Cover image: Illustration using data from Xander Cai's research into super-resolution estimation of bare-Earth digital terrain models using deep learning (page 26-27).

Contents

GEOSPATIAL RESEARCH INSTITUTE
TOI HANGARAU

GEOSPATIAL RESEARCH INSTITUTE *Toi Hangarau*

Left to right: Matthew Wilson, Kaihautū (Director) of the Geospatial Research Institute Toi Hangarau and Mokonuiarangi Kingi, Tiamana (Chair), Te Manatōpū Hau Kāinga o Ōhinemutu, sign our memorandum of understanding in Ōhinemutu, Rotorua.

GRI Director’s Statement

Tēnā koe e hoa, haere mai.

Welcome to our report for 2023. I hope you enjoy this issue as we reflect on some of the developments and achievements in the GRI Toi Hangarau. Building from our previous engagements in this area, we continue to strive to develop novel and impactful research which addresses the UN sustainable development goals (SDGs). In the pages that follow, you can see how our research maps onto the SDGs: we currently are addressing 14 out of 17!

The highlight of the year, for me, was to sign a memorandum of understanding with Te Manatōpū Hau Kāinga o Ōhinemutu, in Rotorua (see pages 70-71). This signifies an intention to continue to work closely together, and is a formal declaration of our partnership developed over several years, particularly through the co-development and deployment of a geospatial tool called Te Kete Kōrero o Ōhinemutu (see page 53). Together, we wish to continue to co-develop further initiatives around the use of geospatial research for the benefit of Ōhinemutu and other Māori communities across Aotearoa New Zealand.

In this issue, we highlight the work across several research projects in which artificial intelligence (AI) is playing a central role (pages 25-39), from super-resolution mapping of topographic elevations, to mapping our ecosystems and urban tree landscapes, to estimating soil moisture. Our use of AI is enabling us to develop new insights into areas of importance for sustainable development, and make better, more efficient use of the vast volumes of geospatial data available.

Other research highlights includes geospatial analyses of health (pages 41-52), for example issues such as water fluoridation, mental health, chronic health conditions, vaping, abdominal aortic aneurysms, maternal immunisations, and population mobility. The generation of a "healthy location index" is highlighted on page 52, along with a web application to explore. Our continued developments in the flood resilience digital twin are shown on pages 54-57 along with other projects such as the development of a dashboard for carbon neutral neighbourhoods (page 58). Further data processing and analyses for improving flood risk assessment and planning are shown on pages 59-61.

Our new PhD scholars in the GRI are introduced on pages 63 to 67. GRI Scholarship recipient Sunil Tamang will be working on the use of machine learning to assess rock glaciers in mountain environments, often an important source of freshwater for downstream communities yet one which is under threat from climate change. Two additional PhD students join us as part of the MBIE Endeavour Research programme, Mā te haumaru ō nga puna wai ō Rākaihautū ka ora mo ake tonu: Increasing flood resilience across Aotearoa-New Zealand: Katherine Booker will be researching how we can better account for urban growth within estimates of future flood risk, and Clevon Ash, will be working on how we can better communicate and make management or planning decisions under the uncertainty which is inherent in any flood risk assessment.

Other highlights of the year includes hosting the Spatial Data Science Symposium (pages 72-73), with several presenters associated with the GRI, and hosting a visit and seminar from the Director of Science for Planet Labs, Joe Mascaro, followed by a return visit to their HQ in San Francisco (page 75). As well as Joe’s talk , GRI seminar topics (pages 78-79) included the Rongowai mission (myself and Delwyn Moller), water supply inequities (Tim Chambers and Matt Hobbs), penguins in Antarctica measured from space (Peter Fretwell), and geospatial research in industry (Peter Shaw).

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. Matt Wilson
GRI Director

About us

We conduct interdisciplinary partnership-based geospatial research across the social and physical sciences.

Our objectives:

To conduct excellent, leading and novel geospatial research.

To enable innovative transdisciplinary geospatial solutions

To provide a hub for geospatial capability building

with positive impacts for Aotearoa's communities and the environment

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.

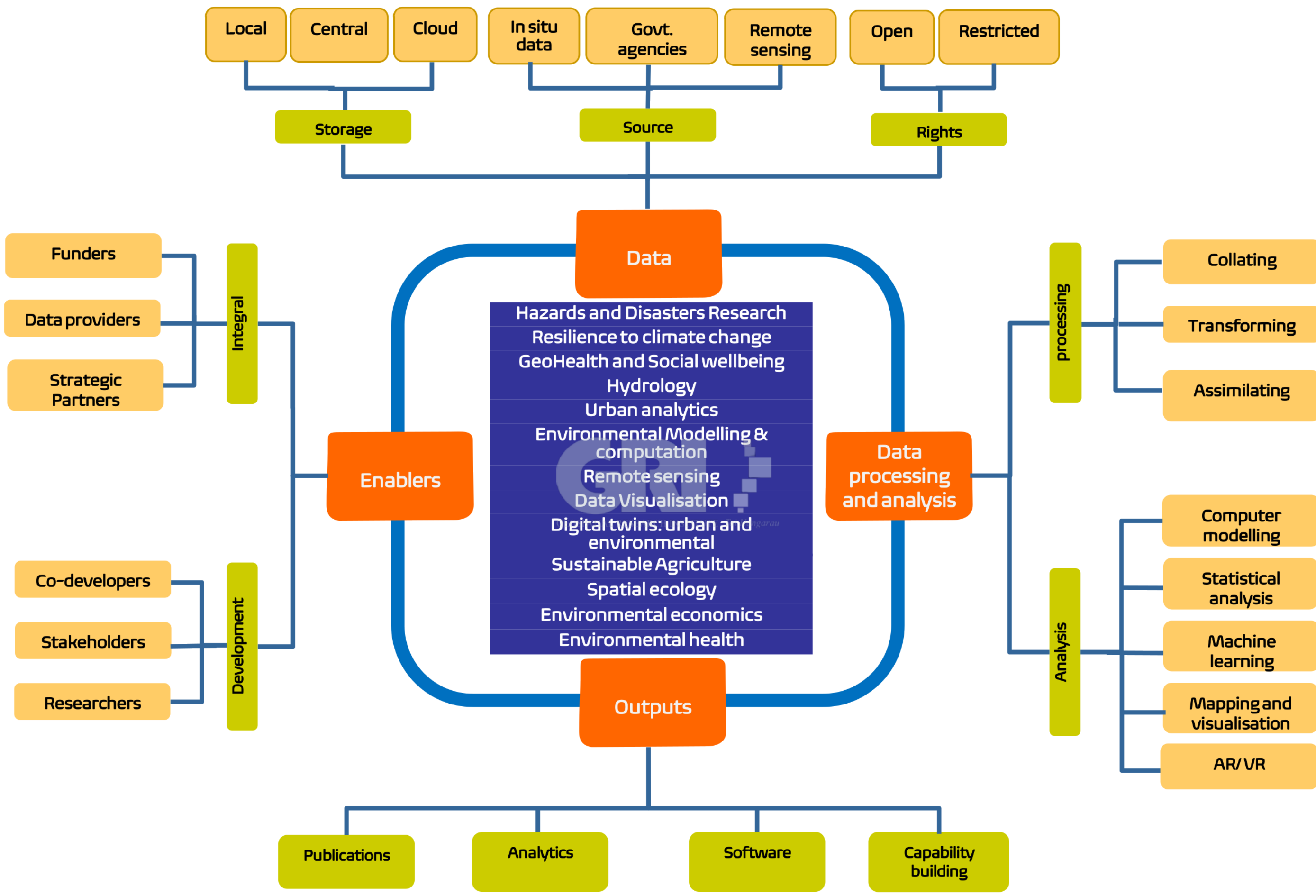
Core values

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

Research domains

Our research domains are aligned to the United Nations Sustainable Development Goals.

GRI research domains



GRI domain map: contextualizing the GRI research domain areas. *The GRI is a data driven institute. At present, one of our focus areas is in the development of integrated and automated data processing. We are developing comprehensive and detailed databases of remote sensing, statistics, demographics and environmental data, which can be shared with research partners. In the near future, we expect to be able to provide reliable databases that can be used for computing modelling, statistical analysis, machine learning, mapping and visualisation.*

Supporting Funders and Partners

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
SCRIPTURA SACRA SOLA FIDE

UC WIRELESS RESEARCH CENTRE

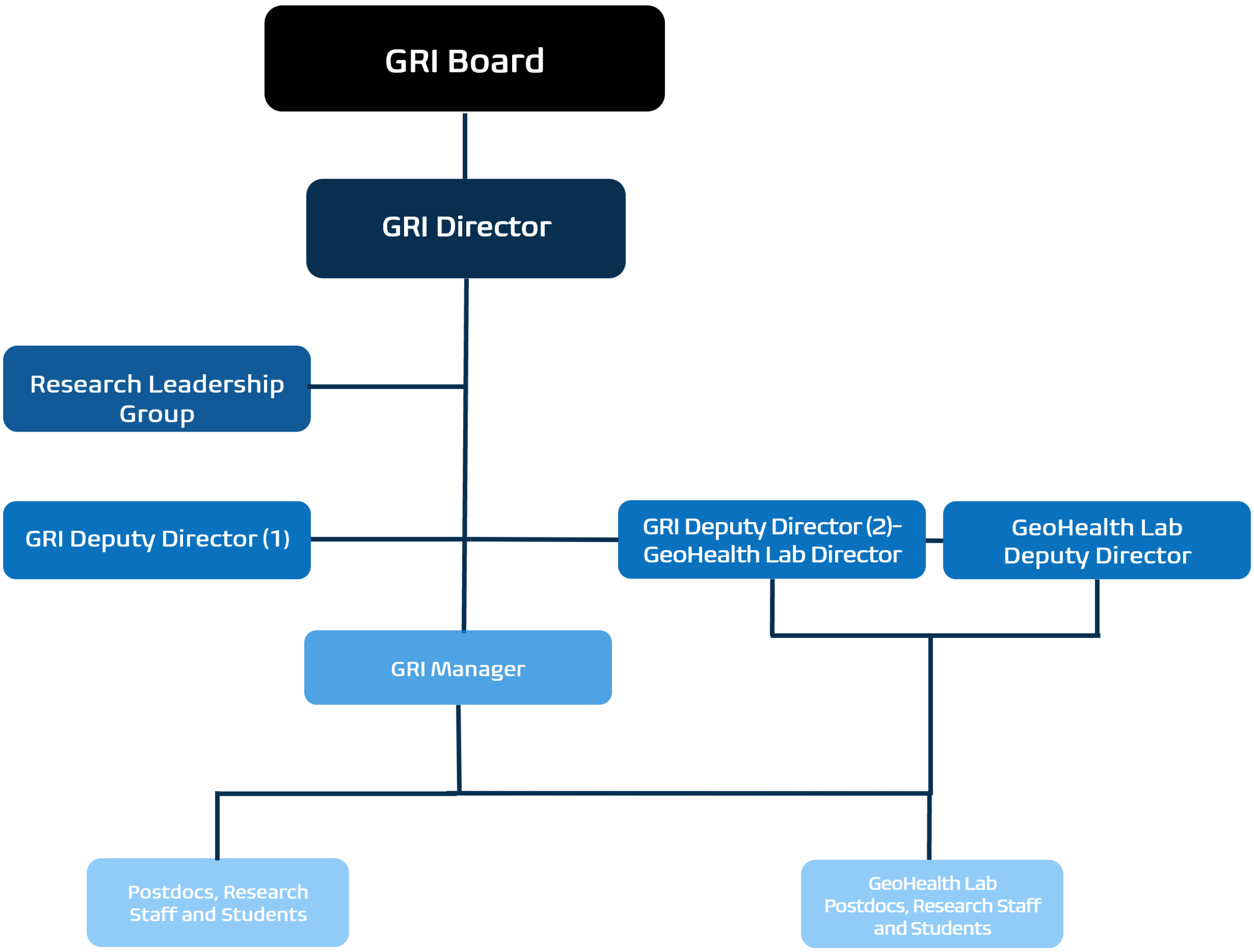
THE OHIO STATE UNIVERSITY

Governance

Mt Saint John, NZ. Photo by: MCVega

GEOSPATIAL RESEARCH INSTITUTE *Toi Hangarau*

The Institute's Structure



Board Members

Jan Pierce (Chairperson)
Deputy Chief Executive,
Land Information NZ.

Ian Wright
Deputy Vice-Chancellor
Research, UC.

Peter Shaw
Engineering Director,
Trimble

Kat Salm
Business Development Manager
FrontierSI

Mike Taitoko
CEO Takiwa

Research Leadership Group

Professor Richard Green
Department of Computer Science
and Software Engineering, UC.

Professor Rob Lindeman
Director, HIT Lab NZ

Dr. Graeme Woodward
Wireless Research Centre, UC

David Humm
Business Development Manager,
Research & Innovation, UC.

Professor Jennifer Brown
Head of Teaching - Data Science , UC.

Dr. John Reid
Senior Research Fellow, UC.

Professor Simon Kingham
Chief Science Advisor, MoT

Management and staff

Matthew Wilson
Director

Simon Kingham
Deputy Director GRI
Dir GeoHealth Lab

Jennifer Brown
Deputy Director

Malcolm Campbell
Co-director
GeoHealth Lab.

Matthew Hobbs
Co-director GeoHealth Lab.

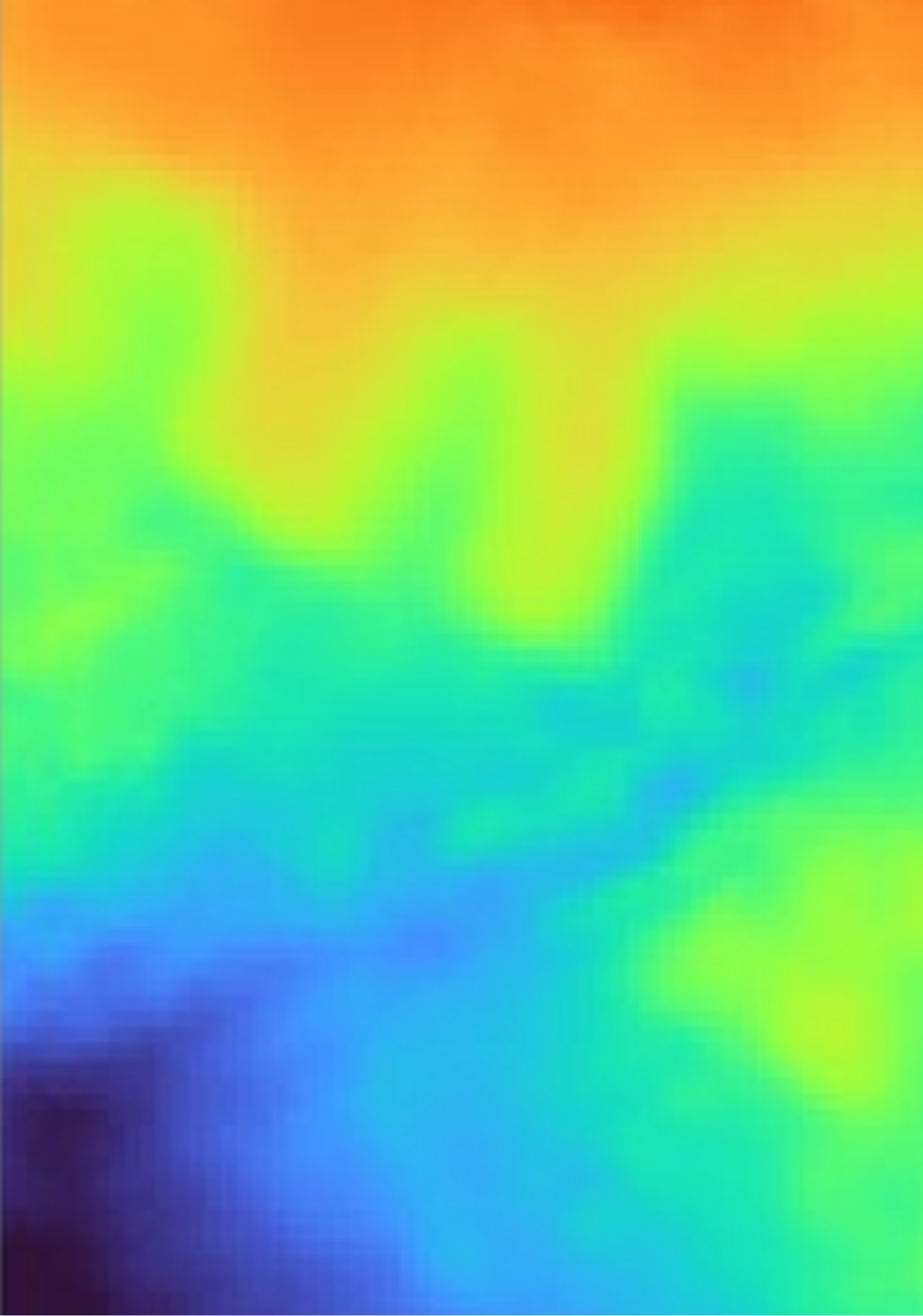
Maria Vega Corredor
Manager

Luke Parkinson
Geospatial Software
Developer

Mary Botting
Administrative Assistant
(Former)

Hannah Walker
Marketing
Administrator

Research highlights



Artificial Intelligence: Building towards improved and more efficient geospatial methods

The ever increasing volumes of data creates both challenges and opportunities. In the GRI, we are exploring how machine learning can make better use of spatial data to gain actionable insights for sustainable development.

While generative artificial intelligence (AI) has captured the public imagination, for example with its ability to conversationally answer queries or generate images on demand, machine learning and deep learning (subsets of AI) are causing a quieter revolution in data science. When applied to the vast volumes of geospatial data, the analytics these methods enable is a leap forward to what was achievable previously. In this section, we explore several of the projects in the GRI which are underpinned by AI:

- Page 26: deep learning from aerial photos can greatly improve digital terrain models, a foundational dataset in many fields such as hydrology, by both removing artefacts caused by surface features and enhancing its spatial resolution.
- Page 28: hybrid approaches of hydrodynamic modelling and machine learning, where the machine is learning from the model, can enable rapid predictions of flooding while maintaining accuracy and transferability.
- Page 30: all flood models contain uncertainty, which is usually assessed using computationally expensive "Monte Carlo" simulations; the uncertainty in flood predictions can be estimated using machine learning, enabling it to be attached to flood predictions at much lower cost.
- Page 32: deep learning is enabling mapping and analysis of trees in urban spaces, and how they have changed, enabling research which is providing new insights into how these important amenities can be better managed.
- Page 34: research which is part of the Eco-Index programme is using machine learning to map and analyse ecosystems from high resolution Planet remote sensing imagery, combined with other datasets such as topography.
- Page 38: the combination of several datasets within a machine learning framework is enabling the estimation of soil moisture from reflected GNSS signals, captured as part of the CYGNSS and Rongowai missions.

Each of these projects is utilising large volumes of spatial data to produce insights that would be difficult or impossible otherwise, with greater levels of detail and accuracy.

Super-resolution for real-world digital terrain models - deep learning approach

Research Team:
Xander Cai (GRI– UoC)
Matthew Wilson (GRI– UoC)

Funding
GRI funds

Duration of the Project
2023

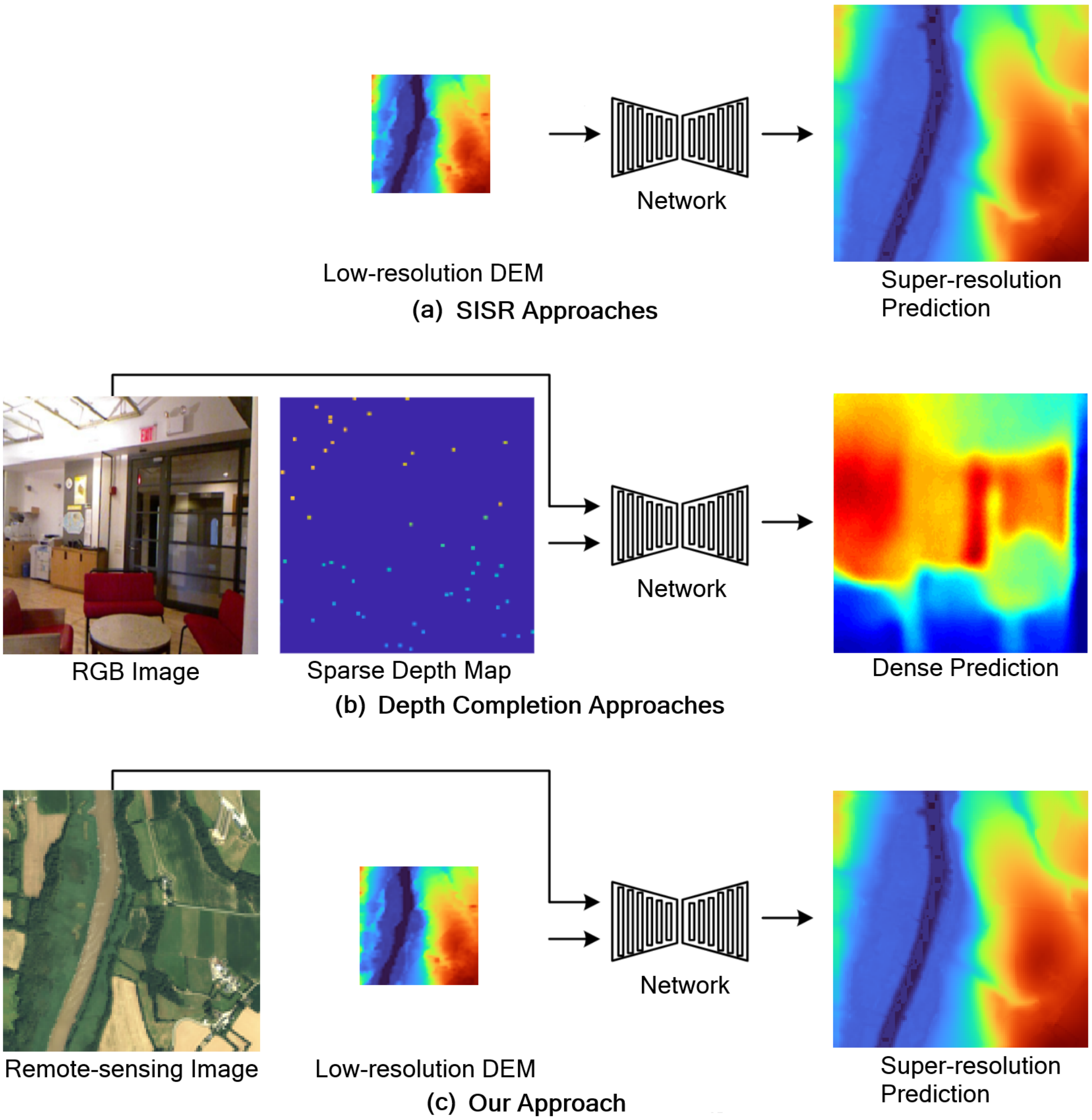
Project Summary:

A Digital Elevation Model (DEM) stores and represents elevation as an image raster, widely used as fundamental data for research, applications and policy decisions related to land and earth. DEMs can be classified into the Digital Surface Model (DSM) and Digital Terrain Model (DTM). A DTM represents the elevation of the bare ground, while a DSM represents the elevation of the highest objects on the ground, which could be a tree or a building. In recent years, Light Detection and Ranging (LiDAR) based on airborne become popularly used to create high-resolution and high-accuracy DTMs because it can distinguish, classify, and remove objects on the ground from the survey data. Spaceborne sensors such as Synthetic Aperture Radar (SAR) and stereoscopic imaging are used to generate coarse resolution (1 arc-second at best, around 30 meters at the equator) global DSMs, more precisely, approximate DSMs due to penetrating vegetation to various degrees.

