

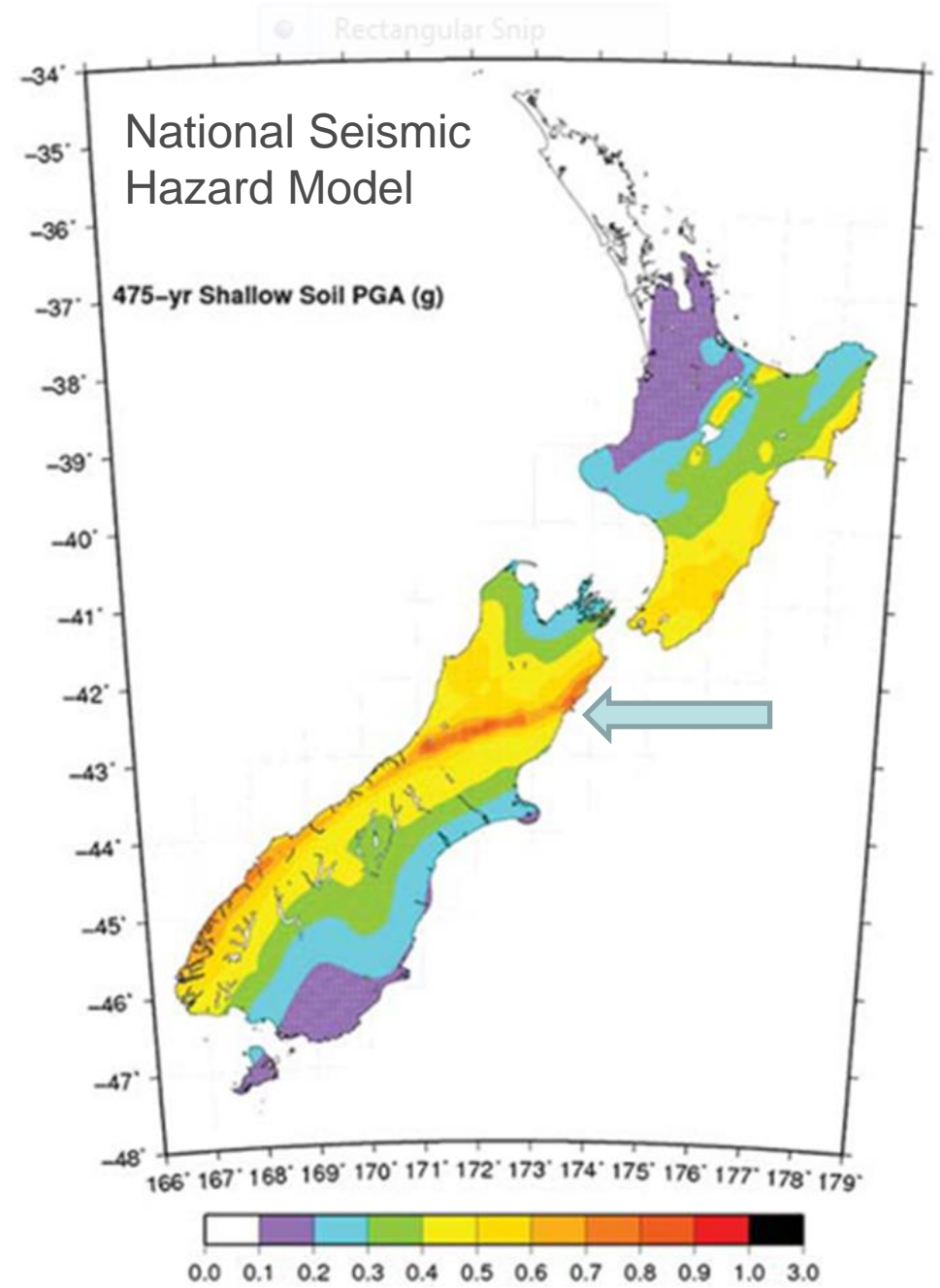
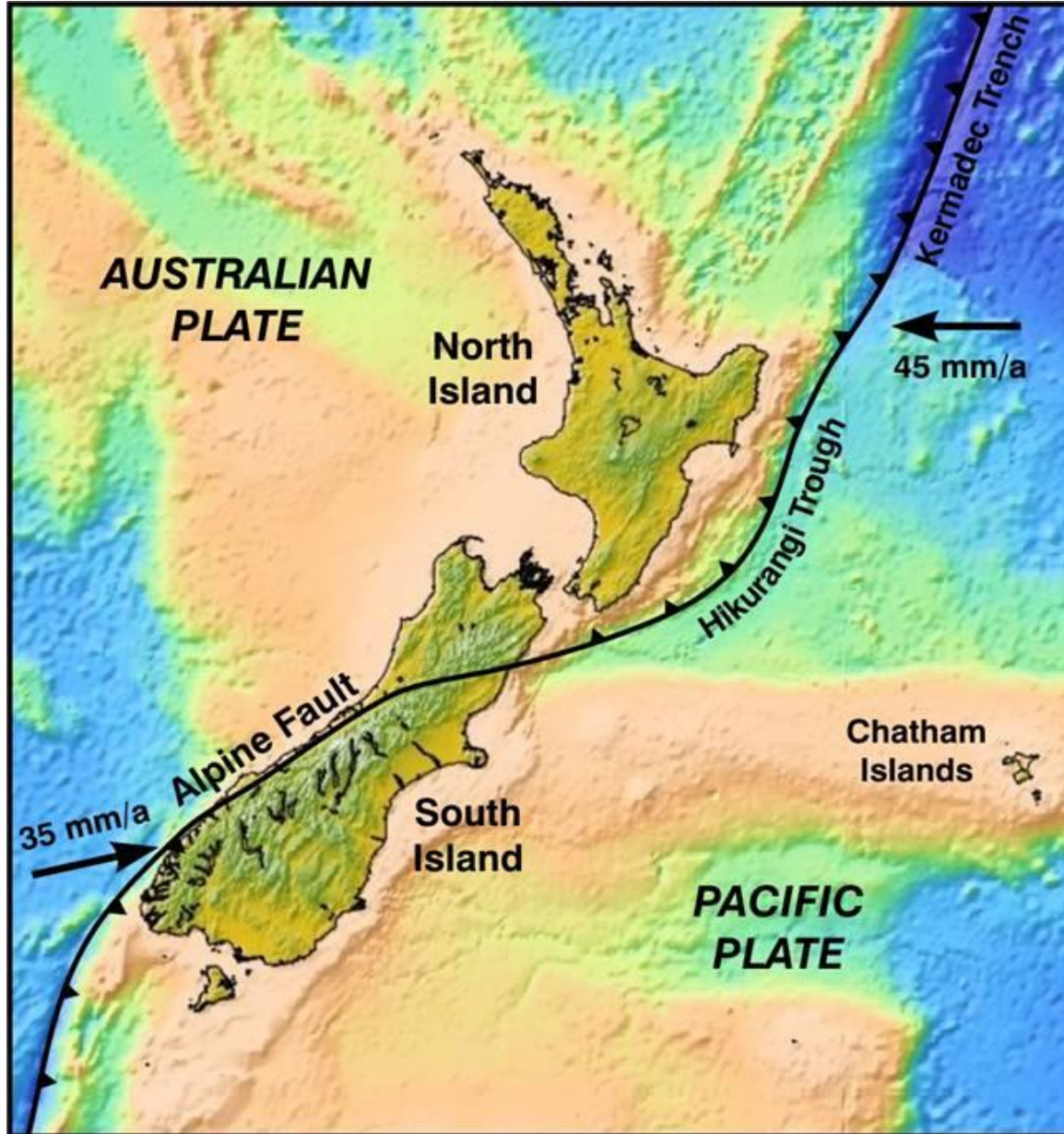
Kaikōura earthquake impacts and lessons for resilience



