The Impact of the Christchurch Earthquakes on the Spatial Infrastructure in New Zealand

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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

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

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

Incoherent regions indicate ground damage.
Geodetic resurveys - regional

East

North

Up

Darfield earthquake horizontal displacements in millimetres as measured by GPS before and after the earthquake. The dots show the GPS sites. Red symbols are the mapped trace of the surface rupture.

Caveat: The pre-earthquake data for many of the GPS sites have not been analysed by us. We have used the established LINZ NZGD2000 pre-earthquake coordinates for these sites, and have used a transformation developed by GNS for LINZ to convert the new coordinates of these stations to their new NZGD2000 values.
Geodetic resurveys - Christchurch
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.

<table>
<thead>
<tr>
<th>Maximum Range (km)</th>
<th>Geodetic marks (order 5 or better)</th>
<th>Cadastral control (order 6 or better)</th>
<th>Total marks</th>
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<tbody>
<tr>
<td>0-20</td>
<td>223</td>
<td>4816</td>
<td>56835</td>
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<td>20-40</td>
<td>1269</td>
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<td>40-60</td>
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<td>28632</td>
<td>387606</td>
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<td>673</td>
<td>3681</td>
<td>143593</td>
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<tr>
<td>80-100</td>
<td>487</td>
<td>2182</td>
<td>103995</td>
</tr>
<tr>
<td>Total</td>
<td>5828</td>
<td>88849</td>
<td>1257921</td>
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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.
Mapping of fault surface rupture by GNS Science and University of Canterbury as at 12 September 2010

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

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
Vertical displacements

Vertical Displacements - DRAFT PROVISIONAL
February 22 2011 Earthquake

Version 0.1, 2 May 2011
Accuracy (standard deviation) 0.06m.
These displacement vectors are only provisional. Analysis is ongoing.
Displacement vectors calculated using GRASS v.7.3.44. Pre and post February origins obtained from stations 9508, 6876 and M225, using NZGD2000 coordinates supplied by GNS Science on 29 April 2011.
LINZ displacement data derived from surveys carried out by Opus International Consultants Ltd, Christchurch City Council (CCC) displacement data derived from surveys carried out by CCC, Anderson and Associates Ltd, Astrolabe NZ Ltd, Aurecon Ltd and Beca Sinclair and Partners Ltd.
Displacement vectors and plot produced by Land Information New Zealand.
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Large residuals (> 60 mm horizontal)

Evidence of lateral spreading or other ground failure
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.
Questions