Although modern measurement technologies can quickly obtain elevation information and provide DEM products for the public, freely available global DEMs are limited in their resolution, accuracy and coverage. Therefore, it is a common practice to generate high-resolution DEMs using the Super-resolution (SR) approach for areas without LiDAR-derived high-resolution DEMs. With the presentation of Super-Resolution Convolutional Neural Network (SRCNN) in 2014, deep learning approaches started dominating the Single Image Super-Resolution (SISR) problems. Consequently, researchers developed and applied methods based on SISR approaches to the DEM Super-Resolution (SR) problems. Among the previous work, little research has been done on real-world DEM SR problems.

Motivated by the difficulties for real-world DEM SR based SISR approach, we investigates real-world DEM SR problems leveraging approaches for sparse-to-dense depth completion problems that infer the dense depth map of a 3-dimensional scene based on its corresponding sparse depth map and a guidance RGB image. The figure outlines different approaches: the depth completion approach exploits the corresponding RGB image to guide the network for predicting a dense depth map from sparse depth maps, while the SISR approach only uses low-resolution images as input to predict SR images. Since both DEMs and depth maps represent 3-dimensional data, assuming low-resolution DEMs are sparse depth maps and high-resolution DEMs are dense ground truth depth maps, employing depth completion approaches to solve DEM SR problems as Figure (c) shown is a promising approach.

In this project, we propose a novel approach for DEM super-resolution that learns non-local weight and offset from fused guidance features to correct errors in the low-resolution DEMs and predict super-resolution DEMs. Our method improves accuracy (RMSE) by over 56%/38% and reconstruction quality (PSNR) by over 9%/4% on 8-meter resolution and 3-meter resolution datasets compared to Bicubic/EDSR. We also propose a dataset for DEM super-resolution based on publicly accessible datasets with high-resolution aerial images, semantic segmentation masks, DEMs, and low-resolution DEMs. This dataset can be used as a benchmark for real-world DEM super-resolution problems to compare different algorithms' performance straightforwardly.



The general approaches of different domains: (a) the approach for single image super-resolution; (b) the approach for depth completion; (c) our approach for DEM super-resolution.

Hybrid hydrodynamic-machine learning model for rapid flood scenario assessment

PhD Student:
Andrea Pozo Estivariz

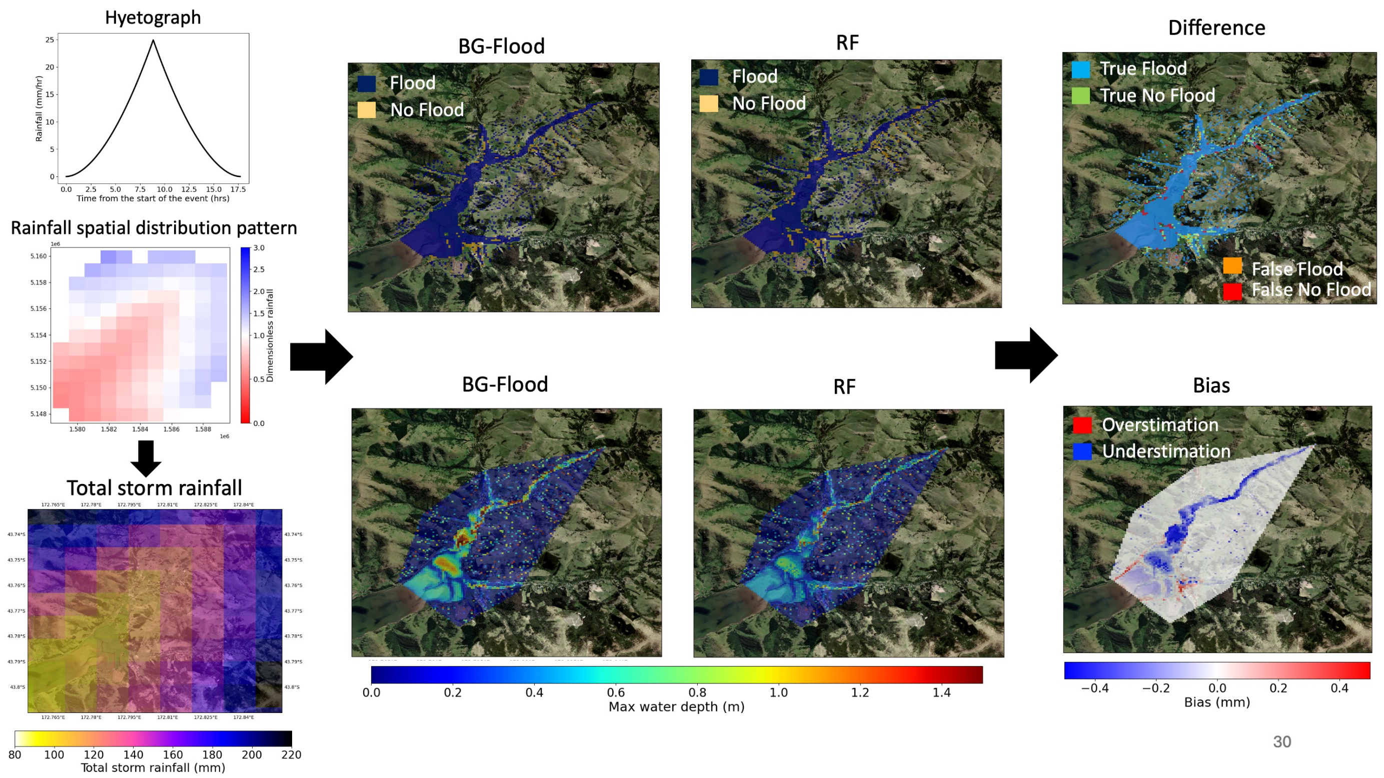
Supervisors:
Emily Lane (NIWA)
Matthew Wilson (UoC)
Marwan Katurji (UoC)
Fernando Méndez (Universidad de Cantabria)

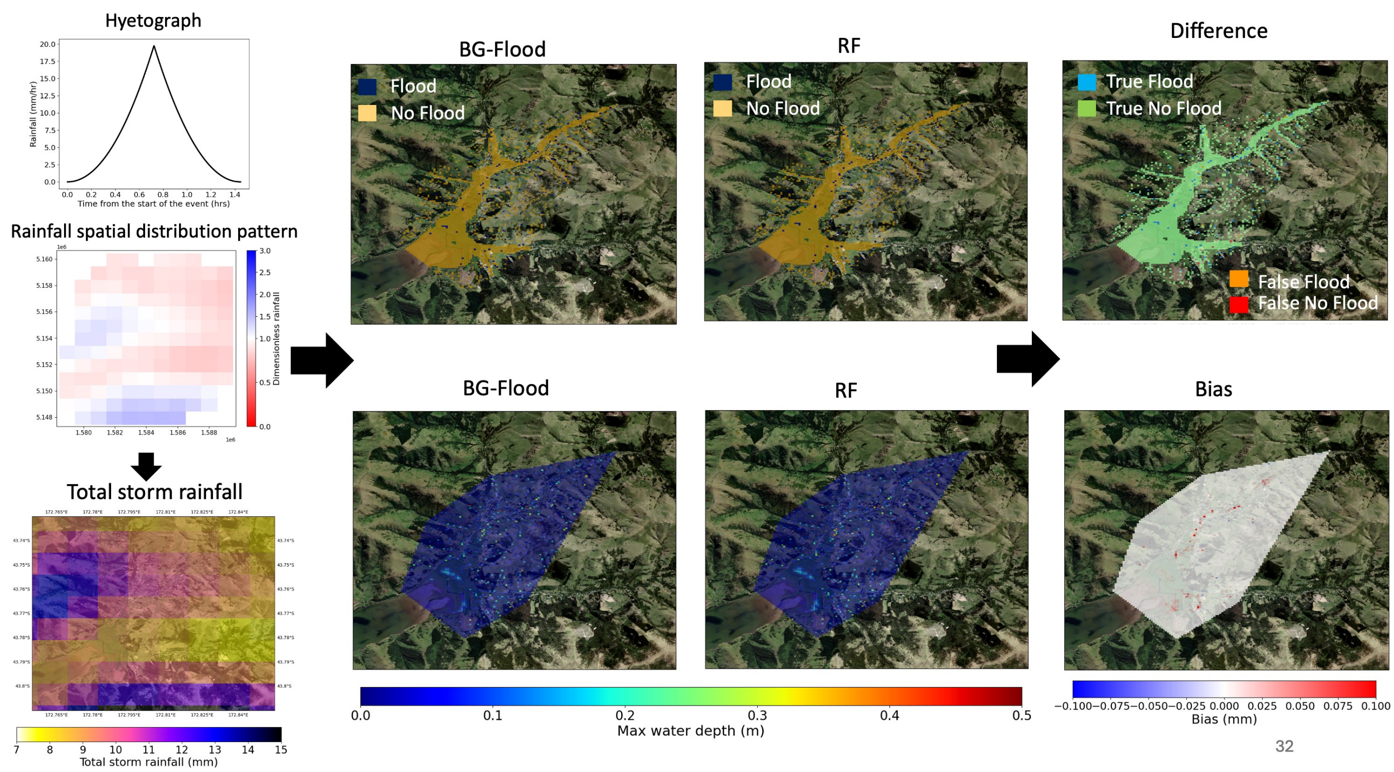
Funding

This research is part of the 5 years NIWA led research programme "Reducing flood inundation hazard and risk across Aotearoa/New Zealand", funded by the Ministry of Business, Innovation and Employment

Project summary

Flooding is the most frequent natural hazard in New Zealand and the second-most costly after earthquakes. It is also expected to become more severe as climate change impacts are realized. Generally, two-dimensional hydrodynamics models are used to simulate flood inundation across a floodplain. These models can provide reliable estimations of the flood extent and magnitude. However, they are also computationally expensive and time-consuming. Current computing power and memory pose a limitation in the number, level of detail and modelling time of assessed flooding scenarios, making rapid real-time or forecast flooding very challenging. This work investigates the application of hybrid hydrodynamic and machine learning (ML) techniques to develop a rapid flood scenario assessment model using the Wairewa catchment (Banks Peninsula, Canterbury) as the study site. This approach aims to reduce the numerical modelling load and enable probabilistic modelling, allowing us to make rapid predictions of potential flooding events from an ensemble of previously assessed events. The hybrid model is able to predict flood extent and maximum flood depth based on the characteristics of the main inundation driver in the area (heavy rainfall) and of the geographic features of the catchment. To do this, firstly, a sample of synthetic storms was created based on the temporal and spatial characteristics of the heavy rainfall events in the catchment. Then, each storm in this sample was modelled using a 2D hydrodynamic model, BG-Flood, to obtain the corresponding flood extent and maximum water depth map. Following this, the sample of storms (with their corresponding inundation maps) was divided into training, validation and testing datasets to experiment with different ML algorithm. Random Forest (RF) is capable of predicting flood extent and maximum water depth in the floodplain of the catchment very well. In the ongoing work a hybrid hydrodynamic and deep learning (DL) model is being built focusing in generating inundation maps at finer spatial resolution (5 m) and in less time.





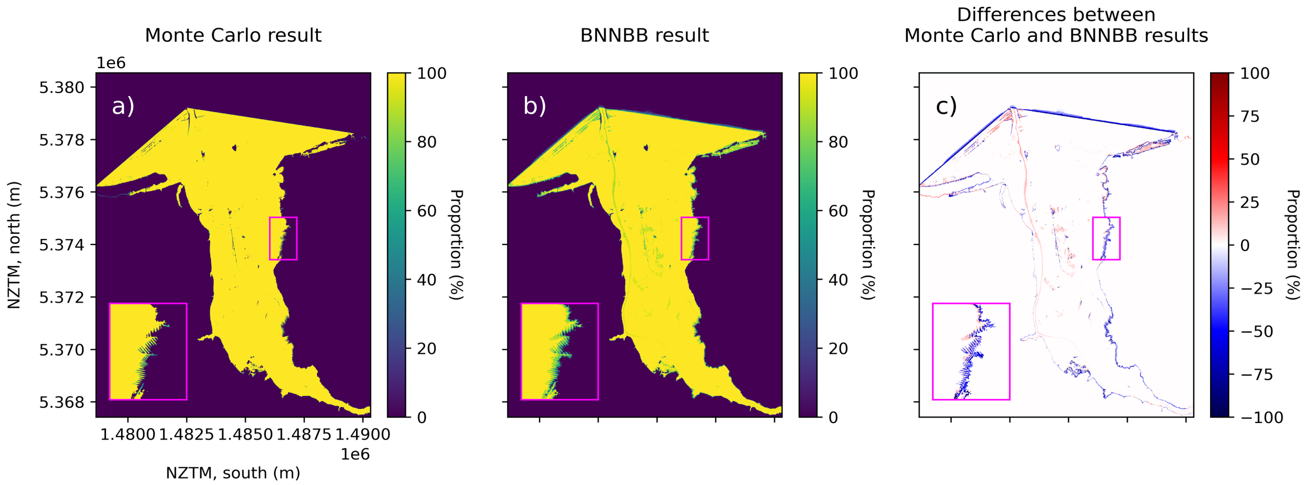
First column of the figure: Storm hietogram (rainfall intensity (mm/hr) versus time from the start of the event (hours)), storm rainfall spatial distribution pattern (defined through the variable named dimensionless rainfall), and the resultant total storm precipitation field (mm) over the study catchment. Second column: BG-Flood (2D hydrodynamic model) outputs, including the classification of cells in flood (blue) and no-flood (brown) in the first row, and the maximum inundation depth map (meters) in the second row. Third column: Random Forest (RF) outputs, including the classification of cells in flood (blue) and no-flood (brown) in the first row, and the maximum inundation depth map (meters) in the second row. Fourth column: differences between BG-Flood and RF outputs, for the classification model (first row), indicating the True Flood (blue), True No Flood (green), False Flood (orange), and False No Flood (red); and for the regression model indicating the bias between RF and BG-Flood (red corresponds to RF overestimation and blue to RF underestimation).

Estimating uncertainty in flood model outputs using machine learning informed by Monte Carlo analysis

PhD student:
Martin Nguyen (PhD student, UoC)

Supervisors:
Prof. Matthew Wilson (Main Supervisor, UoC)
Dr. Emily Lane (Supervisor, NIWA)
Prof. James Brasington (UoC)
Dr. Rose Pearson (NIWA)

Funding:
MBIE Endeavour Research Programme – Increasing flood resilience across Aoteroa, New Zealand.



Proportions of each cell being flooded of Buller River flood event generated from (a) Monte Carlo simulations, (b) predicted from Bayes Neural Network with Bayes by Backprop (BNNBB), (c) and their differences.

Project Summary:

Topography is an important input for flood inundation model and how to obtain accurate representations of it has not been properly studied. In general, 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). 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.

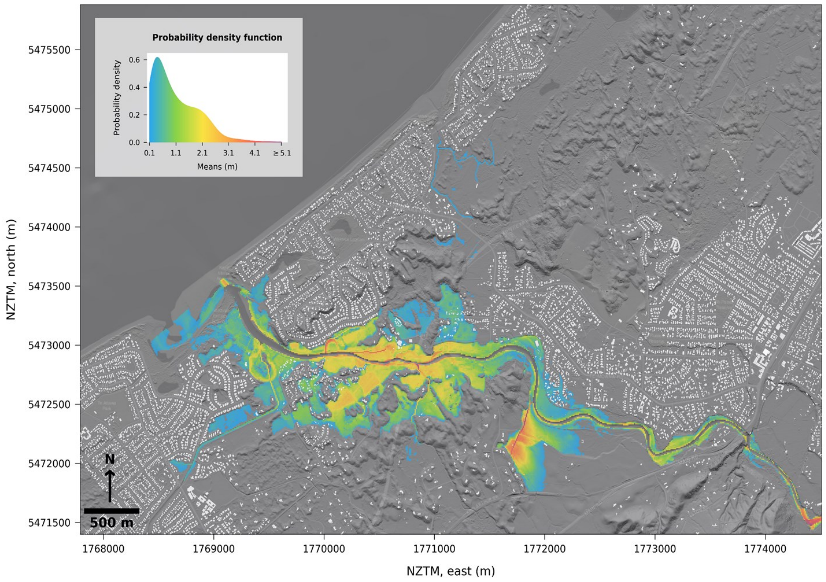
This research investigates the variation in the outputs of a flood model using a Monte-Carlo procedure, where multiple, equally likely DEMs are derived from LiDAR by adjusting the alignment (rotation) and point of origin of the model grid, and each used to predict flood inundation.

To interpret the variability in water depth values when the model grid is transform, two major comparisons were made, The first was to compare different types of transformations and the second was to compare various DEM resolutions.

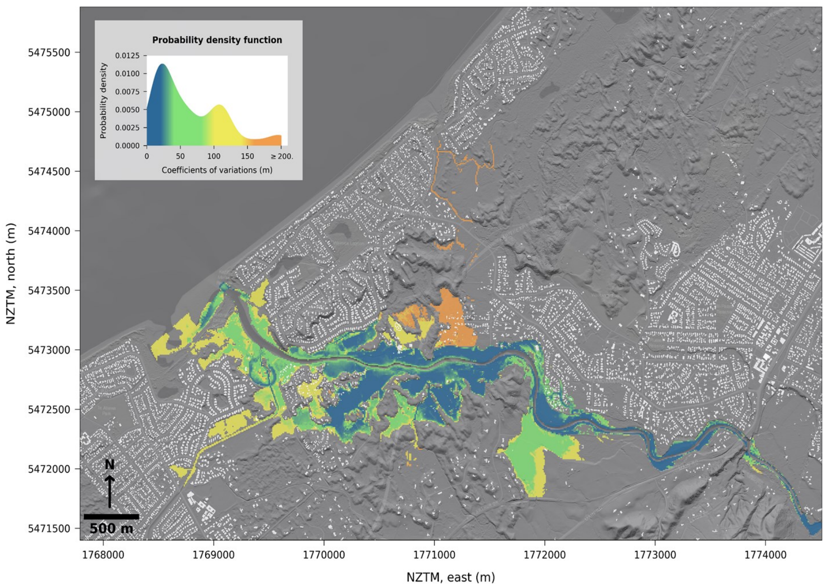
Numerous studies have extensively employed Monte Carlo-based methods to characterise uncertainty in flood modelling due to their simplicity and flexibility. However, these approaches are time-consuming and computationally extensive. Recognising the need for efficiency, machine learning has emerged as a promising alternative with comparable results.

This research introduces an advanced uncertainty estimation method for flood modelling, utilizing the Bayes Neural Network with Bayes by Backprop. The model aims to forecast variations in flood modelling predictions caused by uncertainty in the Digital Elevation Model generation process, offering a more efficient and accurate approach to address the challenges posed by traditional Monte Carlo methods.

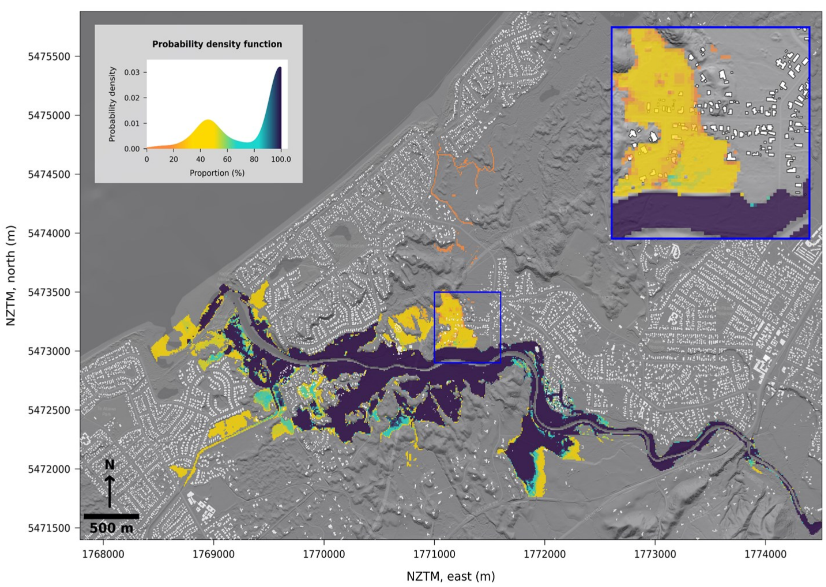
Means of water depths



Coefficients of variation of water depths



Proportions of each location being flooded



Urban Trees and Housing Intensification: A Spatial Conflict?

