

The Impact of the 2010 Darfield and 2011 Christchurch Earthquakes on the Geodetic Infrastructure in New Zealand

FIG Working Week 2011, Marrakech, Morocco

Graeme Blick
Land Information New Zealand

John Beavan
GNS Science



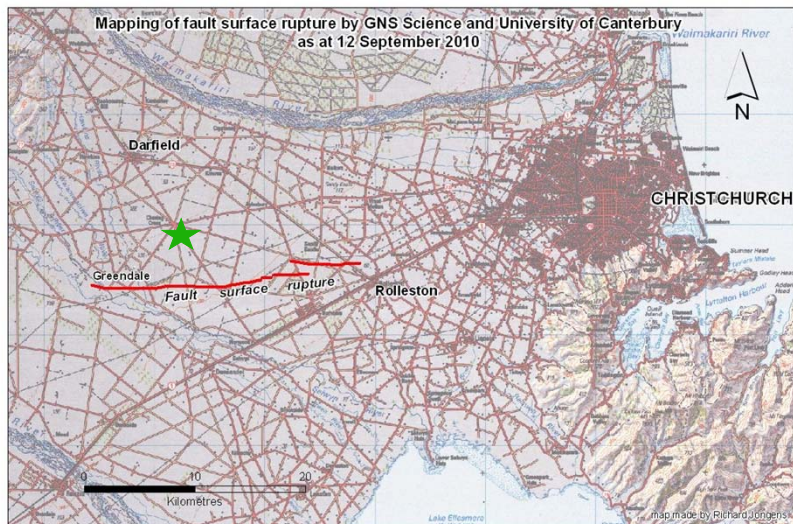
Where is Christchurch ?



Introduction

- Accurate geodetic system – semi dynamic datum
- Urban and peri-urban areas have a survey accurate cadastre – accuracy of cadastral boundary marks 10cm
- Movements associated with the Darfield and Christchurch earthquakes have affected the spatial position of the geodetic and cadastral networks
- Look at impact on geodetic infrastructure

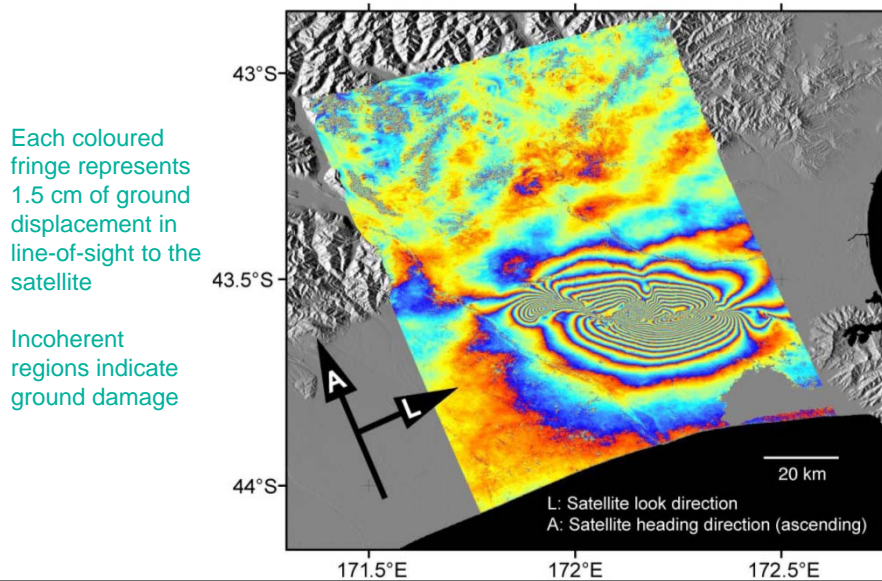
Darfield Earthquake – Sept 4 2010, 40 km W of Christchurch, Mw 7.1, Depth 10 km



