Planning for a future magnitude 8 Alpine Fault earthquake

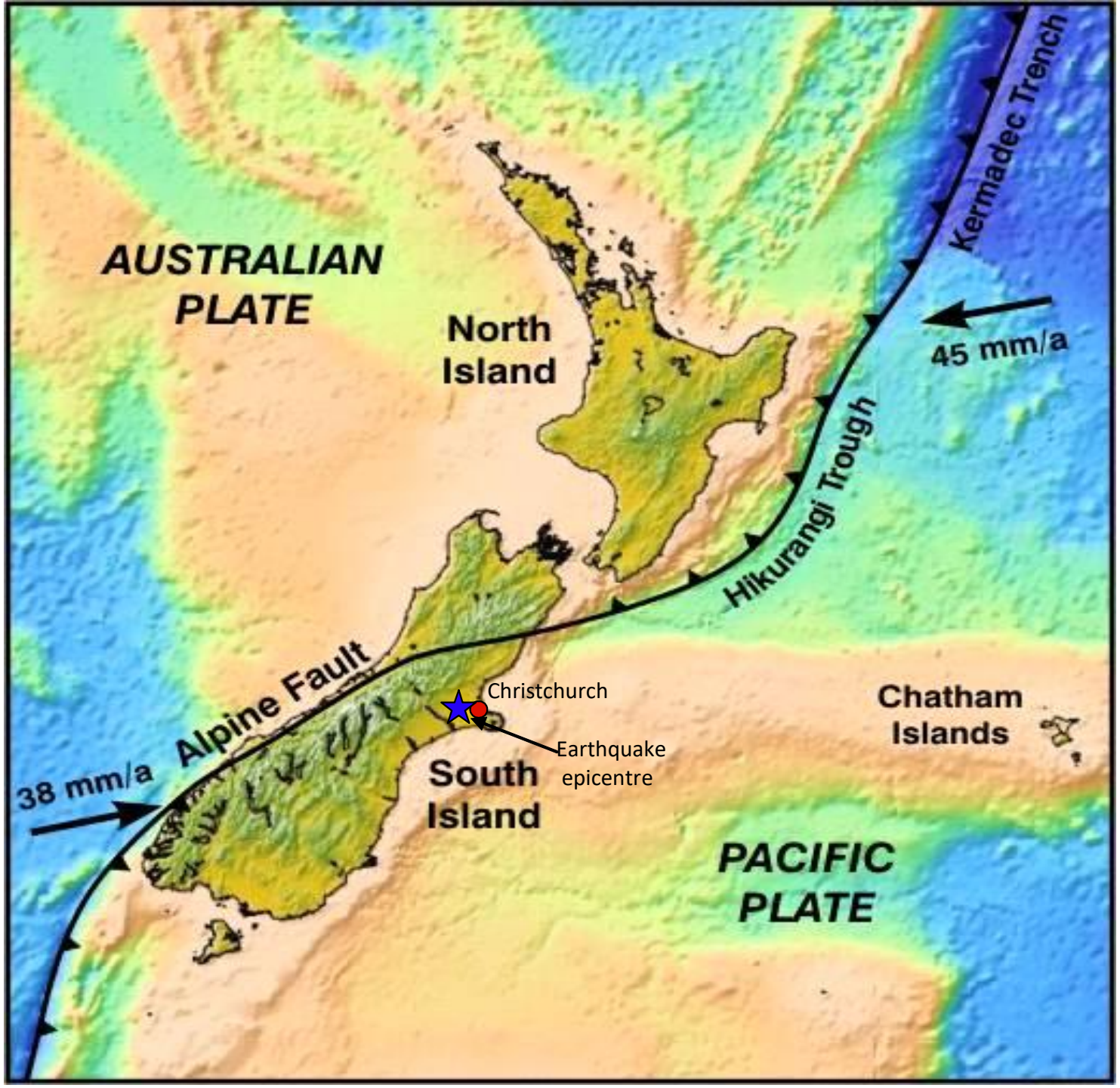
Mat Darling// UNIVERSITY OF CANTERBURY

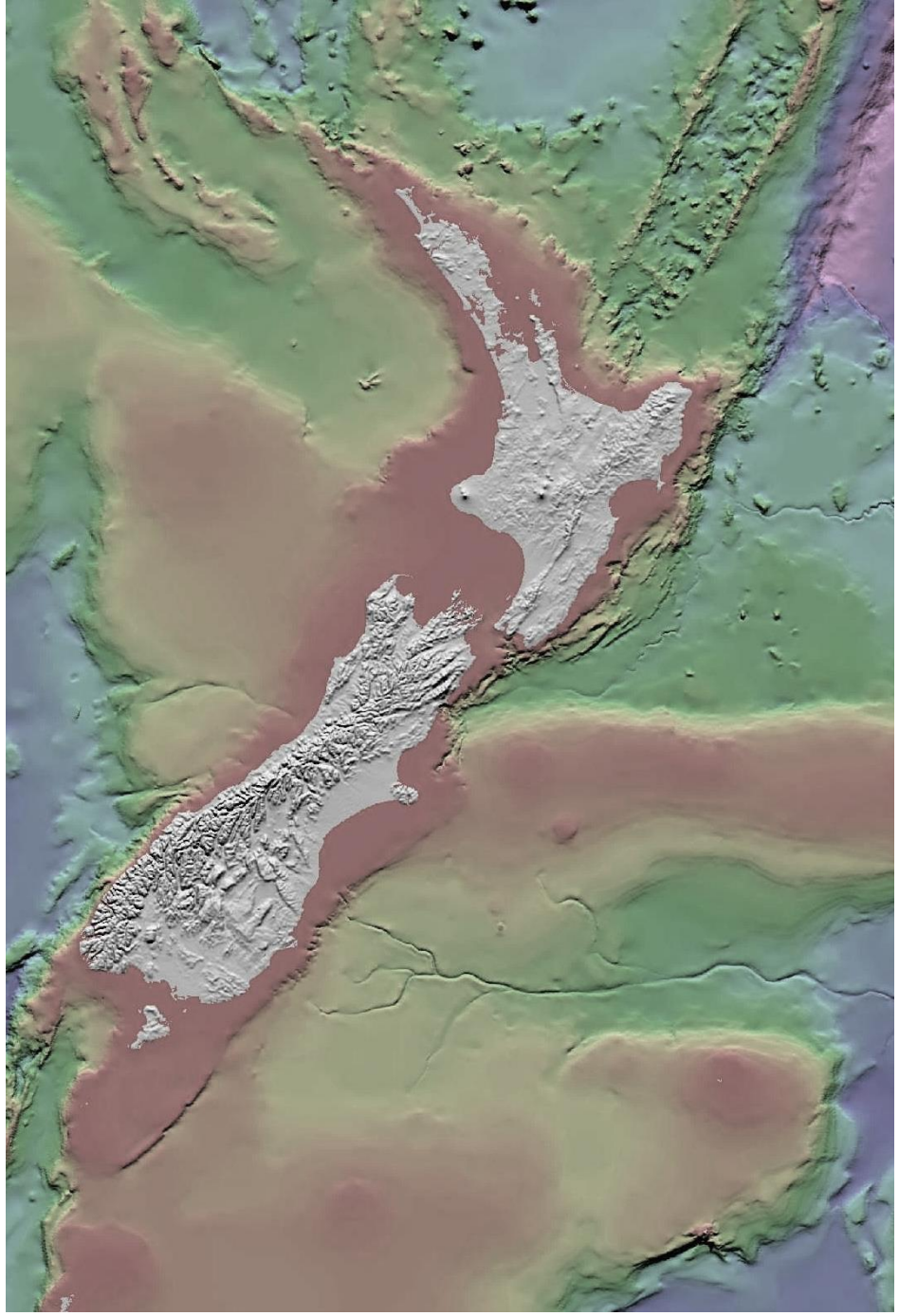
U3A TIMARU, September 2nd 2019

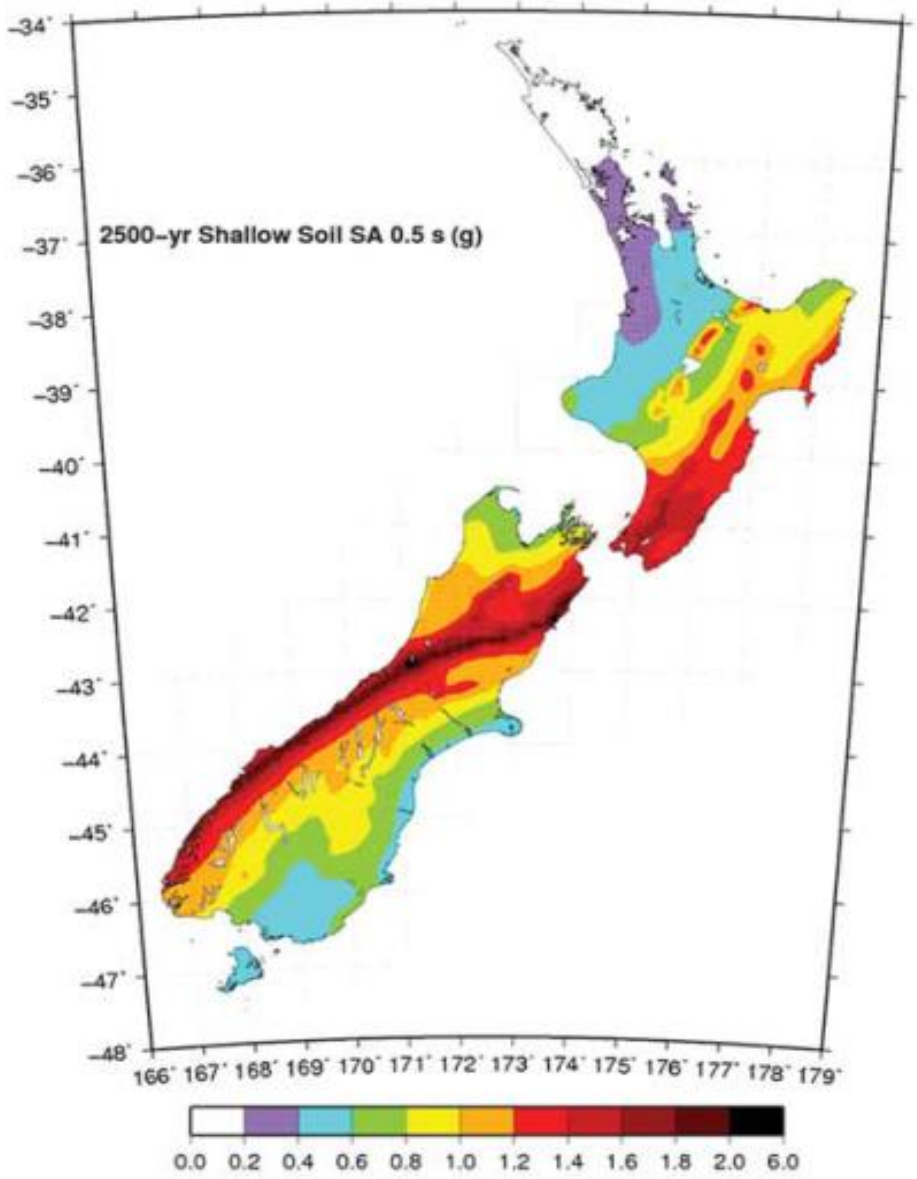
Why has NZ got high seismic risk?

Active Volcanoes, Plate Tectonics, and the "Ring of Fire"

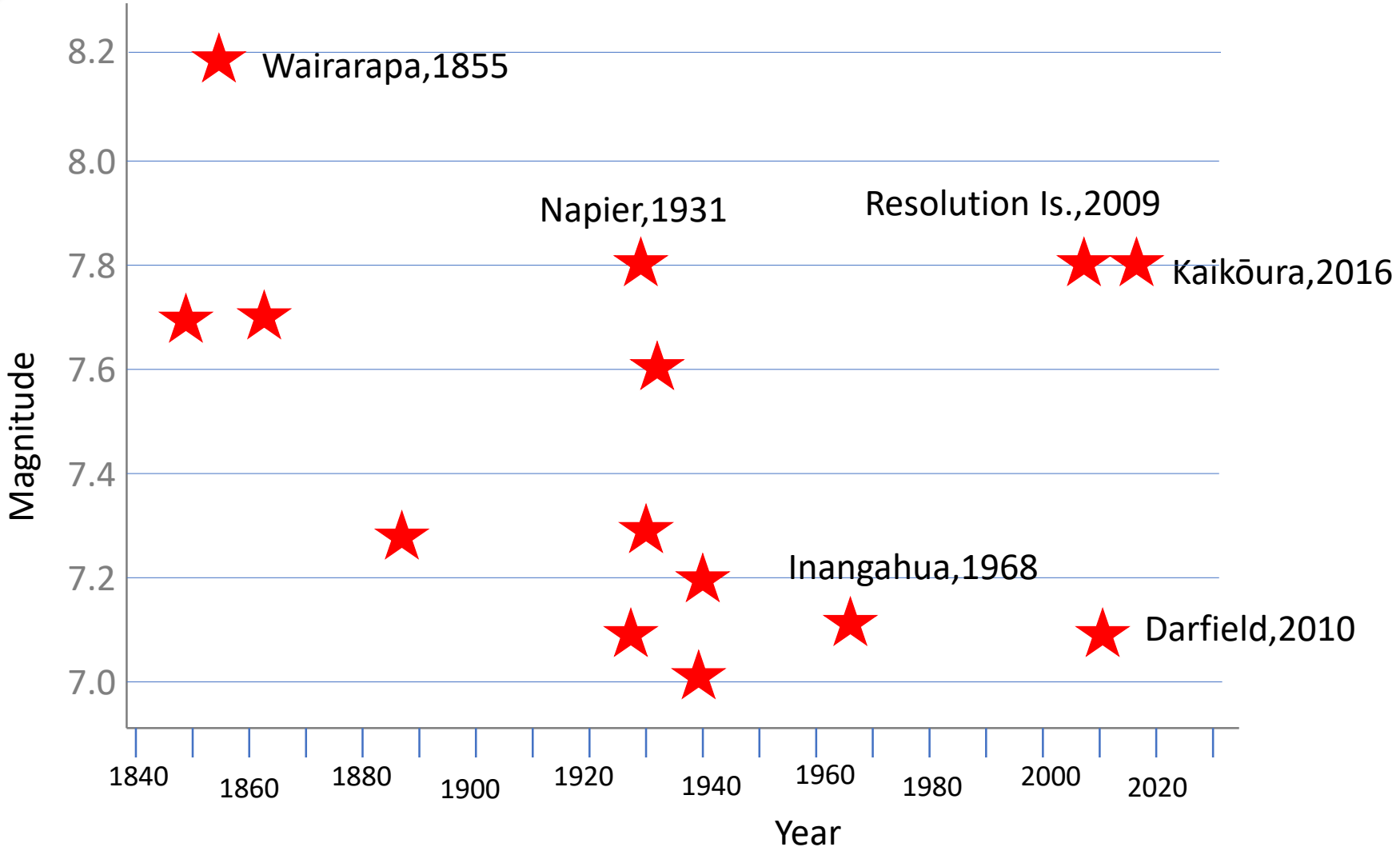
Topinka, USGS/CVO, 1997, Modified from: Tilling, Heliker, and Wright, 1987, and Hamilton, 1976

