GRI

GEOSPATIAL RESEARCH INSTITUTE *Toi Hangarau*

2021-2022 Annual Report

UC

UNIVERSITY OF CANTERBURY

Te Whare Wānanga o Waitaha

CHRISTCHURCH NEW ZEALAND

Cover image: A flood hazard assessment (blue shading) accounting for uncertainty (red hatching) caused by variations in model grid sampling, using a Monte Carlo ensemble simulation approach for a 100-year scenario event (1% annual likelihood). This work was completed by Martin Nyugen as part of his PhD within the project Mā te Haumaru ō te Wai: Increasing flood resilience across Aotearoa (pages 28-29). Illustration by Matt Wilson.

Contents

GRI Directors’ Statement

Background: The logo from the Second United Nations World Geospatial Information Congress (UN-WGIC) in Hyderabad, India, November 2022 (see page 54).

Tēnā koe e hoa, haere mai.

Welcome to our biennial report for the years 2021-2022. I hope you enjoy this issue as we reflect on some of the developments and achievements in the GRI. We have continued to grow and develop our research portfolio, with several new researchers joining our team. While 2021 was characterised by the continuing impacts of the Covid pandemic, in 2022 we have begun once again to pick up the pace of research engagement. Throughout, we have been able to focus on the development of our impactful research.

For me, a particular highlight was being able to attend the Second United Nations World Geospatial Information Congress (UN-WGIC) in Hyderabad, India in November 2022. While it at first felt strange to be back travelling after so long with the New Zealand borders closed, it was fantastic to be reconnected with geospatial developments at the highest level. I was honoured to be able to present some of the work GRI does, with a particular focus on our research in the development of digital twin to enable automated analytics given real-time observational data.

In this issue, we highlight the work on our PhD scholars in the GRI (pages 20 to 25). We host students from diverse backgrounds and research areas, with the common theme that their research contains a significant geospatial component. While students are hosted by the GRI, they are registered for their degrees across the university. This makes the GRI an exciting place to be, and enables exchange of trans-disciplinary ideas and methods. We welcomed two GRI PhD scholars to the team: Sidney Wong joined in 2021 to work on his project on geospatial linguistics with Jonathon Dunn (School of Linguistics) and Ben Adams (Computer Science), and David Pedley joined in 2022 to work on characterising urban trees using LiDAR with Justin Morgenroth and Luis Apilaza (Forestry), and Varvara Vetrova (Maths & Stats.). More information about their projects can be seen on pages 20-21.

Our research profile has continued to grow. Alongside colleagues at NIWA and other institutions, I have continued to work on the Mā te Haumaru ō te Wai programme (page 28), aimed at increasing flood resilience across Aotearoa, for which two PhD students are hosted in the GRI. We have successfully deployed a novel sensor on an Air New Zealand Q300 aircraft for detecting changes in soil moisture and surface water (page 30), and our digital twin for flood resilience is well on its way to the release of a full version (page 34). In the GeoHealth Laboratory, its excellent research has continued to be developed in areas ranging from the characterisation of healthy locations in our urban areas, population mobility, and assessments of chronic health issues across life courses (pages 39-41). In late 2022, we have also welcomed a new post-doctoral research fellow, who is working on the development of machine learning models for characterising ecosystem status for the Eco-Index programme (page 44).

Post-pandemic we've had a bumper GRI seminar series, and have used a hybrid model for most presentations, furthering our outreach. Talks have included a broad range of geospatial topics, from transport to AI in agriculture to novel stratospheric airborne platforms for remote sensing. Outlines of each talk are on pages 50-53.

Thank you for reading and I hope you enjoy this report. Please do get in touch for more information or if you would like to engage with us in your next spatial projects.

Ngā mihi nui,

Prof. Matthew Wilson

About us

The Geospatial Research Institute *Toi Hangarau* is a world class centre of interdisciplinary geospatial expertise in Aotearoa New Zealand.

- With our interdisciplinary partnership-based geospatial research, we aim to assist New Zealand to:
- Leverage latent value from investments in public and other datasets.
- Deliver expected productivity gains from smarter use of geospatial data, technologies and analytics.
- Grow geospatial capacity, by providing access to a range of types and levels of geospatial capability.
- Realise the opportunities for geospatial innovation and R&D offered by the scale and nature of the New Zealand jurisdiction.
- Provide ongoing global leadership in the rapidly growing field of indigenous GIS.

GEOSPATIAL RESEARCH INSTITUTE *Toi Hangarau*

Vision

Leading transdisciplinary geospatial research towards a just and sustainable society for our whānau and communities.

Mission

Our mission is to be a national centre of gravity for geospatial research to deliver transdisciplinary solutions that enables the benefits of spatial information technology to be fully realised.

Core values

We are leading research that is culturally appropriate, ethical, engaged and partnership-based. We promote diversity and inclusion and provide a supportive environment for everyone to flourish.

Supporting Funders and Partners

M
SPRL SPACE PHYSICS RESEARCH LABORATORY

NIWA
Taihoro Nukurangi

Manaaki Whenua
Landcare Research

NGĀ RĀKAU TAKETAKE
Saving Our Iconic Trees
from Kauri Dieback & Myrtle Rust
National Science Challenges

TE TATAU O TE ARAWA

UC Sustainability

MINISTRY OF HEALTH
MANATŪ HAUORA

NASA

GATEWAY ANTARCTICA

NEW ZEALAND SPACE AGENCY

VICTORIA UNIVERSITY OF WELLINGTON
TE HERENGA WAKA

AUGUSTANA COLLEGE ILLINOIS

UC WIRELESS RESEARCH CENTRE

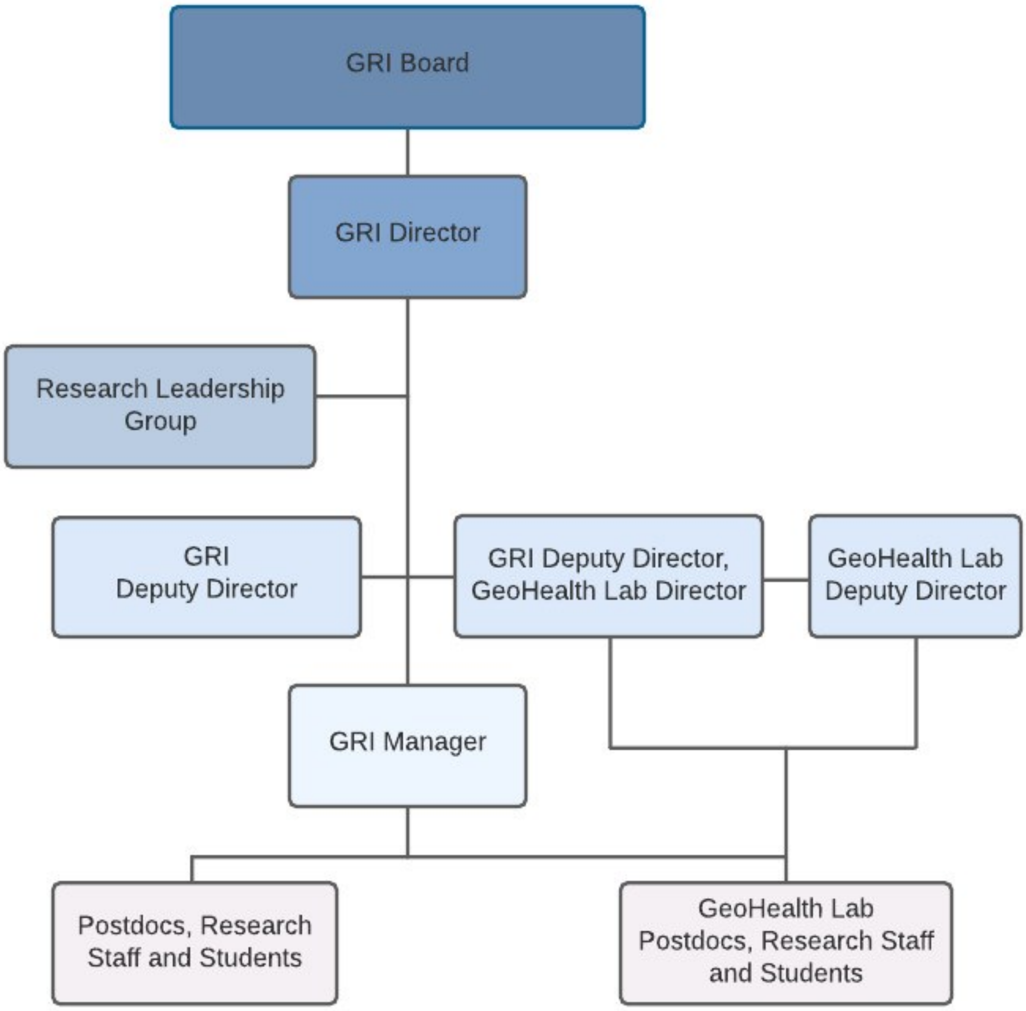
The Ohio State University

Governance

Mt Saint John, NZ. Photo by: MCVega

GEOSPATIAL RESEARCH INSTITUTE *Toi Hangarau*

The Institute's Structure



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Deputy Chief Executive, Land Information NZ.

Ian Wright
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Peter Shaw
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Colin MacDonald (Chair)
MacDonald Consulting.
Finished term in 2022

Richard Gordon
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Finished term in 2022

Mark Nichols
General Manager, Trimble Navigation NZ.
Finished term in 2022

Ahuriri river valley, NZ. Photo by: MCVega

Research Leadership Group

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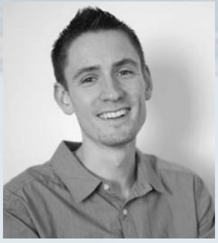
Deputy Director GRI
and Dir GeoHealth Lab

Jennifer Brown
Deputy Director



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Former GRI Manager

Jesse Wiki
Former GeoHealth Lab
Research Manager

Luke Parkinson
Geospatial Software
Developer

Mary Botting
Administrative Assistant

Fiona Cooper
Administrative Assistant
(Former)

PhD research highlights

PhD students

This year we are highlighting the research developed by our PhD students, as they represent the next generation that will drive the future of Geospatial science and technology.

Our PhD students come from many different backgrounds and they clearly demonstrate that geospatial methods can be applied in many areas of research. We are exited to present their novel and inspiring research projects.

Sidney GJ Wong
GRI PhD Scholarship recipient

Sidney is excited to be offered the opportunity through the Geospatial Research Institute Toi Hangarau PhD Scholarship to model the social and linguistic characteristics of local populations using geo-referenced language data. He was attracted by the transdisciplinary nature of this project and is enjoying exploring the possibilities of geospatial linguistics under the supervision of Jonathan Dunn and Ben Adams.

PhD student statement

"I have always been fascinated in the way we use language and how this interacts with the world around us. Whether spoken, written, or signed – we vary and change the way we use language depending on our environment. The topic of my PhD is to model the social and linguistic characteristics of local populations using geo-referenced digital language data. More specifically, I want to extend our understanding of how language varies and changes on social media with the exciting possibility to document the emergence of non-geographically bound digital dialects.

"The link between linguistics and geospatial analysis may not be obvious, but the way we use language is inherently linked to space and place. For example, dialectologists frequently document linguistic variation over space such as the sounds or words we use and even syntactic constructions. We have also noticed how distance (physical, social, or network) between populations have often led to linguistic change. The advent of social media have blurred the boundaries between spaces and places.

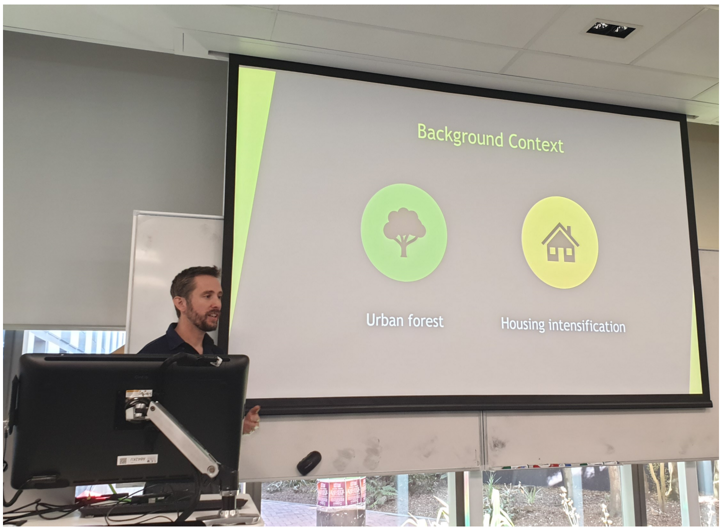
"This is why having access to a longitudinal global dataset of geo-referenced social media language will allow me to investigate how languages might evolve when they are no longer geographically bound to a place in an innovative digital space.

"In order to help me understand how language varies and changes in online spaces, I am first seeking to understand the demographic characteristics of online speech communities. I need to ensure that my sample of geo-referenced social media data is stable. For this, I am developing a demographic profile for each of the approximately 10,000 locations from a global dataset. Measures such as linguistic diversity, are being derived and modelled in order to understand how they change over time.

"Once I have an understanding of the demographic stability of these locations, I will develop models incorporating external real-world socio-demographic variables and linguistic measures to investigate how language varies and changes in online spaces."

David Pedley
GRI PhD Scholarship recipient

David has a professional background as an environmental lawyer and has recently completed a Master's degree in landscape architecture at Lincoln University. Through this experience, David has established a strong interest in the potential of geospatial analysis to help develop effective solutions to complex environmental problems. David's PhD is in urban forestry and will focus on the conflict between housing intensification and the loss of urban trees on private residential land in New Zealand cities.



PhD student statement

"Urban trees provide a multitude of environmental and amenity benefits for city occupants but are under constant threat of removal as cities grow and intensify. The objective of this research is to examine how urban forests in New Zealand cities have been affected by residential housing intensification and provide guidance on how this potential conflict can be managed in the future.

"The first stage of the research will test the potential for deep learning to provide an automated process for detecting changes in canopy cover over time in multiple cities. High resolution imagery and LiDAR will be utilised to provide city-wide coverage at sufficient resolution for site specific property analysis regarding changes in the urban forest, with a particular focus on the loss of trees on private residential land.

"The outputs from this process will be utilised to evaluate the relationship between recent urban intensification and observed changes in tree cover. Spatial data will be used to identify other factors that influence the retention or removal of trees during residential intensification, including the effectiveness of existing regulatory protection.

"The final stage of the research will examine the ongoing risk of tree loss in the face of urban intensification pressure, with a focus on potential solutions to increase the retention of trees on private residential land.

"The subject matter of my project is of strong personal interest as I highly value the important role of trees in urban landscapes. I am also motivated to improve my geospatial skills and test the potential of geospatial research to improve our understanding of important real-world problems. My project provides the opportunity to integrate geospatial methods with my experience in environmental law and landscape architecture to explore cross-disciplinary solutions that benefit our current and future urban forests.

"I started my PhD in late 2022, which is still in the early stages. The process to date has involved developing my research objectives and questions to focus on the issues where new knowledge would be most beneficial. Time has also been spent identifying the relevant geospatial data and methods that will be required to answer these questions. This has involved a review of existing geospatial databases, upskilling in various analysis methods, and an extensive literature review to gain a holistic understanding of the approaches that have been used by other researchers to answer similar questions in related fields."

Wairewa field trip, Winter 2022

Andrea Pozo Estivariz

Andrea has a professional background as civil engineer. After finishing her degree in Spain, she moved to New Zealand to start her PhD in the area of water resource management. Her research is focused on the development of advancing methods of rapid flood risk scenario assessment using hybrid approaches of hydraulic modelling and machine learning.

PhD student statement

"Flooding is one of New Zealand's most damaging hazards. It is also the hazard that will change most rapidly in intensity and nature as climate change impacts become more frequent and extreme.

"My project is focused in helping to develop the tools to build the best approach to flood resilience. I feel very inspired about the innovative nature of this research, its applicability and its potential impact on society and people's live.

"The aim of my research is to development maps to assess flooding, for which geospatial analysis is a fundamental part.

