ABSTRACT BOOK

Water in a Changing Climate (Monday 6th May, 11am-12.30pm)

Applying Real Options Analysis to water storage in a changing climate (Standard)

Presenter: Anita Wreford (Lincoln University)
Other authors: Collins D. (Niwa); Dittrich R. (University of Portland); Renwick A. (Lincoln University)

Planning for climate change adaptation is challenging due to the inherent uncertainty associated with future climate changes. Despite this uncertainty, adaptation decisions may need to be made now, to effectively reduce future vulnerability to climate change. We apply an economic approach for making decisions under uncertainty, Real Options Analysis (ROA), to a water storage investment decision. We are a multi-disciplinary team of applied economists and hydrologists and draw on expertise from engineers and irrigation specialists. Our study site is the Canterbury region of New Zealand (NZ), where water availability is currently under considerable pressure, and is likely to increase further under climate change. Scenarios of future water availability (and from this, reservoir size) are projected based on regionally downscaled climate change projections for a number of climate scenarios. The ROA involves the development of a decision tree with different decision points (2018 and 2040), so that the size of the reservoir in 2018 will be sufficient to provide water availability until 2040, and have the capability to be extended if necessary at the next time period to provide water availability until the end period (2100). We are interested in how the approach will support decision-making in practice, and whether there are ways to increase its accessibility without intensive modelling and analysis.

Risk to drinking water supply associated with as-yet unexperienced droughts (Short)

Presenter: Wageed Kamish (Tonkin + Taylor)

The project aims to determine, at a national scale, the future risk of failure of water supply systems in New Zealand. To achieve this, a methodology based on a custom built yield reliability model that balances the inflows, demands and infrastructure volume will be implemented. NIWA is a project partner and will be providing the streamflow and evaporation input data obtained from 4 RCPs and 6 RCMs for the period 1971-2100 to drive these models.

The project team is currently constituting the Stakeholder Reference Group, which has been a challenging task, mainly due to the need for cold telephone calls or emails to initiate contact with an identified stakeholder. Even if a suitable person was previously identified, several iterations were required due to availability or other issues. Time required for this component of the work can easily be underestimated.

It is envisaged that the outputs from project will provide a methodology for calculating reliability of supply as well as provide participating councils with a reliability of yield diagrams for future scenarios that can be used for water resources planning purposes.

Sustainability of roof drinking water under changing climate - challenge in isolated communities (Standard)

Presenter(s) Hank Dunn, Christian Zammit (NIWA)
Other authors: Henwood W. (Massey University); McCreanor T., (Massey University) Barnes H. M. (Massey University); Brockbank T. (WSP Opus); Moriarty, E. ESR (now at Environment Southland)

Drinking water supply availability in the Far North isolated rural communities relies on precipitation (the source) and household infrastructure (for collection - storage and health). As part of the Te Hiku project, an interdisciplinary team of community researchers, an engineer, a hydrologist and health experts worked with local communities to raise awareness and prepare for the potential effects of climate change on water supply and quality.

Local data gathered in each community (climate, E-coli testing, household survey, interviews) were analysed alongside climate change projections- mātauranga Māori and kaitiakitanga practices, to derive localised simple community tailored tools to support preparedness for climate change and the development of local solutions which complemented local social and economical settings. Through its collaborative approach supported by a strong cohort of local community researchers, the project was able to develop and test protocols and tools that can be replicated easily with the help of local community researchers across New Zealand.

Quantifying 21st century New Zealand droughts using New Zealand Drought Index (Short)

Presenter: Abha Sood (NIWA)
Other authors: Mullan B. (NIWA)

Droughts can have severe socioeconomic impacts in New Zealand, strongly affecting not only the primary industry sector but also drinking water availability. The New Zealand Drought Index (NZDI) is a merged indicator of drought based on four commonly-used climatological drought indicators: the Standardised Precipitation Index, the Soil Moisture Deficit, the Soil Moisture Deficit Anomaly, and the Potential Evapotranspiration Deficit. Computing these indicators for the past climate and the future projections requires high quality simulated rainfall and evapotranspiration data which to date remains a challenge. We present the NZDI as well as related indices using bias corrected climate model data for New Zealand downscaled on a 5 km grid. These projections are now available to the Deep South research community.

What will climate change mean for our stormwater and wastewater systems? (Standard)

Presenter: Katherine Heays and James Hughes (Tonkin + Taylor)
Other authors: Bell, R. (NIWA); Stroombergen, A. (Infometrics); Olesson, E. (Tonkin + Taylor) Bennett, P. (NIWA)

Much of New Zealand's stormwater and wastewater infrastructure is vulnerable to the risks associated with a changing climate, including sea-level rise or increasing extremes of rainfall and/or drought. The nature of existing stormwater and wastewater systems mean that they will be significantly impacted in a wide variety of ways including the increasing occurrence of compounding hazards. For example, many discharge to low lying areas, and it is these coastal and riverine locations that are most at risk to flooding associated with increasing rainfall intensity compounded with rising sea levels and changing groundwater levels.

This paper presents findings from Deep South Science Challenge research on the impacts and implications of climate change on New Zealand's stormwater and wastewater systems. In addition to identifying impacts and implications, the study identifies regional priority areas, and develops a series of guiding principles for managers.

This research was conducted through a comprehensive literature review, and through consultation with a panel of experts comprising private sector engineers and scientists, university researchers,

local and central government specialists, and crown researchers. Stakeholders were engaged via workshops, followed by email and phone correspondence. This group and engagement process added much value to the project, with stakeholders being able to fully understand project context and direction, thus allowing them to provide more thorough and well-considered input and knowledge to the project, as most were very passionate about the research topic.
This research is nearing completion and has not been released to the public. Upon release, the impact of this research will be targeted to infrastructure engineers, asset managers and decision-makers.

Meeting hydro-electricity needs for climate change assessment (Short)

Presenter: Christian Zammit (NIWA)
Other Authors: Conway J., Collins D. (NIWA)

As part of the Deep South Hydrology project potential climate change impacts on hydroelectricity generation to major hydropower schemes were assessed at national scale (Collins et al 2019). While this analysis is useful to perform national analysis on electricity generation capacity that can be coupled to downstream electricity demand models, more specific information associated with change in cryosphere and hydrological conditions is required for each snow and ice hydro power scheme.
We are starting to explore the use of existing CMIP5 hydro-climatological modelling outputs on the Waitaki hydro lake system to derive cryospheric indicators to be used to guide climate change planning effort lead by the industry. Current challenges reside in i) developing bias corrections of current hydro-climatic model outputs to represent historical events (large inflows and low inflows); ii) developing simulations enabling confident simulations of extreme cryospheric conditions and iii) developing a suite of industry specific cryospheric indicators and signatures (across snow, groundwater and discharge domains) to be used for climate change assessment. Discussions with industry stakeholders are on-going.

New Zealand's Coastal and Fluvial Flood Hazard Exposure (Standard)

Presenter: Ryan Paulik (NIWA)
Other authors: Stephens, S, Craig, H, Wadhwa, S, Bell, R., Robinson, B., Daniel Collins, Popovich, B. (NIWA)

This study presents a first attempt at enumerating New Zealand's exposure to coastal and fluvial flooding hazards. Coastal flood hazard maps were developed to identify land exposure to 1% annual exceedance probability extreme sea-level elevations (ESL1) under present-day and future higher sea levels up to +3m above MSL. New Zealand's absence of a national fluvial flood hazard map was addressed by creating a 'composite' flood hazard area map (FLHA) from publicly available (August 2018) modelled and historic flood hazard maps and flood prone soil maps. Exposed elements at risk (i.e. populations, built assets and land cover) for each ESL1 and FLHA scenarios are enumerated at national, region and territory levels. At national level, a linear trend of increasing ESL1 exposure is observed as sea-levels rise. Region and territory level exposure exhibits non-linear behaviors with average exposure rates accelerating and decelerating exposure in response to SLR up to +3m above MSL. Significant national level exposure of populations (674,534), buildings (411,516 with 2016 NZD$ 135 B replacement value), roads (19,098 km), three-water infrastructure pipelines (21,174) and production land (15,202 km2) is also identified within the FLHA. This information provides researchers and practitioners with locations to focus more detailed investigation on the potential impacts and management implications of coastal and fluvial flood hazards under present-day future climate conditions.