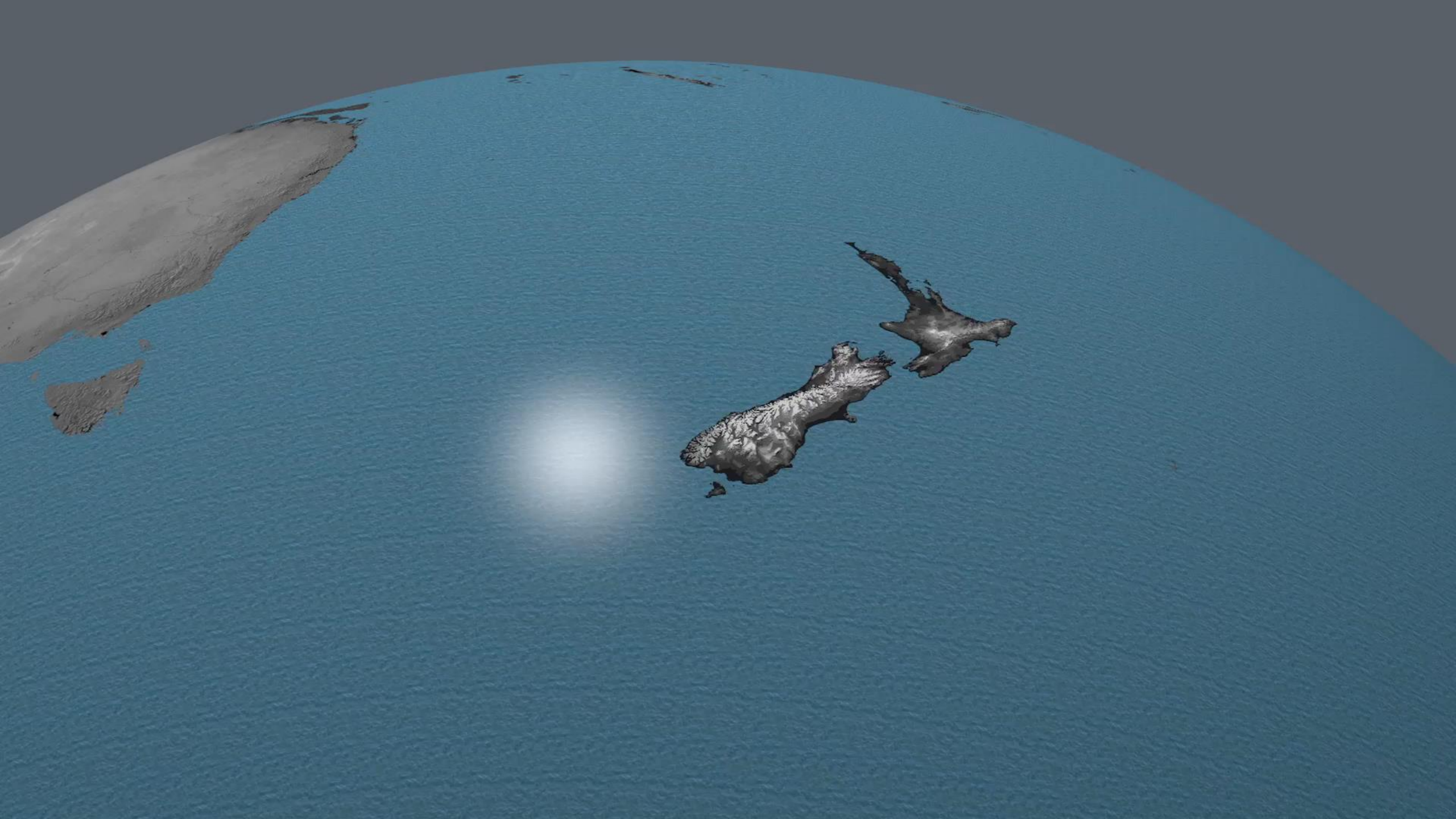

AUSTRALIAN PLATE
North Island
Kermadec Trench
45 mm/a
Hikurangi Trough
Alpine Fault
Christchurch
Earthquake epicentre
Chatham Islands
38 mm/a
South Island
PACIFIC PLATE




2500-yr Shallow Soil SA 0.5 s (g)
-34°
-35°
-36°
-37°
-38°
-39°
-40°
-41°
-42°
-43°
-44°
-45°
-46°
-47°
-48°
166° 167° 168° 169° 170° 171° 172° 173° 174° 175° 176° 177° 178° 179°
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 6.0

NZ Earthquake history – magnitude 7+





Waimakariri River
Alpine Fault
Rakaia River

Photo credit: GNS Science

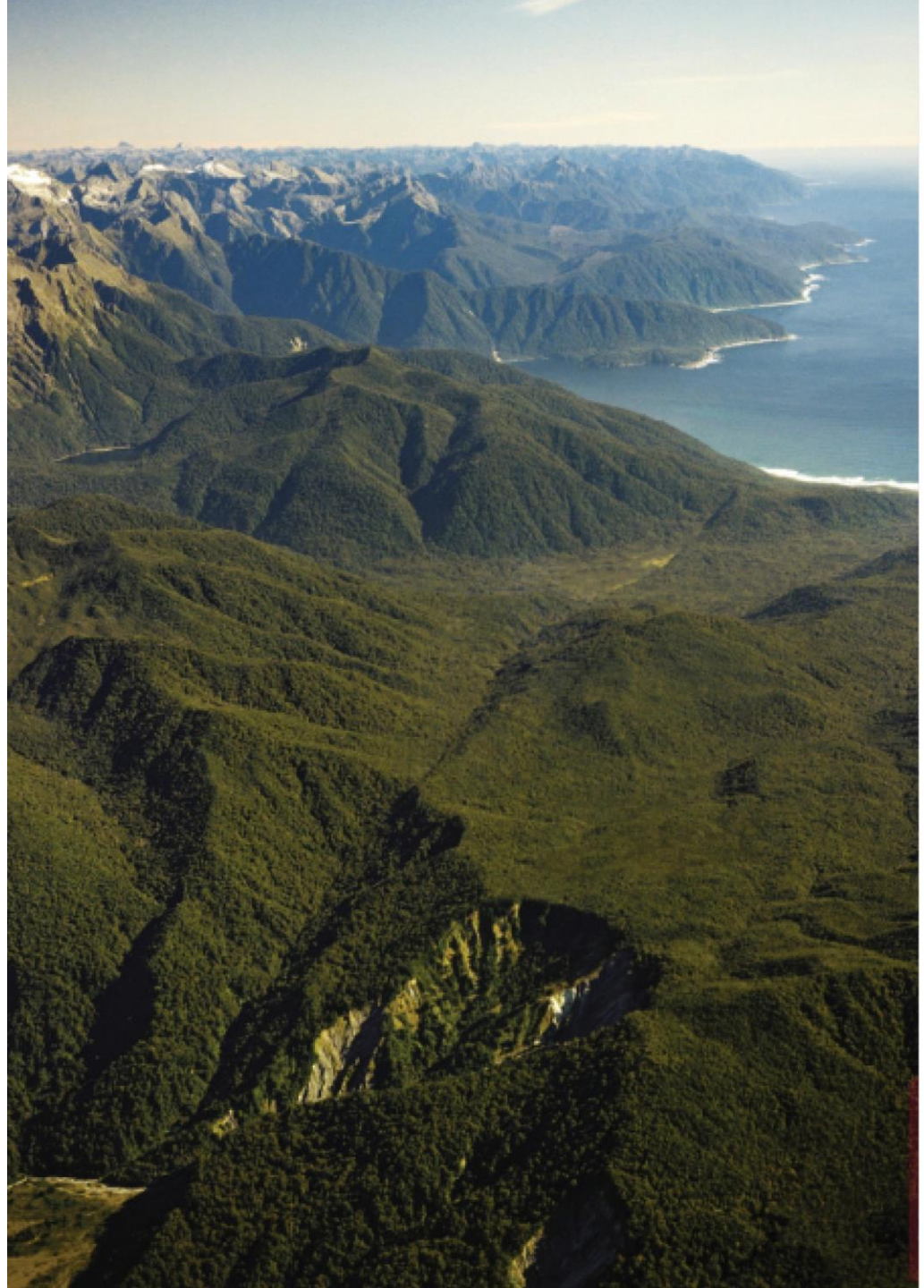
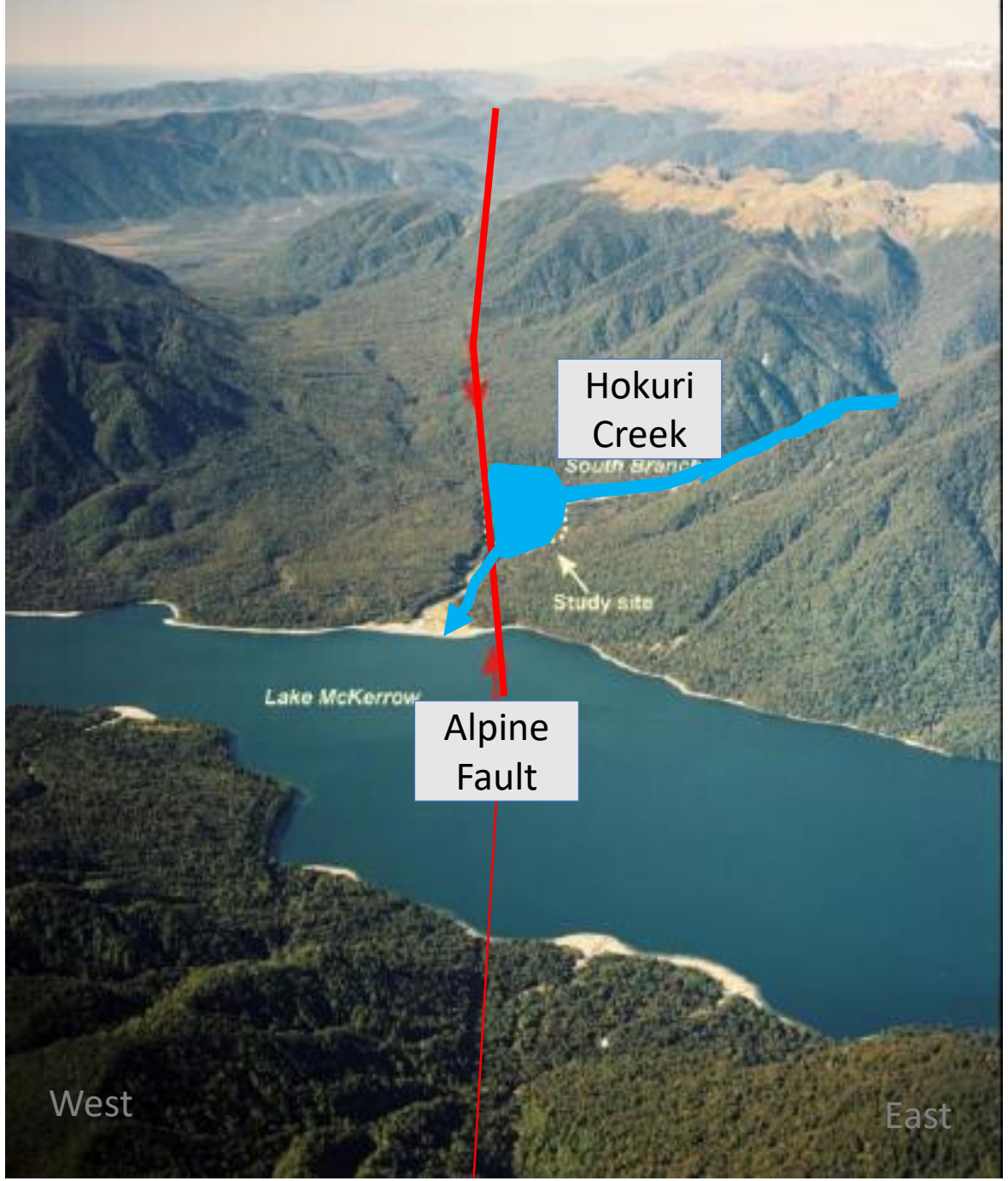