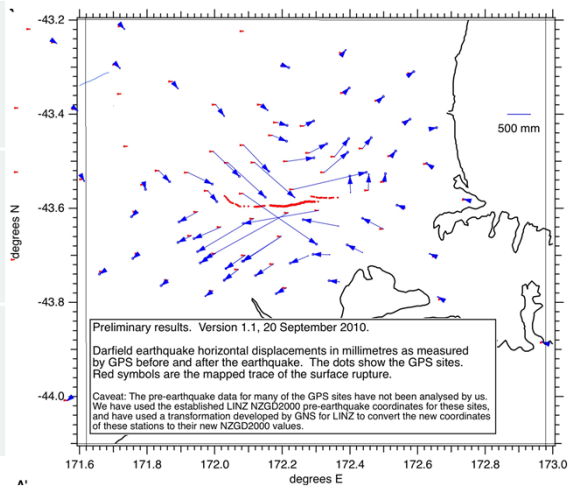
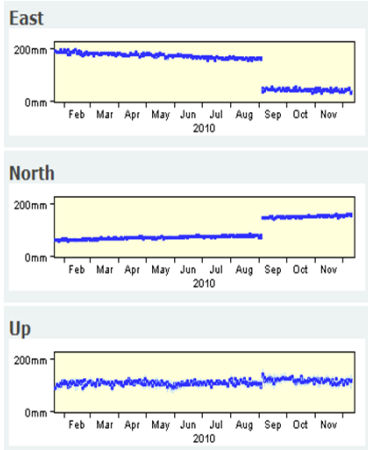
Darfield Earthquake



InSAR interference pattern as a result of the Darfield earthquake



Geodetic resurveys - regional



Geodetic resurveys - Christchurch



Darfield (Canterbury) Earthquake 2010 Provisional Coordinate Change Vectors 201010508 - Christchurch

Version 1.1, 21 October 2010

Modelled Accuracy: 30m. Scale: 1:27000 at A3. Coordinate change vectors scaled by 0.1 when plotted at A3.

These coordinate change vectors are only provisional. Analysis is ongoing.

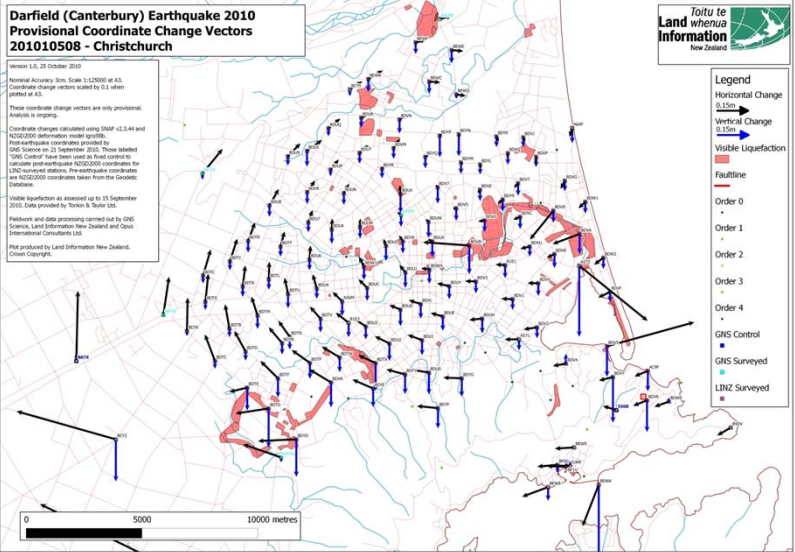
Coordinate changes calculated using ESNZ 10.2.44 and NZGD2000 deformation model (gnss05).

Post-earthquake coordinates provided by GNS Science on 21 September 2010. Those labelled 'Old' are the pre-earthquake coordinates for LINZ-run sites. The post-earthquake coordinates are NZGD2000 coordinates taken from the Geomatics Database.

Visible liquefaction as assessed up to 15 September 2010. Data provided by Dennis & Bruce Ltd.

Fieldwork and data processing carried out by GNS Science, Land Information New Zealand and Opus International Consultants Ltd.

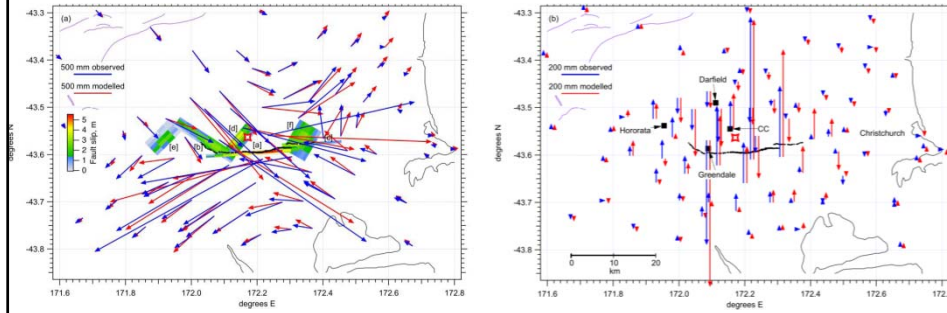
File produced by Land Information New Zealand. Crown Copyright.