PhD Sudent:
David Pedley (SoF- GRI)

Supervisors
Dr Justin Morgenroth (UoC)
Dr Grant Pearse (Flinders University)

Funding
GRI Scholarship and UC Doctoral Scholarship

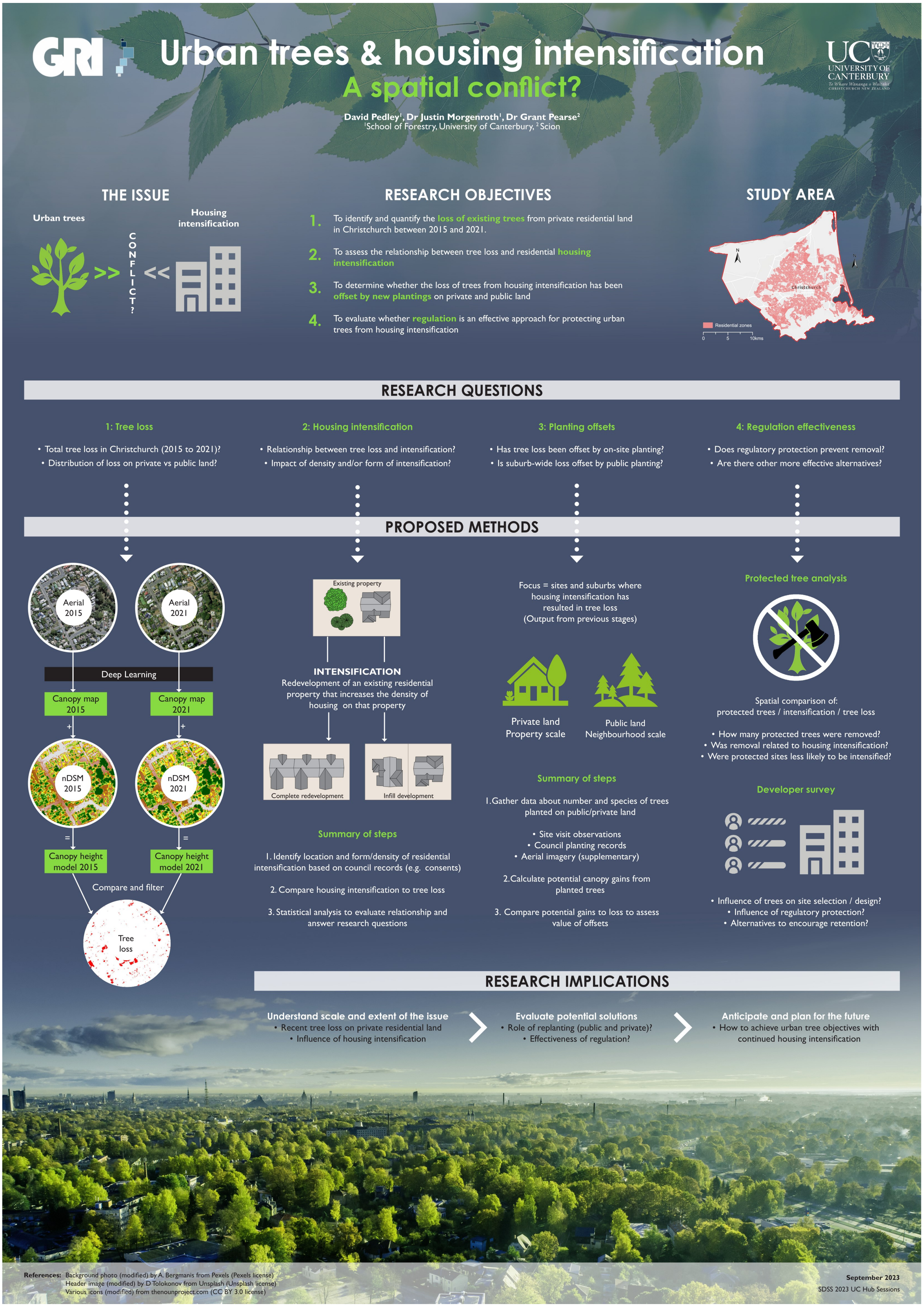
Project summary

Urban trees provide a multitude of environmental and amenity benefits for city occupants yet face ongoing risk of removal due to urban pressures and the preferences of private landowners. Understanding the patterns and drivers of canopy loss on private land is critical for the effective management of urban forests. Although city-scale assessments of urban forest canopy cover are relatively common, the accurate identification of canopy loss at the property scale remains challenging. Evaluating change at the property scale is of particular importance given the localised benefits of urban trees and the scale at which tree removal decisions are made.

The first objective of this study was to detect and quantify the city-wide loss of urban tree canopy (UTC) at the scale of individual properties using publicly available remote sensing data. The study area is Christchurch, New Zealand, with the study focussed on UTC loss that occurred between 2016 and 2021. A common method for mapping UTC is object-based image analysis, where aerial or satellite images are segmented into discrete objects based on their spectral and textural characteristics and spatial arrangement. To improve the accuracy of the output, the study utilises a convolutional neural network deep learning model, which has achieved state-of-the-art performance for UTC mapping that exceeds the accuracy of traditional methods.

The model architecture utilised in this study was DeepLabV3+ with a ResNet101 backbone. The model was pretrained on a large quantity of existing tree canopy data from a previous mapping exercise, before being fine-tuned on hand-annotated training samples created from high resolution RGB aerial imagery for 2016. This method of pretraining a deep learning model using noisy or lower quality training data is a valuable technique to improve the accuracy of model predictions without the need for large amounts of hand-annotated training data. The output of this model was a binary raster of tree canopy, which was then segmented into individual tree polygons using a second deep learning model, being the open-source Segment Anything Model by Meta. The resulting UTC map was compared to height loss polygons (derived from multi-temporal LiDAR) to identify polygons of UTC loss that occurred between 2016 and 2021. These polygons could then be allocated to specific property titles to quantify the extent of UTC loss for each property within the study area.

The property-scale identification of tree loss creates the opportunity for detailed evaluation of the drivers of urban tree loss on private properties to enable better management of existing urban forests. This is the focus of the second research stage, which will investigate the potential conflict between residential housing intensification and UTC loss during the study period. Although the provision of intensified housing can provide many benefits and efficiencies, it is important to understand whether housing intensification may be inadvertently resulting in the loss of existing urban trees. The final stages of the research project will employ a variety of methods to assess the extent to which past tree loss has been offset by new planting and evaluate whether regulation is an effective approach for protecting urban trees.


Urban trees & housing intensification
A spatial conflict?
David Pedley[1], Dr Justin Morgenroth[1], Dr Grant Pearse[2]
[1]School of Forestry, University of Canterbury, [2] Scion
UNIVERSITY OF CANTERBURY
THE ISSUE
Urban trees
Housing intensification
>> CONFLICT? <<
RESEARCH OBJECTIVES
1. To identify and quantify the loss of existing trees from private residential land in Christchurch between 2015 and 2021.
2. To assess the relationship between tree loss and residential housing intensification
3. To determine whether the loss of trees from housing intensification has been offset by new plantings on private and public land
4. To evaluate whether regulation is an effective approach for protecting urban trees from housing intensification
STUDY AREA
Christchurch
Residential zones
0 5 10kms
RESEARCH QUESTIONS
1: Tree loss
• Total tree loss in Christchurch (2015 to 2021)?
• Distribution of loss on private vs public land?
2: Housing intensification
• Relationship between tree loss and intensification?
• Impact of density and/or form of intensification?
3: Planting offsets
• Has tree loss been offset by on-site planting?
• Is suburb-wide loss offset by public planting?
4: Regulation effectiveness
• Does regulatory protection prevent removal?
• Are there other more effective alternatives?
PROPOSED METHODS
Aerial 2015
Aerial 2021
Deep Learning
Canopy map 2015
Canopy map 2021
+
nDSM 2015
nDSM 2021
=
Canopy height model 2015
Canopy height model 2021
Compare and filter
Tree loss
Existing property
INTENSIFICATION
Redevelopment of an existing residential property that increases the density of housing on that property
Complete redevelopment
Infill development
Summary of steps
1. Identify location and form/density of residential intensification based on council records (e.g. consents)
2. Compare housing intensification to tree loss
3. Statistical analysis to evaluate relationship and answer research questions
Focus = sites and suburbs where housing intensification has resulted in tree loss
(Output from previous stages)
Private land
Property scale
Public land
Neighbourhood scale
Summary of steps
1.Gather data about number and species of trees planted on public/private land
• Site visit observations
• Council planting records
• Aerial imagery (supplementary)
2.Calculate potential canopy gains from planted trees
3. Compare potential gains to loss to assess value of offsets
Protected tree analysis
Spatial comparison of:
protected trees / intensification / tree loss
• How many protected trees were removed?
• Was removal related to housing intensification?
• Were protected sites less likely to be intensified?
Developer survey
• Influence of trees on site selection / design?
• Influence of regulatory protection?
• Alternatives to encourage retention?
RESEARCH IMPLICATIONS
Understand scale and extent of the issue
• Recent tree loss on private residential land
• Influence of housing intensification
Evaluate potential solutions
• Role of replanting (public and private)?
• Effectiveness of regulation?
Anticipate and plan for the future
• How to achieve urban tree objectives with continued housing intensification
References: Background photo (modified) by A. Bergmanis from Pexels (Pexels license)
Header image (modified) by D Tolokonov from Unsplash (Unsplash license)
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September 2023
SDSS 2023 UC Hub Sessions

Eco-index Programme: National Science Challenge to conserve New Zealand’s Biological Heritage

Research Team:
Dr Kiri Joy Wallace (UoW)
Dr John Reid (Ngāi Tahu Research Centre, UoC)
Nathaniel Calhoun (Code Innovation)
Kevan Cote (Moose Engineering & Design)
Karen Denyer (Papawera Consulting Ltd)
Saif Khan (GRI, UoC)

Funding:
New Zealand National Science Challenge

Duration of Project:
2022-2024

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”.

Exo-Index long-term vison has been created around three main objectives around Aotearoa NZ National Biodiversity:

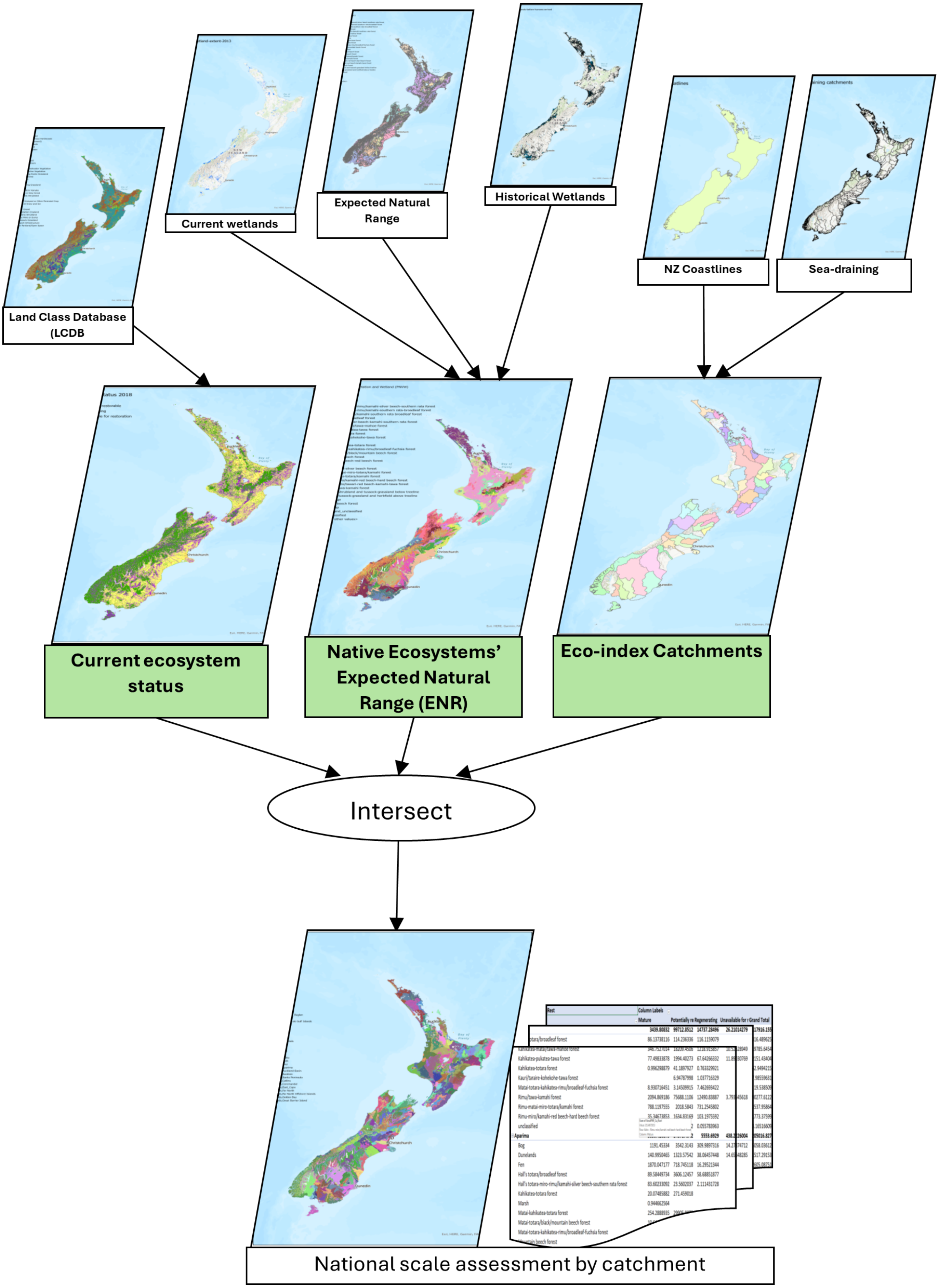
“Protect, restore and connect by 2121’.

- Protect-Tiaki which relates to maintaining current native biodiversity by abating threats.
- Restore - Whakahou a principle that 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.
- Connect- tūhono which means connecting native ecosystems from the mountain to the sea.

The work developed in the GRI has been focused on acquisition, integration and analysis of spatial data as well as the implementation of methods (including machine learning) to achieve the 3 main project’s objectives. Thus, in order to know the current biodiversity status to help planning for future maintenance, the broader Eco-index team, developed an analytical framework.

In this way, we have develop two main outputs: **The Expected Natural Ecosystem Range** (ENR), which encompasses three main data types currently available land cover, native vegetation (potential) and wetland areas , and the **Eco-index catchments layer** which has been develop to calculate the shortfalls to reach 15% of the original native ecosystem types by catchment (see right).

As a digital public good, the reconstruction maps can be visualised via web (https://eco-index.nz/ecosystem-reconstruction-map), and associated geospatial data is available at https://eco-index.koordinates.com/



Geospatial analytical framework for native terrestrial ecosystem reconstruction target mapping through Eco-index programme

Aotearoa, New Zealand wetland (photo provided by Eco-index limited)

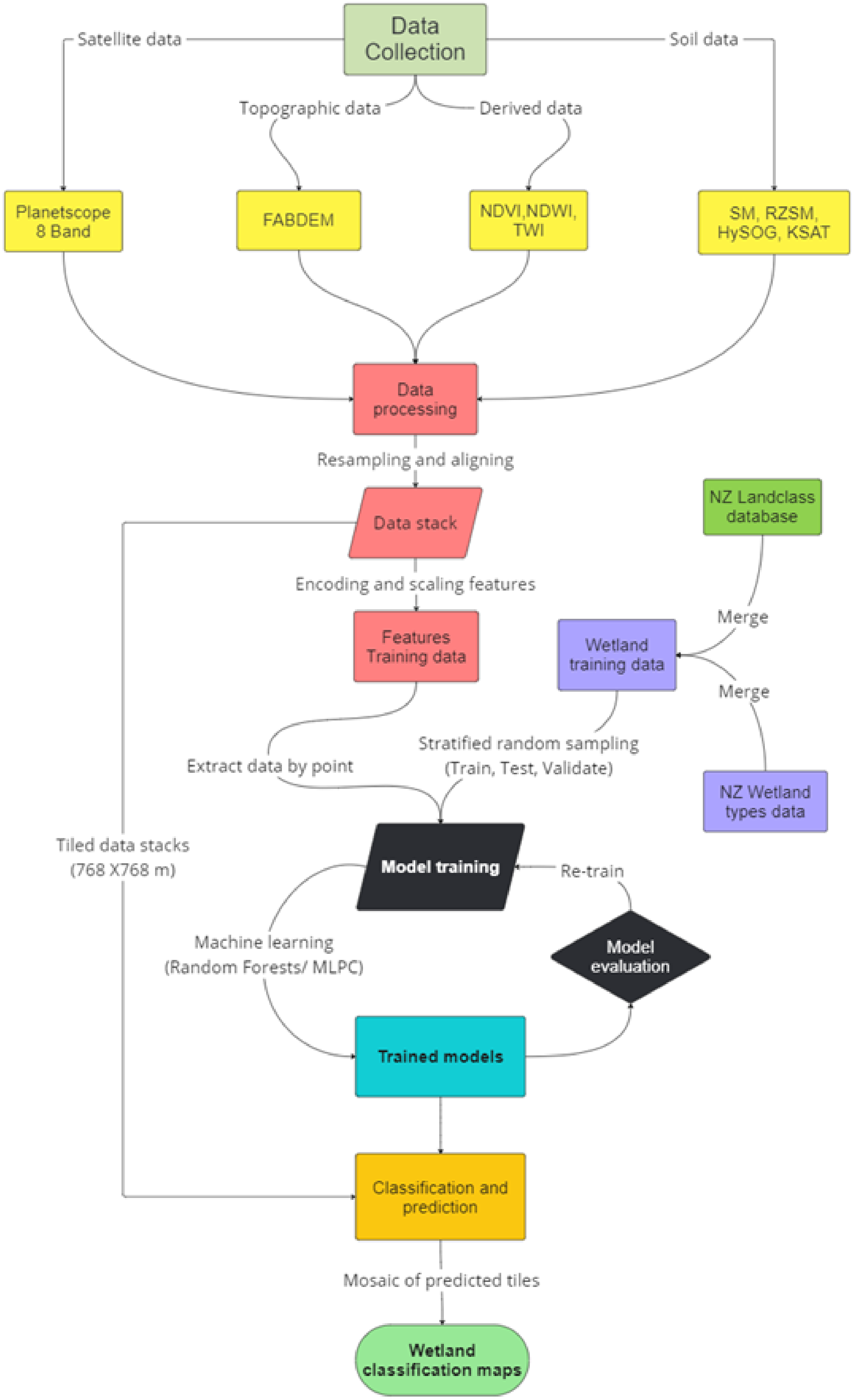
Another main component under development in the Eco-index programme is the **ecosystem detector**.

The Ecosystem Detector algorithm has been developed using remote sensing data i.e. multi-spectral data obtained from different remote sensing sources (e.g. Sentinel and Planet) and bio-physical data (e.g. soil moisture and elevation) together with machine learning. Using these data machine learning algorithms were developed to discriminate signatures for prioritised native ecosystems and vegetated wetlands.

A model for detecting eight Aotearoa wetland types has already been developed and is undergoing evaluation via ground-truth data available from different sources, including regional councils and crown research institutes.

Together with ongoing projects being developed by the GRI team, such as 'Rongowai' and large scale LiDAR data procession, there is highly technical capability to continuo developing cutting-edge research in this area.

A GRI goal is to develop an 'environmental digital twin' to facilitate data-informed decision-making for managers and policymakers in biodiversity space under different management and climate change scenarios.



Process diagram of machine learning-based ecosystem detection model development using satellite images

Using machine learning to estimate soil moisture from GNSS-Reflectometry

Research Team:

Matthew Wilson (GRI– UoC)
Rajasweta Datta (GRI-UoC)
Sharmila Savarimuthu (GRI-UoC)

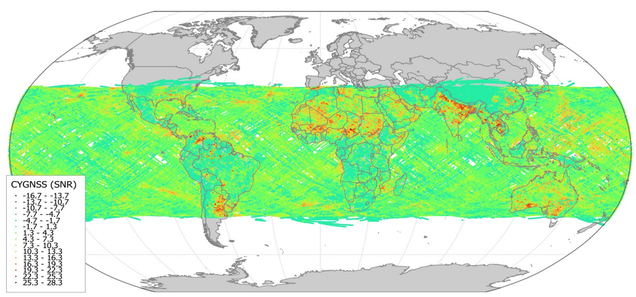
Funding:
MBIE Catalyst programme.

Soil moisture is an important controlling factor in vegetation health and is a significant component of catchment hydrology. Regular soil moisture monitoring across agricultural areas helps to quantify irrigation and check for signs of crop distress, for example using gauges which are part of the International Soil Moisture Network (ISMN). However, gauges provide point-based measurements of soil moisture and there are large gaps in coverage.

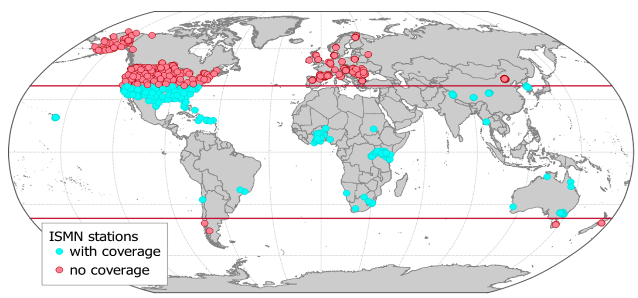
Remote sensing is able to provide estimates of soil moisture to address this issue, and the use of microwave frequencies have shown excellent potential since they are not subject to cloud cover, and have found to be sensitive to soil dielectric properties. Sensors such as NASA's Soil Moisture Active Passive (SMAP) and ESA's Soil Moisture Ocean Salinity (SMOS) provide accurate soil moisture estimates, but at coarse spatial (around 40 km) and temporal (2-3 days) resolutions. As an alternative, the Cyclone Global Navigation Satellite System (CYGNSS) is a constellation of eight microsatellites which have sensors for recording reflections of signals from the Global Navigation Satellite System (GNSS). These signals have been found to be sensitive to geophysical parameters over land surfaces, and studies have used them for the detection of inland water, inundation mapping and soil moisture estimates.

Motivated by the development of algorithms for the Rongowai mission, we developed a random forest model to predict soil moisture at the field scale (~1 km), combining 6.5 years of CYGNSS GNSS-Reflectometry data with observations from 1049 ISMN and several relevant predictor variables (see right). After bias correction, the model was able to predict soil moisture to within 0.048 mm/mm ($R2 = 0.82$).