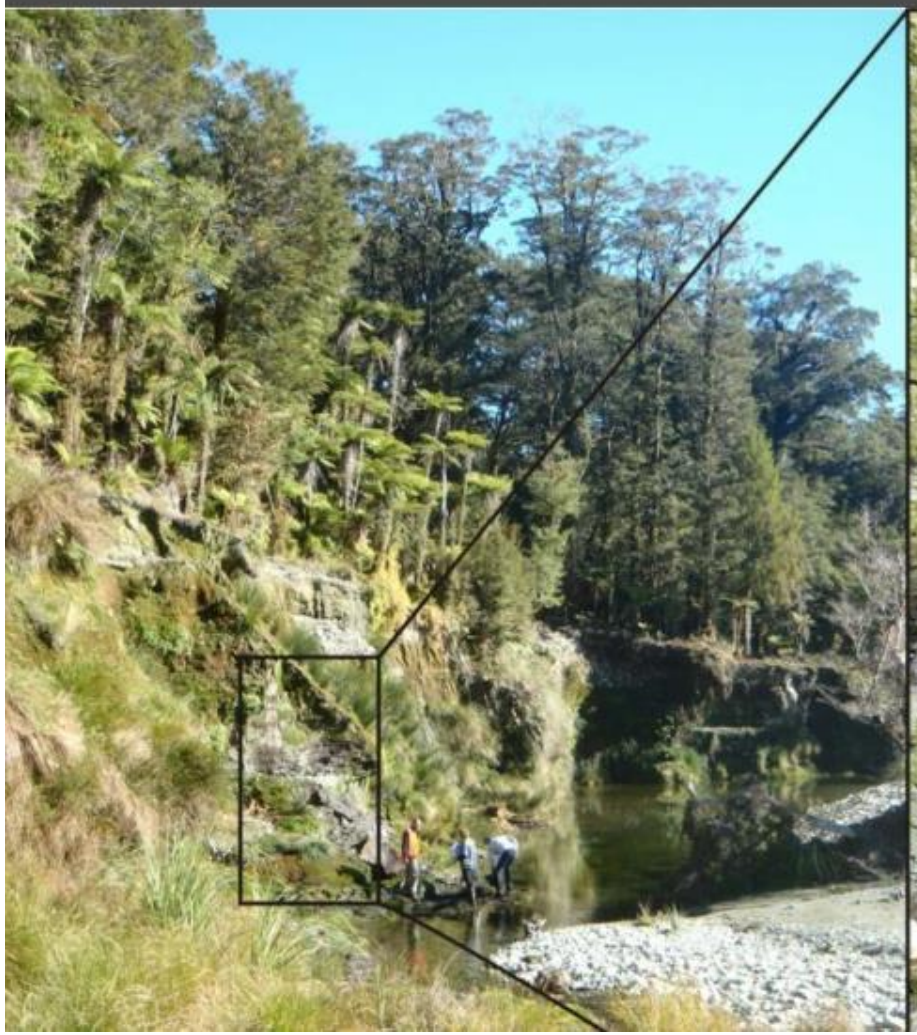
Photo credit: GNS Science

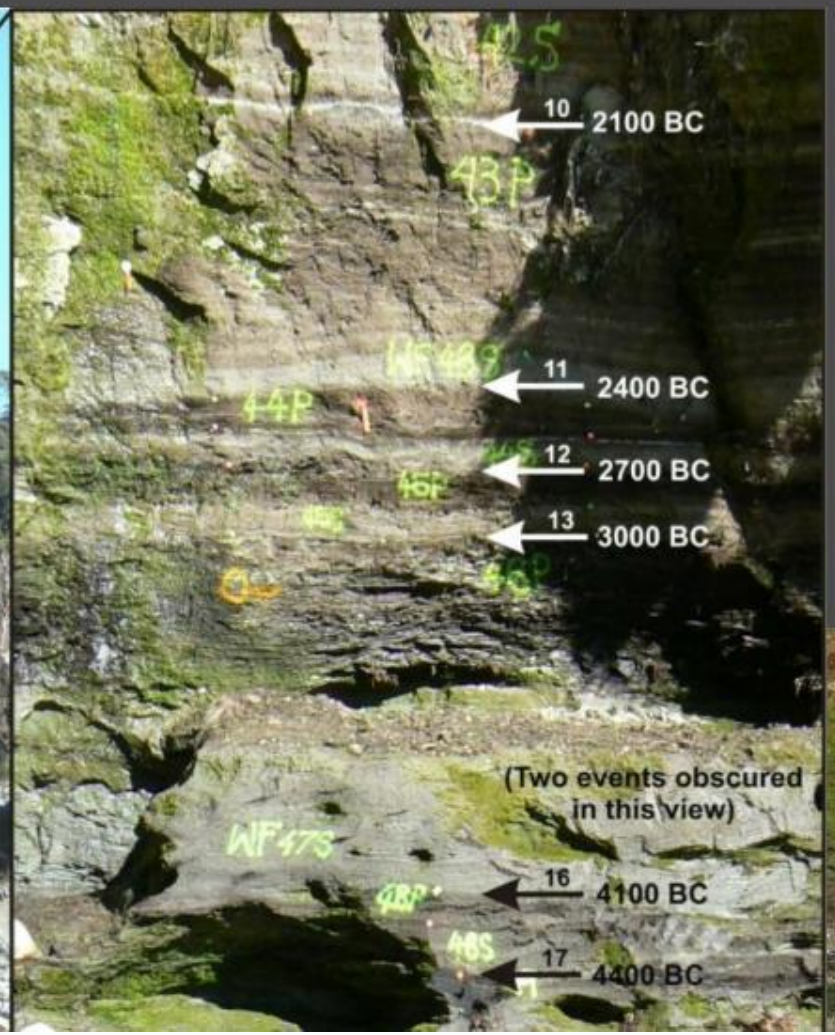


Evidence for past Alpine Fault quakes

Slide courtesy of Dr. Ursula Cochran, GNS Science

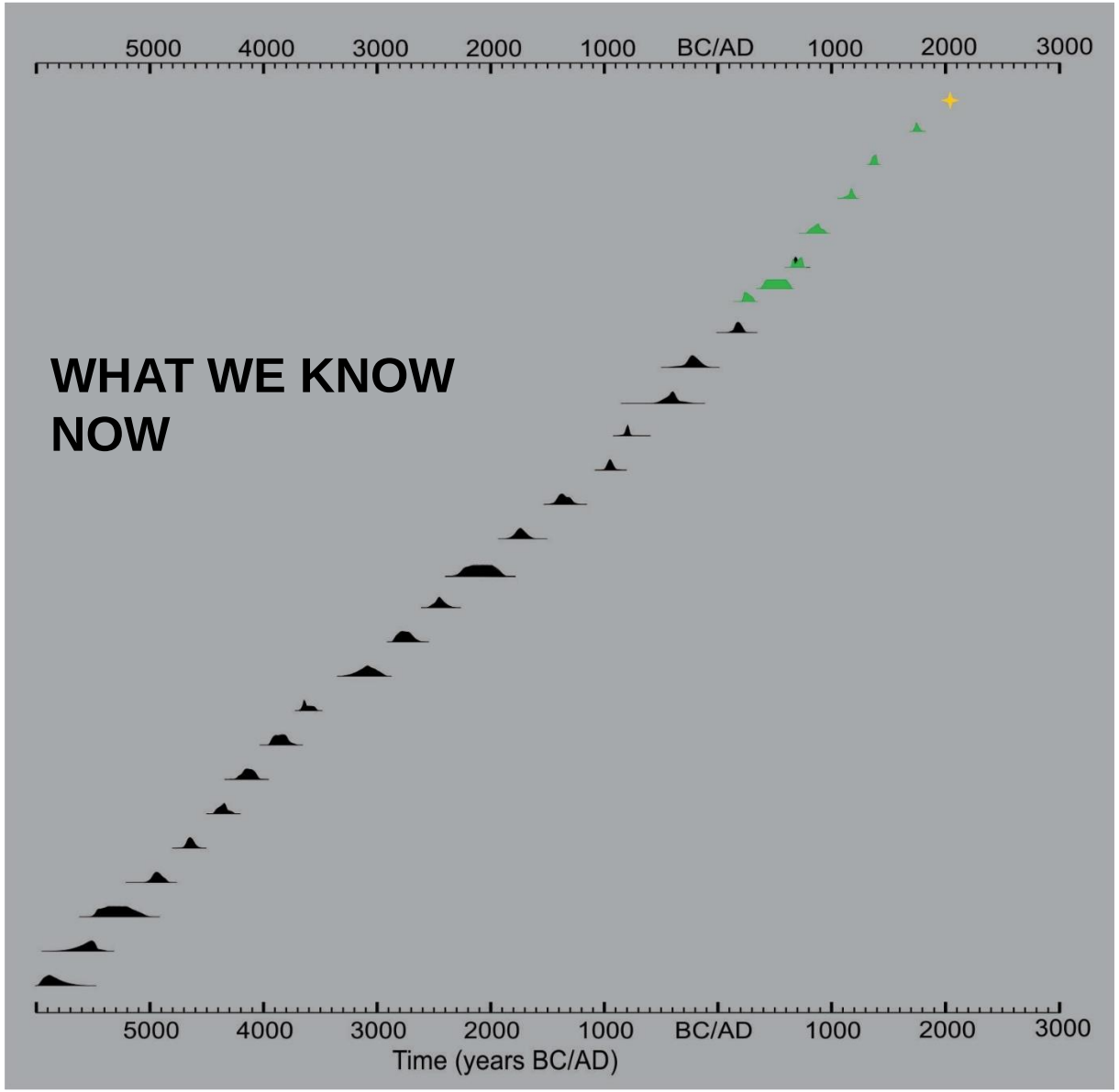
Alternating Soils and Silts at Hokuri Creek





Slide courtesy of Dr. Ursula Cochran, GNS Science

Past large Alpine Fault earthquakes



27 events over the past 8,000 years

Long history of large earthquakes

Remarkable regularity

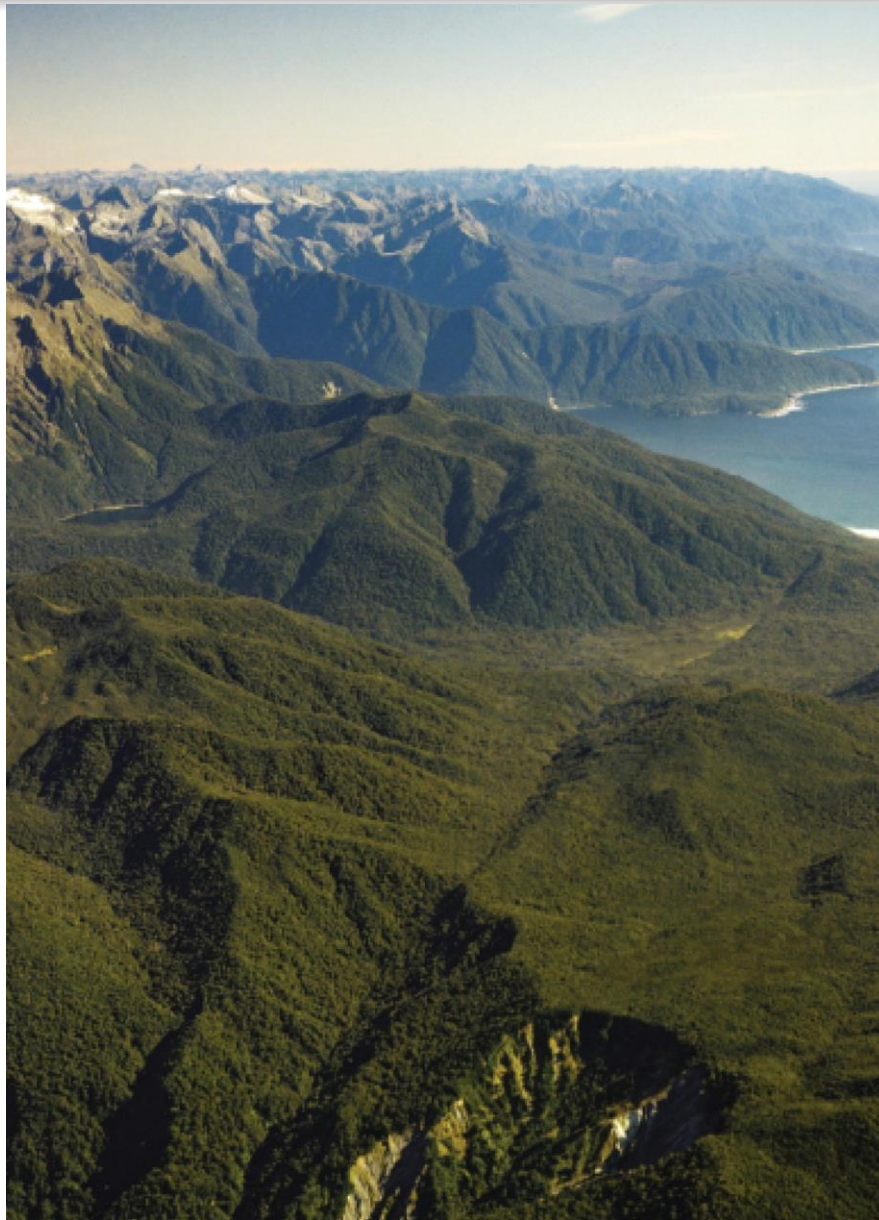
Over 8,000 years on record – no reason for that to stop happening…

Next event is inevitable

Slide courtesy of Dr. Ursula Cochran, GNS Science

Alpine Fault behaviour

- Alpine Fault rupture approx. every 300 years
- Last rupture 1717 AD
- Estimated to produce M7.8-8.2 earthquakes
- Rupture length ~400 km
- 8-10 m horizontal / 2-3 m vertical surface displacement
- Major coseismic + cascading consequences
- Significant human, environment, infrastructure + economic impact



AF8
ALPINE FAULT MAGNITUDE 8

BUILDING OUR COLLECTIVE RESILIENCE

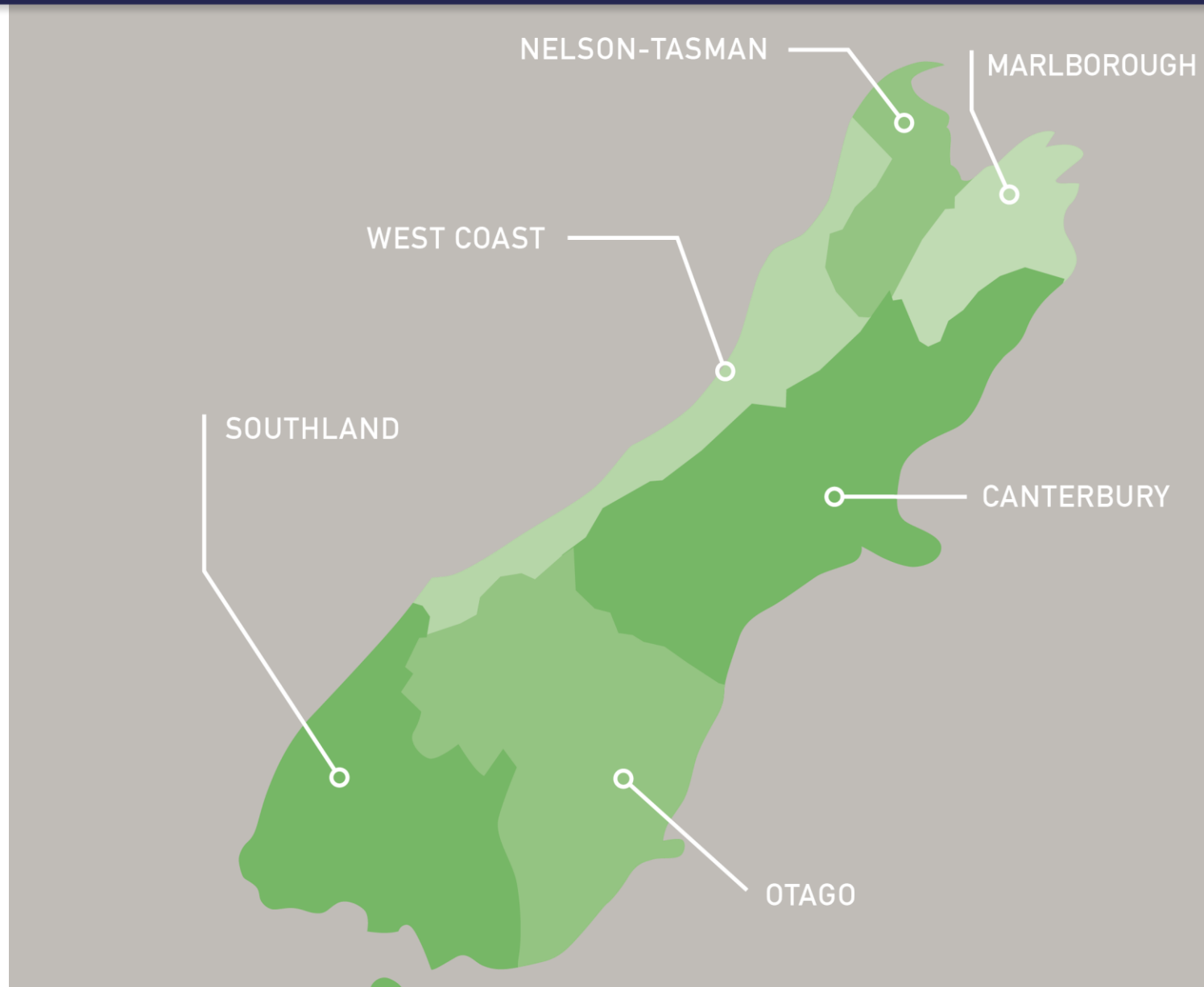
What is Project AF8?

