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ICG-14

Geodesy in support of Disaster Risk Reduction, Response and Recovery: Kaikoura Earthquake a case study

Graeme Blick
Group Manager Positioning and Resilience

LINZ Geodetic Activities: Kaikoura Earthquake

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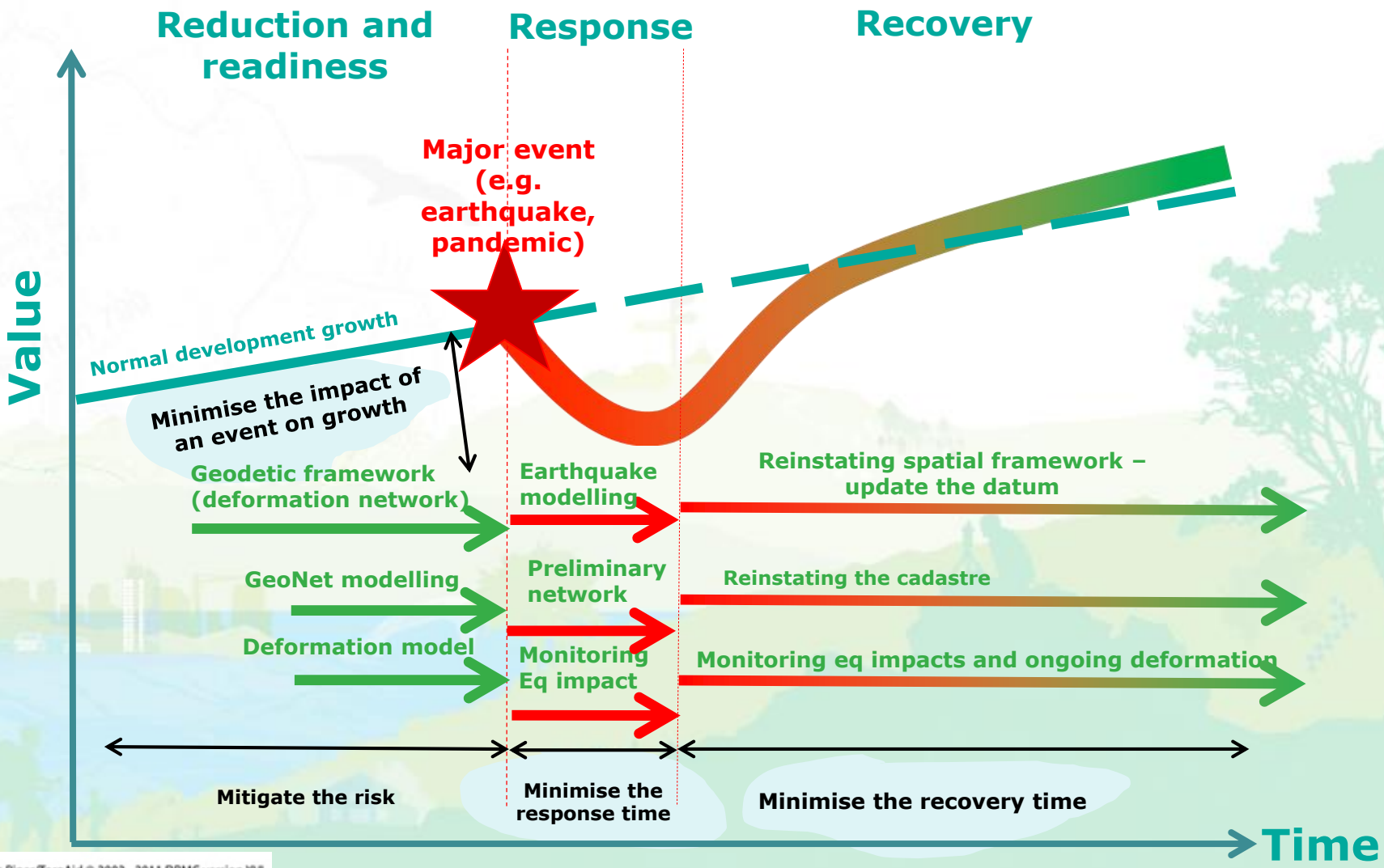

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Risk reduction and readiness

Connecting to the datum

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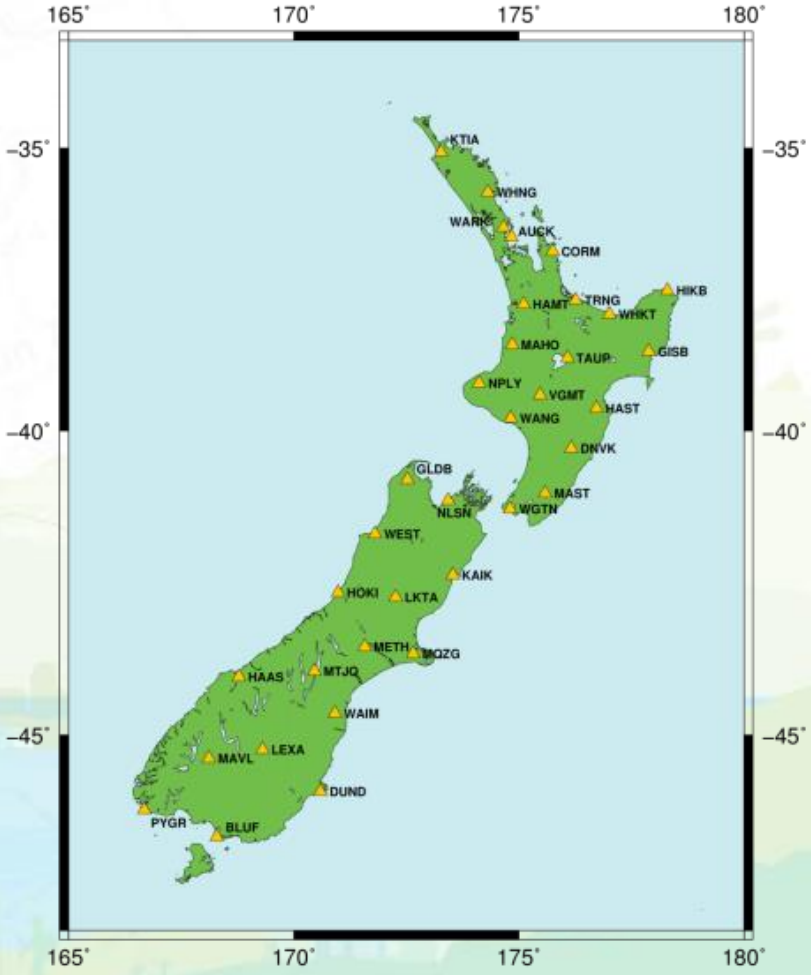

PositioNZ Network

35 on the mainland of NZ

1 on the Chatham Islands

3 in Antarctica

GEONET

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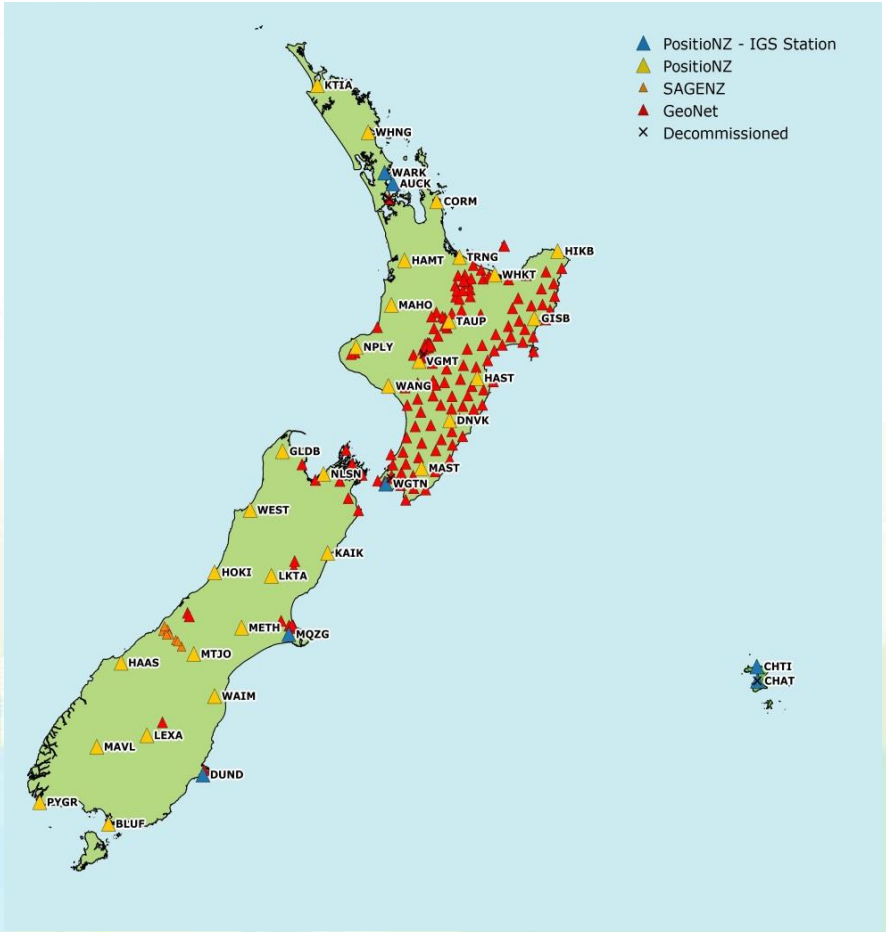

Auckland - stable

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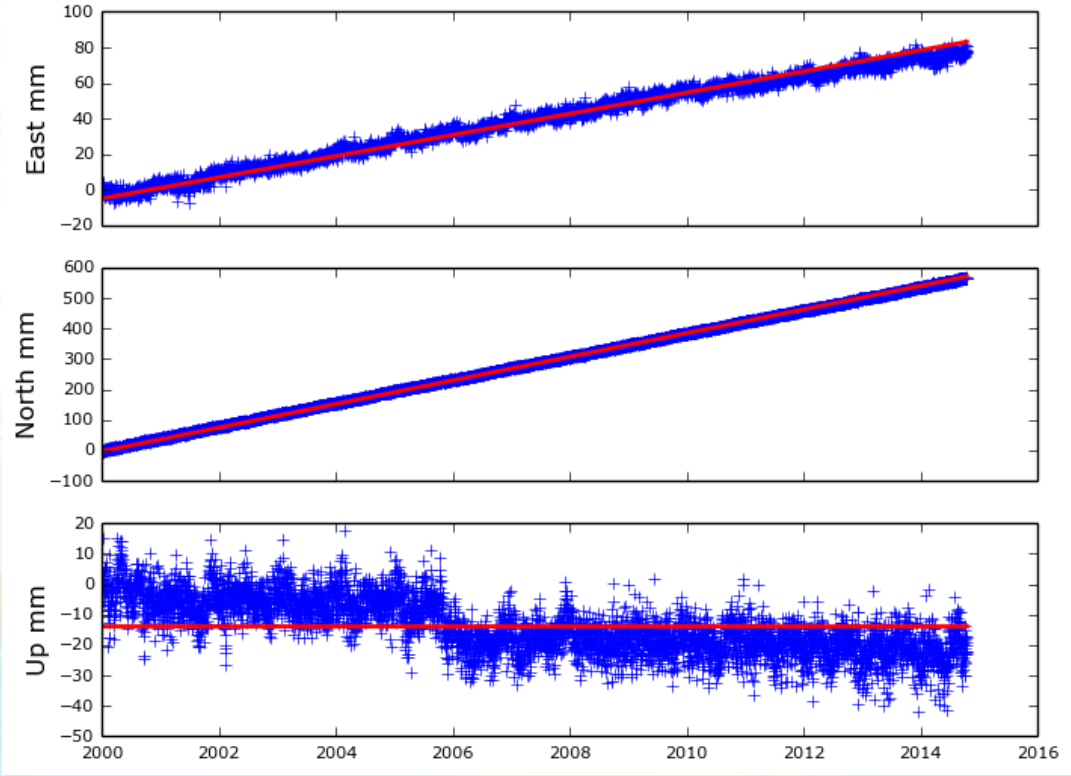

