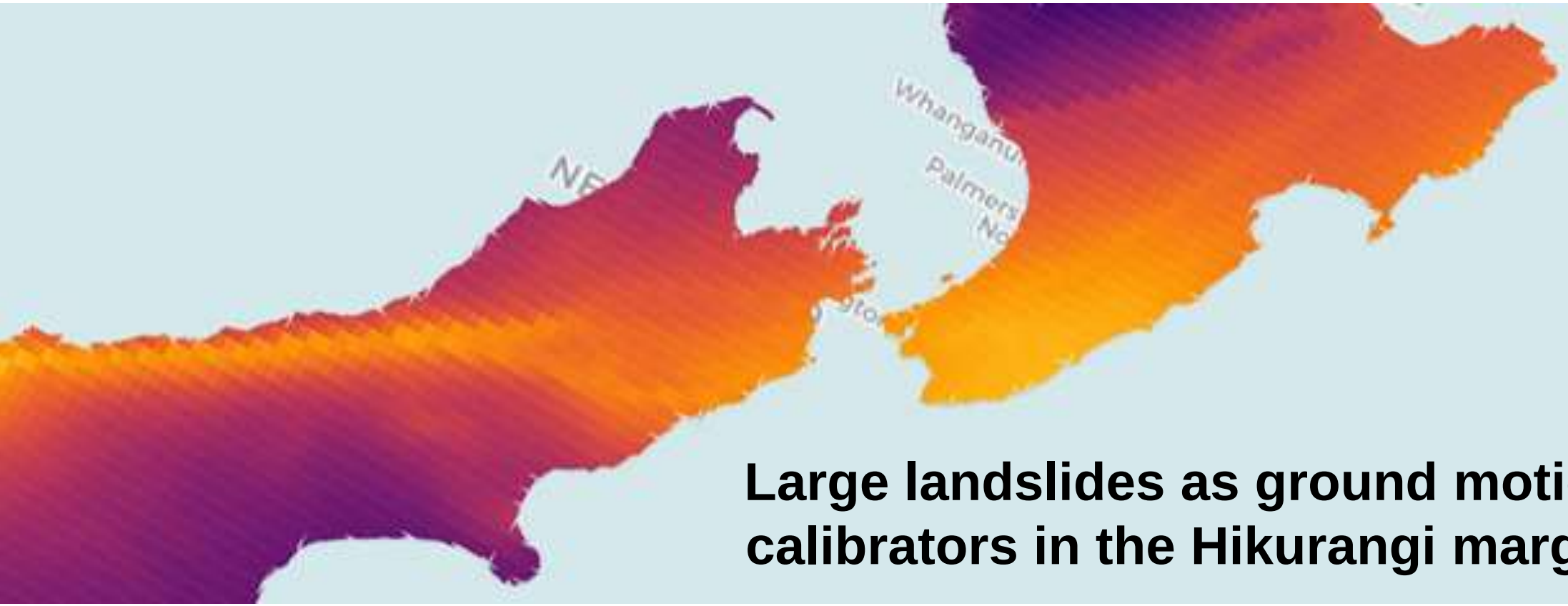


Large landslides as ground motion calibrators in the Hikurangi margin

Rob Langridge, Andrea Wolter
GNS Science *Te Pū Ao*
Tim Stahl, Abbie Underwood
University of Canterbury *Te Whare Wānanga o Waitaha*
Joe Potangaroa
Potangaroa Education; *Rangitāne o Wairarapa*

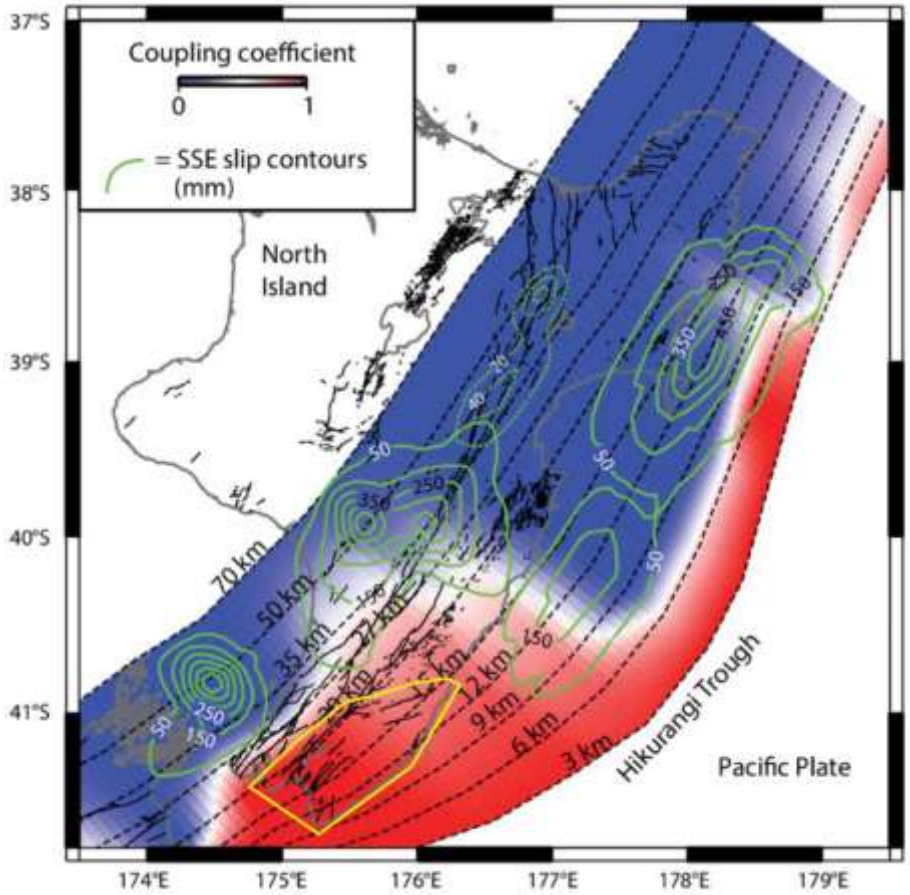
Smart Ideas

UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

GNS SCIENCE
TE PŪ AO

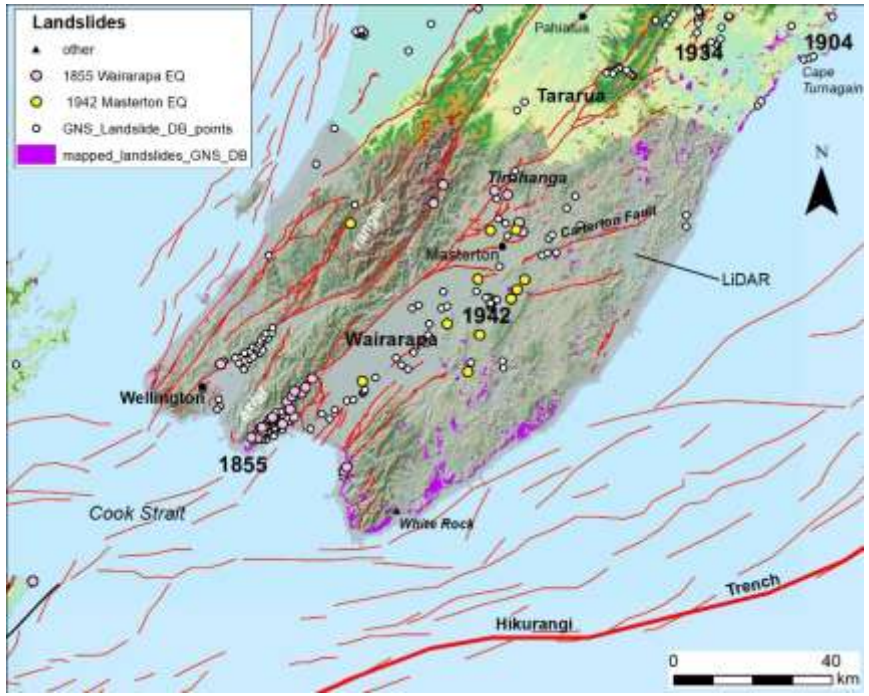
What's in today's talk ?

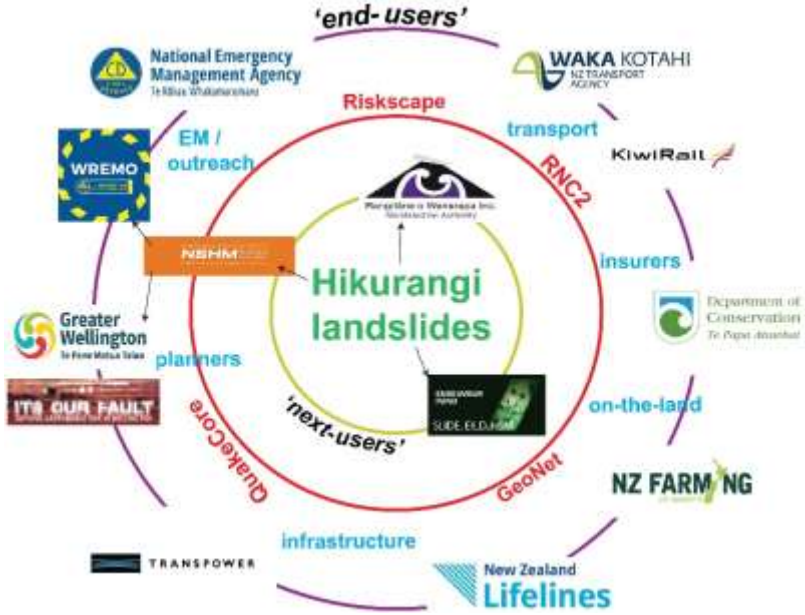
- Introduction to the project
- Landslide mapping
- Modelling landscapes
- Field targets
- Modelling ground motions
- Mātauranga opportunities

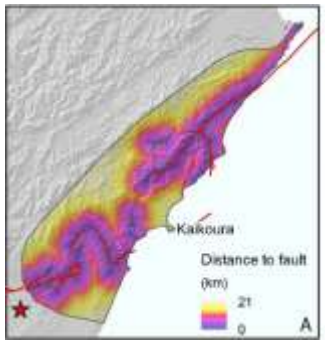


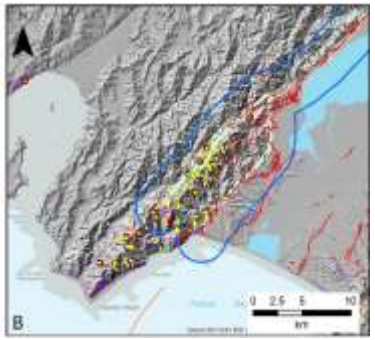
Wallace et al. (2009; 2014)

Large landslides as ground motion calibrators in the Hikurangi margin







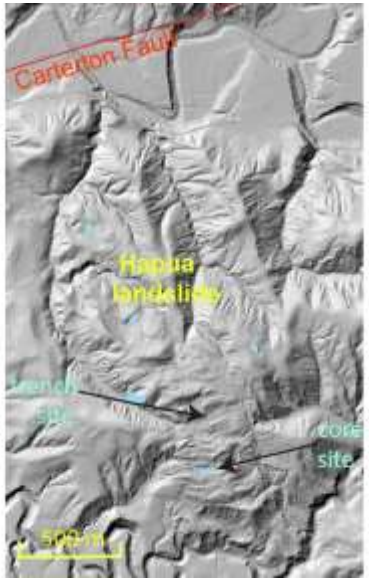


Origin
weather-induced?

- relationship to stream down-cutting
- sea-level change
- period of increased storminess
- dates cluster at 12,000, 7000 yr B.P.

Origin
human-induced?

- relationship to deforestation
- fires, agriculture
- dates cluster at 700, 150 yr B.P.



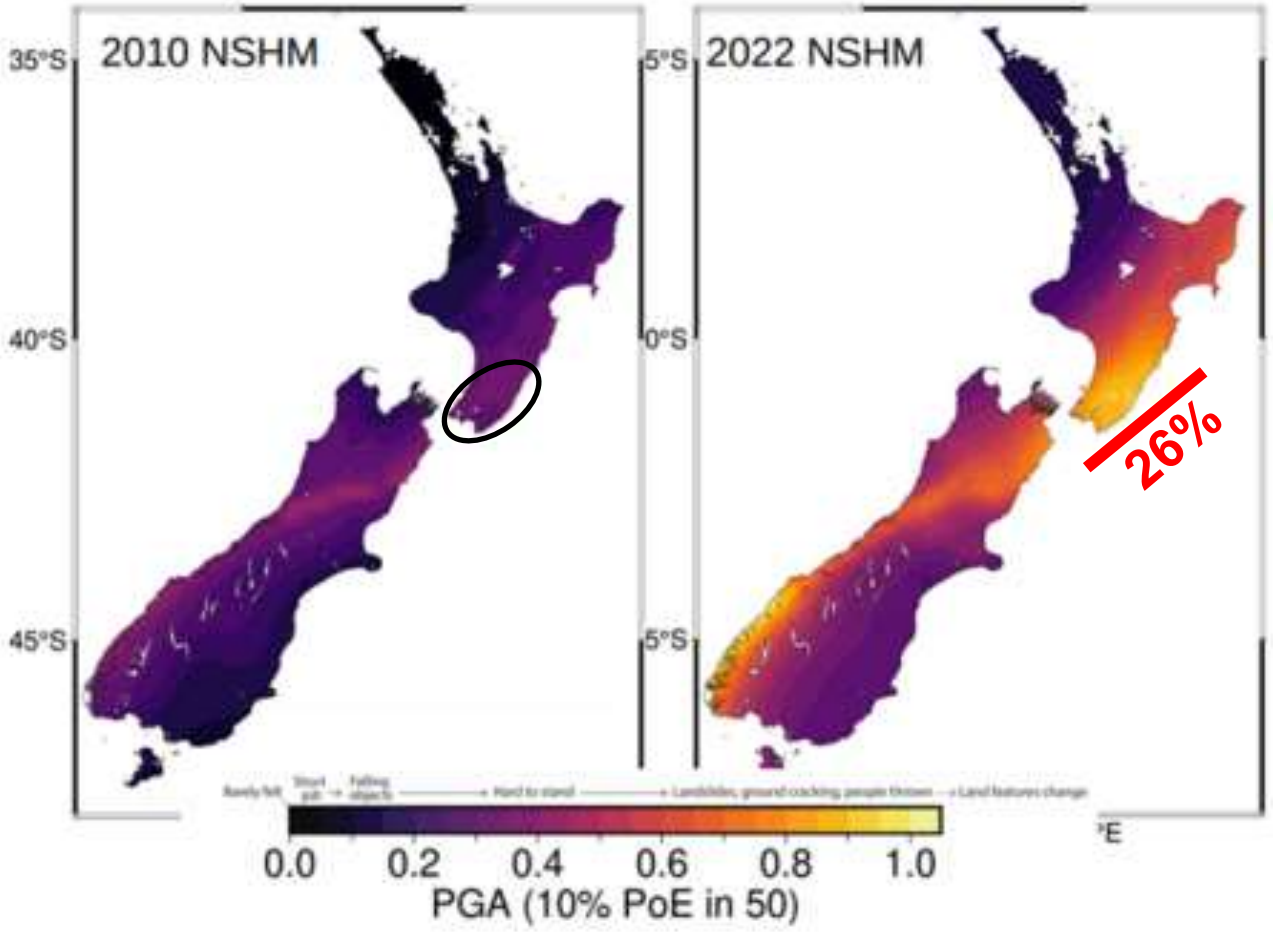
Origin
EQ fault-induced?