Climate Change Impacts and Adaptation (Monday 6th May, 2pm – 3.15pm)

Climate Adaptation Planning: Risks and Opportunities (Standard)

Presenter: Lisa Ellis (University of Otago)

Our DSC project, "How Should the Risks of Sea-Level Rise be Shared?", used game theoretical analysis, critical description, and a survey of the global climate adaptation ethics and policy literatures to clarify the challenges and opportunities facing Aotearoa/New Zealand as it begins to plan for the consequences of climate change. We identified threats to ethically robust adaptation policy and suggested ethically robust practices to mitigate those threats. Conversations with residents of South Dunedin, with local government policy makers in Dunedin, Hawke's Bay, and around Aotearoa/New Zealand, and with fellow researchers from many disciplines, enhanced our research and allowed us to share our results. As participants in the Dunedin City Climate Change Academic Reference Group, and in other capacities, we will continue to work with residents and policy makers in this area. In future, we intend to work with stakeholders to facilitate successful community engagement and deliberative policy planning while conducting research on representation of youth and other underrepresented groups, public values (especially on tradeoffs in climate adaptation), and coordinating local and central decision making to facilitate optimal collective outcomes.

Transition Action Planning for climate change Poutama impacts on Māori coastal ecosystems and economies (Standard)

Presenter: Moira Poutama (*Ngāti Raukawa, Ngāti Tukorehe*) and Aroha Spinks (*Ngāti Raukawa, Ngāti Tukorehe*)
Other authors: Hardy, D.J., Richardson, J., Patterson, M.G., Smith, H. *(Ngāti Raukawa, Ngāti Tukorehe)*, Manning, M.

This research co-developed Transition Action Plans for five Maori-owned land blocks in the Horowhenua Coastal Zone. The project was organised around wānanga, hīkoi and a public exhibition, as ways of co-producing and disseminating new knowledge and capability to identify, respond and adapt to potential climate change impacts. The research team explored three whānau preferred and determined Land Use Adaptations: 1) the use of harakeke as a means of cultural enrichment and income generation from production of harakeke-sourced products; 2) riparian planting and other water quality enhancement activities to increase the abundance of taonga species (such as tuna and īnanga); and 3) construction of sustainable papakāinga. We drew on Mātauranga Māori, Climate Change/ Geomorphology and Ecological Economics to help whānau assess risks and the value of trade-offs between alternative land use options, to address climate change impacts for their rohe. Consideration of whānau and hapū perspectives was critical for ensuring inter-generational kaitiakitanga/stewardship. This presentation discusses the challenges and benefits of cross-cultural collaborative research to bring about transformative change.

Signals and Triggers for Pathways Planning (Standard)

Presenter: Judy Lawrence (Victoria University of Wellington)
Other authors: Bell, RG, Stephens, SA (NIWA); Collins, D (NIWA); Blackett, PE (NIWA); Cradock-Henry, N, (Manaaki Whenua Landcare Research).

Timely adaptation is an essential part of dynamic adaptive pathways planning (DAPP), however there are few examples of monitoring indicators of emerging adaptation thresholds. We discuss a

novel approach to signals and triggers for sea-level rise and fluvial floods. The sea-level indicator reflects probable timing of several flood events culminating in a height threshold triggering the decision on the next adaptation pathway with enough lead time. For low-lying coasts, sea-level signals show thresholds may be reached by 2021-2043. This will require prior assessment, planning and community engagement for developing adaptive plans. Annual flood statistics were used to develop fluvial flood signals and thresholds, however results show they provide limited value as an early-warning signal of an approaching flood threshold: the longer the lead-time, the lower the signal reliability. Due to the uncertain timing of physical signals and triggers, political, social, economic, and cultural signals therefore are needed to inform timely adaptation.

Signals and triggers were tested with practitioners and communities using a range of scenarios of future conditions. Using participatory and collaborative methods, the combination of scenarios and signals and triggers can shift responses to an anticipatory mode that enable short-term actions to be taken, whilst keeping long-term options open.

Protecting the golden egg: Climate change adaptation in New Zealand's tourism sector (Standard)

Presenter: Debashish Munshi (University of Waikato)
Other authors: Kurian, P., Morrison, S., Cretney, R. (University of Waikato); Kathlene, L. (LK Consulting, USA).

Climate change is an increasingly urgent challenge for tourism, New Zealand's largest industry, which contributes nearly $16b to the nation's GDP. Yet public engagement on climate change adaptation in the tourism sector has been limited, if at all. This project has worked with the tourism industry to explore the tangible and intangible impacts of climate change on it and find effective ways of managing risk. The project team created a multi-stakeholder matrix, held system mapping sessions with diverse stakeholders, and engaged with climate scientists, government officials, tourism executives, tourism operators/venue managers, and kaitiakitanga of Maori sites, to co-design collaborative strategies to manage the physical, economic, social, and cultural risks of a climate change. A key focus of the project has been to build and apply a culture-centred engagement framework, which explores how cultural values, embedded in the ways in which different groups of people understand climate change, shape their adaptation strategies to the new realities of climate change. The framework has potential relevance for policy makers and others working to implement climate change adaptation policies.

Engagement in the Deep South Challenge (Standard)

Presenter: Wendy Saunders, (GNS and DSC Engagement Programme Lead)

Programme of the Deep South National Science Challenge (DSC) is a unique programme amongst the the National Science Challenges. Its aim is to "*Engage with its end-users to enable their adaptation options to be informed by our science, particularly our modelling of future climate and climate impacts, ensuring that the programme adequately targets the needs of partners and stakeholders in the four domains of Māori, communities, infrastructure and the national economy*".

This presentation will provide an overview of the Engagement Programme, and introduce our team. In order to meet our aim, the goals of the Engagement Programme will be presented, which are based on the International Association of Public Participation (IAP2; see Figure 1). This is followed by the highlights of each of the workstreams (communications, parnterships, capability and capacity

building, and evaluation); followed by an outline of the Representative User Group membership and input; and the key activities for the next phase of the DSC Engagement Programme.

From this presentation participants will gain an understanding of the scope of the Engagement Programme, its expectations around project versus programme-based engagement, and the direction of the Engagement Programme for the next phase of the DSC.

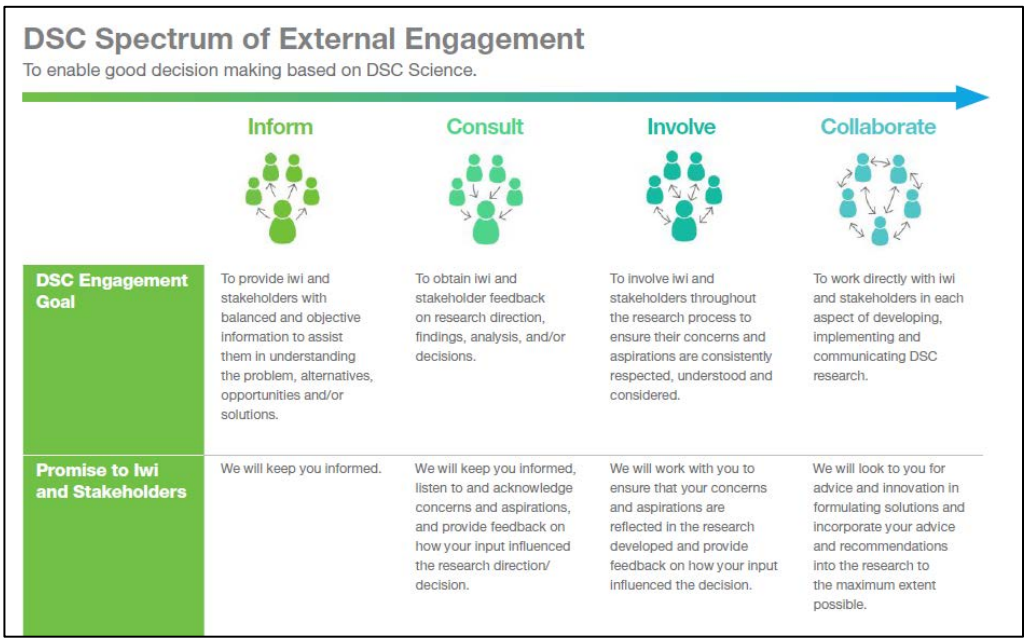

Figure 1: The Deep South National Science Challenge Spectrum of External Engagement (adapted with permission from IAP2).

Building a Better Climate Model (Monday 6th May, 3.45pm – 4.50pm)

The coming of age of New Zealand's earth system modelling capability. (Standard)

Presenter: Jonny Williams (NIWA)
Other authors: Behrens E. (NIWA)

Before the DSC came on to the research landscape just a few years ago, Kiwi climate researchers were already highly regarded. However, with the availability of Deep South funding and our new supercomputer, we are now at the forefront of earth system modelling capability.

To enable a small country like ours to work at this 'cutting edge' we leverage our position within the Unified Model partnership, which includes 9 countries who all use common code base. The New Zealand 'fingerprint' on our work is now coming to fruition through our newly developed capability to embed a high-resolution ocean model within the pre-existing global model. This will provide unprecedented information on how local ocean currents may change in the future, with associated effects on, for example, kaimoana.