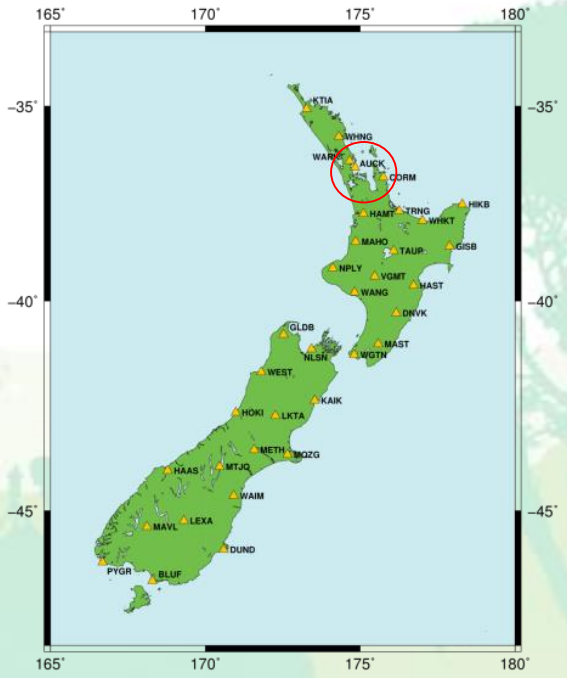

Gisborne – slow earthquakes

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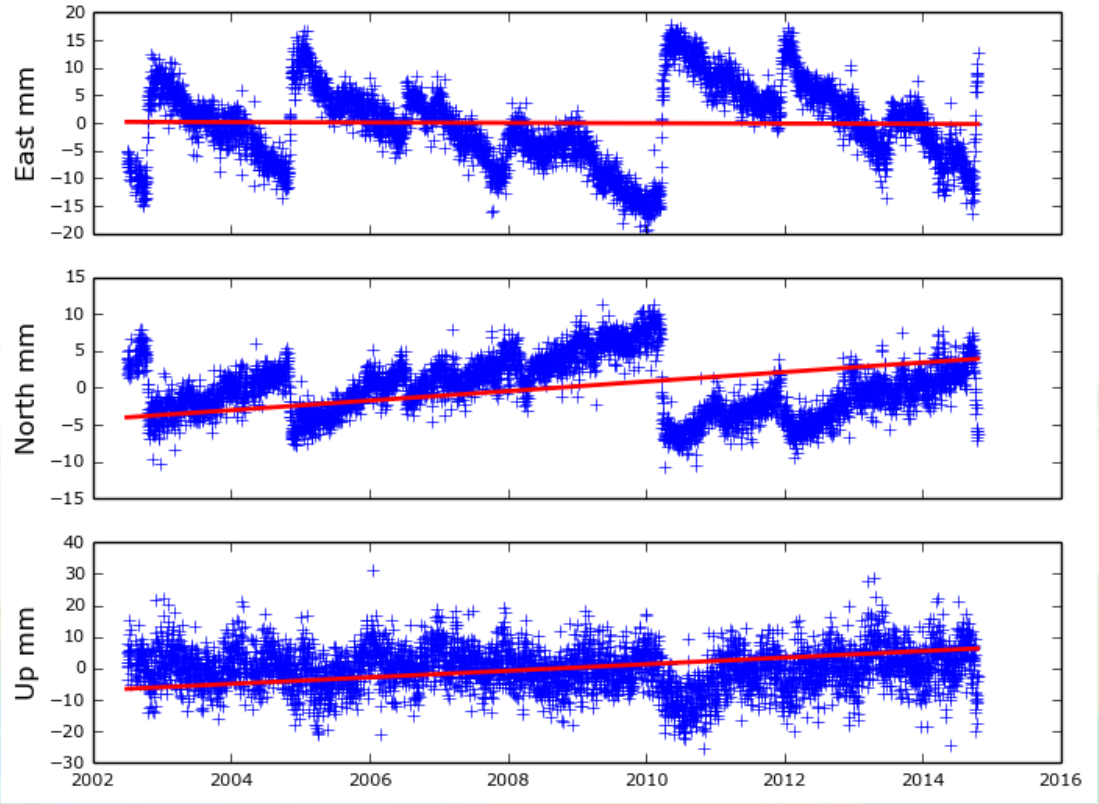

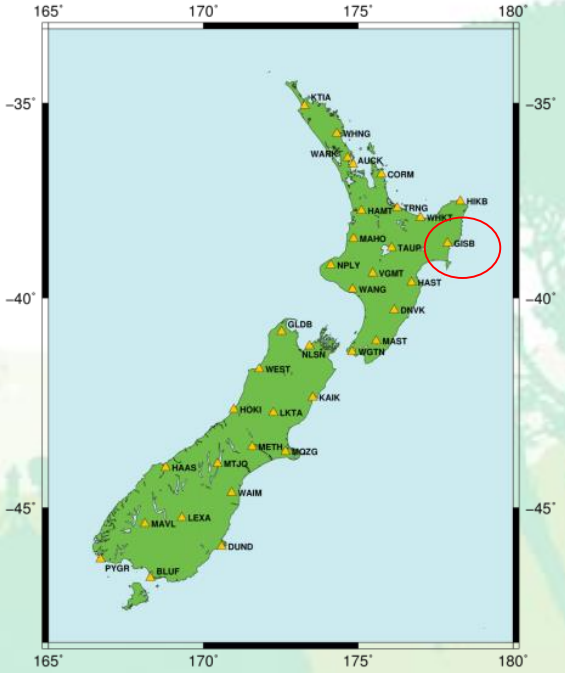

Building a picture of the strain field in NZ

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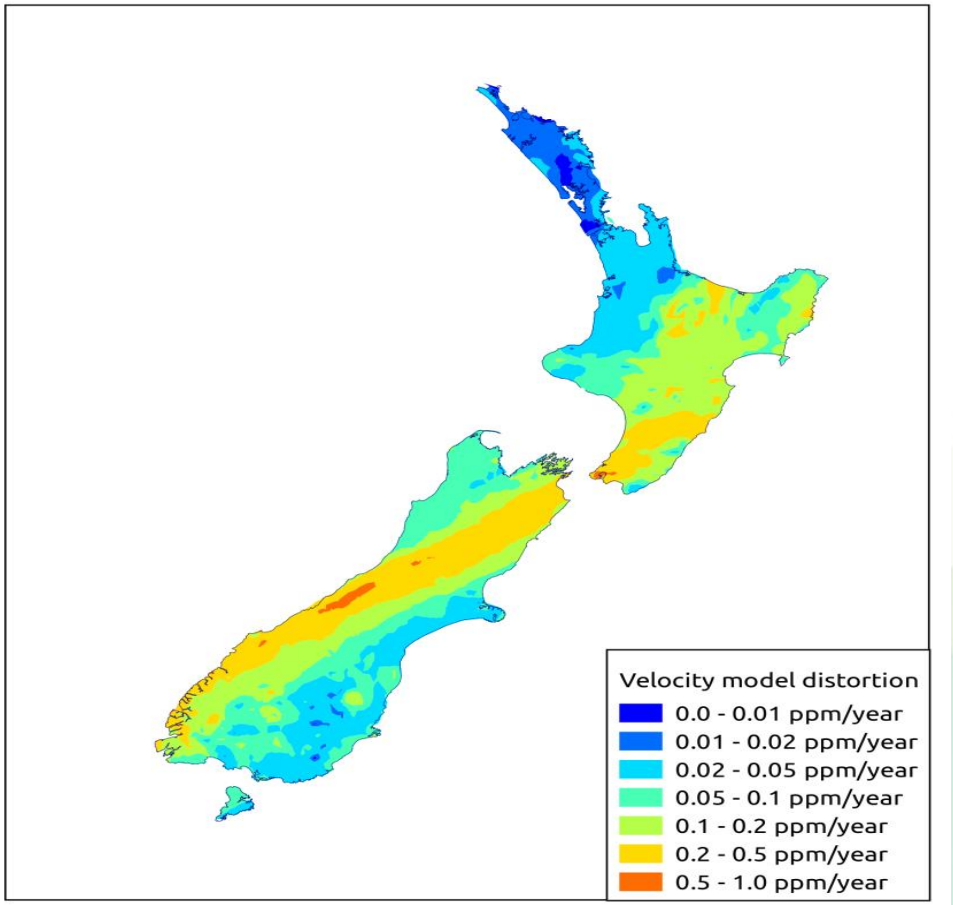

Present-day vertical rates

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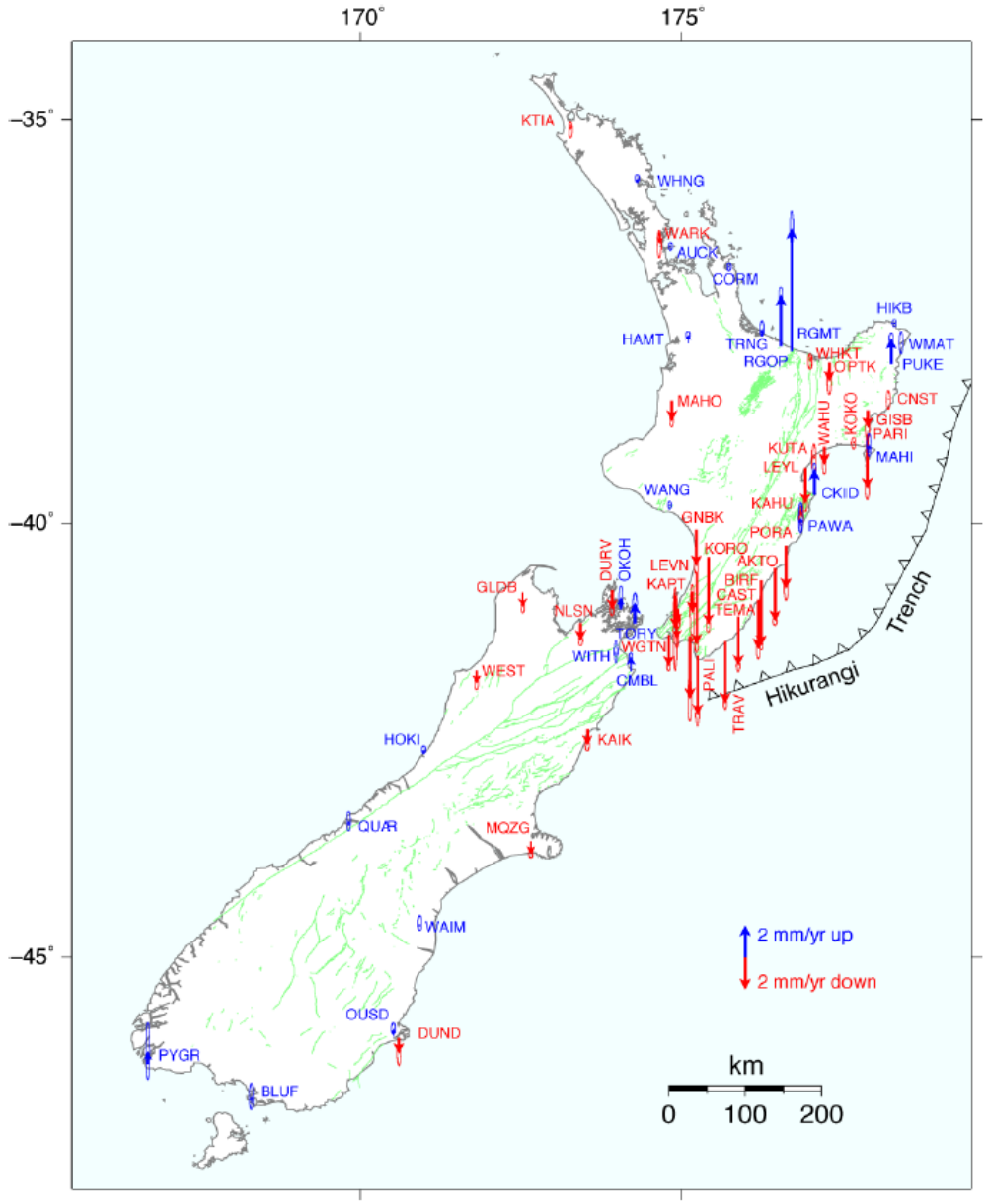
Vertical rates estimated at near-coast GNSS sites. (GEONET/LINZ)

Regional trends - lower North Island subsiding at 1-3mm/year



Beavan, R.J.; Litchfield, N.J. 2012. Vertical land movement around the New Zealand coastline: implications for sea-level rise, *GNS Science Report* 2012/29

Present-day vertical rates

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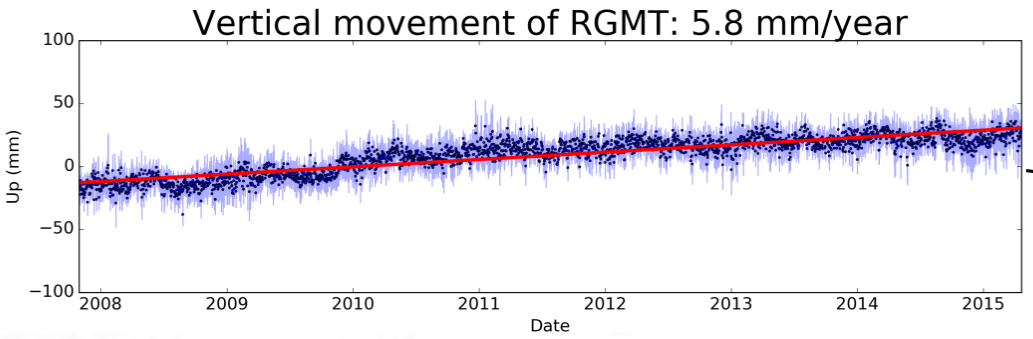