Legend

- Horizontal Change 0.15m
- Vertical Change 0.15m
- Visible Liquefaction
- Faultline
- Order 0
- Order 1
- Order 2
- Order 3
- Order 4
- GNS Control
- GNS Surveyed
- LINZ Surveyed

Observed and modeled displacements



The model consists of slip on the Greendale Fault plus three thrust segments on NE-oriented planes

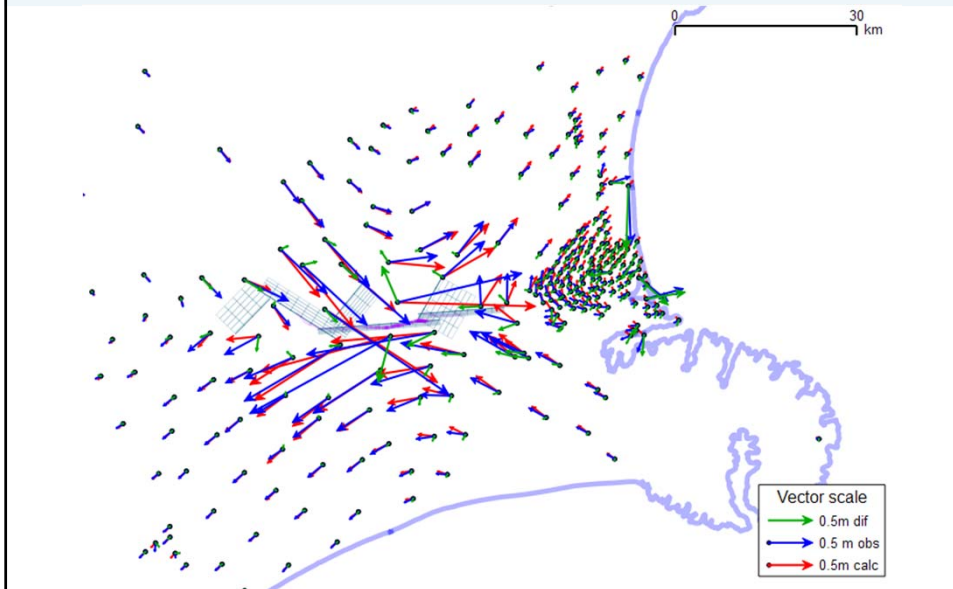
Form Beavan et al. THE DARFIELD (CANTERBURY) EARTHQUAKE: GEODETIC OBSERVATIONS AND PRELIMINARY SOURCE MODEL

Impact on geodetic control

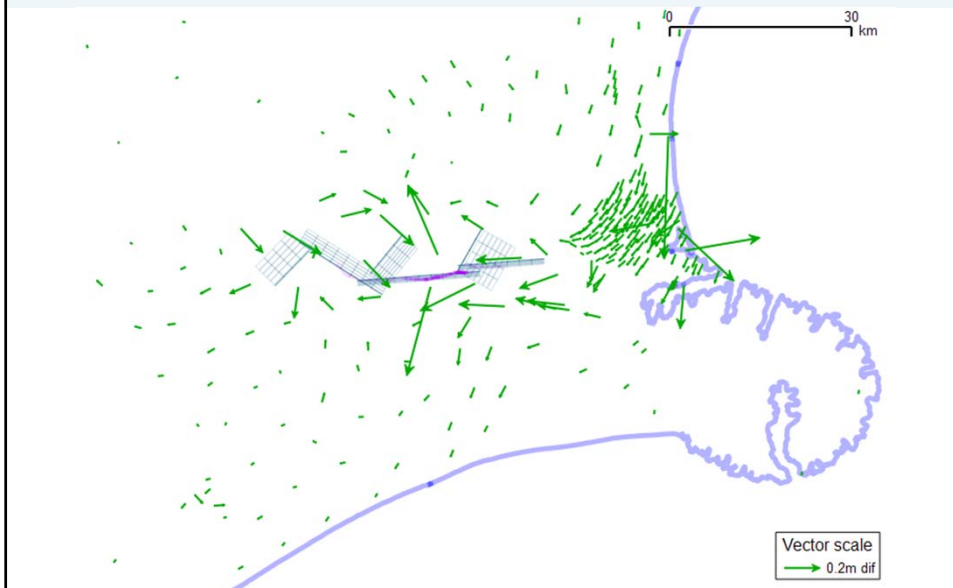
Range is based on the distance from the centre of the fault rupture.