Kekerengu fault rupture, Kaikōura earthquake, 14th Nov 2016

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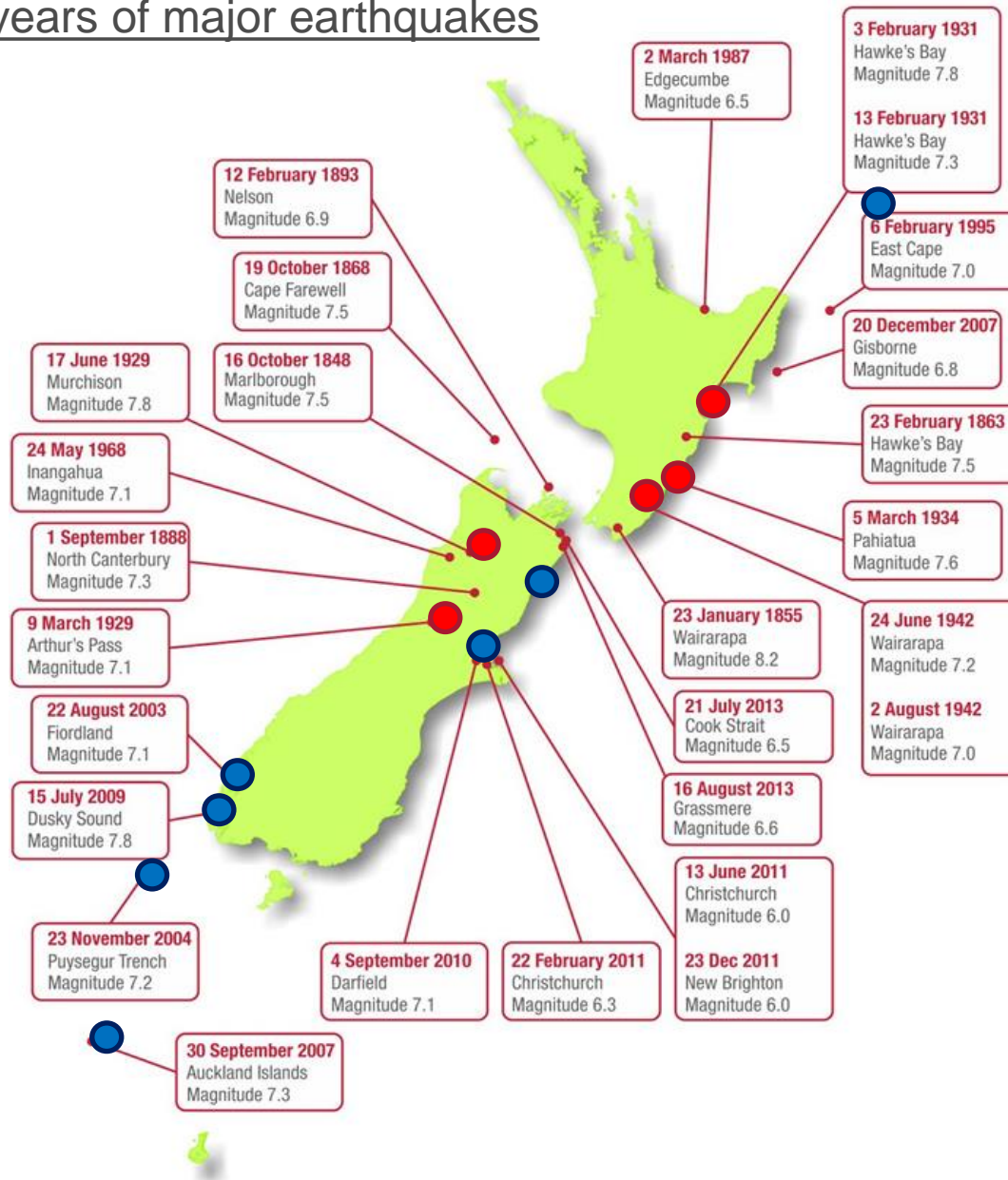
Context



