The 2010/11 Christchurch (NZ) Earthquakes, and the role played by GIS.

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University of Edinburgh
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Disclaimer:

• I’m not a geologist or a volcanologist...
• I was living in NZ at the time... doing a GIS PhD
1) Who has experienced an earthquake?
2) Who has been told/knows what to do in an earthquake?

Earthquakes

- Move no more than a few steps:
  - Drop, Cover and Hold
- Outdoors - same approach
- If driving - pull over
- If in doubt, get out
  - Be aware of broken wires/glass/gas etc..
- Evacuation Procedure
  - Do not re-enter buildings until advised

http://www.earthquakes.bgs.ac.uk/

The largest known British earthquake occurred near the Dogger Bank in 1931, with a magnitude of 6.1. The most damaging UK earthquake was in the Colchester area in 1884. Some 1200 buildings needed repairs, chimneys collapsed and walls were cracked.

WHY?

- Although Britain is far from any plate boundaries we are still being squeezed by motion of the Earth's tectonic plates.
- Northern Britain is also still being uplifted due to the melting of the ice sheets that covered many parts of Britain thousands of years ago. This deformation results in occasional earthquakes.

http://www.earthquakes.bgs.ac.uk/
THE WORLD-WIDE EARTHQUAKE LOCATOR

Coming up....

• **Before:** Life in NZ before 4th September 2010

• **During:** Quakes

• **After:** Response and future plans

Before 4th Sept 2010
Christchurch (NZ)

- Setup by NZ Company (based in London)
  - NZ company mandate was to colonise NZ
  - Build an English society in southern hemisphere
  - Aimed at colonising to follow beliefs of the Church of England

Robert John Godley (1814-1861)

- Irish
- Educated at Christ Church, Oxford
- Worked in Lyttleton (NZ) in 1850
- 4 ships arrived carrying settlers / supplies
- Stayed in NZ for 2 years – believed ChCh should be self-governing

Territorial Area = 1426 km²
Urban Area = 452 km²

390,300 people (June 2010)
Urban Density 863/km²

Garden City

ChCh City Centre
Cathedral Square
South Island NZ East Coast... Looking WEST

Looking WSW

Earthquake Commission
Levy paid by all with house insurance
About $70 (NZ) per year

Alpine Fault:
- Great quake (8+) every ~150 years
- 294 yrs since last great quake (1717)

Next great quake?
- Magnitude 8+
- Horizontal ground movement ~8m
- Vertical displacement of 4m
- Rupture will be about 400km
- Last for about 2 minutes
Quantifying Quakes (Part 1)

Richter scale (invented 1934)

- Quantify the energy contained in an earthquake
- Calc. based on the amplitude of the largest seismic wave from the quake
- Richter magnitudes are based on a logarithmic scale (base 10)
  e.g. A magnitude 5 would result in TEN TIMES the level of ground shaking as a magnitude 4
- As well often expressed in terms of energy release from blowing up N tons of TNT
  e.g. Mag 8 quake equivalent to ~6 million tons of TNT
- Mag > 4.6 can be measured by a seismograph anywhere in the world (outside of quake’s shadow)
Friday Sept 3rd 2010

- Start of Spring
- 15 deg C

You OK? Torch doesn’t work!! You alright Matt? Get away from the chimney! That’s gotta be the Alpine Fault. You guys OK? I’ve hurt my toe...

Sept 4th
4:35am

5 seconds
Epicentre near Darfield
45km (25 miles) WEST of Christchurch

Not Alpine Fault
• Newly discovered fault... name “Greendale Fault”
• Thought to have been inactive for about 16,000 years!

“This earthquake was caused primarily by strike-slip faulting, whereby one side of the fault was jolted to the right relative to the other.”

http://drquigs.com/

Mainly E-W fault
~1.5 metres of vertical movement

The Greendale fault surface rupture length has now been mapped by UC and GNS scientists to have a total length of ~28 km however ongoing studies are refining this estimate
The yellow focal mechanisms are for the mainshock as derived by GeoNet (top) and USGS (bottom). The mainshock (location indicated by a yellow star) has a reverse faulting mechanism. Most of the aftershocks located near the epicentre have strike-slip mechanisms. To the west, closer to the foothills, reverse faulting has also been observed, and the two mechanisms for aftershocks near Christchurch also have strong reverse faulting components.


http://www.g地质.canterbury.ac.nz/earthquake/slideshow.shtml

2 people died from falling a chimney / glass

1 died from heart attack
The Aftershock Sequence

- Sept 4th 2010 – 7.1 Initial Event
  - 7619 aftershocks
  - 32 measuring 5+
  - 348 measuring 4+

Significant Aftershocks

- Boxing Day = 4.9 quake
- Damaged about 20 buildings
- Cut power to 40,000 homes
- Closed Central city for a few days
- Swarm of 32 shallow aftershocks many directly under the city

Boxing Day
22 Feb 2011

- 12:51 pm
- Depth = 5.87km
- Richter scale = 6.3
- TNT = 49 kilo tonnes
- 10km South East of Christchurch
Burst water pipes...
30 million tons of ice broke off Tasman glacier – 200km away – created 3.5m wave which swept up/down the lake for 30mins...
Grass to windows..
House sunk ~50cm

- 50cm drop in concrete slab – taking fence with it.
Power poles - liquefaction

[Image of power poles and liquefaction]

[Map showing liquefaction-related land damage]

[Image of a cat under a bed]

[Image of a map showing liquefaction-related land damage]
• No power
• No water
• No sewage

• No TV
• No WWW
• Very limited mobile / landline telephone
• Radio
• Word of mouth

• 181 people confirmed dead, about 100 of those from 1 building (CTV)
• 220 major trauma cases treated
• ~2000 people treated for minor injuries

• Power lost to 80% of the city
• No water... then when available boil all water (drinking, cleaning teeth etc)
• Airport shut for runway to be checked
• Hospital partly damaged
• University shut until 28 March
• Schools had to share sites – half days
• 2011 Census was cancelled (to be carried out March 2013 instead)

• About 10,000 houses to be demolished
• Some suburbs would not be rebuilt
• 45% of buildings in the city given red or yellow sticker
Quantifying Quakes 2

Ground Acceleration (g)

<table>
<thead>
<tr>
<th>Year</th>
<th>Mw</th>
<th>Depth</th>
<th>Magnitude</th>
<th>Location</th>
<th>Event</th>
<th>Earthquake</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>8.8</td>
<td>10 km</td>
<td>9.0</td>
<td>Chile</td>
<td>earthquake</td>
<td>Tocopilla earthquake</td>
</tr>
<tr>
<td>2011</td>
<td>7.2</td>
<td>30 km</td>
<td>7.7</td>
<td>Japan</td>
<td>9.0</td>
<td>2011 Tohoku earthquake</td>
</tr>
<tr>
<td>2011</td>
<td>7.2</td>
<td>60 km</td>
<td>7.8</td>
<td>Japan</td>
<td>9.0</td>
<td>2011 Tohoku earthquake</td>
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<tr>
<td>2011</td>
<td>7.1</td>
<td>90 km</td>
<td>7.2</td>
<td>Japan</td>
<td>9.0</td>
<td>2011 Tohoku earthquake</td>
</tr>
<tr>
<td>2011</td>
<td>7.0</td>
<td>120 km</td>
<td>7.0</td>
<td>Japan</td>
<td>9.0</td>
<td>2011 Tohoku earthquake</td>
</tr>
<tr>
<td>2011</td>
<td>6.9</td>
<td>150 km</td>
<td>6.6</td>
<td>Japan</td>
<td>9.0</td>
<td>2011 Tohoku earthquake</td>
</tr>
<tr>
<td>2011</td>
<td>6.8</td>
<td>180 km</td>
<td>6.5</td>
<td>Japan</td>
<td>9.0</td>
<td>2011 Tohoku earthquake</td>
</tr>
<tr>
<td>2011</td>
<td>6.7</td>
<td>210 km</td>
<td>6.3</td>
<td>Japan</td>
<td>9.0</td>
<td>2011 Tohoku earthquake</td>
</tr>
<tr>
<td>2011</td>
<td>6.6</td>
<td>240 km</td>
<td>6.1</td>
<td>Japan</td>
<td>9.0</td>
<td>2011 Tohoku earthquake</td>
</tr>
</tbody>
</table>