Led by Emergency Management Southland

Angus McKay
Project AF8 Leader

Dr. Caroline Orchiston
Science Lead

Alice Lake-Hammond
Programme Coordinator



Project AF8 Overview

- Alpine Fault Magnitude 8 is a three-year programme of scientific modelling, response planning and community engagement.
- Particular focus on impacts of a rupture for people living in South Island communities.
- Involves all 6 South Island CDEM Groups

AF8 Otago Planning Workshop (2016)

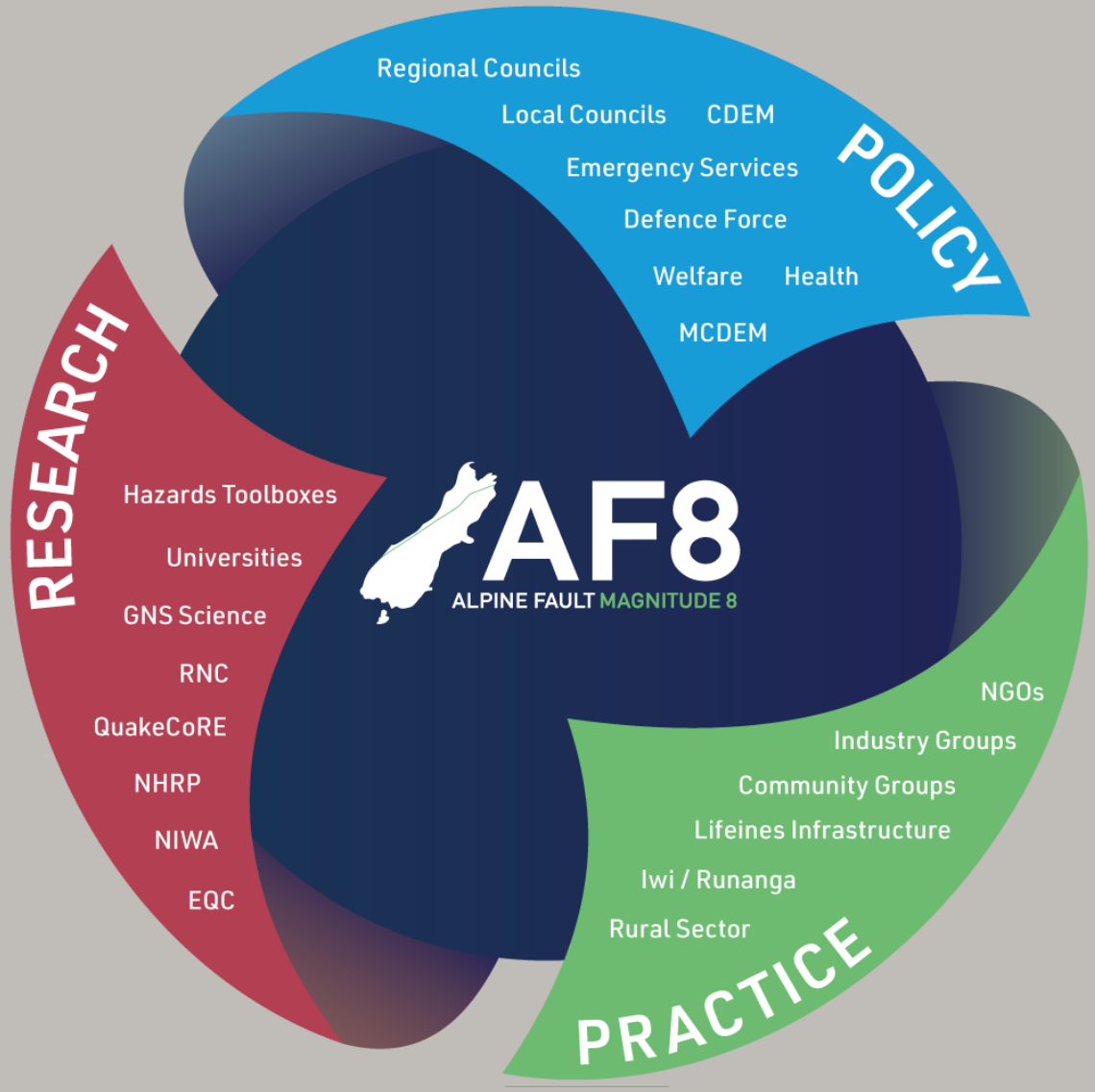
AF8 collaboration

AF8 ALPINE FAULT MAGNITUDE 8

RESEARCH

POLICY

PRACTICE



AF8 Milestones to date

- Year 1-2 focus: to co-create a collaborative response framework (SAFER)
- Year 3 focus: to outreach and engage widely (Roadshow)
- Year 4 focus: Response, Engagement, Risk Communication and Recovery

Response Framework

South Island Alpine Fault Earthquake Response Framework

Available for download from the AF8 website:

www.af8.org.nz

RISK TEAM
30+ researchers
6 Universities
2 CRIs
2 consulting firms

Scenario

AF8 workshops
CDEM
Infrastructure Lifelines
Local/Central Govt
Industry Groups
Community Groups
Rural sector
Iwi/Runanga
NGOs

Southland | Marlborough
Otago | Nelson/Tasman
West Coast | Canterbury
Wellington

RESPONSE TEAM
South Island
Alpine
Fault
Earthquake
Response

Framework

Compiled by:
6 CDEM Groups

Project AF8
Programme Manager

MCDEM

So, what will a magnitude 8 be like?

Magnitude: 8

How much energy is released by an earthquake

Measured from:
M1 – M10
Log scale
e.g. each full step is 32 x more energy released

Damage is worst around the rupture zone

Intensity: 4 to 10

How much damage is done to the built environment

Measured from:
MM1-12

Damage related to distance from epicentre, and local ground conditions

Alpine Fault hazard-risk-impact

- **Frequency** – when is the next event likely to occur? (probability)
- **Magnitude** – how big?

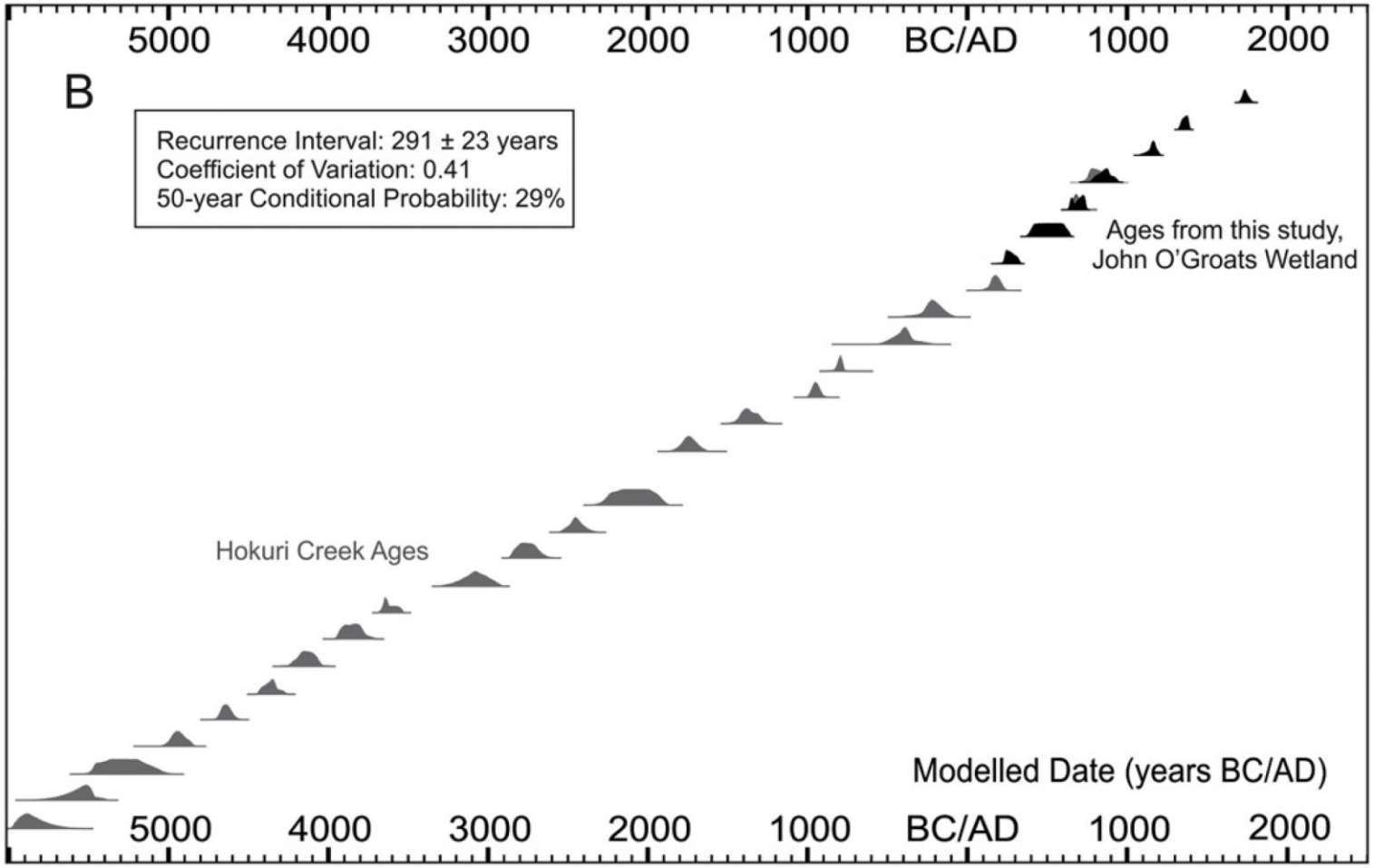
- **Intensity** – how strong/long will the effects be?
- **Hazard footprint** – what area will be affected?

- **Impacts/Consequences?**
- **Risk reduction - infrastructure/community/societal resilience?**

Frequency

Frequency – when might the next event(s) occur?

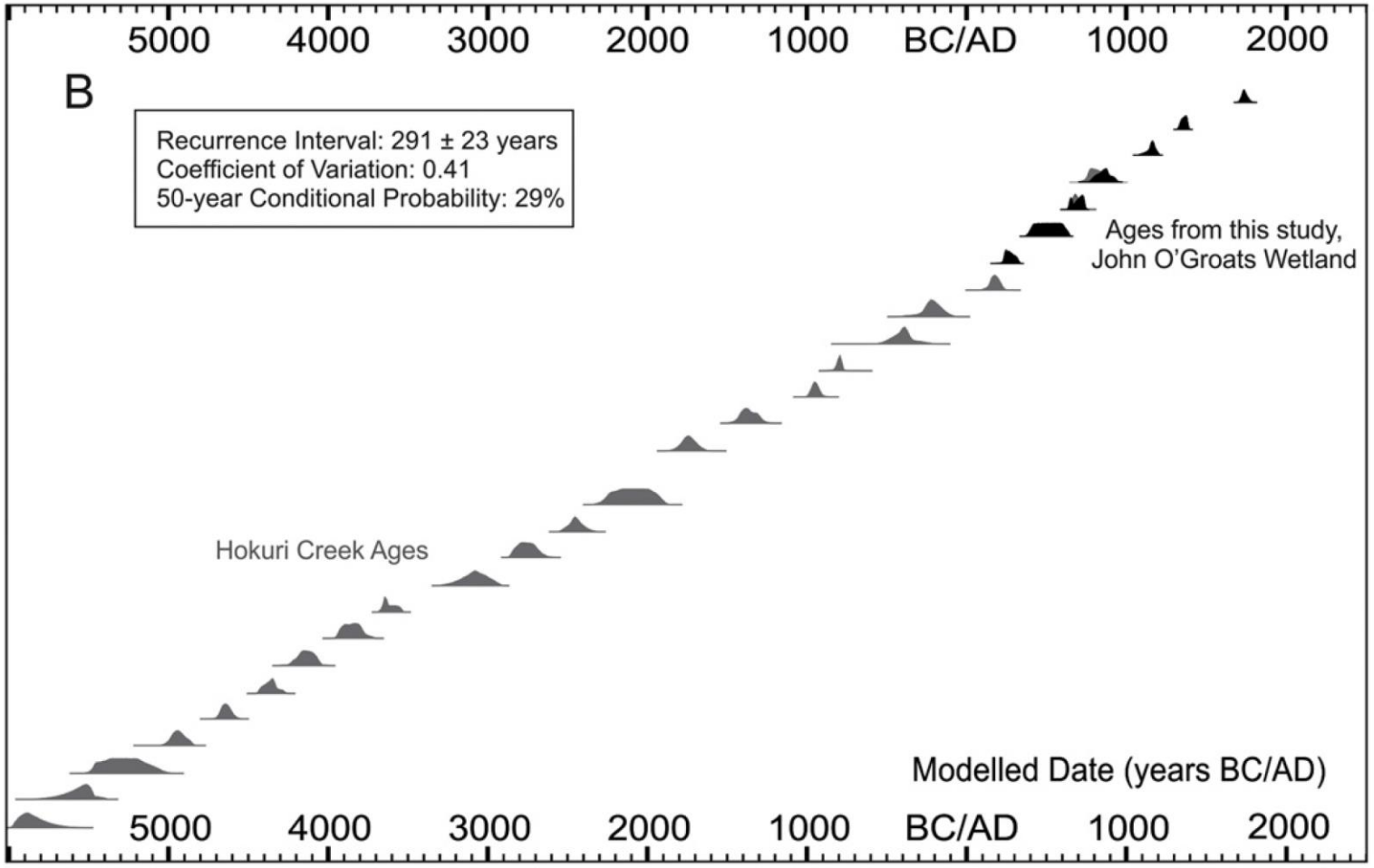
- 27 earthquakes since ~6,000 B.C.
- Regular occurrence through time
- Longest interval ~510 yrs
- Shortest interval ~140 yrs