- spatially associated with fault
- one of several LEILs near a fault
- dates cluster with fault paleoseismicity

Origin
HSZ-induced?

- not spatially associated with a fault
- one of many regional LEILs
- dates cluster with HSZ paleoseismicity

motivation – Δ NSHM 2012 vs. 2022



- **10% PoE from ↑ 0.3 to 0.8 g**
- **GW region now region of highest hazard**
- **↑ largely due to treatment of sthn Hikurangi**
- **26% chance in 50 yr of sthn Hikurangi event**

https://nshm.gns.cri.nz/HazardMaps

Research Aims

- **Identify and map prehistoric *coseismic* landslides (or coseismic displacements within existing landslides)**
  - Site investigations and characterisation of historical EQ-induced landslides

- **Improve chronologies of large landslides and earthquakes on crustal faults in the eastern Wairarapa**
  - Regional mapping
  - Detailed geomorph mapping, trenching, dating (absolute and morphological/calibrated)

- **Compare landslide chronology with earthquake chronology & landslide susceptibility and Eng. Geol. physics-based models using ground motion scenarios**
  - Surface roughness-based age models
  - Rupture-rate-based susceptibility models (drawing on NSHM products)
  - Ground models, Geotech, UDEC/3DEC modelling






the team

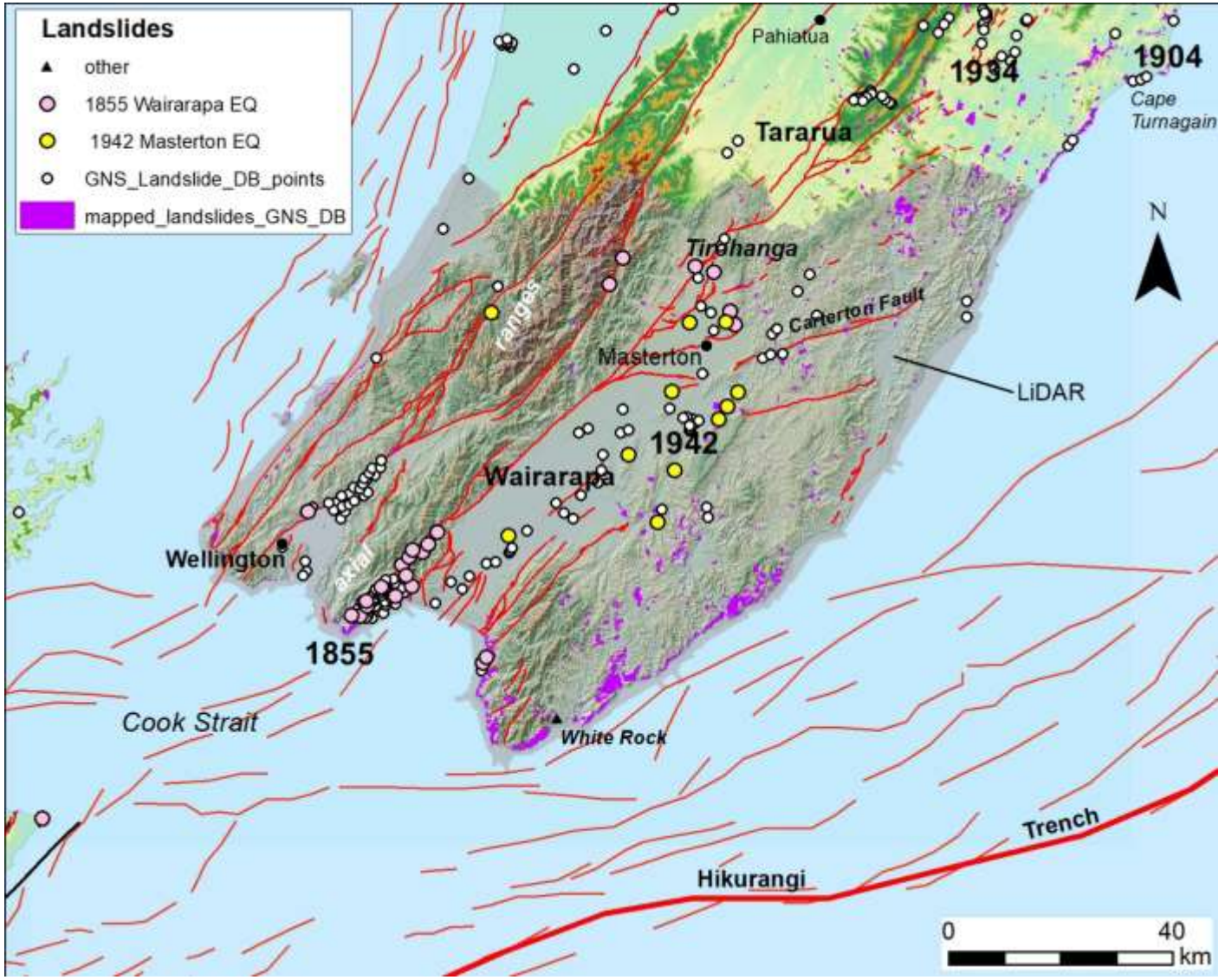
- GNS: Rob, Andrea Wolter, Brenda Rosser
- UC: Tim Stahl, Abbie Underwood
- GNS Dunedin: Tatiana Goded
- Wairarapa iwi: Joe & Paris Potangaroa

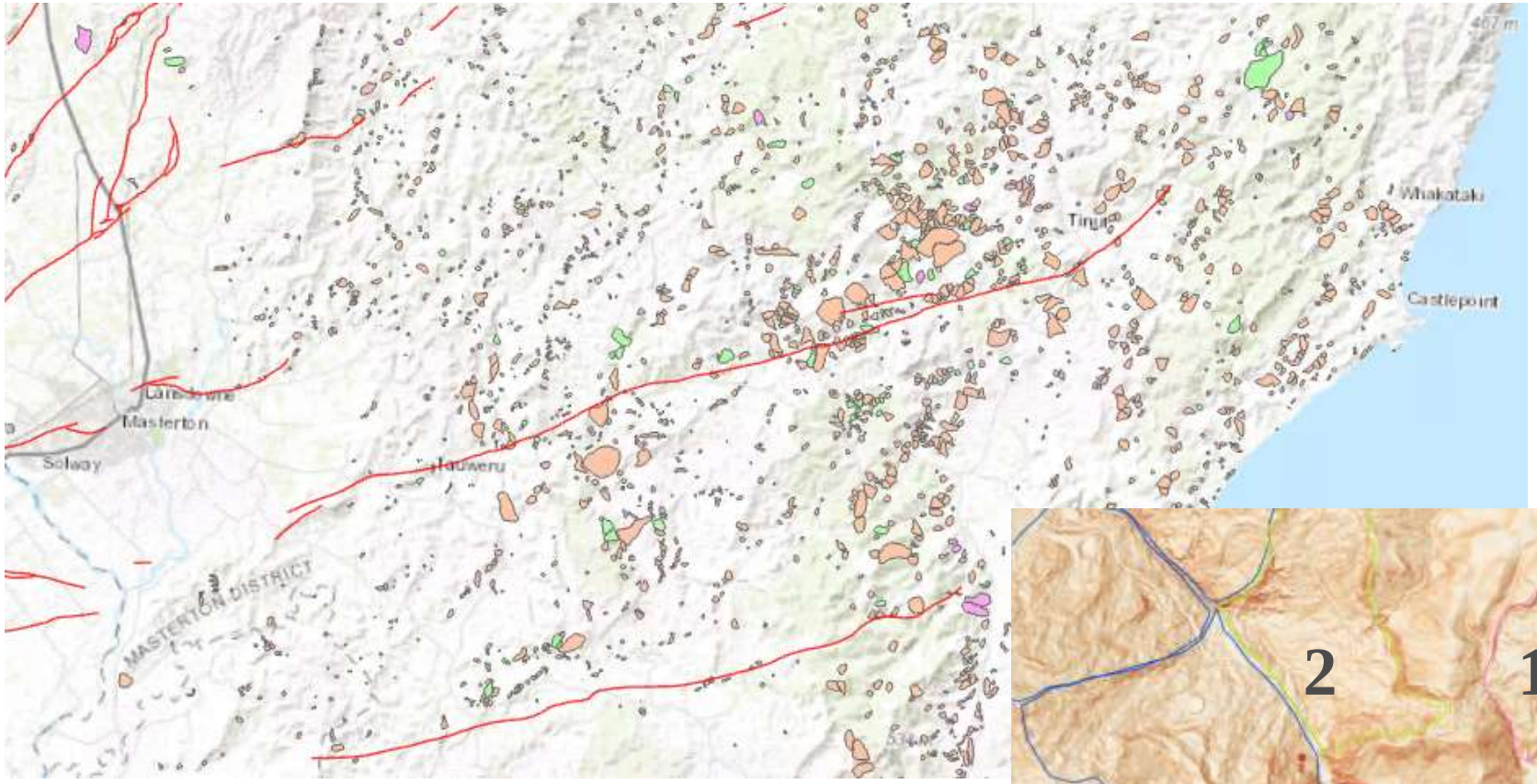

Abbie

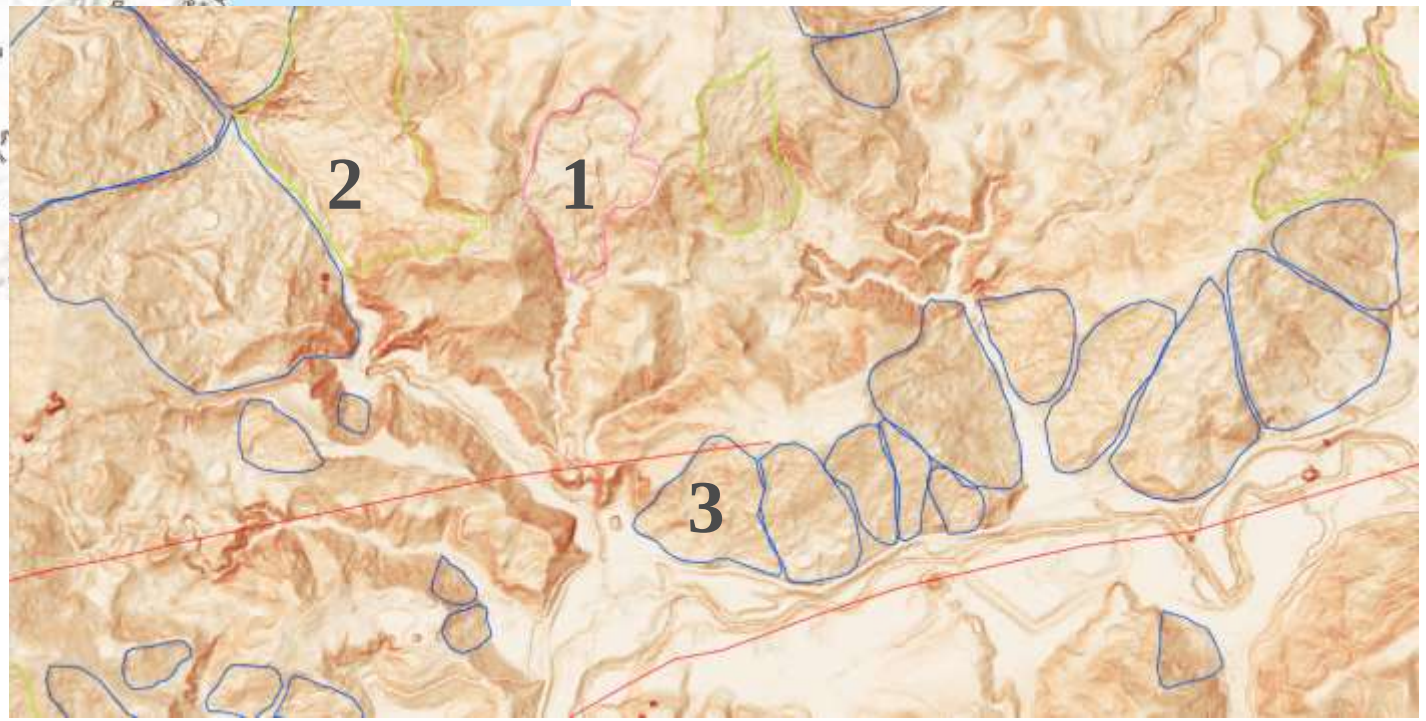

Paris

Regional landslide mapping

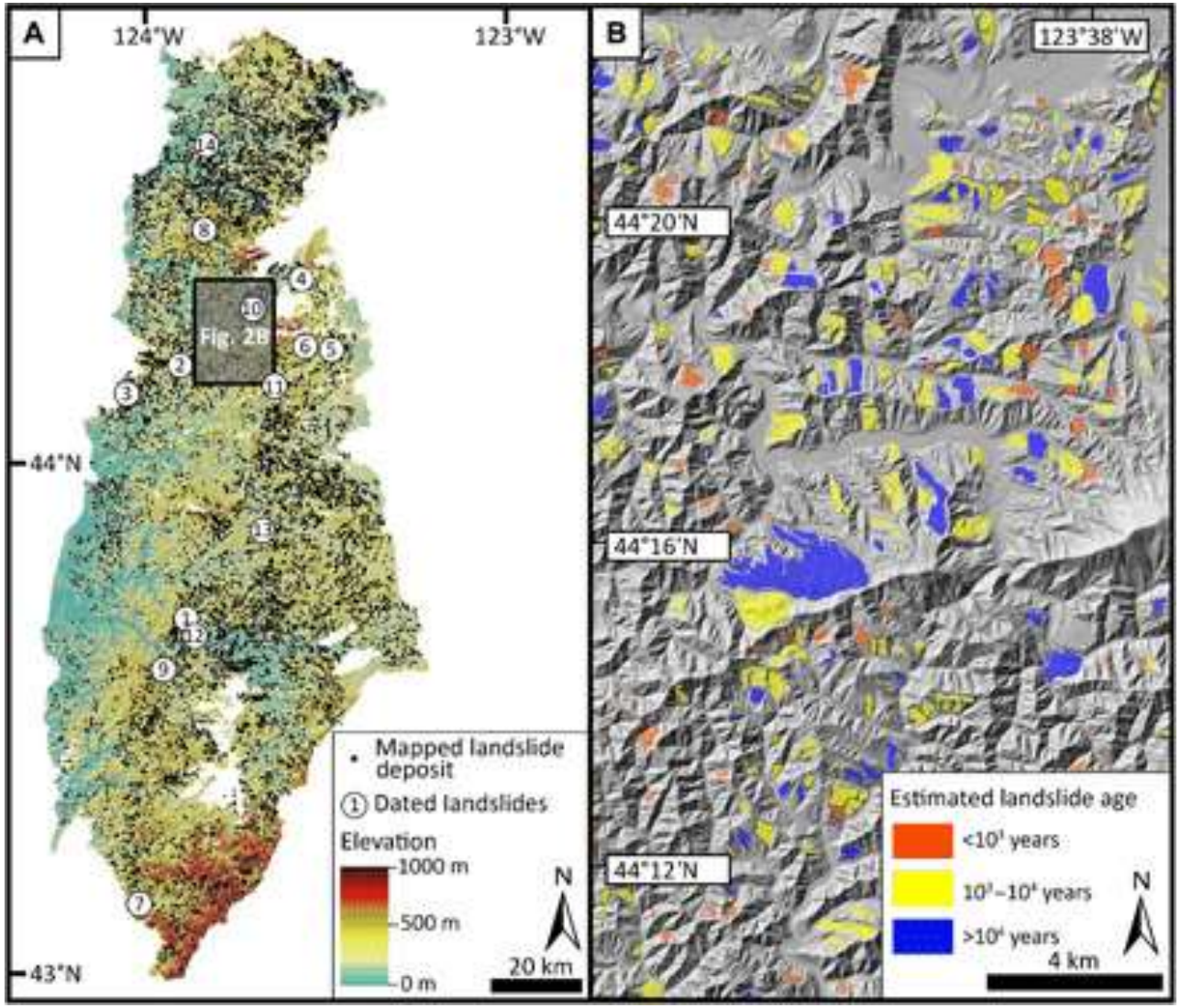
- Able through regional airborne lidar cover
- Building on GNS Landslide db
- Focus on: Historical EQ datasets
- and, Coastal landslides





