

The 09/03/2010 Darfield Earthquake and its Aftershocks, Including the 02/21/2011 Christchurch Event

Educational Slides

Created & Compiled by Gavin Hayes

U.S. Geological Survey, National Earthquake Information Center

Contributions from:

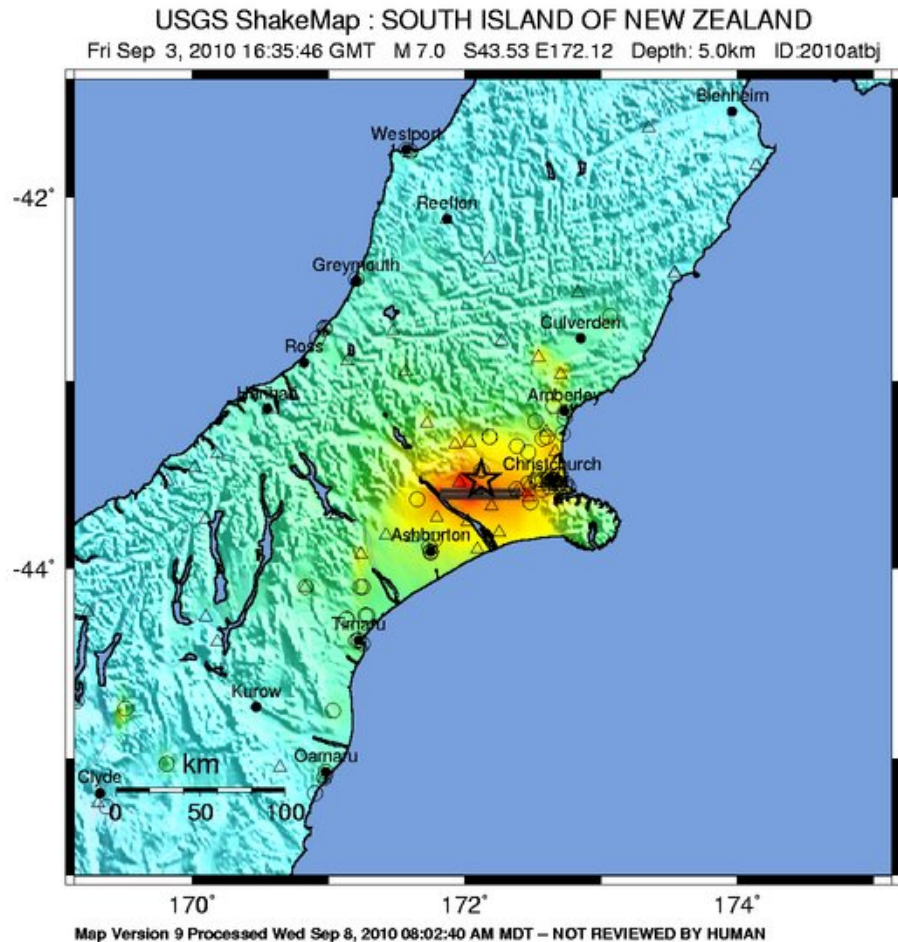
David Wald, USGS NEIC

Kuo-Wan Lin, USGS NEIC

Kishor Jaiswal, USGS NEIC

Brendon Bradley, U. Canterbury, New Zealand

Darfield Earthquake, 09/03/2010, Mw7.0



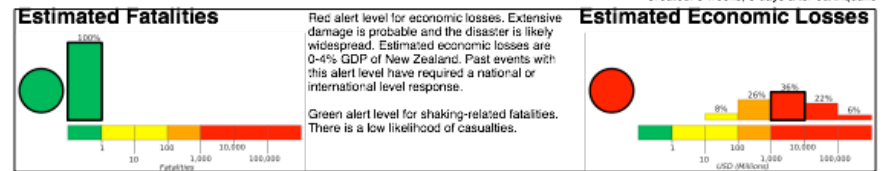
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Earthquake Shaking Red Alert

M 7.0, SOUTH ISLAND OF NEW ZEALAND

Origin Time: Fri 2010-09-03 16:35:46 UTC (04:35:46 local)
 Location: 43.53°S 172.12°E Depth: 5 km

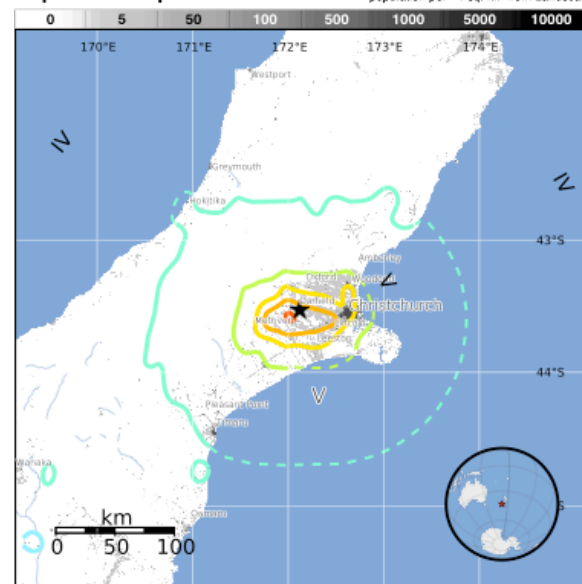
USAID FROM THE AMERICAN PEOPLE
 ANSS PAGER Version 2
 Created: 3 weeks, 0 days after earthquake



Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)	--*	2k*	129k*	86k	139k	298k	20k	2k	0	
ESTIMATED MODIFIED MERCALLI INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+	
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme	
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy	V. Heavy

Population Exposure



Structures:
 Overall, the population in this region resides in structures that are highly resistant to earthquake shaking, though some vulnerable structures exist.