Ursula Cochrane et al. – GNS Science

Frequency

- **Mean recurrence interval ~300 years**
- **Last significant earthquake was in 1717AD**
- **29% probability the southern section of the Alpine Fault will rupture in the next 50 years**

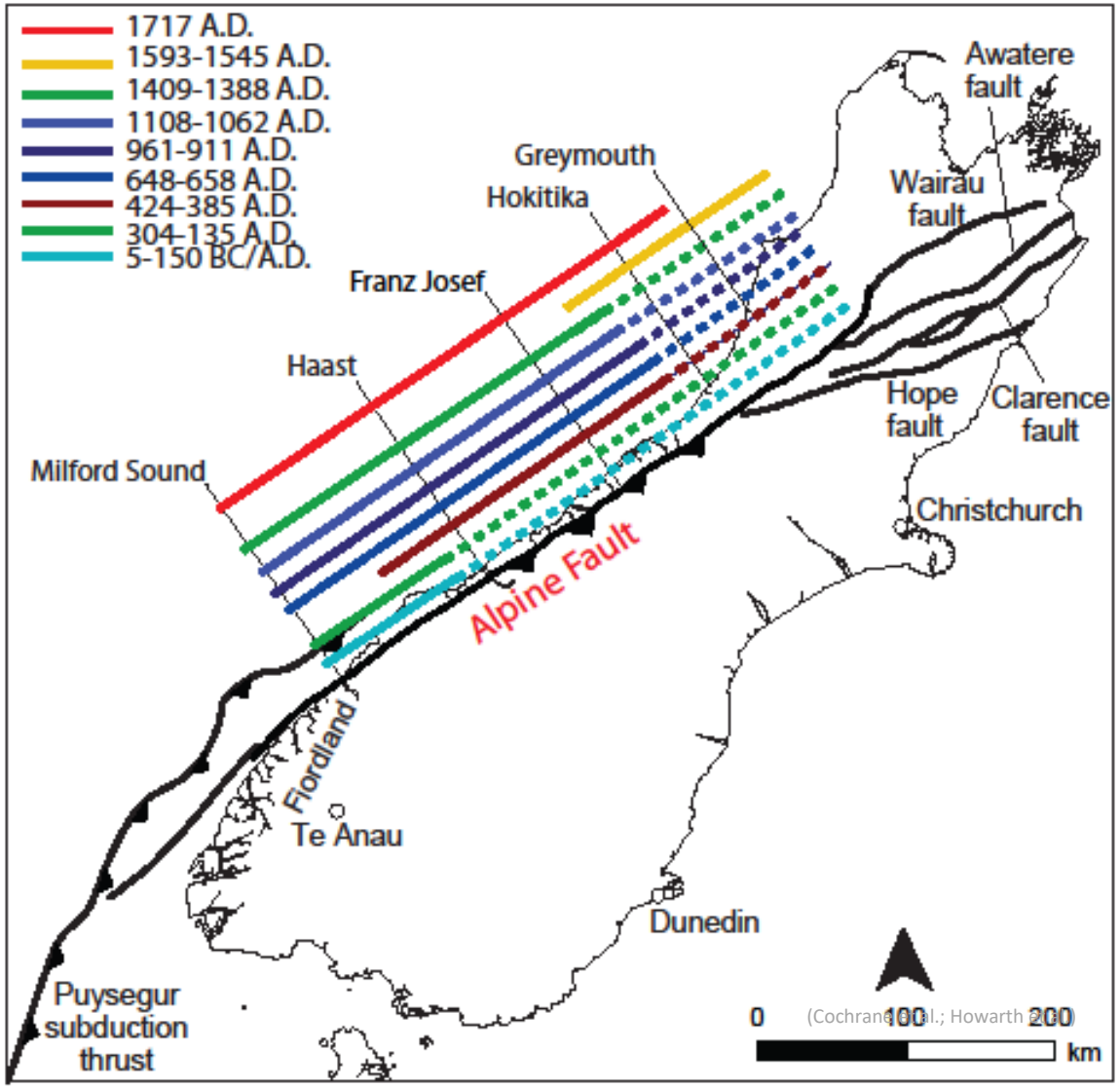


NEW RESEARCH 2017

Ursula Cochrane et al. – GNS Science

Magnitude

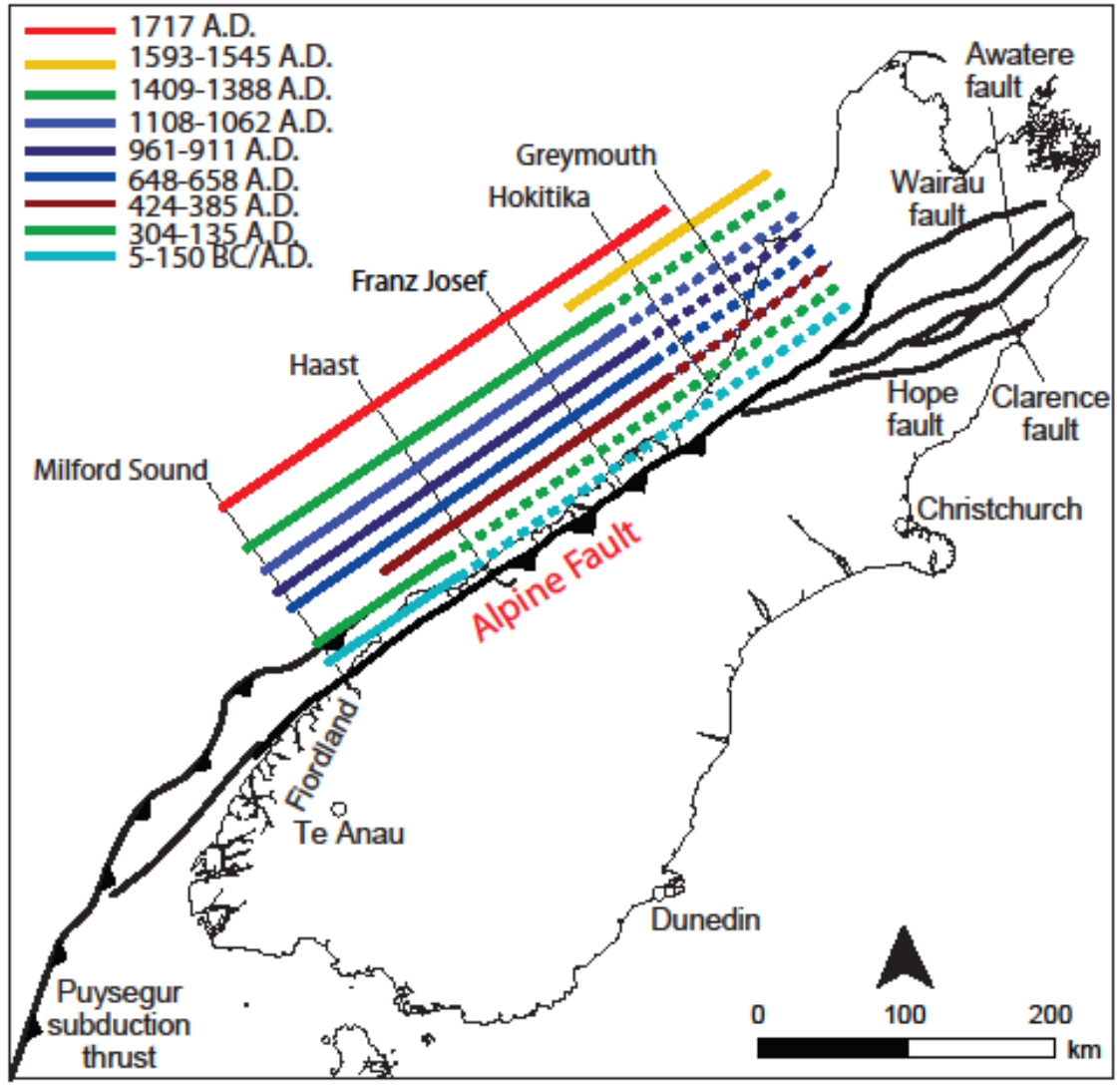
- **Of the last 9 earthquakes, 8 appear to have been >400 km Mw8 events**
- **Fault has stored enough energy to move >8 m horizontally and >2 m vertically**



Magnitude

Next earthquake likely to be ~Mw8.0

- 32x more energy released than 4 Sept 2010 Darfield EQ (Mw 7.1)
- 1000x more energy released than 22 Feb 2011 Christchurch EQ (Mw 6.2)

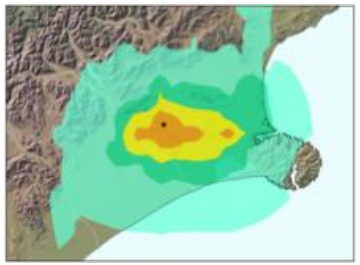


(Cochrane et al.; Howarth et al.)