"My study site is the Wairewa catchment (Canterbury, New Zealand), and one of the reason for choosing this catchment in particular, was the fact that this area has a changing topography, and the rainfall, the main inundation driver, varies spatially. These geospatial factors must be carefully considered due to their impact in the resultant flooding depths after a storm.

"Current computing power means flood risk assessments are usually limited to a handful of scenarios for each catchment of interest. During my PhD I will investigate the feasibility of using a hybrid hydrodynamic/machine learning model to reduce the numerical modelling load and enable probabilistic modelling.

"My PhD is part of the 5-year multi-stakeholder research Endeavour Programme "Reducing flood inundation hazard and risk across Aotearoa/New Zealand", MBIE funded and led by the National Institute of Water and Atmospheric Research (NIWA).

"My research's results will provide the tools to aid discussions with the Wairewa Rūnanga and be used to develop a Mātauranga Māori approach to flood resilience.

"My supervisory team includes Prof Matthew Wilson (UC), Dr Emily Lane (NIWA), Prof Marwan Katurji (UC) and Prof Fernando Méndez (University of Cantabria)."

Phoebe Eggleton

Phoebe is a PhD candidate at the University of Canterbury (School of Health Sciences) and is hosted by the GeoHealth Laboratory/GRI. She completed a Master of Spatial Analysis for Public Health in 2021 at UC. Her research topic is focused on the relationship between location-based exposure to the Canterbury Earthquake Sequence (2010-11), and associated mental health outcomes. Phoebe will be using spatial methods throughout her project to determine how a cohort was exposed, and how they have relocated in the aftermath of disaster.

PhD student statement

"I was lucky enough to work with the Christchurch Health and Development Study through an internship during the last year of my degree. This was a very insightful experience where I was able to learn about birth cohort studies and the type of data that they have collected over time.

"During my studies at university, specifically in my Masters' year I developed an interest in major disasters. The Christchurch Health and Development Study was in progress during the time of the Canterbury Earthquake Sequence (2010-2011), where they were able to collect very valuable data. After taking a look through this data, an interest to investigate the spatial distribution of this population sparked.

"For my PhD research project, I have been able to combine geospatial methods with my health background to investigate the effects of the Canterbury Earthquake Sequence.

"Whilst major disasters have been studied on many occasions, most do not have the ability to accurately locate where people were at the time of disaster. Through using location-based data, I am hoping to add to the geospatial literature with a new way of defining exposure to a major disaster.

"In my PhD project I will investigate the impact that exposure to the Canterbury Earthquake Sequence (2010-2011) had on the participants of the Christchurch Health and Development Study.

"The main focus of my research project is to investigate individual level exposure to this event, by using anonymised residential and workplace address data. Further, I will be investigating the impact that different types of exposure to this event have on individual mental health outcomes, specifically depression and anxiety."

Martin Nguyen

Martin completed a Master's degree in Applied Data Science at UC, during which he developed a specific interest in the versatility of Artificial Intelligence. He is pursuing a PhD in the area of data science methods for flood risk assessment. Specifically, his research will focus on advancing methods for uncertainty estimation in flood inundation modelling, using machine learning approaches. Martin's PhD supervisors are Prof. Matt Wilson and Dr Emily Lane (NIWA).

PhD student statement

"My PhD research aim is to quantify the uncertainty in the procedure of developing Digital Elevation Models from LiDAR data for flood modelling.

"Accurate representations of topography are an important input for flood inundation model and have not been widely studied. For flood hazard assessment, Airborne LiDAR point cloud data is sampled and interpolated onto a Cartesian grid (raster) to create a Digital Elevation Model (DEM) which is suitable for use in a flood model. Usually, grid alignment is not considered in the processing. However, considering orientation in sampling process may introduce variability in the resulting elevation model, leading to uncertainty that propagates through to flood model output. This may be particularly apparent for raster grid-based models, where the routing of water flow on the grid may not align with environmental features such as drainage channels.

"I am investigating the variation in the outputs of a flood model using a Monte-Carlo procedure, where multiple, equally likely DEMs are derived from LiDAR by adjusting the alignment (rotation) and point of origin of the model grid, and each used to predict flood inundation. I have conducted two major comparisons to interpret the variability in water depth values when the model grid is transformed. The first was to compare different types of transformations and the second was to compare various DEM resolutions.

"My findings have revealed that high variation in water depth values are primarily concentrated along the river banks and at the edges of flood extents. When comparing transformation versions, rotating the model grid orientation resulted in greater variation in water depth values than translating. As a result, the rotation version contributed more to the variation in water depth values when both rotating and translating the model grid. Throughout the resolution versions, the water depth values of finer resolution versions fluctuated more than those of coarser resolution versions.

"My research results suggest that the rotation has a significant impact on model outputs, and coarser resolutions are more likely to cause variations in the estimated flood extents than finer resolutions. Hence, both grid alignment and resolution should be taken into account in the process of generating LiDAR-derived DEMs. Further work is needed to expand the area of interest to a larger site and test for areas where observational data are available."

Susie Deng

Susie (Bingyu) Deng is a PhD candidate in Health Geospatial Science, hosted by the GeoHealth Laboratory/GRI. Her skills include GIS analysis, longitudinal modelling, and programming. Her research primarily focuses on the impact of neighbourhood on health and wellbeing, with a particular focus on greenspaces and mental health. A broad question that her research will answer is, do the places where people lived have an impact on people's health?

PhD student statement

"My project was inspired by a desire to understand the complex relationship between neighbourhoods and health. My research is focused on the impact of greenspaces on mental health outcomes. To do this, I am gathering and analysing various types of spatial data, including demographic information and satellite imagery, using geographic information systems (GIS), in order to understand the relationships between neighbourhoods and greenspaces.

"Following this, I will investigate whether the places where people live have an impact on their health.

"To provide insights to this questions, I will identify people's migration patterns throughout their lives, the socioecological exposures of places where people lived, and examine the association between accumulated socioecological exposures throughout their lives and their subsequent mental health conditions.

"Ultimately, my objective is to provide evidence-based recommendations for policymakers and urban planners to create healthier and more equitable neighbourhoods that improve residents' overall wellbeing."

The overarching aim of this research is to examine the associations between **greenspaces** and **mental health** over **lifecourse.**

Research Highlights

Mā te Haumaru ō te Wai
Increasing flood resilience across Aotearoa NZ

Flooding is one of New Zealand's most damaging hazards. This research programme is supporting the changes that are needed to our flood risk management. The overall aim of the programme is to provide the first, high-resolution flood hazard assessment for every catchment in the country. The research is producing New Zealand's first consistent, publicly available national flood map, showing where flooding is likely to occur and how vulnerable our assets and taonga are.

Project lead: Dr. Emily Lane (NIWA).
GRI team: Matthew Wilson (uncertainty lead), Dr. Rose Pearson (NIWA/ GRI visiting research fellow), Martin Nguyen, Andrea Pozo Estivariz

Key Partners/Stakeholders

NIWA, GRI/Canterbury University, Auckland Council, Waikato University, WSP, LINZ, Maanaki Whenua

Funding

MBIE Endeavour Research Programme

Uncertainties in flood risk assessments

Prof. Matt Wilson is leading the cross-programme uncertainty theme for Mā te Haumaru ō te Wai. This research aims to advance our understanding and handling of the uncertainties which are present in predictions of flood inundation. Flood risk and other planning practitioners worldwide often use the outputs from flood modelling as part of their decision-making, such as when they determine flood hazard zones, design mitigation measures, or assess the potential impacts of climate change on the flood hazard. However, the uncertainty in these outputs is not often quantified or characterised, making the decision-making process more challenging and less reliable.

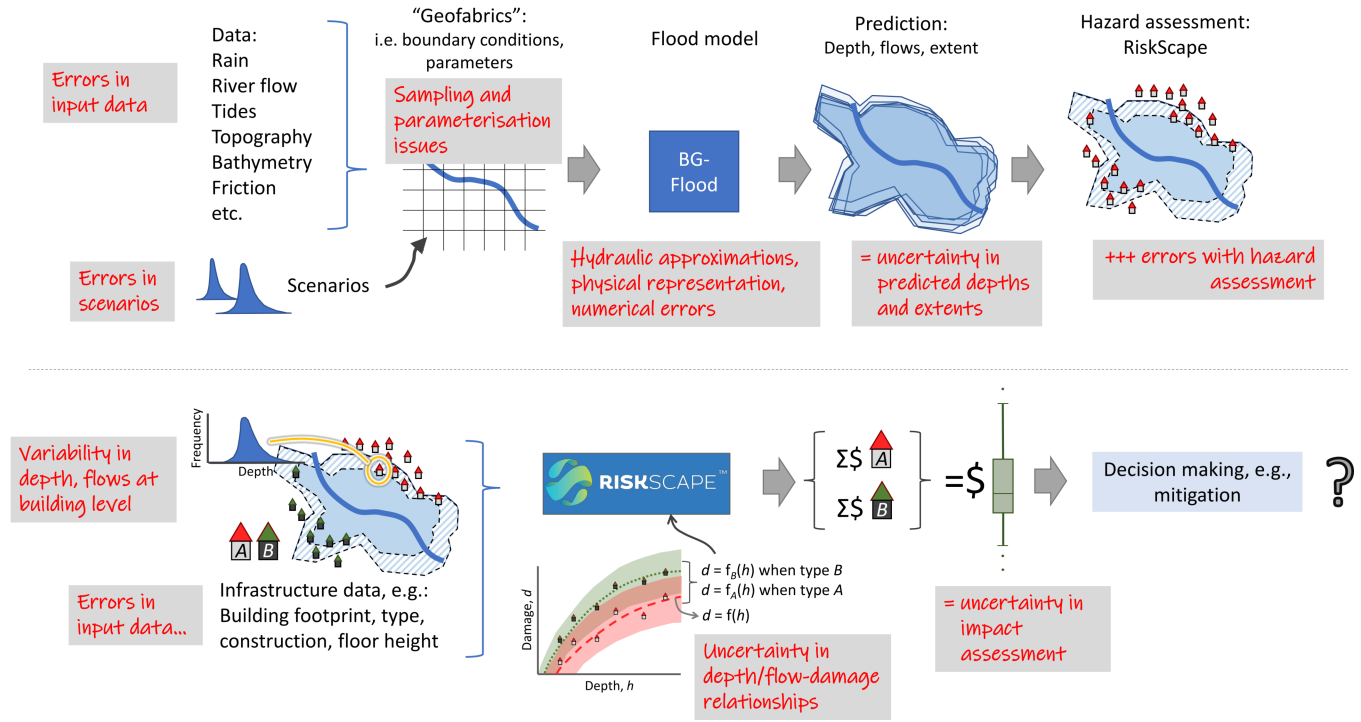
To account for uncertainty, planners may take a precautionary approach, such as adding a freeboard amount to required floor levels in flood zones or designing flood infrastructure such as stopbanks (levees) to a 1% annual exceedance probability (i.e., the 100-year average recurrence interval). However, this approach is questionable in an era of changing risk under climate change. For example, is the freeboard amount used sufficient to prevent serious damage from future floods? Will the area at flood risk increase? Will a current 100-year flood become a 50-year flood in future?

Some of these questions are *aleatoric* in nature: they will always be present and cannot be reduced. This includes issues such as the internal variability of the climate system, the implication of which is that, even if we had complete information about the future climate state, its chaotic nature means our flood risk assessments will still be uncertain. Other uncertainties are *epistemic* and are deterministic and subjective; the uncertainty contained in a flood risk assessment depends on how good (or bad!) are the data which are used within the analysis. Improving input data accuracy and model representations should, at least theoretically, reduce the inherent uncertainty in the predictions obtained and is something we always aim for.

Yet, even if we use the best possible data and model representations, uncertainty will still result from a complex combination of errors associate with source data, sampling and model representation – uncertainties which "cascade" through the risk assessment system (see right), reducing our confidence in any individual prediction and leading to variability in predicted depths and extents across multiple predictions which account for these errors (e.g., within Monte Carlo analysis). These uncertainties, here represented as variability in predicted depths and flows, further cascade through to the analysis of flood impacts.

Uncertainty in predicted depths and flows combine with errors from data such as those for buildings and infrastructure, and the statistical models used to quantify damage (e.g., via depth-damage curves). The end result is uncertainty in quantified damage for a flood scenario, creating issues for the decision-making processes such as determining whether to invest in improved mitigation measures.

Photo: Nelson flooding, August 2022 (Tim Cuff/ NZ Herald)



Top: errors from multiple sources "cascades" through the analysis chain, resulting in uncertainty in predicted depths and extents and the derived hazard assessment; Bottom: analysis using the uncertain hazard assessment creates a further cascade, leading to uncertainty in the impact assessment and causing issues in decision making.

This technical uncertainty is situated within social, economic and political contexts. While we wish to reduce uncertainty as much as possible (e.g., by using better data and models), it will always be present. If we do not develop a clear understanding of uncertainty, and communicate this appropriately, then this is likely to lead to doubts in both decision-makers and the wider public. For example, given uncertainty, a decision-maker may question how their decision would be received by others, or what might happen for different options, or whether their action would actually make a difference. The wider public is likely to question what this means for them: if it would flood again soon, if the next flood might be larger, if they should move, if they can get insurance and what happens if they can't.

Although robust assessments of uncertainty would clearly be helpful, the need to run many 1000s of simulations leads to a high computational demand and, consequently, they are not usually completed, especially at a national scale. In this research programme, one of our current PhD projects (Martin Nguyen) is developing a generalised uncertainty estimation method using machine learning which will enable rapid estimation of the reliability of flood risk estimates for sites, without the need to complete a full uncertainty analysis. A second PhD project (Andrea Pozo) is investigating the feasibility of using a hybrid hydrodynamic/ machine learning model to reduce the numerical modelling load and enable probabilistic modelling, to increase the number of scenarios which can be assessed, thereby enabling us to quantify uncertainties caused by our representation of storm rainfall. Additional PhD projects will start in 2023, with a main focus on the implications of uncertainty in impact assessments on the planning process.

Data processing for flood risk assessments

Alongside the uncertainty research, the GRI is working with NIWA to help produce consistent, open-source methodology for the national flood risk assessments. The methods developed are guided by a number of physically-based flood inundation modelling efforts that have been attempted internationally both at national and global scale. The research programme is specifically addressing common problems, including: the mismatch between resolution, accuracy and the detail required for local-level decision-making; the lack of integration of coastal, fluvial (river) and pluvial (rainfall) hazards; poor integration with urban development futures; and an inadequate representation of uncertainty.

GRI Visiting Researcher Dr Rose Pearson is working towards the development of automated techniques for building a nation-wide datasets suitable for hydraulic modelling, including hydrologically-conditioned digital elevation model (DEM) and roughness maps. Automated processing is needed as these datasets evolve with time, as better survey data becomes available, and in the event of tectonic movements, erosion, earthworks and land-use changes.

An open-source Python library, "*GeoFabrics*", has been developed to support the production of datasets from LiDAR and other data. In addition, another library called "*geoapis*" has been developed to facilitate the programmatic acquisition of the latest LiDAR and vector data available on Open Topography, LINZ LDS, LRIS, and StatsNZ LDS.

Sensing Water: the Rongowai airborne remote sensing mission for GNSS-Reflectometry across New Zealand

GRI Team

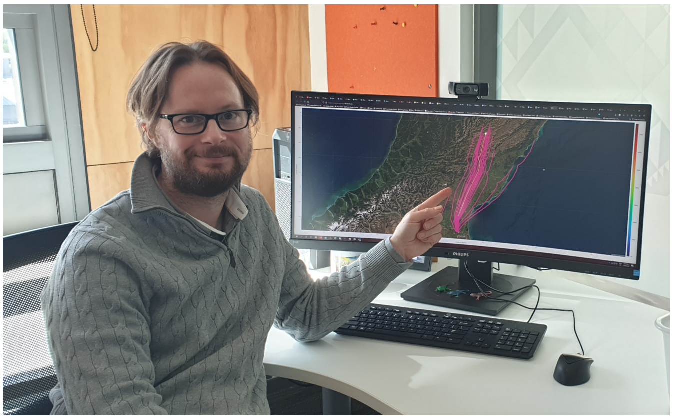
Rajasweta Datta
Sharmila Savarimuthu and
Matt Wilson

Wider team

Delywn Moller, Xiaoyou Lin, Mike Laverick and Chris Seal (University of Auckland), Wayne Thomas (Air New Zealand), Chris Ruf and Steven Musko (University of Michigan), Andrew O'Brien (Ohio State University), Scott Gleason (UCAR) and others.