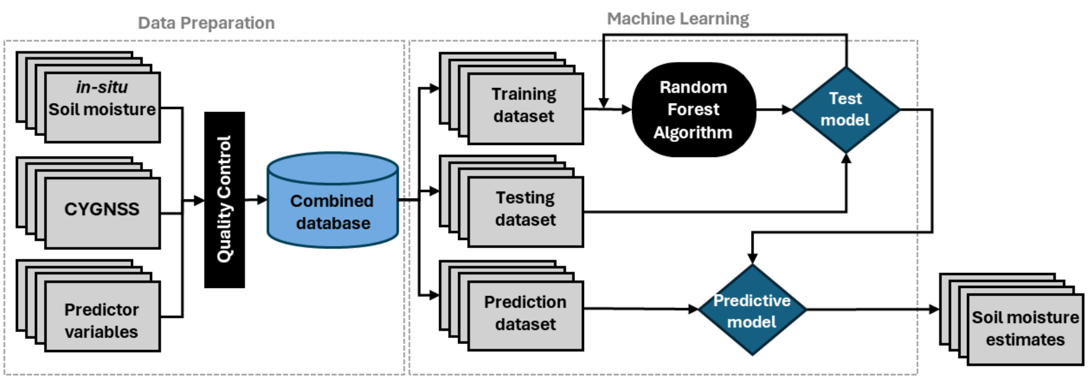
Results will be presented at the 2024 International Geoscience and Remote Sensing Symposium in Athens.



One day of observations from the eight CYGNSS micro-satellites.

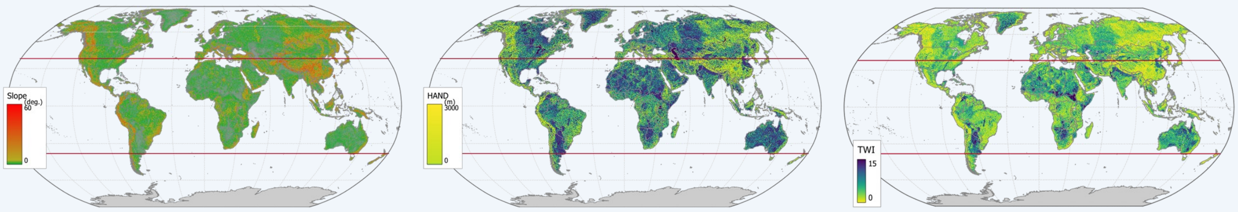


Soil moisture gauges from the International Soil Moisture Network.

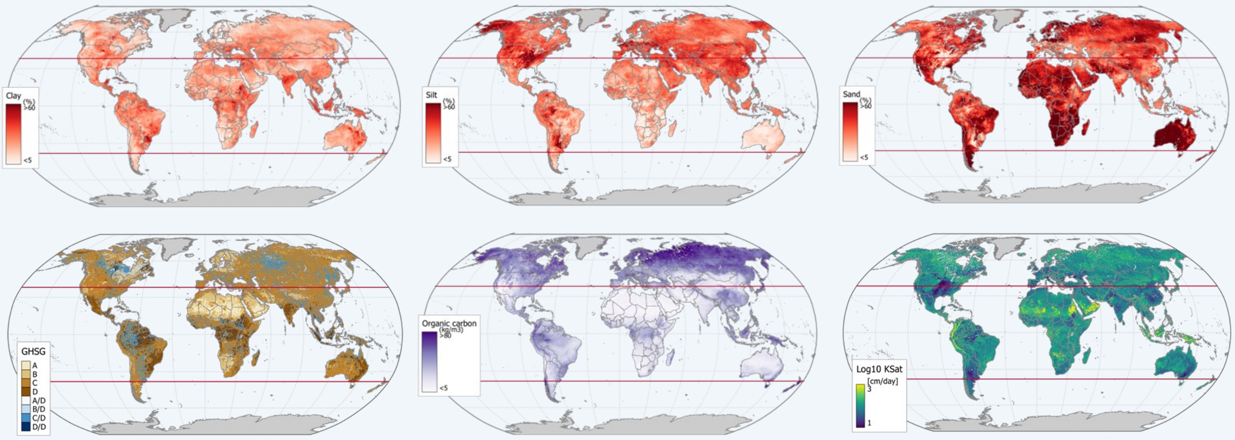


The data processing and machine learning estimation framework developed.

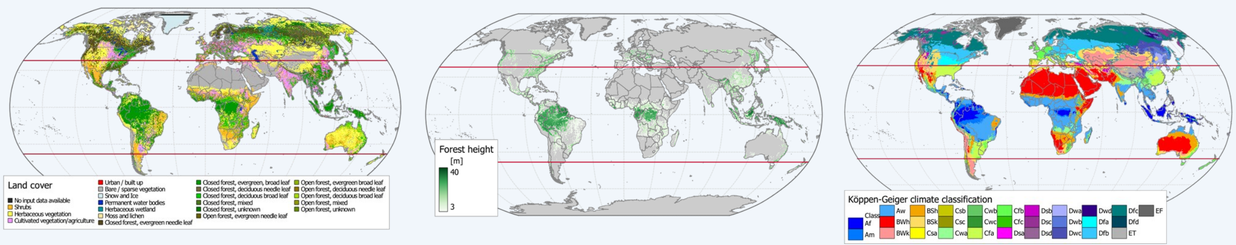
Topography: (left to right) Slope, height above nearest drainage and topographic wetness index:



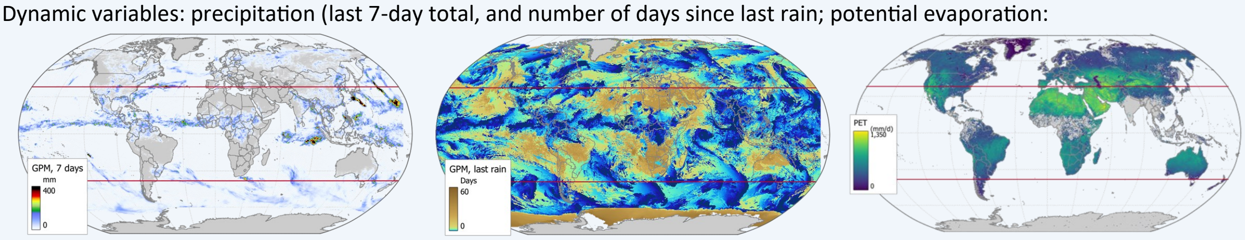
Soil information: minerology (top row), drainage class, carbon and saturated hydraulic conductivity (bottom row):



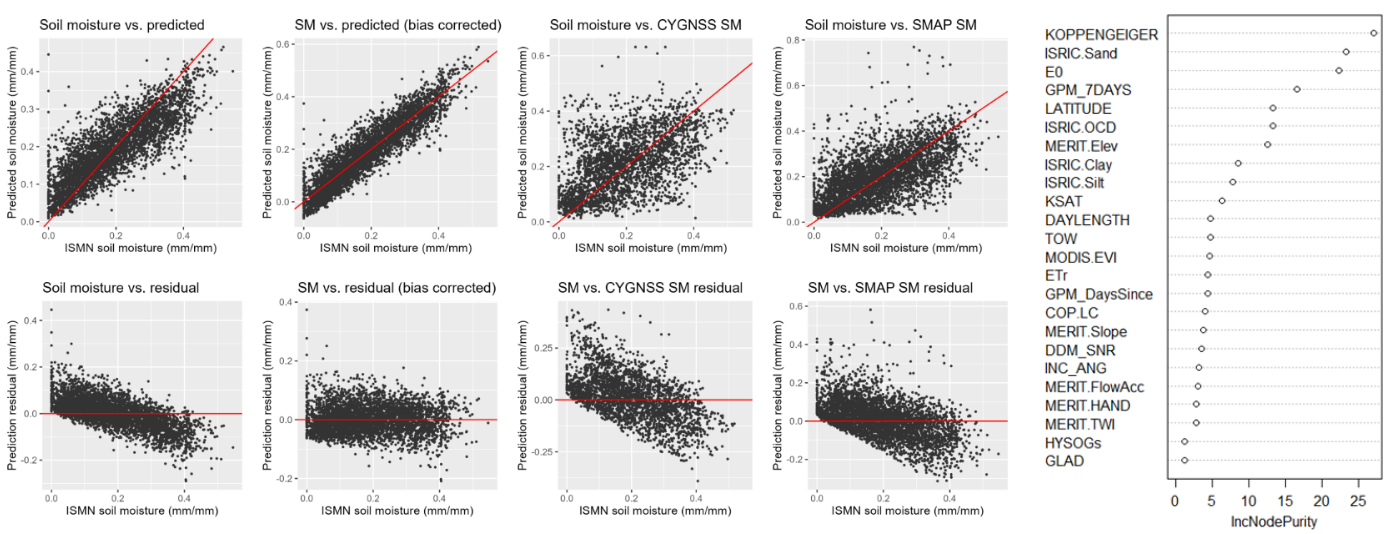
Land cover, forest heights and climatic zones:



Dynamic variables: precipitation (last 7-day total, and number of days since last rain; potential evaporation:



Examples of predictor variables developed
for use in the machine learning model.



Results from Random Forest prediction of soil moisture (left), and the importance of each predictor variable used (right).

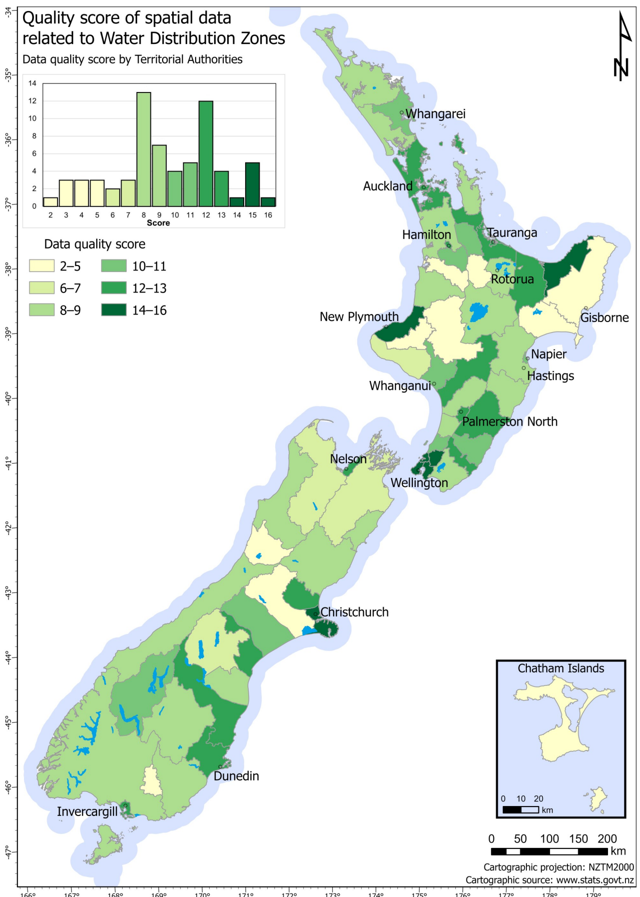
Ongoing Research

Nationwide geospatial study of water fluoridation

Research Team:
Dr. Matthew Hobbs (SoH - UoC)
Dr. Lukáš Marek (GRI GeoHealth Lab - UoC)
Mario Puente Sierra (GRI GeoHealth Lab - UoC)
Dr. Tim Chambers (Ngāi Tahu Research Centre - UoC)

Funding
Ministry of Health Oral Health Research Fund 2022

Duration of the Project
2024-2023 **(**1.5 years)

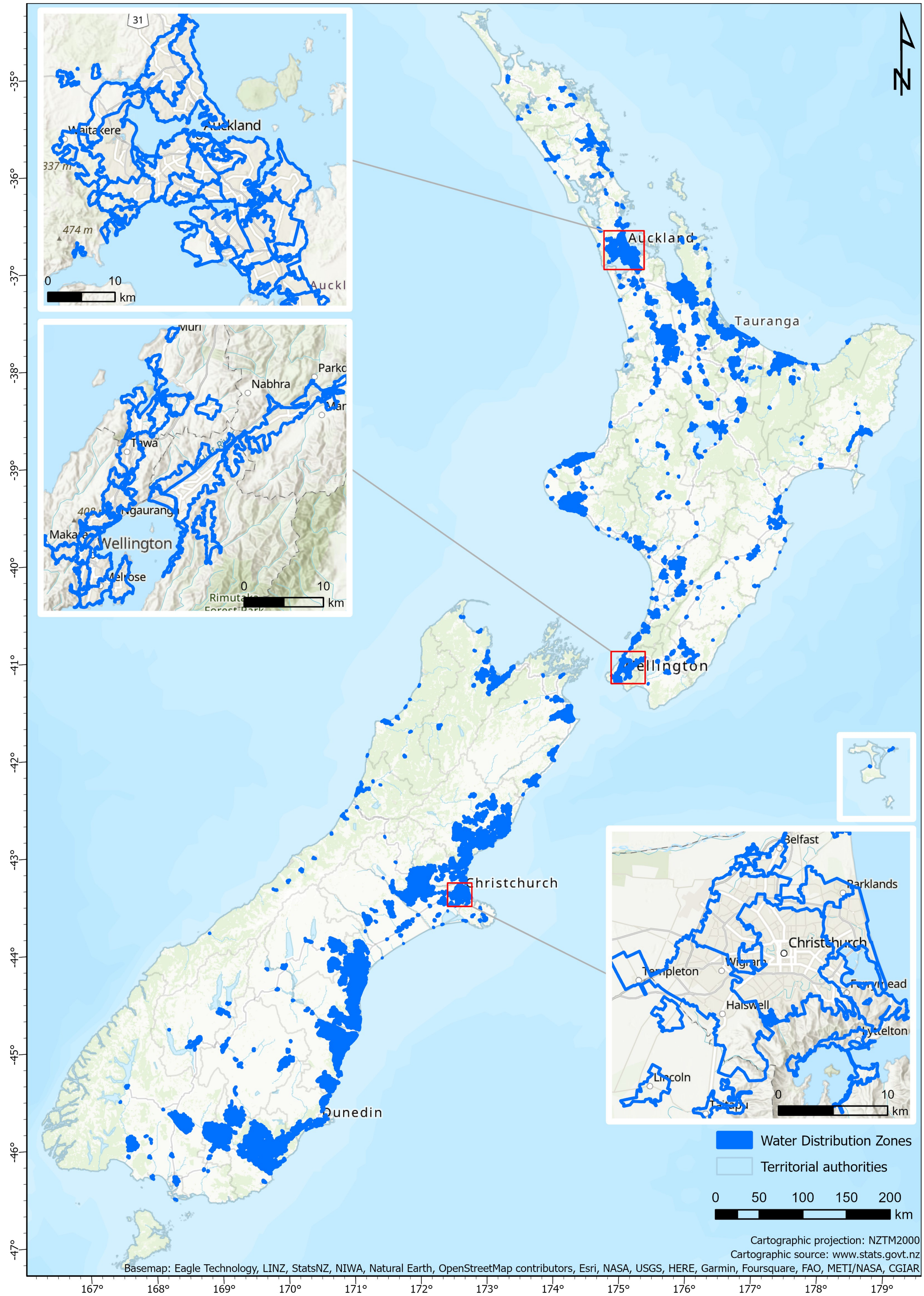


National map of data access and quality scores for spatial data related to drinking Water Distribution Zones

Project Summary:

Community water fluoridation (CWF) is a proven way to prevent tooth decay. The decision to fluoridate in New Zealand has been left to the discretion of drinking-water suppliers such as local authorities, leading to differences between communities. A recent law change now allows for a nationally consistent approach. However, there's no nationwide spatial dataset of water distribution zones (WDZ) and, therefore, fluoride levels in drinking water can't be mapped or spatially studied.

Our aims are to create this dataset, delineate fluoride levels in every supply, assess compliance with recommended fluoride levels, and see if there are inequities in both fluoridation access and compliance based on ethnicity and deprivation. While doing so, we will also examine inequities in the quality of geospatial data of public drinking WDZ across all territorial authorities in New Zealand. This data will help future studies to associate epidemiologic outcomes to public water, improve oral health policies, and ensure water suppliers provide the right fluoride levels for good oral health.



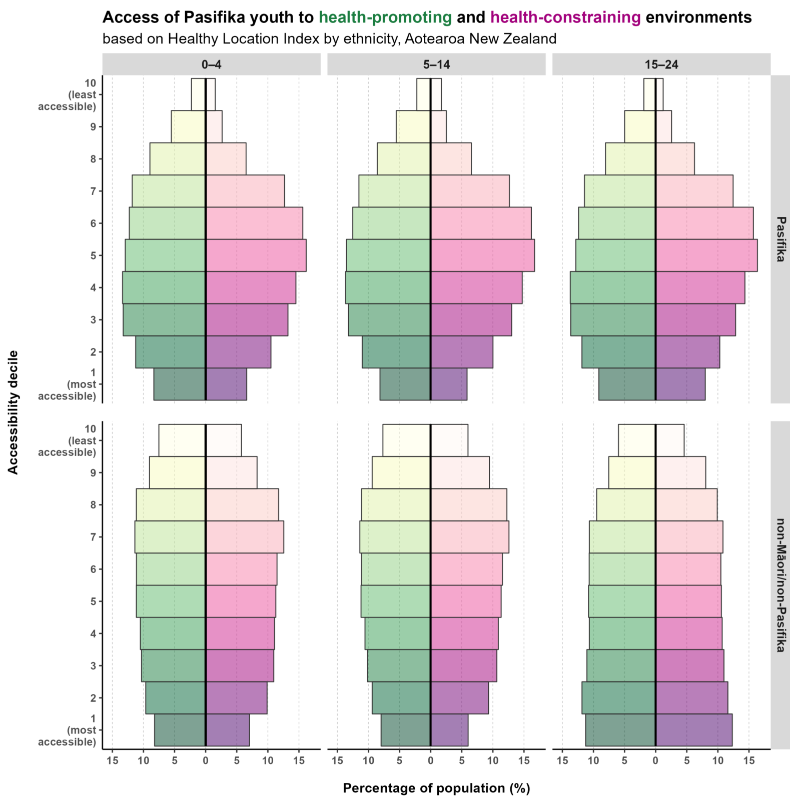
Distribution of Water Distribution Zones across Aotearoa New Zealand with insets for the three major urban areas of Auckland, Wellington and Christchurch

Do the environment young people grow up in promote or obstruct mental health? A nationwide geospatial study

Research team
Lukáš Marek (GRI, - UoC)
Matthew Hobbs (FoH - UoC)
Jesse Wiki (GRI GeoHealth Lab - UoC)

Funding
Cure Kids

Duration
2022-2024



Project summary

Mental health is one of the biggest health challenges facing New Zealand. One in four NZ young people will experience a mental health issue before they turn 18 years old. Inequities in mental health issues and care are persistent and worsening, with Māori and Pasifika over-represented.

The determinants of mental health are multiple and complex, and increasingly the influence of the environment in which young people grow up is the subject of research to better understand mental health.

This study aims to understand the interplay between mental health and the environments in which NZ young people grow up. More specifically, it seeks to determine whether young people have better mental health if they grow up in areas with more ready access to healthy environmental features such as green and blue spaces (e.g. parks and rivers), compared to unhealthy environmental features such as gaming venues, takeaway shops, and liquor outlets.

The study also aims to empower communities to advocate for change (e.g. support positions concerning liquor licence submissions and preservation of natural spaces), inform policy processes and interventions to improve health-enhancing environments, and inform subsequent research to develop culturally specific environmental measures to reflect health-enhancing environments for Māori and Pasifika.

The diverse and dynamic group of researchers undertaking this research has wide-ranging relationships with policy makers, health providers, and community groups that will be crucial to ensure the research has its intended impact of improving the mental health of young people in New Zealand.

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

Research team
Phoebe Eggleton (PhD Candidate)
Malcolm Campbell (Main supervisor - UoC)
Matt Hobbs (Secondary supervisor - UoC)
Joseph Boden (Supervisor - Christchurch Health and Development Study)

Funding
UC Aho Hīnātore | UC Accelerator Scholarship

Duration
2022-2024

Project summary

The Canterbury (NZ) Earthquake Sequence (2010—2011) is made up of four major earthquakes. This project investigates how a birth cohort were exposed to this event.

The Christchurch Health and Development Study follows the health, education and life progress of 1,265 children born in the Christchurch urban region in 1977. Within the cohort, approximately one third were exposed to at least one of the four major earthquakes.

In this research project spatial data of cohort members location at the time of the event have been used to better define 'exposure' to disaster. In addition, health outcomes such as cardiovascular disease will be investigated in relation to the cohorts type of exposure.

Breaking through the cloud: Vaping in Aotearoa New Zealand

Research Team

Isaac Waterman (GeoHealth Lab intern - UoC)
Lukáš Marek (GRI - UoC)
Annabel Ahuriri-Driscoll (FoH - UoC)
Jalal Mohammed (FoH - UoC)
Michael Epton (FoH - UoC)
Matt Hobbs (FoH - UoC)

Funding
HRC Emerging Researcher

Duration
2023-2024

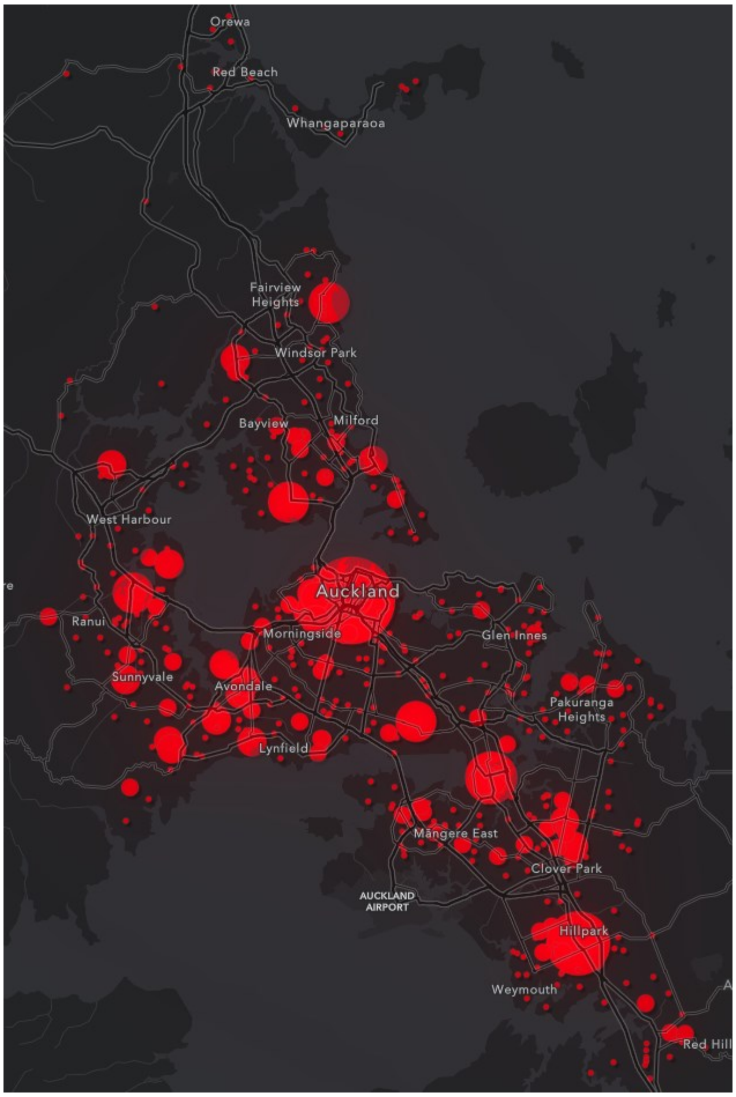
Project summary

Vaping is a relatively new phenomenon that was initially hailed as a promising alternative to smoking. However, the number of non-smokers who have started vaping is increasing. A recent study found that 1.1 million New Zealanders have tried vaping which is about 27% of the population. Another study found that 26% of students had vaped in the past week.