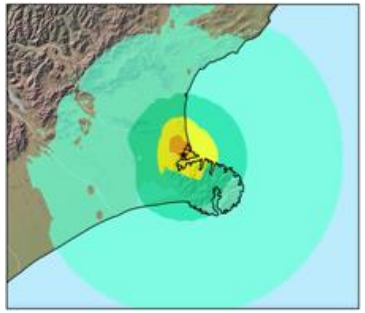
Hazard Footprint

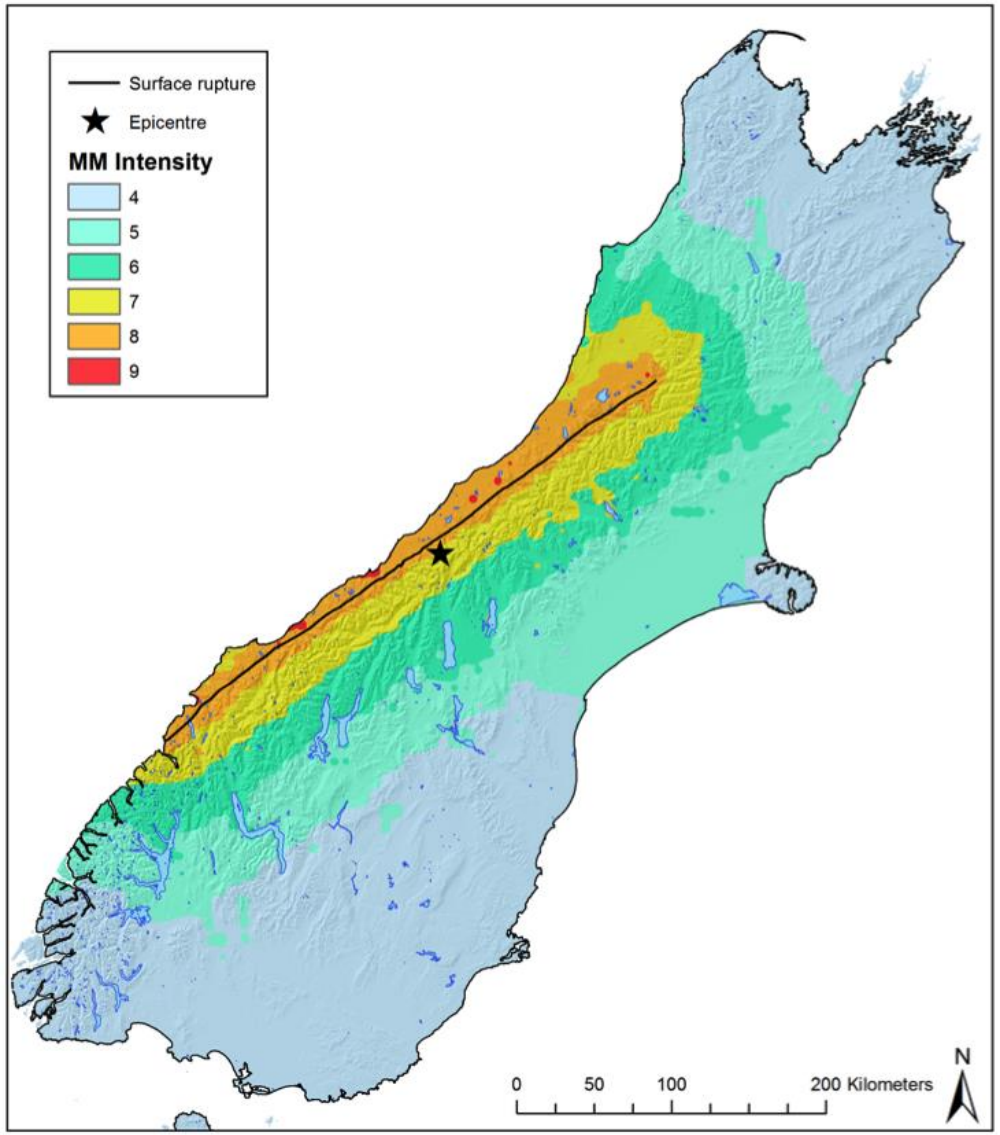
SHAKING INTENSITY

4 September 2010
Darfield Earthquake
(to scale)



22 February 2011
Christchurch Earthquake
(to scale)

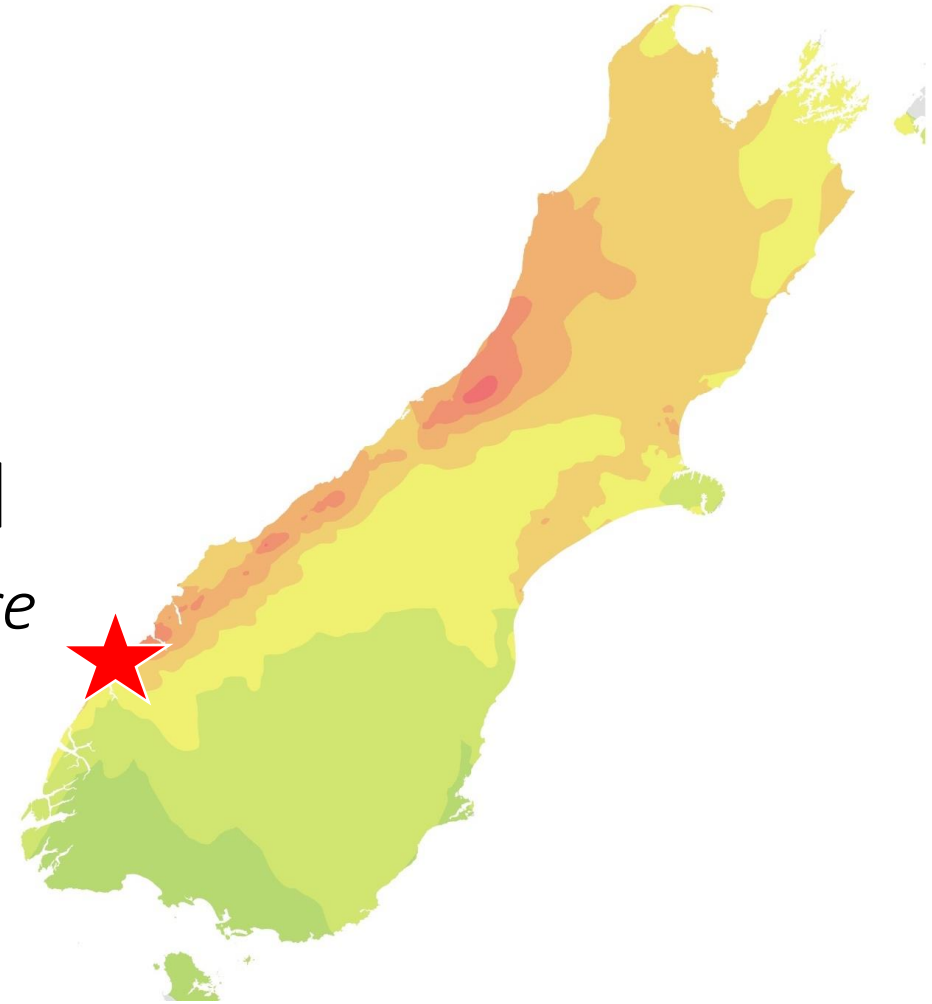




Hazard Footprint

AF8 Scenario
Intensity model

South to North rupture



Nth to Sth

Central

Conrad Zorn (images)
Based on Brendon Bradley et al. (2016)

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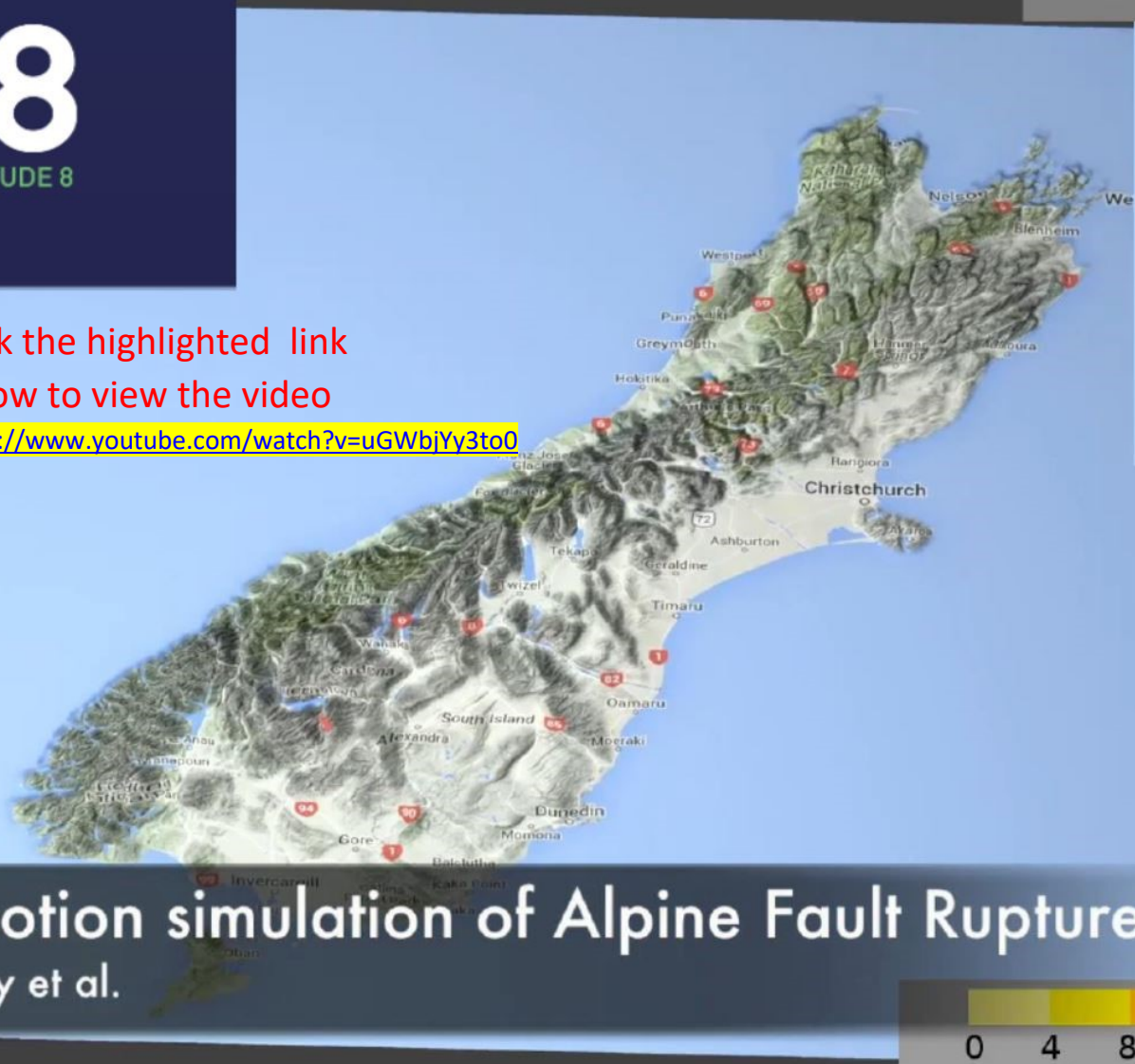
ALPINE FAULT MAGNITUDE 8

Rupture time 0:04

Click the highlighted link below to view the video

https://www.youtube.com/watch?v=uGWbjYy3to0



Ground motion simulation of Alpine Fault Rupture

Brendon Bradley et al.

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ALPINE FAULT MAGNITUDE 8

Earthquake Hazards

Secondary Hazards

Earthquakes are not just the initial several seconds of strong ground shaking

They cause a series of secondary hazards which cascade on from each other

EARTHQUAKE

LANDSLIDE

QUAKE LAKE

DAMBREAK FLOOD

Secondary Hazards

Often these secondary hazards can be worse than the initial shaking:

- **2004 Indonesia – Tsunami**
- **2011 Japan – Tsunami**
- **2010-11 Christchurch – Liquefaction & Landslides**
- **2016 Kaikōura – Landslides**

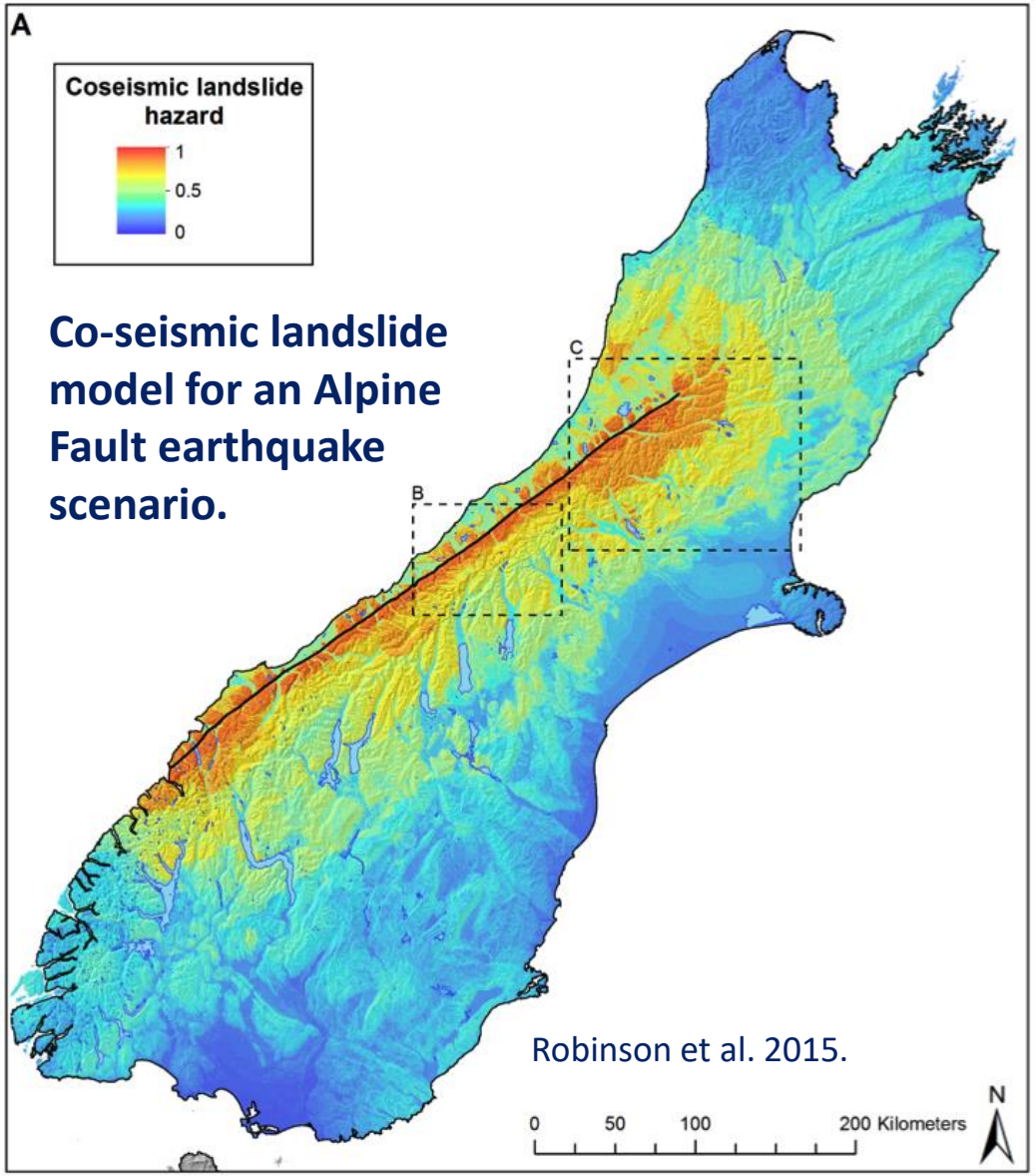
Liquefaction in Christchurch: CEISMIC Digital Archive (Mark Lincoln)

Landslides on SH1 following the Kaikōura earthquake (GeoNet)

Secondary Hazards

Landslide dam following the 2016 Kaikōura earthquake

Rockfall tsunami in lakes and fiords



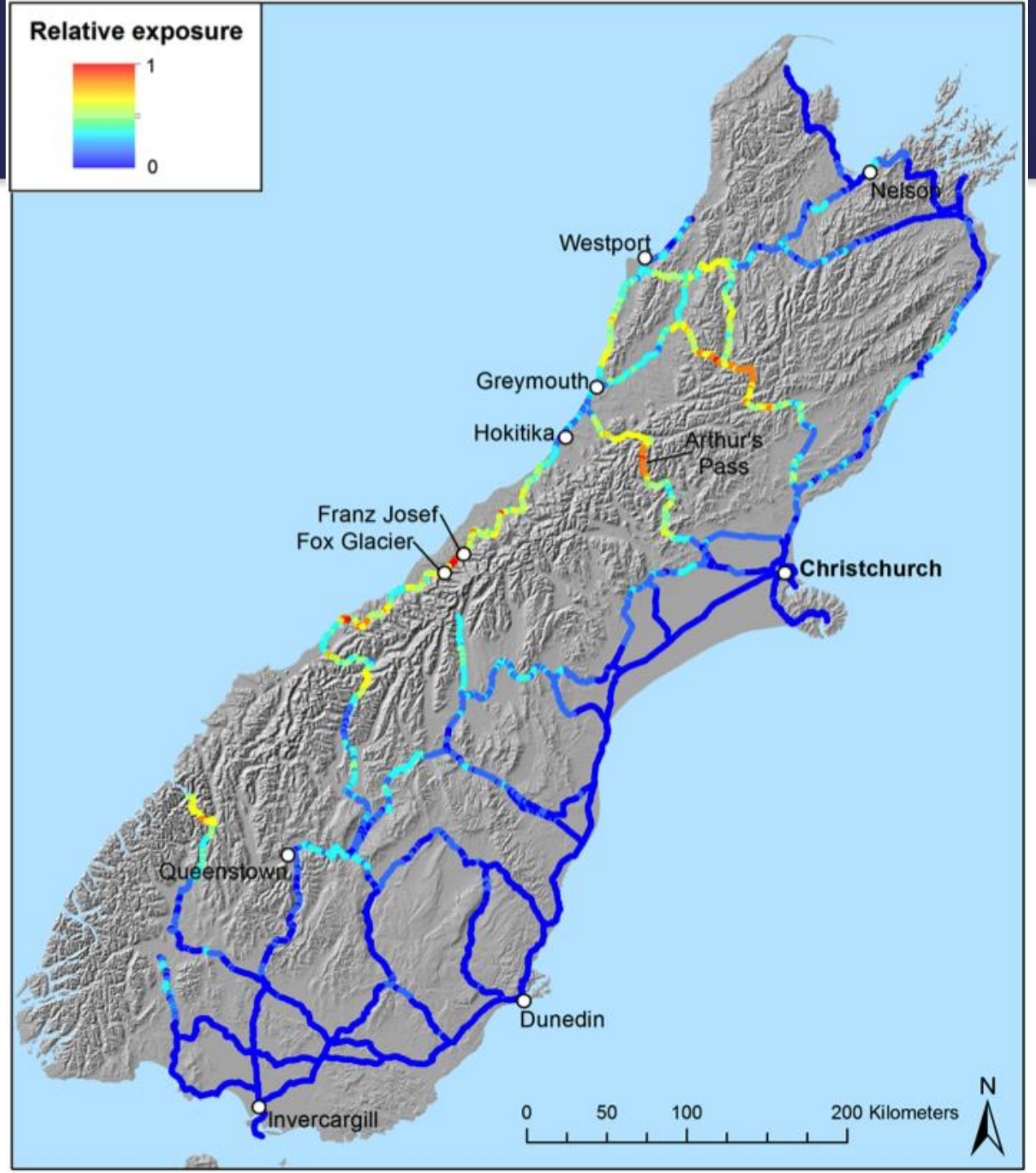
Co-seismic landslide model for an Alpine Fault earthquake scenario.