This work is inherently interdisciplinary and will become more so as the local effects of ocean circulation change are realised. This work will be of high impact both at home and abroad since this work is highly ambitious from a modelling perspective.

We are interested in gaining input from Tangata Whenua and other stakeholders as our modelling results are available in the coming months and we look forward to speaking to you!

Grease Ice Herding in the New Zealand Earth System Model (Short)

Presenter: Shona Mackie (University of Otago)
Other authors: Langhorne, P.J., Smith, I.J. (University of Otago)

The New Zealand Earth System Model (NZESM) is made up of different modules, e.g. ocean, atmosphere, sea-ice, each of which can be run in isolation. In the current sea-ice module, ice crystals form in the ocean in response to supercooling, and rise to the surface where they freeze instantly into a layer of uniformly thick sea-ice. In reality, a slushy mixture of ice and water forms, with a greater volume than the volume of the ice alone. It freezes (or melts) in response to atmospheric heat flux and becomes wedge-shaped as wind drives it against the sea-ice edge. Scientists at Reading University developed a scheme for inclusion in the sea-ice module. Here we extend the scheme to operate in NZESM with ocean and atmosphere, where the exchange of fluxes across modules require conservations of water, salt and energy. This provides a more physically appropriate representation of sea-ice, ocean-atmosphere heat exchange and climate around the Southern Ocean. The sea-ice module is used in many ESMs and our developments will be useful to the climate modeling community, as well as benefiting the NZESM.

The Southern Ocean in a Warming World and New Zealand's climate (Standard)

Presenter: Melissa Bowen (University of Auckland)
Other authors: Behrens, E., Fernandez, D. , Sutton, P., Rickard, G. (NIWA)

The ocean contains over 90% of the excess heat in the climate system: the movement of heat through the ocean and exchange with the atmosphere drives the heat and moisture of the air. In our project, we find the largest changes in ocean heat over the last decade are in latitudes around New Zealand due to the ocean circulation responding to increasing westerly winds, with the result

that heat has been moving from the ocean to the atmosphere. From observations and simulations, we show that the spin-up of the ocean currents around New Zealand has changed ocean temperatures and heat in the Tasman Sea, periodically pre-conditioning the region for marine heat waves and extreme climate events. We have also improved the simulation of the Southern Ocean temperatures in the NZESM by increasing the resolution of the Southern Ocean and better resolving the formation of dense water on the Antarctic shelf. New measurements, collected from the Ross Sea, document the delivery of dense water to the global ocean over tidal cycles to decades and provide boundary conditions for the simulations. Remaining challenges for simulating the movement of ocean heat, which underpin climate projections in our region, will be outlined.

Reducing the Southern Ocean short-wave radiation biases in the New Zealand Earth System Model (Short)

Presenter: Olaf Morgenstern (NIWA)
Other authors: Varma, V., Williams, J. (NIWA)

Many of the present-day global climate models (GCMs) are characterized by a surplus in the absorbed short-wave radiation due to an improper representation of clouds. This bias is especially pronounced over the high-latitude regions of the Southern Ocean (SO). Owing to its role in governing the Earth's climate in general and as a key aspect influencing the climate of southern mid-latitudes, an appropriate representation of SO cloud characteristics in climate models is very important for a realistic simulation of climate. In this study, using a recent version of the MetOffice Unified Model (UM) (which is the atmosphere module for the New Zealand Earth System Model), we show that using a more realistic value for the shape parameter of atmospheric ice-crystals in the cloud-microphysics scheme has a substantial impact on the absorbed shortwave radiation. In the model, for calculating the growth rate of ice via the deposition process, it is assumed that all ice particles are spherical in shape. The reduced value accounts for shapes other than spheres, such as oblate plates or aggregates of ice crystals. Along with modifying ice nucleation temperatures, we simulate a significant reduction in the annual-mean short-wave cloud radiative effect over the SO. We speculate what this modified cloud-microphysics scheme would do in a fully coupled framework, and give an outlook on where we plan to take this work in the 2nd phase.

ACRE Antarctica contributions to meteorological data rescue, analysis of climate modes and improving the 20th Century Reanalysis (Standard)

Presenter: Andrew Lorrey (NIWA)
Other authors: Pearce P., Woolley J.-M., Fauchereau N. (NIWA); Jones J. (University of East Anglia); Brohan P., Allan R. (UK Met Office); Compo G. (NOAA-CIRES); Hawkins E. (University of Reading); Renwick J. (Victoria University of Wellington)

ACRE Antarctica is a component of the Assessment and Validation of the NZ Earth System Model project. Testing the NZESM requires detailed observations that link NZ weather and climate to Antarctica. Key elements for us to understand include how the Southern Ocean, the Southern Westerly Winds, and modes of variability guide our climate - and how Antarctica drives our changeable weather patterns.

At present, the Deep South's climate and weather history seen in daily weather reconstructions (reanalyses) are poor for NZ and the high latitudes prior to 1948. Our work in ACRE Antarctica has Identified, prioritized, and rescued pre-WWII meteorological records spanning southern New Zealand to Antarctica and across the Southern Ocean. Recovery of surface pressure, sea ice and

temperature (sea surface and ambient) measurements has recently accelerated due to international collaborations and the Southern Weather Discovery website. Historians we work alongside helped us successfully locate and scan ‘high value’ paper observations that documented past weather into the late 1800s. These archived data will exceed our goal of adding 250,000 observations to existing reanalyses. The data treasure trove is expected to shed new light on variability, trends and processes behind some of NZ’s worst weather and climate extremes.

Keynote: Council-community engagement for climate adaptation – challenges and opportunities (Tuesday 7th May, 9am - 9.50am)

Notes about presenters:

Janet Stephenson
Janet is the Director of the Centre for Sustainability, an interdisciplinary research centre at the University of Otago. A social scientist, she is interested in how people and organisations are engaging in the transition to a sustainable future. In the Deep South challenge she leads the Climate-Adaptive Communities research project.

Maria Ioannou
Maria Ioannou has worked within the public, private and tertiary sectors in New Zealand, the UK and Europe and leads the Dunedin City Council's policy team. Maria is driving the climate change adaptation and mitigation work for the city, and has taken innovative steps to make this a practical reality including commissioning a carbon assessment of Dunedin's draft 10 year plan – a first in the country.

Eleanor Doig
Eleanor is Chair of the South Dunedin Community Network and active in many aspects of community life in South Dunedin. She lives in the area and has a passion for ensuring the community is deeply involved in decision making around its evolving future.

From being just an abstract possibility just a few years ago, climate change is rapidly becoming a reality for many of New Zealand's councils and communities. Grappling with these new circumstances can be complicated, emotional, costly and exhausting. For communities, some of which are already dealing with early-onset impacts such as flooding and erosion, it already means personal loss and fear. For councils, faced with a future that doesn't align with what they were set up to do, and very different to what their staff were trained to do, it means uncertainty as they try to work out what they should be doing, who is responsible for what, and how to engage with affected communities. For all, there is the unwelcome knowledge that this is the new reality, adding further stress on top of all the other complexities of everyday life.

In the Climate-Adaptive Communities project we have been investigating how councils and communities have been responding to these challenges. In Dunedin, one of our case study areas, we have been lucky to engage closely with the South Dunedin Community and the Dunedin City Council. As a research team we have learned a huge amount through seeing how the community and council have evolved in how they are thinking, talking and acting in response to climate change. In our presentation, we talk about the 3-way learning and support we have experienced between researchers, community and council. We discuss the societal challenges of the adaptation transition, including for wellbeing, justice and equity. We share our experiences and aspirations for how councils, communities and researchers can work together to develop a more positive future.

Climate Change Impacts and Adaptation (Tuesday 7th May, 9.50am -11am)

Te Moana Tāpokopoko a Tāwhaki (Short)

Presenters: Aimee Kaio and Sandy Morrison

Our presentation explores historical associations that Māori and in particular Ngai Tahu has had with the Antarctica and Southern Oceans. We also select key critical impacts that Climate Change will have on Ngai Tahu in the future and some thoughts re creating adaptation strategies to uphold the mana of Ngai Tahu.

Sustainable and efficient water and land resource management and use in the Omaio land-development catchment. Climate-friendly, high-value crops for the whānau of Omaio

Presenter: Chris Insley and Peter Insley

Climate change is already having an impact on communities like Omaio, with flooding, extended dry periods with water ways drying up for extended periods, main arterial roadways and other infrastructure being damaged and severing connectivity with the outside world as repair work is carried out.

Current research in the Omaio community has confirmed and validated national projections, concluding that the impacts of climate change forecast over the next 50 and more years will be significant, unless concrete steps are taken globally, to mitigate greenhouse gas emissions.
Local research has enabled the whanau and community of Omaio to start to plan land-based adaptation strategies in response to these projections. To gather information for planning, the community has installed a new community wide hi-speed WiFi broadband network that is enabling the installation of a new network of technology, including automatic weather stations, a network of environmental monitoring sensors, across several land blocks and stream and waterways.