We wanted to understand the spatial distribution of vape stores in Aotearoa New Zealand; where the stores are and how they change over time. We used the Specialist Vape Retailer register to find the addresses of all of the vape stores in New Zealand. We then used the New Zealand Deprivation Index to see if there is a link between the location of vape stores and area-level deprivation. Using census data, we were also able to look at the demographics of people around vape stores. Finally, we wanted to understand how accessible vape stores are to young people by analysing how many vape stores are around schools.

The interactive map can be visited here:

https://tinyurl.com/vapingnz



Number of vape stores around schools in Auckland. The size of the dot represents the number of vape stores within 400m of the school.

Socioeconomic determinants of Abdominal Aortic Aneurysm Mortality

PhD student:
Andrew Kindon (GeoHealth Lab)

Research team:

Matthew Hobbs (FoH - UoC)
Simon Kingham (GRI - UoC)
Justin Roake (UoO)

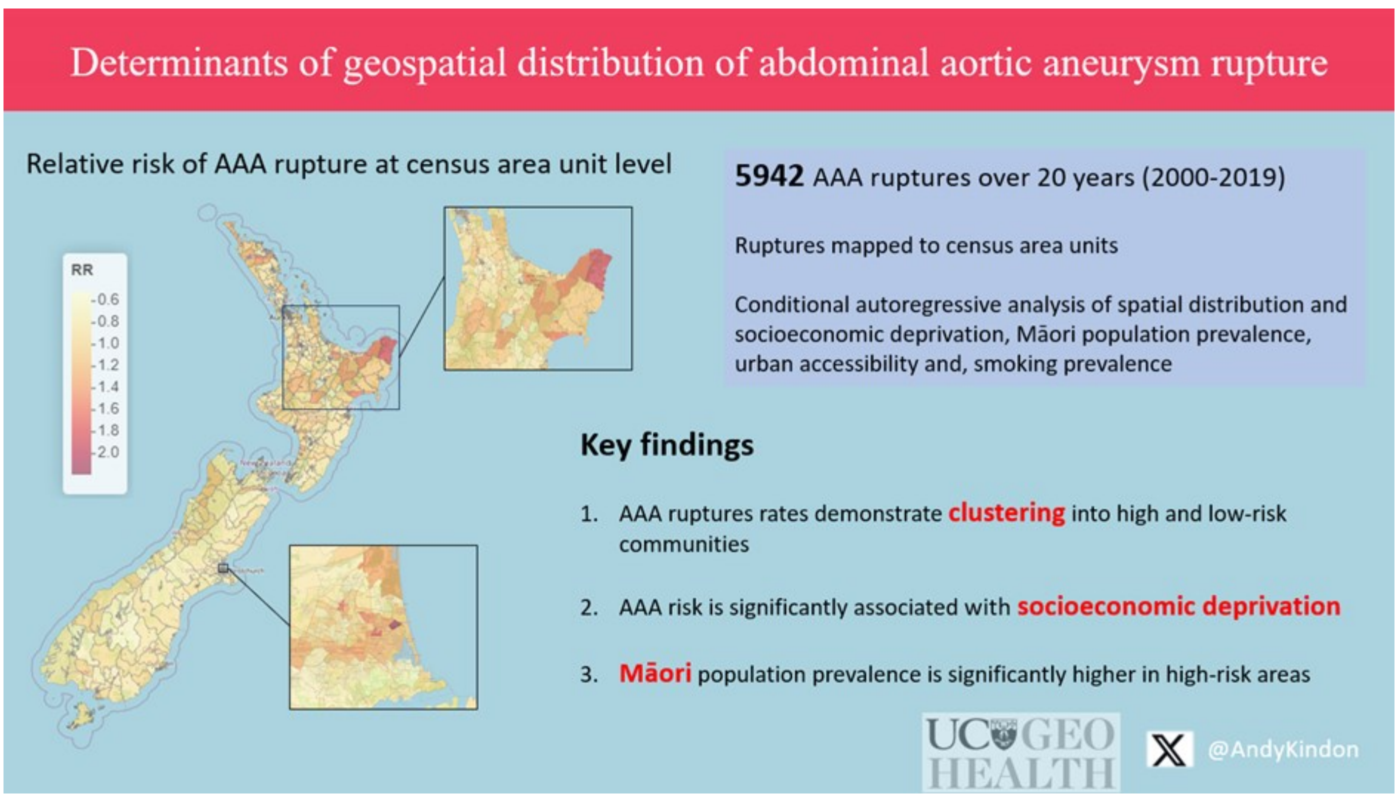
Funding
HRC clinical research training fellowship

Project Summary:

This research uses geospatial technology to spatially identify areas across New Zealand that have excess risk of Abdominal Aortic Aneurysm (AAA) death in New Zealand, and the associated environmental risk factors, including socioeconomic deprivation, accessibility to health services and ethnicity; These factors are known to influence cardiovascular health outcomes but seldom considered in AAA research.

The findings of this research will inform resource allocation in AAA screening. International evidence suggests that communities at high risk of AAA death are also likely to be communities that endure inequitable access to health services (rural, Māori, deprived).

The result obtained from this research could be used to guide future policies related to ensure equitable access to AAA screening.

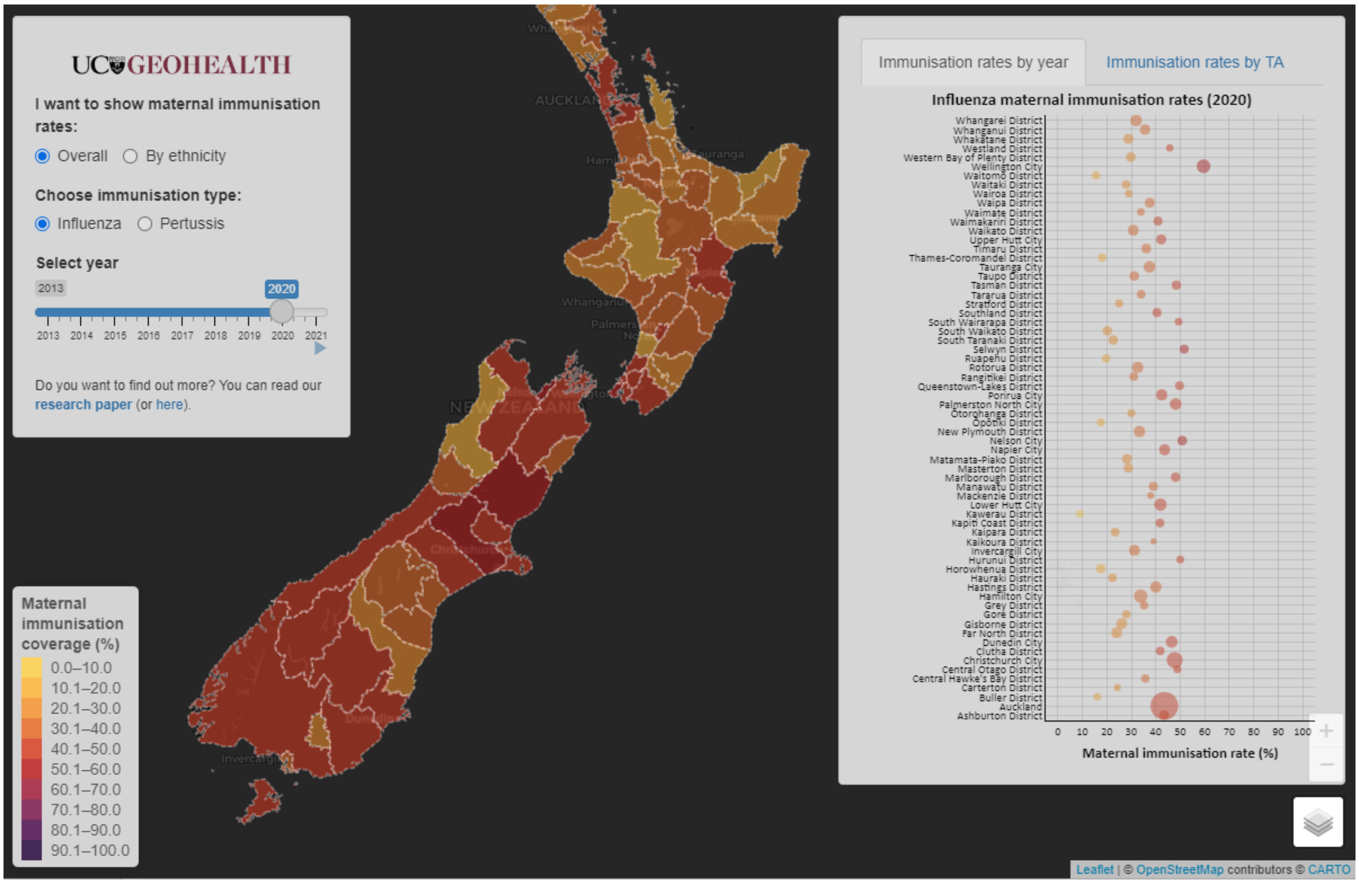


Generating evidence to improve uptake and equity in maternal immunisation

Research Team
Matt Hobbs (FoH - UoC)
Lukáš Marek (GRI GeoHealth Lab - UoC)
Peter McIntyre (UoC)
Pauline Dawson (UoO)
Amber Young (UoO)
Esther Willing (UoO)

Funding
HRC Activation Grant

Duration
2023



Project summary

Immunisation during pregnancy is a safe and effective way of protecting women and their babies against harmful diseases, both during and after pregnancy, however, low maternal immunisation coverage represents a significant public health challenge for Aotearoa/New Zealand. Moreover, inequities exist, with Māori and Pacific women around half as likely to have received maternal pertussis vaccination compared to New Zealand European/ 'Other' women. In addition, while geographical variation in maternal immunisation coverage may exist, this has seldom been explored. Researchers and front-line practitioners in midwifery, pharmacy and immunisation/infectious diseases would like to work together to understand regional differences in maternal immunisation coverage. We will map coverage across New Zealand and develop an interactive web application to visualise maternal immunisation coverage for immunisation policymakers. This project represents the first steps towards reducing inequity and to support finding solutions to low regional levels of maternal immunisation coverage across New Zealand, especially for, and with, Māori wāhine.

Cumulative impacts of air pollution exposure on adult physical and mental health

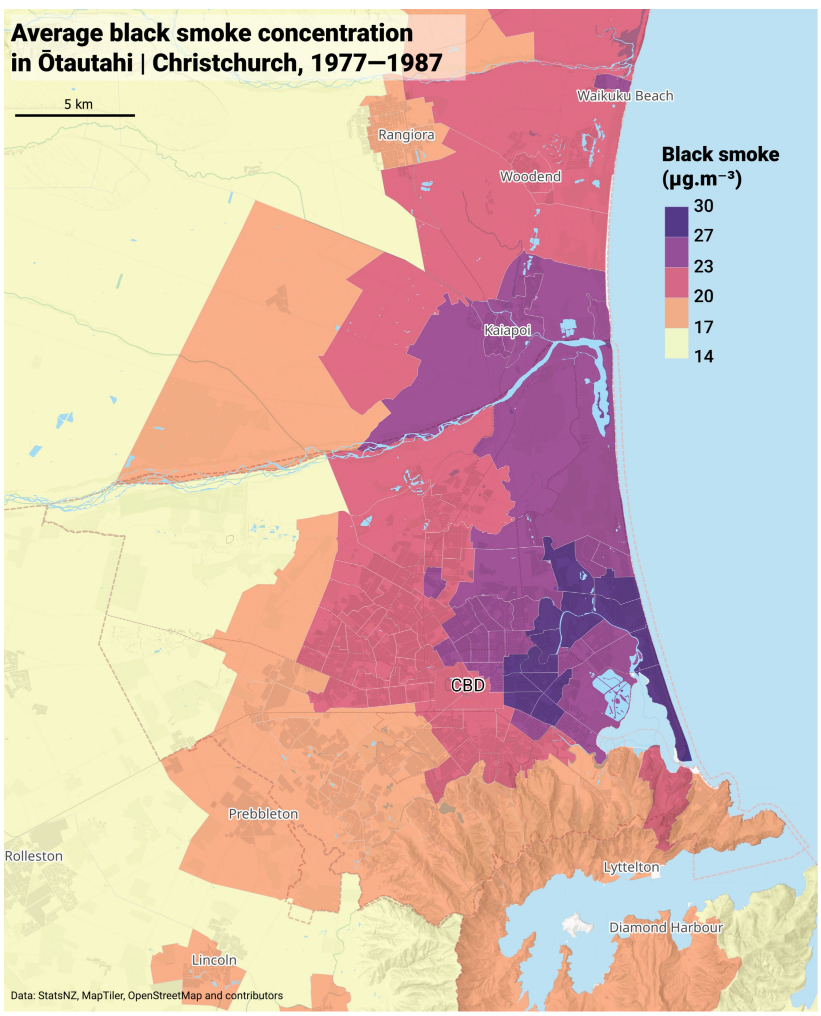
Research Team
Matt Hobbs (FoH - UoC)
Joseph Boden (UoO)
Lianne Woodward (UoC)
Annabel Ahuriri-Driscoll (UoC)

Funding
HRC Emerging Researcher First Grant

Duration
2023-2024

Project summary

Air pollution is recognised as a cause of morbidity but its longer-term and cumulative effects on health are less established. In New Zealand, persistent health inequities exist for Māori who are exposed to poorer environments than non-Māori. Using prospective longitudinal data from a large birth cohort of New Zealanders (n=1,265) we will examine relations between the extent of air pollution exposure from conception to age 40 years and a range of physical (e.g. respiratory disease) and mental health (e.g. depression) and socioeconomic (e.g. education) outcomes. We hypothesise that higher levels of exposure will be associated with poorer outcomes. Exposure is assessed at: conception (1975/76); early-childhood (1981/82); early-adulthood (2001 and 2006); and mid-adulthood (2016). This research advances scientific and public health understanding of the health and socioeconomic impacts of air pollution exposure over the lifecourse. It will also inform cross-sectoral policies on the environmental determinants of health and historical causes of inequity.



Population mobility patterns

Research team
Lukáš Marek (GRI GeoHealth Lab - UoC)
Samuel Hills (Bournemouth University (UK))
Jesse Wiki (GRI GeoHealth Lab - UoC)
Matt Hobbs (GRI GeoHealth Lab - UoC)
Malcolm Campbell (GRI GeoHealth Lab - UoC)

Funding
GeoHealth Laboratory/GRI

Duration
2023

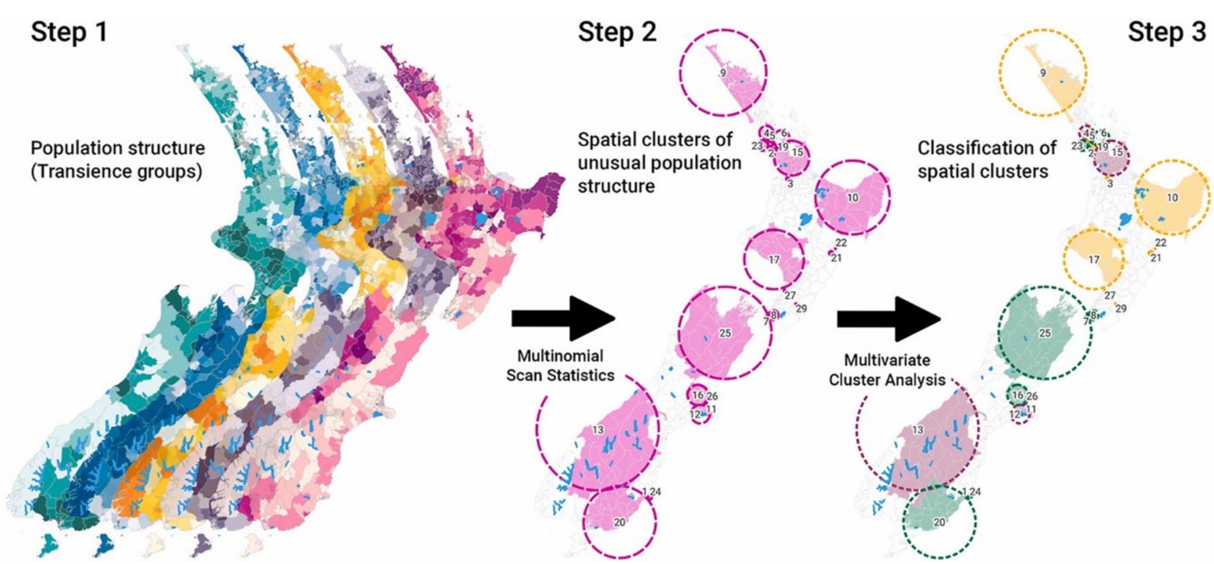
Project Summary

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. The impact of chronic disease of elders on the wider family and whānau

Research team
Lukáš Marek (GRI GeoHealth Lab - UoC)
Simon Kingham (GRI GeoHealth Lab - UoC)

Funding
A Better Start - National Science Challenge

Duration
2022-2024

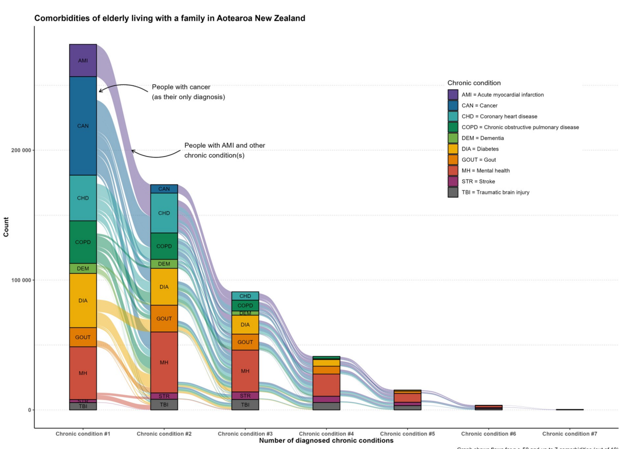
Project summary

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.

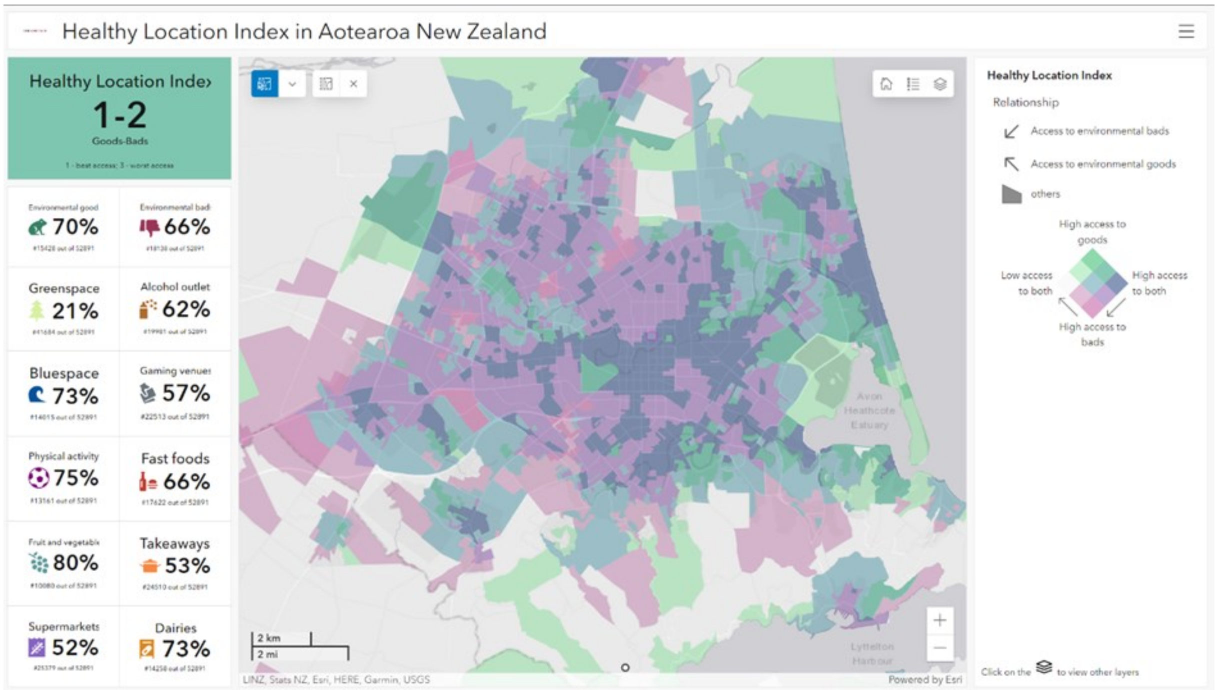
To answer the research questions, we will use mostly administrative data from the Integrated Data Infrastructure (IDI) that is a longitudinal dataset which holds linked individual and household level microdata from a range of Government agencies (e.g. housing, health, policing), Stats NZ surveys, and 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.



Healthy Location Index

Research Team
Lukáš Marek (GRI GeoHealth Lab - UoC)
Matthew Hobbs (GRI GeoHealth Lab - UoC)
Jesse Wiki (GRI GeoHealth Lab - UoC)
Malcolm Campbell (GRI GeoHealth Lab - UoC)
Simon Kingham (GRI GeoHealth Lab - UoC)

Duration
Ongoing from 2021



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.

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, (v) and 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.

The index, that is 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.

