann Ladroit
Pablo Escobar-Flores and Richard O’Driscoll

Mid-trophic level (MTL) organisms play a key role in pelagic open-ocean marine ecosystems, linking primary and tertiary consumers. Despite their importance, our knowledge of MTL organisms is still very limited.

Active acoustic data collected in the New Zealand sector of the Southern Ocean has provided valuable information for studying MTL organisms in the region. Acoustic backscatter, a proxy for MTL organisms, has been used to study the variability of their abundance and describe large scale horizontal and vertical distribution patterns. The data has also been used to develop explanatory and predictive model for acoustic backscatter for the epi- and mesopelagic zones, which provide a tool for inferring abundance and distribution of MTL organisms. Likewise, combining acoustic data, biological information and target strength values from the literature and modelling, the first estimates of density MTL organisms were obtained. This information can feed regional trophic or ecosystem models that incorporate the MTL on their framework.
Our research has established excellent baselines for detecting and monitoring changes in the MTL organisms and Southern Ocean ecosystems. Ongoing data collection initiatives continue providing valuable data and futures studies will focus more on the Ross Sea area and the identification of species using multi-frequency techniques.

### 31. Cyanobacteria Resilience to Pond Ecosystem Changes on the McMurdo Ice Shelf, Antarctica

**Francesca Mills**¹
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¹ University of Waikato

The McMurdo Ice Shelf (MIS), located in the north-west corner of the Ross Sea Region, is dominated by cyanobacteria which are the major contributors of ecosystem productivity and biomass, and provide habitat for other organisms. Terrestrial aquatic environments such as the ephemeral ponds of the MIS are at risk of changes in ice cover, salinity and water-level. These changes will impact resident organism communities through altering levels of UV radiation, electrical conductivity and desiccation.

This research aims to establish whether cyanobacteria communities in the Bratina Island ponds are resilient or resistant to environmental change. Through manipulating UV radiation, electrical conductivity and mat disturbance cyanobacterial productivity can be used to identify potential community change, representing community resilience and structural changes. Community structure will be identified through microscopy and DNA sequencing adding to the baseline knowledge on the community structure of these ponds. Through establishing baseline community structure, future studies can identify changes in pond communities, furthermore, knowledge of the resilience of cyanobacterial communities may improve the understanding of the future for medium-sized ephemeral Antarctic pond communities.
32. Testing environmental tolerances of Antarctic non-marine biota inferred from eDNA, using laboratory cultures

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Studies of Antarctic microbes have often used eDNA to determine their distributions and relate these to environmental predictors. We tested the inherent assumption that environmental drivers of community composition are detectably reflected in the distributions of biota. The distributions of seven non-marine Antarctic organisms were inferred using eDNA analysis of 250 samples, and their growth kinetics under different conditions were characterized in laboratory strains. The test organisms included a cyanobacterium, a heterotrophic bacterium, two eukaryotic algae, two fungi, and a moss, with nematodes as a reference.

The two chosen bacteria and some nematodes were common in samples, but the other eukaryotes were rare. Performances of the latter were therefore compared to the inferred tolerances of their wider taxonomic groups. Salinity, maximum temperature, and growing degree days (accumulated time above 0°C) were inferred as most important.

Four laboratory growth experiments of up to 45 days each revealed some complex responses to treatments; for instance, a simulated guano addition had a negative effect on several strains, but only if salinity was otherwise low, and the positive effect of maximum temperature was mitigated by time spent frozen. In general, however, results were concordant with inferred tolerances, providing support for eDNA approaches.
Classification of Antarctic terrestrial lake and pond systems is mainly based on their size and morphology, as this influences the volume of liquid water, its chemistry and the habitat provided for aquatic life. However, the research underpinning this classification pertains mainly to small ponds, which freeze and thaw each year, and large perennially ice-covered lakes. There is currently little information on what might be termed medium-sized water bodies. In January 2019, medium-sized water bodies in a valley off the northwest margin of the Koettlitz Glacier, were investigated; Ward Lake (950m diameter), Burt Lake (735m) and Keyhole Lake (376 m). All were relatively shallow (<4m) with a predominantly frozen water column at the centre, but only Burt Lake was frozen solid, without liquid water or cyanobacterial mat development. Ward and Keyhole lakes had horizons of water-laden, candled ice within solid lake ice, moat and mat development and a thin layer of liquid brine at the very base of the lake ice. These observations, together those of inflow/outflow regimes and previous lake levels as evident in the valley walls, can help us understand how the interactions of topography and temperature ultimately influence biological productivity in medium-sized pond/lake systems.
34. Environmental drivers of diversity in Antarctic terrestrial plants and animals

**Pamela Olmedo Rojas**¹
Miles Lamare¹, Neil Gemmell², Ceridwen Fraser¹

¹ Department of Marine Science, University of Otago
² Department of Anatomy, University of Otago

To understand the evolution of Antarctic plants and animals, we must determine how and if they disperse into and out of the region, and how they survived recent glacial maxima. In a new PhD project, genomic analyses will be combined with spatial environmental analyses to investigate the key physical factors influencing the dispersal of organisms into and around Antarctica. Similar approaches will also be used to assess the importance of geothermal and other refugial areas in maintaining diversity. We will use intraspecific data for mosses (exon-capture), and interspecific data for soil eukaryotes (metabarcoding), to resolve diversity and connectivity patterns.
35. Biological dispersal to the Antarctic

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Antarctica has long been considered biologically isolated. Molecular studies are, however, starting to indicate that movement into Antarctica has probably occurred, at least occasionally, since the breakup of Gondwana. Our interdisciplinary (genomic and oceanographic) research shows that that kelp rafts and other surface-floating organisms can, and frequently do, drift across the Southern Ocean to reach Antarctica. The unique ecosystems of Antarctica are therefore probably more a consequence of environmental extremes in the region than of isolation. With warming, we can expect to see successful establishment of numerous non-Antarctic species, even without human-mediated transport of organisms to the region.
CRYOSPHERE DYNAMICS
How does Antarctica cool itself? Exploring the far-infrared outgoing radiation

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Not knowing how the world’s highest, driest and coldest continent cools itself, erodes our confidence in model simulations of its response to rising greenhouses gas concentrations. Antarctica, like all continents, cools itself by emitting radiation. About half of that emission is in the far-infrared (\(\lambda>15\mu m\)). While other regions also emit at these wavelengths, much of that radiation is absorbed by water vapour and re-emitted back to the surface. Antarctica’s extremely dry atmosphere allows this far-infrared radiation to escape to space, providing an efficient mechanism to cool itself. Disturbingly, the surface emissivity spectrum, a key input to reliably simulating this Antarctic cooling, is poorly known.

In the absence of measurements of outgoing far-infrared radiation needed to infer the surface emissivity spectrum, climate modellers have assumed values of 1.0 beyond 15\(\mu m\). Cognizant that this assumption is a primary source of uncertainty in model simulations of the evolving climate of Antarctica, researchers in the USA and Europe plan new measurements of the far-infrared outgoing radiation spectrum above Antarctica. In close collaboration with the ESA and NASA teams developing the space-based missions, we are developing a project to scientifically support those missions and design and perform a validation campaign above the Antarctic continent.
The distribution and evolution of supercooled water in McMurdo Sound

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Supercooled water (i.e. colder than in situ freezing temperature) results when ice shelf meltwater rises and therefore finds itself subject to reduced pressure. Supercooling has been identified beneath the fast ice at many locations throughout McMurdo Sound, and is frequently associated with accumulations of platelet ice crystals at the sea ice base.