Historical Earthquakes (with MMI levels):

Date	Dist. (km)	Mag.	Max MMI(#)	Shaking Deaths
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1984-06-24	117	6.1	VIII(18)	0
1990-02-10	147	6.0	VIII(61)	0

Selected City Exposure

from GeoNames.org

MMI City	Population
VIII Rolleston	3k
VIII Burnham	1k
VII Darfield	2k
VII Woodend	3k
VI Leeston	1k
VI Christchurch	364k
V Timaru	28k
IV Oamaru	13k
IV Greymouth	9k
III Blenheim	27k
III Wanaka	4k

PAGER content is automatically generated, and does not consider secondary hazards in loss calculations. Limitations of input data, shaking estimates, and loss models may add uncertainty. <http://earthquake.usgs.gov/pager>

bold cities appear on map (k = x1000)
 Event ID: us2010atbj

Christchurch Earthquake, 02/21/2011, Mw6.1

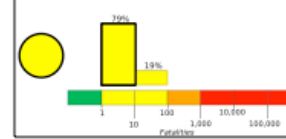
M 6.3, SOUTH ISLAND OF NEW ZEALAND

Origin Time: Mon 2011-02-21 23:51:43 UTC (12:51:43 local)
 Location: 43.60°S 172.71°E Depth: 5 km

PAGER Version 7

Created: 3 days, 22 hours after earthquake

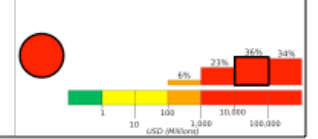
Estimated Fatalities



Red alert level for economic losses. Extensive damage is probable and the disaster is likely widespread. Estimated economic losses are 10-70% GDP of New Zealand. Past events with this alert level have required a national or international level response.

Yellow alert level for shaking-related fatalities. Some casualties are possible.

Estimated Economic Losses

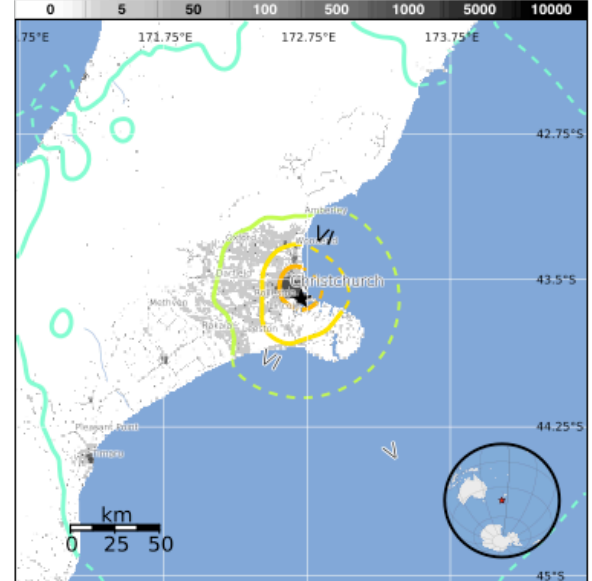


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ESTIMATED POPULATION EXPOSURE (k = x1000)	--*	23*	46k*	91k	50k	63k	228k	92k	0	
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PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme	
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*Estimated exposure only includes population within the map area.

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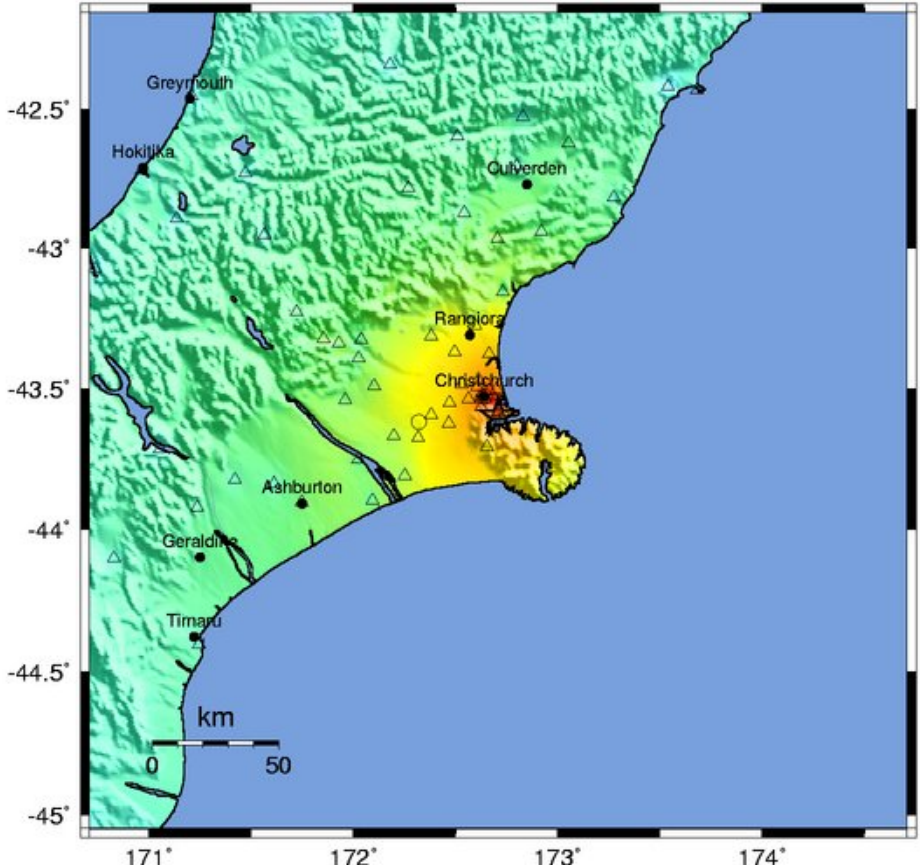
bold cities appear on map (k = x1000)