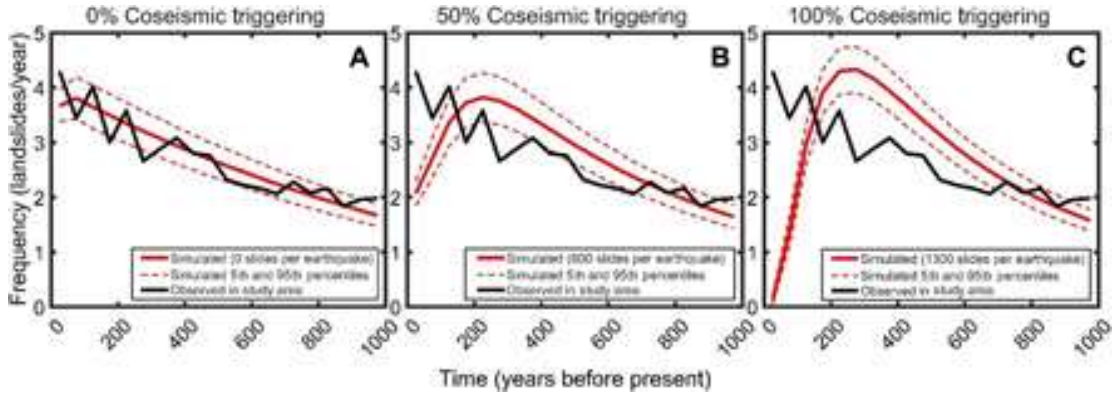


Regional to local landslide mapping



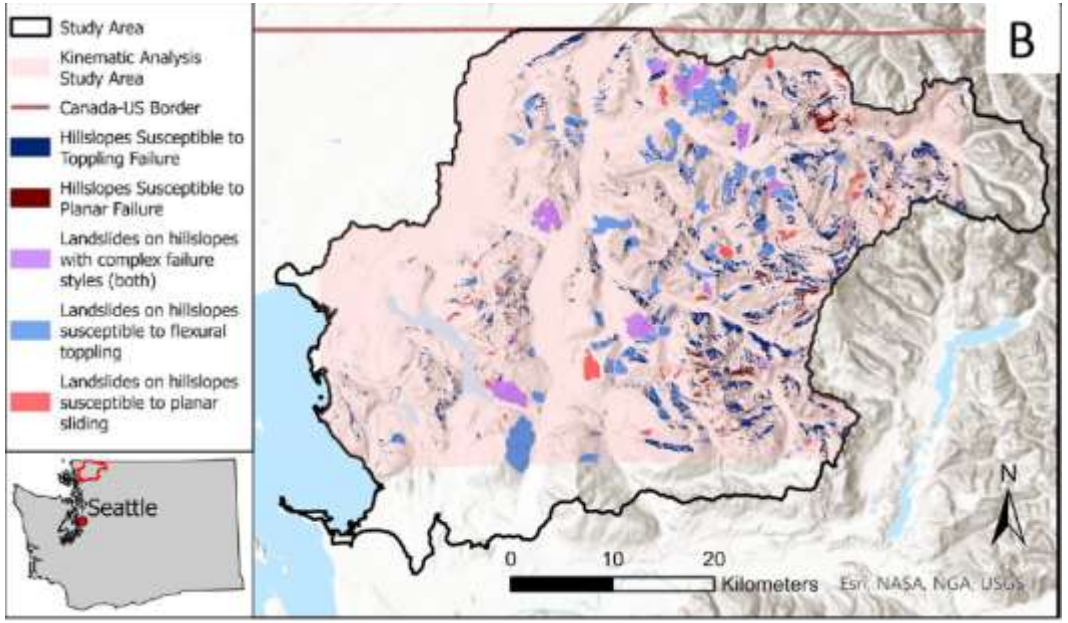
LaHusen et al., 2020
Cascadia landslides

Do we overestimate landslide densities from subduction zone events?



Most Recent Rupture on the Boulder Creek Fault Triggered Bedrock Landsliding in the Nooksack Watershed, Whatcom County, Washington

Abigail Catherine Underwood
Portland State University



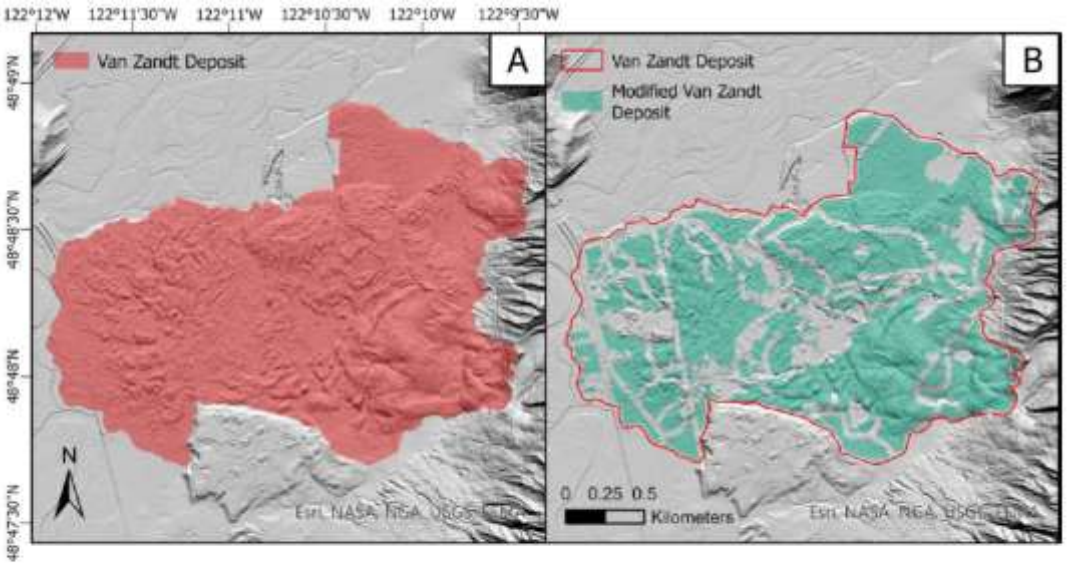
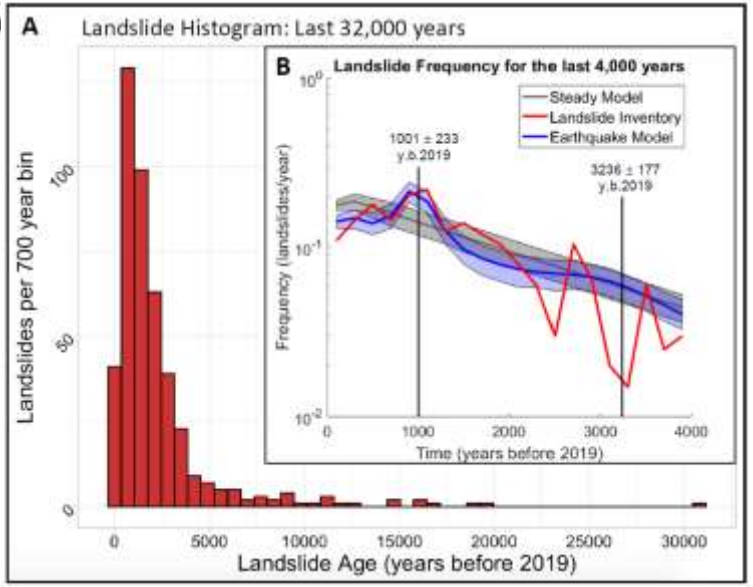
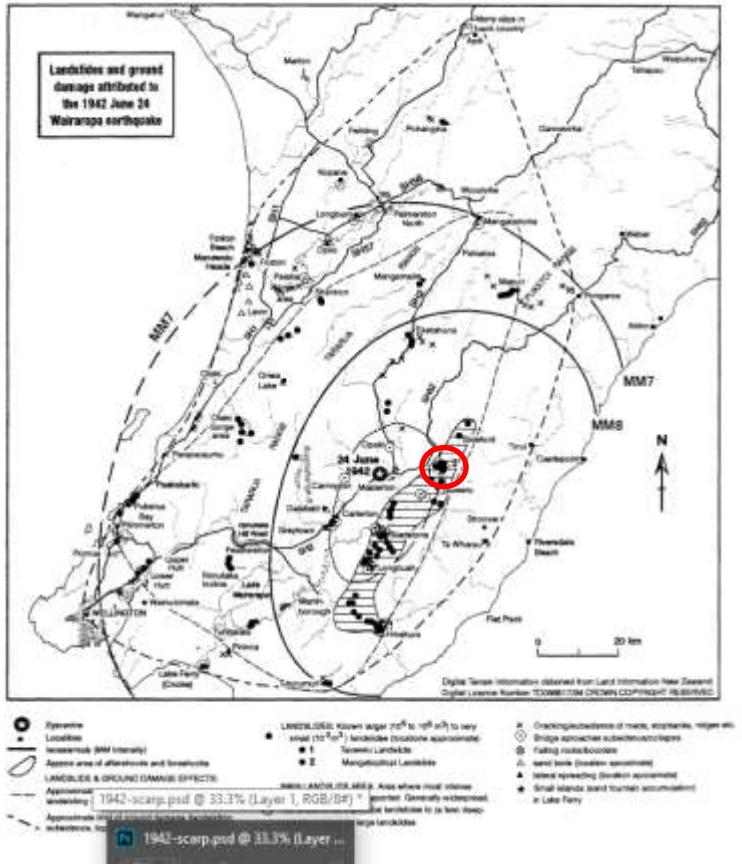


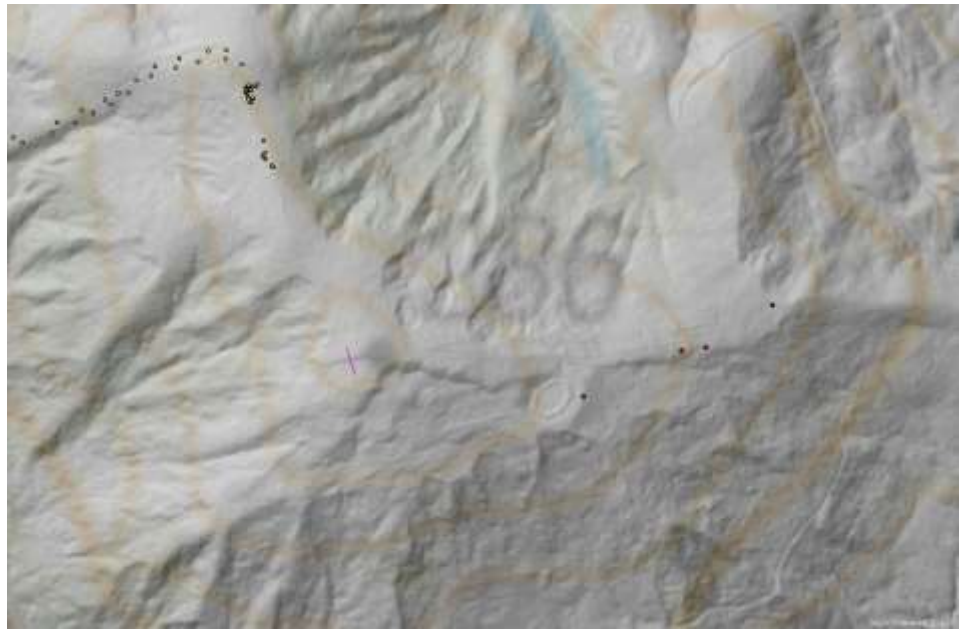
Figure 5. Example of original and modified landslide deposit polygons. A) The original landslide deposit polygon for the Van Zandt landslide. **B)** Van Zandt landslide deposit polygon modified to exclude edges, roads, river cutbanks, ponds, and other anthropogenic features with a 20 m buffer. The surrounding red line represents the extent of the original deposit polygon shown in A. Polygons are draped over hillshade maps derived from ~0