Over the past three field seasons, we have focused on the river of supercooled water that flows through Western McMurdo Sound (>50 m deep and up to 30 km wide) - ultimately sourced by oceanic melting of the Ross Ice Shelf. Here we present spatial distributions of the water column structure in which temperature profiles are normalised by their ice growth potential. We relate this to active quenching of supercooling along its northward flow path by ice growth either onto accreted crystals that form the sub-ice platelet layer, or onto the tiny ice crystals that are held in suspension within the water column.

Future work will explore the role of the platelet layer as a habitat, the significance of the interface structure for representing ice-ocean interactions numerically, and the longer-term implications of changes to meltwater provenance and fate under future climate scenarios.
Airborne measurements of land-fast sea ice thickness in the SW Ross Sea

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The Victoria Land coast is fringed by land-fast sea ice that interacts with ice shelves and floating ice streams, resulting in the presence of a sub-ice platelet layer (SIPL) as an indicator of supercooled ice shelf meltwater at the ocean surface. Airborne electromagnetic induction (AEM) sounding characterises the presence and thickness of sea ice and its SIPL. An extensive AEM survey was conducted in November 2017, off the coast of Victoria Land with a fixed-wing DC-3 aircraft. Fast ice between Terra Nova Bay and the Adare Peninsula was more than 2 m thick and heavily deformed by onshore pack ice drift. A SIPL, up to 2.5 m thick, was observed in front of the Hells Gate Ice Shelf beneath 2 m of level sea ice. The land-fast ice in McMurdo Sound was also mostly level and more than 2 m thick. It was underlain by a well-documented SIPL, with maximum thickness of more than 6 m near the ice shelf edge, in good agreement with in-situ measurements. Our results have important implications for understanding and modelling ice shelf melt, and for the role of the fast ice/platelet ice system in biological productivity, the ecosystem and carbon fluxes in the region.
How do increased Southern Ocean freshwater fluxes affect sea ice over a 150-year period?

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To examine potential future impacts on sea ice area and feedback effects on climate (e.g. surface air temperatures in both hemispheres), we ran three climate model scenarios with enhanced freshwater outflow from Antarctic ice sheet and ice shelves in CCSM4 starting in 1980. We chose a base year of 1980, when we assumed Antarctic ice sheets were in mass balance, and then added freshwater fluxes to give the approximate equivalent of 3 m of sea level rise over a 150-year period. Sea ice area increased for the first half of the period and then turned around and declined through the end. Branched runs were carried out to test the persistence of the response, one without the additional fresh water and latent heat effects and the other where the freshwater was held constant at the point where sea ice area behaviour turned around. Another two shorter runs were carried out, starting in 1850, with ramped freshwater and with latent heat effects included under historical greenhouse gas forcings and with greenhouse gas forcings held constant at 1850 levels, respectively. This was to separate out the effects of greenhouse gas forcings on the ramped freshwater and latent heat effects over long time periods.
Rapid, Dynamic Mid-Holocene Thinning of David Glacier, Antarctica

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Here we present the first high-resolution, terrestrial thinning reconstruction for David Glacier, the largest East Antarctic outlet glacier in Victoria Land. Thinning profiles from two sites, Hughes Bluff along the Scott Coast and Mt. Kring situated at the margin of the East Antarctic Ice Sheet, show that David Glacier experienced rapid, dynamic thinning of up to ~2m/yr during the Mid-Holocene. Regionally, this dramatic thinning event correlates with rapid ice surface lowering and retreat from stable marine configurations at nearby outlet glaciers (Mackay, Mawson and those within Terra Nova Bay) along the Transantarctic Mountains (TAM). Together, this shows that the outlet glaciers along the Scott Coast, western Ross Sea experienced rapid, simultaneous, and regional thinning. The cause of this dramatic change is currently not clear but takes place ~2 kyr after southern retreat of grounded ice in the Ross Embayment. Potential mechanisms for regional outlet glacier thinning and retreat include a previously unrecorded influx of marine heat, marine ice sheet instability and/or dynamic effects associated with early Holocene decoupling from retreating ice sheet/shelf. Importantly, these events are currently not captured in numerical modelling reconstructions aimed at understanding the processes that impact the past, present and future behaviour of the AIS.
Rapid Ross Sea deglaciation as captured in the RICE ice cores

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Rapid deglaciation of the West Antarctic Ice Sheet (WAIS) remains a critical uncertainty in global sea level rise projections, with the potential to affect hundreds of millions of people. On 4 November 2016, the United Nation Framework Convention on Climate Change Paris Agreement came into force with the ambition to limit global warming to 2°C above preindustrial levels. But is that sufficient, or are we committing the WAIS to irreversible collapse, adding >3 m to global sea level? Here we present new insights from the well-dated, 9-nation Roosevelt Island Climate Evolution (RICE) project ice core, drilled at the northern edge of the Ross Ice Shelf, a major drainage pathway of the WAIS. Data presented here capture the past 68 ka including the warming following the last glacial period into the Holocene. We find that atmospheric circulation changes precede the onset of the Antarctic Cold Reversal (ACR) by about 200 years. Moreover, RICE leads the WDC onset of the ACR by about 300 years. The total RICE isotopic warming from the Last Glacial Maximum (LGM) to the early Holocene is 50-200% higher than existing Antarctic ice core records, indicative of rapid elevation changes and regional warming.
36. Spatial and temporal variability in the sub-ice platelet layer near an Antarctic ice shelf

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Spatial variability in the distribution and thickness of ice shelf influenced land-fast sea ice and the sub-ice platelet layer was investigated in McMurdo Sound in 2011, 2013, 2016, 2017 and 2018 with single-frequency, ground-based electromagnetic induction (EM) and drill-hole surveys. Stationary EM surveys were carried out at a sea ice mass balance station near McMurdo Ice Shelf to assess the temporal evolution of the sub-ice platelet layer overwinter in 2018, and in the main path of Ice Shelf Water outflow over a Spring-Neap cycle in late Spring. Interannual variability was apparent with thicker sub-ice platelet layers observed in years influenced by multi-year ice regimes and when winter fast ice formation was subject to strong southerly wind events and polynya-activity. Over shorter timescales (days and weeks), EM surveys detected significant changes in the thickness and distribution of the sub-ice platelet layer. The variability observed in the sub-ice platelet layer indicated that a combination of the tides, wind-driven polynya activity and the presence of multi-year ice influences the circulation of Ice Shelf Water and consequently the evolution of the sub-ice platelet layer over a range of timescales.
Here we present active-source seismic observations on a fast-flowing shear margin in the lower-stream of the Priestley Glacier, Antarctica. Four strings of geophones were deployed parallel or perpendicular to the ice flow direction. The geophones recorded the seismic waves from seventeen separated explosive sources, where each source was buried at the depths of ~2 m. We extracted the direct ray-path P-wave and S-wave arrival times and shear wave splitting (SWS) parameters from the raw geophone measurements. The regional seismic anisotropy was quantified from the P-wave and S-wave velocities and the SWS parameters relative to the ray path azimuth. These data were compared with the velocities and splitting parameters expected for different ray paths, as generated from forward models of the polycrystalline elastic stiffness tensor based on experimentally deformed ice. The result shows that the fast-shearing margin in the Priestley Glacier is dominated by a CPO with the c-axis clustered perpendicular to the shear plane. This CPO is likely to be critical in controlling the rate of marginal deformation associated with further glacier flow and ice shelf break-up. The result suggests that it is essential to consider the anisotropic ice CPO in ice-sheet modelling to predict the future sea level.
38. Comparison of sea ice drift using high-resolution satellite images with low-resolution data in the Ross Sea, Antarctica

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Sea ice drift is a key driver of spatiotemporal variations in sea ice area, concentration and thickness distributions. Consequently, drift affects roughness, the surface albedo, moisture and heat fluxes between the ocean and atmosphere, the freshwater budget and sea ice melt & growth rates. Furthermore, for accurate representation of sea ice in climate models, realistic parameterization of the sea ice motion and deformation rates are required. This study uses sequential high-resolution Synthetic Aperture Radar (SAR) images to calculate the sea ice motion in the western Ross Sea region. In this region, the most significant increase in sea ice extent has been observed in recent decades. By combining the available low-resolution sea ice motion vectors with high resolution drift data, we can quantify the uncertainties of satellite derived sea ice dynamics. The drift velocity is calculated in centimetre per second using phase correlation technique. The images are down sampled from 75m to 150m spatial resolution. The outcome is validated from manually drawn vectors. Here we present the results of a case study for a one-month period.