PAGER content is automatically generated, and only considers losses due to structural damage. Limitations of input data, shaking estimates, and loss models may add uncertainty.
<http://earthquake.usgs.gov/pager>

Event ID: usb0001igm

USGS ShakeMap : SOUTH ISLAND OF NEW ZEALAND

Mon Feb 21, 2011 23:51:43 GMT M 6.3 S43.60 E172.71 Depth: 5.0km ID:b0001igm



Map Version 7 Processed Fri Feb 25, 2011 03:30:14 PM MST - NOT REVIEWED BY HUMAN

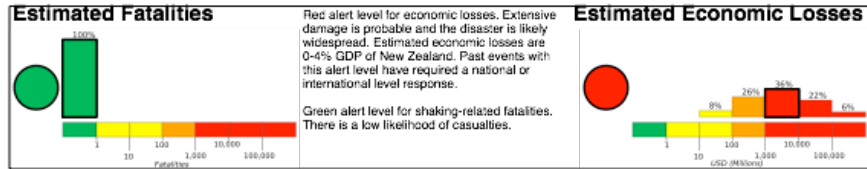
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Comparing Population Exposure

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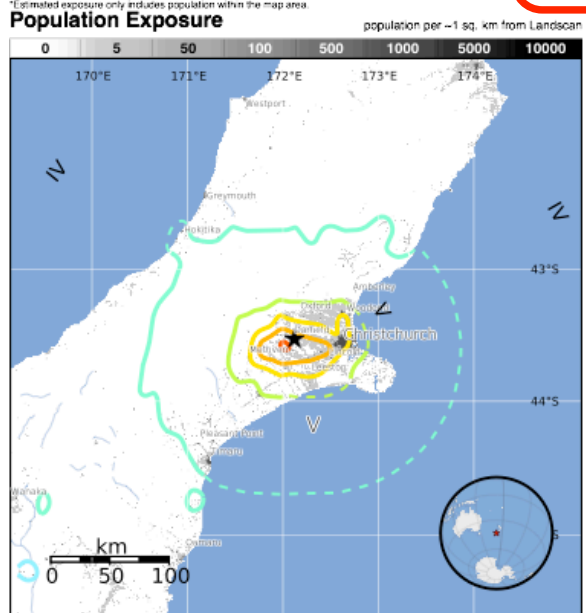
Earthquake Shaking ● **Red Alert**

PAGER Version 2
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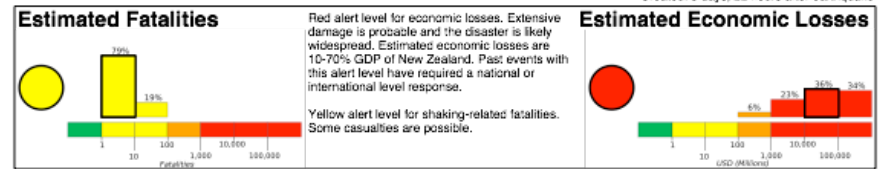
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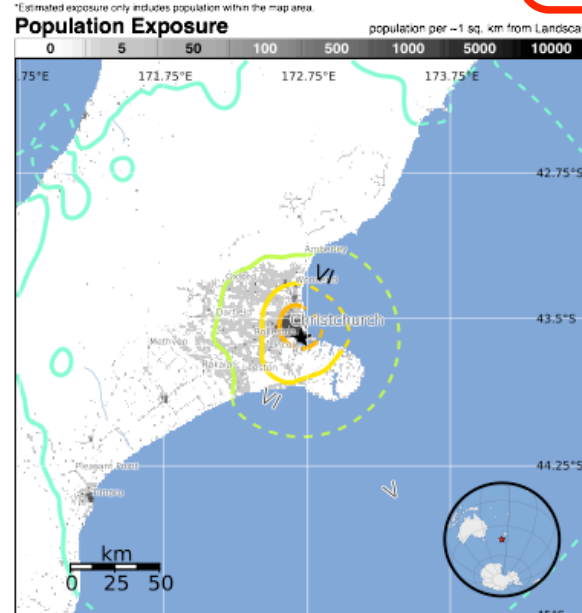
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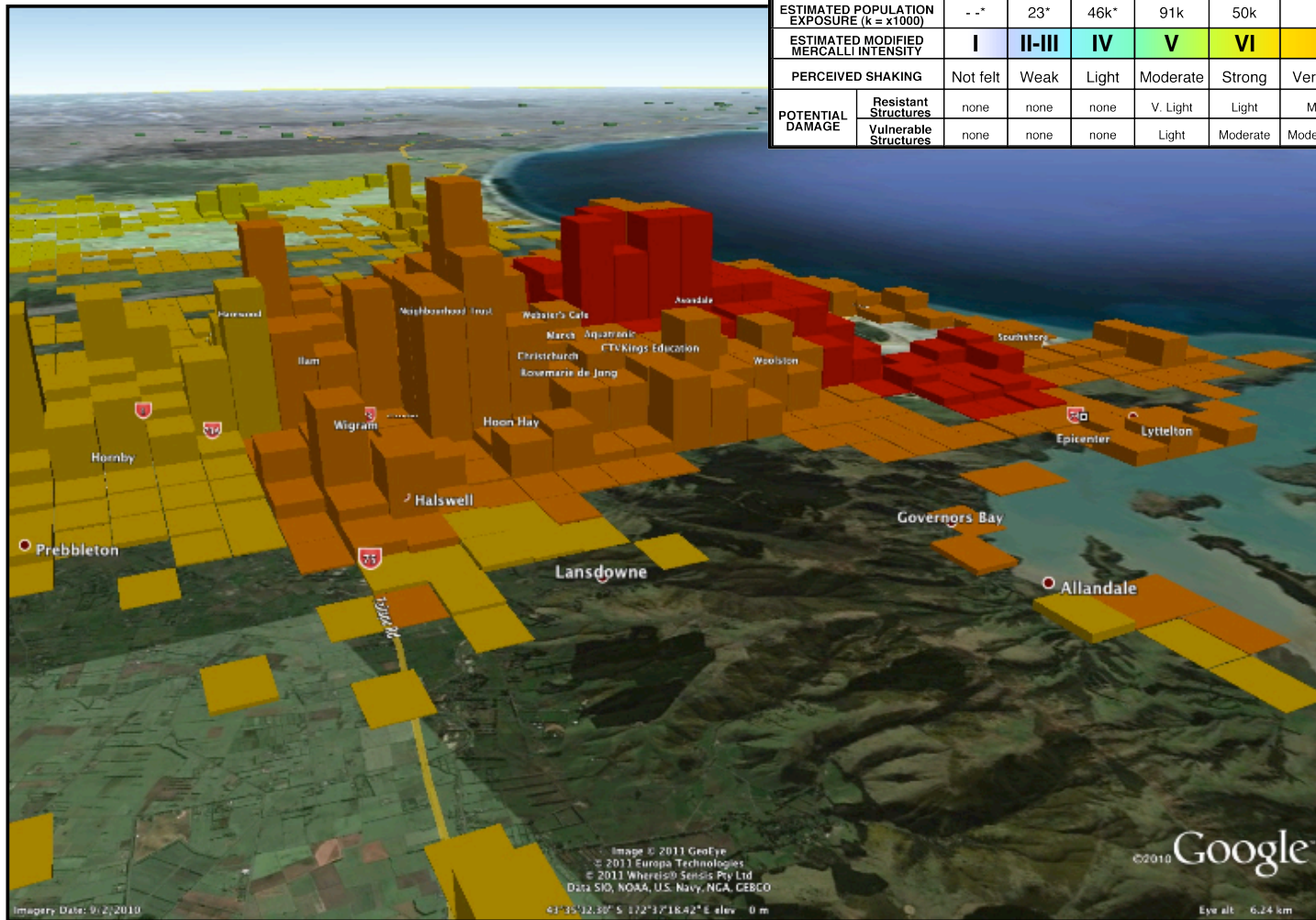
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Much greater exposures at high intensities for the Christchurch earthquake.

Christchurch Earthquake Population Exposure

Estimated Population Exposed to Earthquake Shaking

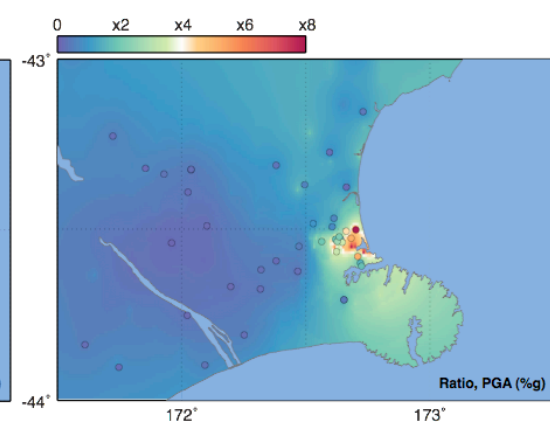
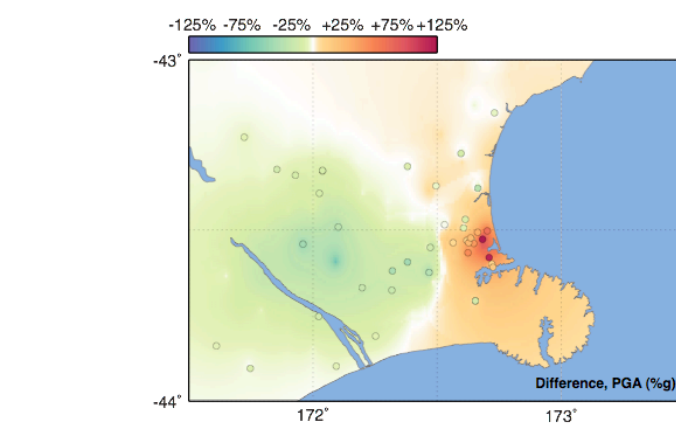
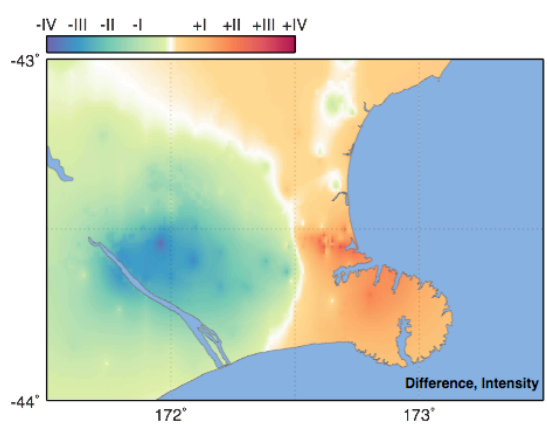
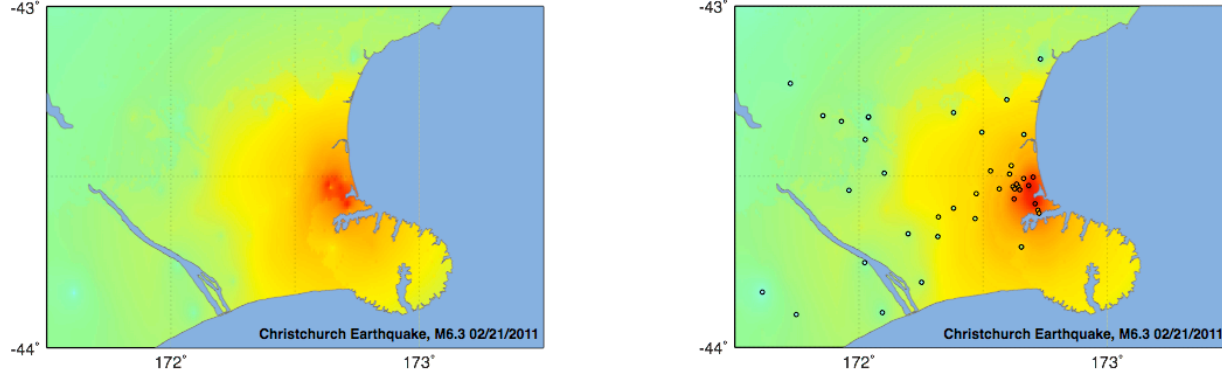
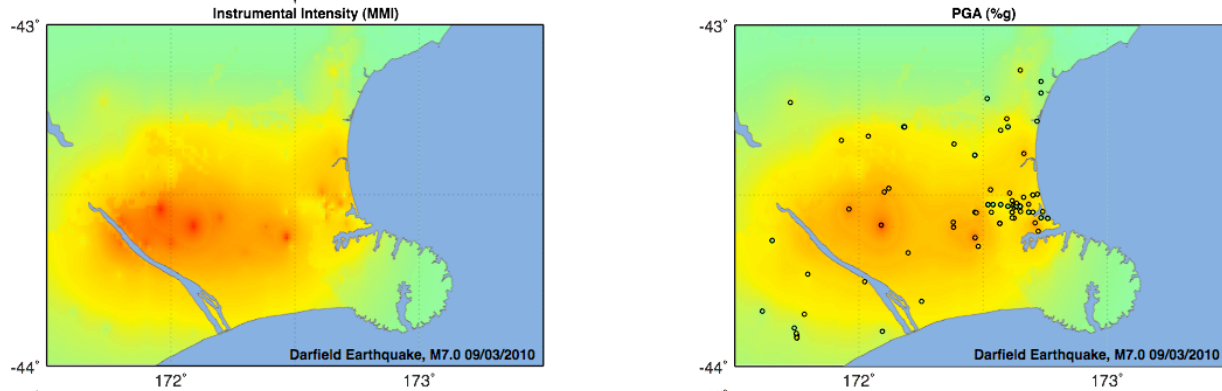
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This Google Earth snap-shot shows the extent of earthquake ground shaking (from USGS ShakeMap; represented in color) overlain on population density (from LandScan 2008, Oakridge National Labs; represented as height of vertical bars) at a grid size of 1 km².