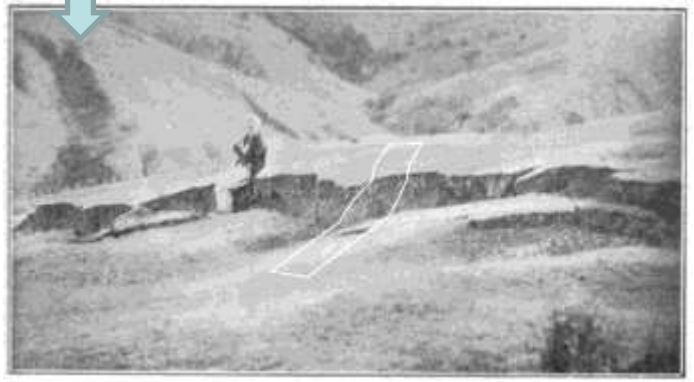


Field targets

- June 1942 Masterton EQ
- sites of land deformation

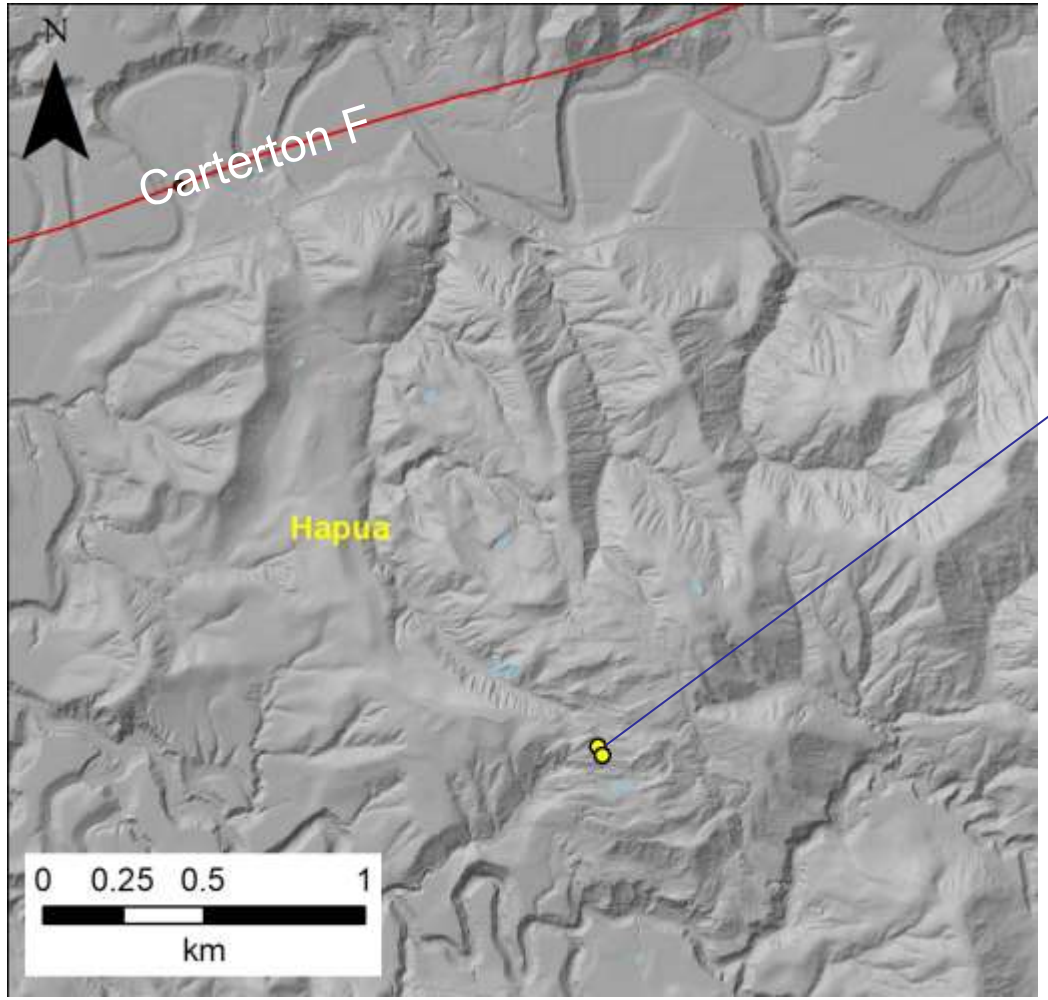






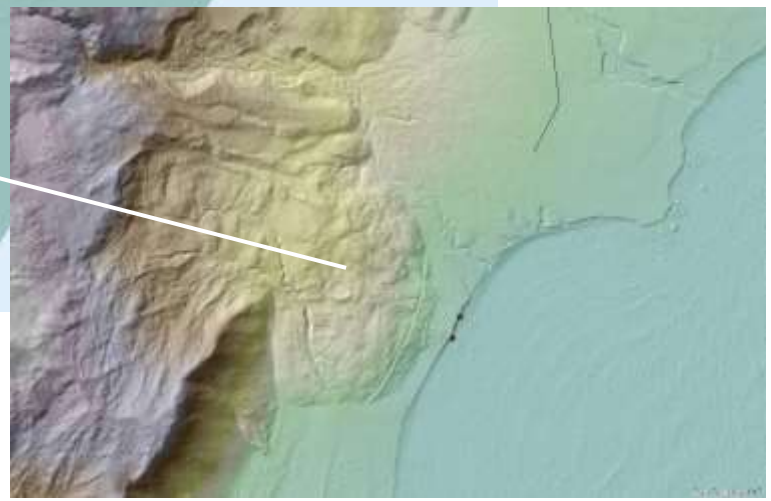
Field targets

- **Large Tauweru landslides**

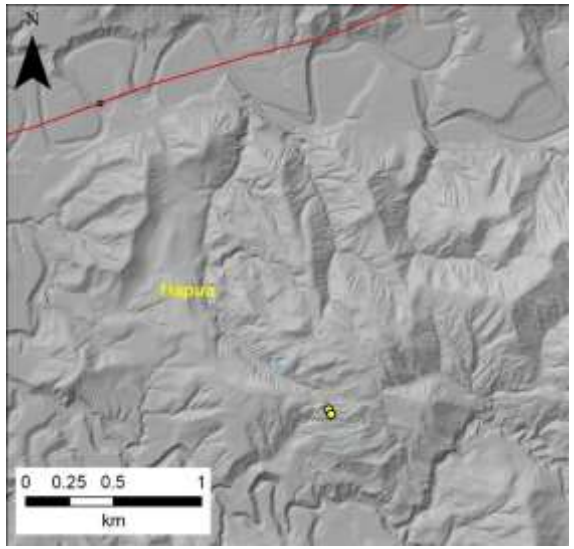


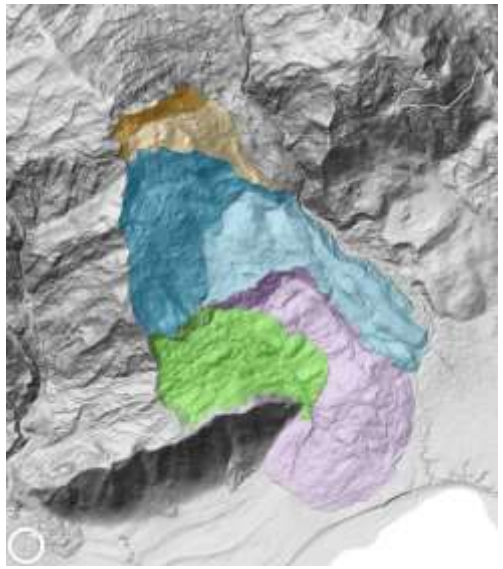
Field targets

- **Coastal sites**



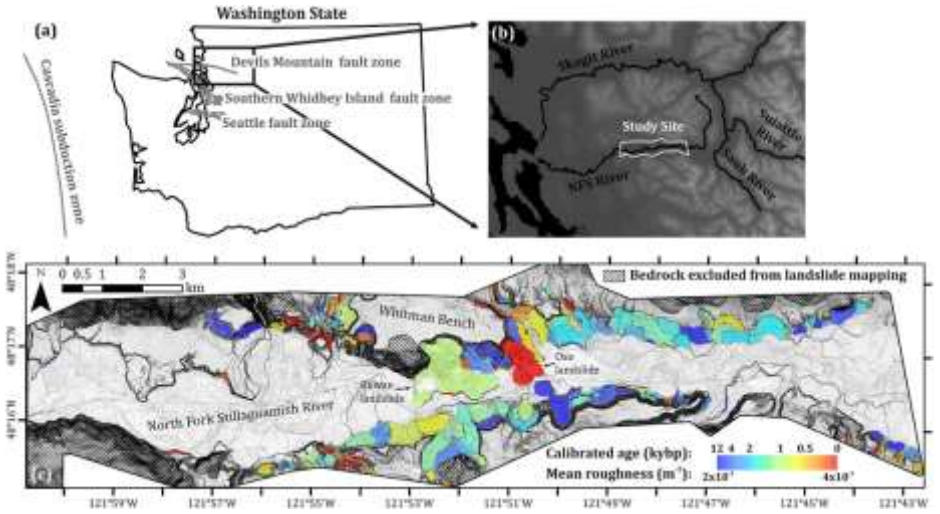
identify



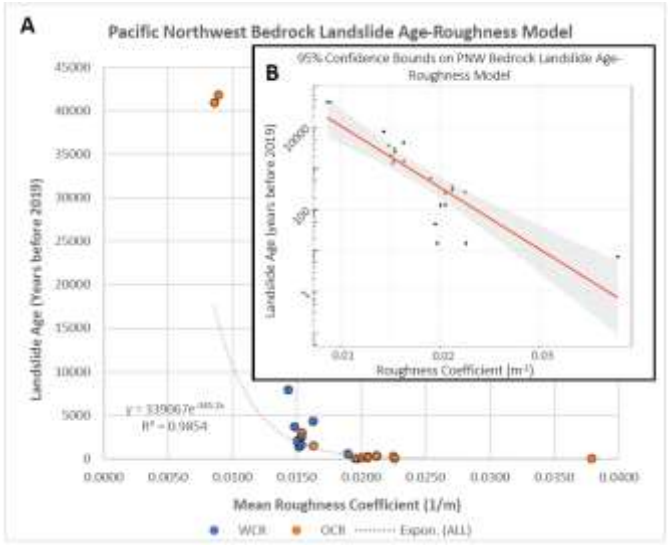


map

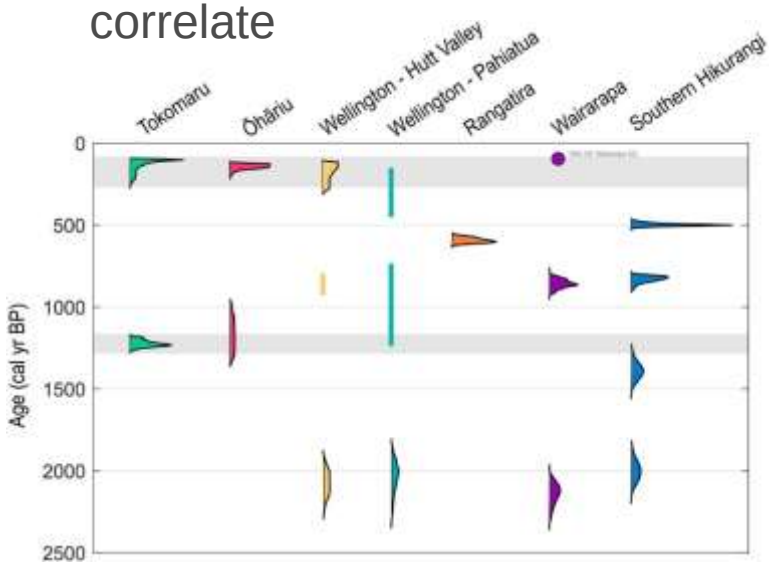
…in a nutshell



landscape model calibrator

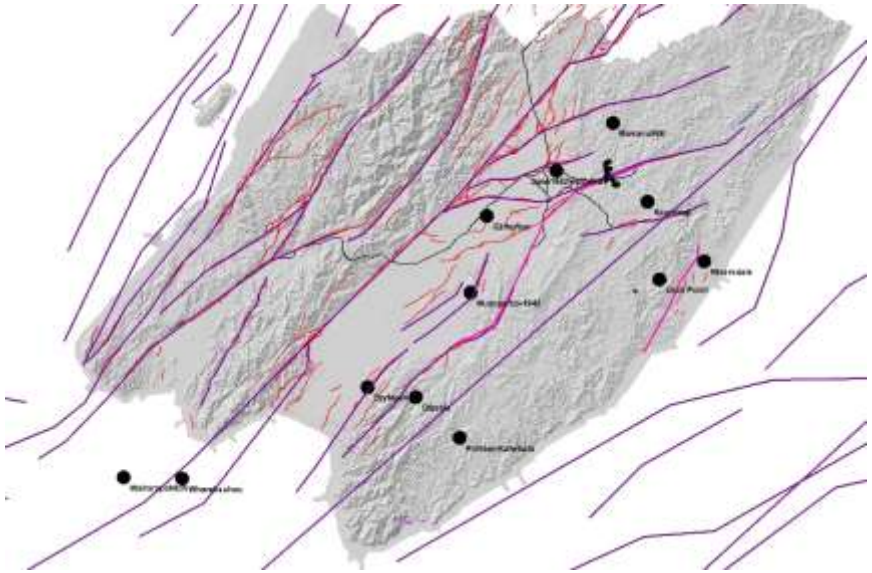


correlate

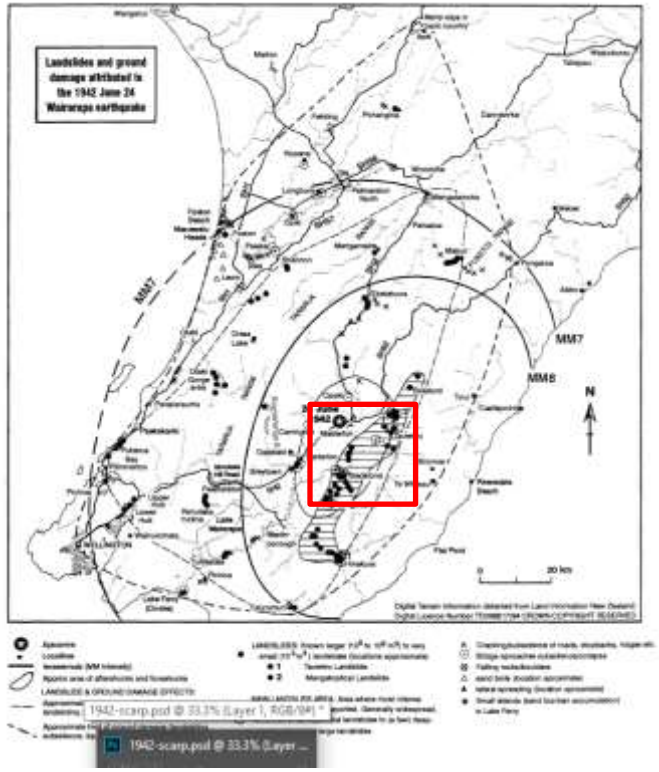


Ground motion calibration

bespoke 1942 EQ source

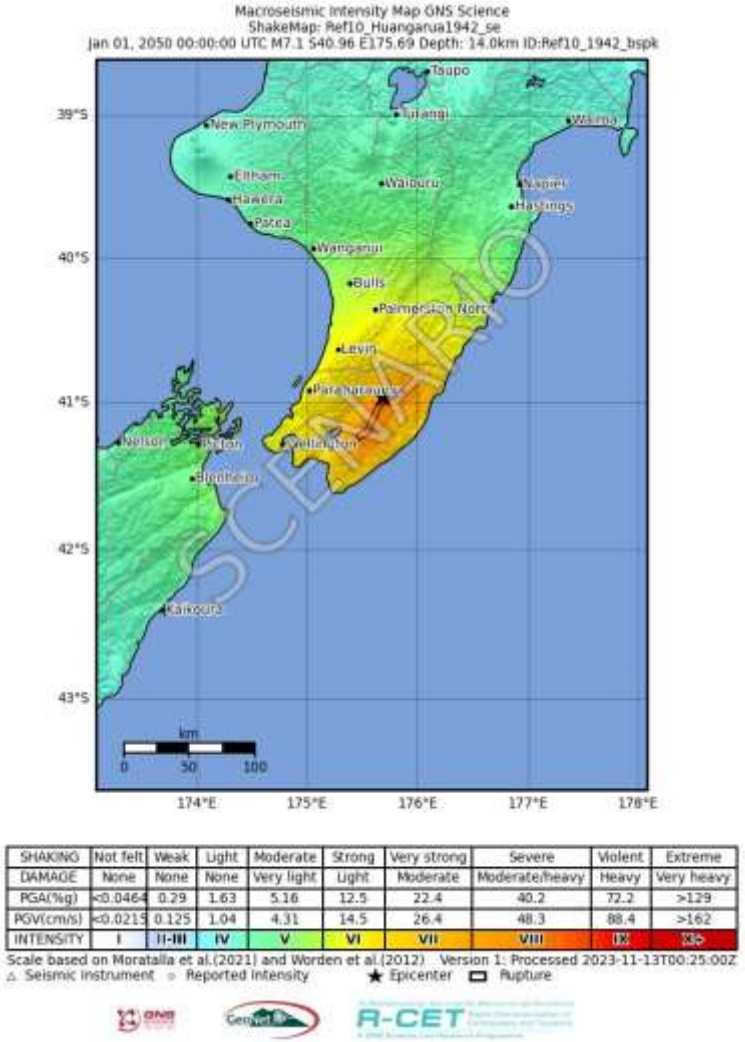


Fault sources and epicentres



Retrolens

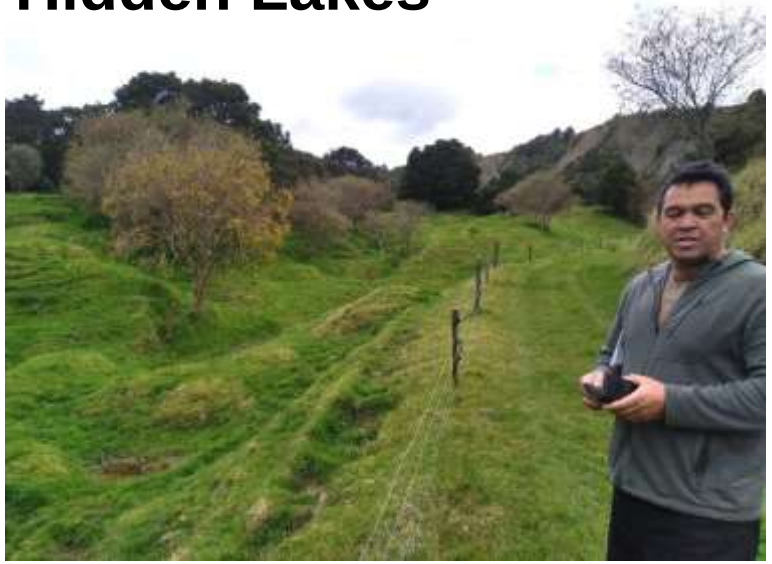
1941 vs 1943 airphotos

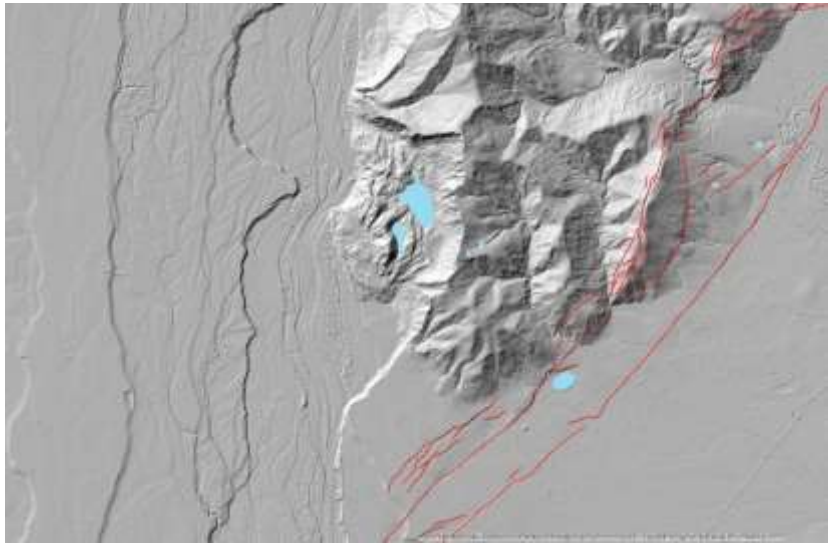


SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	None	None	None	Very light	Light	Moderate	Moderate/heavy	Heavy	Very heavy
PGA(%g)	<0.0464	0.29	1.63	5.16	12.5	22.4	40.2	72.2	>129
PGV(cm/s)	<0.0215	0.125	1.04	4.31	14.5	26.4	48.3	88.4	>162
INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based on Moratalla et al.(2021) and Worden et al.(2012) Version 1: Processed 2023-11-13T00:25:00Z
△ Seismic Instrument ○ Reported Intensity ★ Epicenter ▭ Rupture

Te Tirohanga o Hinetearorangi ki te motu ki a Kāpiti
Hidden Lakes





Hikurangi Landslides - Smart Ideas

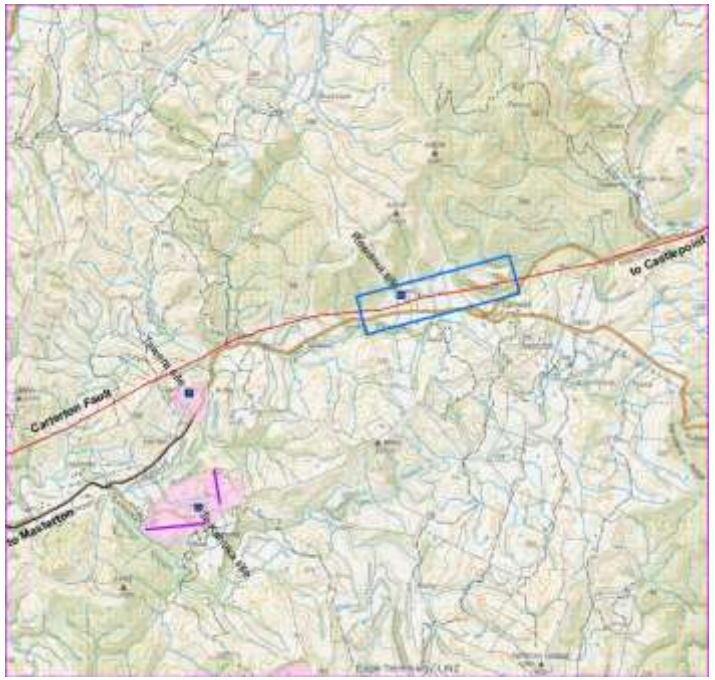
- Integrated ‘proof of concept’ project
- Involves scientists, students and iwi
- About to kick into 3rd gear
- Great potential to add a new element to the Hikurangi story