39. Winter sea ice growth rates from a sea ice mass balance station

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Predicting the response of Antarctic sea ice to a warming world is a complex undertaking as the linkages between enhanced basal melt from cold cavity ice shelves and the thickness and extent of proximal sea ice are not fully understood. The relatively buoyant meltwater is known to
flow out from beneath ice shelves at shallow depths where it interacts with a thickening sea ice cover over the winter growth season. The meltwater is supercooled and can sustain populations of frazil crystals that are deposited at the sea ice / water interface. The distribution of frazil crystals is not uniform and is known to vary substantially over scales of tens of kilometers. We have developed a first-of-its-kind sea ice mass balance station to monitor winter sea ice and sub-ice platelet layer thickness changes. The station integrates standard sea ice mass balance componentry (sea ice temperature and snow sensors) with a Geonics EM31 electromagnetic sensor that can estimate the thickness of the sub-ice platelet layer. Data are collected by a Campbell Scientific datalogger and relayed back to New Zealand in near real-time where it is displayed on the University of Otago’s sea ice mass balance station website (seaice.otago.ac.nz).

40. Pack-ice thickness in the Western Ross Sea from airborne EM measurements

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Ice thickness is the major uncertainty in the assessment of Antarctic sea ice mass balance. Although sea ice concentration and extent are relatively well known from satellite observations, we lack knowledge of thickness to convert area to mass. This is important because the positive trend in sea ice cover in the Ross Sea might be linked to a change in sea ice mass. The production of high salinity shelf water and Antarctic bottom water might therefore have changed, impacting region-wide oceanic circulation and land-ice mass balance.

As satellite-based estimates of ice thickness are problematic, we conducted, partly along satellite tracks, airborne measurements over pack ice. This allowed us to assess ice thickness and morphology near the McMurdo Sound and Terra Nova Bay polynyas. We used airborne electromagnetic induction sounding, deployed from a DC-3 aircraft, simultaneously with a LiDAR and camera.
We observed strong thickness gradients from the polynyas towards the central Ross Sea, with surprisingly thick, deformed sea ice (more than 4 m) where ice exported from the polynyas converges. We present a comparison with satellite measurements and in addition we highlight the requirement for additional missions in conjunction with a snow radar to separate consolidated ice from snow.

41. Rapid regional-scale ice-surface lowering at 6.5 ka in southern Victoria Land, Antarctica

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The observational record of outlet glaciers in Antarctica covers the last ~50 years. This decadal record is insufficient to address the long-term stability of outlet glaciers in Antarctica. Ice sheets adjust and respond to external forcings on the centennial to millennia time scale. Augmenting the observational record with geological dating, we can better understand the timing, rate, and magnitude of changes to these complex systems and better model their response to natural and anthropogenic climate change.

Cosmogenic surface-exposure dating of rocks deposited by outlet glaciers provides insight to the style and rate of change for outlet glacier surface-elevation through geological time. A sampling campaign to southern Victoria Land in 2016 produced two robust, high-resolution age-elevation transects for a large outlet glacier draining the East Antarctic Ice Sheet along the Transantarctic Mountains.

We present 29 10Be ages with clear and consistent evidence for rapid ice-surface lowering at ~6,500 ~700 years ago. This new ice surface elevation chronology from Mawson Glacier is temporally indistinguishable from previous work conducted nearby at Mackay Glacier. Together, these data sets show synchronous, non-linear behavior of two spatially distinct outlet glaciers, which may provide critical insight to regional Holocene ice sheet history in southern Victoria Land.
42. Tidal variability of ice dynamics in the grounding zone of the Priestley Glacier, Antarctica

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Tidal variations in the flow-velocity of glaciers regulate the rate of Antarctica’s ice discharge into the ocean. The mechanism behind tidal modulation of ice discharge across the grounding line, however, remains poorly understood. This lack of consensus across the scientific community means that tidal variability is not yet parameterized in Antarctic-wide ice sheet models, directly affecting the reliability of predictions of future ice loss. In November 2018, we therefore deployed a high-precision radar system (TRI) on the Priestley Glacier, Antarctica. This imaging radar system bridges the gap between rare satellite imagery covering the entire grounding zone area, and point measurements on the glaciers surface of high temporal resolution. We use this unique data set to constrain a state-of-the-art numerical model of tidal ice dynamics, and to identify the mechanism behind short-term modulation of ice discharge. Although the Priestley Glacier is a small, little-studied glacier, it is representative of many outlet glaciers that drain Antarctica into the Ross Sea. If we are to better predict the rate of sea-level rise in an ongoing climate change, fully understanding of tidal modulation of ice dynamics is vital for estimating future ice loss with confidence.
ANTARCTIC
PEOPLE AND
PLACES
Inclusive Antarctic Engagement:
The artist as disrupter in Antarctic Science Communication, Education and Research.

Gabby O’Connor¹

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Enhancing how Antarctica is “valued, protected and understood” requires new ways of connecting science and the environment with the people of New Zealand/Aotearoa. Art is a highly effective delivery system to make this connection. Such creative problem solving provides a way forward in dealing with a changing scientific understanding, industries, social perspectives and climate. Despite this, art is seen as ‘nice but not necessary’ - especially in the context of the growth of STEM subjects as the focal points for education? In this talk I will describe past, present and future art-based initiatives designed to enhance stakeholder’s understanding of science and the environment. This provides examples of how art acts as the perfect cross-over world-view for generating (i) research, (ii) engagement, (iii) education and (iv) marketing.
Media and public perceptions of sea level rise in Aotearoa New Zealand

Rebecca Priestley¹
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Antarctic ice melt could contribute one metre or more of sea level rise by 2100. In this talk, we report findings from a research project associated with the NZ SeaRise programme. Analysis of sea level rise coverage in New Zealand print media from 1980 to 2018 focuses on the way the media has (i) quantified the amount, timing and rate of sea level rise projections, (ii) identified quote-worthy sea level rise experts and (iii) made connections to Antarctic ice melt. A public survey explores public understanding of the mechanisms of sea level rise, and the amount, rate, and timing of sea level rise expected this century. Results of this work will have value for scientists communicating about Antarctic ice melt, sea level rise, and climate change more broadly, in the years ahead.
The resilience of the Antarctic Treaty Systems mechanism for controlling access into and out of Antarctica will be tested by pressures such as increasing visitors, risks to the Antarctic ecosystem from pests and diseases as the climate warms and positioning for post-2048 mining.

While Article IV of the Antarctic Treaty removed the concept of borders from the Antarctic Treaty System (ATS), the ATSs bespoke access mechanism in effect encircles Antarctica with a type of boundary security. The provisions of Article VII and the five gateways that funnel traffic to the continent are central to its current effectiveness.