Maximum Range (km)	Geodetic marks (order 5 or better)	Cadastral control (order 6 or better)	Total marks
0-20	223	4816	56835
20-40	1269	49538	565892
40-60	3176	28632	387606
60-80	673	3681	143593
80-100	487	2182	103995
Total	5828	88849	1257921

Model out the effects of the earthquake



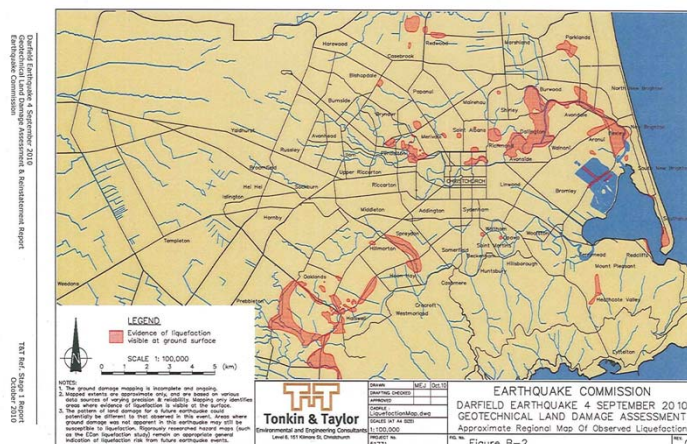
Residuals



Updating the geodetic and cadastral networks

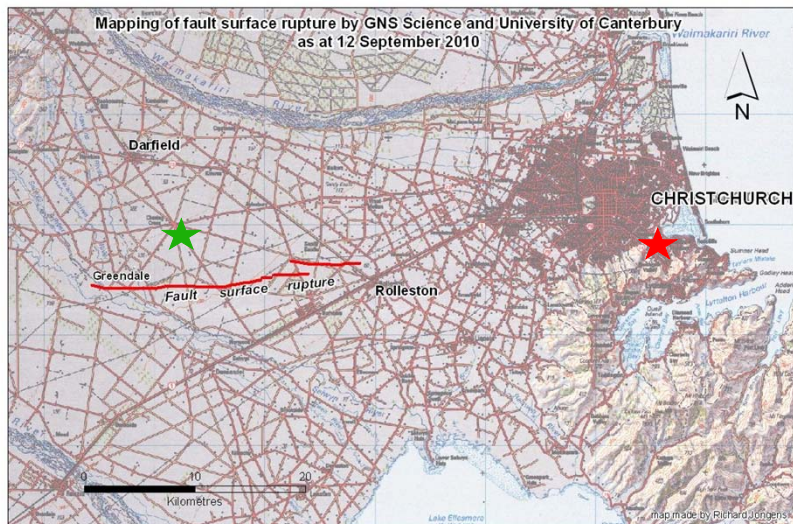
- Working on a model to predict coordinate changes at marks not surveyed:
 - Big cost reduction
 - Quicker to re-establish coordinates
 - Plan to update geodetic control and cadastral coordinates
- Model will enable possibly 90% of geodetic and cadastral marks to be updated
- Update all coordinates in one go, reduce user confusion
- Patch
- In areas close to fault and areas of local non-uniform deformation (liquefaction) further resurvey needed

Areas for detailed surveys



But This All Changed on 22 Feb 2011.