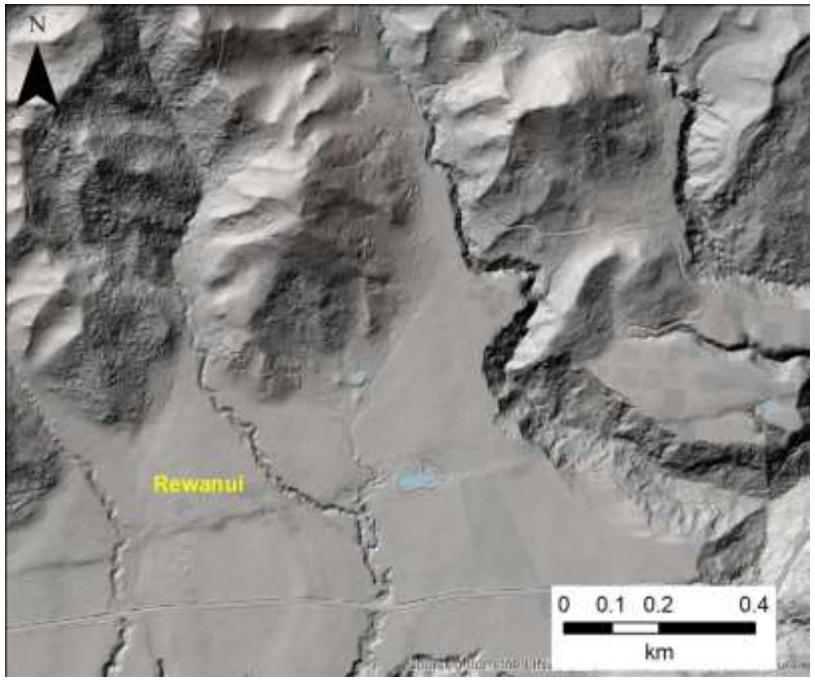
A tale of two seasons

December 2022

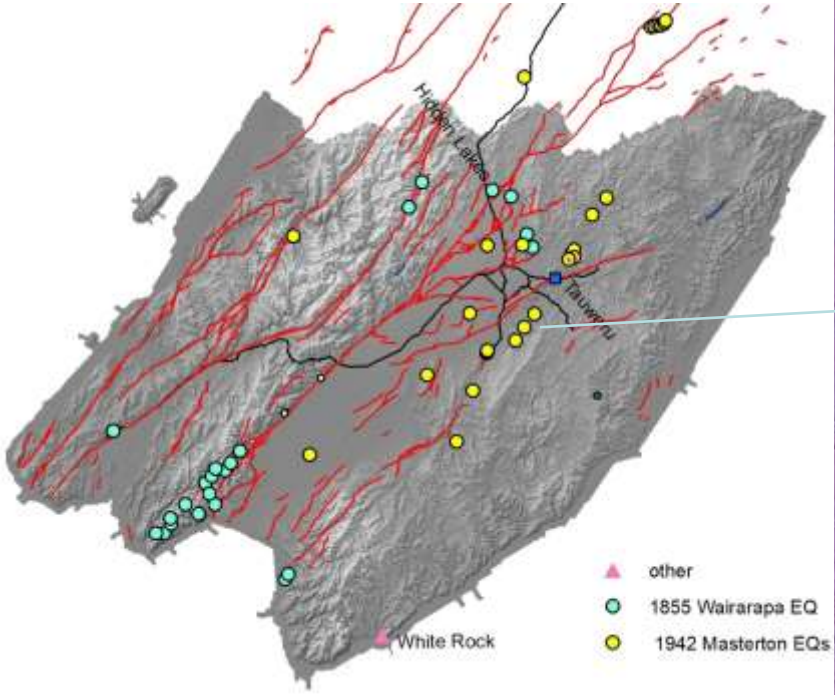
April 2023

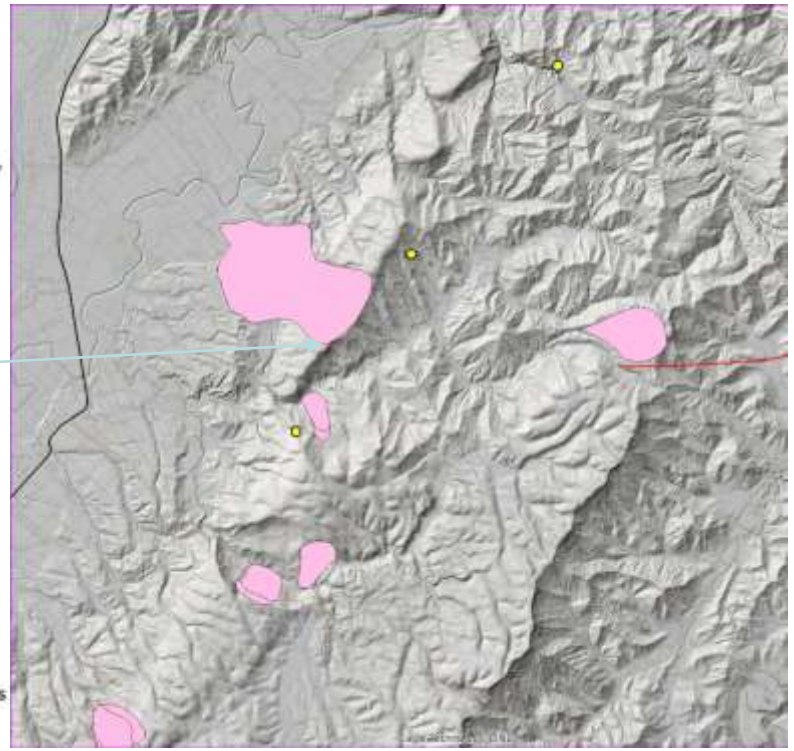
Carterton Fault – Rewanui



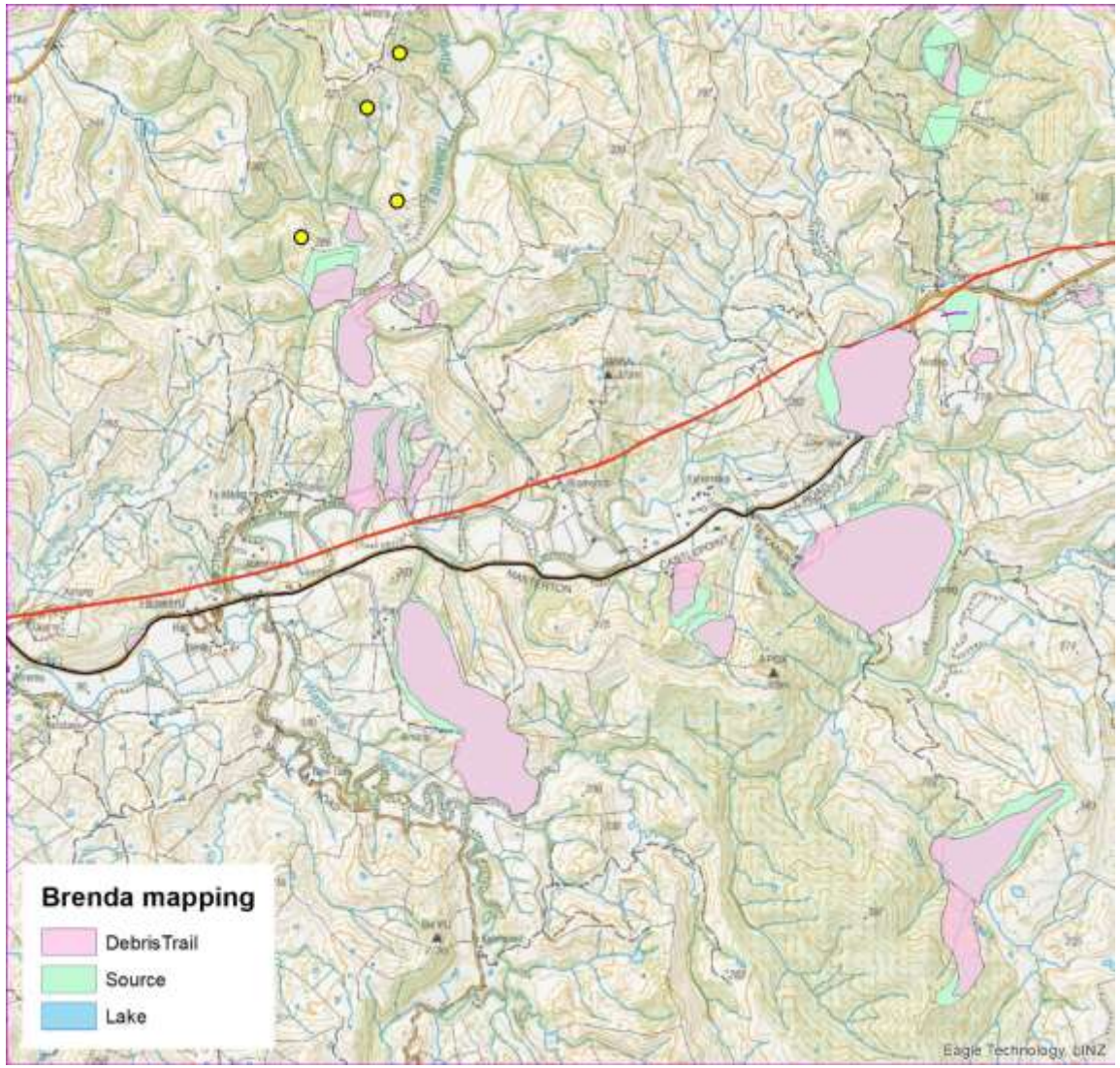


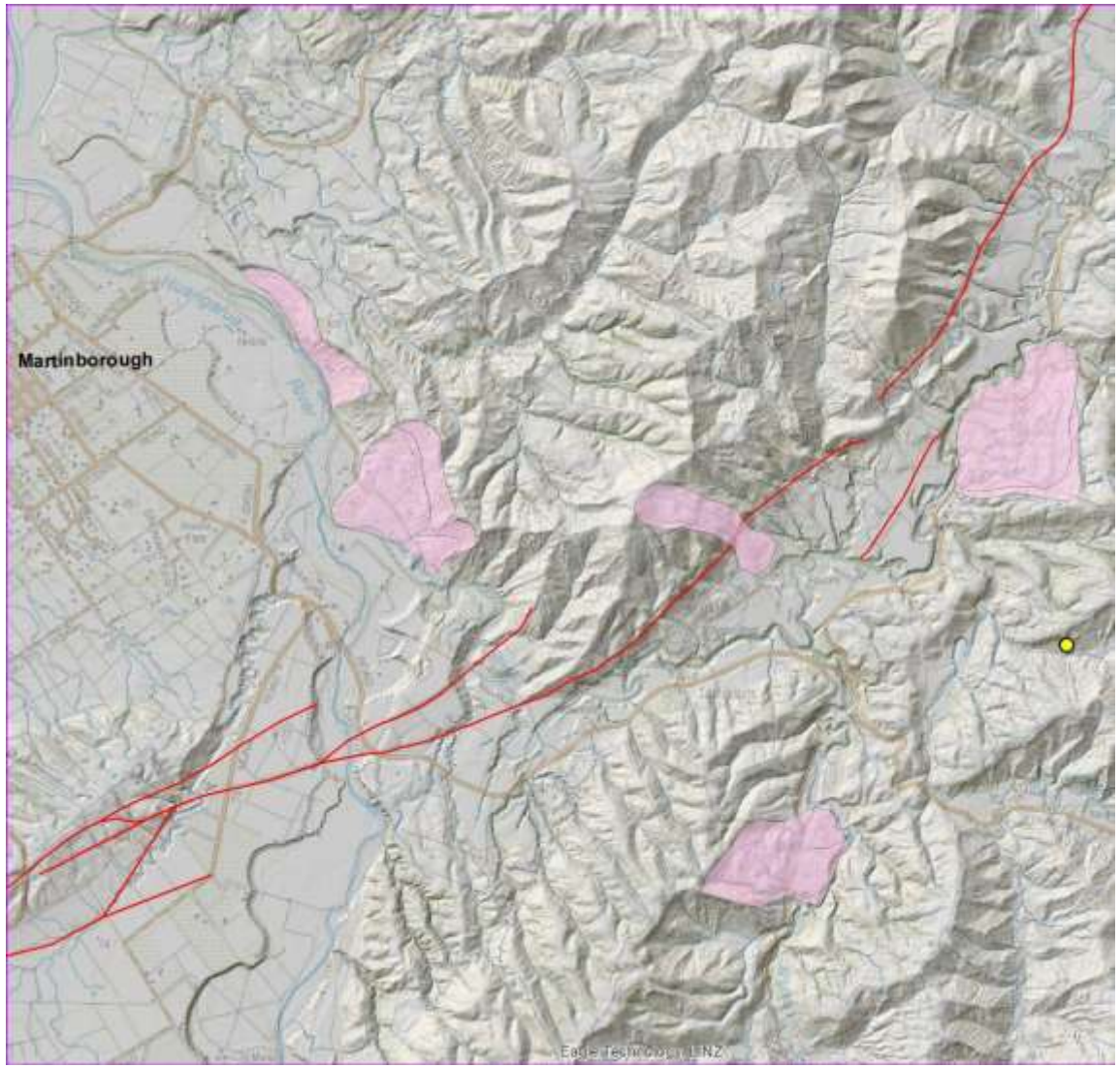
1942 EQ landslides





Tauweru area landslides





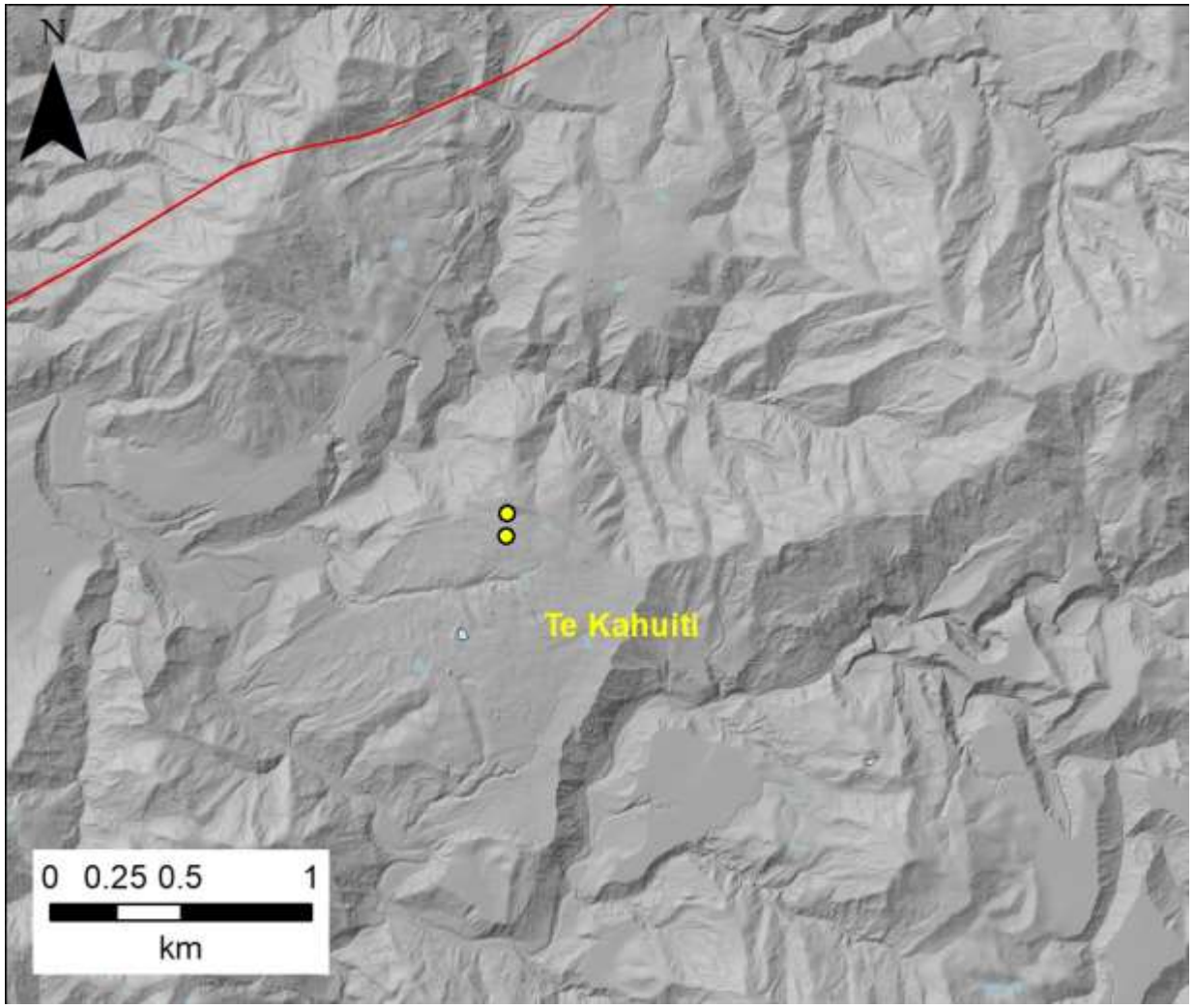
Likely outcomes

- **Significantly expanded paleo-landslide mapping in landslide prone terrain → improved landslide susceptibility & exposure models**

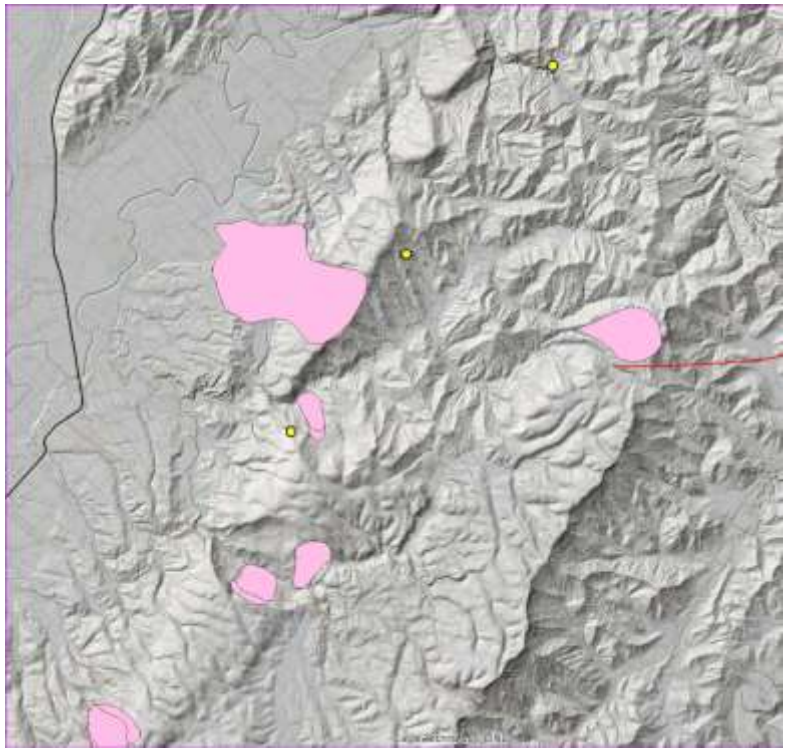
- **Some constraints on (EQ-induced?) landslide age distributions at a regional level → improved planning for future crustal fault and subduction zone events**