This paper argues that the flows of goods, people and craft to and from Antarctica could get distributed beyond the five gateways in the future, requiring a more holistic consideration of Antarctica’s boundary security a consideration that has been limited by an absence of specific boundary narratives. The paper draws on narrative and border studies concepts to interrogate, analyse and provide suggestions for future Antarctic boundary security. It compares the Antarctic boundary security mechanism with state-based border control systems and analyses the implications from the similarities and differences, setting the scene for future research on boundary narratives and human engagement with Antarctica.
Antarctic ambassadorship: An elusive concept?

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A significant amount of scholarly attention has been given to Antarctic tourism, particularly to its characteristics, management and regulation, but research on whether a significant number of tourists return from Antarctica as ambassadors for the continent, as claimed by many tourism operators, is currently largely absent. Such research would require an understanding of the ambassadorship concept. It would also require understanding of the process spanning anticipation of the visit, onsite experience and behaviour, the benefits realised through recollection, and whether the Antarctic experience is significant enough to result in a shift of values, and consequently behaviour, after the return home. With increasing conflict between human use and conservation in the marine and terrestrial Antarctic environments, a better appreciation of the potential for Antarctic ambassadorship will be imperative for the effective management and regulation of Antarctic tourism, especially when considering an expected future growth of tourism numbers in the Antarctic. Our presentation will discuss the results of (a) a Delphi study on ambassadorship in Antarctic tourism and (b) a two-day workshop, which investigated our current state of knowledge regarding the concept of Antarctic Ambassadors and identified areas where further research is required.
Antarctica is now host to a vast range of increasing human activities posing significant threats to the terrestrial, limnological, and marine environments. It is therefore essential that effective and future proofed environmental policy remains apace. Research towards the improvement of the science-policy interface will be central to this process. The aim of this paper is to examine Antarctic stakeholder perceptions around the interaction of Antarctic science and policy, and to offer solutions for strengthening this nexus. Based on empirical data gathered from a survey that reached over 200 members of the Antarctic community, a number of themes and trade-offs have been identified that impact on the credibility, legitimacy and relevancy of the science-policy interface. The most prevalent theme was a lack of communication and trust between scientists and policy makers, and three trade-offs have been identified: 1) Personal Time trade-off; 2) Push-Pull trade-off; and 3) Funding-Relevance trade-off. In response to these findings, four future developments are suggested to strengthen the science-policy interface: incentive rewards, a training programme, improvements to the Antarctic Environments Portal, and the application of virtual reality. This study is a starting point for further examination of the fundamental interaction between Antarctic science, and policy action.
Antarctic Data Analysis - A visualisation tool to support Antarctic policy

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Providing the Antarctic policy community, the tools and knowledge to support environmental management is critical for both the health of the Antarctic environment but also the Antarctic Treaty itself. This presentation will introduce a tool that we have designed to provide context to, and assist, the Antarctic Policy community in the planning, permitting, and implementation of Antarctic activities. The tool, which has been developed with input from the Antarctic Policy community, used scientific data to provide insight into the environmental pressures facing the Antarctic continent. The resulting tool is based on the established principle of a spatial decision support system, an interactive approach that provides knowledge to support management using analysis of spatially explicit data. We expect that this tool would be utilised to enable the conservation of the Antarctic continent, and hope that new data will be included in the tool from the New Zealand Antarctic science community.
43. Waste Management at Antarctica New Zealand

Natasha Gardiner¹

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Antarctica New Zealand has developed, and implements, high-quality environmental standards and procedures in order to demonstrate leadership in environmental management across all activities in Antarctica and New Zealand. An extensive waste management system has been developed to support this high standard of environmental protection and stewardship. The main objective of the system is to minimise, reuse, and recycle the waste generated, and to ensure it is stored, removed, and disposed of, with minimal environmental impact. A number of long-term monitoring projects are in place to temporally measure the performance of the system and identify areas of weakness. Improvements to the system are developed in accordance to findings. The purpose of this poster is to share Antarctica New Zealand’s waste management system with the Antarctic community including: current processes, statistics on performance, and future plans for improvement. Continual improvement, and the sharing of information, are fundamental to Antarctica New Zealand’s approach to environmental management. By creating transparency and sharing our waste management strategy, we hope to foster awareness and raise environmental standards within the Antarctic community, particularly stakeholders that benefit from our logistical support.

44. Meetups: citizen scientists’ SciComm

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In the age of climate change, effective science communication (SciComm) is more important than ever. Reduction of carbon emissions demands painful changes in our societies and economies. Scientists speak with authority and reason into a debate often muddied by emotion, disinformation and misunderstanding.
As a citizen scientist I initiated the Auckland Antarctic Science Meetup in 2017 to facilitate interactions between Antarctic scientists and those curious to understand what research NZ scientists are conducting in Antarctica and the Southern Ocean, and what the implications of the findings might be for everyone in NZ.

Using the Meetup platform and a linked FaceBook page we have built a growing community of more than 300 people, ranging from schoolchildren and students through to the retired, some with a science background, many not. Past topics include marine biology, geology, microbiology and climate change through to conversations with returning winter-over staff. Audiences are very engaged, with lively question sessions. The human interaction between passionate scientists and engaged citizens helps the communication of the core messages.

Meetups represent a powerful, flexible and low-cost addition to the SciComm portfolio, recruiting ambassadors for Antarctica, providing a reliable source of knowledge to the public, connecting citizens and scientists.

45. Polar Impact: Youth experiences in the Polar Regions and their future behaviour

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Although recent studies hint that youth interactions with nature may influence their environmental attitudes in later life, no study has gone beyond the immediate evaluation of such programs to understand the subsequent development of participant values and actual behaviours in the longer term.

This empirical study of real-world impact assesses the effect of youth polar travel experiences on participants behaviour, in some cases, up to 18 years after their polar voyage. Further, this research explores how such adventurous education programs can act as a stimulus to influence lasting behaviour.

In partnership with Students on Ice (SOI), a Canadian-based charitable organisation that leads educational expeditions to the Polar Regions for international high school and university students, participants were
recruited from their 2,500+ alumni to complete an online survey. A mix of quantitative and qualitative analysis is used to analyse participant’s travel patterns, levels of connection to nature, and subsequent travel and lifestyle behaviour decisions.

This presentation will report on the preliminary findings of the research and will traverse topics such as the extent to which time (after visiting) strengthens/dilutes alumni’s pro-environmental behaviours as well as key factors that underpin connections to polar landscapes (including cultural landscapes) within the short-term visitor experience.

46. The benefits of visiting last chance destinations on tourists’ pro-environmental behaviour

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Last-chance tourism is a rapidly growing type of travel for tourists seeking non-consumptive experiences with animals and land/seascapes that are vanishing. However, travel to such threatened areas, like the Polar Regions, raises the spectre of tourists loving an already dying destination to an early death. Though recent studies hint that the increased connection to nature fostered by tourism can prompt visitors to provide philanthropic support for conservation, no study has measured the role of travel on these behaviours.

Collaborating with two leading UK adventure travel tour operators, this mixed-methods research examines the role of perceptions of last-chance tourism and greater connection to nature in explaining how travel can increase pro-environmental behaviour (focusing on philanthropy). Quantitative and qualitative analysis of 924 respondents’ travel patterns, donation histories and levels of connection to nature were analysed to assess the value of travelling to conservation.

Travel to last-chance destinations was associated with the greatest philanthropy to conservation, when compared to other international and domestic trips in nature. Further analysis reveals several factors that underpin emotional connections to Polar environments within the short-term tourist experience.