From these data systems, a smart new remote online reporting dashboard with a suite of land management tools and models has been developed, that will assist whanau with smart landuse decisions. The data systems consider current and historical weather patterns and events, enabling the landowners to better plan for these events, especially in respect of landuse decisions. Seven whanau from the communities of Omaio, Te Kaha and Raukokore have been trained in the use of the dashboard and landuse models.

So while climate change events are occurring in the community of Omaio and projected to get worse, the science, research and installation of smart technologies and decision making tools, is building in resilience in the community, and is enabling also the community to grow and prosper using plans for high value horticulture and other land uses that will create desperately needed whanau jobs in a part of the country with among the worst social deprivation (Cunnilife et al 2018). The creation of these new high value jobs will likely attract skilled whanau to return back home that will also revitalize the marae, culture and te reo.

Liability for sea-level rise adaptation measures (Short)

Presenter: Catherine Iorns (Victoria University of Wellington)
Other authors: James, V,. Watts, J. (Victoria University of Wellington)

My research project addresses financial liability – i.e., who pays – for some climate adaptation measures. It is located within a project on insurance and housing, which is primarily concerned with who pays for housing-related adaptation after insurance retreat in the face of sea-level rise. We have not limited our research to insurance retreat and have produced four substantive reports addressing: "Case Studies on Insurance and Compensation after Natural Disasters", The EQC scheme, Liability of Local Government in relation to Sea Level Rise adaptation measures, and Liability Under the Treaty of Waitangi for Sea Level Rise Adaptation Measures.

I propose to summarise key findings of the last three reports: how the national EQC scheme is not designed nor well-equipped to assist with adaptation to sea-level rise; how Local government is currently financially responsible for most sea-level rise adaptation measures; how duties to uphold the principles of the Treaty of Waitangi are not well considered in the area of climate adaptation; how local government adaptation actions may create Treaty liabilities for central government. The presentation will include comments about our experiences working with stakeholders, the impact of our research, and suggestions for further research.

'Making things better than they are': Community engagement with those more susceptible to harm. (Standard)

Presenter: Sophie Bond (University of Otago)
Other authors: Diprose, G.(Manaaki Whenua/Landcare Research); Simon, K. and Thomas, A. (Victoria University of Wellington); Stephenson, J. and Orchiston, C. (University of Otago)

At a Council-led researchers' forum held in Dunedin earlier this year, a senior policy planner stated that local authorities often 'talk about 'community' as if it is some strange beast that we don't understand'. This view is reflected in research findings from a survey of local governments, which found that while community engagement is under-resourced, there is also a sense that climate change is too big, too hard and too overwhelming for people to engage in. The reluctance to engage is even greater for communities often described as 'vulnerable', or more susceptible to harm from climate change impacts because they tend to be those who struggle to engage or are harder to reach out to. In addition, they tend to be the least understood by planning officers. In this paper, we present findings from research with communities in South Dunedin and Hutt Valley who are more susceptible to harm from climate change impacts, with a view to providing greater understandings of their specific needs and concerns. We identify ways that the participants suggested engagement might work for them, and recommend a series of principles for local authorities to consider when engaging communities that will enable them to move beyond being afraid of the 'strange beast' that they don't understand.

Just having conversations': Uncertainty, connection and community engagement (Short)

Presenter: Gradon Diprose (Manaaki Whenua Landcare Research)
Other authors: Simon, K. and Thomas A.C. (Victoria University)

Community participation in local government policy and project development tends to be focused on an engagement event or series of events, for a specific purpose. It tends to be episodic and top down, privileging Council staff as the experts with the necessary information. This approach often

engages communities in one-off, one-way forms of communication – either extracting views or relaying information. Our research suggests a different approach is required to plan for climate change impacts, and that councils will need to take a long-term view of engagement and be open with communities about uncertainty. We draw on two case studies, from Dunedin and the Hutt valley, to highlight a shift occurring in local authority's approaches to how they engage with communities. The research demonstrates the value of 'just having conversations', of two-way relationship building, of acknowledging that Council don't 'have all the answers'. We suggest that Council's engagement with people around climate change adaptation and mitigation cannot be separated from broader community development and wellbeing initiatives. We conclude by outlining practical ways to facilitate such a shift in approaching community engagement.

Climate Change Impacts on Primary Production (Standard)

Presenter: Troy Baisden (University of Waikato)
Other authors: Ausseil, A (Manaaki Whenua Landcare Research); Beare, M (Plant and Food Research); Guo, J (Manaaki Whenua Landcare Research); Keller, E (GNS Science); Law, R. (Manaaki Whenua Landcare Research); Lieffering, M and Noble, A (AgResearch); Teixera, E (Plant and Food Research); VanDerWeerden, T (AgResearch)

Pastoral and horticultural exports are vital to the New Zealand economy, and totaled $32 billion in 2018. Working jointly between the Deep South and Our Land and Water National Science Challenges, we examined how models and indices can inform decision-makers in these primary sectors to plan for climate change as part of understanding future land use suitability. Here, we focus on how drought and shifting seasonal patterns can be related to production under climate change RCP scenarios from 1986 – 2100, calculated for 6 downscaled GCMs. We compiled annual results from two differing soils in three climates representing Hawkes Bay, Waikato and Southland. We identified indices based on temperature and water that collectively explained 26% and 51% of the variance in pasture production models of high and intermediate complexity, respectively. Pasture production showed changes in both seasonality and annual yield, with the latter being strongly correlated to spring and summer droughtiness. A simulation of silage maize followed by wheat crops highlighted earlier sowing with warming and a larger variability in crop performance. For wine grapes modelled across New Zealand, growing degree day metrics suggest warming will result in a shift in phenology, with earlier onset of flowering dates.

Building a Better Climate Model (Tuesday 7th May, 11.30am - 12.30pm)

Machine learning to create filled total column ozone data sets (Short)

Presenter: Greg Bodeker (Bodeker Scientific)

The primary goal of the Evaluating the NZESM against modern & historical observations project was to generate data sets suitable for validating NZESM. A challenge was that while NZESM creates complete, homogeneous and internally consistent output fields, this is seldom, if ever, achievable in the real world where measurements from multiple instrument, need to be stitched together to create a homogeneous gap-free database. Some instruments cannot measure under certain conditions and many are beset by unavoidable hardware failures. This short talk summarizes a machine-learning (ML) approach that we developed to create filled total column ozone (TCO) fields. It uses a regression model that learns how TCO fields depend on dynamical predictors such as the tropopause height and potential vorticity (a dynamical field known to correlate closely with TCO). A difficultly is that that these dynamical fields can themselves contain anomalies and that the dependence of TCO on these fields can change with latitude, longitude, season and year. The ML algorithm therefore adapts itself to when those predictors can be used and when they can't, and to the global geographical structure of the correlation between TCO and those predictors. The result is a TCO database far better suited to ESM validation.

Targeted Observations of Process-Informed Modeling of Antarctic Sea Ice (Standart)

Presenter: Pat Langhorne (University of Otago)
Other authors: Brett, G. and Frazer, E. (University of Otago); Haas, C. (Alfred Wegener Institute, Germany); Kohout, A. (NIWA); Leonard, G. (University of Otago); Malyarenko, A. (NIWA & University of Otago); Montiel, F., (University of Otago); Rack, W., (Gateway Antarctica, University of Canterbury); Roach, L. (NIWA & Victoria University of Wellington); Robinson, N., Stevens, C., Williams, M. (NIWA)

The poor skill of climate scale models in predicting Antarctic sea ice area is a major issue for the reliable forecast of future climate conditions for New Zealand. As well as influencing the planetary heat balance, sea ice influences storm-conditions in the Southern Hemisphere, and more specifically, affects weather systems over New Zealand. The sea ice team (through TOPIMASI) has captured novel observations of the inner and outer margins of the Antarctic sea ice cover. During a US-funded winter icebreaker cruise (PIPERS), NZ-designed wave buoys were deployed at the outer edge of the Antarctic pack ice. This has allowed us, for the first time, to construct ice condition-dependent measures of wave energy decay, which will be implemented in the sea ice module of an Earth System Model. At the outer margin, close to the coast, an electromagnetic induction device, towed beneath a DC-3 aircraft, performed the first ever airborne measurements of sea ice thickness in Ross Sea pack ice. Sea ice responds dramatically to the storage (or release) of ocean heat, so integration of airborne ice thickness measurements with satellite, on-ice and oceanographic observations is enabling us to quantify the vitally important heat exchange between ocean, sea ice and atmosphere.