Comparing Shaking Distributions

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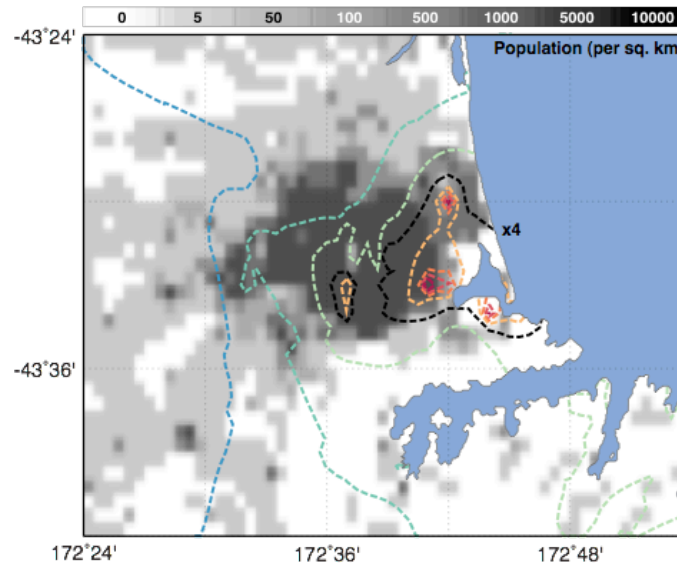
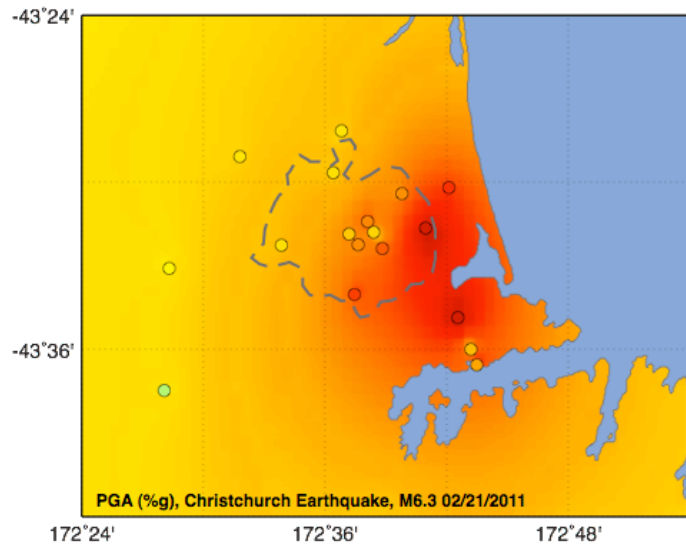
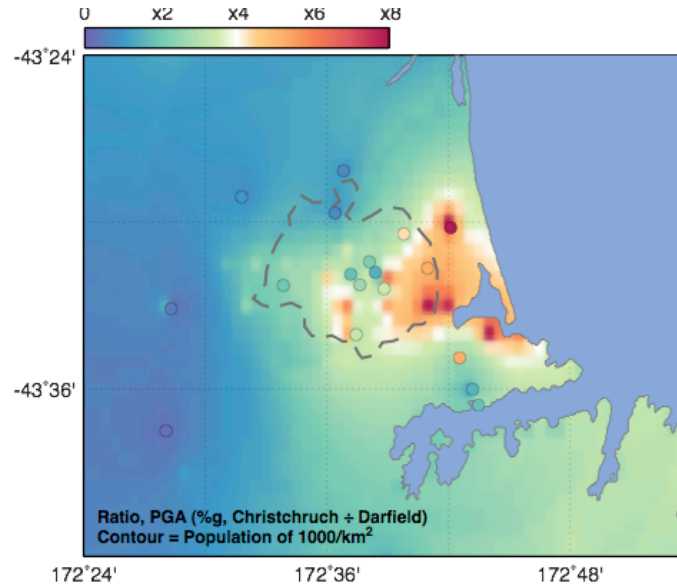
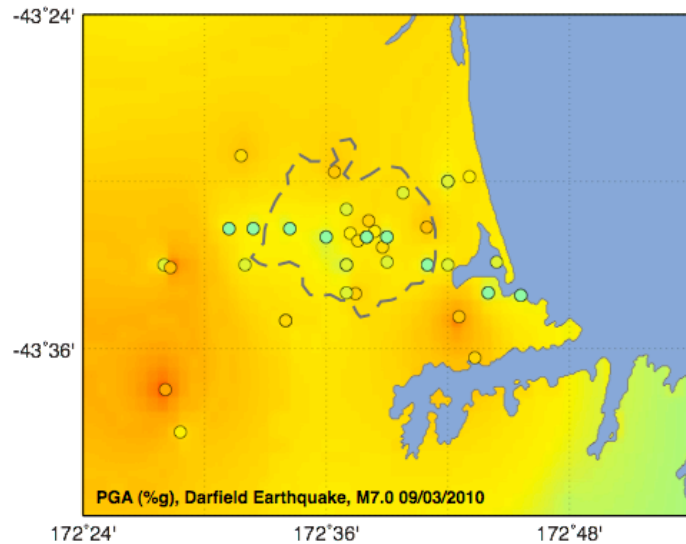
In Christchurch, accelerations were much higher during the 02/21 event - up to x6 the accelerations of the Darfield earthquake.

All difference grids are (Christchurch - Darfield). Similarly, the ratio grid below is (Christchurch PGA) ÷ (Darfield PGA). Circles on the plot below are PGA ratios at common reporting stations in the Christchurch region (ranging from x1.5-x5.2).