- **Some constraints of paleo-earthquake ground motions based on detailed site investigations and models → calibration of NSHM in key area**

Tauweru area landslides – Te Kahuiti

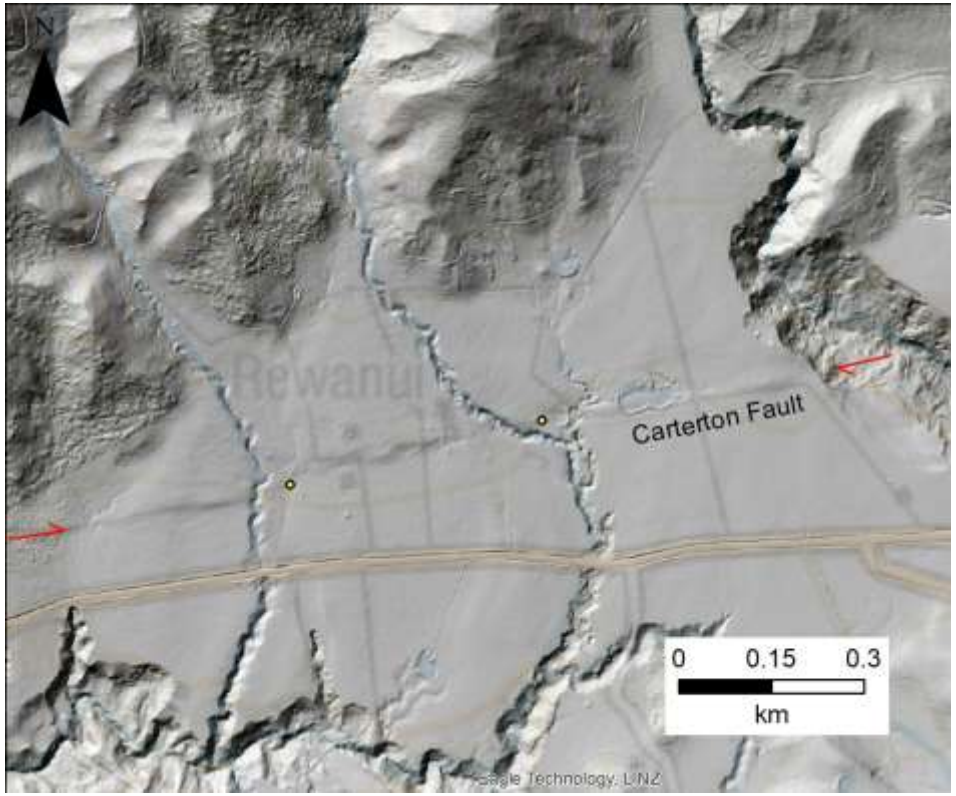


1942 EQ landslides



Field targets

- **Carterton Fault paleoseismicity**



Rewanui Trust Farm block

Carterton Fault – Rewanui

Landslides as tools (proxies)

Origin
weather-induced?

- relationship to stream down-cutting
- sea-level change
- period of increased storminess
- dates cluster at 12,000, 7000 yr B.P.

Origin
human-induced?

- relationship to deforestation
- fires, agriculture
- dates cluster at 700, 150 yr B.P.

Origin
EQ fault-induced?

- spatially associated with fault
- one of several LEILs near a fault
- dates cluster with fault paleoseismicity

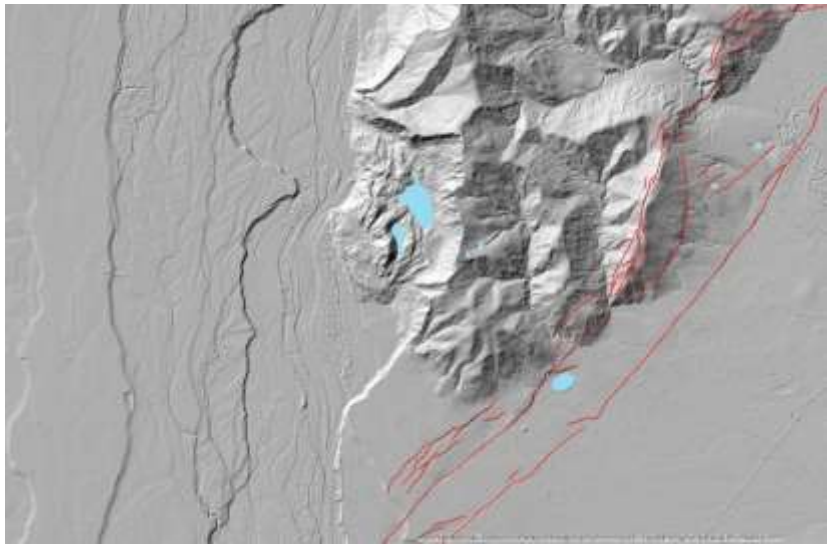
Origin
HSZ-induced?