Stirling et al, 2012

Context: Historical record of clusters of events

150 years of major earthquakes



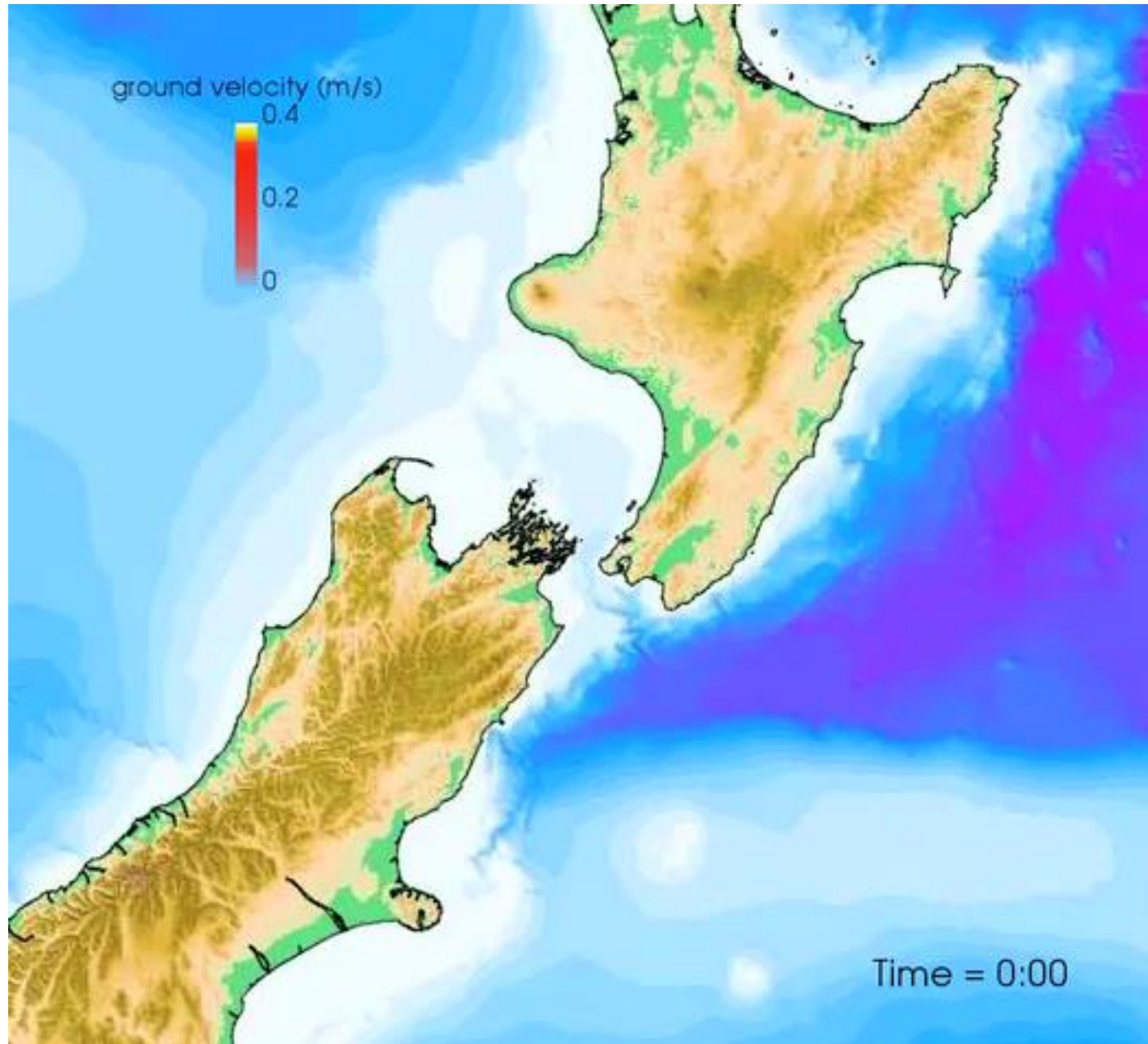
1929-1942

- 9 March 1929
Arthur's Pass
Magnitude 7.1
- 17 June 1929
Murchison
Magnitude 7.8
- 3 February 1931
Hawkes Bay
Magnitude 7.8
- 13 February 1931
Hawkes Bay
Magnitude 7.3
- 5 March 1934
Pahiatua
Magnitude 7.6
- 24 June 1942
Wairarapa
Magnitude 7.2
- 2 August 1942
Wairarapa
Magnitude 7.0
- 24 June 1942
Wairarapa
Magnitude 7.2
- 2 August 1942
Wairarapa
Magnitude 7.0

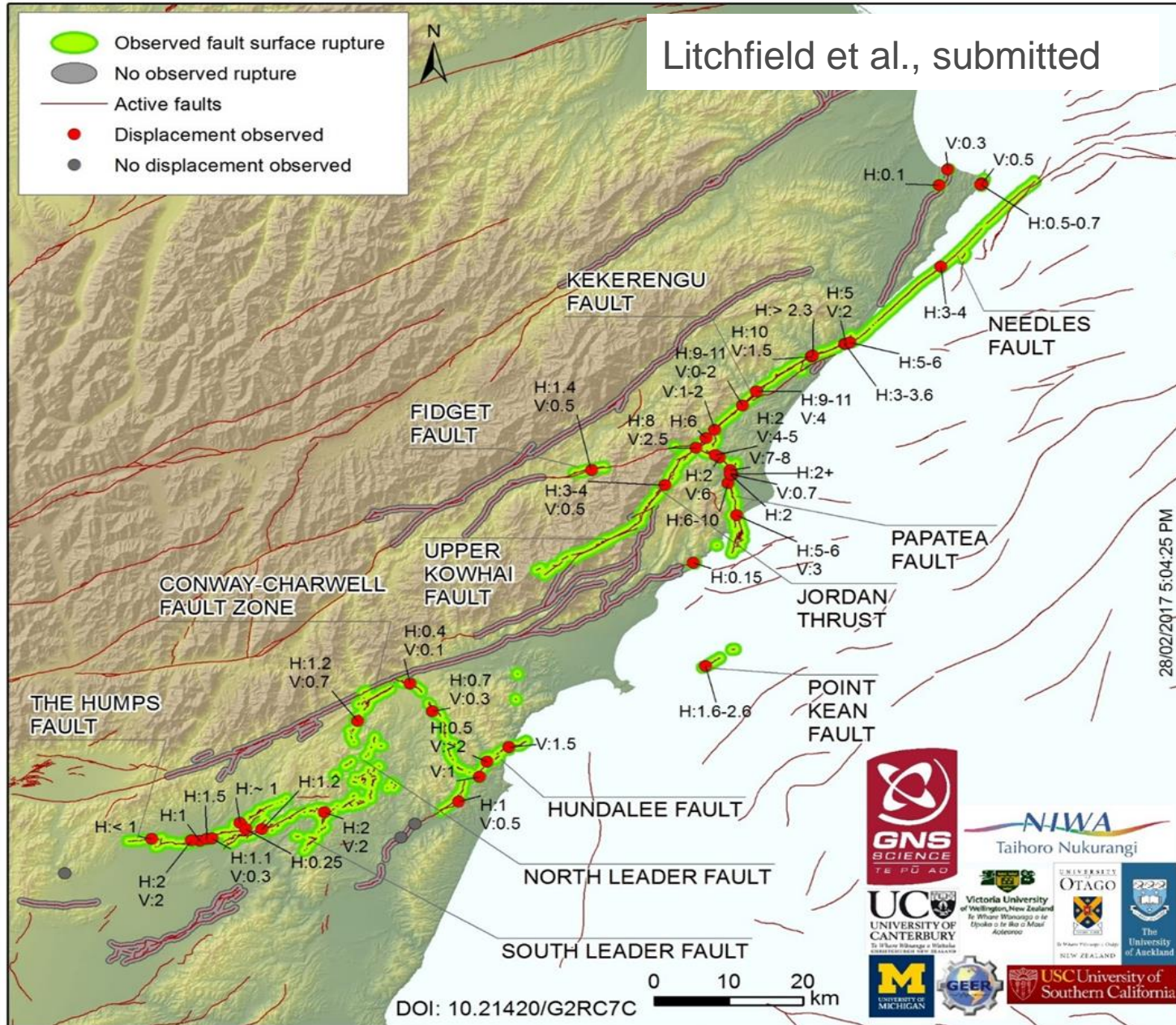
2003-?