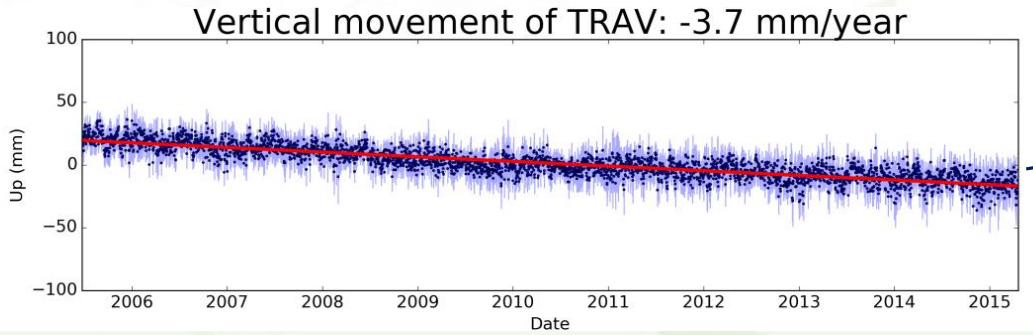

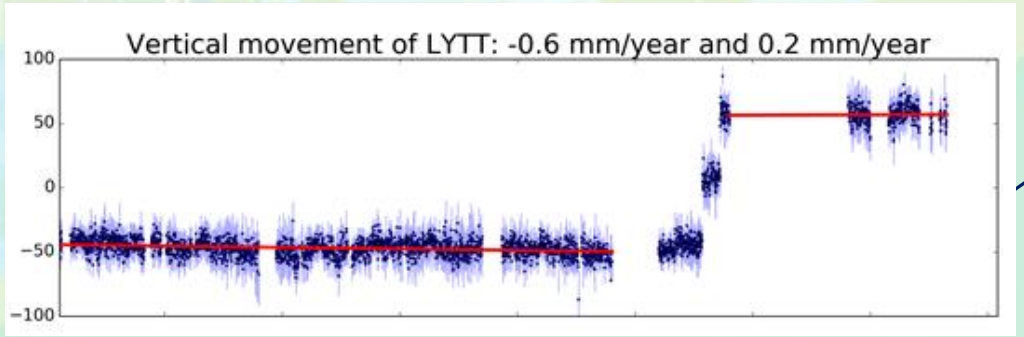

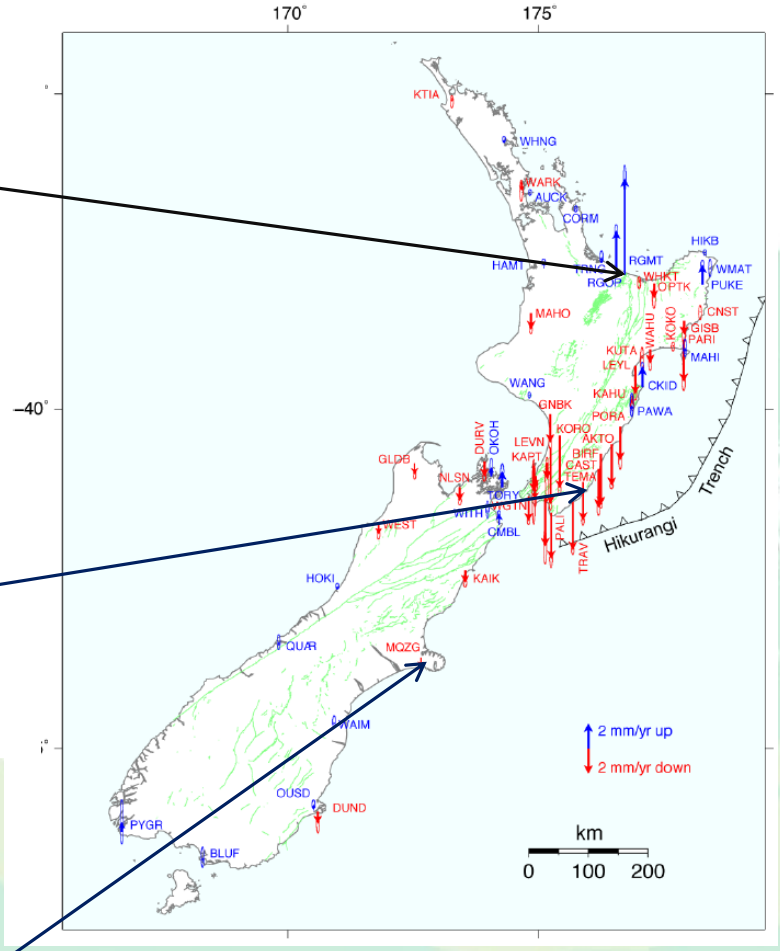

Beavan, R.J.; Litchfield, N.J. 2012. Vertical land movement around the New Zealand coastline: implications for sea-level rise, *GNS Science Report* 2012/29

Local monitoring using GNSS

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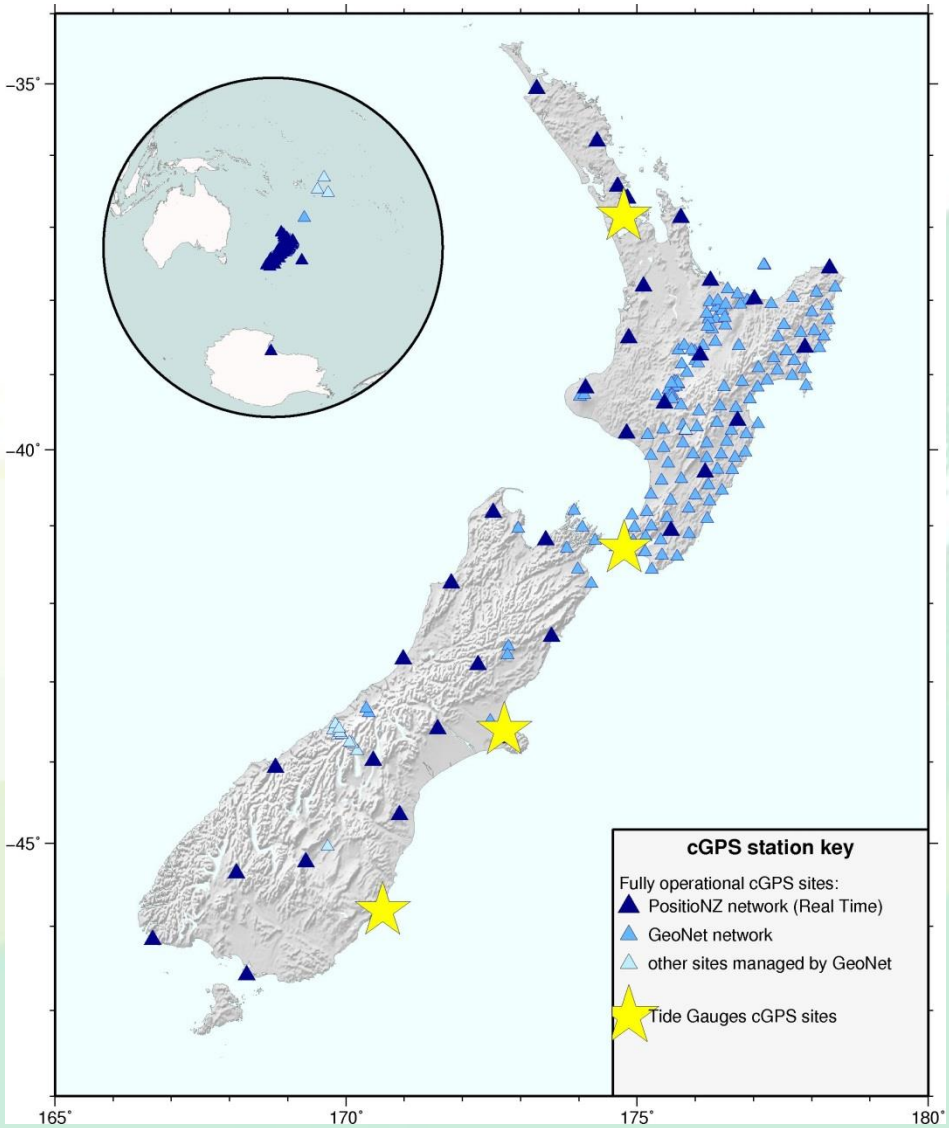
GNSS receivers co-located with tide gauges:

- Auckland
- Wellington
- Lyttelton
- Dunedin



Long term sea level change – Auckland

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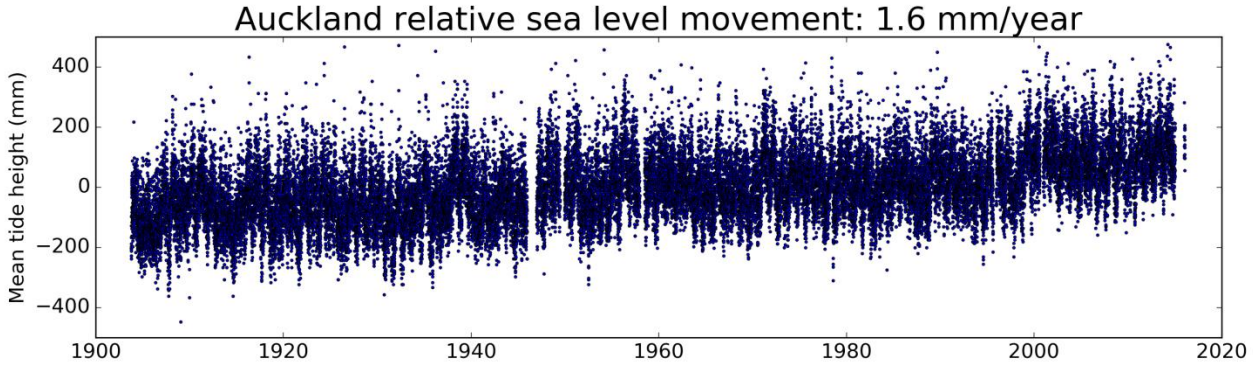

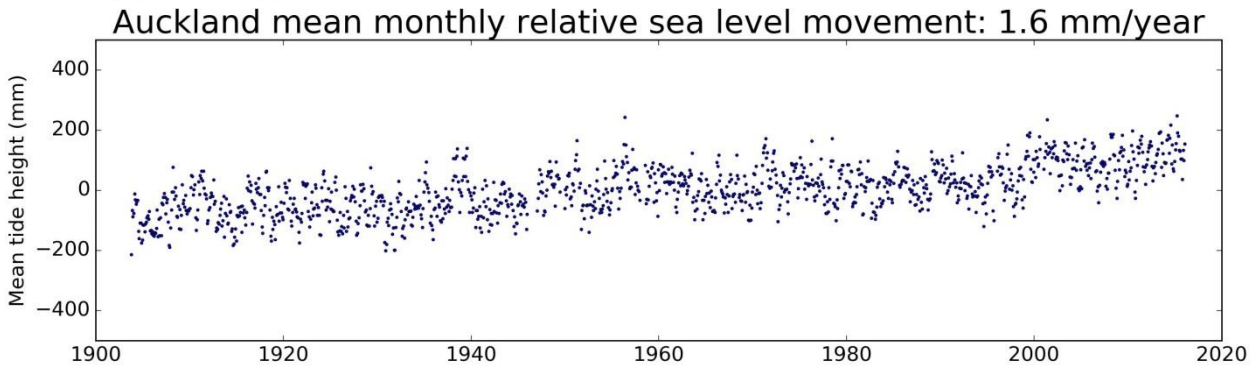

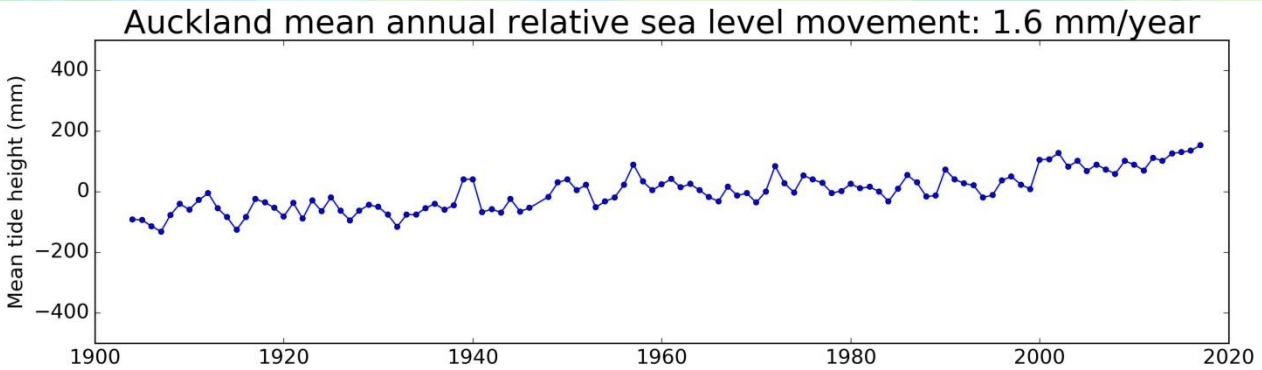

Reference frames in the tidal zone

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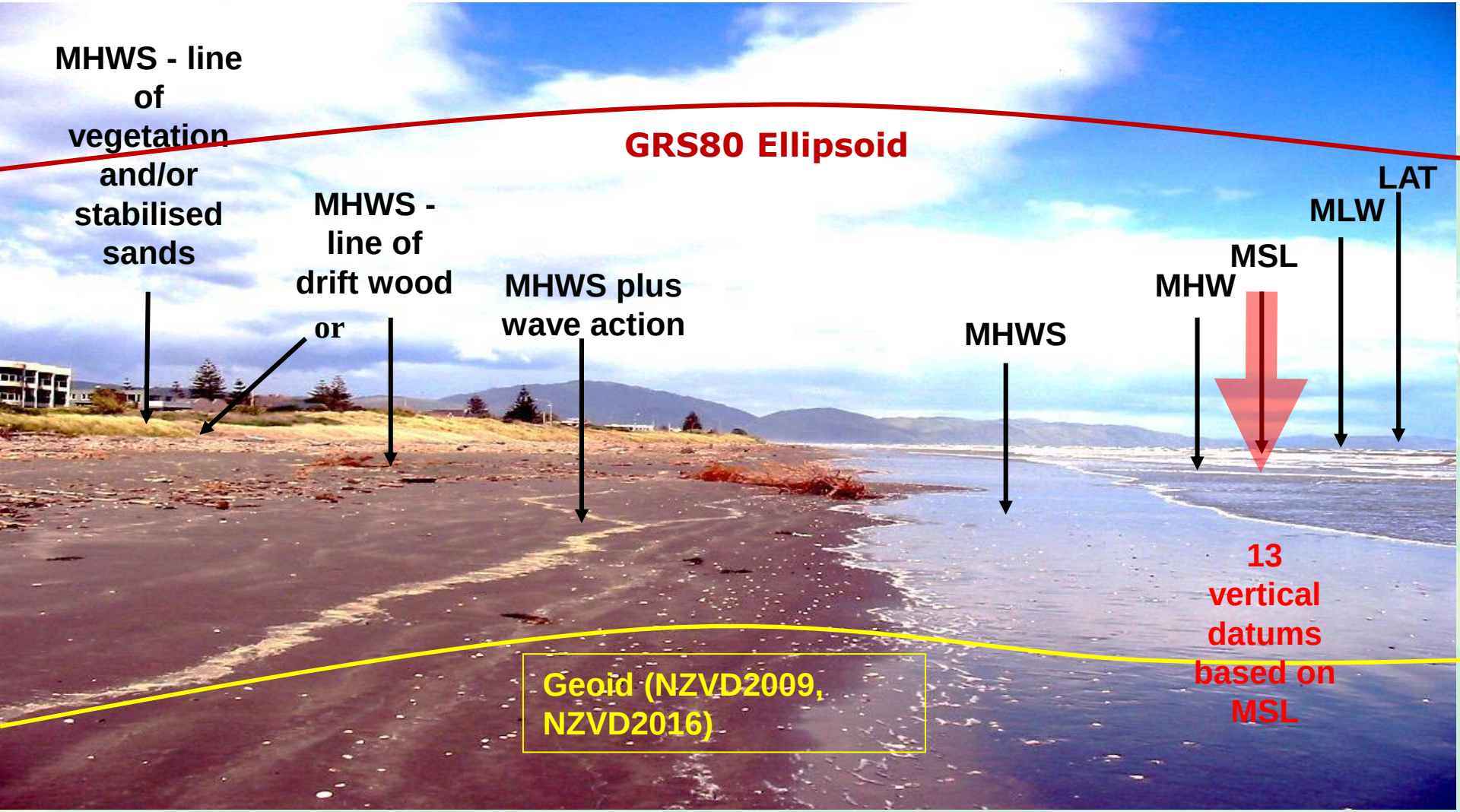