Funding

MBIE Catalyst fund and NASA



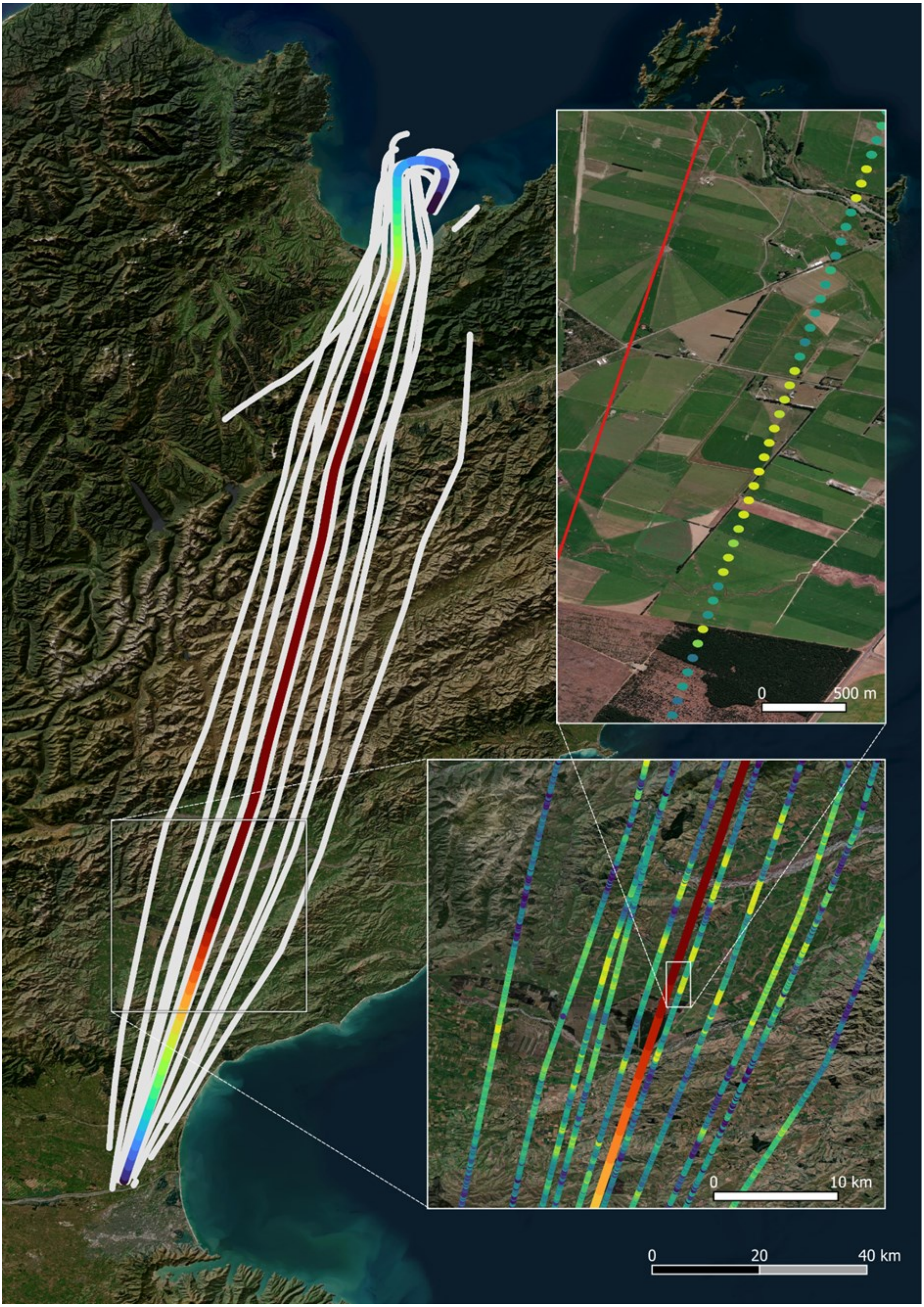
Project summary

The GRI is playing a leading role within the *Rongowai* ("sensing water") mission, that aims to build a detailed picture of the complex patterns of water across New Zealand's complex environment. In a novel partnership with a commercial airline, we have mounted a next-generation GNSS-R sensor on an Air New Zealand Q300 aircraft (tail number ZK-NFA). The sensor records the reflection of signals from the global navigation satellite system (GNSS), which includes the global positioning system (GPS). Usually used for positioning and navigation, these signals are broadcast in L-band radio spectrum and can penetrate clouds, rain and vegetation. The Rongowai sensor uses these "signals of opportunity" to infer properties of the ground surface from where the signals are reflected. In particular, the reflection of signals is changed depending on surface water and soil moisture.

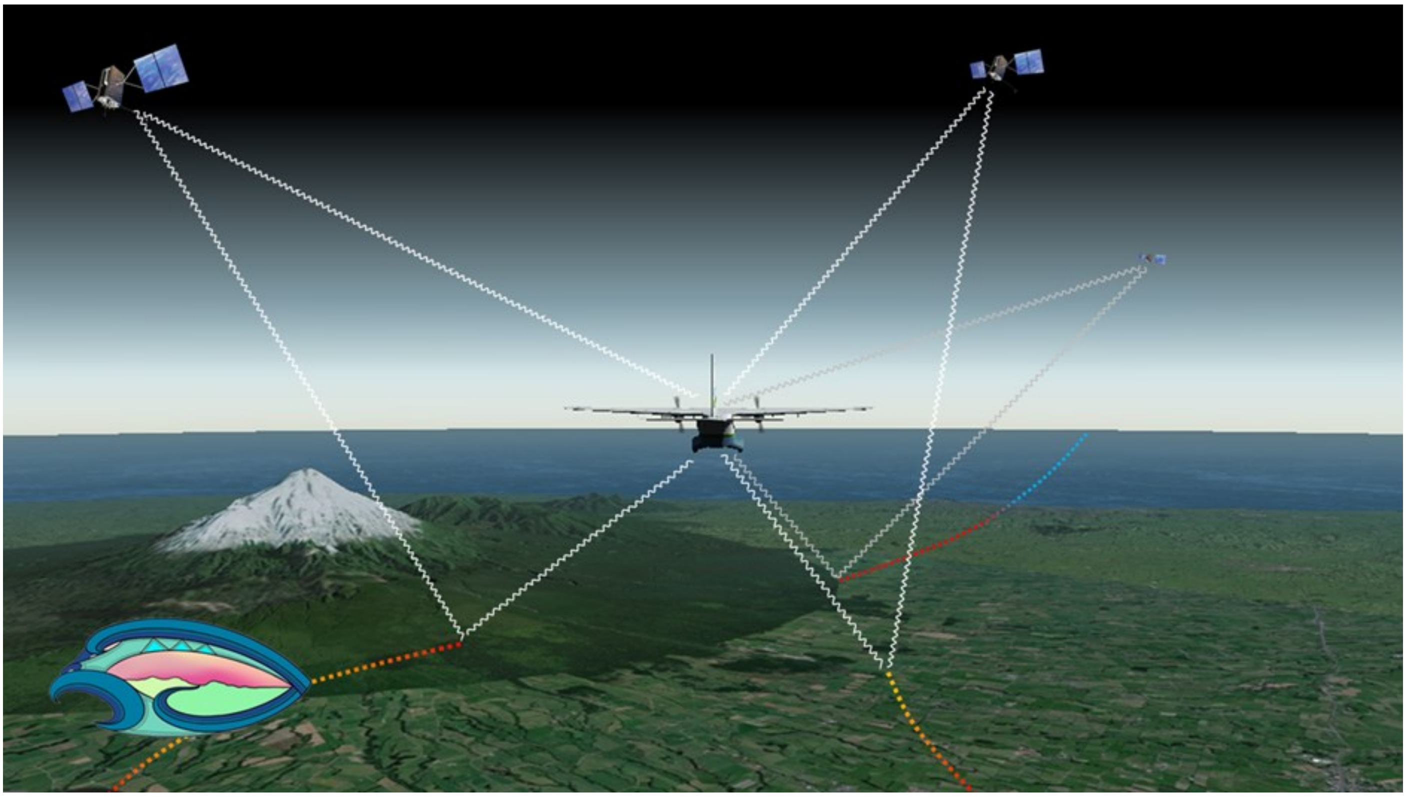
Rongowai will give us significantly improved observations of soil moisture and flood dynamics across most of the country. During each flight, the sensors onboard the aircraft will record direct and reflected signals from up to 20 GNSS satellites simultaneously. The data will enable us to estimate soil moisture and surface water, which will be extremely valuable for shaping our understanding of important issues ranging from water resources in agriculture to wetland dynamics and flood risk.

Mounting the sensor on an Air New Zealand aircraft has only been possible with the strong support of the airline's engineering team. As it is a passive sensor, it does not generate any of its own signals, a necessary characteristic for meeting aviation safety requirements. During each flight, the sensor starts recording signals once the aircraft has reached a set altitude. The data recorded are transmitted via the cellular network only once the aircraft has arrived at its destination.

The locations where observations are obtained is, of course, dependent on the scheduled operations of the Air New Zealand Q300 aircraft. This makes the mission unusual in remote sensing: normally we use either satellite-based data, with known orbits and repeatable observations, or airborne data obtained using private aircraft, with complete control of where and when observations are obtained but with the all the expense of aircraft operations. While using a commercial aircraft means that we do not have any control over where and when observations are obtained, as the aircraft routinely operates several flights a day, we gain a significant volume of data with the other benefits of airborne remote sensing, such as increased spatial resolution compared to space-based remote sensing.



Data from an example flight from Christchurch to Nelson on 5 November 2022. The main map shows the flight track with colours indicating aircraft altitude, and the locations of observations in white; inset maps show observation locations with colours indicating the strength of signal returned (yellow = high; blues = low), a key factor which will be used to infer properties such as soil moisture.



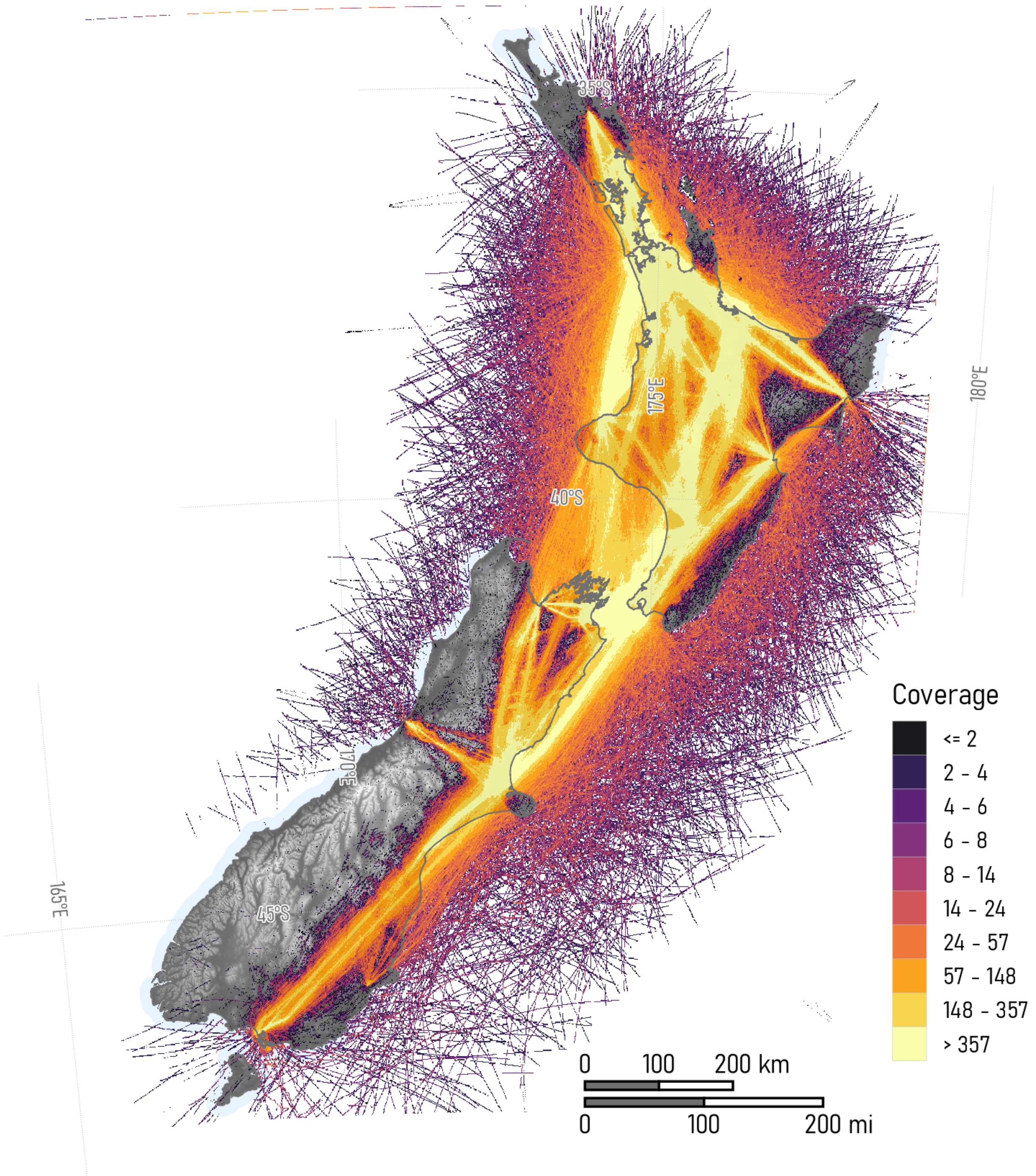
Sketch of how the system works: during a Rongowai flight, signals from GNSS are recorded every second, both directly from the satellite (as is normal for positioning) and reflected from the ground. Transects are formed because of the movement of both the satellites and aircraft; the location and orientation of the recorded signal is primarily dependent on where the satellites are in their orbit.

A Q300 aircraft was selected due to the wide coverage of the type across New Zealand's smaller airports. In particular, the Q300 flies as far north as Kerikeri in Northland, which is not serviced by the Airbus A320 jets. This provides a further opportunity for us to compare data with GNSS-R measurements from the satellite-based CyGNSS ("Cyclone GNSS"), which only observes areas in New Zealand north of Auckland. CyGNSS uses an earlier version of the same type of sensor as Rongowai, but as it is space-borne its ground resolution is much coarser.

Over time, Rongowai will enable an increased understanding of the spatial and temporal variability in surface water and soil moisture across New Zealand. These data will enable us to fill a significant gap in our understanding, due to the current absence of available data.

Currently, soil moisture data are available from satellite systems such as SMAP (Soil Moisture Active Passive), but at a spatial resolution of several kilometres, or from in situ gauges, but only at a point location. The resolution of data from Rongowai data is variable, but in the order of 10s of meters. The first flight of Rongowai was in late September 2022; once testing is processing chains are developed, data from Rongowai will be made freely available, likely sometime in 2023.

To track where Rongowai is scheduled to fly, check here: https://www.flightradar24.com/data/aircraft/zk-nfa



Estimated observation density across New Zealand over a period of 1 year, on a ~800 m grid. The North Island is extensively covered, except north of Kerikeri, which is the furthest airport north. Other than flights into Hokitika on the west coast, South Island coverage is largely limited to the eastern side of the Southern Alps, due to the usual flight paths and high terrain blocking signals from the west.