Te Kete Kōrero o Ōhinemutu: The story of a cultural mapping tool

Research Team
Dean Walker (GRI - UoC)
Rita Dionisio (GRI - UoW)
Luke Parkinson (GRI - UoC)

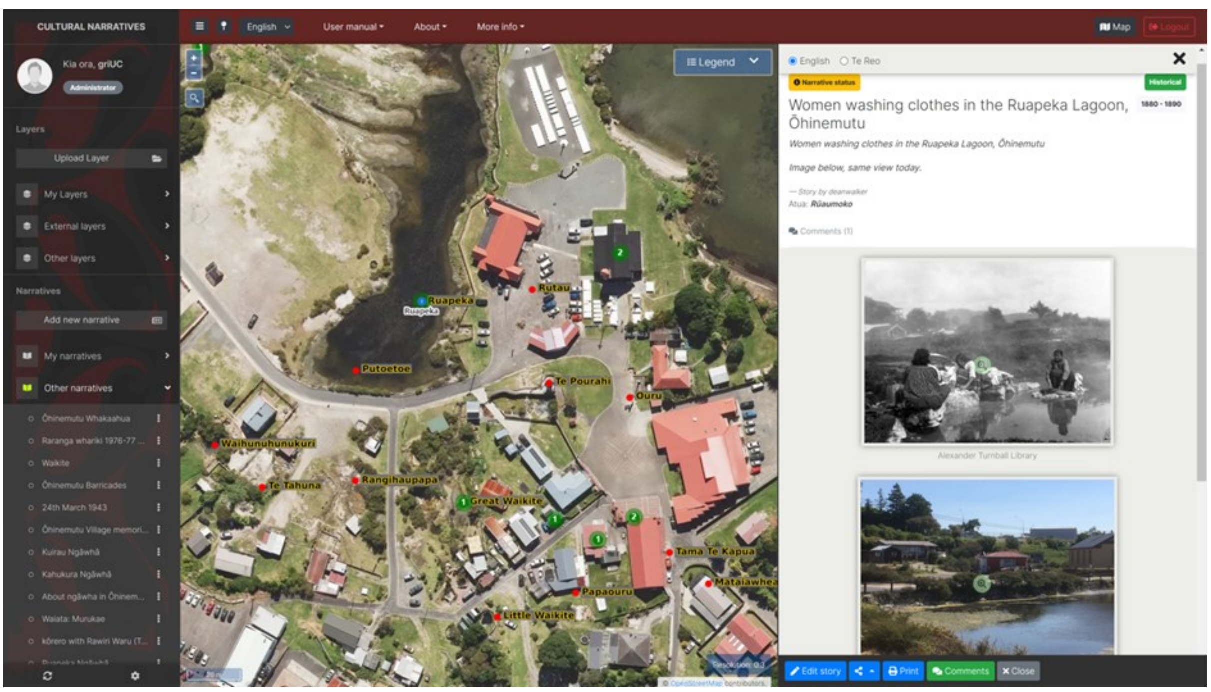
Duration
2016-2023
Continuation of Map-based tools for Community and Rūnanga-led sustainable town planning, in small and medium settlements in New Zealand

Project Summary:

Te Kete Kōrero o Ōhinemutu is a map-based web tool built for the people of Ōhinemutu to preserve personal narratives and histories. The tool allows people to upload scanned documents, photos, videos, audio recordings, and written accounts. The tool links these narratives with places to help draw connections for current and future generations. Community members can keep these narratives private to themselves, share them within their immediate whanau, or share wider through various degrees of privacy groups. Information stored in the tool remains private by default but can be shared with the wider Ōhinemutu community if desired. It can be used to collate specific scientific data around important features such as ngāwhā, or can be used to store letters with historical and sentimental value to whanau. We built this tool to preserve mātauranga within the community, and allow the people of Ōhinemutu to collate their own information, for preservation, and conservation, and to enable community planning and projects.

The underlying code for the tool is open-source, so it can be adapted for different use cases and can be reused for other similar projects by anyone. This allows other communities to build their own map-based tools to place private community data. It also allows the Ōhinemutu community to lead development in adapting the current tool for any future needs.

In 2023, we moved from active development to handing the tool over to the community, ready to be used.



Place-based web tool: Te Kete Kōrero o Ōhinemutu

Data processing for the Flood Resilience Digital Twin

Research Team
Casey Li (UoC)
Luke Parkinson (GRI- UoC)
Xander Cai (GRI - UoC)
Matthew Wilson GRI - UoC)
Pooja Kholsa (GRI - UoC)
Greg Preston (UoC)
Rose Pearson (NIWA)
Rob Deakin (LINZ)
Emily Lane (NIWA)
Cyprien Bosserelle (NIWA)

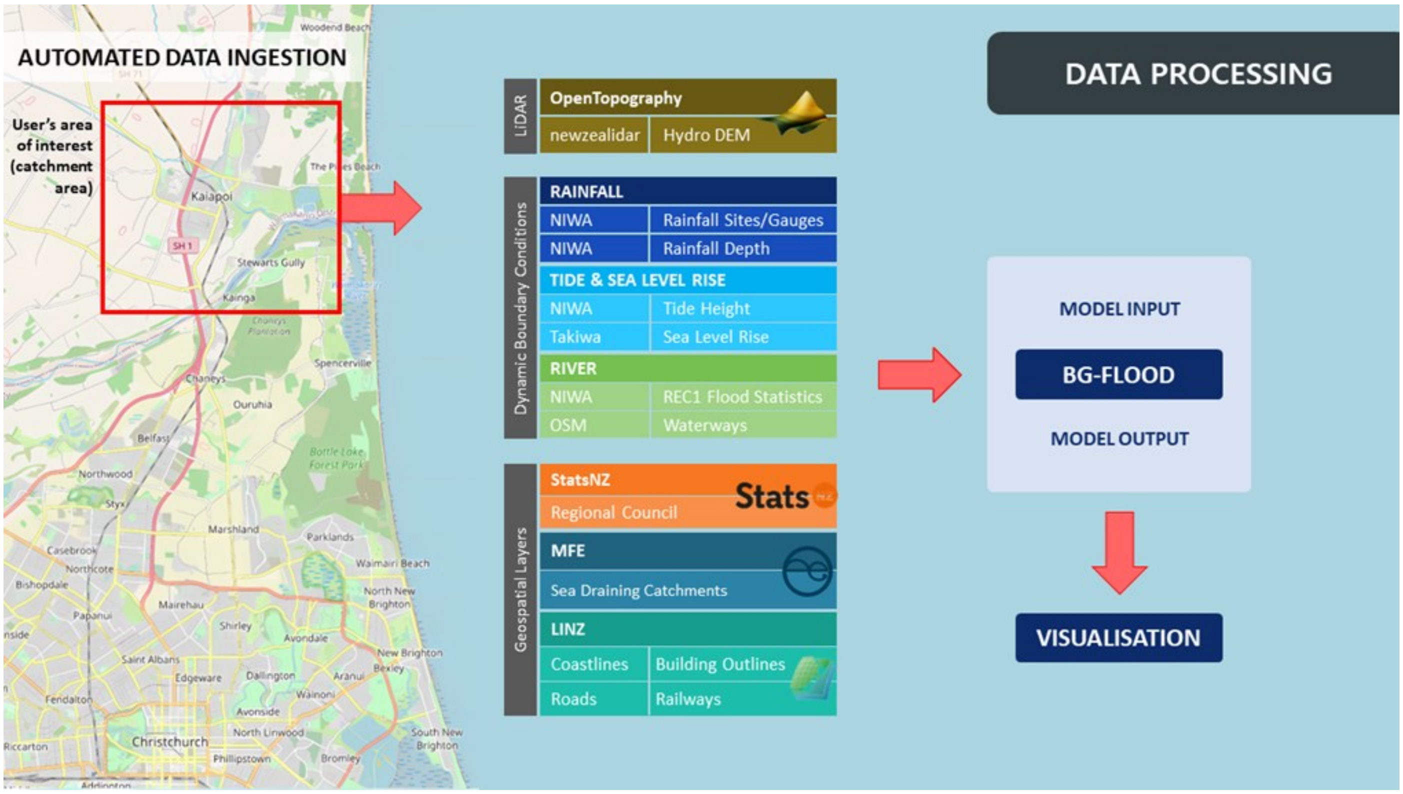
Funding
FrontierSI and
Building Innovation Partnership

Duration
2021-2023

Project Summary

The principle aim of the flood resilience digital twin is to improve and facilitate flood risk assessment and emergency management through automation. This entails the automation of data ingestion, processing, and analysis, enabling the rapid evaluation of multiple scenarios with updated information, and ultimately making the assessment more efficient and cost-effective.

A design principle for the digital twin was that, for a selected area, data not already present in the database would be retrieved from their respective agencies and added to the local database without any modifications. This approach is adopted to circumvent the transmission of multiple repetitive GET requests and expedite data processing. After that, data are further processed within the digital twin to produce standardized model inputs consumable by BG-Flood, which is NIWA's flood modelling tool. These model inputs are then used to run the BG-Flood model to produce model output, which is subsequently incorporated back into the digital twin for further analysis.



As shown in the figure above, a substantial amount of spatial data is required, sourced from various agencies in diverse formats, and often varying in quality. A key input for a flood model is high-resolution topography. The digital twin will acquire LiDAR point cloud data for the area of interest (AOI) from OpenTopography, then automatically process this data to generate a hydrologically conditioned digital elevation model for use in the BG-Flood model.

For rainfall, depth-duration-frequency statistics for rain gauges across the country under different climate change scenarios, obtained from NIWA's High Intensity Rainfall Design System, are used. The digital twin uses the Thiessen polygon method to determine the coverage area of each gauge. When a user selects an AOI, its extent is intersected with these polygons, and the necessary data for each gauge within the AOI for the requested scenario is retrieved from HIRDS. A hyetograph is created for each of these gauges and combined to produce the rainfall model input for BG-Flood.

For tide, if the AOI is within 1km of the coastline, the annual king tide for the year is obtained from NIWA's Tide Forecaster for the nearest available location. Since this data lacks sea level observations, the digital twin subsequently retrieves sea level rise data from Takiwa's NZSeaRise project. This enables the incorporation of varying sea levels on top of the tide level, addressing a key limitation.

For river flow, data from NIWA's River Environment Classification (REC), version 1 is used. This dataset provides flood level estimates for different annual exceedance probabilities, for river vector data across the country. However, their locations often do not precisely align with the rivers in the LiDAR data. To improve accuracy, the river vectors that serve as inflows into the AOI are aligned with waterway data obtained from OpenStreetMap, then the LiDAR elevation data are used to search the local neighbourhood for the correct location of the river entry point into the AOI. After that, hydrographs are generated for river inflow vectors into the AOI, creating the necessary inputs for BG-Flood. Finally, after running the BG-Flood model, the model output, in conjunction with infrastructure data like building outlines, are used to determine the buildings that are flooded, the depth of the flooding, and obtain statistics on this.

Flood Resilience Digital Twin preparations for initial release

Research team
Luke Parkinson (GRI - UoC)
Prasanna Venkataramanan (UoC)
Haritha Parthiban (UoC)
Julian Maranan (UoC)

Funding
FrontierSI and
Building Innovation Partnership

Duration
2021-2023

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

Project Summary:

As the Flood Resilience Digital Twin neared its initial release in 2023, work was focused on ensuring the code could be deployed with stability. Luke Parkinson worked to develop Docker configurations and application architecture that could scale well and perform reliably. He also developed additional visualisations for the web front- end, building out the geo-visualisation-components library built on Cesium, intended for general geospatial visualisation in the web.

In 2023, we also began work on the paper for the Journal of Open Source Software, to coincide with the initial release of the digital twin.

Following on from the work on application stability, Master of Data Science students Haritha Parthiban, Julian Maranan, and Prasanna Venkataramana worked on investigating methods of deploying the web app via cloud using Amazon Web Services. Their findings were insightful to lead further work in adapting the Flood Resilience Digital Twin into 2024.

Investigations into Virtual Reality techniques to visualise flood modelling outputs

Research team
Upasna Choudhary (Software Developer intern - GRI)
Luke Parkinson (GRI - UoC)
Matthew Wilson (GRI - UoC
Maria Vega Corredor (GRI - UoC)

Funding
GRI

Duration:
Summer 2023-2024

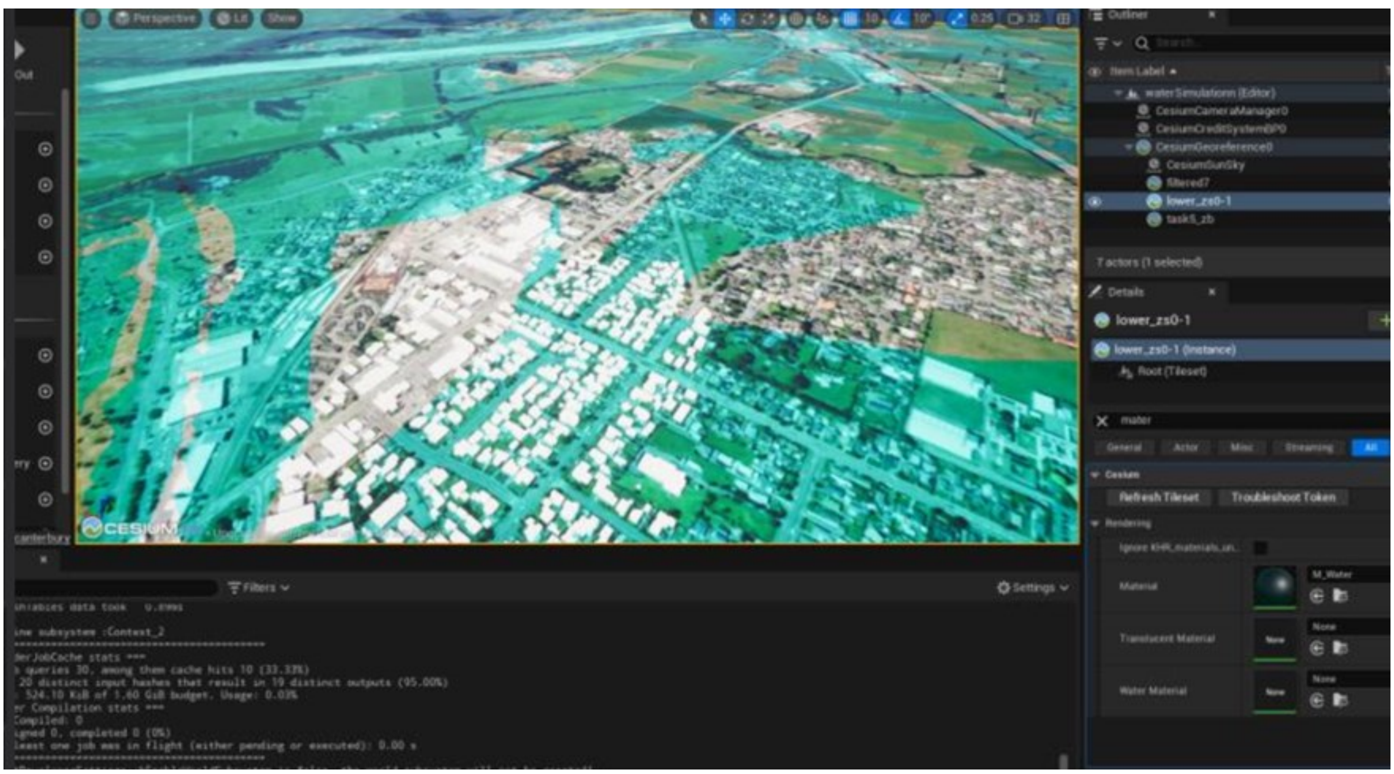
Project Summary:

This project was developed as part of a summer internship program at the GRI. The aim was to investigate and apply methods of visualisation for flood model outputs in realistic virtual reality environments.

Unreal Engine—UE (software ecosystem) and Cesium were used to connect the study area, or area of interest (AOI) to geospatial data. This was followed by the beginning of building a virtual environment.

The final product was a virtual prototype that allowed the visualisation of flood model outputs derived from the Flood Resilience Digital Twin combined with 3D building data derived from LiDAR. More work will be required to improve realistic and dynamic water visualisation as well as including altering flood levels over the timeline of a flood scenario.

The prototype will be later integrated and enhanced in future project developments.



A visualisation of flood model outputs produced with Unreal Engine.

Carbon Neutral Neighbourhoods dashboard development

Project team

Malcolm Campbell (GeoHealth Lab - UoC)
Lindsey Conrow (SEE - UoC)
Tom Logan (Civil and Natural Resources Engineering - UoC)
Simon Kingham (SEE - UoC)

Dashboard development:

Malcolm Campbell (GeoHealth Lab - UoC)
Luke Parkinson (GRI - UoC)
Matthew Wilson (GRI - UoC)

Funding
BRANZ – Funded from the Building Research Levy

Duration:
2023-2024

Summary

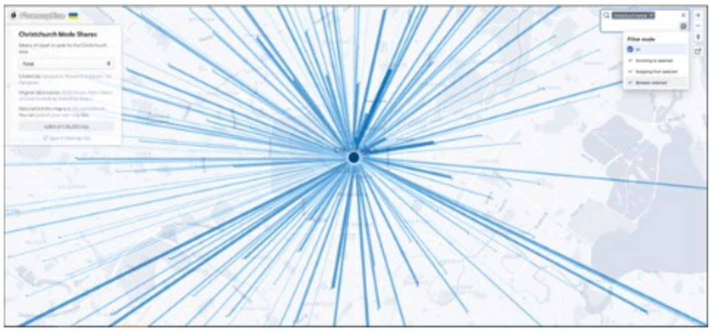
This online mapping tool l was develop with the aim to increase people's understanding of the relationship between urban form and emissions.

The tool allows the visualisation of transport patterns and emissions in some of the main cities of Aotearoa New Zealand, in two ways: the emissions scenarios visualisation and the trend in travel mode. Thus, it can be used to compare how shifts in the fuel type of vehicles may shift the CO2 footprint of an area of interest.

Currently, the data use in the tool is from the 2018 NZ census, and it relates to transport patterns such as active transport, public transport and drive, focused on travel in and out of work. The tool has been designed to be use in a laptop or desktop machine.

More information about the tool is available a at :

https://carbon-neutral.app.geospatial.ac.nz/about



Example of travel trends data visualisation

This web application was developed using GRI geo-visualisation-components including a 3D web visualisation framework based on CesiumJS which was originally developed for the Flood Resilience Digital Twin (GRI) and is being adapted for general use. This is the first GRI-hosted web applications used to visualise geospatial research using GRI products.

In addition, this web app is associated with data derived from the working papers authored by Campbell et al. :

https://dx.doi.org/10.2139/ssrn.4410167.

https://dx.doi.org/10.2139/ssrn.4486347.

Hydrologically conditioned digital terrain models based on LiDAR for New Zealand

Research Team:
Xander Cai (GRI-UoC)
Luke Parkinson (GRI - UoC)
Casey Li (BIP - UoC)
Rose Pearson (NIWA)
Matthew Wilson (GRI - UoC)

Funding
BIP

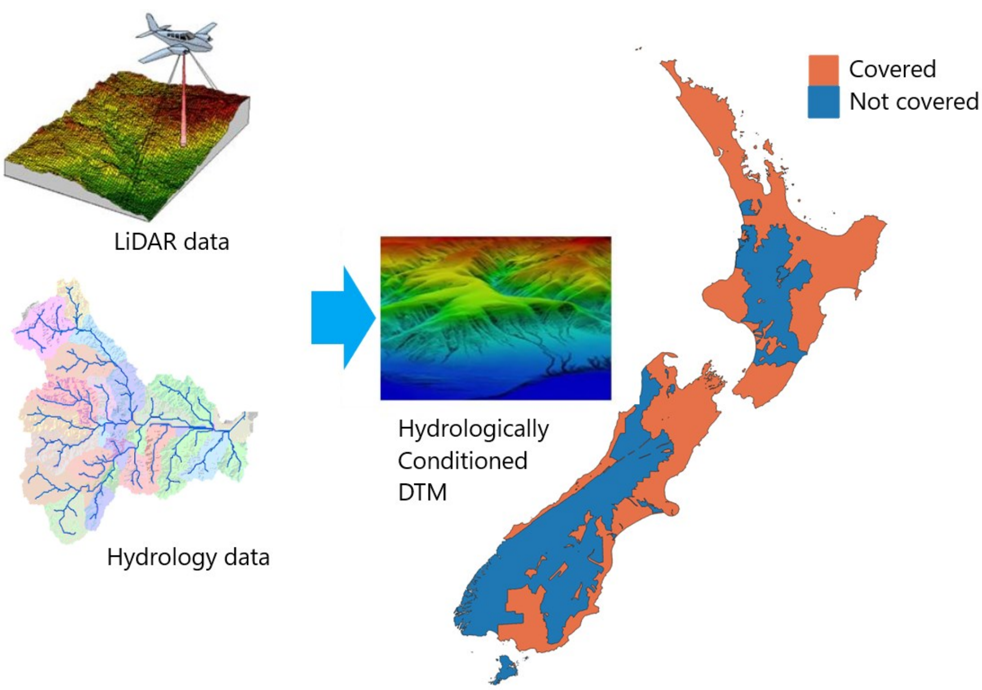
Duration of the Project
2023

Project Summary:

Elevation is the fundamental data in geoscience research and application. The output precision of many GRI projects relies on the accuracy of digital elevation models (DEMs). The NewZeaLiDAR project is an extensive effort to harness the power of Light Detection and Ranging (LiDAR) technology for detailed topographical analysis and hydrology monitoring across New Zealand. It aims to provide researchers, planners, and policymakers with high-resolution and high-accuracy LiDAR-derived hydrologically conditioned bear-ground DEMs through sophisticated data processing, visualisation, and analytical tools. The open-source framework of NewZeaLiDAR encourages community collaboration and continuous improvement, ensuring the project remains current and highly functional.

The project automatically crawls LiDAR datasets in New Zealand's extent from opentopography.org and organises the vast amount of LiDAR data in storage and a database hosted on servers. It leverages the sea-draining catchment dataset from the Ministry for the Environment and other hydrological datasets to calculate and transform geospatial and hydrological data to hydrologically conditioned DEMs. A nationwide hydrologically conditioned DEM dataset is presented by conducting the processing pipeline on all the regions covered by LiDAR datasets. The users only need to input the area of interest (AOI), and the framework will retrieve the database and return the DEM of AOI in a second.