Christchurch Earthquake – Feb 22 2011,
7 km SE of Christchurch, Mw 6.3, Depth 5 km

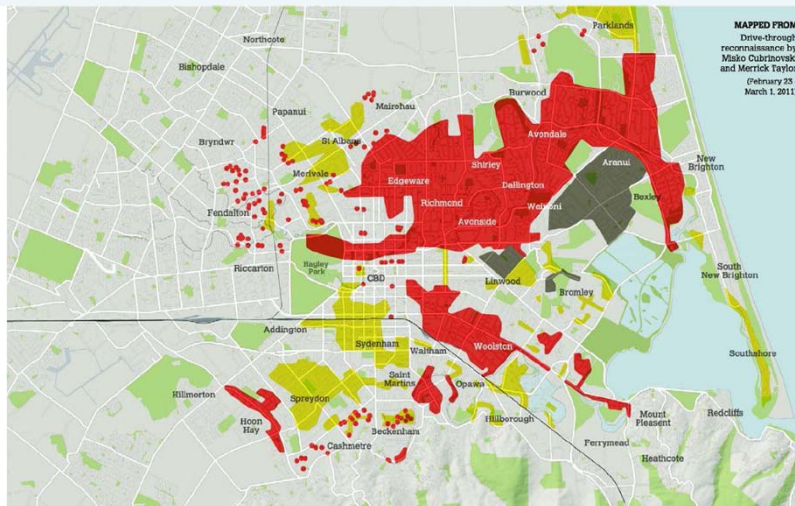


Feb 22 2011, 7 km SE of Christchurch, Mw 6.3, Depth 5 km

Christchurch Earthquake



Areas of Liquefaction



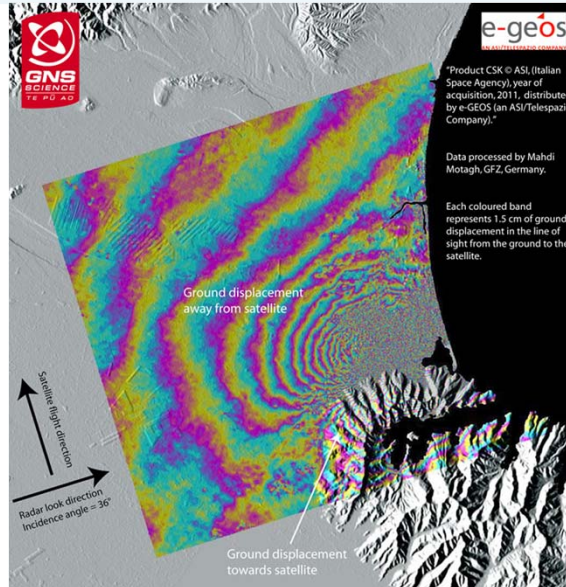
MAPPED FROM
Drive-through
reconnaissance by
Mako Cubrinovski
and Merrick Taylor
(February 23 -
March 1, 2011)

Red = Moderate to severe liquefaction
Yellow = Low to moderate liquefaction
Grey = Liquefaction mainly of roads

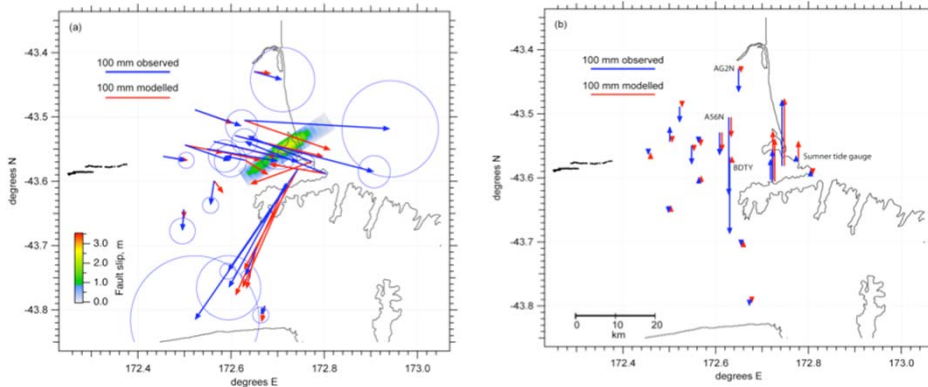
InSAR interference pattern as a result of the Christchurch earthquake.