Digital Twin Digital Twin for Flood Resilience

Project Team GRI

Luke Parkinson (Software developer)
Casey Li (software developer)
Pooja Kholsa software developer) and
Matt Wilson (PI)

Wider team

Greg Preston (BIP)
Rose Pearson
Cyprien Bosserelle (NIWA)
Emily Lane (NIWA) and
Rob Deakin (LINZ)

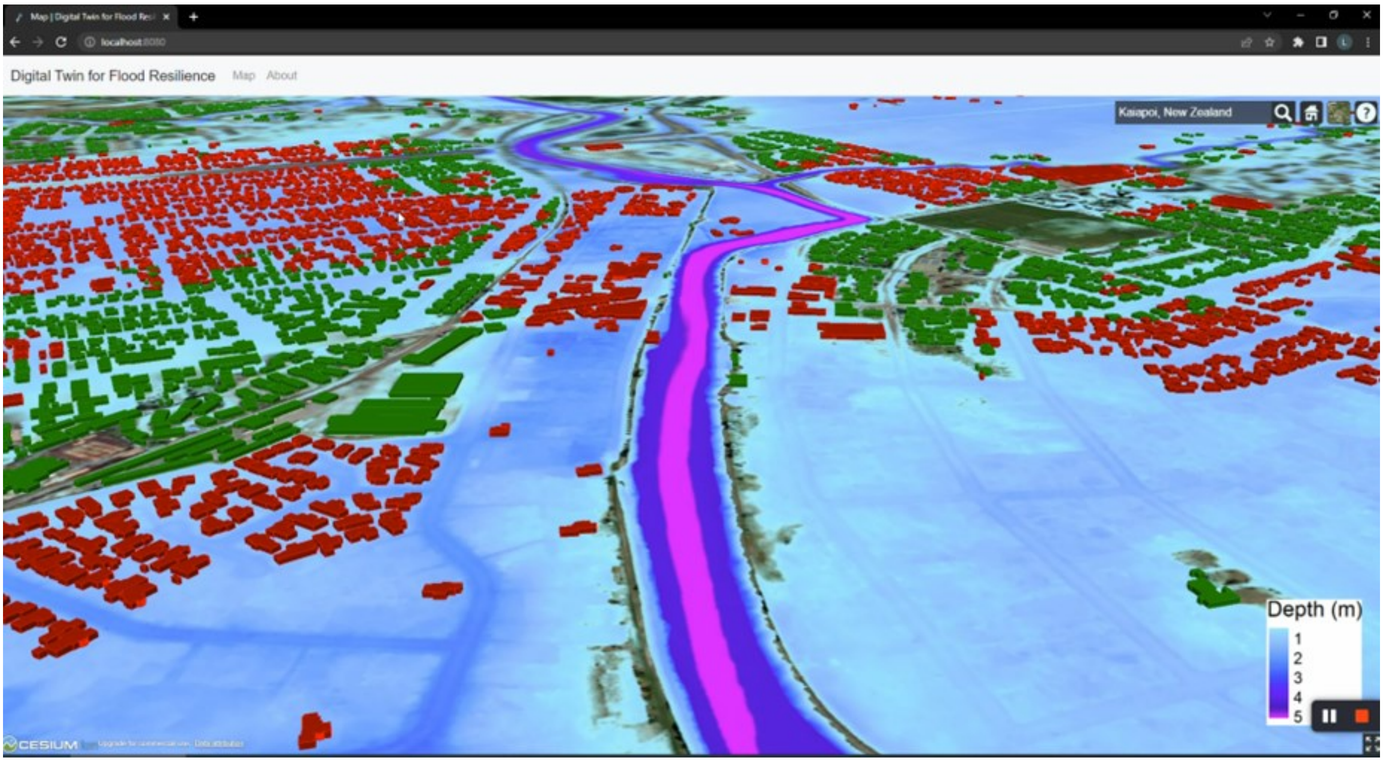
Funding

FrontierSI and the Building Innovation Partnership (BIP).

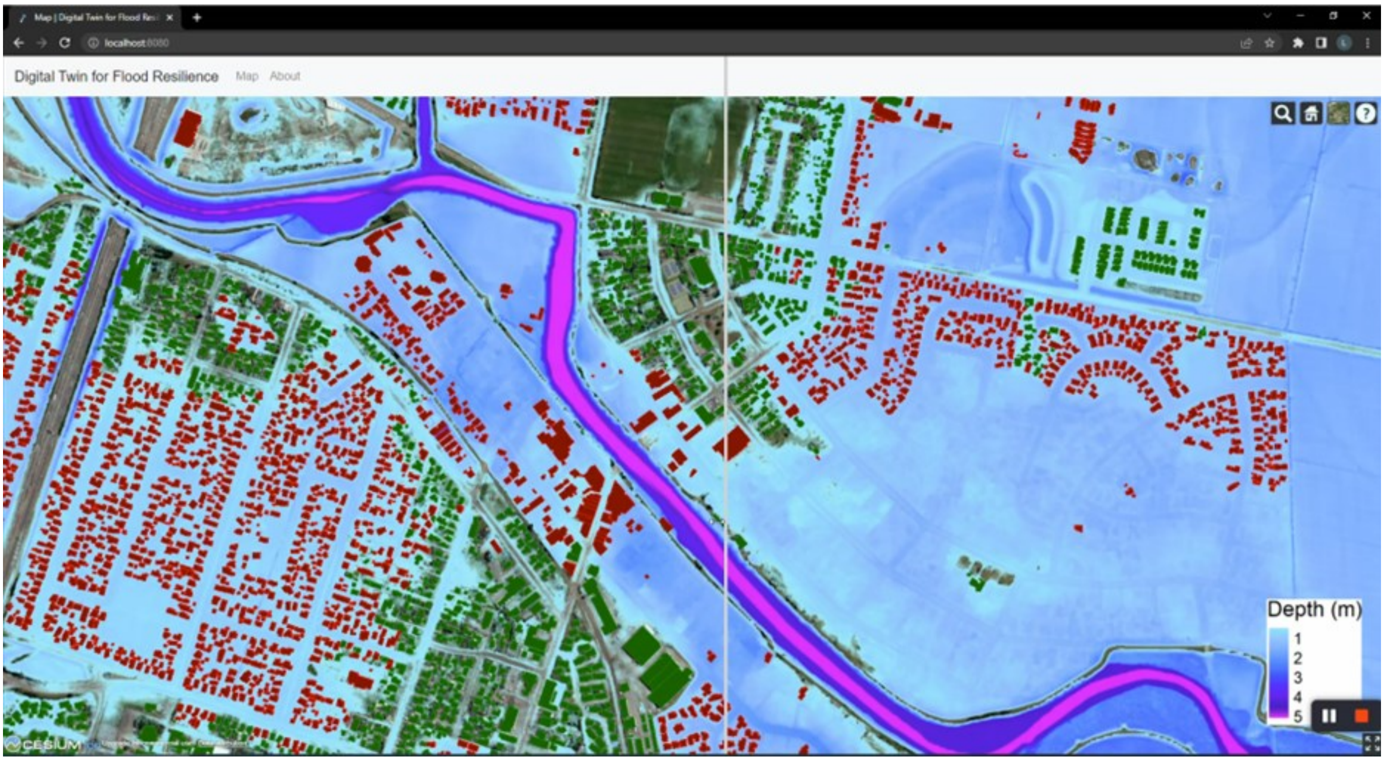
Project summary

This project aims to create a "digital twin" prototype as a proof-of-concept system to assist with more efficient flood risk management. Flood inundation is a frequent and impactful hazard that can cause significant damage to infrastructure, housing, and communities. This technology creates a digital representation of an entity such as a building, city or region, and provides real-time data from sensors for analysis and prediction.

The digital twin aims to address the challenges faced by flood risk managers in processing large amounts of spatial data related to infrastructure and the environment, which can be challenging during natural disasters when quick decision-making is crucial. The problem right now is that the vast amount of data we have makes it an enormous task to process it all in a timely way, if we leave it to individuals or small teams to try and pull it together to make quick decisions.



Currently the front end to the digital twin enables a 3D visualisation of flood water elevation level against buildings and other infrastructure; in this example, buildings coloured red if the flood level is above a selected threshold.



The front end also enables scenarios to be directly compared, for example to account for potential increases to flood risk caused by issues such as increased rainfall intensity or sea level rise.

The technology can overcome this barrier and improve official responses to natural disasters. Moreover, to manage an expected increase in future flood risk, efficient scenario assessment for flood risk management is essential. The digital twin software we have developed integrates spatial and other data from multiple vendors into databases and processes the data for automated simulation of a range of possible flood scenarios using the BG-Flood hydraulic model.

Our digital twin will demonstrate that, by automating analytics, we can help solve problems that can be otherwise very challenging. For example, for flood risk management, there will usually only be relatively few scenarios run within a computer model of flood inundation., which doesn't give much nuance into the risk problem. By automating the workflow, hundreds or even thousands of scenarios become possible, giving decisions makers much more detailed and granular information.

Our processing includes the extraction and conversion of LiDAR point cloud data into hydrologically conditioned digital elevation models. These models are then converted into the required formats to run BG-Flood, along with other data such as land cover which is used to estimate friction and statistically generated pluvial and fluvial boundary conditions. Additionally, we are developing a web-based interface and visualization tool as the front-end for the digital twin. All software we are developing is available under open-source licensing.

Read more here:

Wilson, M.D., Preston, G., Kholsa, P., Parkinson, P., Pearson, R., Bosserelle, C., Lane, E., and Deakin, R, 2022. Towards a National Digital Twin for Flood Resilience in New Zealand, *Stormwater 2022, Te Roopu Wai Āwahātanga*, 18-20 May, Christchurch, New Zealand. Available at: https://bipnz.org.nz/wp-content/uploads/2022/05/2022-Final-Paper-Towards-National-Digital-Twin-for-Flood-Resilience-in-New-Zealand-final-version.pdf

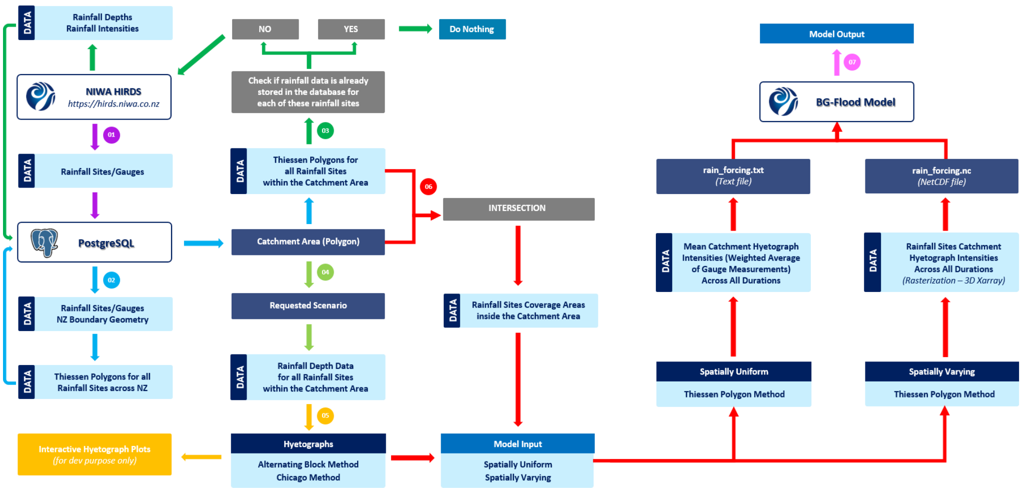
Automation Of Rainfall Data For The Flood Resilience Digital Twin

Developed by: **Casey LI**
Software Developer

This work is part of the project *Digital Twin for Flood Resilience*, developed in a partnership among the GRI, FrontierSI and Building Innovation Partnership.

The principal aim of the Digital Twin is to facilitate the automation of flood risk assessment, which entails the automation of data ingestion, processing, and analysis. This requires a significant volume of spatial data from diverse sources as input, which is subsequently processed automatically to enable the evaluation of various scenarios.

The present area of focus involves the acquisition and automation of dynamic boundary data processing, with emphasis on rainfall data sourced from the National Institute of Water and Atmospheric Research's (NIWA) High-Intensity Rainfall Design System (HIRDS). The objective is to establish standardized rainfall model inputs that can be utilized in BG-Flood, a flood modelling tool developed by NIWA, to produce corresponding model outputs. The process is illustrated in the figure below.



Methods

This process involves first the automatic retrieval of rainfall site/gauge data from HIRDS, which is stored in a database. The area covered by each rainfall site/gauge across New Zealand is then computed and saved in the database as Thiessen Polygons. Thereafter, Thiessen Polygons that intersect or lie within the catchment area are obtained from the database. For a user-selected area, solely the rainfall depths and intensities data for sites not currently available or stored in the database are automatically fetched from HIRDS and stored in the database without any modifications. This approach is adopted to circumvent the transmission of multiple repetitive GET requests and expedite data processing. Subsequent to this, rainfall depth data corresponding to a user-specified scenario is extracted from the database for all rainfall sites situated within the catchment area.

This information is used to create hyetographs through the application of either the Alternating Block Method or the Chicago Method. While only these two methodologies are currently implemented, it is possible that other methods may be introduced in the future. Following this, the extent of coverage and percentage of the catchment area covered by each rainfall site is calculated. This information is then combined with the hyetographs data to construct either spatially uniform or spatially varying model input for BG-Flood, utilizing the Thiessen Polygon Method. It is noteworthy that alternative methodologies may be employed in the future to generate the required model input. Ultimately, the produced model input is utilized to execute the BG-Flood model, producing the corresponding model output.

Prospective work encompasses the integration of the BG-Flood model output back into the Digital Twin for comprehensive flood impact analysis, including the identification of flood extent and depth, as well as impacted buildings and roadways, among other pertinent factors.

Open-source 3D Web Geospatial Visualisation for Data Analysts

Developed by: **Luke Parkinson**
Software Developer GRI

This work is towards the creation of a performant 3D geospatial visualisation software library that GRI and other researchers can use to communicate the results of their research. The library is being used as the front-end to the Digital Twin for Flood Resilience.

Summary

Common approaches to open-source geospatial web visualisation have obstacles limiting data analysts from effectively showing their work. While open-source tools such as R Shiny, Terria.js, and others have effective ways of quickly showing geospatial data in clear and professional apps they are limited in their analysis performance. Terria.js is focused on displaying many forms of data but would need to be heavily adapted by experienced web developers in order to run any analysis and calculations. R Shiny makes it easy for data analysts to produce web apps with analysis and calculations but the open-source Shiny Server limits the performance of these to only single R processes.

To build large-scale production-ready web applications that can handle large amounts of data processing another approach is being developed. Geo-visualisation-components is a JavaScript Vue library that is being developed to make it easier to build open -source, performant geospatial web apps. It runs on the Cesium.js visualisation engine and is being designed to be easier accessible to Data Analysts with limited experience in web development. Geo-visualisation-components are being used within the Digital Twin for Flood Resilience in Aotearoa to provide the user interface to run flood models and analyse the data. This library is in its alpha stage of development, with expansion to other small visualisation projects underway .

A visualisation produced with geo-visualisation-components comparing two model scenarios of flooding in Kaiapoi.

Towards personalised digital health services for preventable health conditions - virtual reality and cue reactivity

Research team

Melanie Tomintz
Simon Hoermann
Maria C Vega Corredor
Dr. Merel Keijsers
MSc. Nawam Karki

Funding

HRC

Summary

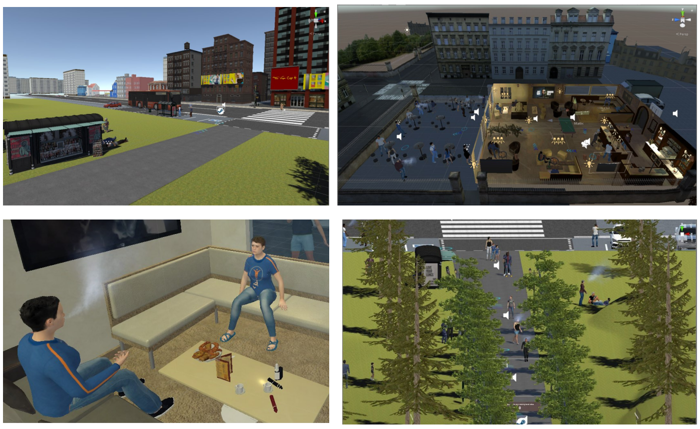
Electronic nicotine delivery systems (ENDS), were developed to provide an effective substitute for quitting smoking and as an alternative to conventional cigarettes. Nowadays, their use has rapidly grown and transformed into a popular and distinct form of nicotine consumption. The upsurge of ENDS, has introduce a whole new spectrum of types of consumers who now are differentiated from the conventional cigarette user.