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Response

Kaikoura M7.8 Earthquake
14 November 2016

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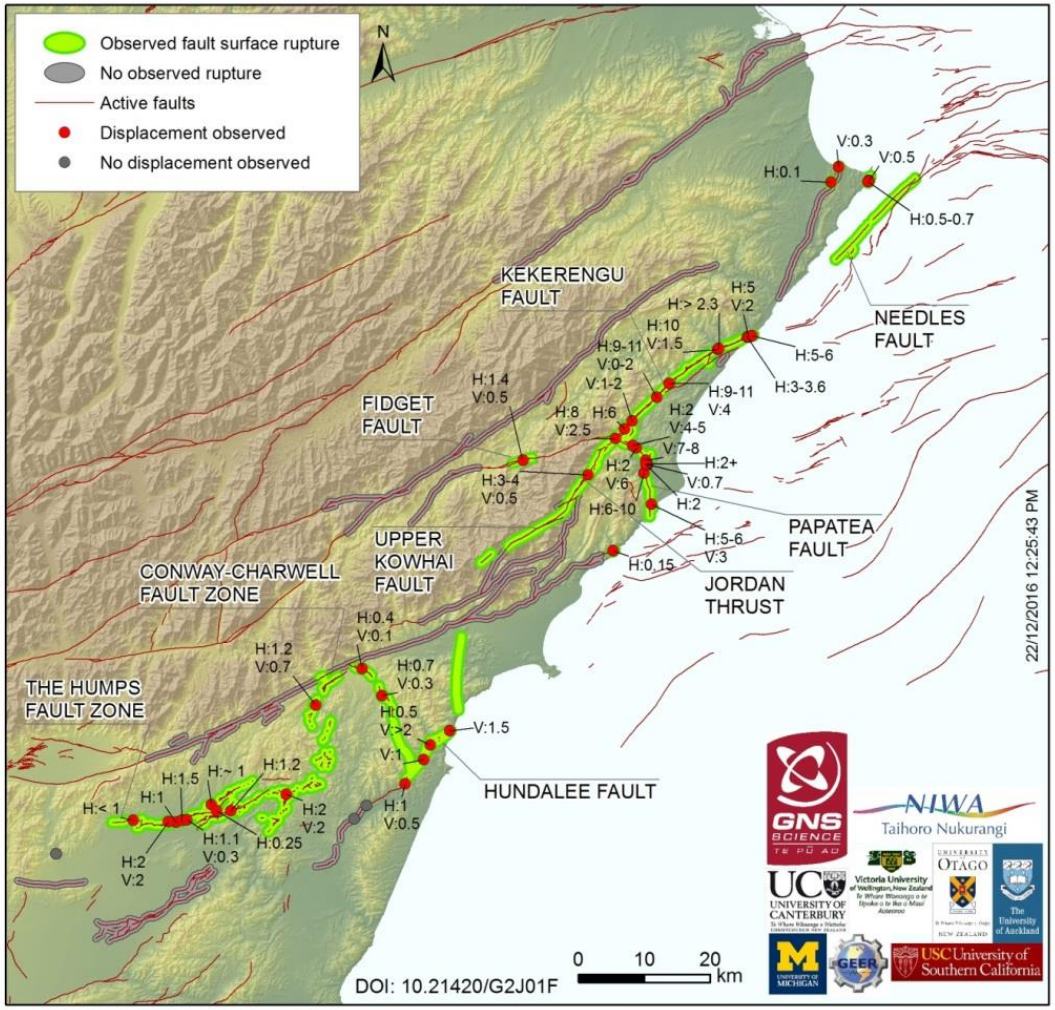

- Multiple faults ruptured
- Displacements exceeding 5m (horizontal and vertical)
- Serious property and infrastructure damage

Significant ground displacement

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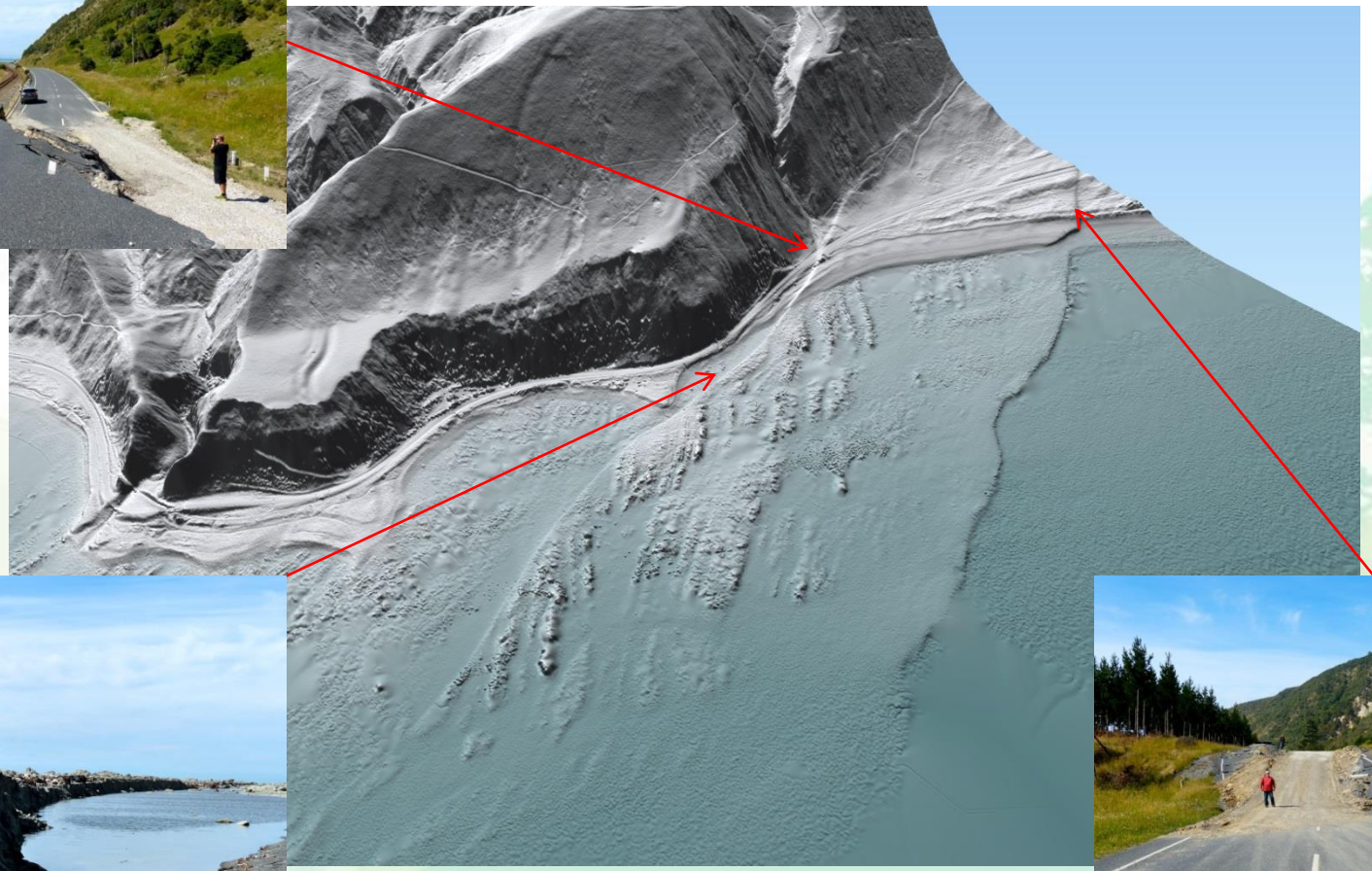

Severe land sliding and fault ruptures

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Photo Robert Langridge/Julie Rowland

Photo Kate Pedley

Photo Robert Langridge/Julie Rowland

Drone Photo Courtesy Julian Thomson, GNS

Role of geodesy/survey

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- **Rapidly assess impact on geodetic system**
- **Compute deformation models to assist understanding of earthquake mechanisms and update the control networks**
- **Fast re-establishment of base level of horizontal and vertical control to support rebuilding of basic infrastructure**
- Providing the framework to enable surveyors/engineers to generate their own control where and when they need it
- Facilitate the updating of the cadastre

Horizontal and vertical movements

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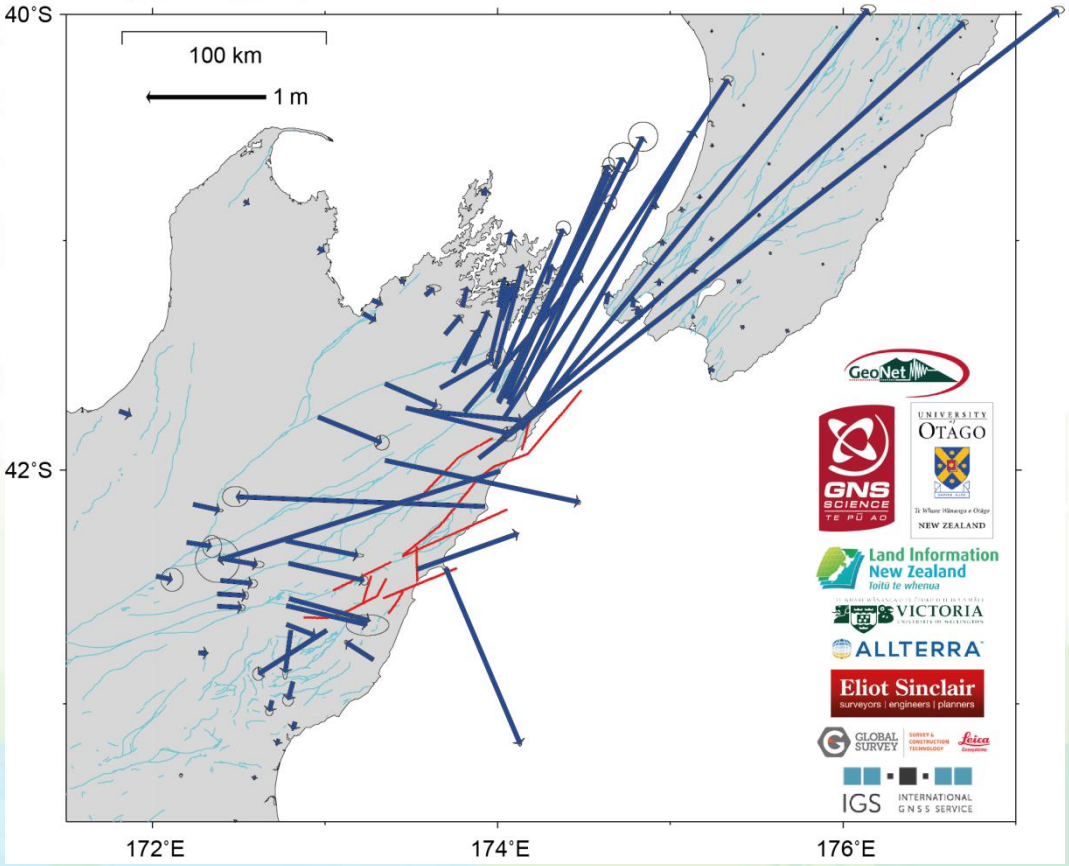

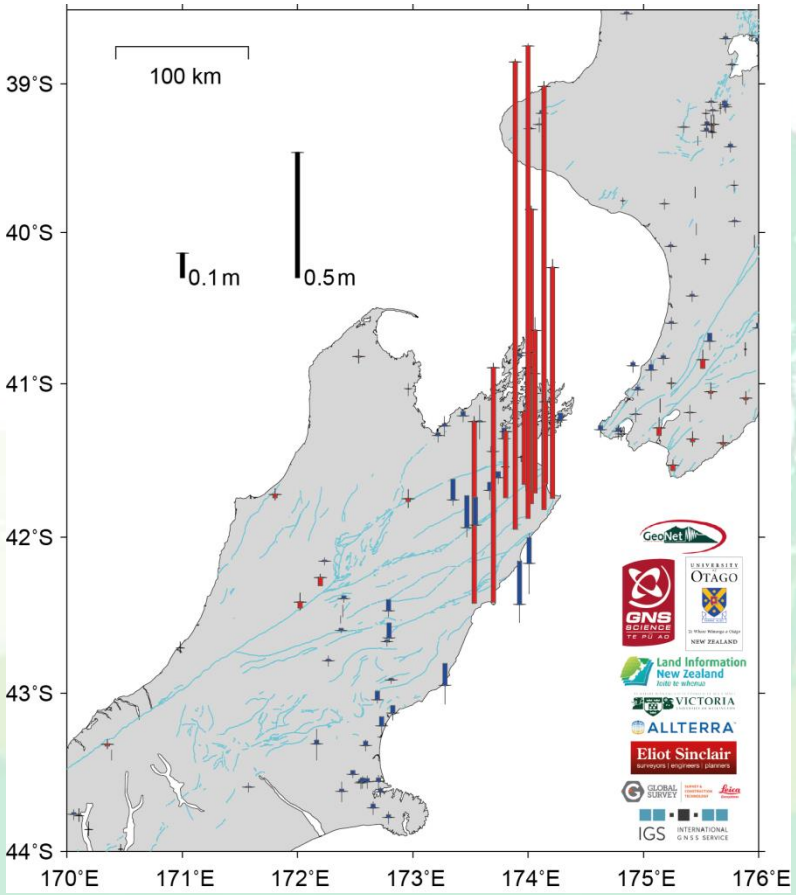

Post-seismic movements

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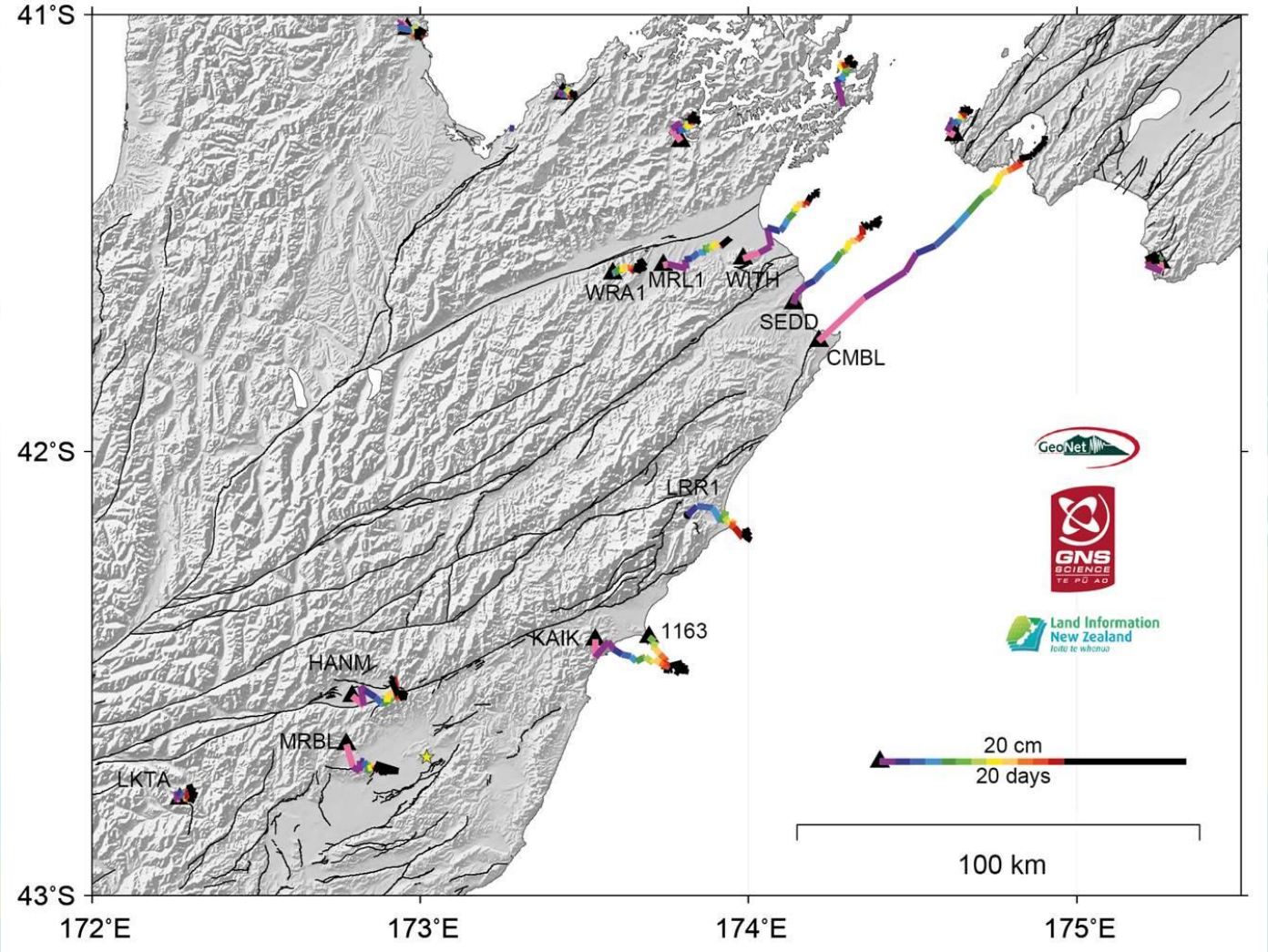

Use of InSar

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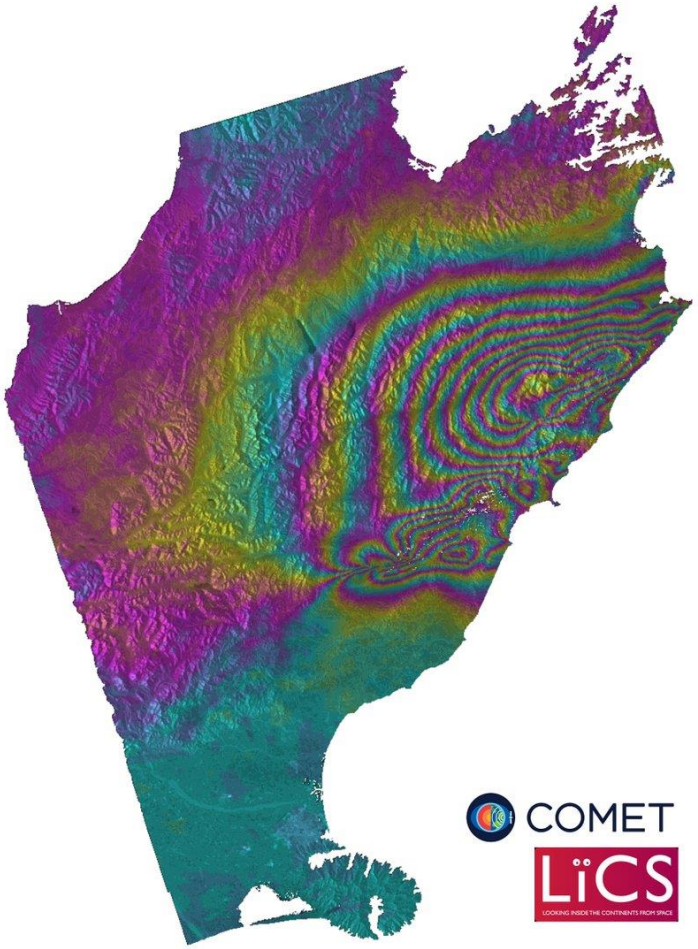

Near and far field movements

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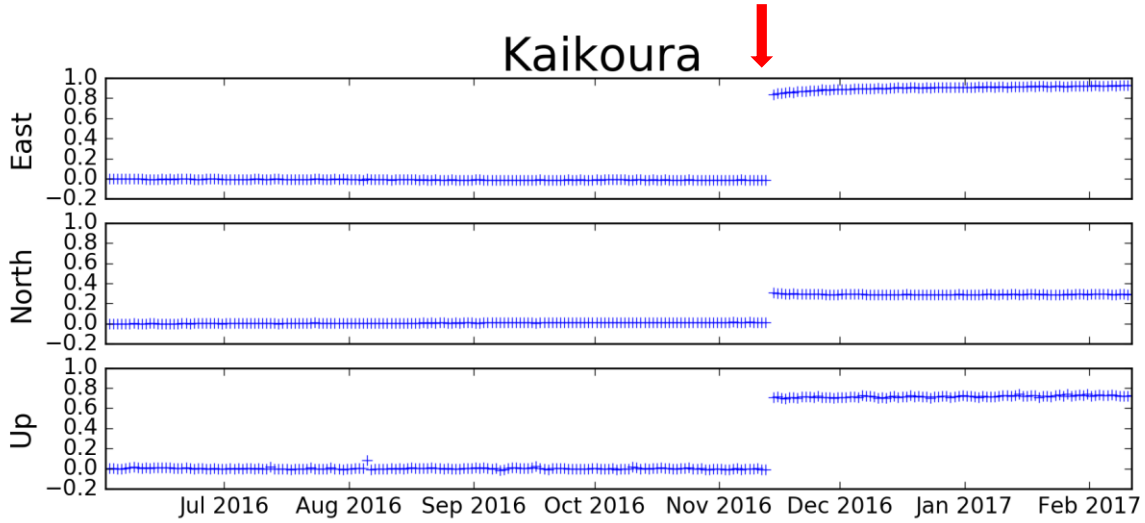

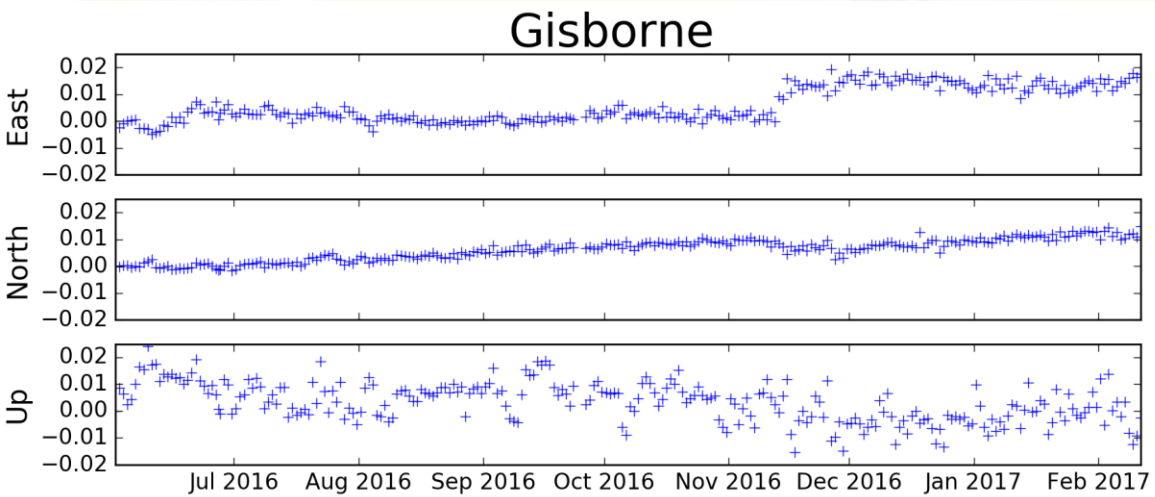

Modelling the fault ruptures

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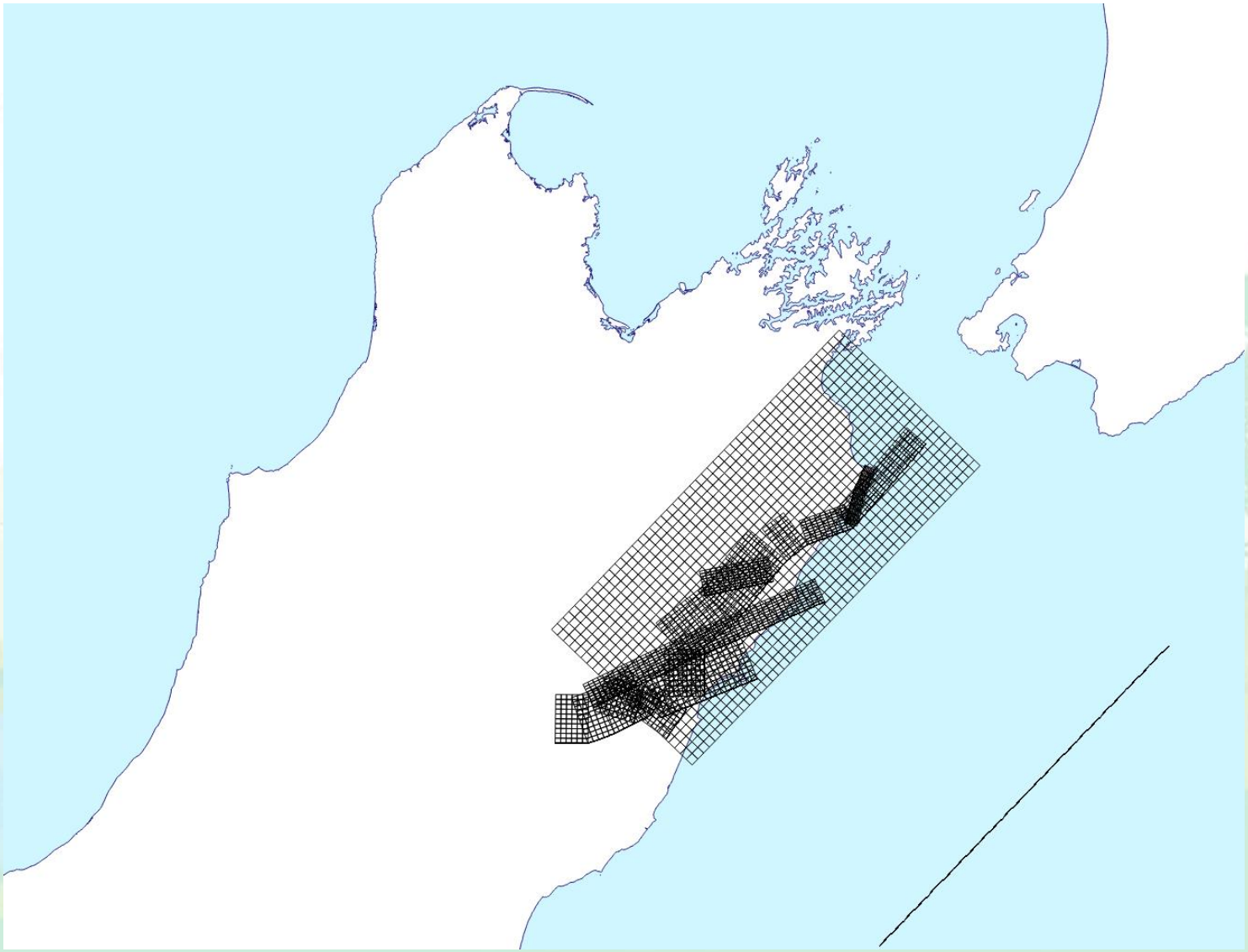

Modelled verse observed displacements

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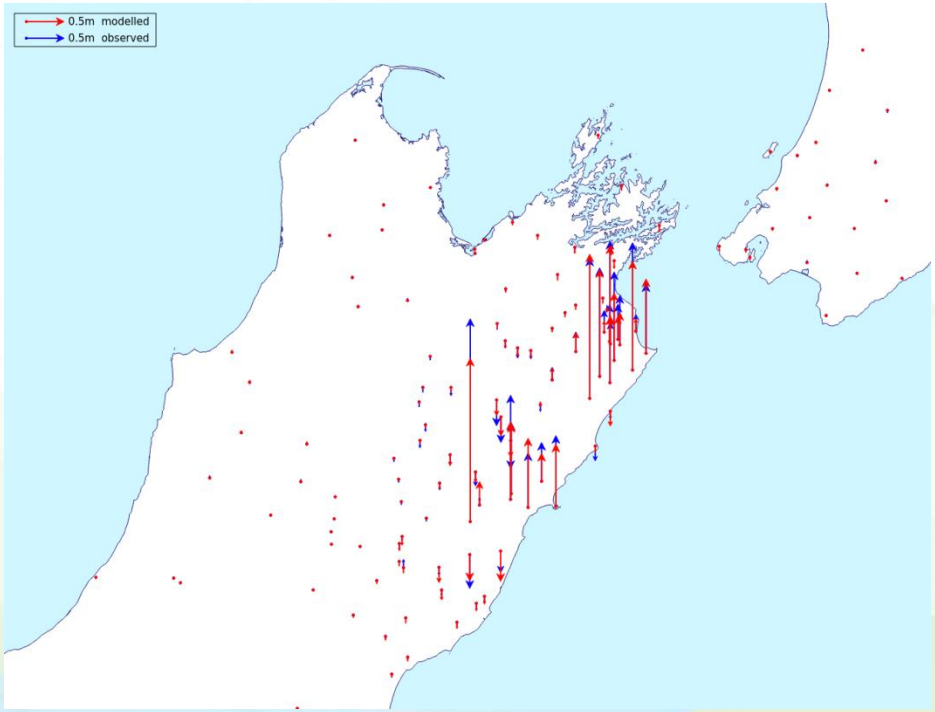

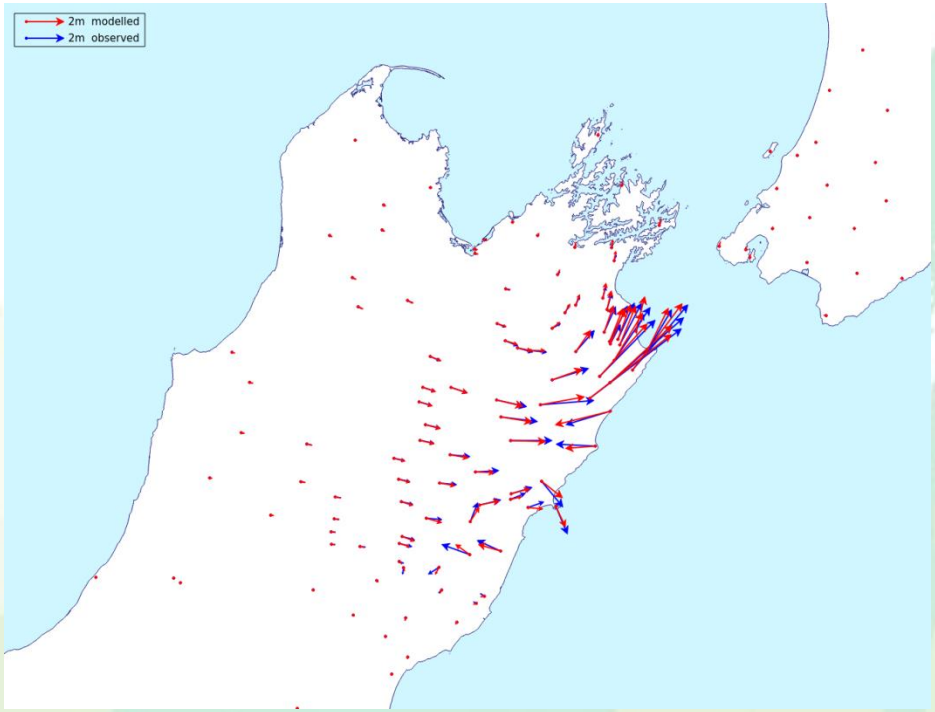

Kaikoura earthquake deformation

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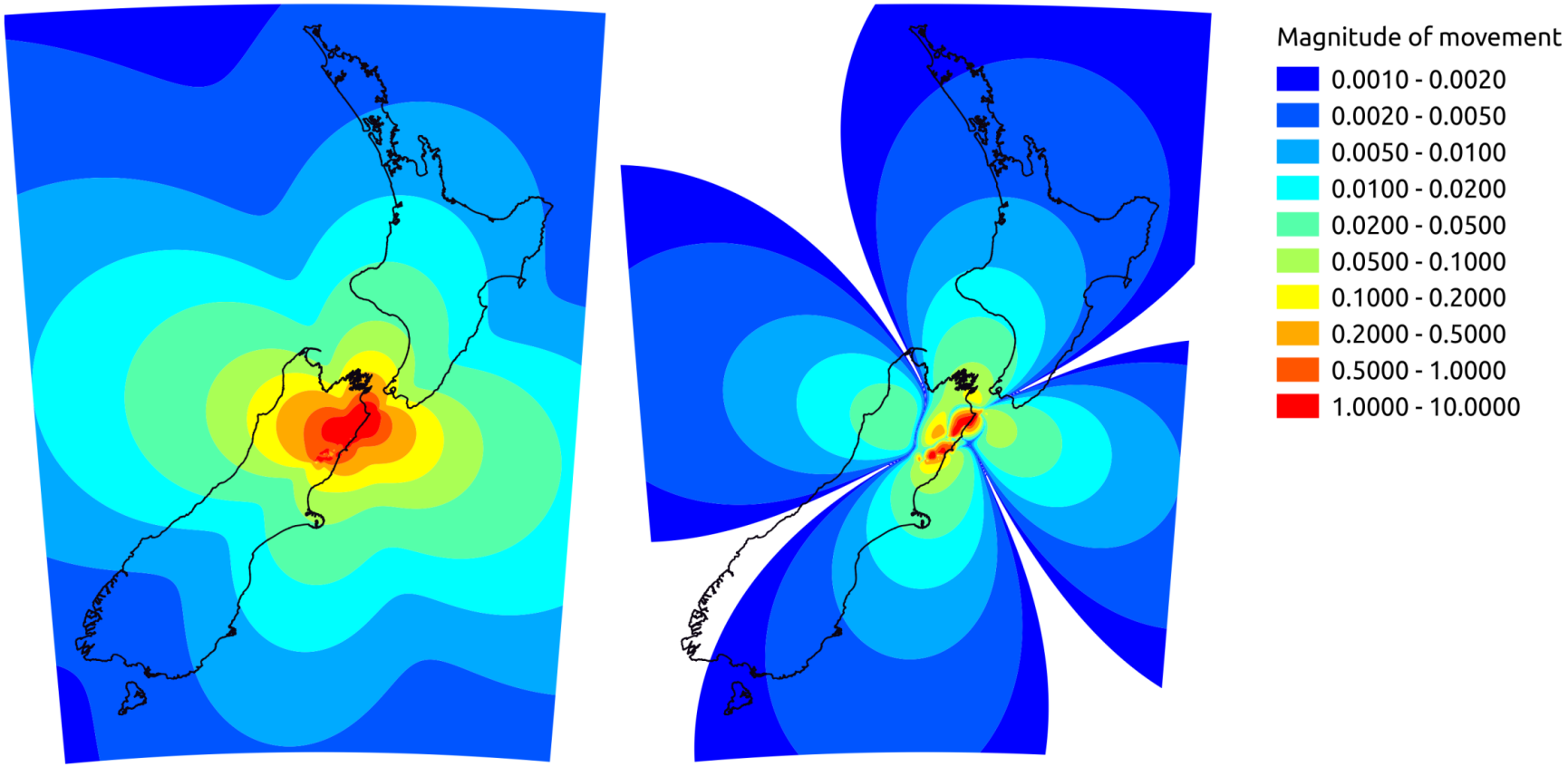
Horizontal movement

Vertical movement



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Recovery

Role of geodesy/survey

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- Rapidly assess impact on geodetic system
- Compute deformation models to assist understanding of earthquake mechanisms and update the control networks
- Fast re-establishment of base level of horizontal and vertical control to support rebuilding of basic infrastructure
- **Providing the framework to enable surveyors/engineers to generate their own control where and when they need it**
- **Facilitate the updating of the cadastre**

Impact of faulting and land sliding on boundaries

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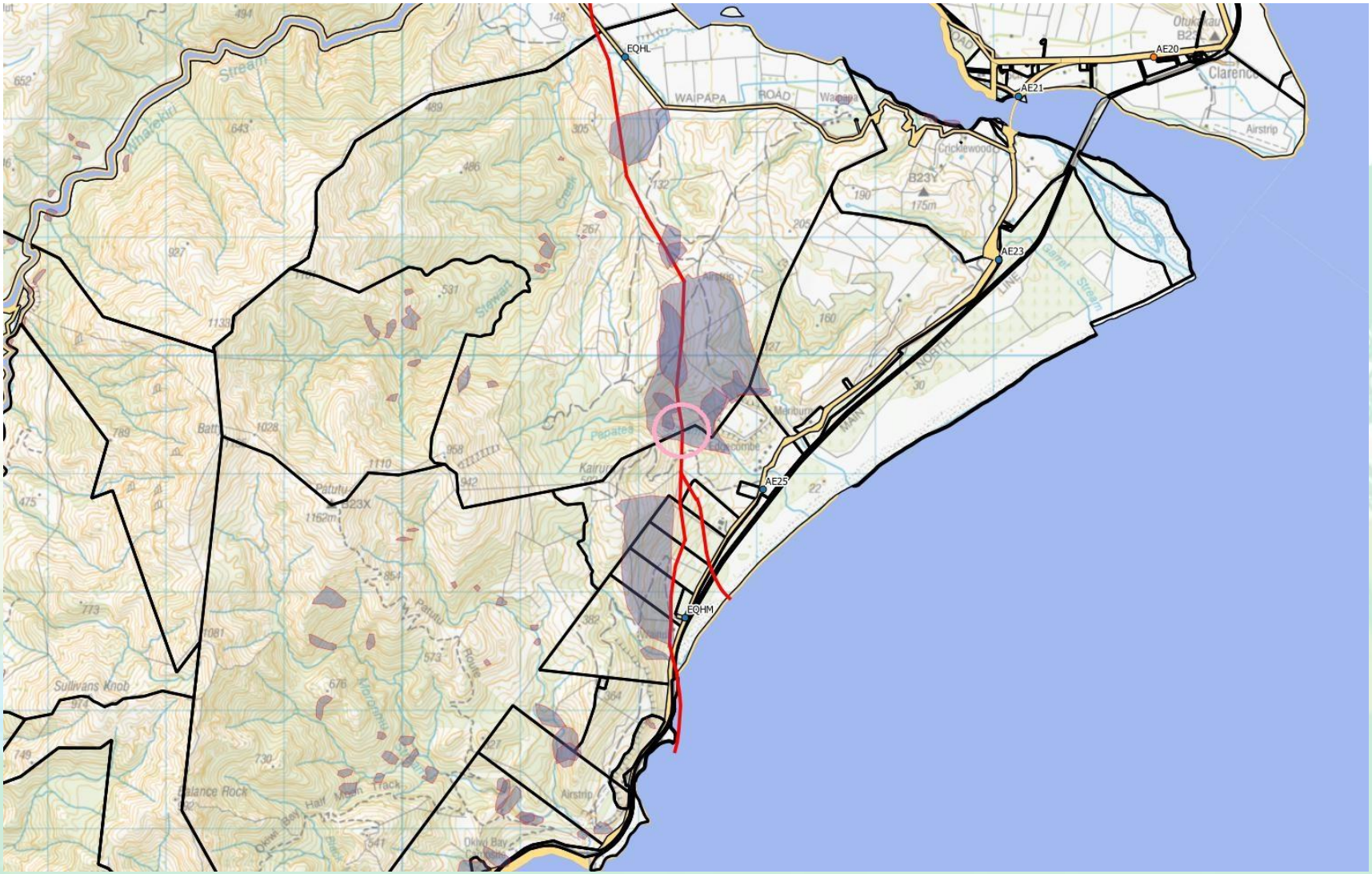

Boundaries Affected by Block Shift

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- A boundary that has been affected by a block shift will have maintained its relativity with local survey marks and other physical evidence although its absolute geographic position will have changed.

- In these cases, the established hierarchy of evidence will apply; that is, the boundary re-location must be based on reliable local survey marks and other physical evidence, all of which will have been subject to the same or similar block shift.