This study facilitates greater collaboration between the tour operator and non-profit sector to more effectively meet their financial conservation goals.
47. A changing cultural climate: harnessing the value of artists working in Antarctica

Adele Jackson

1 Gateway Antarctica

The first decade of the 21st century saw a dramatic increase in the number and diversity of visual artists working in Antarctica. This was in large part due to: increased numbers of National Antarctic Programmes supporting artist residencies; collaborative projects during the International Polar Year (IPY); and opportunities created through tourism and independent ventures. In the last two years the numbers of artists being supported to work in Antarctica has declined to startlingly low levels. In this paper I will argue strongly that artists are a vital presence in Antarctica. Using early findings from my international research project, which examines the value of visual artists working in Antarctica, I will highlight the value to science and society of artists presence in Antarctica. I will conclude with some observations on how we might reverse the trend of decline.

48. New Zealand Antarctic Society

Linda Kestle

Peter Barrett, Nicholas O’Flaherty, Bill Nye

1 President, Unitec Institute of Technology, Auckland
2 Patron, Victoria University of Wellington, Wellington
3 North Island Vice-President, The Antarctic Report, Auckland
4 South Island Vice-President, Adventure Books, Oamaru

The New Zealand Antarctic Society is one of the oldest in the world. The first meeting in November 1933 was convened by Wellington businessman Arthur Leigh Hunt and Antarctic adventurers Rear Admiral Byrd and Douglas Mawson to discuss the future of Antarctica. It became a moving force on the Government of the day to commit to the International Geophysical Year and the Commonwealth Trans-Antarctic Expedition. Today it comprises over 300 members that connect through their common interest in the Antarctic region. It communicates through its website and Facebook page, regular branch meetings and other events, and its magazine Antarctic, published quarterly since 1956. It runs an Oral History project and contributes to discussion on issues of the day including climate change.

The Society brings together people with experience and expertise in Antarctica and the Southern Ocean to share their knowledge and
stories, and to inform and educate the public. It is a strong advocate for maintaining and enhancing the quality of NZ’s research in Antarctica and the Southern Ocean, and for experienced leadership to achieve this.

49. Meditations on ice: Antarctica’s impact on the human psyche

Sean McBride

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Antarctica elicits a strong spiritual response in tourists and visitors and these responses often include feelings of awe and humility. This paper examines theories that may explain this response. A comparison is made between four Darwinian based theories of landscape psychology and the predictive ability of each theory is applied to the expected experience of people viewing Antarctic landscapes and compared to the general results of surveys of actual experiences of Antarctic tourists/visitors. In contrast to these theories, based as they are on an idea that humans are adapted to an ancestral environment, one researcher found the anomaly that Tundra was highly preferred in his study. Antarctica has many similarities to Tundra. The mechanism for this preference is not understood considering that Tundra would not logically be considered a prime habitat for humans. Psycho-evolutionary theory, Attention Restoration theory and Prospect Refuge theory fail to predict the experiences of Antarctic visitors whereas Attention Restoration theory has potential for understanding the Antarctic experience and can deal with the Tundra anomaly as well. The implications of this are discussed in relation to tourism and the Antarctic research stations. Some recommendations for further research are outlined.

50. Three-Dimensional-Printing of habitable buildings in Antarctica. Feasibility of additive manufacturing techniques as a sustainable construction method for extreme environment

Dian Munoz and Alicja Podemska

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Additive manufacturing techniques are being used for prototype residential and commercial building construction globally, in urban and rural settings under normal condition environments, and demonstrating
a cost-effective, low-maintenance construction solution. Technological advancement of 3D printers is resulting in the generation of naturally inspired geometric designs by printing multiple materials at upper micrometre resolutions. 3D printers and digital modelling designs are also facilitating testing of new bio-inspired composite materials, which aim to simulate structural and multifunctional abilities of natural materials, yet achieve high mechanical resilience, reliability and environmental compatibility in complex engineering applications. Can these innovative techniques be incorporated into constructing habitable buildings in extreme environments? The mixed-method research initially explored the benefits and disbenefits of current construction methods in extreme environments, as well as how hostile environments condition the architectural and structural design of habitable buildings. The literature review and analysis was focused on relevant publications regarding additive manufacturing technologies, 3D printing as a sustainable construction method, and the feasibility of these innovative techniques in extreme environments.

Key words: 3D printing, bio-inspired composites, construction, extreme environments, habitable structures, temporary shelters, transportable structures.

51. Mapping Antarctica - a historical approach from early days to satellite imaging

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Gateway Antarctica, University of Canterbury

The purpose of early mapping was to show the world as it was imagined and demonstrate the status of the map maker and his purchaser. The Enlightenment changed this view of the world. The first attempts to draw functional maps in the far South date back to the early explorers in the 1770s to 1850s. Cooperation in research and mapping of the Antarctic started with the First International Polar Year (1882 1883) and continued through the international activities in the Antarctic in 1900 1904. Significant revolution in mapping emerged through the use of aeroplanes, and then came the view of the world from space. Maps and their modern Google type counterparts serve many different purposes and it is interesting and important to ask how maps will develop into the future.

The poster is based on a book chapter in The Routledge Handbook of Polar Regions, published in 2018 about mapping the Antarctic and showing the development of different focuses over time up until the present day.
52. Portrait of Antarctica - Artwork as Communication

**Tatyana Kulida Shelley**

1 *Self*

Portrait of Antarctica body of work is a series of paintings, drawings and sculptures, which through visual media are describing the complexity and breadth of work carried out in Antarctica. Through a series of interviews with Antarctic scientists, activists and policy makers I am fleshing out the network of effort with the goal to transform the science and related roles into visual stories that connect to the broader public on a very personal level in New Zealand and beyond. Further, the project is aimed to contribute to shaping a sustainable future for our children’s generations, transcending current research, numbers and cautionary tales into sitters life commitments and personal stories, life-long passions all coalescing into the cumulative portrait of the monumental effort required to make the change. Through appealing to human emotion and sense of unity required to mitigate the threat of radical Climate Change I am looking to drive home the urgency needed in addressing the issue before irreversible tipping points are reached.

53. Scott Base Redevelopment

Environmental Monitoring Programme

**Pauline Sitter**

1 *Antarctica New Zealand*

Tanya O’Neill2, Clare Beet2, Pierre Roudier3, Barbara Bollard4 and Ashray Doshi4

1 *Antarctica New Zealand*
2 *University of Waikato*
3 *Landcare Research Manaaki Whenua*
4 *Auckland University of Technology*

Scott Base was officially opened in 1957. 60 years on, the base is reaching the end of its functional life. The Scott Base Redevelopment (SBR) is the largest project ever undertaken by New Zealand in Antarctica. The Antarctic Treaty System requires that an environmental impact assessment be completed prior to undertaking any activity in Antarctica. A Comprehensive Environmental Evaluation (CEE) of the project is underway. A monitoring programme will verify the accuracy of the CEEs impact assessment and detect unforeseen impacts.
In seasons 2018/19 and 2019/20, a multidisciplinary team will establish an environmental baseline against which future natural and SBR-related changes can be measured. In 2018/19, 25 monitoring plots were established around Scott Base. They were selected by stratified sampling. Biodiversity surveys, chemical, spectroradiometry, and microbial DNA analysis of soils were completed. 3 seals cameras and 12 dust collectors were installed. A multispectral imagery drone survey captured vegetation and surface disturbance. In 2019/20, marine monitoring, LiDAR surveys, and a resurvey of the plots are planned.

The draft CEE and fieldwork findings will be presented at the 2020 Committee for Environmental Protection. SBR and the CEE are opportunities for NZ to demonstrate environmental best practice in the Antarctic Treaty community.