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/heavy	Heavy	Very Heavy
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Comparing Shaking Distributions



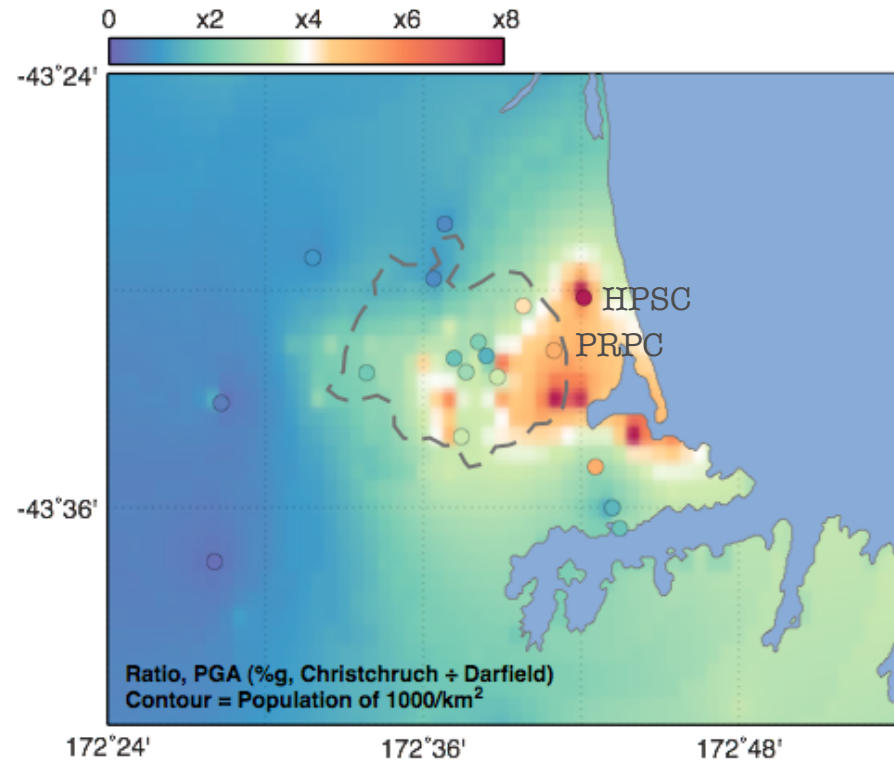
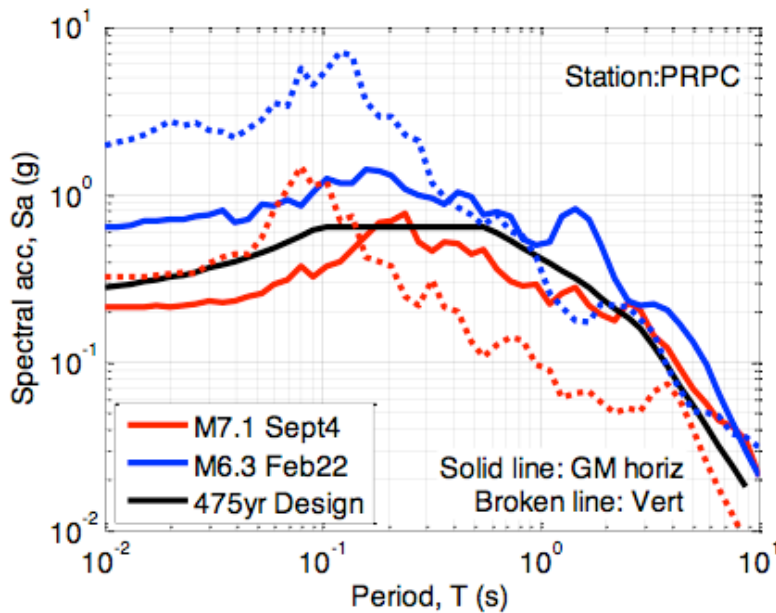
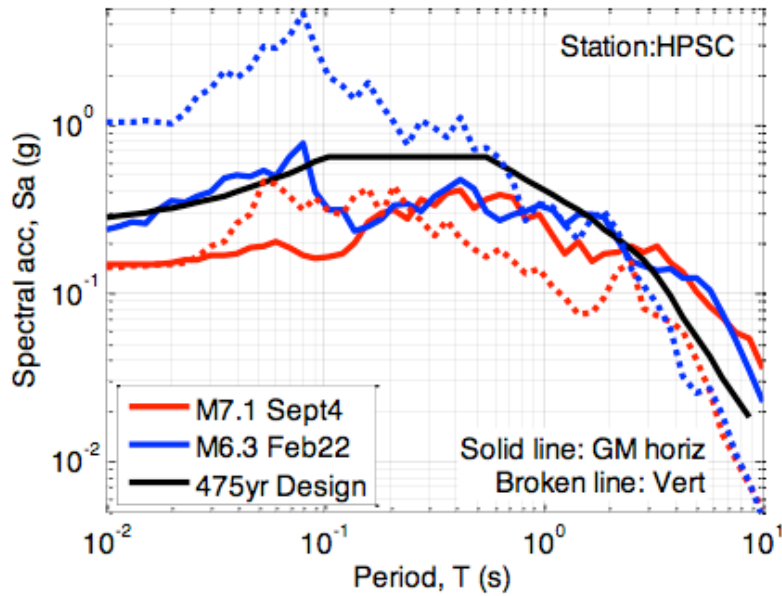
The concentration of higher accelerations coincided with the regions of highest population density. Population data from LandScan 2008, Oakridge National Labs.