- 22 August 2003
Fiordland
Magnitude 7.1
- 23 November 2004
Puysegur Trench
Magnitude 7.1
- 30 Sept 2007
Auckland Islands
Magnitude 7.3
- 15 July 2009
Dusky Sound
Magnitude 7.8
- 4 September 2010
Darfield
Magnitude 7.1
- 2 September 2016
East Cape
Magnitude 7.1
- 14 November 2016
Kaikoura
Magnitude 7.8

Kaikōura Earthquake



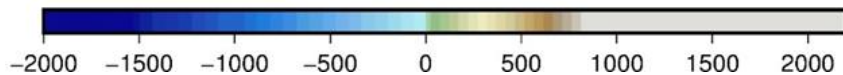
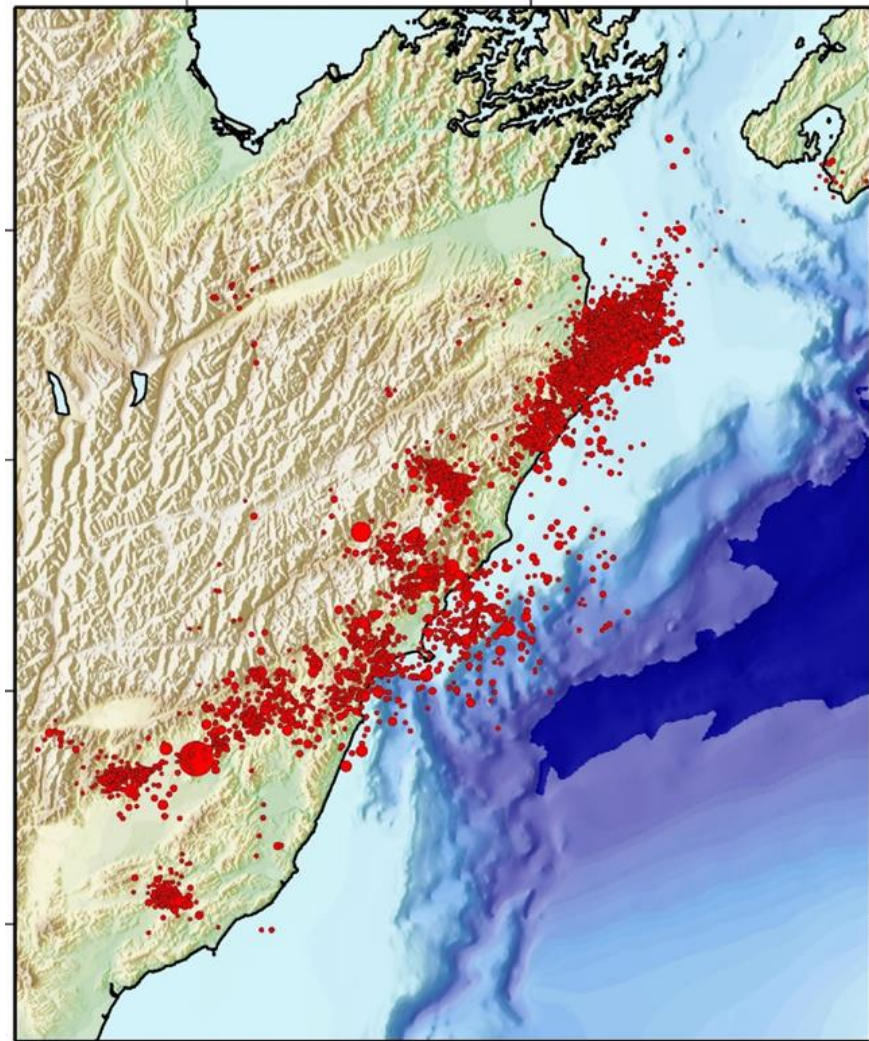
Kaikōura Earthquake