Our research uses virtual reality technology to study how people respond to vaping and smoking craving related cues (i.e. virtual reality vaping stimuli). Virtual reality technology allows to precisely design and control what and when participants are exposed to cues and hence, allows to record and analyse data on the effects of those cues on participants. The aim of this study is to build a multi-sensory environment that allows us to measure people's behavioural and psychophysiological reactions (e.g. increased heart rate, sweat) when placing them into different virtual environments using virtual reality technology and simulating different cue exposure e.g. tobacco, different flavours of e-cigarette liquids, food, weather conditions, that can evoke different subconscious reactions. Our results will help to inform the design of vaping cessations interventions for example through potentially increased self-awareness of participants on how they react to cues and help them to be better trained to manage vaping urge and dependency.

Outcomes

Vaping virtual environments: Five virtual environments (scenarios) were designed and implemented specifically to replicate and evaluate vaping cue exposure. Virtual reality environments for vaping cue simulations are novel. Hence, the simulation system had to be built from scratch. So we have developed and tested several virtual environments and virtual multi-sensory feedback and interaction paradigms to simulate vaping cues. We explored computational methods to analyse craving levels for vaping based on physiological data as well as traditional questionnaires. Vape users and no users experimentally tested the virtual reality scenarios in order to investigate their capacity to elicit vaping cravings.

Online survey: We have also completed a detailed survey for future dissemination and potential therapeutic applications in New Zealand. The survey was completed by over 800 participants of which more than 200 identified as Māori. The survey aimed to gain a better understanding of the experiences and behaviours of electronic cigarette users in New Zealand including the length of use, reasons for use, shopping preferences, and general perception of vaping among users.



Virtual environments developed to study vaping cue-reactivity

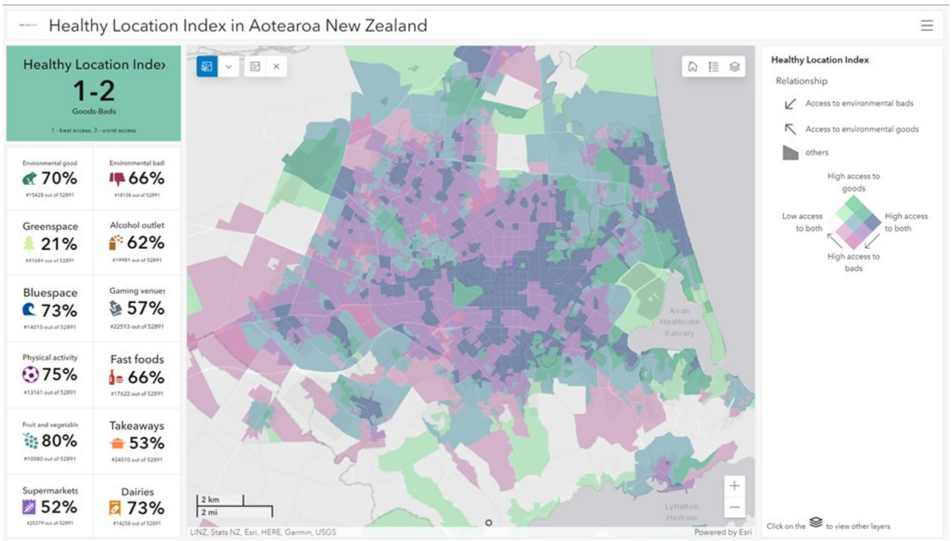
Healthy Location Index

Research team

Lukas Marek
Matthew Hobbs
Jesse Wiki
Malcolm Campbell
Simon Kingham

Funding

GeoHealth Lab/GRI



Project summary

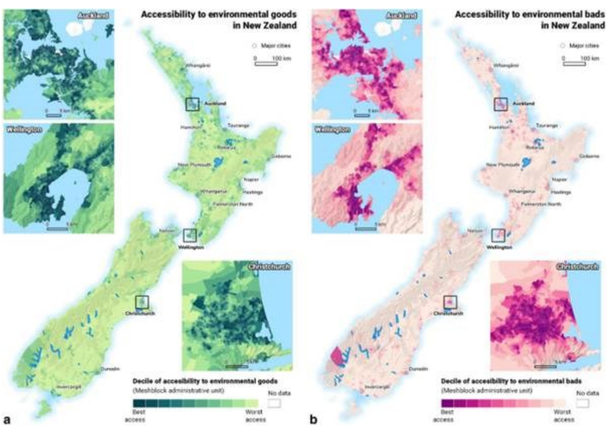
Accounting for the co-occurrence of multiple environmental influences is a more accurate reflection of population exposure than considering isolated influences, aiding in understanding the complex interactions between environments, behaviour and health. Healthy Location Index describes how environmental 'goods' such as green spaces and environmental 'bads' such as alcohol outlets co-occur in Aotearoa New Zealand New Zealand.

We collected, processed, and geocoded on a comprehensive range of environmental exposures. Health-constraining 'bads' were represented by: (i) fast-food outlets, (ii) takeaway outlets, (iii) dairy outlets and convenience stores, (iv) alcohol outlets and (v) gaming venues. Health-promoting 'goods' were represented by: (i) green spaces, (ii) blue spaces, (iii) physical activity facilities, (iv) fruit and vegetable outlets, and (v) supermarkets.

The HLI was developed based on ranked access to environmental domains and can be used to investigate socio-spatial patterning by area-level deprivation and rural/urban classification.

Results showed environmental 'goods' and 'bads' co-occurred together and were patterned by area-level deprivation. The novel HLI shows that the most deprived areas of New Zealand often have the most environmental 'bads' and less access to environmental 'goods'. These results further reinforce the need to embrace the multidimensional nature of neighbourhood and place not only when designing health-promoting places, but also when studying the effect of existing built environments on population health.

The index, now publicly available (tinyurl.com/goodsbads), is able to capture both inter-regional and local variations in accessibility to health-promoting and health-constraining environments and their combination.



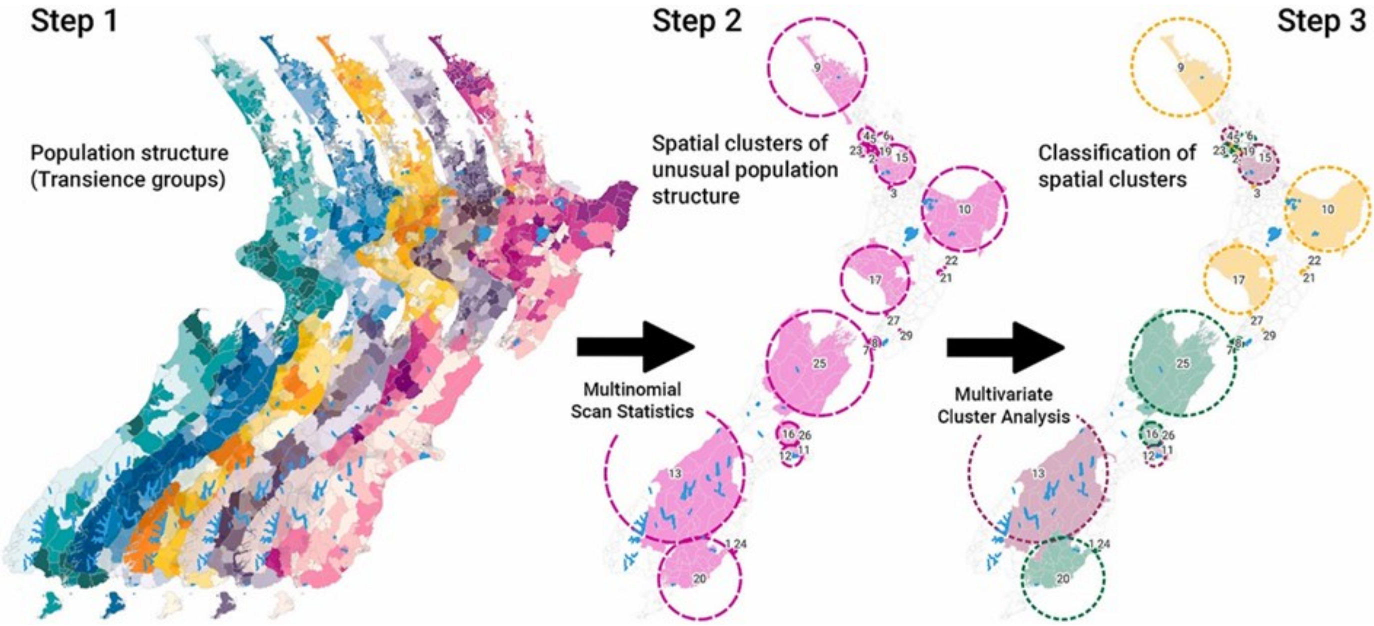
Population mobility patterns

Research team

Lukas Marek
Samuel Hills (Bournemouth University, UK)
Matthew Hobbs
Dr Jesse Wiki (University of Auckland)
Malcolm Campbell

Funding

Based on the previous work funded by the Ministry of Health, NZ.



Project summary

This nationwide geospatial study from Aotearoa New Zealand describes the frequency and spatial patterning of residential mobility and examines the interplay between patterns of residential mobility and the environments in which adults reside.

Data from the Integrated Data Infrastructure (n = 4,781,268 adults) defined levels of residential mobility in 2016–2020. We then used nationwide environmental data included within the New Zealand Healthy Location Index to define access to a range of health-promoting and health-constraining features.

We identified 29 spatial clusters based on the mobility characteristics of the population living within selected administrative units that were further classified into five groups based on the similarity of residential mobility groups. Each group was described by its relation to the Healthy Location Index, urbanicity and ethnicity.

A greater proportion of residential mobility was related to metropolitan and large regional centres, and Māori, Pacific and Asian ethnicities. Areas with higher levels of vulnerable mobile population were identified in the North Island (Northland, Gisborne, Whanganui and urban pockets of Auckland, Hamilton, Napier and Hastings). While there was poor access to health-promoting environments for the mobile population living in the inner cities, areas with higher residential mobility elsewhere are often associated with better access to health-promoting and neutral features.

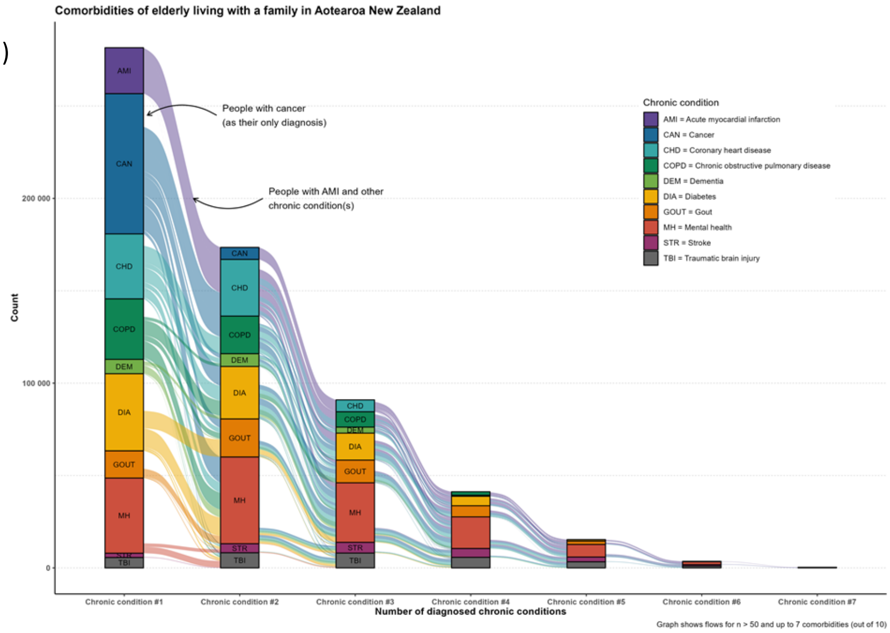
Life-course impact of chronic health conditions: A family and whānau perspective

Research team

Lukas Marek
Simon Kingham
Hamish Jamieson (University of Otago)
Ulrich Bergler (University of Otago)
Lisa Underwood (University of Auckland)
Barry Milne (University of Auckland)

Funding

MBIE - National Science Challenge



Project summary

A life-course approach is essential to inform health and wellbeing policies and programmes that make a difference for children, youth, adults and later in life. An understanding of the factors that impact individuals at different stages of their life courses is crucial for designing such policies and programmes. Chronic diseases such as cancer, cardiovascular disease, diabetes, mental health and obesity have a direct effect mainly on the middle and later life-course (slightly younger for mental health). However, the indirect effect of chronic diseases on whānau and families has been less well-studied, and is likely to have impacts across the entire life-course.

While the general focus of the wider project is to investigate the influence of chronic disease on the wider family and whānau at different life stages with four groups of interest: children, households, partners and carers, and elders. This particular part of the research will focus on the elders experiencing chronic disease and how they impact on the wider family and whānau. The study will (i) identify older people with prevalent chronic conditions; then it (ii) evaluate household circumstances for such people; and (iii) quantify the health and social wellbeing of other whānau members.

This is an administrative cohort study which will follow individuals and families over time. We will compare results for individuals within families containing a chronic disease sufferer, with individuals within families not containing a chronic disease sufferer. This study will build on our pioneering research on the impact of loneliness (Jamieson et al. 2019), frailty (Burn et al., 2018), incontinence (Jamieson et al., 2017), dementia (Jamieson et al., submitted), and polypharmacy (Jamieson et al. 2018; 2019) on older people.

To answer the research questions we will use mostly administrative data from the Integrated Data Infrastructure (IDI) that is a longitudinal dataset which holds linked individual and household level microdata from a range of Government agencies (e.g. housing, health, policing), Stats NZ surveys, and non-governmental organisations (Statistics New Zealand, 2013). However, to provide a broader context, we aim to include additional data sets such as derived residential mobility and transience (Marek et al., 2021b), New Zealand index of socioeconomic deprivation (Atkinson et al., 2014) or Healthy Location Index (Marek et al., 2021a) that provide area-based measures of locally varying environmental and socioeconomic determinants.

Map-based tools for Community and Rūnanga-led sustainable town planning, in small and medium settlements in New Zealand

Research team

Rita Dionisio (Principal investigator, GRI and SEE-TKA)
Dean Walker (Post-doctoral fellow GRI)
Ines Falco (Software developer GRI, until Aug 21)
Sharmila Savarimuthu (Software developer GRI, until Oct 21)
Luke Parkinson (Software developer GRI)
Professor Hirini Matunga (key researcher, Lincoln University)
Professor Angus Macfarlane (key researcher, UC, Te Arawa and Ngāti Whakaue) and
Professor Simon Kingham (key researcher, UC).