Snow, ice and glaciers in our changing climate (Short)

Presenter: Brian Anderson (Victoria University of Wellington)
Other authors: Cullen N. (University of Otago); A. Mackintosh, (Victoria University of Wellington); J. Conway (NIWA); R. Dadic (Victoria University of Wellington); T. Kerr (Aqualinc Research Ltd.); H. Purdie (University of Canterbury); P. Sirguey (University of Otago); C. Zammit (NIWA)

New Zealand is projected to warm by 1-4°C during the 21st century. This warming will melt our frozen water resources – our snow, ice and glaciers. However, the scale and timing of this melt is not clear.

Mountain rivers in both the North and South Islands of New Zealand feed our largest hydro-electric power schemes, and provide critical water for irrigation, especially during drought. Melting snow and ice may also cause increased flooding.

In our research project, affectionately nicknamed "The Icy Project," we have made projections about how water stored in New Zealand's glaciers and seasonal snow will change in the future. The research team is also engaging with iwi, industry representatives and local authorities to determine the specific needs of communities that use water. This data is crucial for decision makers in government, communities and industry.

The core strength of our research team is that it has brought together, for the first time, the leading snow and glacier scientists in New Zealand. Working together as a team under the Deep South umbrella has given us the opportunity to directly contribute to the challenge mission of enabling New Zealanders to anticipate, adapt, manage risk, and thrive in a changing climate.

Simulating aerosols over the Southern Ocean in the New Zealand Earth System Model (Standard)

Presenter: Laura Revell (University of Canterbury)
Other authors: Kremser, S. (Bodeker Scientific); Harvey, M. (NIWA); Hartery, S. (University of Canterbury); Morgenstern, O., Varma, V., Williams, J. (NIWA)

A key challenge addressed in Phase I of the DSC was to improve the representation of clouds over the Southern Ocean in the New Zealand Earth System Model (NZESM). Tiny particles in the atmosphere such as dust and sea spray ("aerosols") seed cloud formation and may therefore contribute to cloud biases simulated by the NZESM. We evaluated the simulation of Southern Ocean aerosols in the NZESM and the role they play in cloud formation. Unexpectedly, we identified biases in the seasonal cycle of aerosols in this region compared with satellite observations; the NZESM simulates too much aerosol in winter and too little in summer. These seasonal biases are related to errors in how the two dominant aerosol sources – sulfate and sea salt aerosol – are produced in the NZESM. We tested alternative aerosol production pathways based on observations collected on the Southern Ocean during the 2018 RV Tangaroa voyage. We show that "activated aerosols" – those that can seed cloud formation – are highly sensitive to these new production pathways and affect the simulation of clouds and radiation globally.

Sea ice response to ice shelf freshwater fluxes in an Earth System Model (Short)

Presenter: Inga J. Smith (University of Otago)
Other authors: Andrew G. Pauling (University of Otago, University of Washington), Cecilia M. Bitz (University of Washington), Katherine Lilly (University of Otago), Patricia J. Langhorne (University of Otago), Christina L. Hulbe (University of Otago)

As part of the DSC Targeted Observations and Process-Informed Modeling of Antarctic Sea ice project and the NZARI-funded Aotearoa New Zealand Ross Ice Shelf Programme, we examined how sea ice extent would change in the future under three different idealized scenarios of Antarctic ice sheet and ice shelf freshwater flux changes. We ran three climate model scenarios of changes in freshwater in CCSM4 starting in 1980 to examine potential future impacts on sea ice extent and feedback effects on climate (e.g., surface air temperatures). Greenhouse gas forcings used for those three runs were historical and RCP8.5 from 2006 onwards. We then ran two idealized experiments starting at 1850 for comparison. We chose to run from a base year of 1980, which we assumed to be when the Antarctic ice sheet was in mass balance, and then increased freshwater fluxes to add an amount of ice shelf meltwater over 150 years that was the approximate equivalent of 3 m of sea level rise.

Connections in Sea Ice between the Deep South Challenge and the Antarctic Science Platform (Short)

Presenter: Natalie Robinson (NIWA)
Other authors: Langhorne, P. (University of Otago); Rack, W. (University of Canterbury); Renwick, J. (Victoria University of Wellington), Keller, L. (GNS); Stevens, C. (NIWA), Bertler, N.; Smith, I., Mackie, S. (University of Otago), Leonard, G. (University of Otago, Dunedin)

Sea ice is poorly resolved in global climate models yet is a significant influence on climate and weather. This talk will describe how sea ice work conducted as part of the Deep South Challenge (DSC) has forged new opportunities within the Antarctic Science Platform (ASP). Under the DSC programme, novel observational techniques for understanding the influence of ice shelf melt on sea ice variability were developed. The Challenge is also supporting work to implement process-informed representation of sea ice in global climate models based on this new knowledge.

Under the ASP, which stretches from 2019 to 2025, sea ice is recognised as shaping Antarctica's influence on global climate in a variety of ways. Here we will outline plans for sea ice research under the ASP, and how these interface with on ongoing work under the DSC. The ASP's aim is to better understand the response of sea ice to climate change to date and project its response under future climate scenarios. This will be accomplished with a multi-disciplinary effort incorporating reanalysis of climate data and satellite observations; year-round oceanographic observations; airborne observations of sea ice thickness; polynya process studies; metrics of ecosystem dependence on sea ice; and will include further steps of implementation and improvement of sea ice representation in global climate models.

Economic Implications of Climate Change (Tuesday 7th May, 4pm – 4.45pm)

Economic impacts of Flood Schemes and Local Flood Management (Short)

Presenter: Patrick Walsh (Manaaki Whenua-Landcare Research)
Other authors: Robertson, T. (Coco Analytics); Paulik, R. (NIWA)

Flood management in New Zealand has changed significantly over the past several decades, from a centralized to a devolved approach. In most regional councils, flood schemes use targeted rates to tax flood prone areas, with the resulting funds used for flood infrastructure. This project investigates flood scheme locations and their impacts. An expansive data collection effort was undertaken, contacting regional councils, consultants, and interest groups involved in flood planning and research. The project brought together a wealth of data from several disciplines, including building location, flood risks, flood schemes, geographic information, and Earthquake Insurance (EQC) claims. Using these data, we analyse the impact of schemes using econometric regressions. Our results suggest that flood schemes have an impact on both the frequency and severity of EQC claims. Since those claims are only a fraction of private insurance claims, our results suggest that flood schemes can have a substantial impact. Finally, using data on the risk of sea level rise, we explore the potential impact of flood schemes on unprotected areas. Overall, the research highlights several important gaps in existing New Zealand flooding data and management.

Estimating financial costs of climate change in New Zealand (Standard)

Presenter: Suzanne Rosier (NIWA Wellington)
Other authors: Frame, D. (Victoria University of Wellington), Carey-Smith, T. (NIWA Wellington), Harrington, L. (Oxford University Centre for the Environment), Dean, S. (NIWA Wellington), Noy, I. (Victoria University of Wellington)

Extreme weather matters in Aotearoa New Zealand, and changes are afoot with climate change. In a recent decade (2007-2017), insured and economic losses due to flooding and drought totalled at least $4.7bn. This study, commissioned by the NZ Treasury and supported by the Deep South National Science Challenge, brought scientists and economists together to estimate, for the first time, the financial costs associated with climate change. It was found that, of the $4.7bn total, about $840m could be attributed to the human influence on climate.

This was a low-budget pilot study which necessarily involved a number of approximations, and uncertainties were generally large. It was challenging and illuminating to bring together both the scientific and economic aspects of this issue and acknowledge the differing levels of certainty in the two distinct types of information. Despite the uncertainties, and the exploratory nature of the study, the report has been well received and outlines worthwhile avenues for further investigation of just one of the areas where the impacts of climate change will be felt.

Climate resilient Māori land investment decisions to enhance prosperity (Short)

Presenter: Shaun Awatere *(Ngāti Porou),* Manaaki Whenua Landcare Research and Tui Warmerhoven (*Ngati Porou, Ngati Uepohatu & Te Whanau A Apanui),* He Oranga Trust.
Other authors: Pohatu P (He Oranga mō ngā Uri Tuku Iho Trust, Ruatōrea, New Zealand) ; Daigneault A (University of Maine, USA); Harrison D , Monge J , Dowling L (SCION); Marden M (Manaaki Whenua Landcare Research).