Each coloured fringe represents 1.5 cm of ground displacement in line-of-sight to the satellite

Incoherent regions indicate ground damage

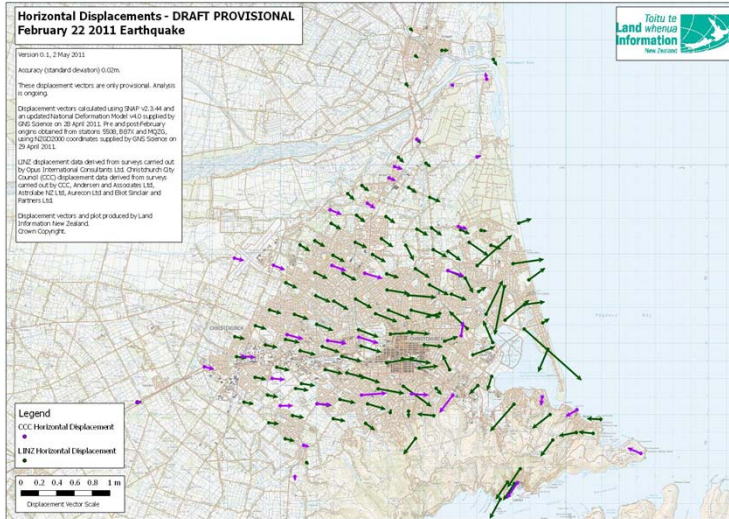


Observed and Modeled Displacements

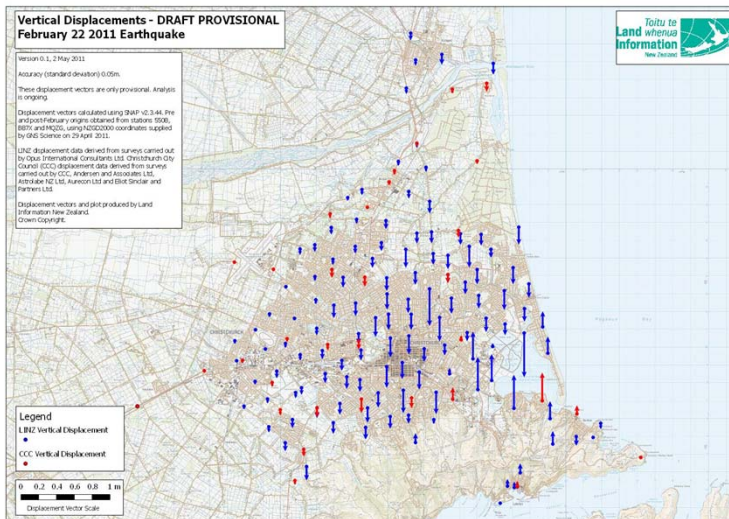


Fault displacement as viewed from above

Horizontal displacements

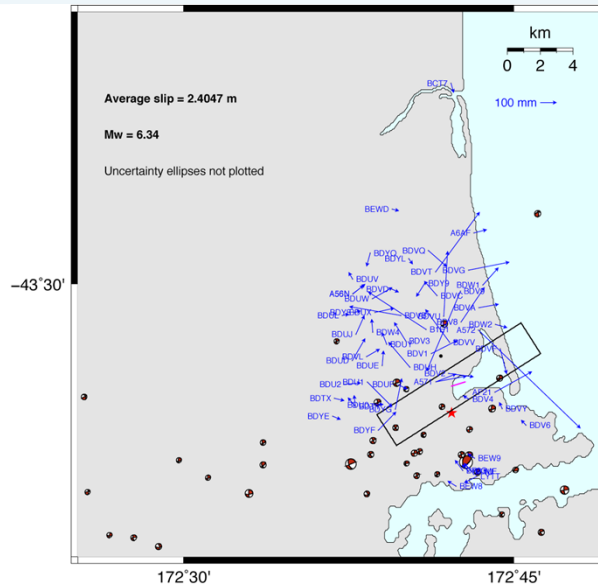


Vertical displacements



Large residuals (> 60 mm horizontal)

Evidence of lateral spreading or other ground failure



Updating the geodetic and cadastral networks - final summary

- Models will enable possibly 90% of geodetic and cadastral marks to be updated from the Darfield earthquake
- Models will enable maybe less than 50% of geodetic and cadastral marks to be updated from the Christchurch earthquake
- This will result in the need to resurvey much of the geodetic in the Christchurch area
- It will also result in the need to resurvey much of the cadastre – this may not happen in the short term

FIG WW



2016



**CHRISTCHURCH
NEW ZEALAND**