54. State-of-the-art data for place naming in the Ross Sea region of Antarctica

Christopher Stephens¹

⁠¹ New Zealand Geographic Board Nga Pou Taunaha o Aotearoa and LINZ

Whether on land or undersea, the New Zealand Geographic Board Ngā Pou Taunaha o Aotearoa (NZGB) is using state-of-the-art data to accurately position and define geographic features. The NZGBs poster highlights recent place naming decisions informed by modern data.

In 2018 the Polar Geospatial Center, University of Minnesota, released version 1 of its Reference Elevation Model of Antarctica (REMA). An openly available and continent-wide dataset, REMA provides satellite imagery based elevation data at 2m and 8m spatial resolution. The NZGB can now accurately position features and consider them in context by deriving contours, hill shade, and 3D models from REMA.

In the Southern Ocean the NZGB uses bathymetry from NIWA and GNS Science to accurately locate undersea features and assess their physiography - is it a Seamount, a Guyot, or a Knoll? Using the correct generic term is particularly important for the international Sub-Committee on Undersea Feature Naming accepting the NZGBs proposals. The NZGB encourages new naming proposals, including from other nations operating in the region, backed by the best information available.
55. The role of weather, water, ice and climate (WWIC) information for Antarctic tourism

Emma Stewart\textsuperscript{1} and Daniela Liggett\textsuperscript{2}
\textsuperscript{1} Lincoln University
\textsuperscript{2} University of Canterbury

The tourism sector in Antarctica has witnessed considerable growth and diversification over the last decade. To help facilitate safe travel in remote and dynamic polar environments more detailed and specialised weather, water, ice and climate (WWIC) information services are required. However, there is not a sufficiently detailed understanding of what such specialised polar environmental forecasting services should look like, to ensure that tourism operators receive timely and targeted information that can assist them in decision-making.

Given the paucity of research, this poster seeks to explore the following overarching question: What is known about the role of WWIC information in Antarctic tourism (i.e. how is WWIC information used, and what are the WWIC needs of the sector?) This poster is the result of an extensive literature review coupled with three years of collective brainstorming, focus-group discussions and a number of workshops involving researchers and representatives of the WWIC user community.

This research is part of the World Meteorological Organization (WMO) Polar Prediction Projects (PPP) Societal and Economic Research and Applications (PPP-SERA) working group. The primary goal of the PPP is to advance scientific knowledge such that society may benefit through improved services. The authors of this presentation are members of PPP-SERA.

56. A comparative analysis of regulatory instruments for managing marine-based tourism in Arctic Canada and the Ross Sea

Daniela Liggett\textsuperscript{1} and Emma Stewart\textsuperscript{2}
\textsuperscript{1} University of Canterbury
\textsuperscript{2} Lincoln University

Human activities, including tourism, in the Polar Regions are increasing and diversifying. The most common mode of transport in support of polar tourism is by cruise ship. At the same time, we are witnessing a rapid increase in the number of small vessels, such as yachts, exploring the
Polar Regions. From a political and legal perspective, operating cruises to the Arctic and Antarctic is highly complex. In order to better understand whether the current regulatory mechanisms are sufficient for the rapidly changing nature of Polar marine tourism activities, this poster presents the results of a desk-based analysis of the regulatory landscape in two contrasting case studies. Our first case study focuses on Arctic Canada, where significant regulatory complexity currently represents significant barriers to entry for new tourism operators. The second case study we explore is marine tourism to the Ross Sea region, where a short season and the destinations remoteness limit the number of operators. Tourism here, and across the entire Antarctic region, is subject to high-level regulation under the Antarctic Treaty System as enacted by national jurisdictions. The interplay of international regulation through, e.g., the IMOs Polar Code or UNCLOS, with national policies is the focus of our examination.

57. Whakairo, research and building Maori values into Ross RAMP

Priscilla Wehi¹
James York², Poutama Hetaraka³, Fayne Robinson², Arielle Monk⁴ and Te Warihi Hetaraka³

¹ Manaaki Whenua Landcare Research
² Ngai Tahu
³ Ngati Wai
⁴ Te Runanga o Ngai Tahu

Whakairo is a traditional Māori art form that embeds both values and history, and acts as a repository of knowledge. In 2018 we came together over the course of the year to consider Māori relationships with Antarctica, particularly in light of the new Ross Sea Marine Protected Area, and how those might be expressed in whakairo, or carving. In February 2019, James and Poutama travelled to Antarctica to complete the carving of a door lintel and sides, which was unveiled at Scott Base. The whakairo draws attention to the partnership of mātauranga Māori and science, the maramataka and global climate changes, and the contribution of scientists. We discuss how perceptions of these relationships and values are expressed and embedded in whakairo, and the greater context of Māori experience and knowledge of Antarctica.
58. Penguins in the Popular Imagination: The Quest for New Climate Change Metaphors

Caroline Ziemke-Dickens

University of Canterbury

The current dominant metaphors framing the global response to climate change are not working. Rooted in the Enlightenment and Scientific Revolution, these metaphors are human-centred, focusing on man’s ability to conquer, shape, and control the natural environment. As such, they inspire unsustainable responses that reflect neither emerging systems-based science nor non-Western cultural understandings of natural balance in which humanity is just one part of a great and complex web of nature. New metaphors are needed that create compassion for everything human and non-human that suffers as a result of climate change. The evolution of the human relationship with penguins over time provides insight into how new climate change metaphors might emerge. First seen as resources to be exploited, penguins with their unique, somewhat comical, and always endearing charm quickly inspired human empathy and the urge to protect, rather than exploit, these representatives of a mysterious web of nature. Penguins captured the popular imagination, raising awareness of both the fragility of their environment and the complexity of their lives. The establishment of sustainable metaphors that will motivate positive responses to climate change will need to convince us on an emotional as well as a rational level that we all stand to pay a painful price when human activity harms even the most seemingly insignificant thread on the nature’s web. At first glance, the challenge may seem insurmountable, especially in the current political and diplomatic environment. The evolution of the human-penguin interface may give slight cause for optimism.

59. Antarctica New Zealand Supported Science

Esme Robinson

Antarctica New Zealand

Science supported by Antarctica New Zealand in the 2017/18 and 2018/19 summer season is summarised in three posters. These three posters represent our science themes – Inland and Coastal Ecosystems; Climate, Cryosphere, Atmosphere and Lithosphere; and Marine Systems, and also incorporate achievements in our Long Term Monitoring science.
60. New Zealand and SCAR

Royal Society Te Apārangi National Committee on Antarctic Science (RSCAS)¹

¹Gary Wilson (Chair, GNS Science), Miles Lamare (Life Sciences rep, Otago University), Regina Eisert (Canterbury University), Craig Cary (Waikato University), Mary Sewell (Auckland University), Richard Levy (Geosciences Rep, GNS Science), Peter Almond (Lincoln University), Huw Horgan (Physical Sciences rep, Victoria University of Wellington), Daniela Liggett (Humanities and Social Sciences, Canterbury University), Fiona Shanmun (Data Management rep., Antarctica New Zealand), Graeme Blick (Geographic Information rep., LINZ).

New Zealand undertakes year-round Antarctic research, with significant participation and collaborations within the Scientific Committee on Antarctic Research (SCAR) research programmes. New Zealand’s science outcomes shape Antarctic policy via the IPCC, the Antarctic Environments Portal, CCAMLR and the Antarctic Committee for Environmental Protection. The Royal Society Te Apārangi National Committee on Antarctic Science (RSCAS) acts as New Zealand’s national expert panel on Antarctic Science when coordinating matters for the Scientific Committee on Antarctic Research.

SCAR science activities are currently organized into Action and Expert groups under the standing Science Groups of Life Sciences, Geosciences, and Physical Sciences. The standing Science Groups also help generate SCAR’s Scientific Research Programmes, which undertake time and policy relevant research over six-year periods. SCAR also has a number of standing committees including for the Humanities and Social Sciences. The main SCAR science advice to the Antarctic Treaty System and CCAMLR is prepared by the Standing Committee on the Antarctic Treaty System (SCATS).

Through RSCAS, New Zealand has statutory representation to each of the standing Science Groups as well as through the SCAR Delegate and Alternate Delegate. As the SCAR structure is currently being reviewed, we encourage you to share your thoughts and views both through the online survey and RSCAS committee.
An international team of 21 scientists and 19 crew spent six weeks on RV Tangaroa in January and February 2019 studying the Ross Sea environment and ecosystem. The eight voyage objectives covered everything from oceanography to bacteria to whales. The main aim was to provide baseline information on the new Ross Sea Marine Protected Area for evaluating its ecological status, spatial adequacy, and effectiveness. This talk will cover the voyage highlights, with a focus on a seabed and demersal survey of the continental slope at depths of 600-1500 metres.
Phytoplankton community composition, primary production and grazing consumption in the Ross Sea Marine Environment and Ecosystem Voyage 2018

Andres Gutierrez-Rodriguez\textsuperscript{1}
Karl Safi\textsuperscript{1}, Moira Decima\textsuperscript{1}, Hyunsik Chaeh\textsuperscript{2} and Matt Pinkerton\textsuperscript{1}

\textsuperscript{1} NIWA
\textsuperscript{2} Korea Polar Research Institute

Microbial communities (i.e. bacteria, phytoplankton, and microzooplankton) provide the fundamental trophic and biogeochemical foundation to Antarctic marine ecosystems. Understanding controls on biomass, diversity and activity of these communities is therefore critical to predict the impact of climate change in the ecosystem structure and function of the Ross Sea region and wider Southern Ocean. During the Ross Sea Ecosystem Voyages in 2018 and 2019 we collected plankton samples to characterise the composition of eukaryotic plankton communities and conducted shipboard incubation experiments to estimate primary production and microzooplankton consumption rates through the euphotic zone. Preliminary analysis of pigment and DNA data suggests the prevalence of diatoms, prymnesiophytes and pelagophytes, with relatively low productivity of oceanic offshore waters. Results from microzooplankton grazing experiments showed grazing rates matched consistently low phytoplankton growth rates indicating that the majority of phytoplankton production was consumed by microzooplankton grazing. The vertical resolution of these experiments revealed that balance between production and grazing varied with depth. The effect of light on controlling phytoplankton growth, grazing mortality and resulting net accumulation rates is discussed in the context of water column stratification and potential effects of climate change on the ecosystems of the Ross Sea region.
The Ross Sea region of the Southern Ocean is a significant focus of global research. Important unanswered questions remain on the drivers and extent of oceanographic change and on the response of marine ecosystems to a changing environment. Managing and mitigating the effects of human activities (especially fishing and tourism) against this backdrop of environmental change is challenging and has led to the establishment of the world's largest Marine Protected Area (MPA) in the Ross Sea region. Ongoing stewardship requires an understanding of environmental-ecosystem interactions and the development of an effective approach to monitoring.

In this presentation we report on progress within Ross Sea region Research and Monitoring Programme (Ross-RAMP), a 5 year Endeavour Programme which began in September 2017. We outline progress within Ross-RAMP towards characterising the present-day ecosystem baseline, developing approaches to measure change, and creating new analysis/modelling approaches to evaluate the effect of the MPA. We highlight work on mapping long-term change in circumpolar environmental conditions in the Southern Ocean, including identifying spatial patterns of trends in sea-ice, surface temperature, frontal activity and mixed-layer depth. We present new information on the responses of primary production and the lower food-web to these environmental drivers.
Sharing the Southern Ocean: Ecophysiology of Diving Ability in Marine Mammal Predators

Regina Eisert¹
Andrew Wright² and Lloyd Peck³

¹ University of Canterbury
² Fisheries and Oceans Canada, Maritimes Region
³ British Antarctic Survey

Southern Ocean marine mammal predators target prey resources using a range of foraging strategies. Top predators that capture discrete prey items (odontocetes, most pinnipeds) vary widely in their diving capacity and hence their ability to access resources that require prolonged submersion due to either depth and/or the presence of sea ice. While diving ability would be predicted to correlate with body size, this relationship does not hold even within the same suborder. Instead, we show that routine dive duration of odontocetes and pinnipeds is strongly correlated with relative brain oxygen demand, i.e., the rate of brain oxygen uptake relative to total body oxygen stores (Spearman rank r=0.926, n=14). A comparison of marine mammals of similar body mass but varying degree of encephalisation (phocids, delphinids, ziphiids) clearly demonstrates the negative correlation between brain mass and diving ability. This analysis has important consequences for understanding how sympatric predators exploit key prey resources in the Southern Ocean, such as toothfish, silverfish, myctophids and squid, both with regard to foraging strategies and to segregation in time and space. For the Ross Sea region Marine Protected Area, this means that an exclusive focus on continental shelf predators may underestimate the importance of deep-diving toothfish predators.
Ross Sea ice-oblige predators: a review of technology and population status update

Michelle LaRue

David Ainley, Leo Salas, Nadav Nur, Sharon Stammerjohn and Jean Pennycook

1 University of Canterbury
2 HT Harvey and Associates
3 Point Blue Conservation Science
4 University of Colorado-Boulder

Accessing the coastline of Antarctica to study ice-oblige vertebrates penguin and seals has traditionally been problematic due to weather and human safety concerns. However, within the last decade high-resolution satellite imagery (VHR; 0.31-0.6m spatial resolution) has provided a solution to the remote nature of these habitats, allowing for routine assessments of penguin and seal populations across large spatial scales and over ~10 years. Furthermore, VHR has recently been used in citizen science to increase efficiencies in such assessments and to engage people with the ecology of the Southern Ocean. Here, I will discuss the state of the science for remote sensing of vertebrates in Antarctica, update on the most recent population estimates and trends, and discuss the future of research in the Ross Sea in an era of big data and satellite technologies.
61. Verification Based Image Annotation for Counting Antarctic Wildlife using Convolutional Neural Networks

Oliver Batchelor
Shanelle Dyer, Regina Eisert, Richard Green, Fiona Shanhun and Kerry Barton

1 University of Canterbury
2 Antarctica New Zealand
3 Landcare Research

Counting wildlife represents a labour-intensive task. Convolutional Neural Net object detectors are a potential solution. Automated counting is possible after an initial time investment. However, labelling image data is still laborious, and the quantity required uncertain. We developed an image annotation tool as a human-machine collaboration based on a human annotator verifying (and correcting) predictions from a machine model and using those adjustments to improve an object detection model online. Application to counting Antarctic wildlife offers two advantages: (a) a large number of images can be annotated quickly; (b) the models bias and accuracy can be quantified, and uncertain imagery identified for verification by a human operator.

Using our method, we counted Weddell seals over time series at two locations, Turtle Rock (4400 instances, 240 images, 90 minutes) and wide-angle images at Scott Base (7800 instances, 300 images, 2 hours). We annotate a small fraction of the images and extrapolate trends using the trained detector, and show the extrapolated counting error is similar to that between two human annotators. In addition, we exhaustively count Adlie penguins from large aerial photographs (13,000 instances, 2 hours) and compare the effect of uncertainty on the annotation process.
62. Long Term Passive Acoustic Monitoring in the Ross Sea Marine Protected Area

Alexandra Constaratas¹
Giacomo Giorli² and Matt Pinkerton²

¹ Pytheas Institute, Aix-Marseille University
² NIWA

The world’s largest marine protected area (MPA) was established in the Ross Sea in 2017. As part of a research program that aims to establish the conservation value of this MPA, three passive acoustics recorders were deployed in the Ross Sea to: 1) provide baseline information on the seasonal occurrence of vocalising marine mammals in the region; and 2) understand ecological connectivity between toothfish and sperm whales to investigate potential effects of commercial toothfish fisheries on sperm whales in the Ross Sea region.

The moorings were deployed in February 2018, and two of them recovered in February 2019. Data collection was duty cycled to record for 342 seconds at a sampling rate of 48 kHz, then 64 seconds at a sampling rate of 125 kHz, and then to turn off for 12 minutes. Preliminary data show the presence of baleen and sperm whales, odontocetes and leopard seals. We were also able to detect vessels transiting the area. We outline plans for using the acoustic information collected in the next five years of this project to understand how climate variability and change affect the soundscape of the region and provide information on key predators in the region.


Shanelle Dyer¹
Regina Eisert¹, Oliver Batchelor¹, Stuart Grayson² and Richard Green¹

¹ University of Canterbury
² Tenzing Limited

Artificial Intelligence (AI) and citizen science (CS) are novel methodologies relevant to analysing big data sets of primarily visual information, including wildlife monitoring. We have developed and tested AI and CS methods to process over 4,000 images of a seal colony at Turtle Rock, Ross Sea, Antarctica, to determine diel variation in seal activity. We compared the
two methods, AI and CS, and assessed their accuracy relative to a subset of images counted by experts.

While the overall pattern of seal activity detected was similar, CS underestimated the number of seals relative to AI (Passing-Bablok [PBR] regression: $AI = 1.21 \cdot CS - 2.3$, $r=0.97$, $n=2,896$). Though AI and expert counts (EC) were not different (paired t-test: $P=0.95$, $n=46$), CS gave significantly lower results (paired t-test: $P<0.001$; PBR: $EC = 1.11 \cdot CS - 0.7$, $r=0.98$, $n=46$), suggesting that AI is more accurate than CS.

Although it appears that new AI methods offer significant advantages in terms of speed and accuracy for analysing big visual data sets, one important advantage of CS is its potential for outreach and easy integration with social media. We propose that well-designed online CS platforms are effective vehicles for outreach and science communication that can also add value to AI methods, particularly in conservation research.

64. Weddell Seal Monitoring at Scott Base: Preliminary Results from the First Season

Shanelle Dyer$^1$
Regina Eisert$^1$, Oliver Batchelor$^1$, Mark Murphy$^2$, Pauline Sitter$^2$ and Richard Green$^1$

$^1$ University of Canterbury  
$^2$ Antarctica New Zealand

In anticipation of the proposed Scott Base redevelopment, we are implementing a joint monitoring programme to detect potential impacts from human activity on the local Weddell seal aggregation. Three survey cameras mounted on the hillside behind Scott Base take simultaneous images every ten minutes to record the seals in front of the Base. The images are processed to count seals using an innovative artificial intelligence (AI) programme and results are validated using expert image and ground counts. We present preliminary survey results that indicate large daily and seasonal variations in seal numbers. For example, from 21 to 28 December 2018, detected seal counts in the study area fluctuated between zero and 98. Across the entire survey period (9 December 2018 to 9 March 2019), the maximum detected seal count was close to 200. In a given 12-hour period, the number of hauled-out seals varied by up to
a factor of 12 (from three to 36). The large natural variation in seal haul-out reported here emphasises the importance of understanding diel and seasonal patterns for accurate monitoring of seal populations. Our data provide new insight into haul-out patterns in a Weddell seal aggregation immediately adjacent to one of Antarctica’s oldest stations.

65. Feeding behaviour by Weddell Seals *(Leptonychotes weddellii)* on Antarctic Toothfish *(Dissostichus mawsoni)* in McMurdo Sound, Antarctica

**Regina Eisert**

Andrew Wright, Steve Parker, Sal Genovese and Paul Ensor

1. University of Canterbury
2. Fisheries and Oceans Canada, Maritimes Region
3. NIWA
4. Boston University
5. Balena Research Ltd

The Weddell seal *(Leptonychotes weddellii)* is a known predator of Antarctic toothfish *(Dissostichus mawsoni)* in the Ross Sea. However, the few published observations of predation to date have involved seals exploiting artificial ice holes drilled through fast ice. We present opportunistic observations of Weddell seal predation on toothfish that were made during two consecutive summer seasons (2013/14 and 2014/15) near Scott Base in McMurdo Sound, Antarctica. Predation of toothfish by Weddell seals was recorded (video and stills) at both natural and artificial openings in the sea ice. We present: (1) video documentation of predation on toothfish by Weddell seals in their natural sea ice habitat, a first for this species; (2) twist feeding reminiscent of crocodilian feeding behaviour, a first for any phocid seal; (3) removal of toothfish from the water and consumption on the ice surface at a considerable distance from the water, a first for any pinniped; and (4) grip-and-tear feeding, a behaviour that has to date been assumed to be limited to just leopard seals *(Hydrurga leptonyx)* among the pinnipeds. Our tool observations extend current understanding of how pinnipeds process large prey, and contribute to research on the evolution of foraging strategies in marine mammal predators.
66. Antarctica Marine AR: An Augmented Reality Experience of the Ross Sea Marine Protected Area

Alaeddin Nassani

1 HIT Lab NZ, University of Canterbury

The marine protected areas (MPA) of the Ross Sea has significant importance for the species protected. Benefits of the MPA include preservation of the ecosystem and endangered species of Antarctica. Toothfish was identified as a keystone species for the ecosystem, and that was affected by unsustainable fishing. Unfortunately, not many people of the public know about the importance of the MPA and its benefits.

This poster describes and demos an interactive experience through an augmented reality (AR) headset (Microsoft HoloLens) of the marine protected area. The experience focuses on a simplified version of the food web in the Ross Sea targeted for primary school students. A user wearing the headset would see a smaller version of Antarctica overlaid on the ground and highlighting the Ross Sea area, the user walks through the experience to discover main species (including killer whales, seals and penguins) on the Antarctic food web that are benefiting from the MPA.

This work aims to increase awareness and understanding of the MPA and its benefits for the ecosystem by introducing an AR experience. Future directions include more interactive elements such as simulating overfishing effect on the areas.
In December 2017, the world's largest Marine Protected Area (MPA) was established in the Ross Sea. Monitoring is required to evaluate the effectiveness of this MPA in conserving ecological structure and function, which includes protecting Antarctica’s key predators, such as the Weddell seal. We present preliminary results from work conducted during the 2018-19 Antarctic field season in which we: 1) Examine fine-scale foraging behaviour of female Weddell seals during pup rearing when they are proximate to the colony; 2) Determine the long-term over-winter movement and dive behaviour of post-partum female Weddell seals and identify productive foraging locations that enable seals to regain physiological condition after pupping; 3) Assess energy dynamics and reproductive status throughout the year by measuring body composition, blubber depth, and pregnancy status. During the pupping season (October-November), we collected movement and video data from 21 seals, recording both foraging dives and prey capture events. During our second deployment in February-March, we instrumented 17 female Weddell seals with long-term tags which continue to transmit location, dive, and environmental data via satellite across the winter. These data will improve our understanding of Weddell seal movement and foraging behaviour relative to the boundaries of the MPA.
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