Robinson et al. 2015.

Impacts – Critical Infrastructure

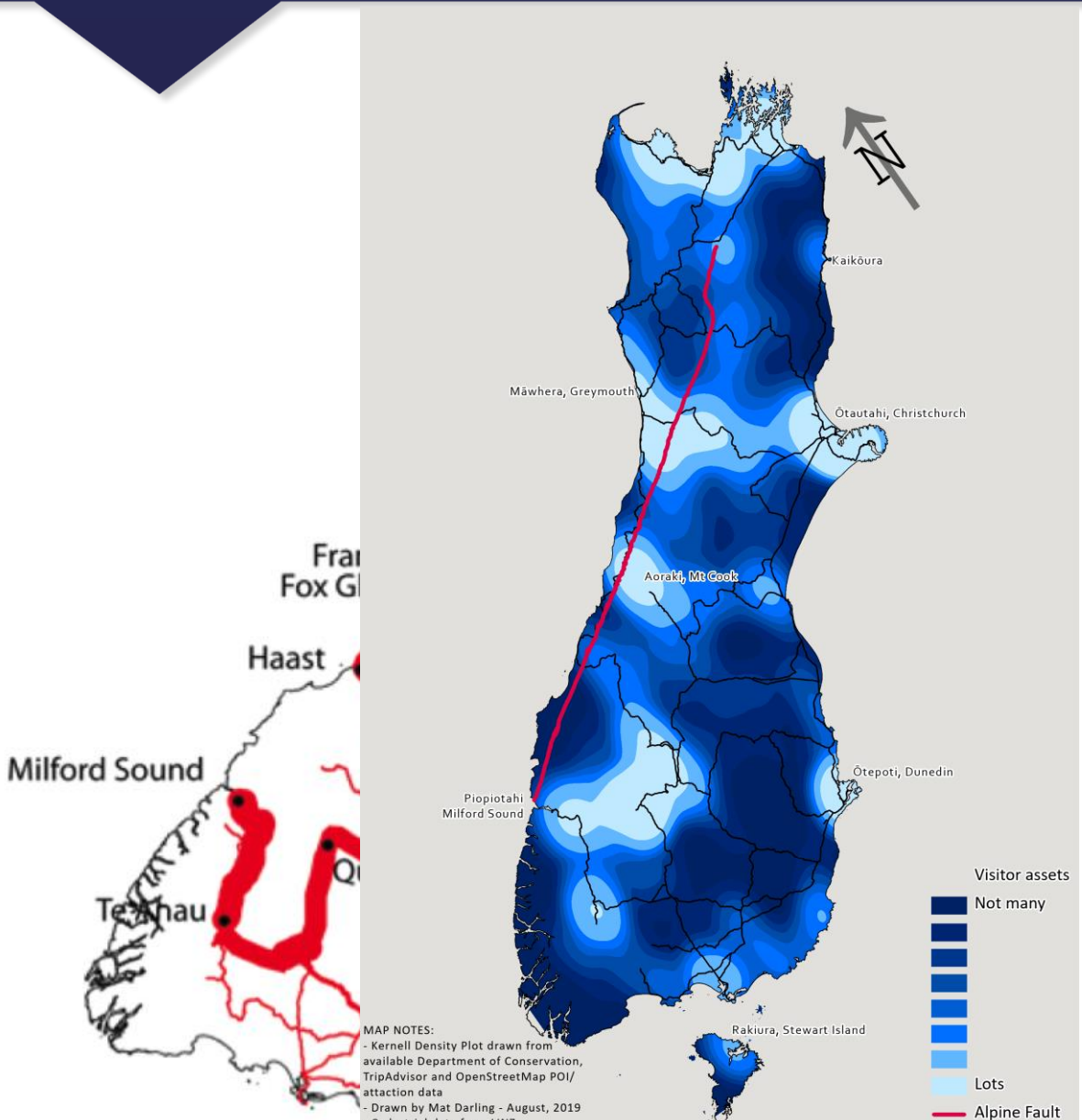
State Highway Network

- Exposure maps show likelihood of road sections being affected by a landslide
  - 1 = almost certainly
  - 0 = almost impossible
- 5 sections particularly exposed:
  1. Arthur's Pass
  2. Lewis Pass
  3. Fox Hills (Franz-Fox)
  4. Haast Pass
  5. Milford Road (Homer Tunnel)



Highway network

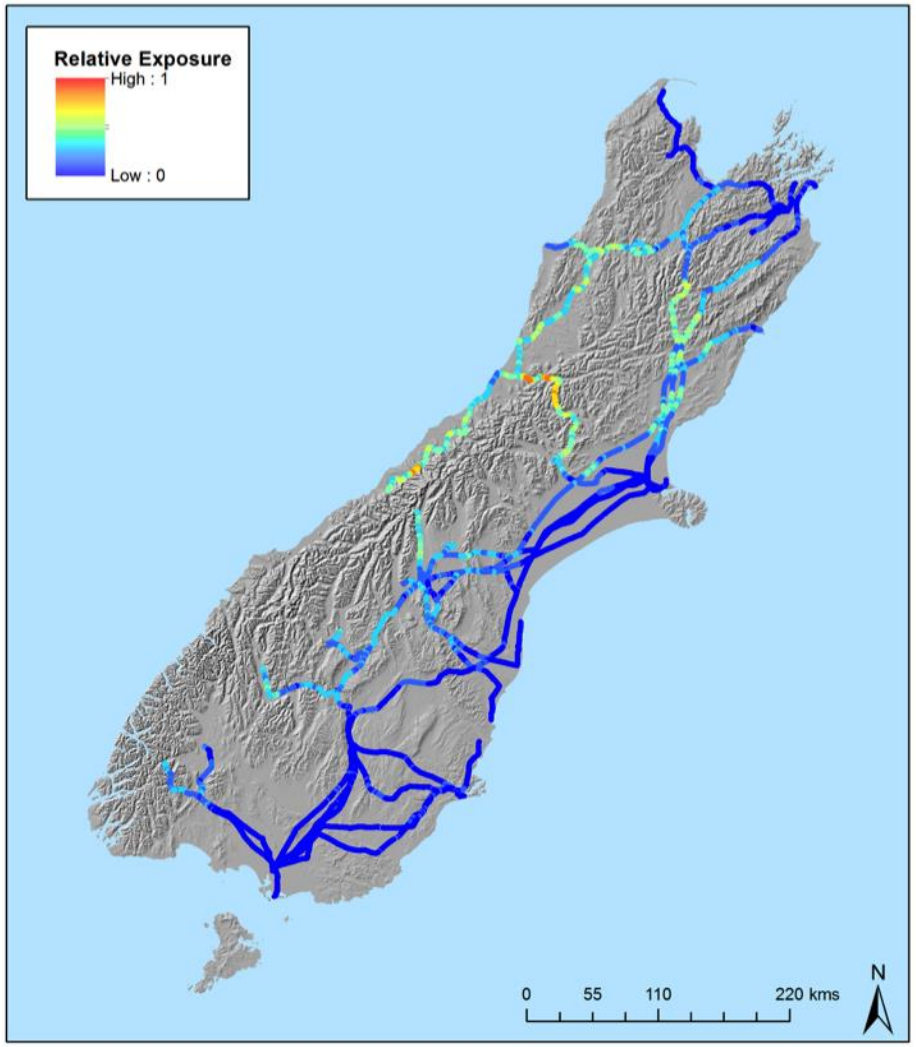
Kaikōura evacuations, 2016



- State Highways are crucial for general access, tourism, and goods (dairy/mining) transportation
- Passes through steep, landslide prone terrain
- Little redundancy
- Isolated communities

Electricity Network

- Pylon/poles damaged
- Transformers damaged
- Dam shutdowns - restart requires power
- Inter-island connection vulnerable
- Implications for North Island supply



Transmission network exposure to Alpine Fault co-seismic landslide scenario (Robinson et al. 2015)

Benmore Dam

Lessons from the Kaikōura earthquake

Lessons from Kaikōura

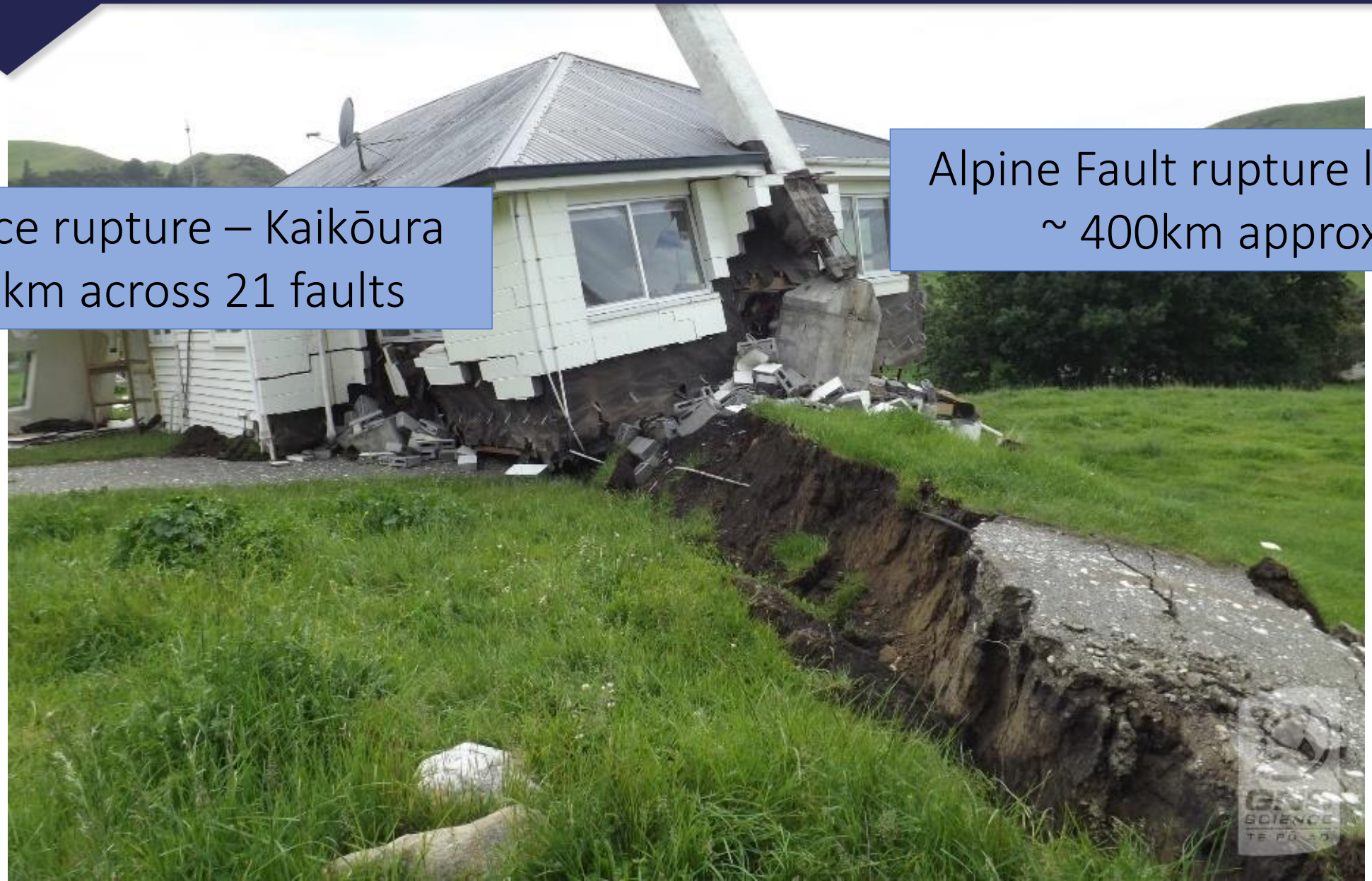
© GNS Science / EQC, Julian Thomson

© GNS Science, Lloyd Homer

Lessons from Kaikōura

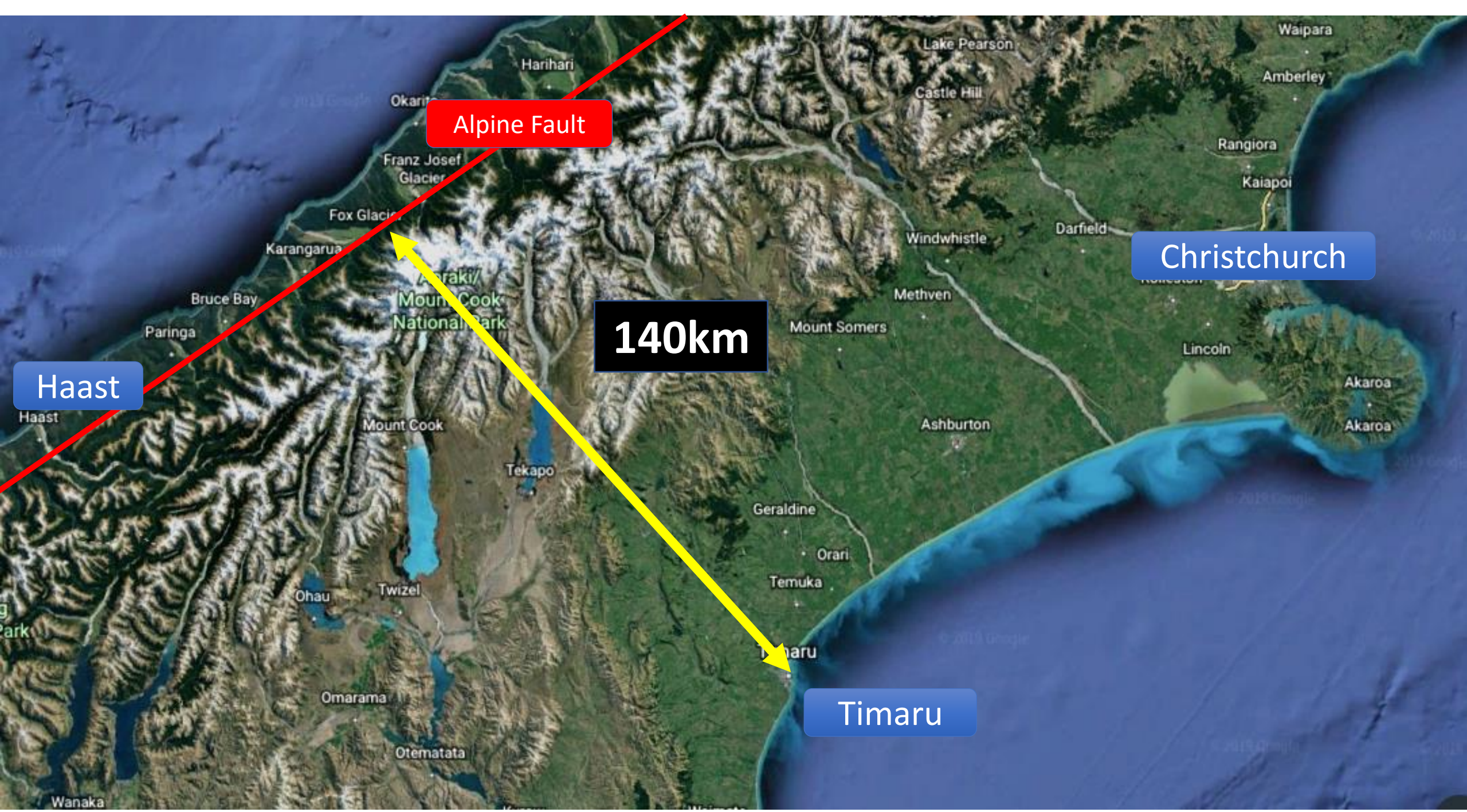
Surface rupture – Kaikōura
~ 180km across 21 faults