- not spatially associated with a fault
- one of many regional LEILs
- dates cluster with HSZ paleoseismicity

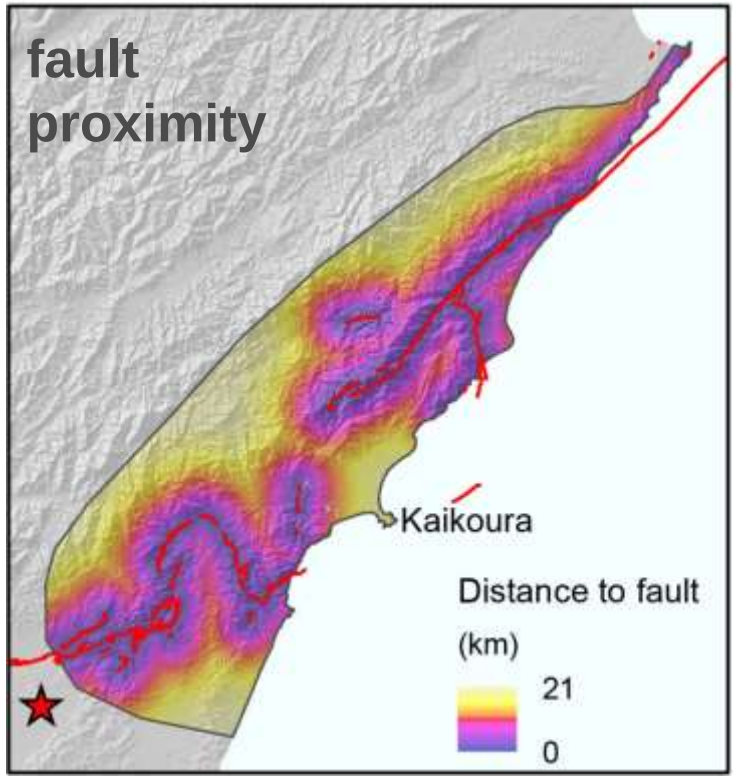
- **Objectives of this project**
- **to map large landslides in the Wairarapa region**
- **to date the inception of these large landslides**
- **consider their triggers (UP vs. SZ vs. other)**
- **model ground motions from UP vs. Hikurangi**
- **utilise aspects of mātauranga and pūrākau**

Science Excellence

- **novel approach to viewing Hikurangi shaking through the lens of paleo-landslides**
- **inverting LS predictor tool for paleo-LSs**
- **developing maps that indicate the probability of damaging LSs**
- **presenting CPs for sections of the Hope Fault zone**



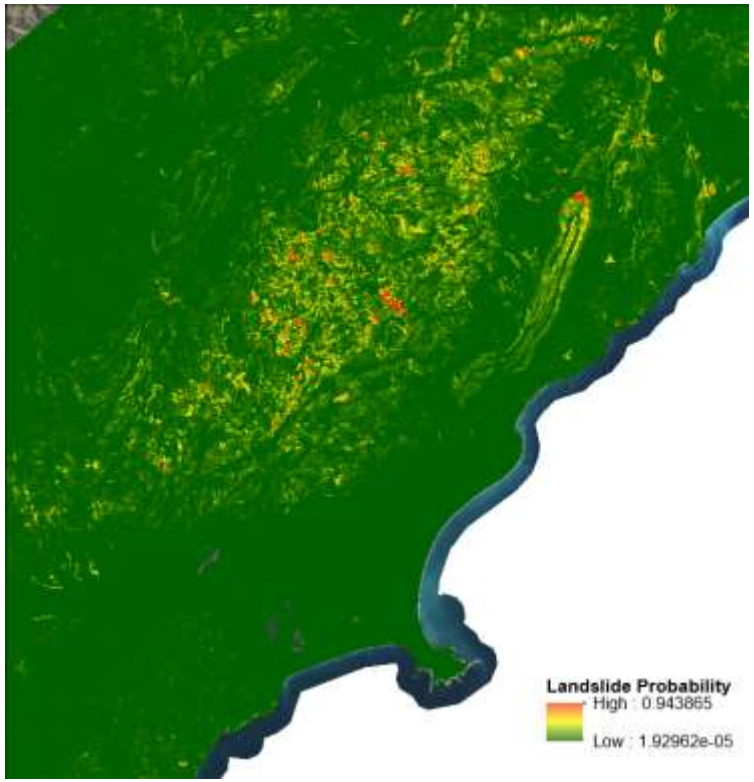
LiDAR

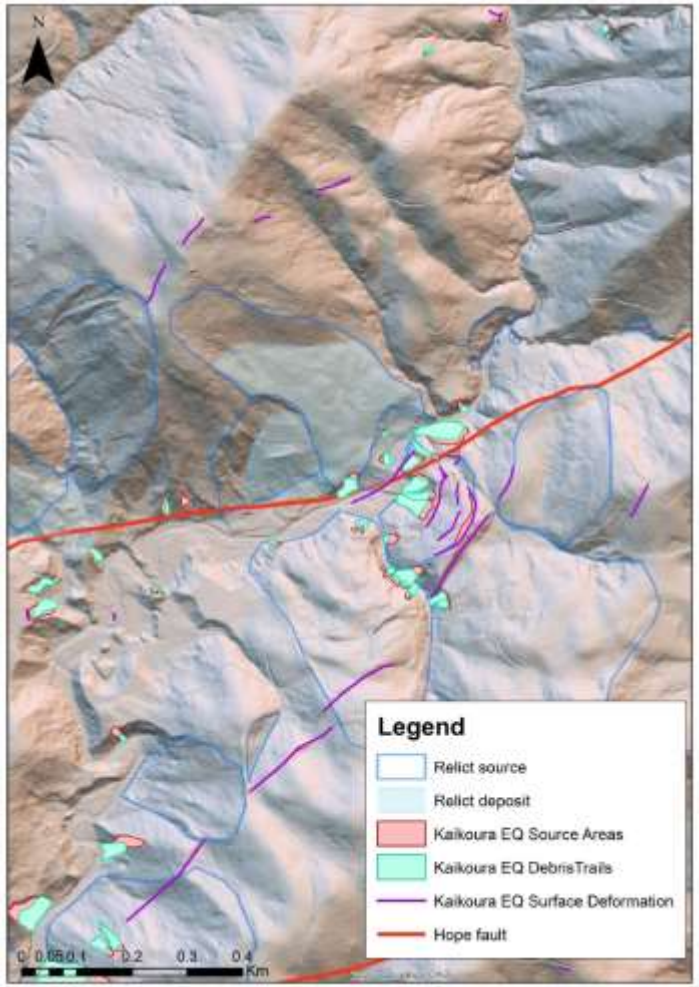


field data

Science Excellence

- novel approach to viewing paleo-EQs through the lens of paleo-LSs
- **inverting Landslide Susceptibility Tool to consider paleo-LSs**
- developing maps that indicate the probability of damaging LSs
- presenting CPs for sections of the Hope Fault zone





Science Excellence

- novel approach to viewing paleo-EQs through the lens of paleo-LSs
- inverting LS predictor tool for paleo-LSs
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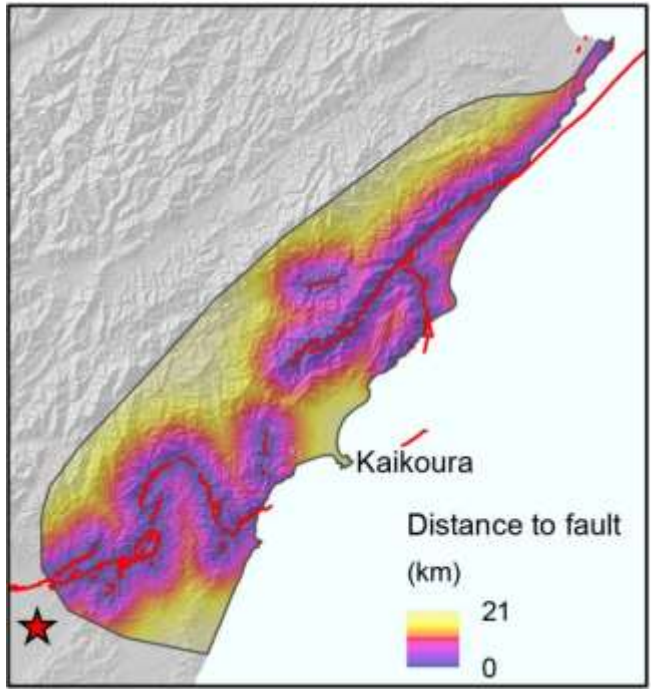
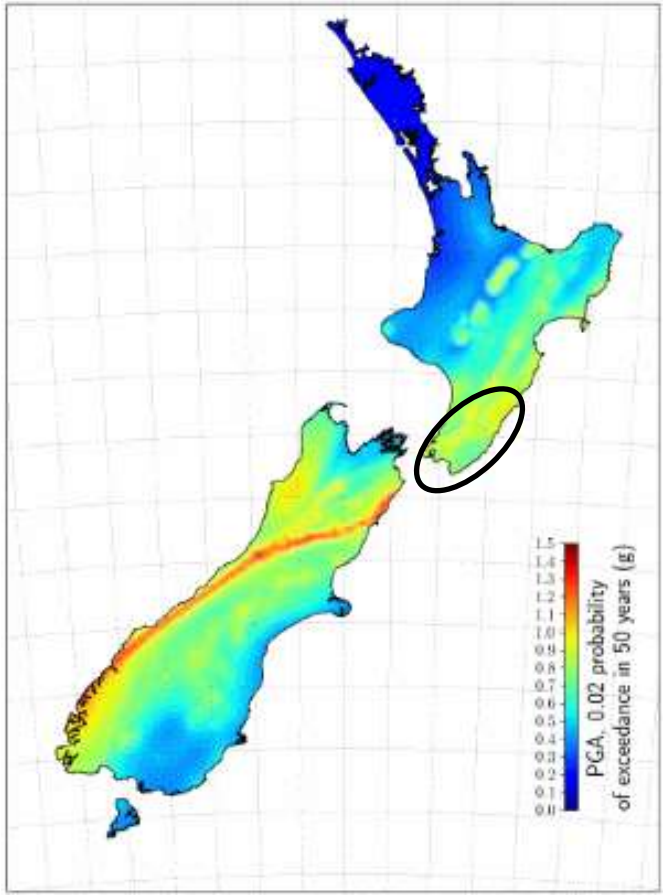
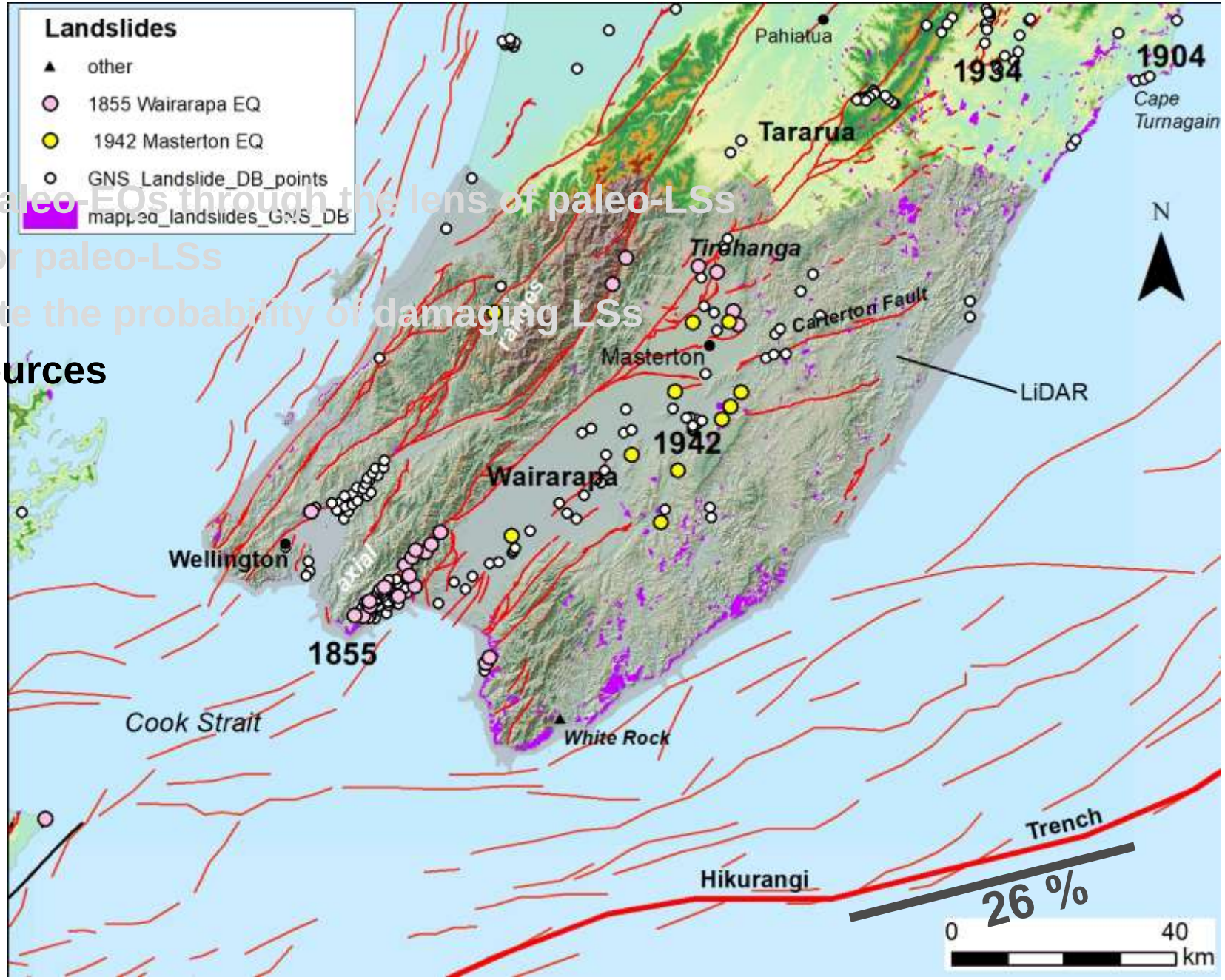


P(ls) α Fault R.I. and Dist (f)



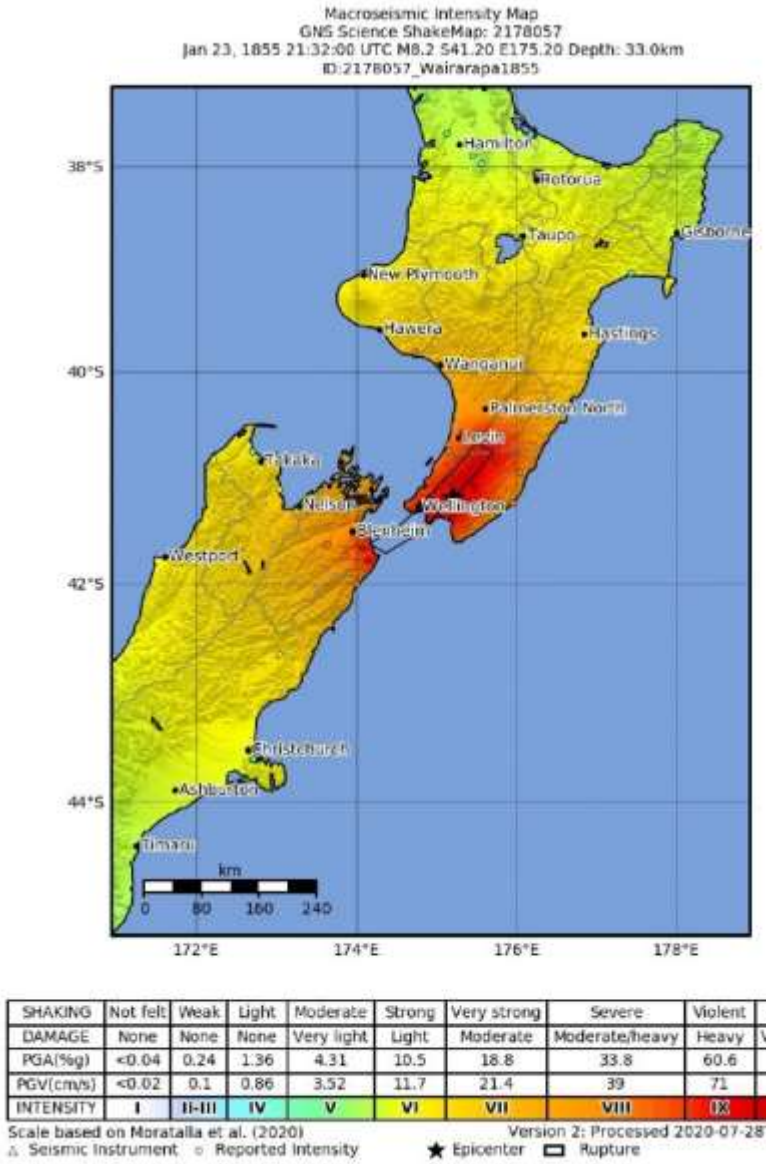
Science Excellence

- novel approach to viewing paleo-EQs through the lens of paleo-LSs
- inverting LS predictor tool for paleo-LSs
- developing maps that indicate the probability of damaging LSs
- **disentangling UP vs. HSZ sources**