Funding

MBIE- Endeavour Fund (2017-2021)

Collaborators

Ruiha and Katie Caldwell - Whenua Maori Services Limited, Waimakariri,
Monty Morrison – Te Tatau o Te Arawa, Rotorua,
Geoff Rolleston - Te Tatau o Te Arawa, Rotorua,
Jude Pani - Te Tatau o Te Arawa, Rotorua,
Rawiri Waru - Te Tatau o Te Arawa, Rotorua,
Mokonuiarangi Kingi - Te Manatōpū Haukāinga o Ōhinemutu,
Riria McDonald - Te Manatōpū Haukāinga o Ōhinemutu,
Jody Paul - Te Manatōpū Haukāinga o Ōhinemutu

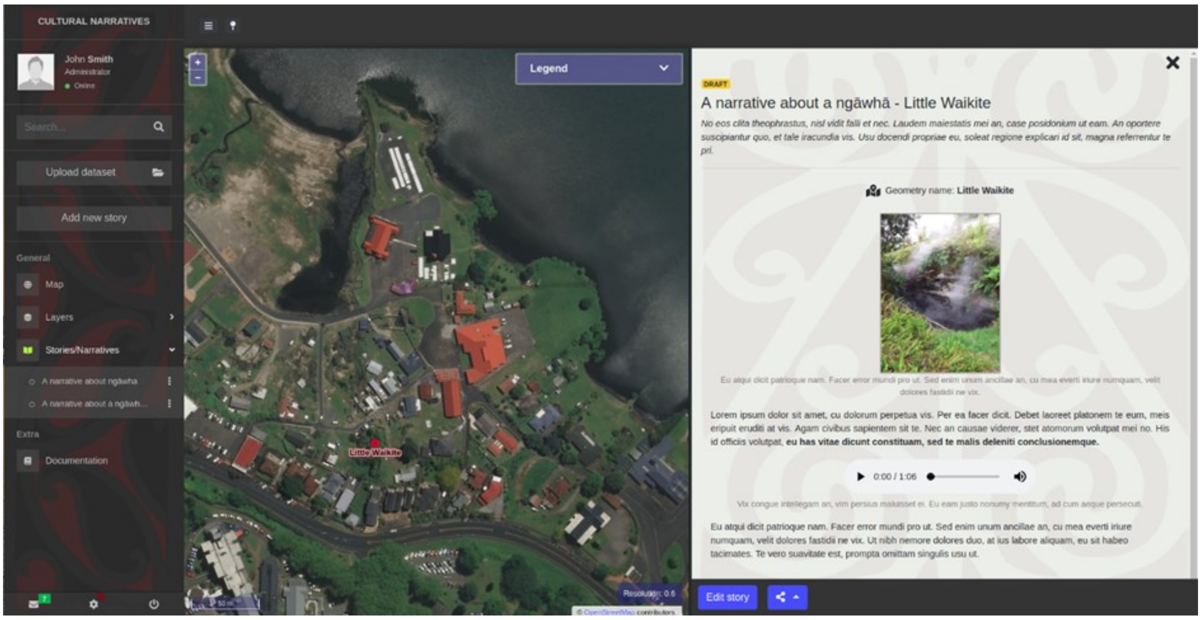
Project Description

Our research focuses on the development of place-based tools to support local Māori communities to engage in and lead local spatial planning processes. The overall aim of the project is to strengthen the integration of mātauranga Māori and local knowledge in town planning in Aotearoa New Zealand. We are working with two local communities – Tūāhiwi Village in the Waimakariri District and Ōhinemutu Village in Rotorua – to co-create bicultural spatial planning tools for this purpose. Our research incorporates appropriate collaborative methodologies and co-creation processes.

Protection, partnership, and participation – three principles of the Treaty of Waitangi – are key to guiding the development of authentic partnerships with both communities. These processes reflect the unique organisational structures and planning priorities of each community. Other local communities around Aotearoa New Zealand will be able to utilise this research customising tools developed to support their own cultural aspirations, both in terms of land – community revitalisation as well as regeneration processes for villages and neighbourhoods.

Research Outcomes

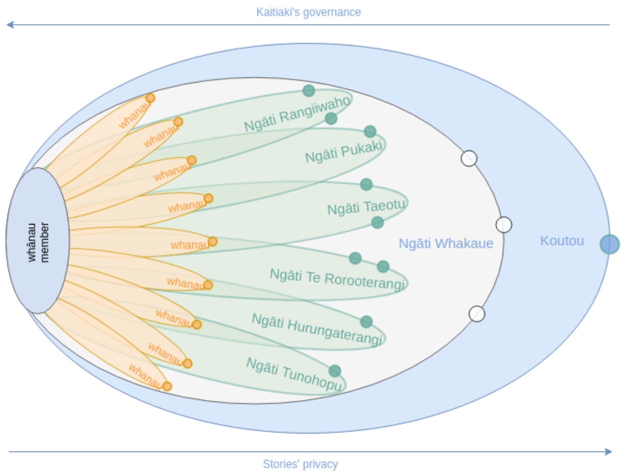
Case Study 1: In partnership with Ngāi Tūāhuriri, through Whenua Maori Services Limited, we have developed 'Common Ground'. This place-based web tool has been developed to reconnect Ngāi Tūāhuriri whānau with each other and their whenua, including Tuahiwi village and other Māori Reserves within the Waimakariri District. The research aims to support whānau to improve land management across their takiwā . End-users include Ngāi Tūāhuriri whānau and authorised stakeholders who provide land use revitalisation services (e.g. native ecosystem experts, carbon farming consultants). Mātauranga specific to each land block is able to be collected, development options for the whenua developed and actions recorded. This may be of interest to other mana whenua and local communities, specifically villages that have gone into significant decline or ceased altogether as a result of urban migration and coloniality processes, communities who wish to reconnect with their land. Supporting mana whenua in socio-economic revitalisation of their whenua is crucial to bicultural approaches to spatial planning and regional development.



Place –based web tool: Te Kete o Kōrero o Ōhinemutu.

Case study 2: In partnership with Te Manatōpu Haukāinga o Ōhinemutu, supported by Te Tatau o Te Arawa, we have developed Te Kete o Kōrero ki te Ōhinemutu. This place-based web tool collates, protects and enables the sharing of local knowledge collectively held by Ngāti Whakaue and the people of Ōhinemutu Village. The research initially focussed on gathering cultural narratives about ngāwhā (geothermal phenomena and landscapes) and their relationships with the community. However the tool has been designed to hold other mātauranga within other realms of knowledge. These narratives are organised through koromātua (sub-tribe), type (including traditional, planning, Treaty, lived experiences, historical and scientific narratives), and through Atua (seven key spiritual guardians).

Te Kete o Kōrero o Ōhinemutu will assist community led urban regeneration of the village. The cultural narratives contained in the tool will guide decision-making around spatial planning. The tool will link the community to multiple end-users (e.g. wider whānau, local planning authorities, public, etc.) and enhance awareness of the wealth of mātauranga within Ōhinemutu village and Ngāti Whakaue. The tool takes a layered approach to privacy and the protection of IP, with different levels of access and detail for tool users – public, koromātua, and whānau. Connecting mana whenua, local communities and planning authorities through place-based mātauranga is crucial to ensure bicultural approaches to urban regeneration.



Governance architecture of Te Kete Kōrero o Ōhinemutu

Partners/Stakeholders

Whenua Maori Services Limited, Te Tatau o Te Arawa, Te Manatōpū Haukāinga o Ōhinemutu

https://www.commonground.kiwi.nz/#/

https://www.ohinemutukorero.co.nz/#/

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HIKINA WHAKATUTUKI

TE TATAU O TE ARAWA

Biological Heritage Challenge: Eco-Index Programme

Research team

Dr Kiri Joy Wallace (University of Waikato)
Dr John Reid (J D Reid LTD)
Ngāti Pikiao (Tainu and Ngai Tahu Research Centre, University of Canterbury).
Nathaniel Calhoun (Code Innovation)
Kevan Cote (Moose Engineering & Design)
Karen Denyer (Papawera Consulting Ltd)
Saif Khan (GRI)

Funding

New Zealand National Science Challenge.

Project summary

The Eco-index programme is funded through the New Zealand's National Science Challenge "New Zealand's Biological Heritage - Ngā Koiora Tuku Iho". Through this initiative, the Eco-index programme has set a long-term National Biodiversity Vision 'protected, restored and connected by 2121'. The Protect-Tiaki entails maintaining current native biodiversity by abating threats. The Restore - Whakahou is based on a land cover target for native ecosystems in every catchment to be restored to a minimum of 15% of their original extent. The connect- tūhono means connecting native ecosystems from the mountain to the sea.

At GRI, we analyse spatial data to generate the information required to achieve these vision components. To protect, we need to know the current biodiversity status to plan for their maintenance. Along with the broader Eco-index team, we have developed an analytical framework using currently available land cover, potential native vegetation and wetlands (PNVW), and Eco-index catchments layer to calculate the shortfall to reach 15% of the original native ecosystem types per catchment, which can be visualised in a dashboard (Figure 1).

This data leads to calculating the required biodiversity investment. Work is currently underway to develop the biodiversity connectivity analysis.

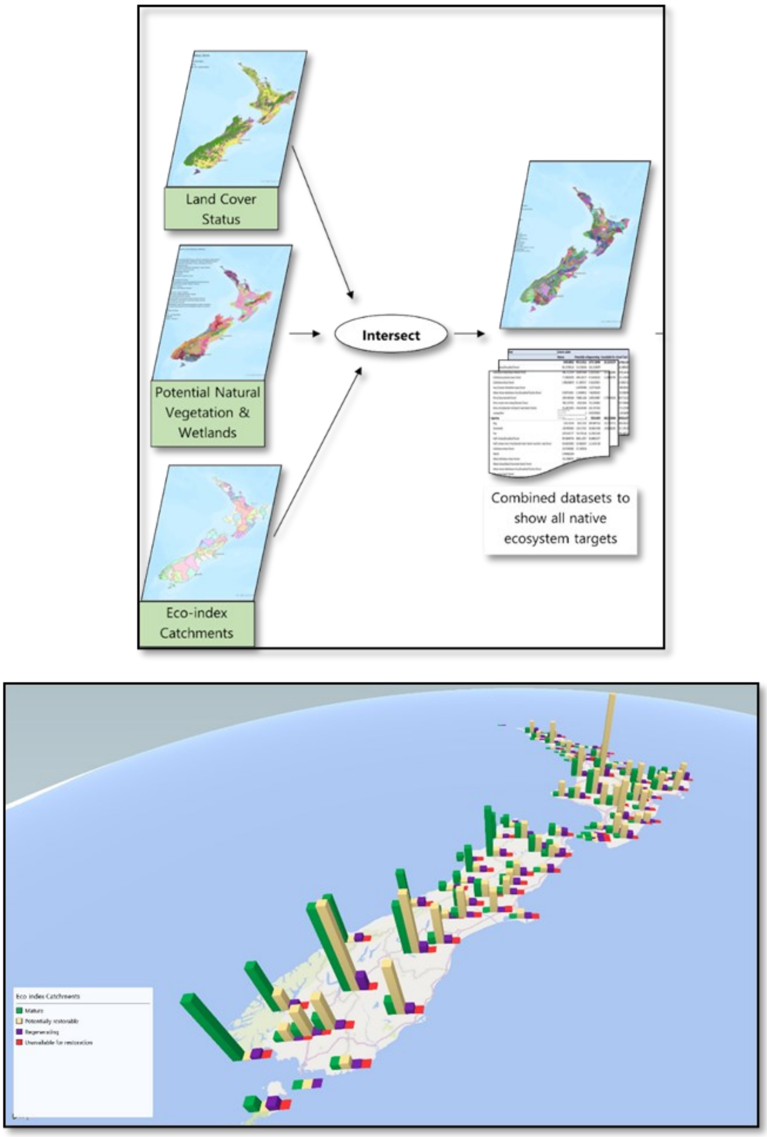


Figure 1. Geospatial analytical framework and dashboard for Eco-index programme

Another ongoing effort under the Eco-index programme is developing ecosystem detectors based on remote sensing data (Figure 2). We use multi-spectral data from various satellite images (e.g., Sentinel, Planet) and develop machine learning algorithms to discriminate signatures for prioritised native ecosystem types such as Kahikatea, and freshwater wetlands. Alongside reflectance data, other bio-physical data such as soil moisture, elevation data also helps identifying ecosystems. With simultaneously ongoing projects such as Rongowai and access to LiDAR datasets, GRI is well placed for achieving such highly technical cutting-edge research in this area.

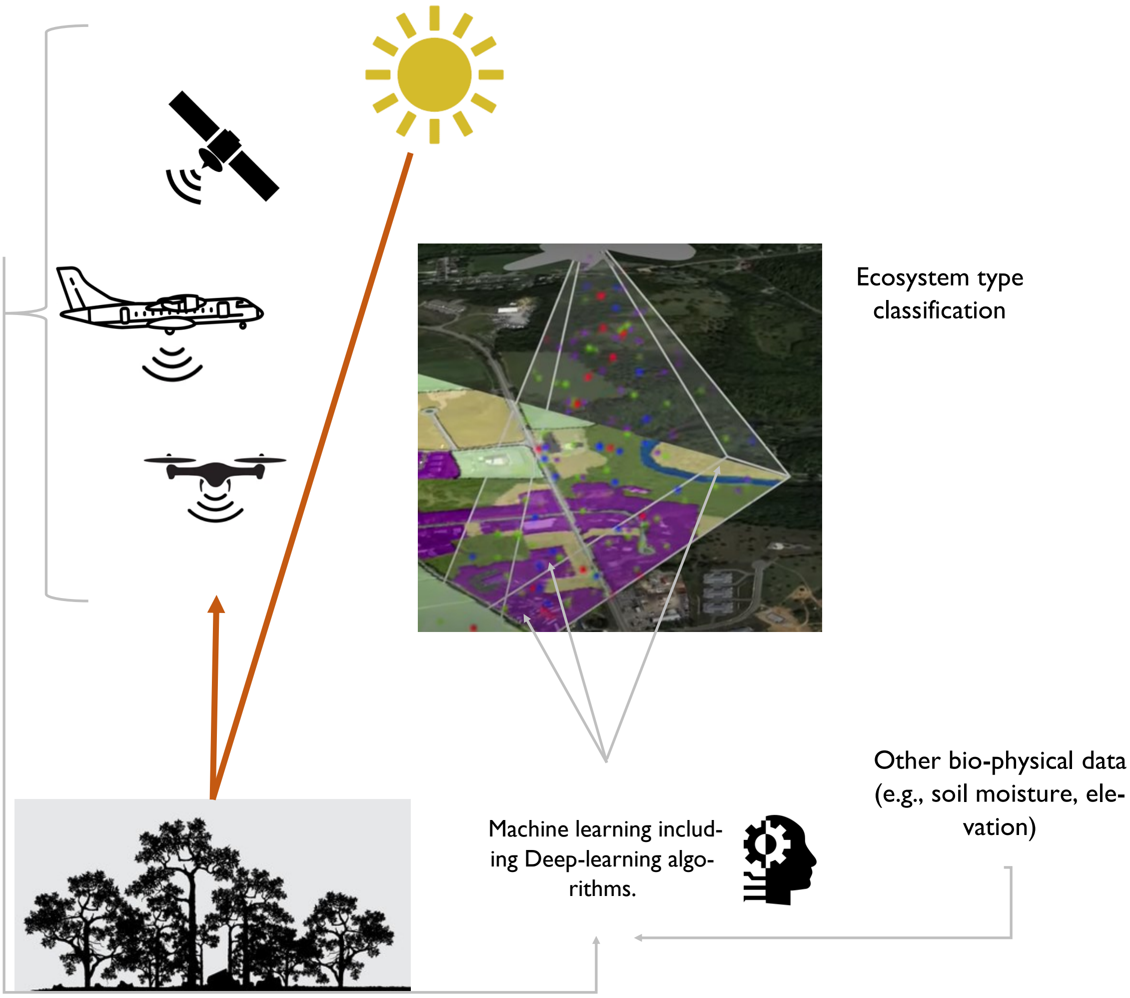


Figure 2. Workflow for ecosystem detector development

Mātauranga Māori Framework For Surveillance (MMFS) For Plant Pathogens

Research team

Manaaki Whenua –
***Landcare Research*:**
Audrey Lustig
Waitangi Wood,
Dean P. Anderson,
Maria C. Latham.

GRI
Sharmila Savarimuthu

Funding

MBIE

Summary

In the past, there has been a disconnect and little collaboration between the people and organizations doing work on the plant pathogens that cause myrtle rust and kauri dieback. This has stymied progress in the management of these plant pathogens and diseases, to the extent that it is still unclear where they occur and where they do not. In this project we introduced the principles and methodologies of the Mātauranga Māori Framework for surveillance (MMFS) for plant pathogens.

The aim of the framework is to elevate mana whenua into the biosecurity system through the establishment of a surveillance system that is hapū based and that encourages strategic trust relationships between hapū kaitiaki and rangatira directly with central, regional and local organisations that generate science and research, and provide funding. It considers the current processes involved in the collection of data and information required on pathogen presence and absence and addresses challenges of trust between interested groups, informed consent, and data ownership, sovereignty, and rights. The framework includes the development of a data storage platform, which anchors data to the place of origin and ensures mana whenua access to information, as well as a 'proof of pathogen absence' tool, which uses surveillance data from areas where the disease hasn't been detected to quantify the probability of its absence given it has not been detected.