Boundaries Affected by Deep-Seated Distortion

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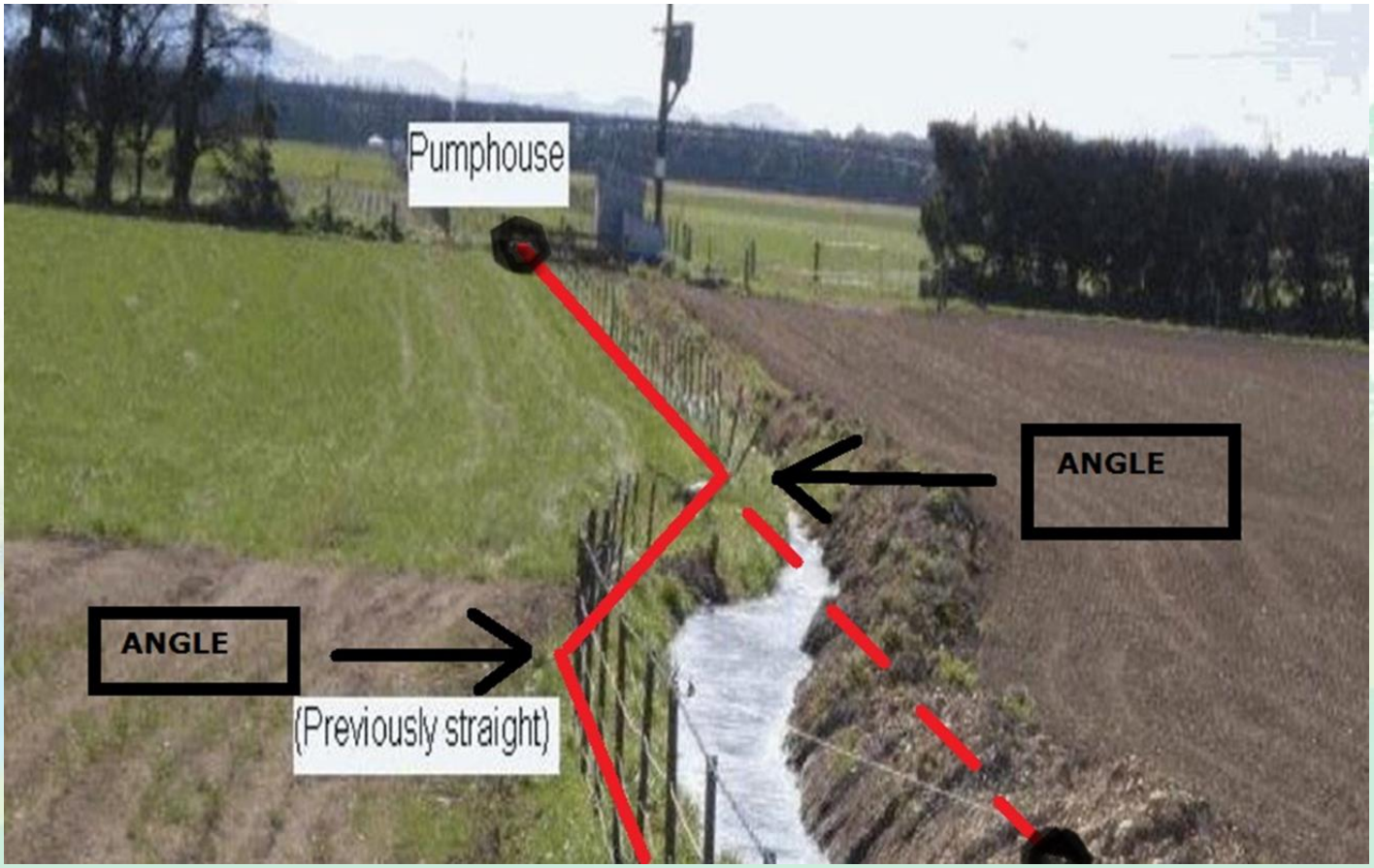
Where a boundary has shear or lateral distortion (normally at a fault rupture).

A boundary that was formerly a straight line may now include one or more angles.



Geodetic Survey Work Planned and Underway (v20161130)

14 November 2016 Earthquake

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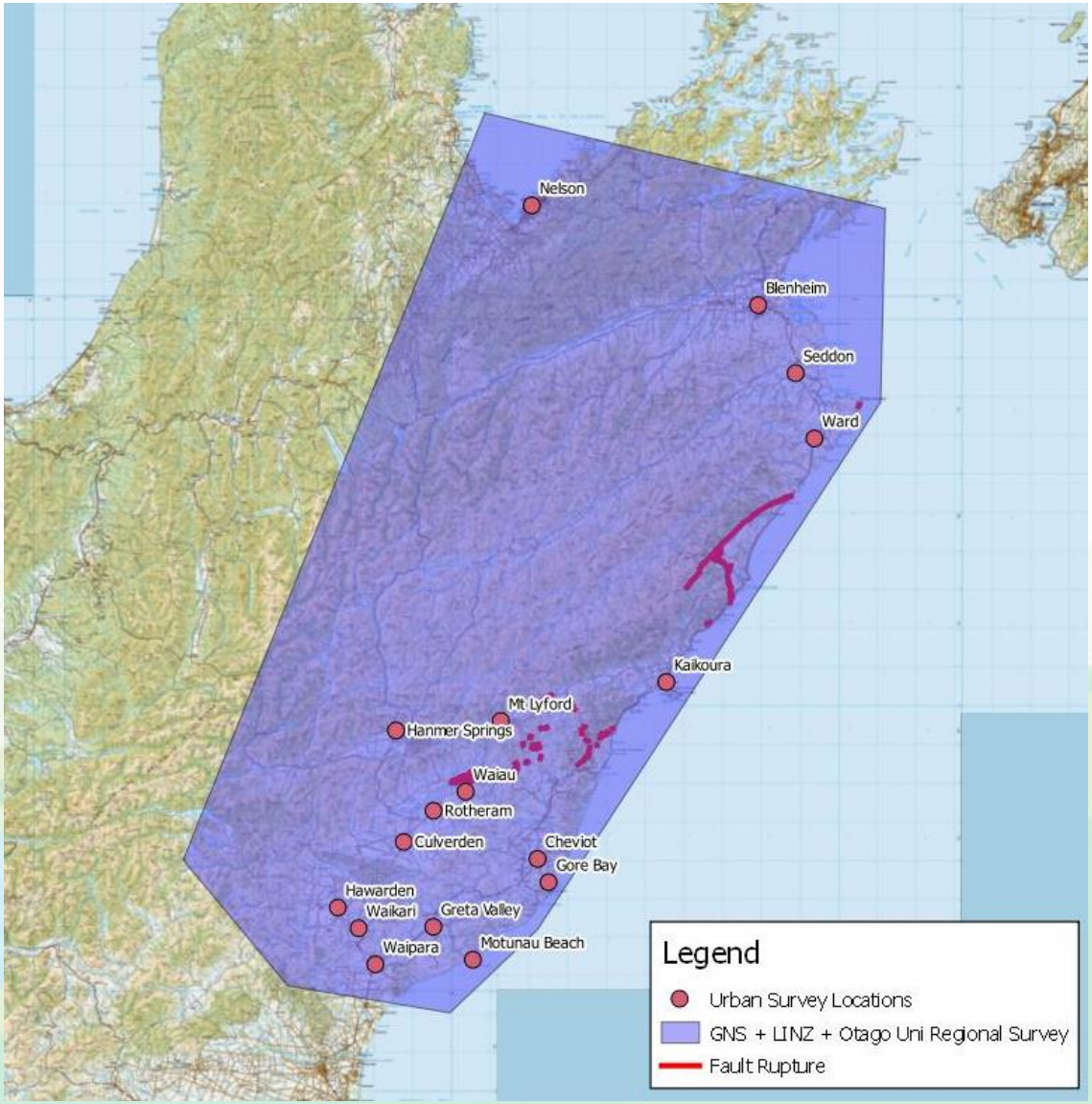

Blenheim - Horizontal and Vertical Movement Provisional (v20170131)

14 November 2016 Earthquake

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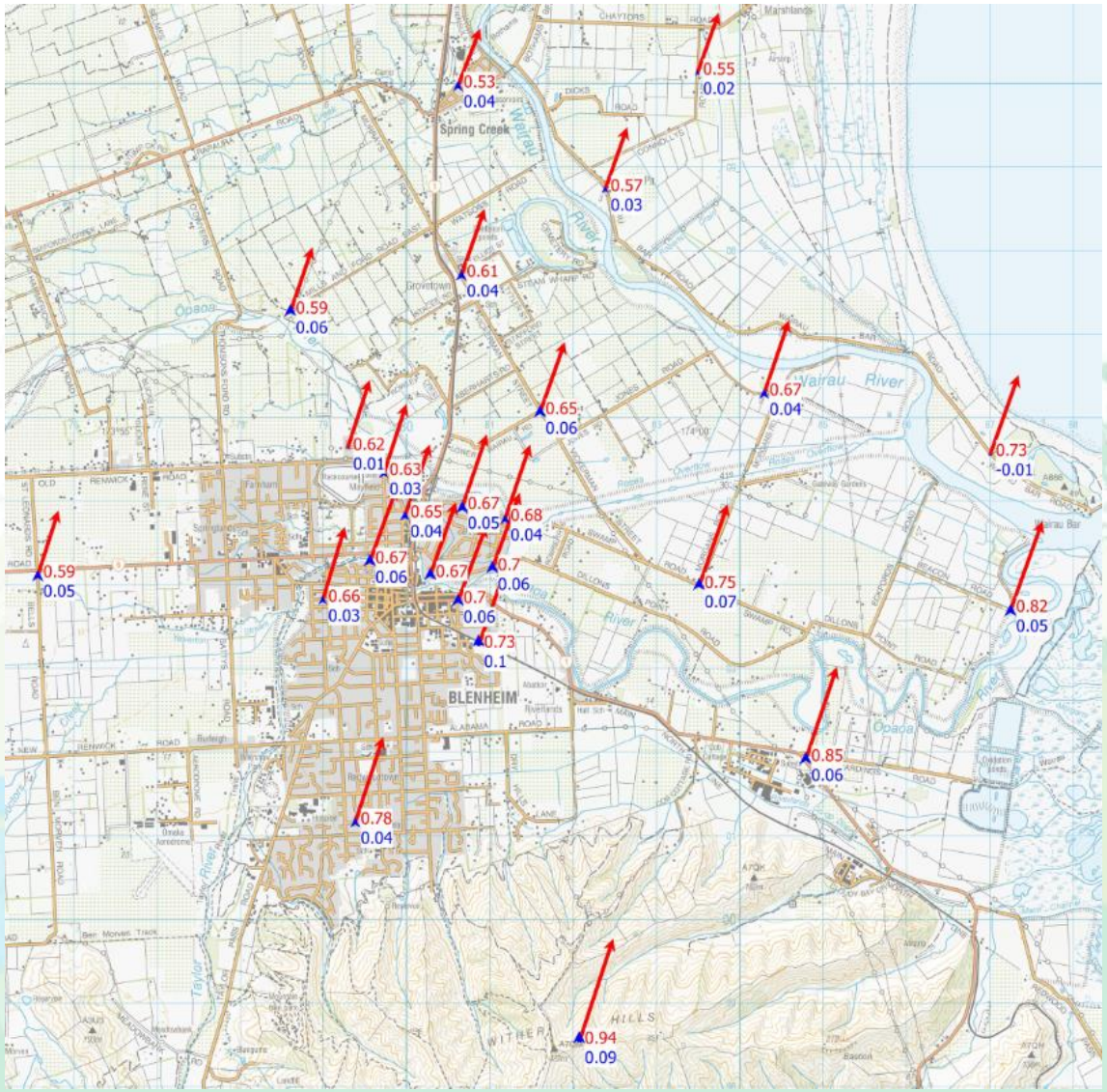

Legend

- Vertical Movement (m)
- Horizontal Movement (m)

Kaikoura - Horizontal and Vertical Movement Provisional (v20161213)

14 November 2016 Earthquake

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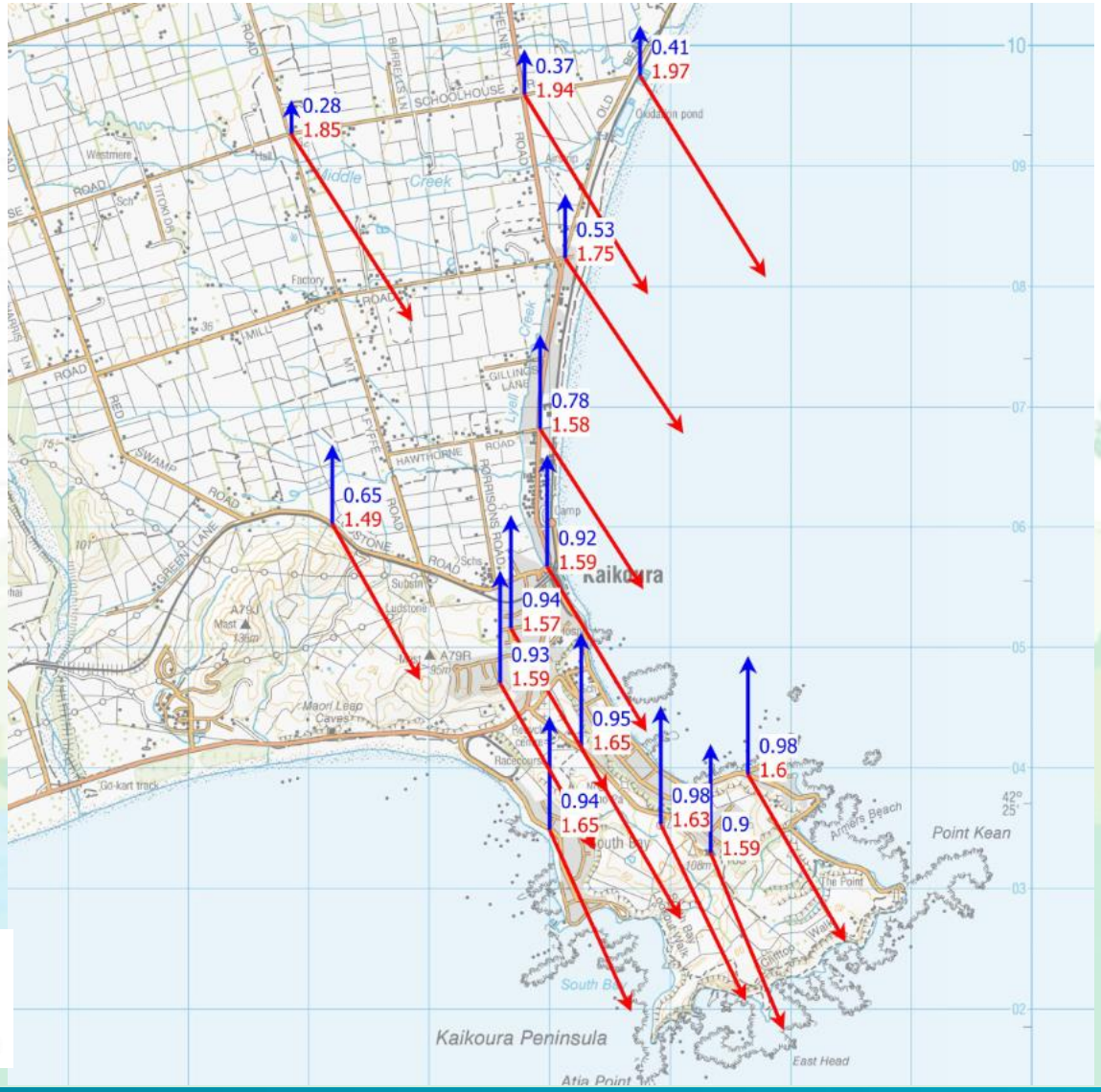