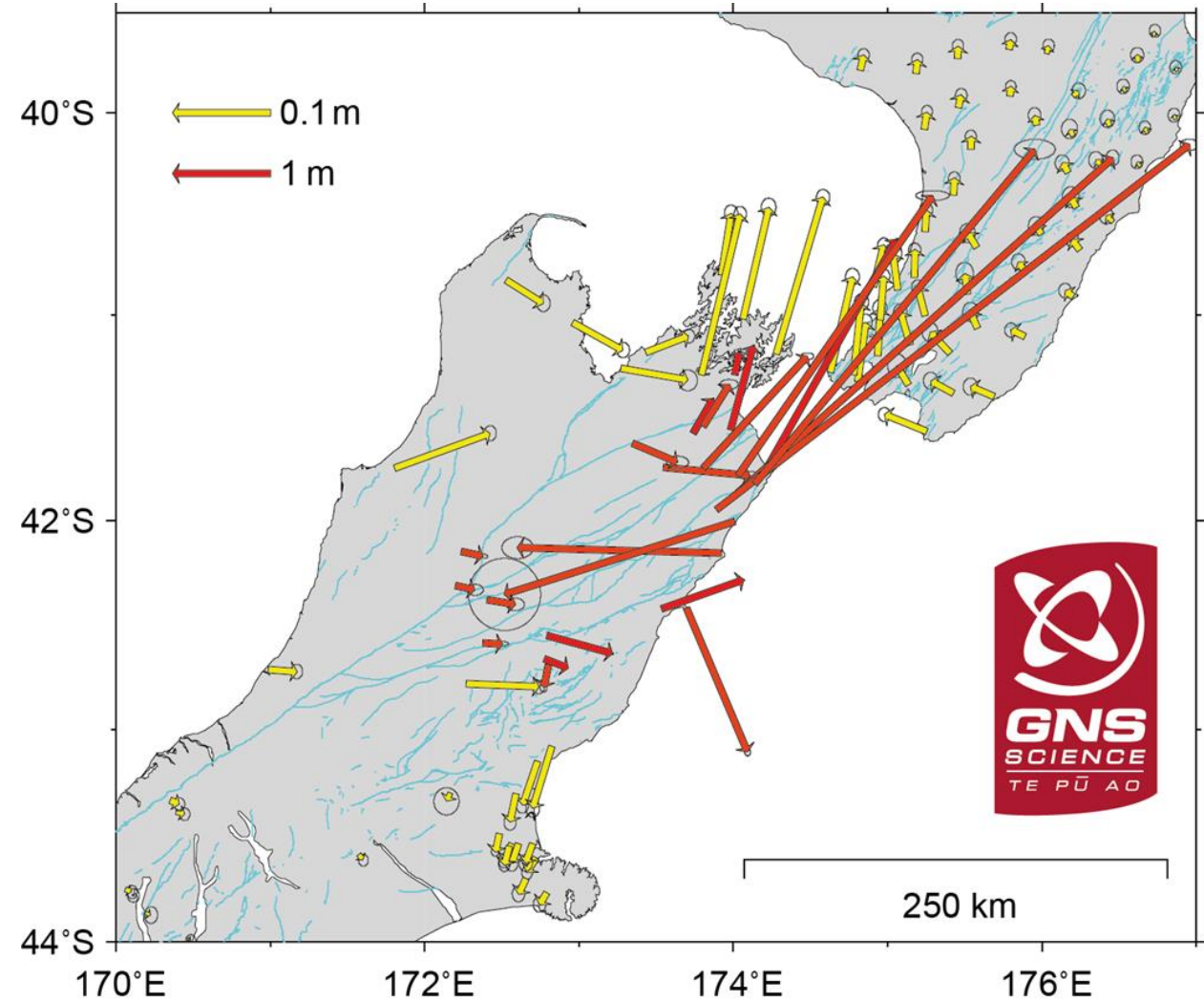
Surface Fault Ruptures

Kaikōura Earthquake

Aftershocks, Nov 13th - 30th, depth <25 km

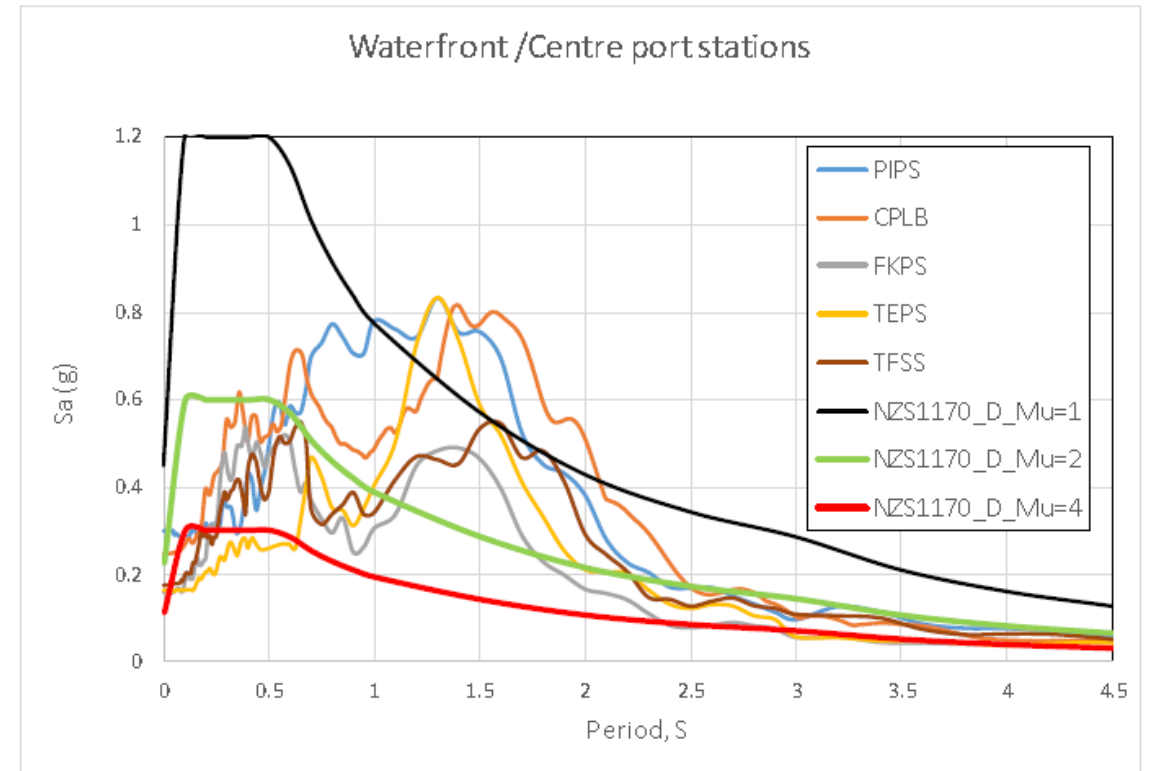
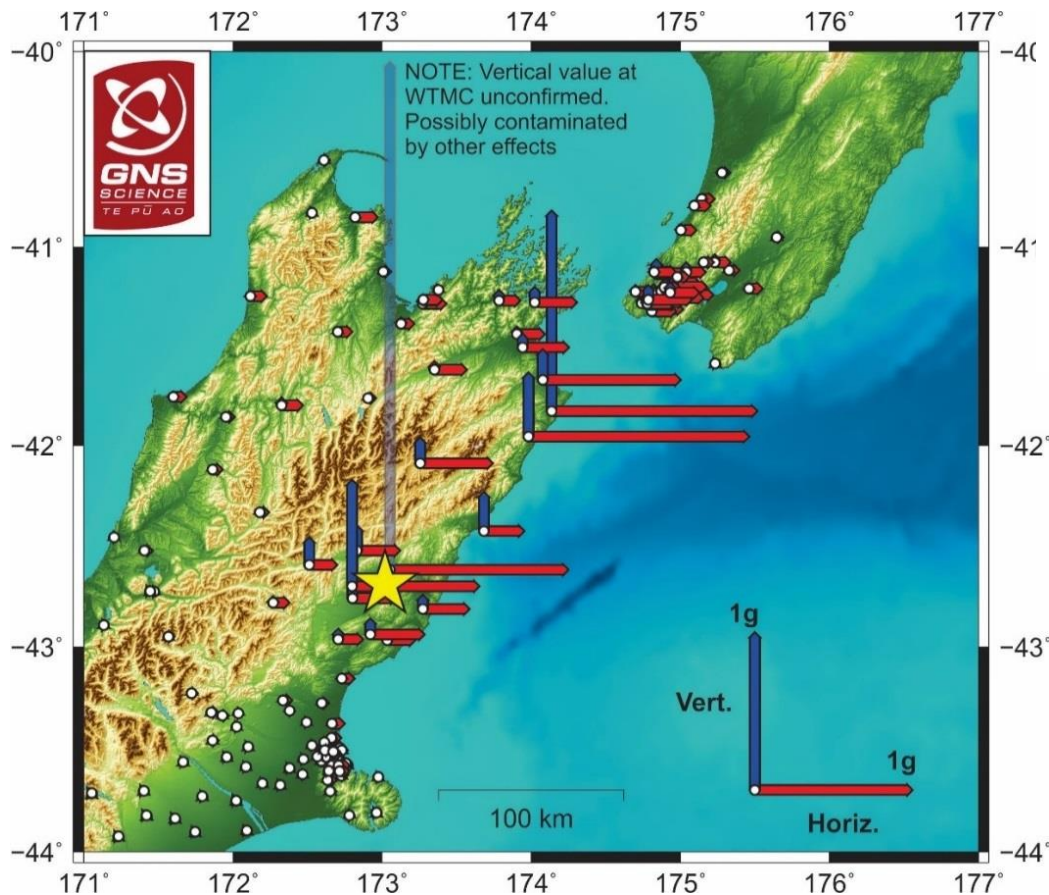


Geodetic station displacements
Hmax: 6m; Vmax: 2m



Ground Motions

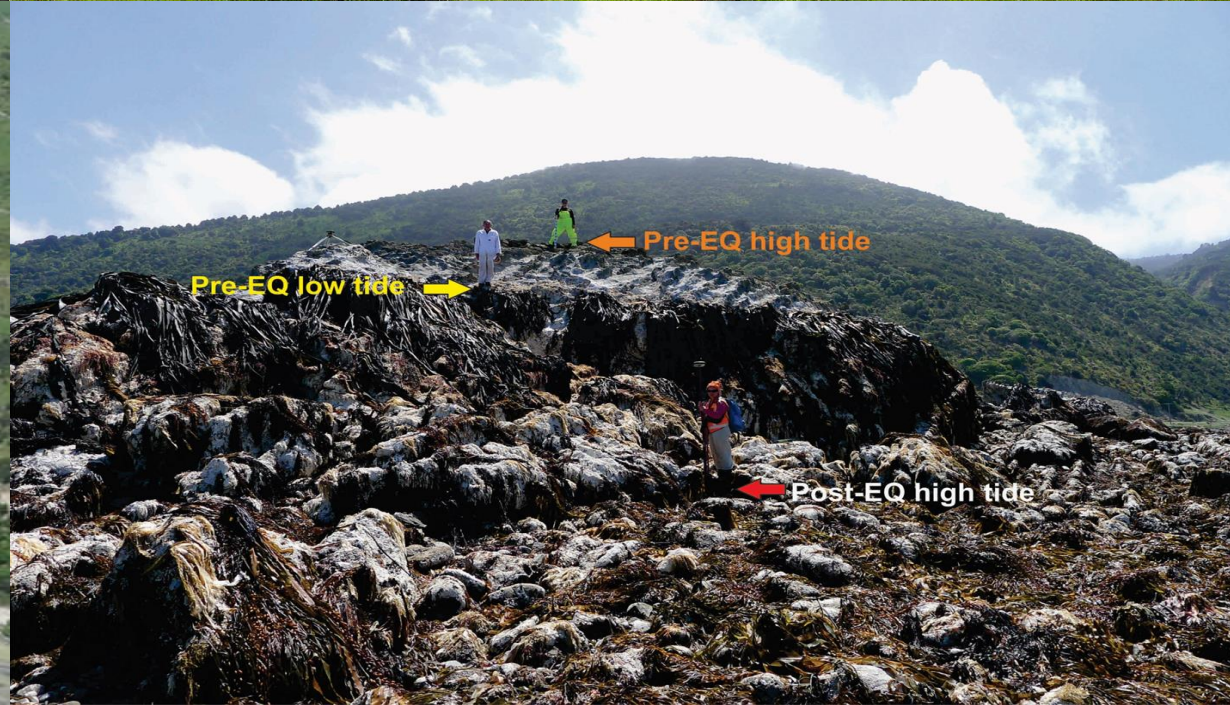
- Two 'nodes' of large motions – epicentre and northeast
- Similar ($>1g$) to Christchurch
- Because of directivity effects in Wellington $>$ Christchurch



- In Wellington shaking damage dependent on ground conditions and building height
- Motions exceeded earthquake-prone criteria
- For taller buildings especially on weak soils or at basin edges motions exceeded building code



Surface faulting, landslides and coastal uplift



Coastal Infrastructure - cut for ~12 months (or longer?)



Residential Damage

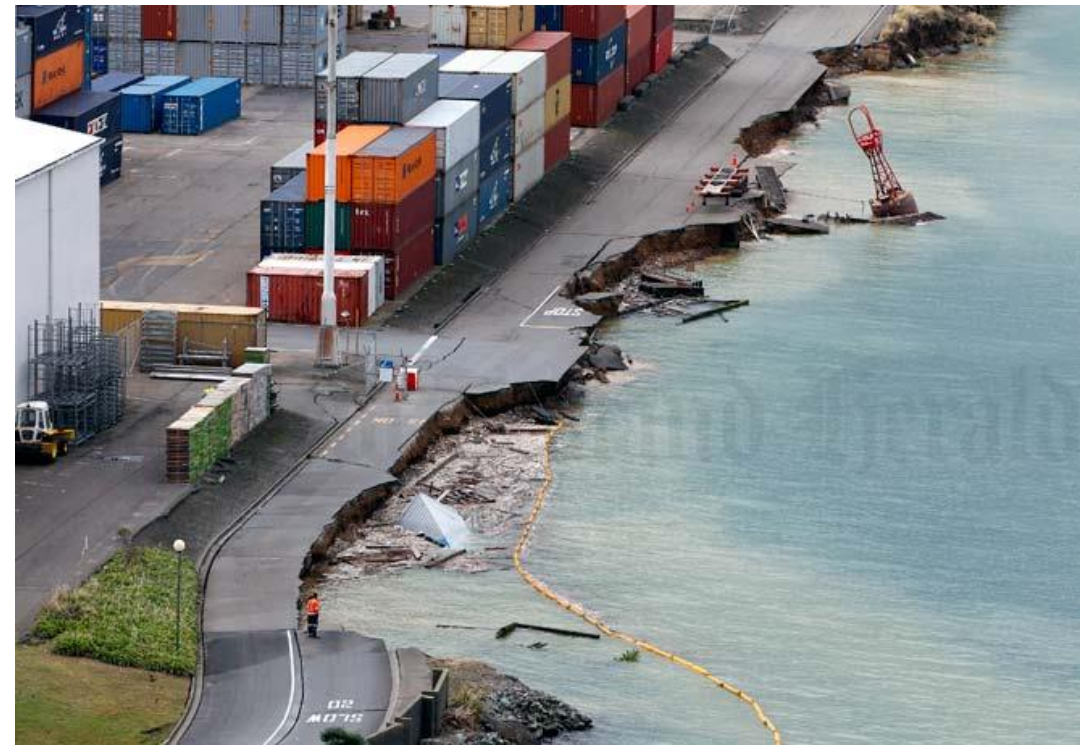


Wellington City – in the global 100 Resilient City Programme



CentrePort, Wellington

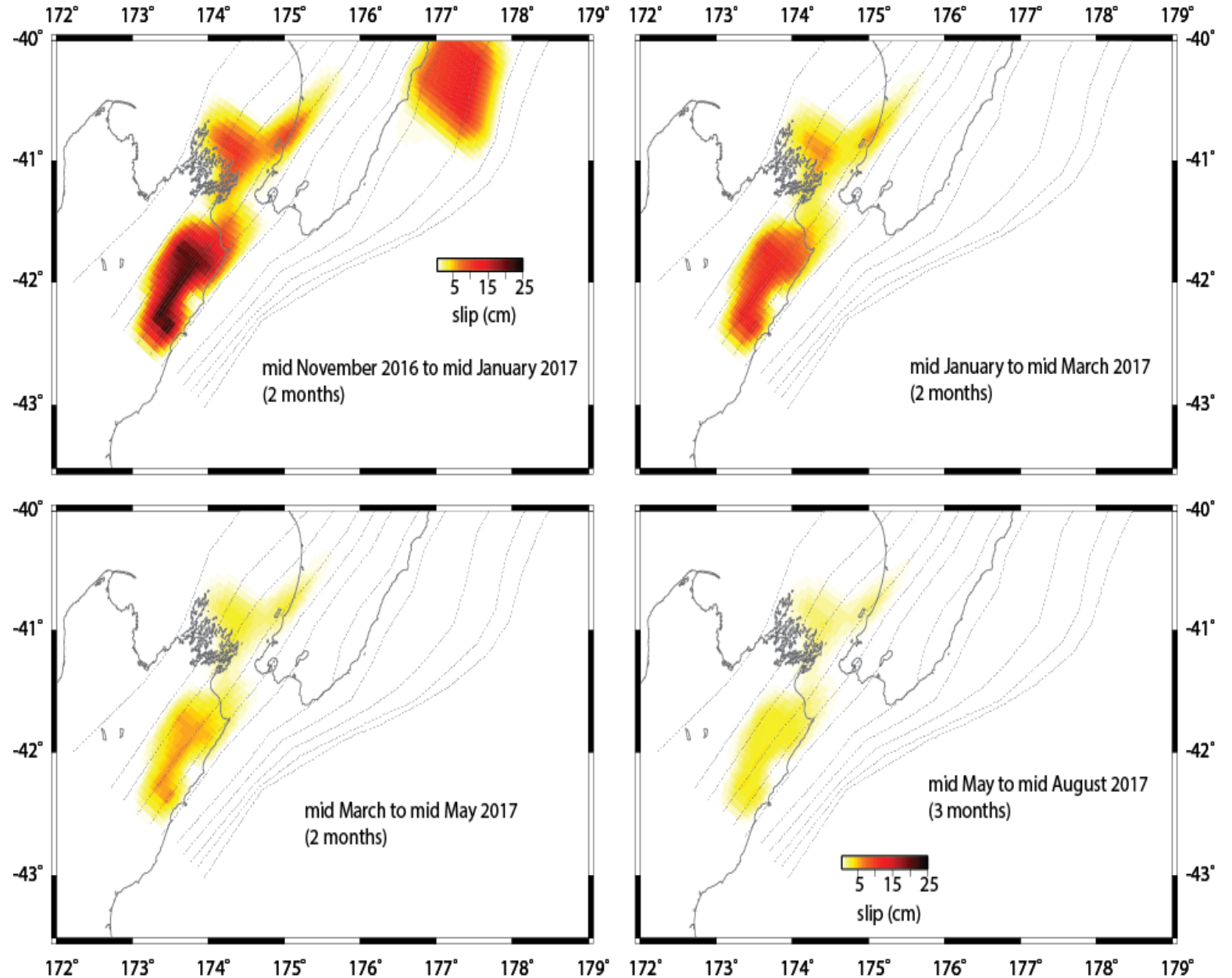
- \$ 340M repair bill
- Repairs not complete until 2022 or later
- Extensive damage to commercial buildings, cranes, RORO linkspan, wharves & container terminal