Field studies to delineate the timing and style of LEILs

Ways of modelling ground motions



SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	None	None	None	Very light	Light	Moderate	Moderate/heavy	Heavy	Very heavy
PGA(%g)	<0.04	0.24	1.36	4.31	10.5	18.8	33.8	60.6	>109
PGV(cm/s)	<0.02	0.1	0.86	3.52	11.7	21.4	39	71	>129
INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based on Moratalla et al. (2020) Version 2: Processed 2020-07-28T02:20:20Z
△ Seismic Instrument ○ Reported Intensity ★ Epicenter ▭ Rupture

PGA (%g)	0.1	0.2	0.5	1	2	5	10	20	50	100

Scale based on Moratalla et al. (2020) Version 2: Processed 2020-07-28T02:20:20Z
△ Seismic Instrument ○ Reported Intensity ★ Epicenter ▬ Rupture

Some Team news

Your name here

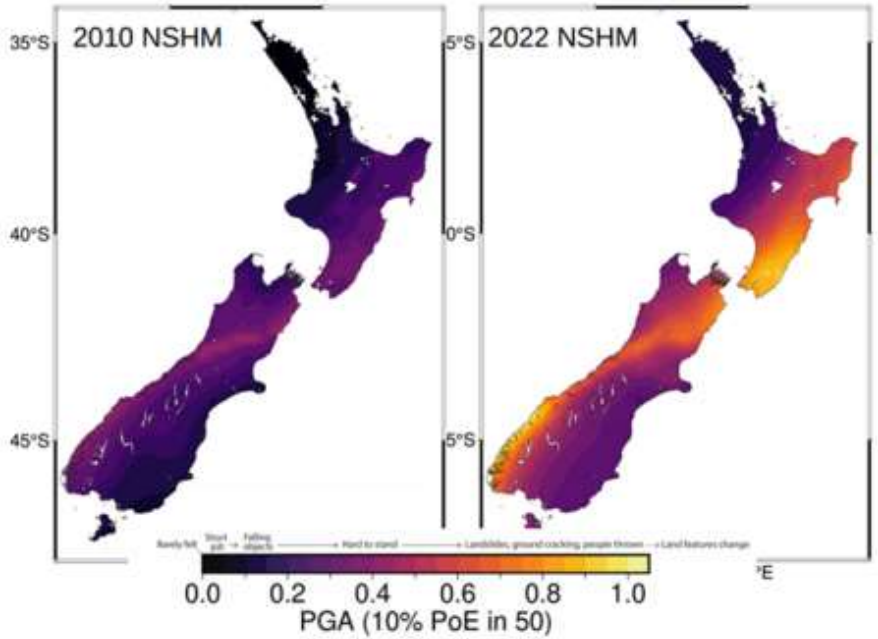
- potential PhD candidate

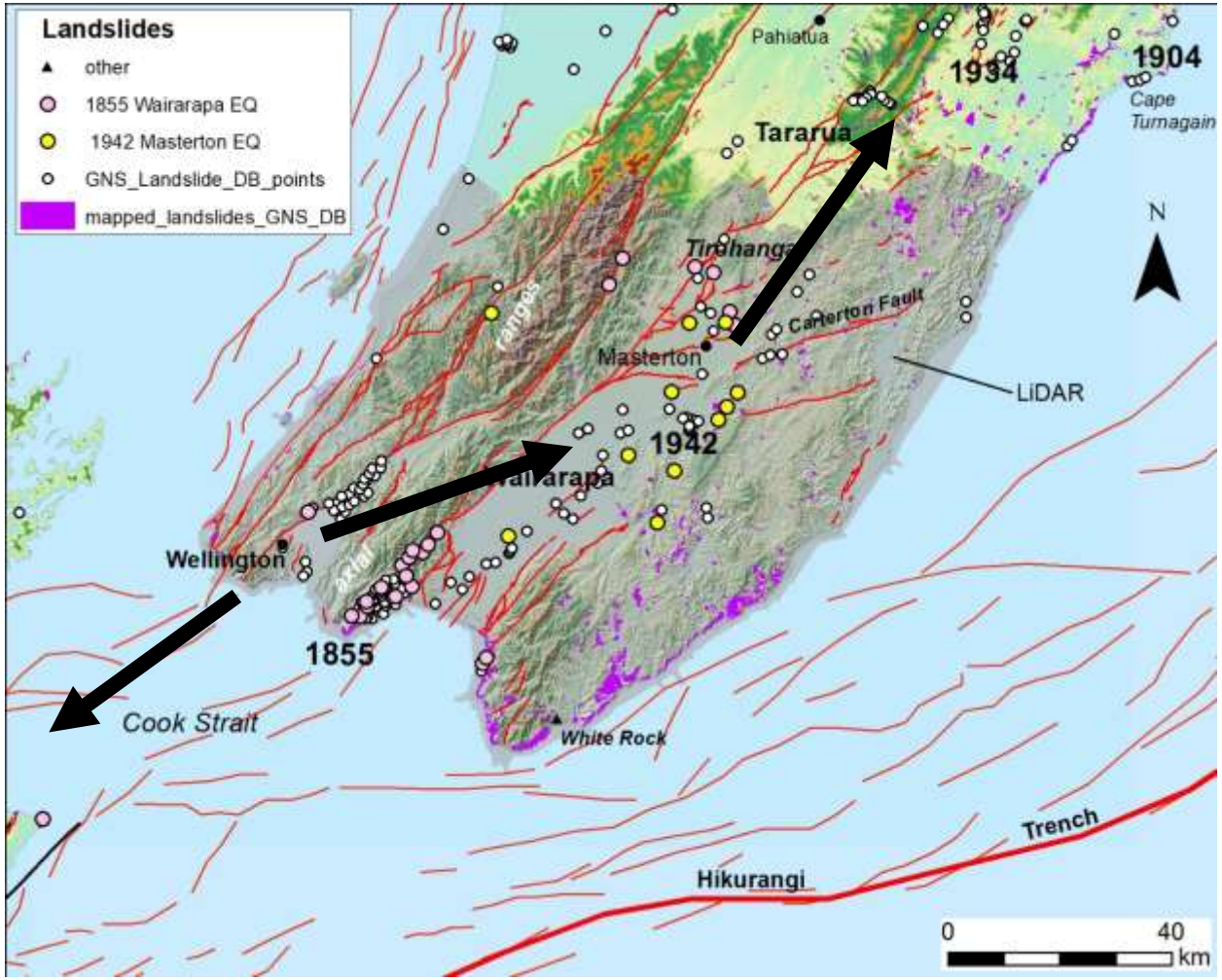
Vision Mātauranga

- Build on early meetings with Joseph
- First visit to Hidden Lakes landslide and Mokonui
- Get stuck into outreach, mātauranga, pūrākau
- Year 2 and 3 calls for Ahunuku scholars

Benefit to Aotearoa-NZ

- testing the new NSHM + RNC2 !
- Testing the EIL tool for subduction EQs
- more resilient infrastructure e.g. highways, lifelines
- more resilient and better prepared communities
- diminished economic impacts from natural disasters
- huge impact for ‘Wellington Inc’ – IOF, WREMO, GWRC

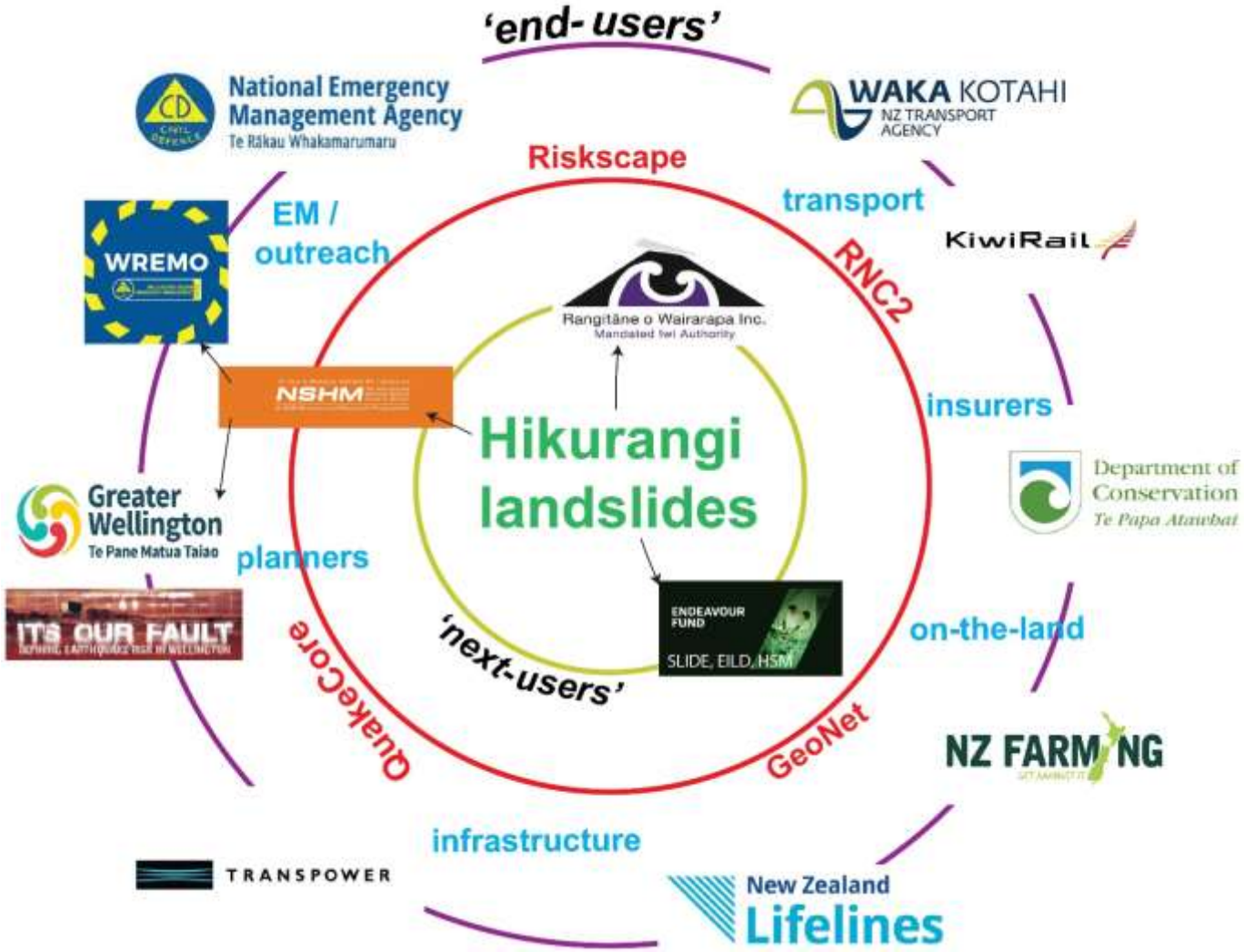




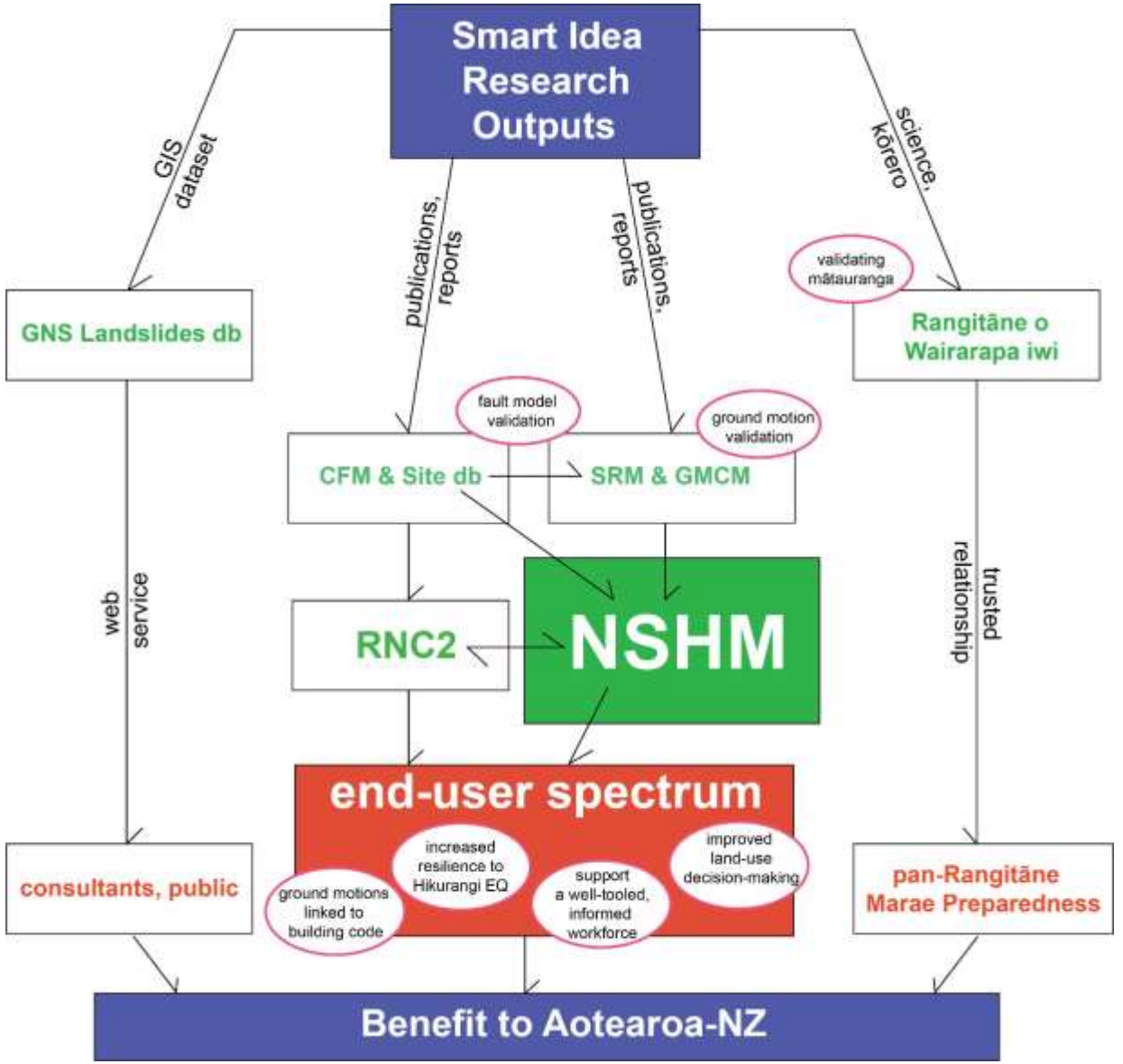
Implementation Pathway

- next users
- End users and stakeholders

  → to be approached post-funding



Implementation Pathway



- **next users**
- **End users and stakeholders**

  → **to be approached further post-funding**