Photo: MCVega

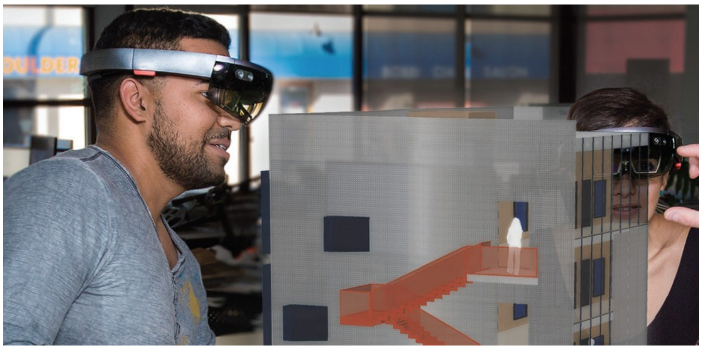
Research dissemination

Geospatial Research Institute Seminar Series

2021

March 2021

Adam Greenland and Graeme Blick. Land Information New Zealand (LINZ). *The* ***Development of a Regional Satellite Based Augmentation System****:* Unlike most regions of the developed world where SBAS is available, Australasia does not currently have access to any reliable free-to-air augmentation services. LINZ and Geoscience Australia are working together to develop a regional SBAS to improve the accuracy of GPS.

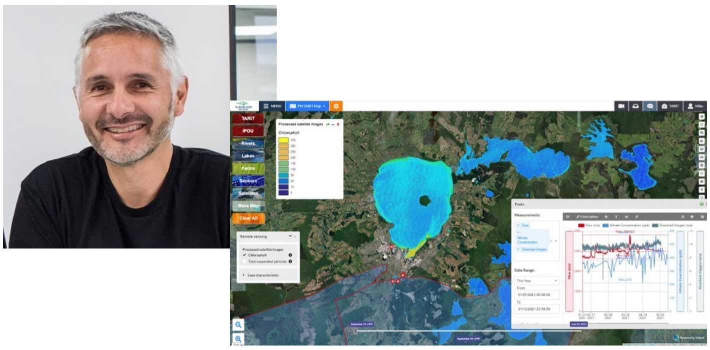


April 2021

Larry Bellamy. University of Canterbury. ***Accelerating Digitalisation of the Infrastructure Sector****:* The seminar focused on two applications of data and digital methods: pipe information to improve investment and management decisions related to three waters networks and building information to improve the management of vertical infrastructure.

May 2021

Steve Abley and Chris Morris. Abley Limited. ***Saving your Life without you even Knowing it:*** The *Safer Journeys Risk Assessment Tool* or **'MegaMaps'**, produced by Waka Kotahi NZ Transport Agency with the assistance of Abley, is a unique tool developed to identify high risk locations for safety interventions in order to reduce the horrific financial and emotional cost of road fatalities.



June 2021

Mike Taitoko. CEO, Takiwā. ***Democratising GIS Data to Solve Aotearoa's Freshwater Challenge****:*Takiwā is a data management and analytics platform that allows end-users to upload, analyse and present multiple types of data within a spatial context. It has the ability to draw together cultural and maatauranga Māori data and information alongside Western scientific data while managing cultural and commercial sensitivities of any datasets.

2021

July 2021

Rafael Kargren. MAXAR—Oceania and Pacifica. ***From Data to Insights:*** In this time of rapid global change, we need new ways to identify, monitor and understand the impact of change on environments and human dynamics such as economy, health and sociopolitical stability. Maxar Earth Intelligence capabilities help customers map, detect, address and predict change at unprecedented speed and scale. Fueled largely by Maxar's own constellation of high-resolution imaging satellites and combining multi-source data and applied artificial intelligence, machine learning and rich domain knowledge is able to deliver insight as a service.

September 2021

Keri Niven, Digital Practice Leader, Aurecon. ***Humanism in a Technology Centric World. Enabling a Digital Twin for Industry 5.0:*** As engineers and designers, we have a responsibility to create a sustainable and responsible human-centric physical and digital legacy. Our decisions, particularly regarding how we use technology to solve problems, will profoundly shape our future. This obligation has been recognised by the shift towards industry 5.0. This latest revolution represents the return of human-centric activities that are enabled by technology – and a refocus of technology towards supporting the collaboration and creativity that we as humans crave.

October 2021

Prof. Richard Green. University of Canterbury. ***Sub-mm 3D Semantic Models of Plants over Large Areas:*** There is vast plant data beyond the traditional birds-eye-view of remote sensing. Our research is interested in the petabytes of data per farm (such as orchards or vineyards) from sub-mm under-canopy/underwater proximal sensing. Challenges include generating accurate 3D semantic models of each plant, 3D reconstruction of constantly moving seaweed and wind-blown leaves, storing/accessing petabytes of data/models, under-canopy data improving remote-sensing information, instance segmentation of multi-storied forests, etc.

November 2021

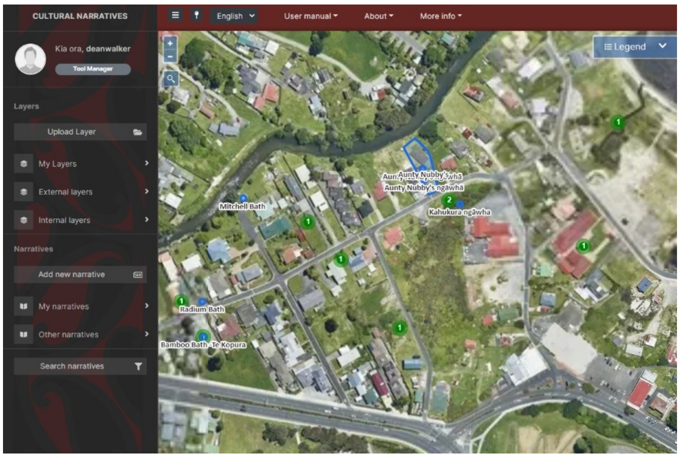
Philipp Sueltrop. Kea Aerospace. ***Reaching the Stratosphere and Beyond:*** Kea Aerospace is developing the Kea Atmos, the largest unmanned aircraft in the Southern Hemisphere to harvest aerial data from the Stratosphere flying at around 20km altitude. With a wingspan of over 30m and fully covered in solar panels the Kea Atmos will operate for weeks without landing. A fleet of Kea Atmos will be continuously operating and carrying different payloads from high-resolution multi-spectral cameras to synthetic aperture radars and atmospheric sensors. Kea's remote sensing data will have much better image resolutions than satellites, which will allow Kea Aerospace to fill significant data gaps and enable better decision-making.

May 2022

Barrett Ens. Monash University (AU) ***Using Space Around us for Sensemaking:*** While its internal components have been vastly miniaturised, the computer as we know it has come to be defined by the rectangular glass form of its user interface. Emerging display and interaction technologies offer new potential for us to 'step through the glass' and embrace the contextual associations of information with the space around us. Can spatial interaction improve the way we perceive, interact with, and understand information? The talk was centred on spatial interface design, and recent applications for data exploration and sensemaking, as well as discussed what we have learned about the benefits of using space around us and some of the challenges that lie ahead.

September 2022

Dean Walker and Luke Parkinson. GRI—UC. **Te Kete Kōrero o Ōhinemutu; Geospatial Tool for Community & Māori-Led Planning:** This is a map-based tool co-created by the community of Ōhinemutu and the GRI - Toi Hangarau. Ōhinemutu is a village with deep connection to Ngāti Whakaue. Built on the shores of Lake Rotorua, it is famed for its geothermal features and Te Papa-i-Ouru marae. This tool has been built to hold and share historical narratives of Ōhinemutu as well as current community initiatives. The range of narratives includes traditional, historic, scientific and lived experiences. Current and potential uses of the tool include community planning, environmental management and the general sharing of narratives of Ōhinemutu whilst at the same time holding and protecting mātauranga through protected levels of access.



November 2022

Audrey Lustig , Cecilia Arienti & Sharmila Savarimuthu. Manaaki-Whenua – Landcare Research and GRI. ***Māturanga Māori framework for surveillance (MMSF) for plant pathogens:*** In the past, there has been a disconnect and little collaboration between the people and organizations doing work on the plant pathogens that cause myrtle rust and kauri dieback. This has stymied progress in the management of these plant pathogens and diseases, to the extent that it is still unclear where they occur and where they do not. In this presentation we will introduce the principles and methodologies of the Mātauranga Māori Framework for surveillance (MMFS) for plant pathogens.

Dr Sharmila Savarimuthu presenting at GRISS on 25 November 2022.

Second United Nations World Geospatial Information Congress

"Geo-Enabling the Global Village: No one should be left behind"

Stefan Schweinfest, Director of the United Nations Statistics Division.

"The convening of the UNWGIC arises out of the mandate from the United Nations Economic and Social Council (ECOSOC) to UN-GGIM to organize global forums to promote comprehensive dialogue on global geospatial information management with all relevant governments, international organizations, and stakeholders".

United Nations World Geospatial Information Congress.

Assembled by the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) and organized by the Department of Economic and Social Affairs of the United Nations, the Second United Nations World Geospatial Information Congress (UNWGIC 2022) took place in Hyderabad, India, between 10-14 October 2022. The event was hosted by the Ministry of Science and Technology of India.

Under the theme: "Geo-Enabling the Global Village: No one should be left behind," the Congress brought together specialist, government representatives and stakeholders from around the world, to discuss the role of geospatial information as an enabling engine for sustainable social, economic and environmental development. For this, the Congress addressed key issues around integrated geospatial information management, its capacities and capabilities within social wellbeing, climate change, digital transformation, and technological development. Moreover, the importance of international cooperation and coordination for building a human data and geography community was highlighted as a key component to achieve sustainable development in an inclusive and fair global society.

Photos

Closure Ceremony of the 2nd UN World Geospatial information congress, Hyderabad 14-10-2022

GRI research presented at the Second United Nations World Geospatial Information Congress

Lesley Arnold (Director, Geospatial Frameworks Pty Ltd, Au), Akhi Rokade (Assistant Manager, Tata Trust, India) and Matthew Wilson (GRI Director, NZ)

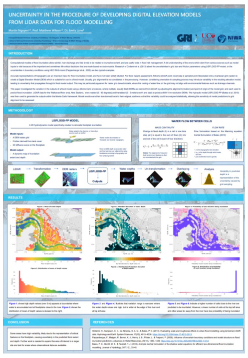
The GRI director, Professor Matthew Wilson gave a talk called: "***Empowering decision making for sustainable development through environmental digital twins***". The presentation was centred around two main matters:

- Exploring possibilities through a prototype under development for flood risk assessment and management.
- Calling for embedding computational models within a framework of interconnected digital twins, enabling automation of scenarios in response to real-time information.

> "*Flood risk management and mitigation requires substantial amounts of spatial data related to infrastructure and the environment, making it expensive to develop suitable risk assessments or scenarios, particularly when the information needed is time-critical.*"
>
> Prof. M. Wilson, 2nd UNWGIC 2022.

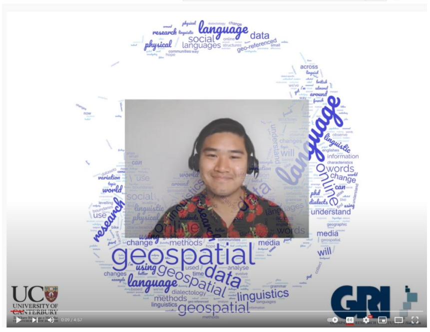
Closure ceremony of the 2nd UN World Geospatial information congress, Hyderabad 14-10-2022

Geospatial Research Institute: Research dissemination



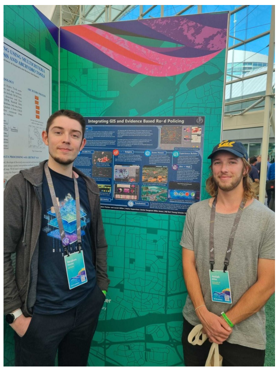
Martin Nguyen a GRI PhD student won the 2nd Prize for Best Poster at Waterways Conference November 2021. The poster's title was: *"Uncertainty in the procedure of developing Digital Elevation Models from LiDAR data for flood modelling".*

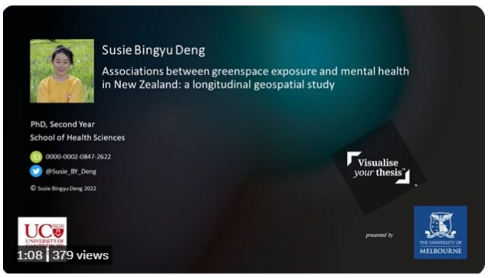
PhD student, Sidney Wong, gave a talk about Geospatial Linguistics at the 2022 Emerging Spatial Professionals mini-conference in Tāmaki Makaurau (Auckland), Aotearoa (New Zealand), April 2022.



PhD student, Phoebe Eggleton won the **regional heats in the QuakeCoRE Lightning Talk Competition**. June, 2022.

2022 Young Scholar winners of Esri-NZEUG Josiah Miller and Reuben Painter from UCNZ- GeoHealth Lab presenting their work in San Diego, California at the Esri User Conference, July 2022.





Susie B.Y. Deng won 2nd place in the Visualise Your Thesis Competition at the University of Canterbury — UC Library. July, 2022.

Matt Hobbs was recognised for outstanding work in his field. He won an award for researcher's efforts to help NZers stay healthy (November 2022).

More information available at:
https://www.canterbury.ac.nz/news/2022/award-for-researchers-efforts-to-help-nzers-stay-healthy-.html

University of Canterbury Professor Simon Kingham is leading a team of researchers from Canterbury, Lincoln and Otago universities as part of a study for two National Science Challenge – Ageing Well and Healthier Lives – to understand what happens when shared transport was introduced in two demographically different Ōtautahi communities. More information available at:

https://www.canterbury.ac.nz/news/2022/will-shared-transport-improve-our-lives.html

Rongowai project, whose name combines the Māori words *rongo* (to sense) and *wai* (water), was launched in September 2022. MBIE signed agreements with NASA and Air New Zealand to enable collaboration for the mission.

For more information go to:
https://youtu.be/cSsDn6Son68

The GRI hosted members of The Association of Local Government Information Management (ALGIM). Members of the GRI team presented their research work. November, 2022.

Takiwaehere Geospatial Hackathon

GRI in the hackathon

The hackathon took place on 17-18 April, 2021, across several university campuses in New Zealand. The GRI hosted Takiwaehere on behalf of the University of Canterbury. It was the first joint initiative supported between MBIE and Maxar.

The criteria for project evaluations included: creativity, type of problem/opportunity addressed, novelty of the solution, and the potential competitive advantage of it. Programming, remote sensing, artificial intelligence and machine learning, were some of the areas of expertise of the participants in the competition. More than 40 projects were submitted to the event., from which several projects used innovative techniques based on computer vision. Many of the topics chosen by the teams were focused on important issues for New Zealand, with many investigating the economic aspects and implications of the targeted problems.

The prizes

The first place prize consisted of: $5000, new imagery tasking, 3 months SecureWatch data access, 50 Gb limit and a "space selfie". The prize was awarded to *Auckland University Neuron Transmitting Students (the AUNTS)* .The project used a GIS interface and spectral signatures to provide rapid flood impact assessment.

The second place prize was awarded to team *The Interpolators*, a joint team from AUT and University of Auckland. Their app provided an automated assessment of local water ways health, using a novel river health index created from the multispectral bands of the Maxar imagery.

The third place was awarded to Team SeeReef, from the University of Canterbury. The project's theme was ***planning for a changing coast***.