Kaikōura Earthquake

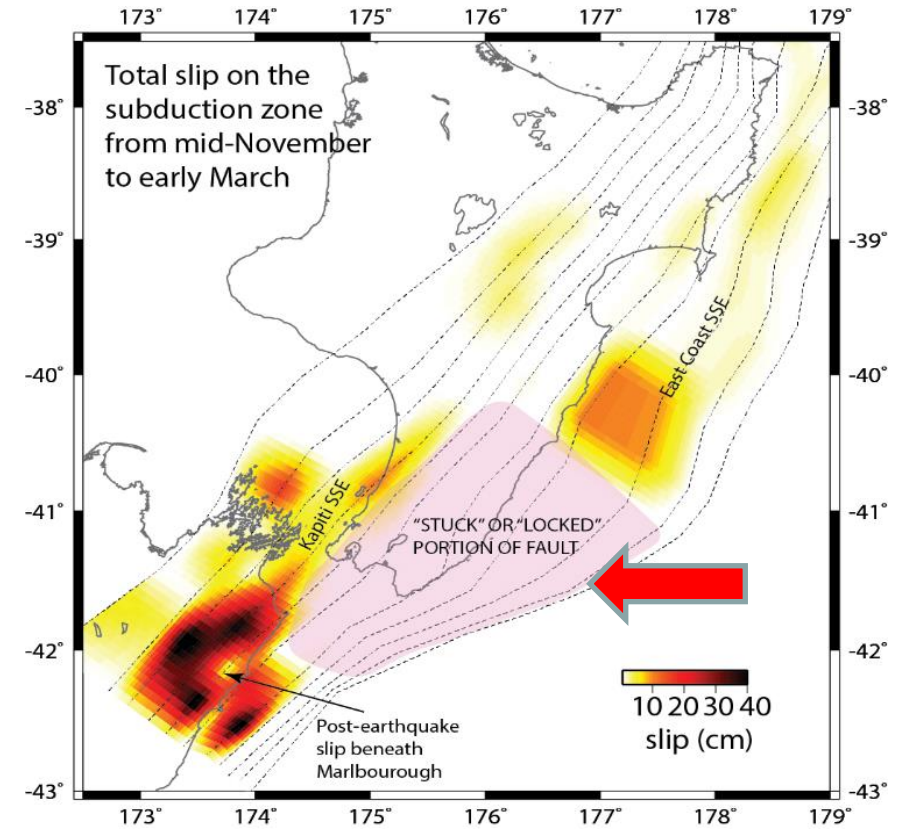
Kaikōura earthquake & slow slip

Slow slip events started along the whole margin within 1 week of Kaikōura EQ



What are the scenarios following the Kaikōura Earthquake?

- **Scenario One: Likely (54% within the next year)**
 - Aftershocks will continue to decrease in frequency over the next year and no aftershocks of M7 or larger will occur, but a M6+ remains likely
- **Scenario Two: Unlikely (approx 6% within the next year)**
 - An earthquake smaller than the main shock but between M7.0 and M7.8 will occur (*a fault in Cook Strait is one of the possibilities*)
- **Scenario Three: Very Unlikely but cannot be dismissed**
 - A mega-quake on the locked part of the Hikurangi subduction zone – potentially M8+



More Broadly – what should NZ be preparing for ?

| Event | Likelihood in next 50 yrs | Possible economic loss (2015 estimates) |
|--|------------------------------|--|
| • Alpine fault - M8 earthquake | 30% | >> \$10bn |
| • Ruapehu/Tongariro/Ngauruhoe White Island major eruption | almost certain | > \$1bn |
| • Taranaki eruption | 20% | > \$10bn |
| • Hikurangi subduction zone M8+ and tsunami | 30% | \$30-40bn |
| • Hope fault M7.2 earthquake | 50% | ~\$1bn? |
| • South America M9+ earthquake & NZ tsunami | 50% | >\$1bn? |
| • Taupo region major eruption | 10% | >> \$10bn |
| • Auckland volcanic eruption | 5% | ~ \$30bn |
| • NZ earthquake sequence like 1929-1942 | 50% | >> \$10bn |
| • Wellington fault earthquake | 5% | \$40-60bn |

Note: New Zealand
GDP 277B NZD
(2013)

What can be done now ?

- Continue research to extend and refine past record of major events – analogues for the future;
- Use the scientific evidence to guide appropriate policy;
- Evaluate consequences of possible future events and act when risk (economic as well as safety) is unacceptable;
- Use all available risk management options – accept, reduce, avoid, transfer
- Scenarios and exercises, develop contingency plans – personal, family, community, city, country
- Invest in resilience – well chosen investment will have a 10:1, or more, return and protect economic and social prosperity



Drop, Cover and Hold is still the right action to take



Drop, Cover and Hold



long or strong, get gone

What lessons for Resilience from the Kaikōura Earthquake – a few personal thoughts

For Land Use Planning

- No major issues identified – minimal liquefaction, some lateral spread issues at Lyell Creek, Kaikōura;
- Landslides in the farm country of north Canterbury suggest some improved on-farm practices are possible.

For Infrastructure

- Not too many surprises (to scientists) regarding landslides and impact on transport, but,
- Seemingly not much attention to redundancy in transport system (e.g. no coastal shipping to back up rail), alternate highway not up to standard;
- CentrePort – neglected maintenance?, seemingly weak risk management.

Business Continuity Planning

- Despite Canterbury & Cook Strait EQ's little planning by central govt. agencies prior to Kaikōura earthquake – being redressed now;
- Wellington, the 'resilient city', image a little tarnished – cordons & some demolition (above code but not by much - future events expected to be much worse);
- Rural and tourism sectors hard hit;
- 5 million litres of wine lost – storage tanks - code or compliance?