The NewZeaLiDAR project represents a significant contribution to the field of geospatial sciences and remote sensing. The effective implementation of data processing algorithms, advanced visualisation techniques, and comprehensive geospatial analysis tools underscores the project's technical robustness and versatility. By providing tailored utilities specific to New Zealand's diverse landscapes, NewZeaLiDAR addresses unique geospatial challenges and opens new avenues for research and practical applications.



Implications of uncertainty in flood hazard assessments for planning under climate change

PhD student:
Clevon Ash (GRI - UoC)

Supervisors:
Matthew Wilson (GRI - UoC)
Iain White (UoW)
Carolynne Hultquist (SEE - UoC)

Funding
Ministry of Business and the Environment funded Endeavour Project

Duration of project
3 years

Summary

Like many other countries around the world, New Zealand experienced numerous floods between 2022 and 2023. In 2022, Aotearoa experienced over 600 million dollars in losses; however, in 2023 this figure skyrocketed to over 3.5 billion dollars with the passage of Cyclone Gabrielle and the Auckland Anniversary weekend floods. According to the National Institute for Water and Atmospheric Research (NIWA) who uses complex flood models to predict how flooding is going to change over the next few decades, these figures are likely to increase based on climate projections. The aim of this research is to develop a better understanding of uncertainty representation in flood risk management and to determine the impact that it has on decision making. As the uncertainty associated with flood risk grows due to climate change and other factors it becomes imperative that decision makers can make the decisions needed within acceptable margins of error to protect the people of Aotearoa and its assets.

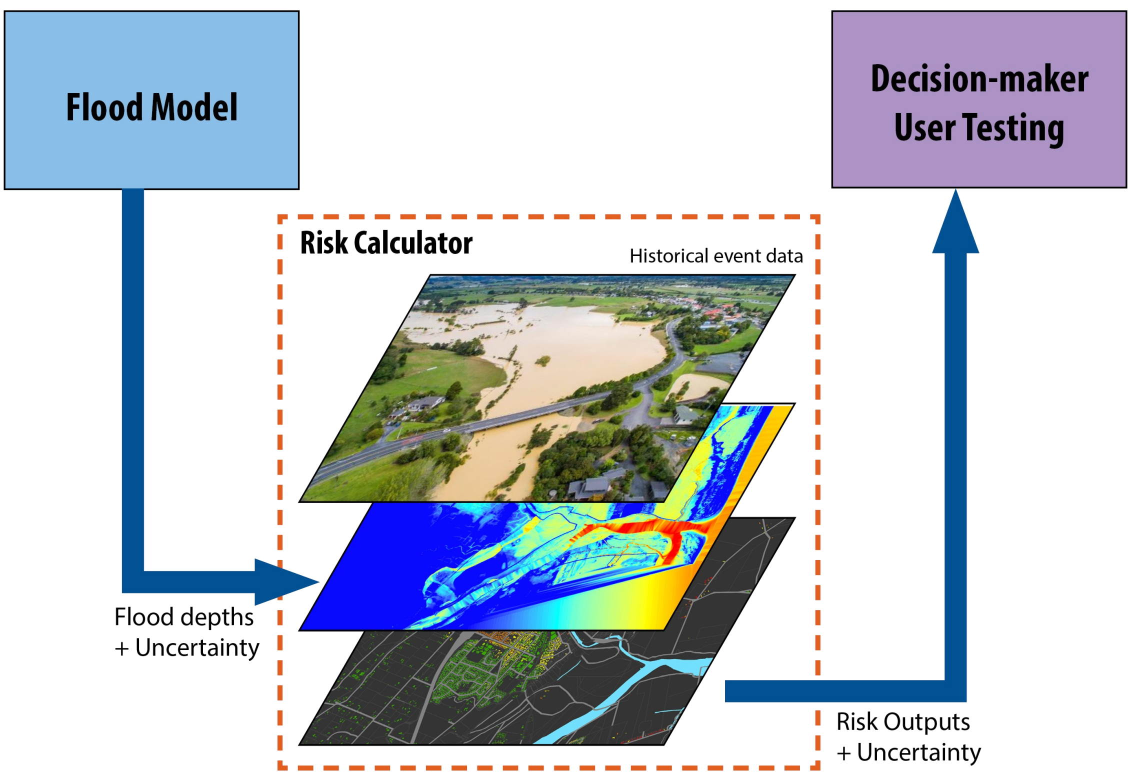


Figure: Simplified workflow of how flood risk uncertainty will be created and then tested for its impact on decision making

Building urban development scenarios into assessments of future flood risk

PhD student:
Katherine Booker (UoW)

Supervisors:
Iain White (UoW)
Matthew Wilson (GRI - UoC)
Dr. Xinyu Fu (UoW)

Funding
MBIE-Endeavour fund (2020-2025) *Institute of Water and Atmospheric Research (NIWA), running from 2020 to 2025.*

Duration of Project
PhD May 2023 - May 2026 (3 years)

Project Summary:

The devastating impact of flood events around the globe demonstrates the need for more comprehensive assessments of future flood risk in urban policy. In Aotearoa-New Zealand, flooding is one of the costliest natural hazards, in part due to the relatively high clean-up costs, but mostly due to the frequency of flood events. With a warming climate, changing precipitation trends, and rising sea levels, flooding is expected to become more frequent and more severe in the future. Flood risk assessments based on future flood projections paired with current urban plans are missing a key characteristic of the hazard – what will urban areas in Aotearoa-NZ look like in 2050 or 2100? With a continually growing and urbanising population we are facing a housing crisis, we must build houses. How might flood risk change over the next 100 years due to changes in urban landscapes? This PhD research project seeks to explore, test and develop methods to generate a range of alternative long-term urban development scenarios. The goal is to create a robust methodology for generating and then integrating urban futures with flood futures to provide a more comprehensive assessment of the uncertainties and inequalities of future flood risk.

New PhD students

2023 PhD students

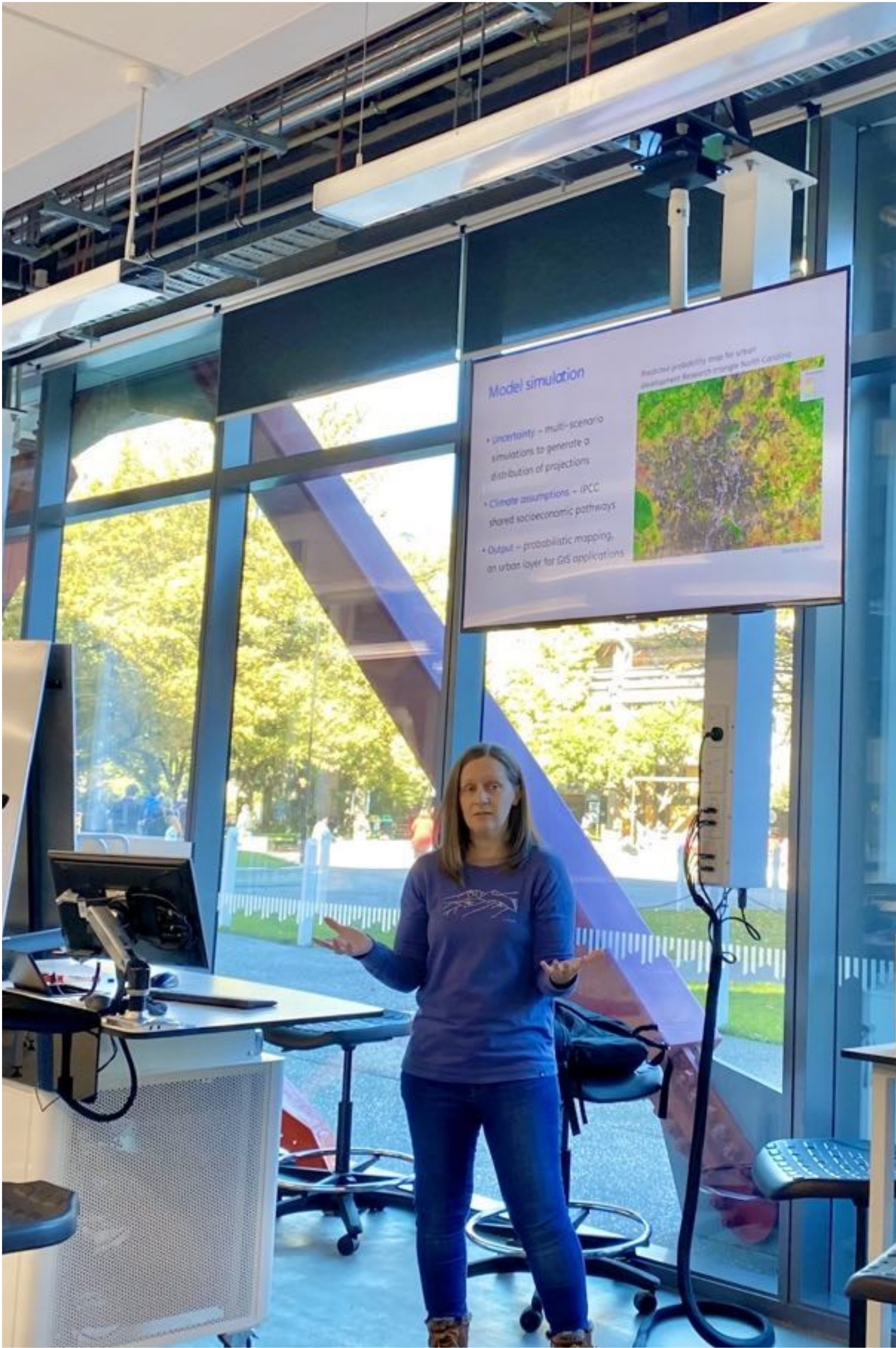
Our PhD students come from many different backgrounds and they clearly demonstrate that geospatial methods can be applied in many areas of research.

Katherine Booker
GRI PhD Student

Katherine is a PhD candidate at the University of Waikato, hosted by the GRI, with supervisors Prof. Iain White (Waikato) and Prof. Matt Wilson. She has a professional background as an economist, previously working at the UK Treasury, and recently completed a Master's degree in Applied Data Science at UC. That experience inspired a strong interest in the potential for data analysis and geospatial modelling to help develop effective solutions to environmental problems. Katherine's PhD is in environmental planning and will focus on how to generate urban development scenarios to integrate into assessments of future flood risk across Aotearoa-New Zealand.

PhD student statement

"Flooding is one of the costliest natural hazards in Aotearoa-New Zealand due to the relatively high clean-up costs and frequency of flood events. With a warming climate, changing precipitation trends, and rising sea levels, flooding is expected to become more frequent and more severe in the future. At the same time, with a continually growing and urbanising population we are facing a housing crisis, we must build houses. How might flood risk change over the next 100 years due to changes in urban landscapes? My research seeks to explore, test and develop methods to generate a range of alternative long-term urban development scenarios. The goal is to create a robust methodology for generating and then integrating urban futures with flood futures. My PhD is part of the 5-year multi-stakeholder Endeavour research programme "Mā te haumaru ō nga puna wai ō Rākaihautū ka ora mo ake tonu: Increasing flood resilience across Aotearoa-New Zealand", which is MBIE funded and led by the National Institute of Water and Atmospheric Research (NIWA). I am highly motivated to be working in an area where my research can contribute to improving flood resilience in public policy, specifically the challenge of enabling future development despite a changing climate. I also welcome the opportunity to integrate my experience in econometric forecasting with geospatial modelling methods. The first stage of my research has involved an extensive literature review of urban growth modelling. I have identified a decision pathway for model development, based on best-practice methodological choices, that will ensure resulting urban projections are suitable for informing flood risk assessments. The next step is to test different model configurations for a case study urban area in NZ, working with urban planners and policy makers to deliver a solution that is practically implementable and fit-for-purpose. The final stage of the research will examine how urban scenarios can be integrated with flood risk models to provide a more comprehensive picture of the uncertainties and inequalities of future flood risk."


Model simulation
• Uncertainty – multi-scenario simulations to generate a distribution of projections
• Climate assumptions – IPCC shared socioeconomic pathways
• Output – probabilistic mapping, an urban layer for GIS applications

2023 PhD students

Clevon Ash
GRI PhD Student

Clevon Ash who comes from the island of Trinidad & Tobago in the Caribbean, is a PhD candidate in the GRI and the Waterways Centre at the UoC. Having completed a Master of Disaster Management at The University of Auckland in 2021, he is now using his experience in Emergency Communications, Policy Development and Scientific Research towards improving the understanding and representation of uncertainty in flood risk management. His research is a part of the cross cutting theme of uncertainty in the MBIE Endeavour research programme, "Reducing flood inundation hazard and risk across Aotearoa/New Zealand", also known as : "Mā te haumaru ō te wai" which means "By keeping the water safe".

PhD student statement

"Being a geographer at heart, I have always enjoyed studying the interactions between natural man-made systems. We don't exist outside of nature, so finding that balance is crucial to our survival. Natural hazards and by extension flooding, represents one of the biggest challenges we face right now, both in the short- and long-term development of the spaces we live in. This often requires wearing multiple hats, such as the physical and social sciences but I believe that this type of interdisciplinary research provides more impactful results."

"As scientists and researchers, it is important that the products we develop are user-friendly and that the persons tasked with making the tough decisions about planning our futures can use these outputs to successfully navigate this complex space. The results of this research will hopefully shed some light on the way in which these decisions about flood risk and flood hazards are made which could then be used as a guide to tailor the types of outputs that are generated."

"Before we get to the outputs and decision making, we need to quantify and represent the uncertainty found in flood risk assessments. This can be done in several different ways, so exploring and fine-tuning which models are most feasible has been the first stage of the research. The second stage would be to use the chosen model along with the RiskScape risk assessment engine, to produce a variety of uncertain outputs. There is a wide variety of visual representations that can be used to communicate uncertainty and exploring how much of an impact they would have, is of particular interest to me, having worked in the hazard communications space for several years."

"The final stage of the research would be to test the different outputs produced using hypothetical scenarios with focus groups of different decision-makers in New Zealand. Collecting their feedback and incorporating it into the final outputs and findings is essential to the success of this research."

2023 PhD students

Sunil Tamang
GRI PhD Student
2023 GRI Scholarship Recipient

Sunil comes from Langtang Valley, Nepal. He holds dual master's degrees- one in Disaster Risk Management and another in Geospatial Technologies. Currently, he is pursuing his PhD research, focusing on the development of a machine learning framework to interpret earth observation data, with a specific emphasis on regional scale mapping of rock glaciers and other cryosphere landforms. Sunil is grateful and excited for the opportunity to pursue his doctoral studies, made possible through the Geospatial Research Institute Toi Hangarau PhD Scholarship, along with the UoC Doctoral scholarship.

PhD student statement

"The cryosphere is undergoing rapid change, significantly impacting water resources, natural hazard occurrences, and habitat availability in mountainous regions. Recent progress in remote sensing technology alongside high-resolution satellite and drone-based sensors available through open access channels presents new opportunities for interpreting various cryosphere landforms, including rock glaciers."

"How rock glaciers are defined, understood, and interpreted varies between cryosphere researchers, which in turn impacts how rock glaciers are mapped. This has led to data-driven, and operator-driven biases when creating rock glacier inventories making it hard to compare rock glacier occurrences between different regions. As machine learning (ML) continues to progress, there is increasing interest in utilising artificial intelligence to automatically delineate cryosphere landforms, including RGs which would contribute to consistent and objective rock glacier inventories. The few studies that have experimented with using ML to delineate RGs have used different ML architectures, remote sensing data, and training data, making it complicated to compare classification strategies. This is further compounded by questions of how to assess the trustworthiness of ML applications when applied to landforms such as RG where the data and definition used may result in variable and non-consistent training data."

"The study aims to explore how subjective, data-driven, and operator biases impact the applicability of ML for creating regional-scale RG inventories. I began my PhD in February 2024, so I am currently in the early stages of defining my research objectives and questions. Under the supervision of Shelley MacDonell, James Brasington, Benjamin Robson, and Jamie Shulmeister, my research will explore machine-learning approaches to quantify rock glacier changes across various periglacial catchments in Aotearoa New Zealand, Chile, Norway, and Nepal."

Engagement and research dissemination

MOU signing between Te Manatōpū Haukāinga o Ōhinemutu (TMHoŌ) and the GRI Toi Hangarau

Signing ceremony of MOU between TMHoŌ and GRI, 27/04/2023.

After years of close research co-development, on April 27th, 2023, Te Manatōpū Haukāinga o Ōhinemutu (TMHoŌ) and the Geospatial Research InstituteToi Hangarau (GRI) signed a non-binding MOU. The signing ceremony was held at Te Ao Mārama at the Ōhinemutu community. Mokonuiārangi Kingi and Matthew Wilson signed the document as representatives of both parties. In addition, participants of both the GRI and Ōhinemutu signed the document as witnesses. The MOU states:

"For the last few years, the partners have co-developed research to generate geospatial products to benefit the preservation and dissemination of the cultural heritage of Ōhinemutu village. As a result, a geospatial tool called Te Kete Kōrero o Ōhinemutu was developed and deployed. Following the same initial aim of the collaboration, the partners wish to continue to co-develop further initiatives around the use of geospatial research for the benefit of Ōhinemutu and other Māori communities across Aotearoa New Zealand".

Ōhinemutu village, Rotorua Aotearoa NZ.

Te Manaputu Ōhinemutu Workshops

Also on April 23rd 2023, **the geospatial tool** Te Kete Kōrero o Ōhinemutu was officially presented and handed over to the community.

The tool works as a repository where the Ōhinemutu whānau can collect and preserve narratives of cultural e historical value. Thus, among other functions, the tool can be use to visualise pictures, letters, manuscripts, found in local and public archives (e.g. radio stations, TV production companies, museums and libraries).

The official presentation of the geospatial tool was followed by a workshop in which members of the Ōhinemutu community and the GRI team participated. The aim of the workshop was to analyse the current and potential use of the Te Kete Kōrero o Ōhinemutu tool and to discuss future research projects that could be co-developed between the GRI and TMHoŌ.

Topics of importance for the Ōhinemutu whānau related to the tool's use ranged from data sovereignty, support for planning to connectiveness (with rangatahi and whānau living abroad).

In terms of future research the discussion was focused in topics such as the historical and socio-cultural significance of the village's Ngāwhā, climate change resilience, tourism and Matauranga Māori.

Further discussion were held in a second workshop which took place in the Ōhinemutu village on October 2023. The idea of developing a research proposal related to the historical and cultural significance of the Ngāwhā as a vehicle to transmit Matauranga Māori and to connect the broad whānau and rangatahi using state of the art technology was the main topic of discussion.

The fourth spatial data science symposium

September 5th and 6th, 2023

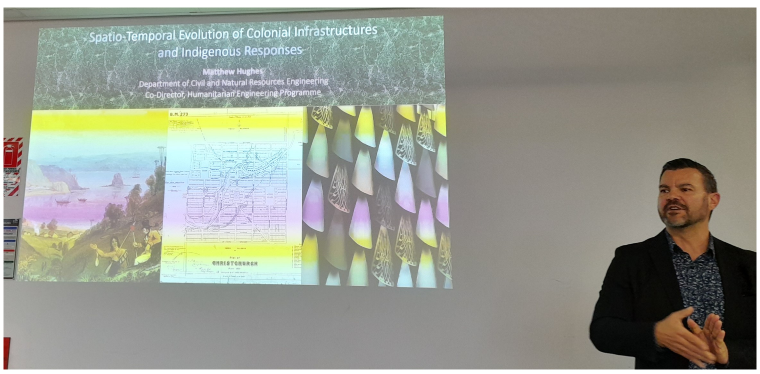
The Fourth Spatial Data Science Symposium took place on September 5th and 6th, 2023. It was a free distributed online symposium that brought together researchers from academia, industry, non-profits, and government from all over the world. Nine hubs around the world were organised parallel to the event. In Aotearoa New Zealand two hubs were held, one at the University of Aukland and another one at the UoC, for which Dr Vanessa Brum-Bastos was the coordinator.

The format of the symposium was a combination of keynotes, scientific sessions (online and in-person), as well as paper presentations. In contrast to classical conferences, the community decided on these sessions, and the main focus was on interaction.

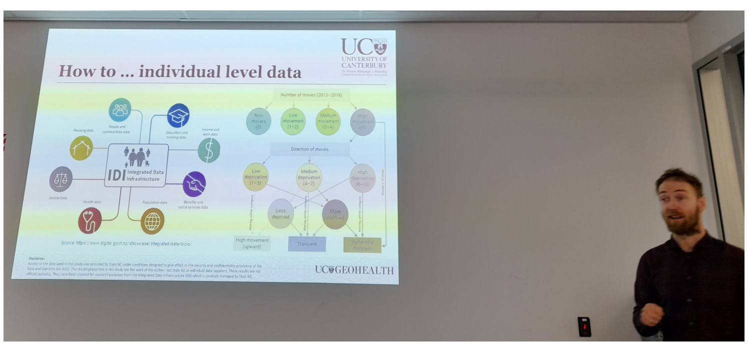
At the UC hub, academics, members of the geospatial industry and students presented and discussed experiences, insights, methodologies, and applications of geospatial science.

Two main events took place at the UC hub:

- Oral in-person presentation session: A space for speakers to share their views around taking spatial and temporal knowledge into account while addressing their domain-specific problems.
- Poster session: This was an opportunity for under and postgraduate students to present and discuss their research related to geospatial science.