Legend

- Vertical Movement (m)
- Horizontal Movement (m)

Ward - Horizontal and Vertical Movement Provisional (v20161221)

14 November 2016 Earthquake

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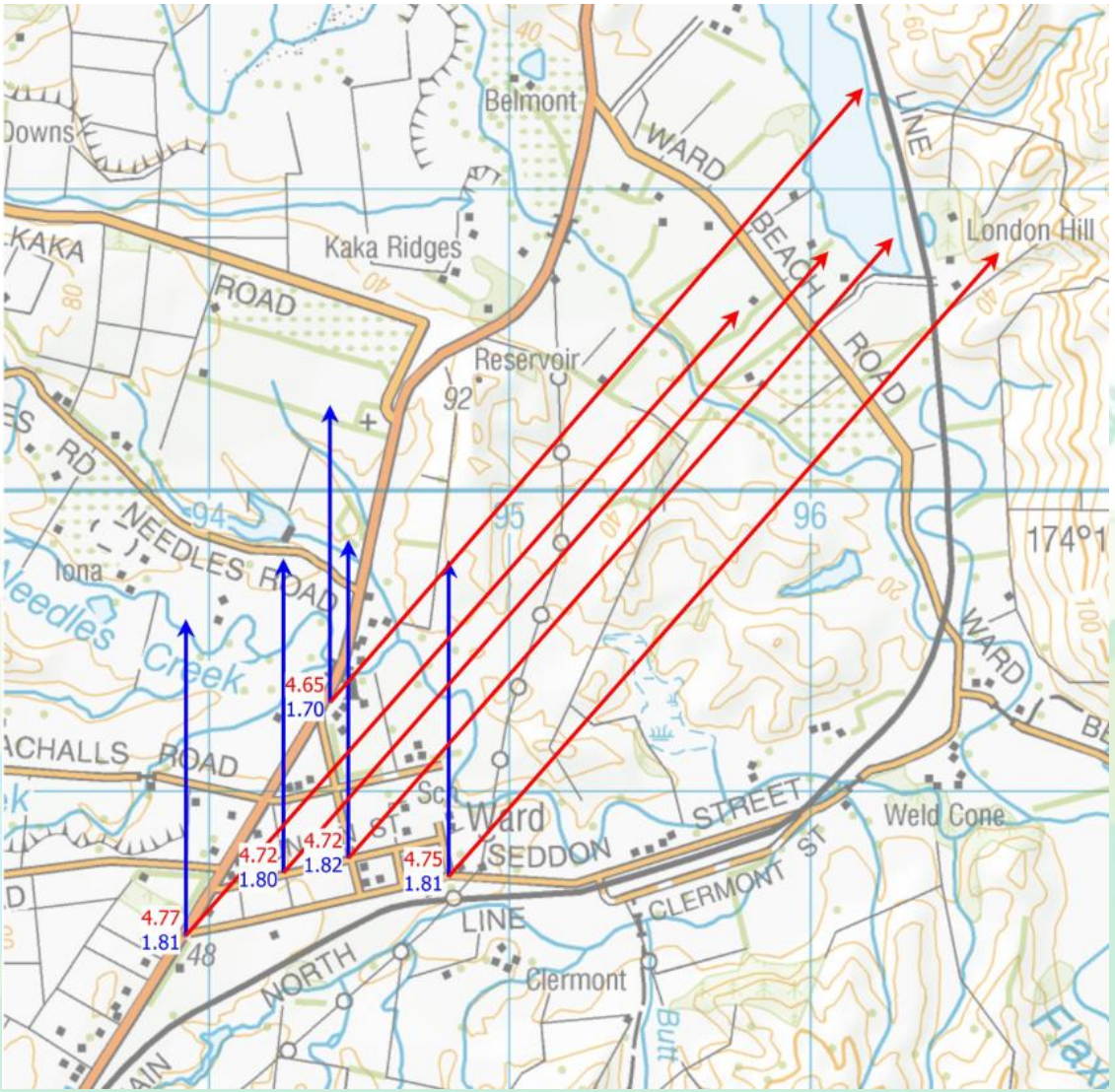

Legend

- Vertical Movement (m)
- Horizontal Movement (m)

Northern South Island - Horizontal and Vertical Movement Provisional (v20161221)

14 November 2016 Earthquake

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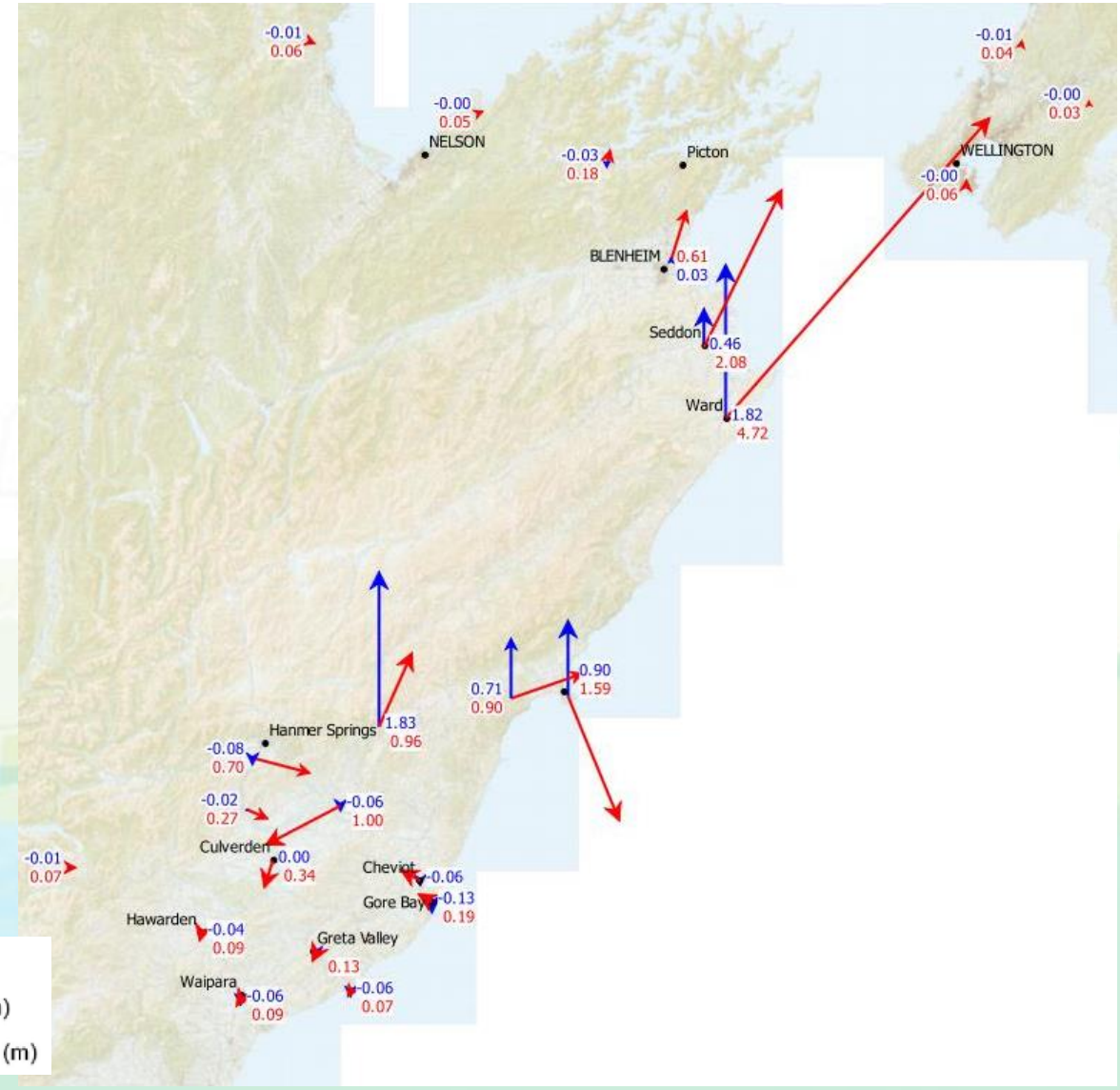

Legend

Vertical Movement (m)

Horizontal Movement (m)

Boundaries affected by shallow surface movement

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- Where an area of land has been affected by shallow surface movement (including liquefaction, slumping, and landslip) **a boundary should be relocated back in its original position in relation to marks not affected by the shallow movement.**

- In Christchurch the difficulty was identifying reliable marks and positions not affected by shallow movement.

- The evidence in Kaikoura showed that shallow movements were localised and reliable marks were be able to be found.

Shallow movements – Lyell Creek

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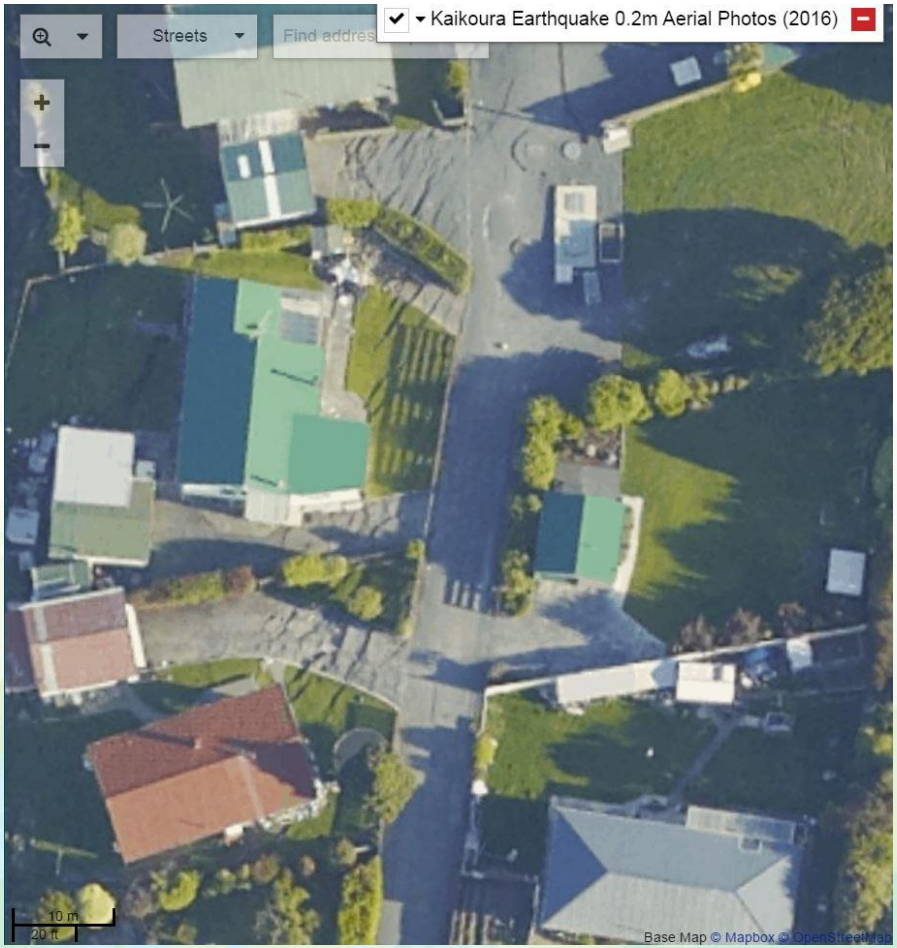

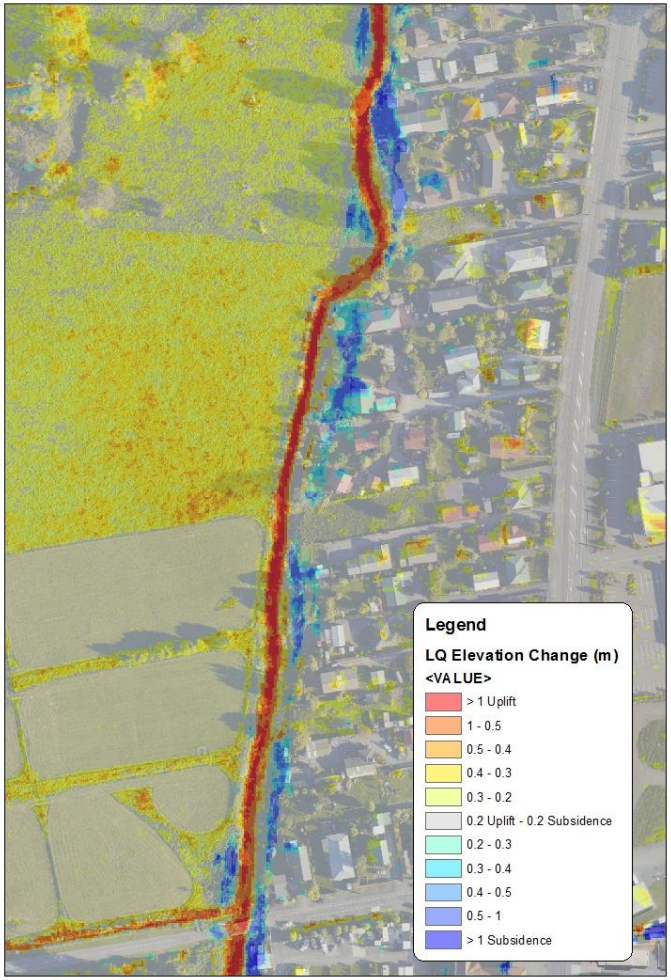

Summary

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Geodesy and geodetic survey played and important role is responding to and recovery from the impacts of the Kaikoura earthquake. It enabled:

- A better understanding of the earthquake mechanisms
- An co- and post-seismic movements to be determined and modelling of these movements
- Updates to the datum and the spatial network – critical for the re-establishment of critical infrastructure including the cadastre

Coastal monitoring

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