Our team of multidisciplinary researchers (ecologists, economists and kaupapa Māori researchers) produced a paper and a report that outlines how we used the NZFARM model to estimate the potential impact of climate change on erosion and to spatially identify the optimal areas to be afforested to achieve various erosion-reduction goals in Te Tairāwhiti (East Coast). We promoted the findings to the Waiapu Restoration Programme (a governance group tasked with restoring the health of the Waiapu catchment) in October 2017; the results support the continued efforts of the group to address afforestation in the catchment through the Erosion Control Funding Programme and MPIs 1 Billion Trees Programme. With assistance from the DSC Communications team particularly Alex Keeble, we produced a short media clip that socialised the findings with a broader base of Māori land-owners in Te Tairawhiti through Facebook. Māori Landowners who had been involved with the project were interviewed and discussed their: aspirations for the whenua, the implications of the main findings from the project for them and their whenua, and the steps required to mitigate erosion such as afforestation options. A significant challenge raised by our technical report is the need for future research/policy work that will help land-owners choose the right mix of tree species for their specific ecology to mitigate climate change impacts and realise long term inter-generational aspirations for their whenua.

Extreme Weather Events: Future Liabilities of the Public Insurer (the EQC) (Short)

Presenter: Jacob Pastor (Victoria University)
Other authors: Noy, I (Victoria University); Sin, I (Motu)

Climate change (manifested as periods of intense precipitation) will exacerbate the potential liabilities of New Zealand's public insurer, the Earthquake Commission (EQC). The EQC is liable for some of the damages associated with flooding and rainfall-induced landslips to insured residential properties. In this paper, we estimate the relationship between past extreme precipitation events and the weather-related insurance claims made to the Earthquake Commission (EQC) from 2000 to 2018. We then predict the impact of future extreme events on the number and value of insurance claims using precipitation projections for different RCP scenarios. We can thus quantify the total future liability of the EQC to weather-extremes for different time horizons and different future RCPs.

Poster Presentations

(Posters are on view on the Board Room during break times)

Flood inundation and broader ecosystem service modelling in a sparse data catchment: application of LUCI to Marakopa, NZ

Presenter: Barlow Kameta, R.
Other Authors: Maxwell, D, Jackson, B (Victoria University of Wellington)

Flooding and erosion are two earth system processes which impact data-scarce Marokopa, 80km south-west of Hamilton on the Waikato-west coast. Two approaches are used to describe the current and future flood risk experienced by the local community. Using the Land Use and Capability Indicator (LUCI), data from a variety of sources are used to holistically describe the hazard, but also analyse the potential of different land use change scenarios.

First, traditional rainfall-runoff modelling of the upper karst catchment is used to relate rainfall events under various climate change and greenhouse gas scenarios to flooding at Marokopa. While quantitative data is essential for model calibration and validation, personal experiences of flooding were also essential for model set up and understanding of the catchment hydrology. This was utilised in the aforementioned flatwater inundation flooding of the Marokopa floodplains. Second, ecosystem service (ES) modelling builds on the theory that land management decisions are increasingly becoming hazard management decisions. Different services, including flood mitigation, erosion risk, sediment delivery and agricultural productivity are modelled. ES modelling quantifies current service performance based on landscape land use and soils type, but also looks at the potential for those services with land use change.

This project highlights the importance of holistic modelling by combining models that look at flooding as a hydrological process, but also as a land management process that is connected to many other facets of community life.

On multi-scale high latitude oceanic processes

Presenter: Graham Rickard (NIWA)
Other authors: Behrens E. (NIWA), Madawi A. (UoA)

Results from a DSC ocean modelling project are presented. Here output from first DSC phase high-resolution nested models for the Ross and Amundsen Seas are examined to consider the impact of the improved resolution compared to the globally coarse spatial scales typical of most ocean components of global climate models.

This project shows that high latitude oceanic process simulations become more realistic with the increasing model resolution as a result of explicitly resolved mesoscale eddies, compared to their parameterization required at the coarser scales of typical global models. This has implications for the large-scale ocean circulation, such as the shape and strength of the Ross Sea gyre, and Ross Sea Antarctic Bottom Water pathways. The improved quality of the model fields from this project enables more sophisticated investigation of the life cycle of Antarctic toothfish for example, thereby connecting DSC project outputs to the Ross Sea Marine Protected Area (MPA) project.

On multi-scale high latitude oceanic processes: Internal wave dynamics

Presenter: Graham Rickard (NIWA)
Other authors: Behrens E. (NIWA), Madawi A. (UoA)

Results from a DSC ocean modelling project are presented. Here high-resolution internal wave modelling for examining mixing dynamics at high latitudes is presented using the adaptive Gerris fluid dynamics solver. The adaptivity is exploited to capture details of boundary layer processes around the relatively sharp topographic features imposed by ice shelves and tongues around Antarctica, while enabling flows over depths of around 1000 metres or so to be adequately resolved.

Internal waves promote mixing, yet are under-resolved by present models, especially around ice shelf/tongue edges at high latitudes. Further, at these latitudes, internal waves can change from being propagating to trapped (evanescent). This project uses high resolution modelling to look at these specific internal wave processes, and what they might mean for high latitude mixing and processes. This work will inform small-scale and large-scale dynamics for potentially improved estimates of ocean-ice interactions.

Climate Response to Increasing Mass Loss from Antarctica

Presenter: Shona Mackie (University of Otago)
Other authors: Smith, I.J. (University of Otago); Ridley, J.K., (MetOffice, United Kingdom); Stevens, D.P. (University of East Anglia); Langhorne, P.J. (University of Otago)

Antarctica is losing mass at an increasing and spatially variable rate. Research shows a spatially variable climate response to increased freshwater input, suggesting sensitivity to the sources of water from icebergs and ice-shelf basal melt. However, climate projections traditionally assume a constant and spatially uniform rate. The physical core of the NZESM, HadGEM3GC3.1, includes spatial variability by using glaciology estimates to distribute mass loss in a realistic way around the coast. Basal melt and icebergs are produced at each ice-shelf front: melt enters the ocean immediately while icebergs are transported and melt according to ocean properties. The total mass loss rate, however, remains temporally constant. We introduced flexibility into NZESM to allow polar mass loss rates to vary temporally, to determine the implications of this assumption for projected climate (experiments run at UK MetOffice). Future development may allow the increase to vary spatially, facilitating updated climate projections in response to new ice-shelf specific estimates of mass loss. This is the first evaluation of climate response to an increasing rate of Antarctic mass loss with melt realistically distributed using a coupled model to capture feedbacks, and provides insights into aspects of future climate not captured in current projections.

Using the singe-column version of the New Zealand Earth System Model (NZESM) for surface and top-of-the-atmosphere radiation experiments in the low southern latitudes

Presenter: Jordis Tradowsky (Bodeker Scientific)
Other authors: Conway, J. (NIWA)

The NZESM is a powerful tool for simulating the climate system. However, because of its complexity, it can be difficult to assess how well the NZESM represents some physical processes occurring in the real world. The single column version of NZESM allows to analyse processes in an individual column through the atmosphere and enables easier validation of processes with the model. In the project presented here, the single column model has been used to compare modelled radiation at the surface with surface measurements close to Scott Base in Antarctica, which have been measured

during the Atmospheric Radiation Measurement West Antarctic Radiation Experiment (AWARE) campaign. Profile measurements from AWARE have been used to constrain the single column model for this task. Furthermore, the radiation calculated using the single column model for a location above the Southern Ocean has been compared with the results from the full NZESM at this location.

Aerosol and Cloud Observations over the Southern Ocean from the Ross Sea Marine Ecosystems and Environment voyage

Presenter: Mike Harvey (NIWA)
Other authors: Hartery S., Kuma P. (University of Canterbury); Marriner A., McGregor J. (NIWA); Archer S. (Auckland University of Technology), Brailsford G. (NIWA), DeMott P. , Hill T. (Colorado State University); McDonald A. (University of Canterbury), Morgenstern O. (NIWA), Geddes A. (NIWA), Kremser S. (Bodeker Scientific), Cliff Law (NIWA), Lennartz S. (Geomar, Kiel, Germany), Parsons S. (University of Canterbury), Querel R. (NIWA), Rack W. (University of Canterbury), Sellegri K. (Laboratoire de météorologie physique, France), Varma V. (NIWA), von Hobe M. (FZ Jülich Germany)

Two years ago, we proposed a multi-disciplinary study of the linkage between marine aerosol (particulates) and clouds on a voyage to the Southern Ocean. With inputs and funding from at least 10 institutions, a range of observations were made by a small on-board team. The goal of the work is “An improved understanding of processes required to adequately represent Clouds and Aerosols globally in Earth System Models including in the Southern Ocean” where there is a history of poor model performance”.

Currently, observations are sparse, and process understanding is incomplete. In the present work, a number of new findings have been made, covered in accompanying presentations. We show that surface emissions and processes in the lower atmosphere are critical to understanding cloud properties, and linked through micro-physical processes in aerosol-cloud interactions. Updated data are needed - in the case if ice nuclei measurements, it has been about 30-40 years since the previous focus on measurement and the new findings are feeding through to model development.

In this presentation we consider “why persevere with making in situ measurements in one of the most challenging environments known given the expense and logistic difficulties? Is there specific relevance to New Zealand?

Redistribution of Southern Hemisphere oceanic heat content by ocean dynamics

Presenter: Denise Fernandez (NIWA)
Other authors: Bowen, M. (University of Auckland), Sutton, P., (NIWA)

The Southern Hemisphere has made the largest contribution to the observed increase in global heat content in the past decades. Observations and simulations indicate that the ocean stores heat at mid-latitudes (30˚- 45˚S) where sea surface temperatures are rapidly increasing at a rate of over 0.1˚C per decade since 1950s. In contrast, the ocean south of 50˚S is showing little warming in comparison to global averages despite being characterised as the region of greatest heat uptake from the atmosphere. Recent studies, based mainly on model simulations, indicate that this pattern of warming and cooling at different latitude bands is shaped by the balance between heat uptake and surface equatorward heat transport. In this study we investigate the role of winds as the main forcing of the warming signal observed at mid latitudes. We use 14 years of observations and reanalysis of temperature, sea surface height and surface fluxes to investigate trends and the

mechanisms driving the heat in the Southern Hemisphere via ocean dynamics. The main contribution of this DSC project is to inform whether the paradigm of winds driving the redistribution of ocean heat content is changing.

Southern Weather Discovery: Citizen science as a tool for rescue of Deep South meteorological observations

Presenter: Petra Pearce (NIWA)
Other authors: Lorrey A. (NIWA), Woolley J.-M. (NIWA), Fauchereau N. (NIWA), Wilkinson C. (University of East Anglia), Hawkins E. (University of Reading), Brohan P. (UK Met Office), Allan R. (UK Met Office)

19th and 20th Century whaling, trade, exploration and migration ships took regimented weather observations in New Zealand, the Southern Ocean and near Antarctica where where land-based meteorological stations do not exist. These old weather observations can help test and validate the New Zealand Earth Systems Model, a central aim of the Deep South National Science Challenge (DSNSC). Augmenting Southern Hemisphere data coverage would help improve the veracity of the 20th Century Reanalysis - a unique global daily weather reconstruction based only on surface observations.

Our research has been assisted by the Copernicus Climate Change Service (C3S), who contracted NIWA to develop rapid recovery and digitization techniques for meteorological observations not yet in databases. A citizen science website, Southern Weather Discovery (www.southernweatherdiscovery.org; SWD) was set up on the Zooniverse platform for volunteers to transcribe meteorological data. After launch in October 2018, over 1400 volunteers have participated in the data recovery effort. SWD has recovered >150,000 barometric pressure and temperature (air and sea surface) observations. We expect maintenance of SWD will continue after DSNSC phase I concludes. Improvements for logbook image preparation, transcription, quality control, and data munging will help streamline the flow of “new” old data underpinning the 20th Century Reanalysis.

Constraining parameterizations of sea spray aerosol flux in the Southern Ocean

Presenter: Sean Hartery (University of Canterbury)
Other authors: Toohey, D. (University of Colorado, Boulder); Revell, L. (University of Canterbury); Sellegri, K. (LaMP-OPGC, Université Blaise Pascal); Kuma, P. (University of Canterbury); Harvey, M. (NIWA); McDonald, A. (University of Canterbury)

To better understand the relationship between wind speeds over the Southern Ocean and the resulting flux of sea-spray aerosol (SSA) into the marine boundary layer (MBL), we examined a time series of sea-level concentrations of aerosol between 0.3–3 µm measured during an austral summer voyage to the Ross Sea aboard the R/V Tangaroa. These measurements were compared to calculations of aerosol concentrations using the Gong (2003) parameterization of SSA flux and source-receptor calculations from the Lagrangian particle dispersion model, FLEXPART-WRF, using meteorological information from Antarctic Mesoscale Prediction System (AMPS) weather forecasts. Throughout the voyage, we found that ship-based observations of near-surface wind speeds were well-correlated with predictions from the AMPS forecasts over a broad range of wind speeds (0–20 m s-1). We found that our observations of sea-level concentrations of SSA were best reproduced using a more conservative estimate of the wind speed dependence of SSA flux than predicted using the Monahan and Ó Muircheartaigh (1980) equation used within the Gong (2003) parameterization. We employed a least-squares analysis between the observations of SSA concentrations and

predictions derived from the FLEXPART-WRF source-receptor analysis to estimate the wind speed dependence of SSA flux and the lifetime of SSA within the MBL. Our comparison methodology showed that model-observation mismatch was partially linked to sea surface temperature, which would have limited bubble size and ultimately aerosol production; however, it was more strongly linked to the scavenging of aerosol from low cloud or fog within the MBL. These findings were confirmed with an independent set of aerosol concentration measurements collected on board an aircraft during the SOCRATES campaign, highlighting the reproducibility of this study. Finally, we present a new parameterization of SSA flux constrained by our observations which would potentially correct biases in aerosol optical depth over the Southern Ocean between current climate-chemistry models and satellite observations.

Long-term data sets of ozone derived from observations

Presenter: Stefanie Kremser (Bodeker Scientific)
Other authors: Hassler, B. (DLR), Bodeker, G.E. (Bodeker Scientific), Lewis, J. (Bodeker Scientific), Thomason, L.W. (NASA)

NZESM is designed to simulate how our climate will change over the coming decades. These projections enable policy-makers to plan for changes in diverse aspects of climate including its impact on agriculture and resources such as water and power. NZESM is complex and requires high fidelity in all of its components. In this project, we constructed global observation-based records of ozone and other gases that absorb or emit solar radiation, such as ozone. To do that, we used measurements of ozone from multiple satellite-based instruments that cover the target observation period (1980 to present). These global observation-based records of ozone are essential to evaluating the ability of NZESM to correctly simulate changes in the stratosphere which are known to affect surface climate. This presentation describes the data sets produced and outlines the important aspect of screening satellite data before their use in constructing the database. For example, in collaboration with NASA and DLR researchers, we have developed new and simplified SAGE II ozone data usage rules which are based on how the measurements were made. This new approach results in more SAGE II data being available for use as well as a more robust elimination of potentially erroneous data.

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

Presenter: Peter Kuma (University of Canterbury)
Other authors: McDonald A.J. (University of Canterbury); Morgenstern O. (NIWA); Parsons S. and Hartery S. (University of Canterbury); Alexander S.P. (Australian Antarctic Division); Cassano J.J. (University of Colorado Boulder); Halla J. (New Zealand Defence Force,); Garrett S. (New Zealand Defence Force); Harvey M. J. (NIWA); Plank G. (University of Canterbury,); Williams J. (NIWA)

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 atmopsheric 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.

Improving stratospheric chemistry in the New Zealand Earth System Model

Presenter: Olaf Morgenstern (NIWA)
Other authors: Dennison F. (NIWA, now CSIRO, Australia); Zeng G. (NIWA); Keeble J. and Abraham N.L. (University of Cambridge); Yang X. (British Antarctic Survey, Cambridge, UK)

Ozone depletion driving the formation of the Antarctic ozone hole is a leading form anthropogenic climate forcing in the Southern Hemisphere. The New Zealand Earth System Model comprises a middle-of-the-road, coupled stratosphere-troposphere chemistry scheme, in principle capturing this human influence, but not all aspects of that scheme are state of the art. Here we report on two advances enabled by Deep South support: One is to introduce solar variability into the chemistry scheme. The Sun has an 11-year solar cycle (i.e. its output is modulated on an 11-year cycle), with the intensity of solar output varying by more than 20% in the far ultraviolet part of the solar spectrum. This variability in solar forcing substantially affects ozone chemistry. We have introduced a relatively simple method of capturing this aspect of natural forcing of the climate system.

The second advance is about renewing and expanding the package of heterogeneous reactions occurring on stratospheric aerosols (in particular on polar stratospheric clouds) leading to activation of chlorine and ozone depletion. Updating the chlorine activation reactions leads to a decrease in ozone depletion, whereas introducing reactions coupling chlorine and bromine activation leads to an increase. Overall, these reactions improve the linkage between polar stratospheric temperatures in spring and polar ozone depletion, a key stratospheric “emergent constraint”, but do not address a cold bias in the model which leads to exaggerated ozone depletion and an ozone hole persisting for too long into early summer.

Pathways of Antarctic Bottom Water from the Ross Sea

Presenter: Abdullah Madawi (The University of Auckland)
Other authors: Bowen M. (The University of Auckland), Sutton P. (NIWA), Behrens E. (NIWA)

High salinity Antarctic Bottom Water from the Ross Sea accounts for about 25% of total Antarctic Bottom Water, the dominant bottom water mass in the Pacific, Indian and South Atlantic Oceans. The effect of mesoscale eddies on the temporal and spatial variability of Antarctic Bottom Water pathways from the Ross Sea was investigated between 2 different resolution models using a Lagrangian particle tracking tool. Enhanced mixing and better represented mesoscale eddies in the finer simulation corresponded with longer pathways but quicker arrival times. On average, particles in the finer simulation arrived 8 years earlier and had pathways 20000 km longer than particles in the coarse simulation. This has significant implications for the advection of changes in Antarctic Bottom Water source water properties and warming signals throughout the Southern Ocean and to the deep North Pacific.

Diagnosing the Southern Ocean Overturning Circulation from Atmospheric Radiocarbon Observations

Presenter: Jocelyn Turnbull (GNS Science)

Other authors: Mikaloff Fletcher, S. (NIWA); Behrens, E (NIWA); Corran, R (GNS Science); Brailsford, G (NIWA); Collins, J (GNS Science)

Correct simulation of Southern Ocean temperatures is critical to projections of New Zealand's climate. Yet the current generation of climate models have significant Southern Ocean temperature biases which have been attributed to biases in the overturning circulation. Recent modelling studies hypothesize that decadal changes in Southern Ocean carbon and heat uptake may be driven by changes in the deep water upwelling component of the overturning circulation.

The radiocarbon content of atmospheric CO_2 ($\Delta^{14}CO_2$) is altered when deep waters that are low in 14C reach the surface and release carbon into the atmosphere, providing a tracer for the upwelling component of the overturning circulation. Our new four year time series of observations of radiocarbon in atmospheric CO2 ($\Delta^{14}CO_2$) from shipboard transects across the Southern Ocean from New Zealand to the Ross Sea reveals lower $\Delta^{14}CO_2$ values in the region of upwelling south of the Antarctic Convergence. Substantial interannual variability is also seen in the $\Delta^{14}CO_2$ growth rate. We will present analysis of these measurements and implications for the carbon cycle and the overturning circulation.

Climate Change –the cascade effect

Presenters: Judy Lawrence (Victoria University of Wellington), Nick Cradock-Henry (Manaaki Whenua Landcare Research), Paula Blackett (NIWA)

Climate change impacts propagate as cascades across physical and human systems, compounding due to the interdependencies between the changing systems. We examined how increased frequency of high-intensity rainfall events, sea-level rise and drought, cascade across urban, water and financial services systems. We integrated our understanding of the physical climate impacts with how they propagate in natural and human systems by working with a range of stakeholders using network and systems tools. Stakeholders found the systems mapping tools to be an effective way to communicate cascading impacts to their decision makers. The research found far-reaching implications for community wellbeing, adaptive capacity, and governance across all the decision settings, thus enabling the science to be relevant and useful for decision makers.

"This work recognises the interconnected nature of climate change and gives us the means to consider potential impacts beyond the obvious. It allows us to get nearer to answering those so-what questions that relate to the four well-beings now and into the future. A step closer to sustainable decision-making."

Without considering the cascade effect is likely to lead to blind spots in adaptation and an over-confidence in New Zealand's ability to cope with such a highly pervasive risk will continue.

Marae-opoly: A climate change adaption game to enable collective decision making regarding the (re)location of a Marae.

Presenter: Paula Blackett (NIWA)
Other authors: Colliar, J. (Hamilton City Council), Hopmans, T. and Lawrence, H. (Maungaharuru-Tangitū Trust)

The impacts of climate change will affect Māori land and marae especially if they are situated near the coast or on flood plains. Simply waiting and reacting to an event puts important taonga and land at risk. The people of Tangoio Marae, near Napier, had the foresight to discuss the current flood

hazard risk that their marae is exposed to, and confront the potential exacerbation of flood risk due to a changing climate. To aid this discussion, we designed a serious game informed by the goals and aspiration of the people for their marae, the local flood risk and the potential future extent and impact of the hazard based on multiple possible futures, estimated financial resources, and the range of adaptation options and their estimated costs. Played in small groups, the paper-based game facilitated the construction and testing of adaptation pathways over a 100-year timeframe. During the game a "rain-maker" generated floods and presented numerous opportunities for groups to reflect on their decisions and adjust their strategy, provided they had the available cash flow. We will overview key elements of the game and evaluate its success as a learning and planning device.

Limits to hydrological foresight and implications for adaptation.

Presenter: Daniel Collins (NIWA)

Hydrological modelling of the impacts of climate change is an important element of both mitigation and adaptation. Model results paint numerical pictures of potential future changes in river flows, floods, and droughts, providing motivation for emissions reductions or for shifts in urban planning, agriculture, or conservation activities. To be useful these numbers must be put into context. When comparing hydrological conditions between past and future decades many projected differences fade into statistical insignificance, immersed by natural year-to-year variability. The rarity of consequential rare events further helps to hide the emergence of a climate change fingerprint. Questions of model validity add an additional shroud of uncertainty to these numbers, and the modelled spatial precision belies excess confidence in the patterns of impacts across catchments and regions. Taken together, these limitations mean that we can achieve no better than sub-regional, hedged numerical or qualitative narratives of potential effects of climate change, even for individual emissions scenarios – limits that are likely to remain for the foreseeable future despite adaptation decisions being needed now. This stresses the importance of using hydrological modelling to inform qualitative scenarios when discussing impacts with stakeholders and the public, and of resilient, robust, and precautionary decision-making under deep uncertainty.

What are the options and expectations of local government when responding to sea level rise?

Presenter: Vanessa James (Victoria University of Wellington)
Other authors: Iorns, C and Gerard, P (Victoria University of Wellington)

Local authority options for responding to sea level rise impacts exist within a complex legal framework which is not specifically designed to support or enable adaptation measures. In addition, capability and capacity constraints within local government, plus central government's approach of providing guidance rather than national direction, mean that decision-making varies significantly between local authorities and that available resourcing is not being utilised efficiently.

We researched responses available to local authorities, then undertook a survey to determine the practicalities of each response. We identified 63 local authorities whose area adjoined or included the New Zealand coastal marine area. Fifty-two organisations agreed to participate and we received 33 responses. The poster (or presentation) will summarise the results of this survey.

The results address: the lack of preparedness of councils to respond to the effects of sea level rise; the respondents' perceived need for more central government direction; respondents' preferred options to support local authorities' adaptive responses to sea level rise; key concerns in relation to

future adaptation needs, particularly in relation to infrastructure; respondents' opinions on where financial responsibility should lie, including for damage to and loss of value of private property.

A method to develop signals to trigger adaptation to sea-level rise

Presenter: Scott Stephens (NIWA)
Other authors: Bell R. (NIWA), Lawrence J. (VUW)

Dynamic adaptive pathways planning (DAPP) is emerging as a 'fit-for-purpose' method for climate-change adaptation planning. A key component of DAPP is to monitor indicators of change such as flooding and storm events, which can trigger timely adaptive actions (change pathway/behavior) ahead of thresholds. Signals and triggers are critically needed to support DAPP—the signal provides early warning of the emergence of the trigger (decision-point), and the trigger initiates the process to change pathway before a harmful adaptation-threshold is reached. We developed a new approach to designing signals and triggers using the case of increased flooding as sea level continues to rise. In New Zealand, we expect early signals to be observed in 10-year monitoring periods beginning 2021–2043 depending on location. Urgency is required to begin the assessment, planning and community engagement required to develop adaptive plans and associated signals and triggers for monitoring. Triggers can be designed with confidence that a change in behavior pathway (e.g. relocating communities) will be triggered before an adaptation threshold occurs. However, it is difficult to avoid the potential for premature adaptation. Therefore, political, social, economic, or cultural signals are also needed to complement the signals and triggers based on coastal-hazard considerations alone.

Extreme weather, climate change, and weather-related EQC claims

Presenter: Sally Owen (Victoria University of Wellington)
Other authors: Professor Ilan Noy, Dr. David Fleming, Jacob Pástor-Paz

Climate change has implications for New Zealand's public natural hazard insurer, EQC, which covers residential properties for some landslip, storm, and flood damage.

First, we investigate this weather related EQC claim data, finding no clear upward trend yet emerging in the number of claims or their value. We find that the average property which lodges a claim tends to be twice as close to the coast as the national average, that properties making claims tend to be on steeper land, and that higher income neighbourhoods tend to be most utilising the EQC cover for weather-related hazards.

We also investigate recovery by exploring the relationship between claim payments and a proxy for short-term economic recovery; remote sensing (satellite imagery) of average monthly night-time radiance. Utilising observed precipitation we are able to construct plausible counterfactuals (properties which were exposed to the hazard but did not make claims). Using three events as case studies, we find that while having EQC claimants s in the community is correlated with improved recovery in areas which moderately experience the extreme weather event, this effect diminishes when we isolate those properties which experienced the brunt of the event.