Alpine Fault rupture length
~ 400km approx



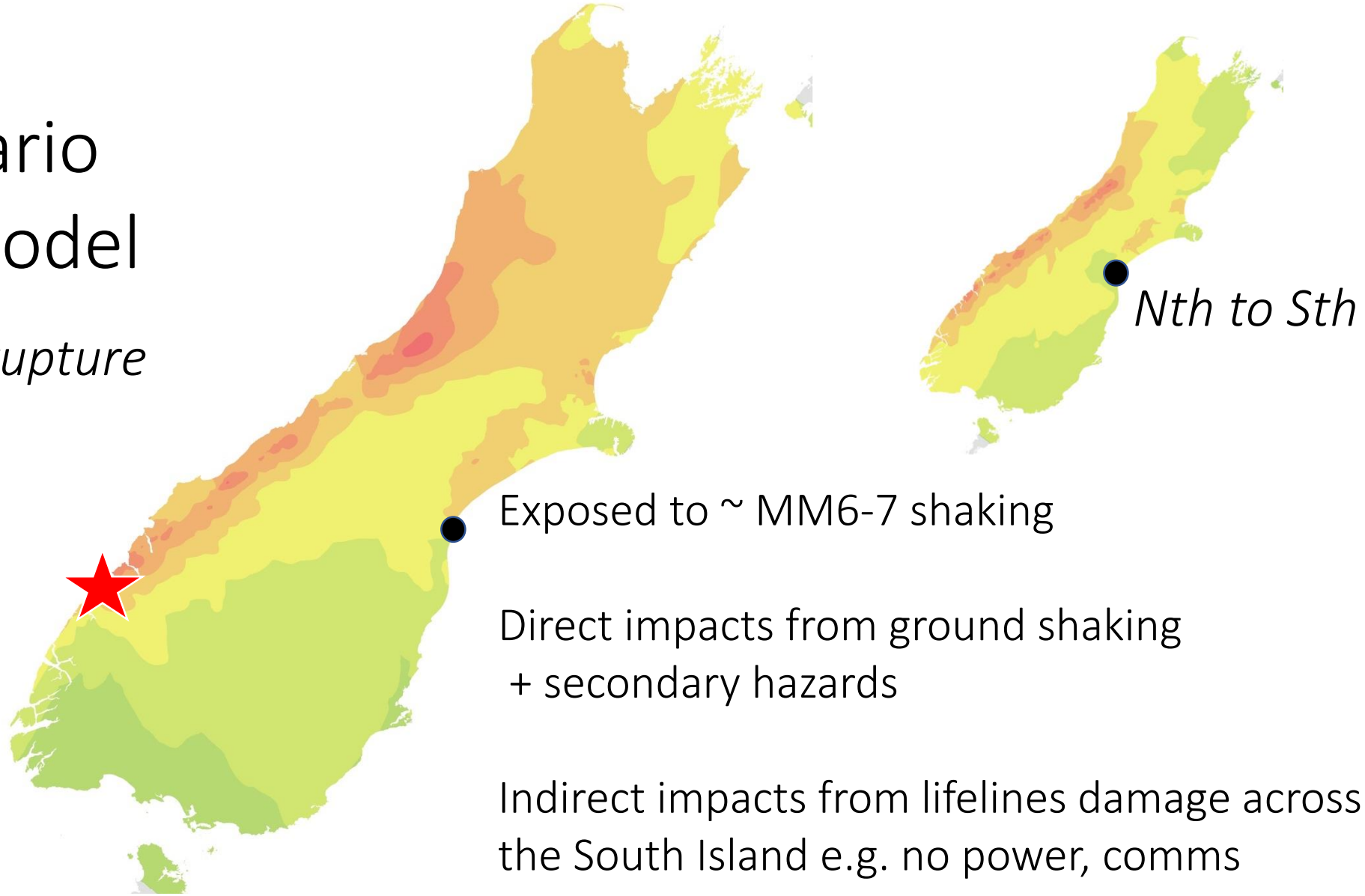
Lessons from Kaikōura

So, what about Timaru?


Alpine Fault
Haast
Christchurch
Timaru
140km
Harihari
Franz Josef Glacier
Fox Glacier
Karangarua
Bruce Bay
Paringa
Haast
Mount Cook National Park
Mount Cook
Tekapo
Twizel
Ohau
Omarama
Otematata
Wanaka
Lake Pearson
Castle Hill
Waipara
Amberley
Rangiora
Kaiapoi
Darfield
Windwhistle
Methven
Mount Somers
Lincoln
Akaroa
Ashburton
Geraldine
Orari
Temuka

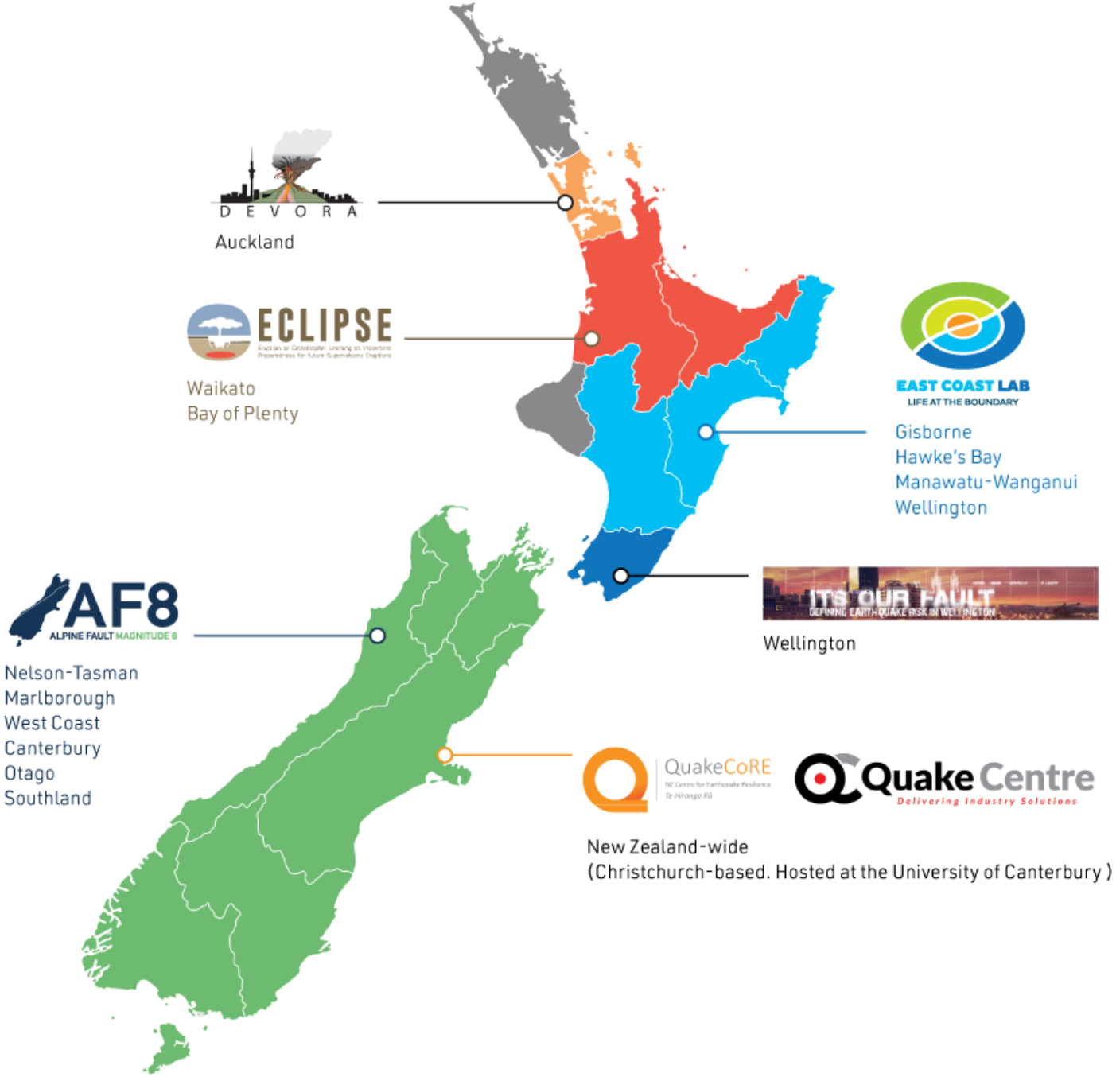
AF8 Scenario Intensity model

South to North rupture



Conrad Zorn (images)
Based on Brendon Bradley et al. (2016)

Regional Natural Hazard Programme Alliances



How do you get prepared?

Get to know your neighbours – more engaged communities do better

Engage in your local community

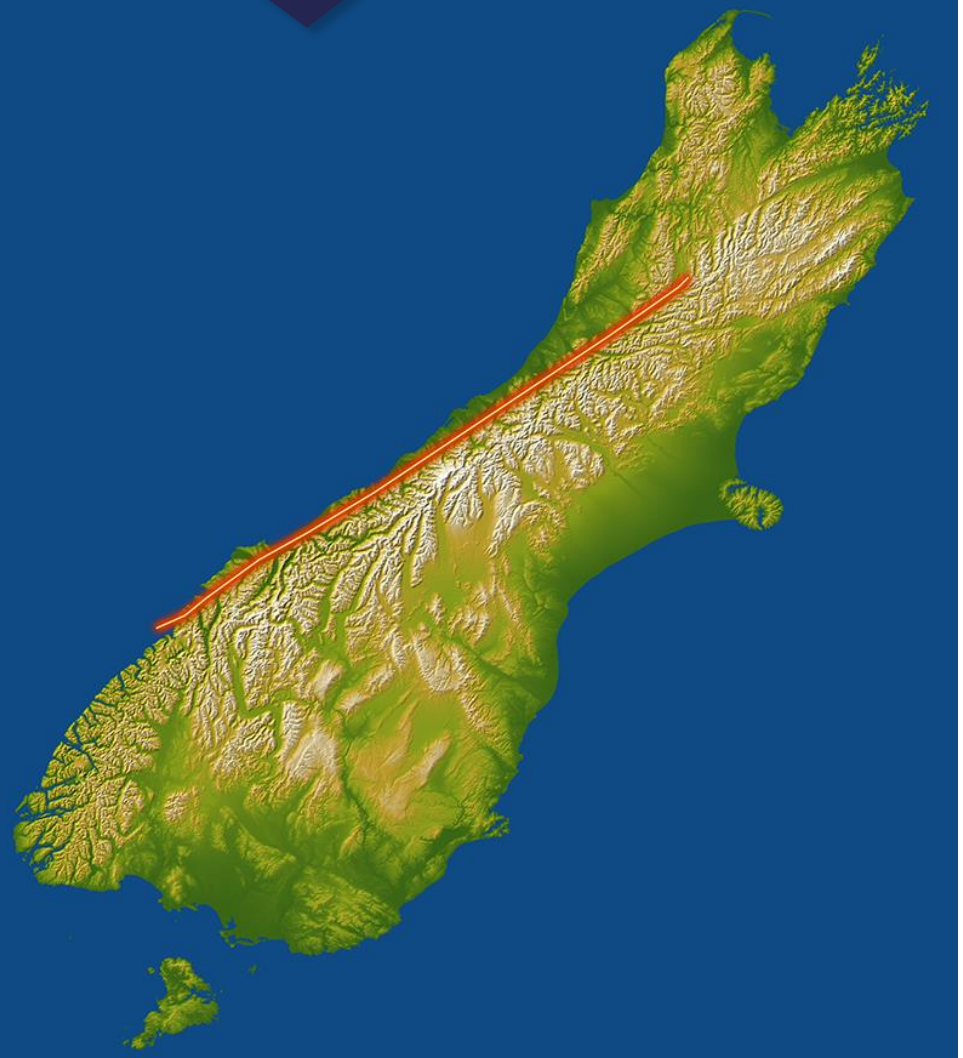
- e.g. find out about your local community response plan
- e.g. talk with your local school
- e.g. build your 'risk knowledge/literacy' – lots of resources available
- e.g. become a volunteer for CDEM

Make a family plan

Business Continuity planning - talk with your employees, within your supply chain

Anything you do now will help make a difference afterwards

AF8 – KEY MESSAGES



- High chance next AF earthquake will be a Mw8
- Effects across South Island and lower North Island
- Widespread secondary hazards (e.g. landsliding) will present immediate and long-term issues
- Likely isolation of areas for long periods of time, and extended utility service outages
- ‘Scenario earthquakes’ never quite what is expected
- Strong pre-existing networks essential

- An Alpine Fault earthquake will happen again
  Preparation is key

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www.AF8.org.nz

Thank You

UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha

Ministry of Civil Defence & Emergency Management
Te Rākau Whakamarumaru

RESILIENCE TO NATURE'S CHALLENGES
Kia manawaroa – Ngā Ākina o Te Ao Tūroa
National SCIENCE Challenges

GNS SCIENCE TE PŪ AO

QuakeCoRE
NZ Centre for Earthquake Resilience
Te Hiranga Rū

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND