Meteorological Society of New Zealand

Annual Conference and AGM 2021

Time	Title	Speaker	Institute	Session
8:45-9:00	Welcome and Housekeeping	Luke Sutherland-Stacey	MetSoc	
9:00-10:00	KEYNOTE	**Mr Stephen Hunt**	**MetService**	
10:00-10:30	Morning Tea Break (tea and coffee provided)			
10:30-11:00	New Zealand Modelling Consortium and Open Environmental Digital Library	Marwan Katurji	Christchurch	Morning Chair: Neelesh Rampal
11:00-11:30	Climate System Science at the University of Auckland	David Noone	UoA	
11:30-11:40	The Auckland Rainfall Observation Test Bed	John Nicol	WRNZ	
11:40-11:50	The search for mass balance: Brewster Glacier, Southern Alps	Nariefa Abrahim	University of Otago	
11:50-12:00	Formation mechanisms of tropical cirrus clouds inferred from CALIPSO	Huang Qin	University of Auckland	
12:00-12:10	High-resolution downscaling with interpretable deep learning: resolving precipitation extremes over New Zealand	Neelesh Rampal	NIWA	
12:10-12:20	Dynamical Feedback in a 2D Radiative-Convective Model	Nick Edkins	University of Auckland	
12:30-13:15	Lunch Break (bring your own lunch)			
13:15-13:45	The work of the Meteorology and Remote Sensing Group at NIWA	Stuart Moore	NIWA	Afternoon Chairs: Michael Martens and James Renwick
13:45-14:15	Beyond The Point – The Rise, Fall and Rise of Area Forecasts	Michael Martens	MetService	
14:15-14:25	"Offshore" mountain waves extending horizontally from ranges	Tahlia Crabtree	Victoria University of Wellington	
14:25-14:35	RainCast: a rapid update rainfall forecasting system for New Zealand	Sijin Zhang	MetService	
14:35-14:45	Atmospheric impacts of local ocean grid refinement in a coupled earth system model	Jonny Williams	NIWA	
14:45-14:55	Where oh where is the data for severe weather impact forecasts and warnings?	Sara Harrison	Massey	
15:00-15:30	Afternoon Tea (tea and coffee provided)			
15:30-17:00	Closing Remarks followed by AGM		MetSoc	
17:00-19:00	Networking Event			

Morning Session

New Zealand Modelling Consortium and Open Environmental Digital Library, Marwan Katurji Zhang, University of Canterbury

Dr Marwan Katurji is a Senior Lecturer. He specialises in surface-atmosphere interactions. His research interest is in modelling, simulating, measuring and analysing atmospheric phenomena, using advanced in-situ, aerial and remote sensing measurements and numerical modelling techniques.

In the recent decade, enormous amount of observational and numerical data has generated in Aotearoa, New Zealand. These data are useful for all kinds of atmospheric studies including climate projection, wind resource assessment, dynamic/statistical downscaling, etc. However, the difficulty of getting data from various sources is hindering the progress of scientific research. The New Zealand Modelling Consortium aims to assist to solve the problem by building the Open Environmental Digital Library (www.envlib.org) and providing an open data hub for sharing atmospheric and environmental datasets and analysis toolsets. We have established partnership between Universities, Crown Research Institutes, and research and public service organizations. The vision of the consortium is to ensure cutting-edge research and development in the areas of numerical weather, climate and environmental modelling for New Zealand through collective efforts. We have processed various observational and numerical datasets from FENZ, MetService, University of Canterbury and other partners. Easy access to the data are provided through direct web interaction, API and Python library. We are also developing analysis toolkits for the datasets using Jupyter notebooks.

Climate System Science at the University of Auckland, David Noone, University of Auckland

David is most well-known for his work on using stable isotope information to evaluate clouds, precipitation and atmospheric circulation – work that was recognized by an award from the Obama administration in the US. His group developed the water tracking schemes in global and regional atmosphere models, he has worked on several NASA satellite and aircraft teams on clouds, aerosols and atmospheric composition, and seems to find ways to go to exotic field sites with isotope spectrometers to evaluate processes controlling climate of the past and present.

Understanding a broad range of environmental threats is an arena where university research blends fundamental sciences with applied solutions. For instance, the recent IPCC report continues a legacy of exposing incomplete understanding of many critical areas in the climate system, including clouds, land surface exchange and processes controlling weather extremes. We present an overview of recent research activities within the climate research group in the Physics Department of the University of Auckland that addresses clouds in the climate system. The results highlight the application of complementary approaches that include the extensive use of satellite observations, reanalysis data and theoretical modelling to study maritime boundary layer clouds and cirrus clouds. The former have albedos that are poorly parameterized in models, and the latter are an early indicator of climate change, and have a significant greenhouse effect. The large discrepancies between satellite observations and model parameterizations are of particular interest because they expose a lack of understanding. These examples illustrate the value of blending rigorous climate and environmental science within wider ambitions to inform long-term sustainability that ensures equitable outcomes for all. We discuss the role universities can play in advancing national capacities in modeling, remote sensing, and environmental information custodianship.

The Auckland Rainfall Observation Test Bed, John Nicol, Weather Radar New Zealand Limited

John has over 20 years experience developing weather radar technologies and measurement techniques in academia and working with national weather services. He now works for Weather Radar NZ.

Flood responses and 3-waters operations require accurate and timely precipitation observations and forecasts. Region-wide rainfall observations can be provided by weather radar, however the radar platforms must be well calibrated and the data rigorously quality controlled. This is more easily said than done: a lack of suitable comparative observations make it rather difficult to accurately calibrate weather radar systems. In this talk we will briefly outline plans for deployment of dual-wavelength vertically profiling radars around the Auckland region. The profiling radars will be used to accurately cross-calibrate the MetService radar reflectivity measurements and provide constraints on the appropriate reflectivity-rainfall (Z-R) relationship to use in Auckland. Preliminary results for long-term calibration of the MetService Auckland radar with the aid of single wavelength profilers will be presented.

The search for mass balance: Brewster Glacier, Southern Alps, Nariefa Abrahim, University of Otago

Nariefa is a PhD candidate in the School of Geography at the University of Otago. Her research interests include glacier modelling, glacier-climate interactions and boundary-layer meteorology in high alpine regions. She is currently in her final year.

Understanding the response of mountain glaciers to atmospheric forcing is important, but long-term meteorological and mass balance measurements in these areas are often difficult. In this study, a fully distributed surface energy and mass balance model forced with a 10-year meteorological record collected next to the terminus of Brewster Glacier is used to explore the atmospheric drivers of glacier mass loss in the Southern Alps. The model is calibrated and validated with seasonal and annual glaciological mass balance measurements over the study period. The model provides valuable insights on the spatio-temporal patterns of the surface energy and mass balance fluxes and allows us to examine changes that may not be captured in the glaciological measurements.

Formation mechanisms of tropical cirrus clouds inferred from CALIPSO, Huang Qin, University of Auckland

Qin Huang is a doctoral candidate in Physics at the Department of Physics, University of Auckland. His research mainly focuses on tropical convection and its influence on cloud occurrence from different time scales.

The formation mechanisms of cirrus clouds in the tropics (24S–24N) are investigated using the monthly data in 2007–2015 from the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO). Based on the contributions of the specific humidity (SH) and temperature anomalies to the relative humidity anomalies in cloudy air samples relative to cloud-free air samples, we obtain two categories of clouds: convection-driven cirrus which are formed following the SH and temperature anomalies produced by convection, and non-convective cirrus which are formed by the temperature anomalies unrelated to convection. Averaged over all altitudes of the tropical atmosphere, there are four to five times more convective cirrus than non-convective ones. The seasonal cycle of convective cirrus is consistent with that of tropical convection, while the seasonal cycle of non-convective cirrus is consistent with that of the cold point tropopause. There are two maxima in the frequency of occurrence of convective cirrus, one at 8–12 S in the austral summer, and the other at 8–12 N in the boreal summer. In contrast, non-convective cirrus occur most frequently near the equator in the boreal winter.

Dynamical Feedback in a 2D Radiative-Convective Model, Nick Edkins, University of Auckland

Nick is an ECR specialising in the modelling of extreme climates, with a focus on the simpler end of the model hierarchy. This talk reports on some results from Nick's recently completed PhD.

A 2D RCM is a valuable extension to a 1D RCM because climate variables are not distributed uniformly with latitude. If there is no communication between latitudes, a 2D RCM offers little advantage over an ensemble of 1D RCMs. However, if changes at one latitude induce changes in another by changing the meridional heat transport between the two, an ensemble of 1D RCMs is insufficient, and a 2D RCM is crucial. This dynamical feedback affects the overall climate sensitivity; this is explained by decomposing the total effects into contributions from each latitude. Several assumptions about the representation of meridional transport in a 2D model are explored.

High-resolution downscaling with interpretable deep learning: resolving precipitation extremes over New Zealand, Neelesh Rampal, NIWA

Neelesh is Data Scientist at NIWA and specialises in the development of machine learning models for applications in climate science and weather forecasting.

The typical spatial resolution of a General Circulation Model (GCM) is of the order of 100 km which does not capture precipitation variability across NZ's complex terrain. Dynamical downscaling is computationally expensive which limits our ability to downscale large ensembles of GCMs. While existing statistical techniques (e.g. linear regression) are computationally inexpensive, they struggle to capture the distribution of precipitation extremes across NZ.

We used a Convolutional Neural Network (CNN) to downscale climate change projections (~100 km) of NZ to a resolution of 5 km. Using this approach, we can explain an average of 53% of variance in non-zero daily rainfall for New Zealand (20% improvement). Furthermore, we have been able to reduce in the 99th percentile of rainfall by an average of 30% across NZ.

To dig deeper beyond the black box of deep learning, we used explainable AI techniques. We find that CNNs can learn and associate complex large-scale features from atmospheric rivers and cyclones at coarse resolutions (~100 km) to highly localized precipitation extremes across the country. CNNs can dramatically reduce the computation time required to downscale large ensembles of GCM that rival existing dynamical methods.

Afternoon Session

The work of the Meteorology and Remote Sensing Group at NIWA, Stuart Moore, NIWA

Stuart completed his PhD in physical oceanography at the University of Reading looking at the treatment of flow along irregular coastlines in numerical ocean models before moving to the Met Office and working in the regional model evaluation and development team where he started working with international collaborators at the beginning of what is now the Unified Model Partnership. At NIWA, he is responsible for the development of a number of the core NWP modelling capabilities, focussing on the reanalysis, ensemble and dispersion modelling activities."

The Meteorology and Remote Sensing group at NIWA is responsible for developing and maintaining all of NIWA's Numerical Weather Predication (NWP) capabilities such that New Zealand's weather can be accurately forecast at the landscape-scale and the best possible forcing data is provided for NIWA's downstream multi-hazard modelling activities. The current capability comprises three deterministic models, running at horizontal resolutions ranging from 4.4km to just 333m and an ensemble forecasting system with 18 members running at a 4.5km resolution. In addition, the group undertakes research into understanding NWP model behaviour, including the strengths and weaknesses of NIWA's own forecasting systems, improvement of NWP accuracy through enhanced simulation of land surface and atmospheric processes, the use of statistical and dynamical methods to remove model biases in downscaled forecasts, and the specification of forecast error probability density functions through post-processing of ensemble forecast output.

In this presentation, we will introduce the members of the group, the NWP systems we are currently operating and developing and give an overview of the main research projects currently underway.

Beyond The Point – The Rise, Fall and Rise of Area Forecasts, Michael Martens, MetService

Michael studies a Master of Meteorology at the University of Hamburg in Germany. He joined the MetService in 2013 and worked a a forecaster until recently. Since April Michael is the manager of marine and regional weather services and the MetArea XIV Coordinator to WMO.

Early meteorological forecasts were mostly manual interpretations of expected weather over defined areas, such as regions or provinces. With the improvement of Numerical Weather Prediction (NWP), many suppliers of weather forecasts base their business model on creating millions of automatically-generated point forecasts, the number of which currently outstrip area forecasts by many orders of magnitude.

However point forecasts have their downsides. Firstly, they cannot convey information over broad areas, as is needed for marine forecasts, Severe Weather Warnings and scripts for TV and radio. Secondly, they do not cover the range of conditions possible in mountainous regions, where variation within an NWP grid cell can be significant. Lastly, they can perform poorly in convective situations.

Methods exist to improve the accuracy of point forecasts, including meso-scale ensembles and "neighbourhood" methods. Many suppliers also provide maps of NWP output for extra context. However there are still many forecasts that need a true areal consideration, and most of these are prepared manually by National Weather Services.

MetService is in the process of developing methods for fully or semi-automating area forecasts, utilising a method that allows for similar scalability of automatic point forecasts. Early prototype testing has shown promising results.

"Offshore" mountain waves extending horizontally from ranges, Tahlia Crabtree, Te Herenga Waka - Victoria University of Wellington

Operational meteorologists in New Zealand have on numerous occasions observed what appears to be mountain wave cloud forming along a straight line extending over the ocean, aligned with, but not downstream of, a mountain range. An initial research project confirmed that these events exhibited signatures of mountain wave activity in both observed and modelled data. A second project built on those results, using high resolution Weather Research and Forecasting (WRF) model data to investigate two cases in greater detail. A strong mountain wave response was discovered in levels above the tropopause, and from this certain similarities were found to research carried out during the “Deep Propagating Gravity Wave Experiment over NZ” (DEEPWAVE, 2014). Our research has not yet determined a cause for these 'offshore mountain wave' events, although directional filtering of wavefronts seems a promising avenue for further investigation. Further high resolution modelling of case studies, with the ability to modify terrain and meteorological variables, is expected to be crucial. Since the phenomenon has not, to our knowledge, been previously described in literature, we also hope that exposure to a wider audience might help form new hypotheses to be tested in future research.

RainCast: a rapid update rainfall forecasting system for New Zealand, Sijin Zhang, MetService

Dr.Sijin Zhang is a senior scientist from MetService, and he has been working on projects around short range high impact weather forecasting for New Zealand.

A rapid update Rainfall foreCasting system (RainCast) is developed to improve the (very) short range precipitation forecasting for New Zealand. This system blends the extrapolation based nowcast with numerical weather prediction models and generates hourly updated forecasts up to 24 hours ahead. The objective verification indicates that RainCast provides a moderate improvement on rainfall forecasts, especially for the first 3 to 4 hours, compared to the NWP based predictions in New Zealand.

Atmospheric impacts of local ocean grid refinement in a coupled earth system model
Jonny Williams, NIWA

Jonny is a climate scientist at NIWA Wellington, he is the lead developer of the New Zealand Earth System Model. He previously worked at the UK Met Office, in the private sector as an environmental consultant, and at Bristol University, where he was a paleoclimate modeller.

We have studied the atmospheric behaviour of two historical simulations between 1989 - 2008 with and without a nested, regional ocean model in the region surrounding Aotearoa New Zealand. In all other respects the models are identical.

The temperature response follows that reported in Behrens et al. (2020) for 1995-2014 but with less spatial structure; a reflection of the coarser gridscale in the atmosphere model.The response - particularly in regions distant from the nested ocean region - is predominantly unchanged. However there are some non-trivial differences in the response of the cloud and radiation components of the model.

The change in the total cloud amount in the NZESM compared to the UKESM is dominated by changes to stratocumulus and this is strongly negatively correlated with shortwave cloud radiative effect - SWCRE.

In general, clouds and their radiative effects over the Southern Ocean are not well simulated by models - and the changes made here significantly improve the agreement between the simulated and observed SWCRE.

This improvement is especially clear between -60S and -80S where the results lie more than 2 standard deviations from the control mean and are hence statistically significant at the 95% level, assuming normally distributed data.

Where oh where is the data for severe weather impact forecasts and warnings? Sara Harrison, GNS Science/Massey University

Sara Harrison recently submitted her PhD thesis titled "Exploring the Data Needs and Sources for Severe Weather Impact Forecasts and Warnings" at Massey University and is now continuing her work on Early warning systems and alternative data sources at GNS Science. Her upcoming presentation will summarise the findings of one chapter of her thesis which was recently published in the International Journal for Disaster Risk Reduction.

Notable historic severe weather events have exposed major communication gaps between warning services and target audiences, resulting in widespread losses. The World Meteorological Organization (WMO) has proposed Impact Forecasts and Warnings (IFW) to address these communication gaps by bringing in knowledge of exposure, vulnerability, and impacts; thus, leading to warnings that may better align with the position, needs, and capabilities of target audiences. A gap was identified in the literature around implementing IFWs: that of accessing the required data around impacts, vulnerability, and exposure. This research aimed to address this gap by exploring the data needs of IFWs and identifying existing and potential data sources to support those needs. Findings from conducting and analysing 39 interviews with users and creators of hazard, impact, vulnerability, and exposure (HIVE) data within and outside of Aotearoa New Zealand indicate a growing need to model and warn for social and health impacts. Findings further show that plenty of sources for HIVE data are collected for emergency response and other uses with relevant application to IFWs. Partnerships and collaboration lie at the heart of using HIVE data both for IFWs and for disaster risk reduction.