Note: The table provides a summary of significant earthquakes with their magnitude, depth, and location.
June Aftershock

- 13 June 2011
- 2:20pm
- 6.3 on Richter scale
- 6km deep
- 13km from city centre
- Building collapse
- Phone lines damaged
- Liquefaction
- Rockfall...
- 54k homes without power...
- 46 people injured
- 1 death
After the Quakes

- Maps, maps, maps.....

- Public lectures..

http://www.communityed.canterbury.ac.nz/earthquake_lectures.php

80 mins video

The Canterbury Earthquakes: Geological and Seismological Context for what is Happening Beneath our Feet

by Professor Jarg Pettinga and Dr Mark Quigley

Sold for $50,000 (+ $10,000)
Interferogram - Feb 2011


GNS

http://www.geonet.org.nz/

GNS
~3000 members

http://ushahidi.com/

- Swahili word meaning "testimony or witness"
- Open source tool for mapping and data collection
- SMS, MMS, video, tagging, posting, etc.
- Run your own copy on your server
- Collection, visualisation, interaction

http://eq.org.nz/

Used the Ushahidi platform

They aggregated information via email, tweets with an #eqnz hashtag, SMS and a locally-hosted web-form. Also they scanned local newspaper websites, Google's Crisis response page, and TradeMe.

100,000 unique visitors within first week
Click on map icons to see local reports

http://quake.crowe.co.nz/
Ceismic – Digital Archive

• A million-dollar digital archive drawing together people’s earthquake experiences will be launched in Christchurch tonight.

• University of Canterbury Associate Professor Paul Millar created the archive – Ceismic – to provide a record of stories, images and documents about the Canterbury quakes.

• The archive would become an evolving resource available to researchers worldwide for generations, he said.

http://www.ceismic.org.nz/

Timeline Map


Magnetic South


What now?

- Suburbs being zoned red = off the map (e.g. Brooklands – 400 properties)
- Liquefaction mapping
- LiDAR mapping
- Rock fall studies

Photos from October 2011
• Crowne Plaza & Copthorne Hotels - Victoria & Durham Streets.
• Both these hotels will be demolished.
Future?

• On going rebuild
• Still shut down of RED zone
• People’s houses still being assessed
• Still getting aftershocks
• Freeze on house insurance
• NZ trying to get re-insurance from around the world
• Many assets now not insured

• EQC spent 32 million in claims in 2009-2010 and had built up reserved of $5.9 Billion.
• EQC 2010- June 2011 had liabilities of $11.4 billion from quake claims
• Canterbury Uni has experienced a 13% drop in student numbers... And having to axe 350 staff
Outdoor AR

- Highly accurate outdoor AR tracking system
- GPS/inertial, RTK system
- HMD
- First prototype
  - Laptop based
  - 2-3 cm accuracy

Earthquake AR Project

- **Goal:**
  - To allow people to see Christchurch as it was
  - To provide a tool for visualizing the city as it could be

- **Technology**
  - Mobile AR platform
  - Smartphone hardware
  - 3D content

Image Registration

AR Stakeout Application
Earthquake Reconstruction

- See past, present and future building designs
- Earthquake survivor stories shown on map view
- Collect user comments
- Android platform

Architecture

- Web Interface
- Web application
- Java and PHP server
- Database server
- Android application

Thanks for listening!