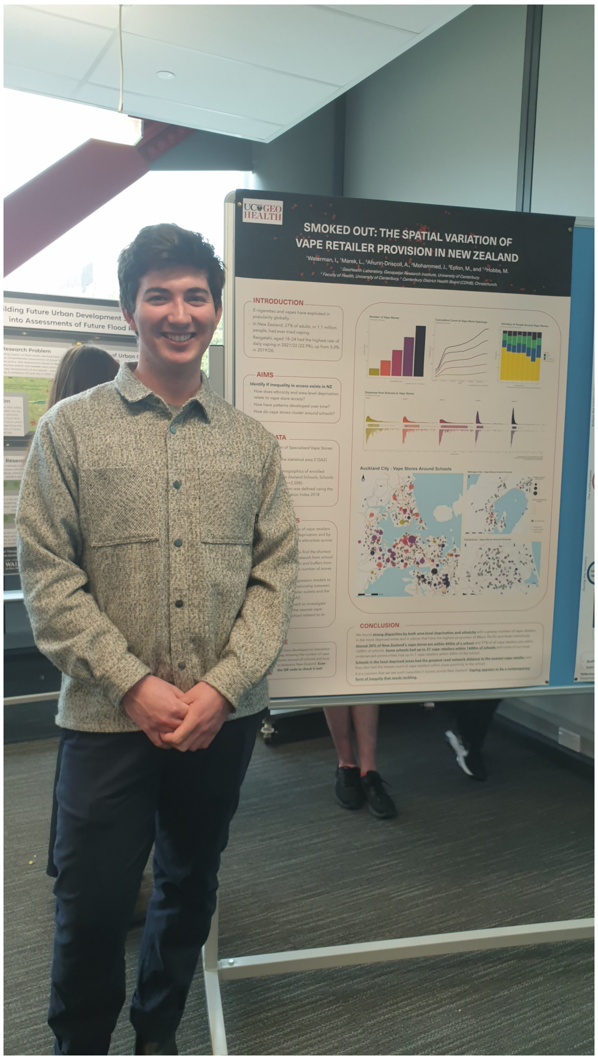
***Matthew Hughes** from UoC, Civil and Natural Resources Engineering, Faculty of Engineering presenting his research on spatio-temporal evolution of colonial infrastructures and indigenous responses.*



***Lukas Marek,** From the UoC, GRI Toi Hangarau, presenting his research work related to population transcendence in Aotearoa New Zealand.*

***Keri Niven**, Digital Practice Leader at Aurecon gave an oral presentation and was one of the judges in the poster competition.*

Vanessa Brum-Bastos (in white and pink) from the UoC, School of Earth and Environment was the UC hub co-ordinator.



Isaac Waterman, *Poster winner*

Posters presented at the Fourth Spatial Data Science Symposium 2024:

- Ishwarya Anand, Vanessa Bastos, Steve Pawson, Andrew Robinson, Heyang (Thomas) Li, Unravelling the Biosecurity Implications of International Tourism in New Zealand
- Katherine Booker, Building Future Urban Development Scenarios into Assessments of Future Flood Risk
- Katherine Booker, Water Allocation and the Canterbury Land and Water Regional Plan
- Hazel Fraser, Use of Felt Rapid Reports as a reliable data source in the production of Earthquake Intensity Maps
- David Pedley, Urban Trees and Housing Intensification. A Spatial Conflict?
- M. Nguyen, M. D. Wilson, E. M. Lane, J. Brasington, R. Pearson, Uncertainty in Bathymetry Estimation
- Waterman, I., Marek, L., Ahuriri-Driscoll, A., Mohammed, J., Epton, M., Hobbs, M., Smoked Out: The Spatial Variation of Vape Retailer Provision in New Zealand
- Sidney Gig-Jan Wong, Monitoring Hate Speech and Offensive Language on Social Media

LINZ Visit to the GRI

On September 16, 2023, a team from Land Information New Zealand, (LINZ) led by Jan Pierce, Kaihautū Customer Delivery and the GRI's board chair person, visited the UoC.

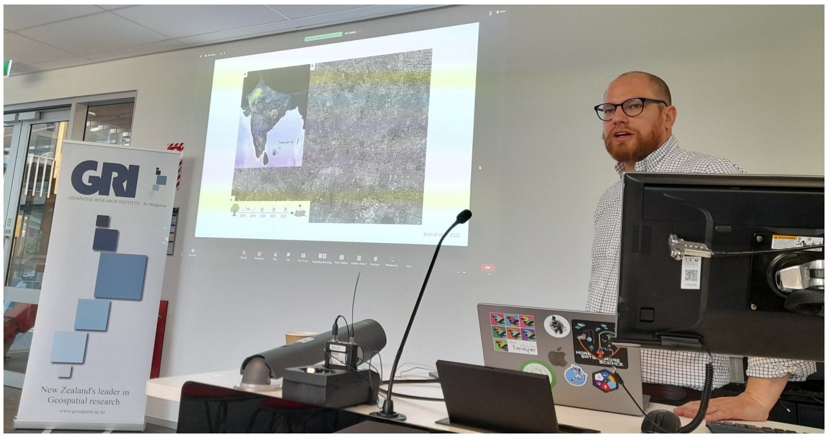
Among other commitments they attended a series of presentations of the ongoing project developed in the GRI using data provided by LINZ. A list of the projects presented is shown below.

GRI – projects overview

Welcome and Intro	Matt Wilson
LINZ - LiDAR data processing: A GRI and NIWA initiative for the benefit of Aotearoa NZ	Xander Cai
Digital Twin: partnering towards open-source technological innovations.	Luke Parkinson and Casey Li
Ecoindex project overview	Saif Khan
GeoHealth projects overview	Lukas Marek
Rongowai: Overview	Matt Wilson
Q&A	

Toitū Te Whenua
Land Information
New Zealand

Engagement with Planet Labs PBC



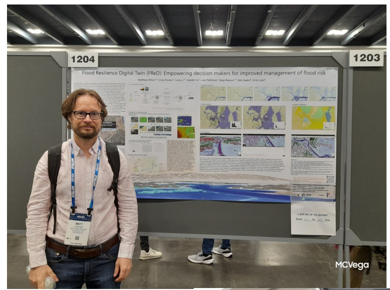
On October 20, 2023, a delegation from Planet Labs PBC, **Planet "a leading provider of geospatial data for use in agriculture, government, and commercial mapping"** from the San Francisco and Australia offices, visited the GRI. Some of the ongoing projects at the GRI using remote sensing were presented. We also discussed future partnerships to develop research in the GRI using Planet products.

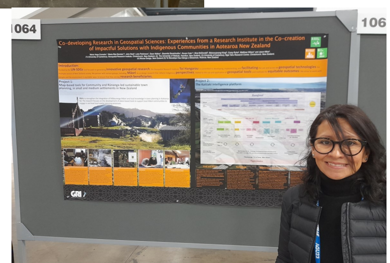
Joe Mascaro, Director Science Strategy & Programs also gave a seminar in the GRI Seminar Series.

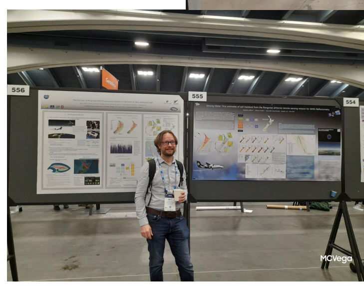
On December 2023, members of the GRI attended a talk session at the Planet offices in San Francisco while taking part of the AGU conference.

GRI presented at AGU Conference 2023

PhD student, ***Martin Nguyen*** *presented his research in Estimating uncertainty in flood model outputs using machine learning informed by Monte Carlo analysis.*





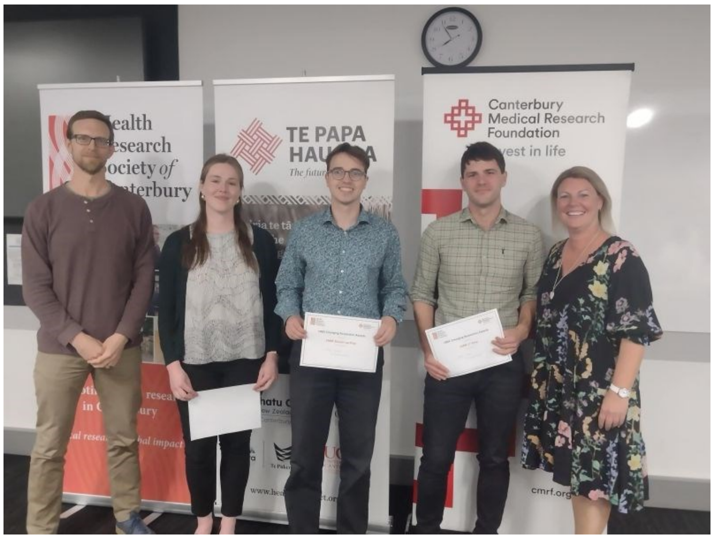


The GRI Director, ***Matthew Wilson*** *presented research related to the Flood Resilience Digital Twin and Rongowai project. The GRI Manager,* ***Maria Vega*** *presented some projects of GRI co-develop research.*

Academic members of the School of Earth and environment from the UoC also attended and presented their research work at AGU 2023.

AGU23
San Francisco, CA & Online Everywhere
11-15 December 2023

Other conferences and events in 2023



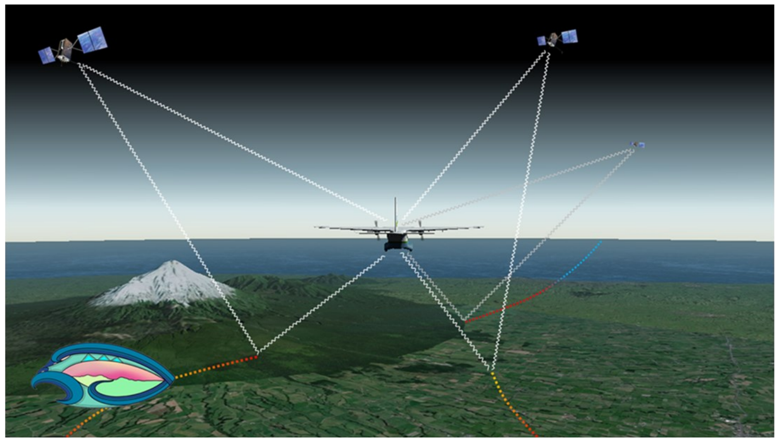
Andrew Kingdom, a GRI hosted PhD student, won the 1st Prize presenting: A geospatial analysis of Abdominal Aortic Aneurysms (AAA) ruptures to guide screening in NZ at the Health Research Society of Canterbury's 2023 Emerging Researcher Awards Evening.

Deputy Director of the GeoHealth Laboratory, Matt Hobbs presented at the World Conference on Drowning Prevention in Perth from 4-7 December 2023.

The Waterways Postgraduate Student Conference showcased freshwater-related research being undertaken by postgraduate students at the University of Canterbury and Lincoln University. In 2023, the Conference was held Tuesday 7 November.

Geospatial Research Institute Seminar Series

2023



April 2023

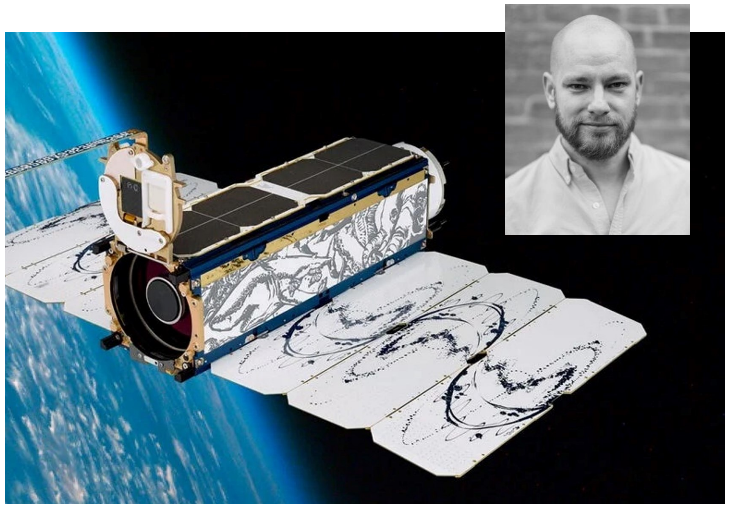
Prof Matt Wilson, UoC and **Prof Delwyn Moller**, University of Auckland. ***Sensing Water: The Rongowai airborne remote sensing mission for GNSS-Reflectometry across New Zealand.*** Rongowai has recorded reflected GNSS signals across much of the country. This talk provided an overview of the mission, outlined the current and planned data processing, and presented some of the early findings.

July 2023

Tim Chambers, University of Otago and **Matt Hobbs,** UoC. ***Using nation-wide geospatial data to build a comprehensive understanding of public water supply, quality and inequity in New Zealand.*** The seminar outlined the development of a nationwide geospatial dataset of water distribution zones (WDZ) using data compiled from the 67 district and city councils in A-NZ. The talk also outlined several early use cases for the WDZ dataset .

August 2023

Peter Fretwell, British Antarctic Survey. **Penguins from Space:** ***Using satellite imagery to monitor emperor penguins in their struggle against a warming Antarctica.*** This seminar discussed the advances in use of satellite imagery that has enabled scientists to find, count and monitor penguins, transforming the emperor penguin from one of the least studied species in Antarctica to one of the best.



October 2023

Joe Mascaro, Director Science Strategy & Programs at Planet.
Earth Science in an Age of Change. This seminar shared results from Planet's researcher network, discussed the scientific value of Planet's persistent monitoring capability, and talked about methods by which the data could be accessed by the scientific community.

October 2023

Peter Shaw. Engineering Director at Trimble. ***Geospatial Research in Industry.*** In this seminar, Peter Shaw gave an overview of areas of interest at Trimble, particularly, their ongoing pursuit of increased accuracy, reliability, and efficiency in positioning techniques (including mitigation against space weather/ ionospheric effects) and the application of AI to Geospatial problems.

GRI Publications and Outputs

Publications

Campbell, M. Spatial Microsimulation. A Short Explainer. (2023). http://dx.doi.org/10.2139/ssrn.4565410.

Campbell, M., Conrow, L., **Kingham, S.** and Logan, T. (2023). Working paper: Lessons learned on how to design Aotearoa New Zealand's urban centres to better enable low(er) carbon living. http://dx.doi.org/10.2139/ssrn.4486347.

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Deng, B., Campbell, M., McLeod, G.F.H., Boden, J., Sabel, C. E. and **Hobbs, M.** Examining the long-term impact of childhood area-level socioeconomic status on adolescent and adult mental health: a birth cohort study in Aotearoa New Zealand. International Conference on Urban Science and Sustainability Conference, Xiamen, China. December 14, 2023.

Moller D., Ruf, C.S., Al-Khaldi, M., Bai, D., Gleason, S., Lin, X., Musko, S., O'Brien, A. and **Wilson, M.** The First Year of Rongowai GNSS-R Operations Hosted on a Domestic Air New Zealand Aircraft. AGU23. San Francisco, December 14, 2023.

Vega-Corredor, C.M., Dionisio, M.R., **Reid, J., Walker, D., Parkinson, L., Savarimuthu, S.,** Cote, K., McDonald, R., Kingi, M., Ruha, C. and Mika, J. Co-developing Research in Geospatial Sciences: Experiences from a Research Institute in the Co-creation of Impactful Solutions with Indigenous Communities in Aotearoa New Zealand. AGU23. San Francisco, December 14, 2023.

Nguyen, M., **Wilson, M., Lane, E.,** Brasington, J. and **Pearson, R.** Uncertainty in Flood Predictions Caused by River Bathymetry Estimation. AGU23. San Francisco, December 12, 2023.

Wilson, M.D., Preston, G., **Li, C., Cai, X.,** Pearson, R., **Parkinson, L.,** Deakin, R. and **Lane, E.** Flood Resilience Digital Twin (FReD): Empowering Decision Makers for Improved Management of Flood Risk. AGU23. San Francisco, December 12, 2023.

Pozo, A. Analysis of New Zealand daily weather patterns (DWTs) and large scale climatic patterns as heavy rainfall and flooding drivers. Australasian Groundwater & New Zealand Hydrological Society Joint Conference. Auckland, December 2023.

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Booker, K., White, I. and **Wilson, M.** Building Urban Development Scenarios into Assessments of Future Flood Risk. Waterways Centre Postgraduate Conference. UoC, Christchurch, November 7, 2023.

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Ash, C. Using RiskScape to measure the Impact of Flood Uncertainty on Decision-Making. The Fourth Spatial Data Science Symposium. UoC, Christchurch, September 5, 2023.

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Booker, K., White, I. and **Wilson, M.** Water Allocation and the Canterbury Land and Water Regional Plan. The Fourth Spatial Data Science Symposium. UoC, Christchurch, September 5, 2023.

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Strang, A., Anderson, D., Robinson, E., Ballard, G., Schmidt, A., Ainley, D., Barton, K., Shanhun, F., Macneil, R., Cameron, E. and LaRue, M. Advancing Efficiencies in Remote Sensing of Ross Sea Adélie Penguin Populations. The Fourth Spatial Data Science Symposium. UoC, Christchurch, September 5, 2023.

Waterman, I., Marek, L., Ahuriri-Driscoll, A., Mohammed, J., Epton, M. and **Hobbs, M.** Smoked Out: The Spatial Variation of Vape Retailer Provision in New Zealand. The Fourth Spatial Data Science Symposium. UoC, Christchurch, September 5, 2023.

Wong, S. G.-J., Monitoring Hate Speech and Offensive Language on Social Media. The Fourth Spatial Data Science Symposium. UoC, Christchurch, September 5, 2023.

Deng, B., McLeod, G., Dhakal, B., Mackenbach, J.D., **Eggleton, P., Marek, L., Campbell, M.,** Boden, J. and **Hobbs, M**. Identifying typologies of residential mobility in childhood and associated factors: A prospective birth cohort study in New Zealand. New Zealand Population Conference 2023, Auckland, New Zealand. August 30, 2023.

Deng, B., Hobbs, M. and McLeod, G. Change in the food environment and measured adiposity in adulthood in the Christchurch Health and Development birth cohort, Aotearoa: A cohort study. New Zealand Population Conference 2023, Auckland, New Zealand. August 29, 2023.

Wong, S. G.-J., Durward, M., Adams, B. and Dunn., J. Shared Task on Homophobia and Transphobia Detection in Social Media Comments. New Zealand Institute of Language, Brain and Behaviour Seminar. UoC. August 3, 2023.

Moller, D., Al-Khaldi, M., Gleason, S., Ruf, C., Lin, X., O'Brian, A., **Wilson, M.,** Musko, S., McKague, D. and Wang, T. On the Sensing Applications of Rongowai's first dual-polarization GNSS-R observables. International Geoscience and Remote Sensing Symposium. IGARSS. Pasadena, July 16, 2023.

Eggleton, P., Campbell, M., Hobbs, M., McLeod G. and Boden, J. Defining exposure to the Canterbury Earthquake Sequence (2010-11): a spatio-temporal birth cohort study. Places and health: data needs and analysis techniques. Institute of Australian Geographers Conference. Perth, Australia, July 5, 2023.

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Moller, D., **Wilson, M.,** O'Brien, A., Ruf, C. and Lin, X. An airborne multi-year mission for GNSS-R Advancement: Operations and initial results. IEEE GNSS+R 2023. Boulder, May 24, 2023.

Campbell, M. Airbnb: 'disrupting' the regions in NZ and how this has changed during the COVID period. April 5, 2023. https://hdl.handle.net/10092/105529.

Pozo, A. Towards a method of rapid flood risk scenario assessment using hybrid approaches of hydraulic modelling and machine learning. The General Assembly 2023 of the European Geosciences Union (EGU) Vienna, April 2023.

Marek, L. and Hobbs, M. Inequities in life course air pollution exposure and health. 2023 AAG Annual Meeting. California State University, Fullerton, March 26, 2023.

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Eggleton, P., Campbell, M., Hobbs, M., McLeod, G. and Boden, J. Investigating the spatial exposure of a birth cohort to the Canterbury Earthquake Sequence (2010-11). Cluster for Community and Resilience Poster Symposium. Christchurch, March 21, 2023.

Kindon, A. A geospatial and demographic analysis of incidental AAA detection rates in New Zealand. Vascular Society of New Zealand Annual Meeting, Nelson. March 3-5, 2023.

Wong, S. G.-J. Developing a global model of emerging non-geographic digital dialects. Sprachwissenschaftliche Tagung für Promotionsstudierende. Augsburg/Budapest/Vienna. February 24-26, 2023.

Team building activity highlights

GRI members tramping in Dean Walker's forest

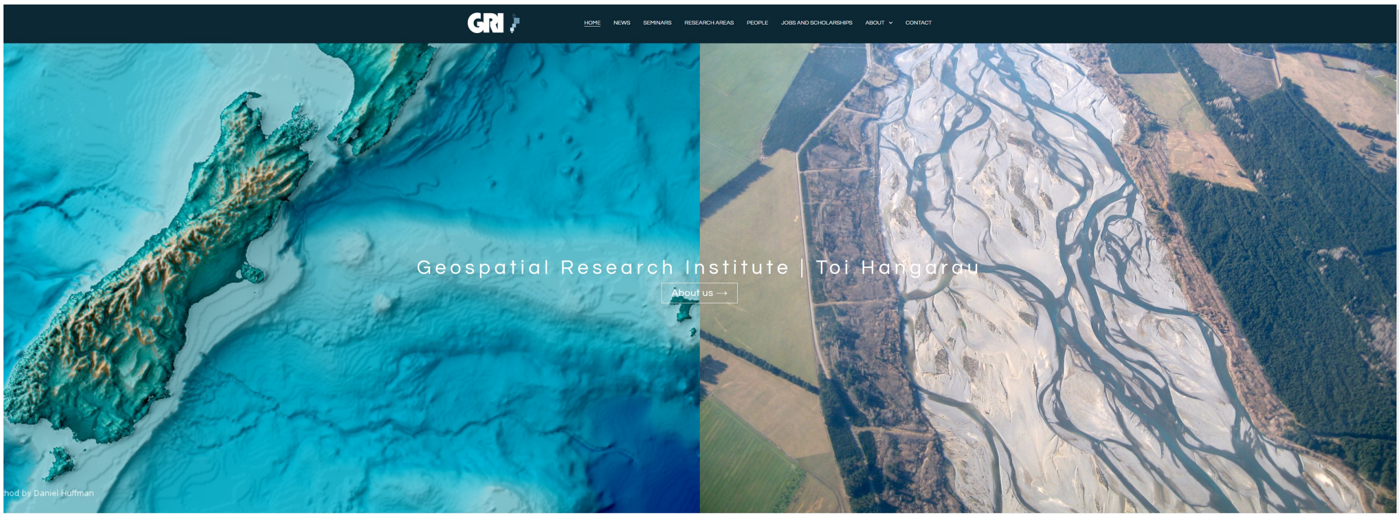
GRI Annual Ski Trip 2023

Financial report and Contact

Financial report

Accounts	FY2023
Operating Income	
Government Grants	239,846
Student Tuition Fees	0
Other Income	884,811
Total	**1,124,657**
Operating Expenditure	
Personnel Expenses	590,131
Site and Property Expenses	
General Expenses	318,944
Depreciation	9,893
Overheads	110,448
Total	**1,029,416**
Net Income	**95,241**
Net Income %	8.5%
EBITDA	105,134

Contact us



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

https://www.facebook.com/geospatialri