About their project, The UC students in the SeeReef team's stated: *"SeeReef is a maritime navigational tool that identifies hazardous features in shallow waters. As existing seacharts do not have the resolution or update-rate to track small, shallow water features, navigating through our changing coastal waterways is challenging even for experienced mariners. SeeReef overcomes this by providing near real time detection of mobile coral bommies, submerged rocks and sandbars.*

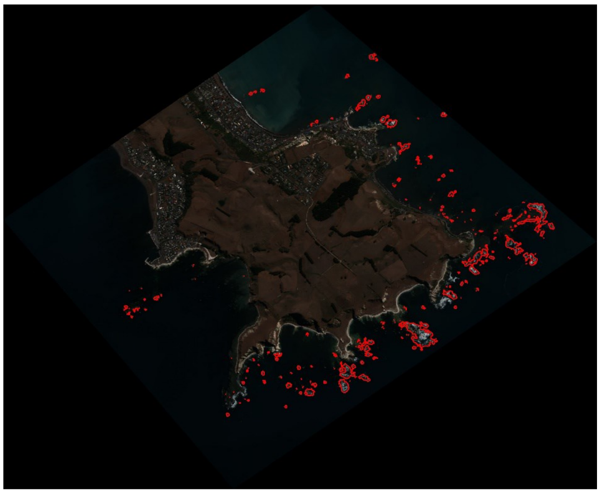
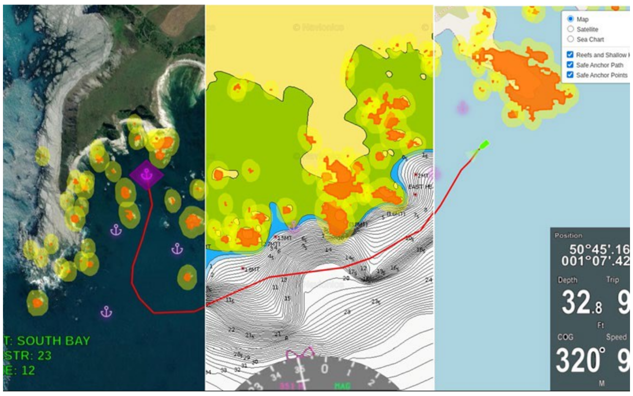


Image: Identifying hazardous features from Maxar imagery. (Credit: Team SeeReef)

"With underwater collisions being a leading cause of ecosystem damage, and maritime cost, our ambition is to provide mariners with the information they need to ensure safe passage and anchorage in shallow waters. The SeeReef overlay illustrates hazards identified from our OpenCV computer vision pipeline. With integrations to existing chart-plotting software, SeeReef may autonomously map safe passages and determine safe anchorage locations that free of rocks or coral bommies."



Screenshot of the app developed by the South Island Students team. Credit: Team SeeReef. The app is available at: http://seereef.ddns.net

Team SeeReef members were: Henry Seaton, Georgia Reynolds, Fletcher Walmsley, Sam Hogan, Hank Wu and Zach Preston. All team members were 4th year mechatronics students from the College of Engineering, and were mentored by Prof. Richard Green with additional advice from several others. The team assigned roles for the hackathon across computer vision processing, backend development, frontend development, writing and design. The developed app is available at http://seereef.ddns.net/, and a video which introduces it is on YouTube here: https://youtu.be/5eoTIVopWiQ

Team SeeReef aims to provide mariners with the information they need to ensure safe passage, avoiding underwater collisions and damage to marine ecosystems. (Credit: Team SeeReef)

Presentations and prize ceremony of the Geospatial Hackathon Experience at the University of Canterbury

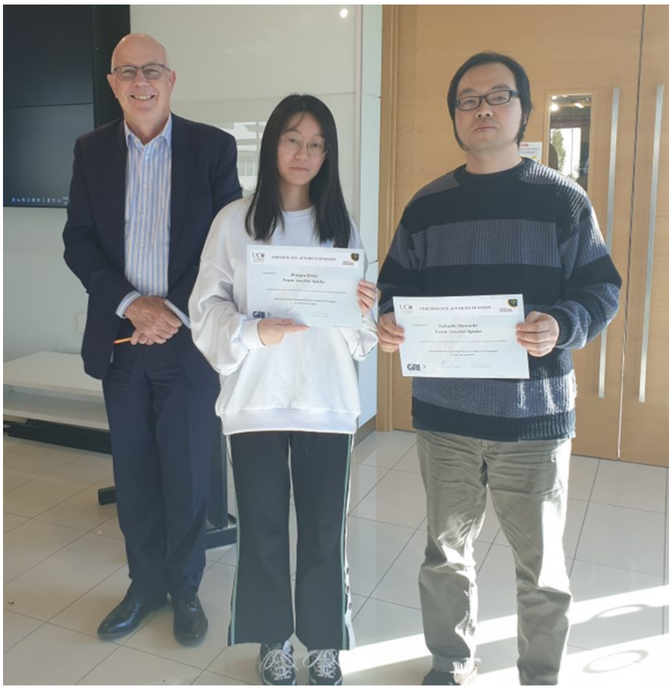
On the 3rd June 2021, the GRI celebrated the achievements of the UC teams who participated in the Geospatial Hackathon.

Four or the teams presented their work and experience. Prof. Ian Wright presented awards and certificates. The top three UC teams were:

1st Prize: *Auckland University Neuron Transmitting Students (the AUNTS)*

2nd Prize: *The Interpolators from the University of Auckland and Auckland University of Technology*

3rd Prize: *The South Island Students (Team SeeReef) from the University of Canterbury*



Prof. Ian Wright Deputy Vice Chancellor, Research from the University of Canterbury congratulates hackathon participants, Susie Deng and Takashi Murachi from team GeoNet Spiders.

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Schindler M. and **Dionisio R.** (2021) A framework to assess impacts of path dependence on urban planning outcomes, induced through the use of decision-support tools. Cities 115 http://dx.doi.org/10.1016/j.cities.2021.103256. (Journal Articles)

The Truth behind Mapping. UC Science Radio. 6 May 2021.

Vannier C., Mulligan H., Wilkinson A., Elder S., Malik A., Morrish D., **Campbell M**., **Kingham S**. and Epton M. (2021) Strengthening community connection and personal well-being through volunteering in New Zealand. Health and Social Care in the Community 29(6): 1971-1979. http://dx.doi.org/10.1111/hsc.13340.

Watkins A., Curl A., Mavoa S., **Tomintz M**., Todd V. and Dicker B. (2021) A socio-spatial analysis of pedestrian falls in Aotearoa New Zealand. Social Science and Medicine 288 http://dx.doi.org/10.1016/j.socscimed.2020.113212. (Journal Articles)

Wiki J., Marek L., Hobbs M., Kingham S. and **Campbell M.** (2021) Understanding vulnerability to COVID-19 in New Zealand: a nationwide cross-sectional study. Journal of the Royal Society of New Zealand 51(S1): S179-S196. http://dx.doi.org/10.1080/03036758.2021.1900294. (Journal Articles)

Conference papers and presentations:

Wong, S. #linguistics: exploring variation and change using social media language data. Presented at the Linguistic Seminar, November 2, 2022, University of Waikato, New Zealand.

Pozo, Andrea. Cross validation of characterisation of rainfall extreme events between rain gauge data and WRF model in North Canterbury. Waterways Postgraduate Students Conference, Christchurch, 8 November 2022.

Nguyen, M. Uncertainty in bathymetry estimation. Waterways Postgraduate Students Conference, Christchurch, 8 November 2022.

Dunn, J., & **Wong, S.** Stability of Syntactic Dialect Classification Over Space and Time. Proceedings in the 29th International Conference on Computational Linguistics (COLING), October 12-17, 2022, Gyeongju, Republic of Korea

Wilson, M.D., Empowering decision making for sustainable development through environmental digital twins: Second United Nations World Geospatial Information Congress, Hyderabad, 10-14 October 2022.

Wong, S. UCI Summer School on Computational Cognitive Modelling for Language. Presented at the New Zealand Institute of Language, Brain and Behaviour Seminar, October 10, 2022, University of Canterbury, New Zealand.

Eggleton, P. An investigation into how exposure to the Canterbury Earthquake Sequence (2010-11) is associated with mental health: a spatio-temporal birth cohort study. QuakeCoRE Annual Conference, Napier, 31st August 2022.

Wong, S; Dunn, J, & Adams, B. Comparing Measures of Linguistic Diversity Across Social Media Language Data and Census Data at Subnational Geographic Areas. Proceedings in New Zealand Geospatial Research Conference, August 29-30, 2022, Massey University, Wellington, New Zealand.

D Moller, **M Wilson, R Datta**, A O'Brien, R Linnabary, C Ruf, Rongowai: A pathfinder NASA/NZ GNSS-R initiative supporting SDG-15 – Life on Land: International Geosciences and Remote Sensing Symposium (IGARSS), Kuala Lumper, 17 - 22 July, 2022.

Wong, S. Geospatial Linguistics: Connecting Language to the Land. Presented at the New Zealand Institute of Language, Brain and Behaviour Seminar, June 30, 2022, University of Canterbury, New Zealand.

Wilson, M.D., Preston, G., Kholsa, P., Parkinson, P., Pearson, R., Bosserelle, C., Lane, E. and Deakin, R., Towards a National Digital Twin for Flood Resilience in New Zealand: Stormwater New Zealand conference, Christchurch, May 2022.

Hobbs, M., Howe, A., Marek, L., Young, A., Dawson, P., Willing, E., McIntyre, P. (2022). Generating evidence to improve uptake and equity in maternal immunisation. Presentations at Regional Immunisation Advisory Meetings (Christchurch, Auckland, Palmerston North)

Marek, L. et al. Goods and bads of the built environment and their associations with mental and physical health outcomes in Aotearoa New Zealand. International Medical Geography Symposium (IMGS) 2022 (Edinburgh, UK).

Wilson, M.D., Empowering decision making for local government through environmental digital twins: Association of Local Government Information Managers (ALGIM) conference, Christchurch, 21-22 November 2022 (invited)Erin McEwan, E., Stahl, T.A., Andy Howell, A., Langridge, R.M., and Wilson, M., Earthquake-induced river avulsion and flooding along surface rupturing faults: AGU Fall Meeting, Chicago, 12-16 December

Wong, S. Navigating Aotearoa New Zealand's Multilingual Social Media Landscape. Paper presented at the Linguistic Society of New Zealand Conference, December 8-9, 2022, University of Otago, New Zealand.

Datta, R., Wilson, M., Moller, D., and Ruf, C., Soil Moisture Estimation from CYGNSS using Machine Learning: AGU Fall Meeting, Chicago, 12-16 December

Nguyen, M., Wilson, M., Lane, E., and Brassington, J., Uncertainty in Predictions of Flood Inundation Caused by Model Grid Sampling: AGU Fall Meeting, Chicago, 12-16 December

Moller, D., Ruf, C., **Datta, R**., Gleason, S., Laverick, M., Lin, X., Musko, S., O'Brien, A., Seal, C., **Wilson M.,** First Results from the Rongowai Airborne GNSS-R mission: AGU Fall Meeting, Chicago, 12-16 December.

Wong, S. (2022). Exploring Geospatial Linguistics. Lightning talk presented at the Emerging Spatial Professional Mini-Conference, April 2, 2022, Auckland, New Zealand.

Wong, S., Jones, J., Hay, J., Fromont, R., Haywood, B., Durward, M., & Kaefer, S. (2022). Many Speech Analyses. Presented at the New Zealand Institute of Language, Brain and Behaviour Seminar, July 14, 2022, University of Canterbury, New Zealand.

Hobbs M. (2021) *What can geohealth-related research offer psychologists?* Christchurch, New Zealand: University of Canterbury, School of psychology, speech and hearing seminar series, 28 May 2021. (Oral Presentation)

Hobbs M. (2021) *What is geohealth: a research showcase for the Born in Bradford longitudinal cohort.*. Online (to Bradford, UK): Born in Bradford Seminar Series, 29 Apr 2021. (Oral Presentation)

Other Highlights

GRI members playing mini golf and skiing!

Lukas

Matt

Ski Trip 2022

Ski Trip 2022

Christmas celebrations!

GRI Christmas 2021

GRI Christmas 2022

Financial report and Contact

Financial report

Accounts	FY2021	FY2022
Operating Income		
Government Grants	286,272	267,377
Other Income	1,368,240	631,222
Total	**1,654,511**	**898,599**
Operating Expenditure		
Total	**647,470**	**570,654**
General Expenses	1,033,842	139,374
Depreciation	13,103	11,994
Overheads	-149,444	175,220
Total	**1,544,971**	**897,242**
Net Income	109,541	1,357

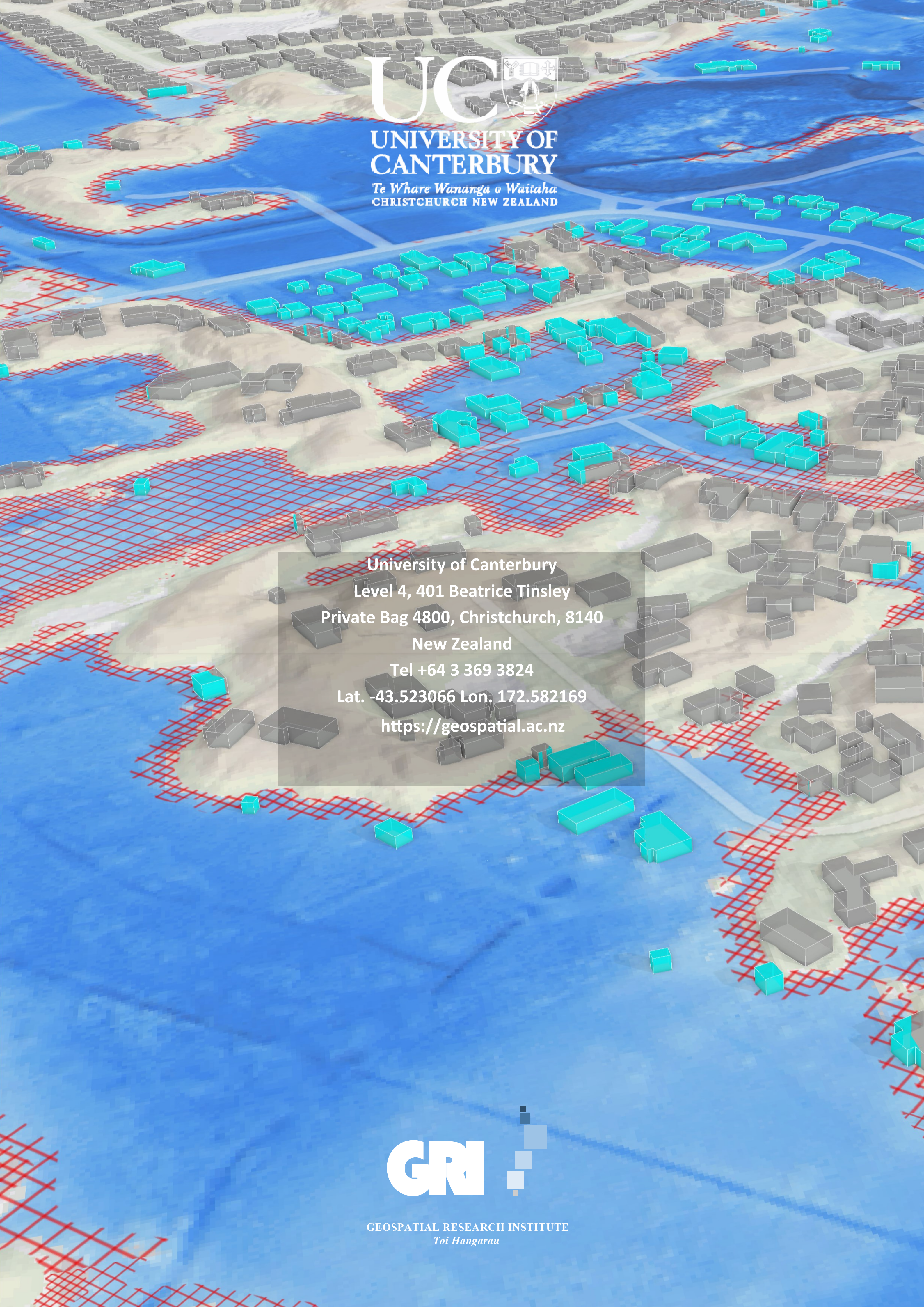
Web pages outlining the GRI activities are available at:

https://geospatial.ac.nz

The GRI uses social media to disseminate news and features:

https://www.twitter.com/geospatialnz

https://www.linkedin.com/company/geospatial-research-institute



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