Comparing Shaking Distributions

Christchurch			Darfield					
LON	LAT	PGA	LON	LAT	PGA	SEP(km)	DIFF	RATIO
172.64	-43.53	25.22	172.64	-43.53	17.30	0.00	7.92	1.46
172.72	-43.60	34.55	172.72	-43.61	22.48	0.65	12.07	1.54
172.62	-43.53	27.05	172.62	-43.53	14.94	0.00	12.11	1.81
172.65	-43.54	69.14	172.65	-43.54	20.22	0.07	48.92	3.42
172.63	-43.54	51.11	172.63	-43.54	19.78	0.23	31.33	2.58
172.62	-43.57	79.55	172.62	-43.57	23.72	0.00	55.83	3.35
172.70	-43.50	85.73	172.70	-43.50	9.68	0.40	76.05	8.86
172.71	-43.58	146.60	172.71	-43.58	28.04	0.00	118.56	5.23
172.72	-43.61	41.25	172.72	-43.61	22.48	0.47	18.77	1.84
172.68	-43.53	162.89	172.68	-43.53	31.08	0.00	131.81	5.24
172.64	-43.52	52.84	172.64	-43.52	24.63	0.00	28.21	2.15
172.56	-43.54	18.84	172.57	-43.53	9.68	1.16	9.16	1.95
172.66	-43.51	50.02	172.66	-43.51	11.52	0.00	38.50	4.34
							45.33	3.37

Table comparing peak ground accelerations (%g) in the vicinity of Christchurch for the Christchurch 02/21/11 (M6.3) and Darfield 09/03/10 (M7.0) earthquakes. Station locations are identical where possible; otherwise nearest reported PGA is shown. Values in the last row show average PGA differences (Christchurch – Darfield) and average PGA ratios (Christchurch ÷ Darfield). Data from USGS Shakemaps.

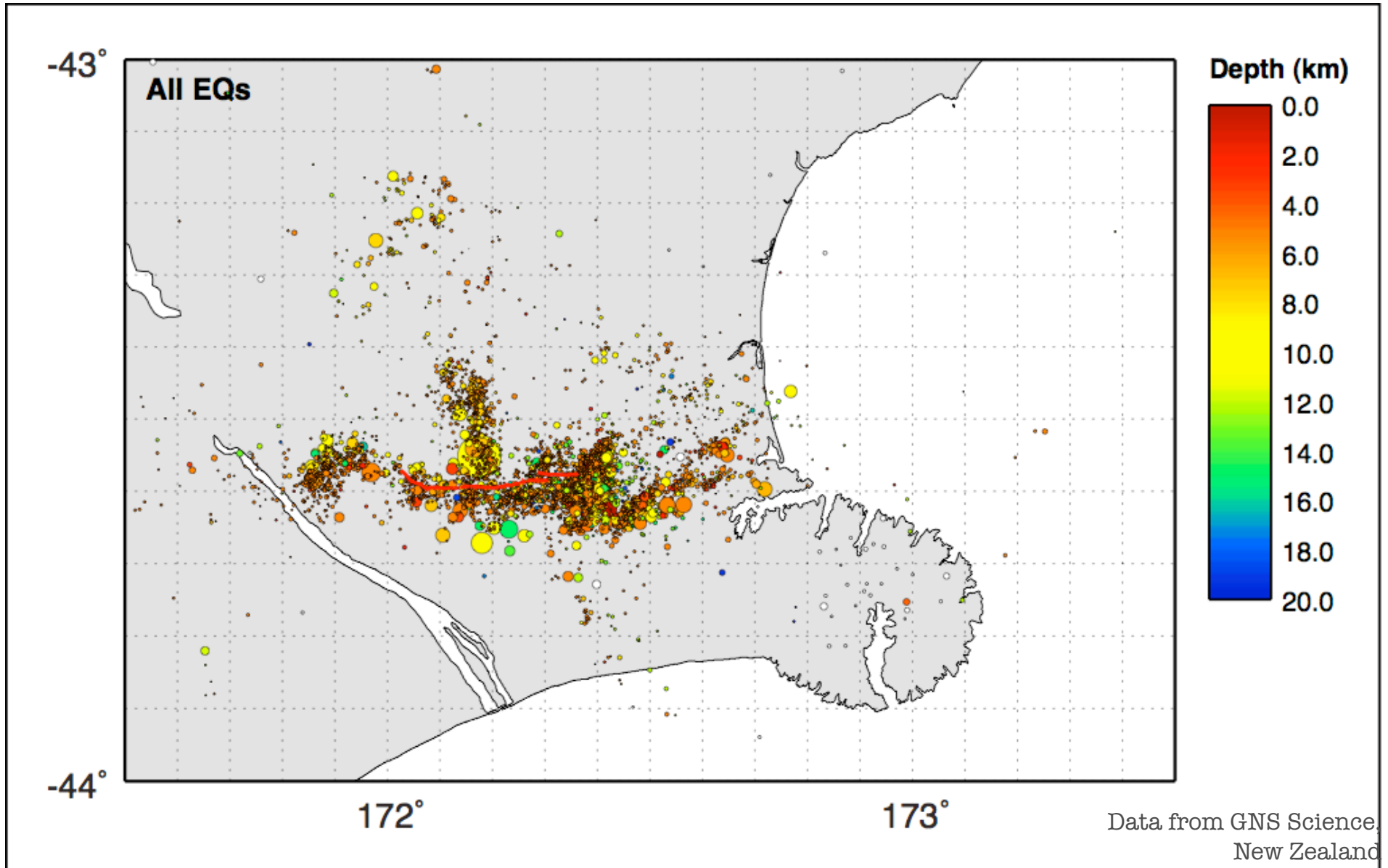
Comparing Ground Motions



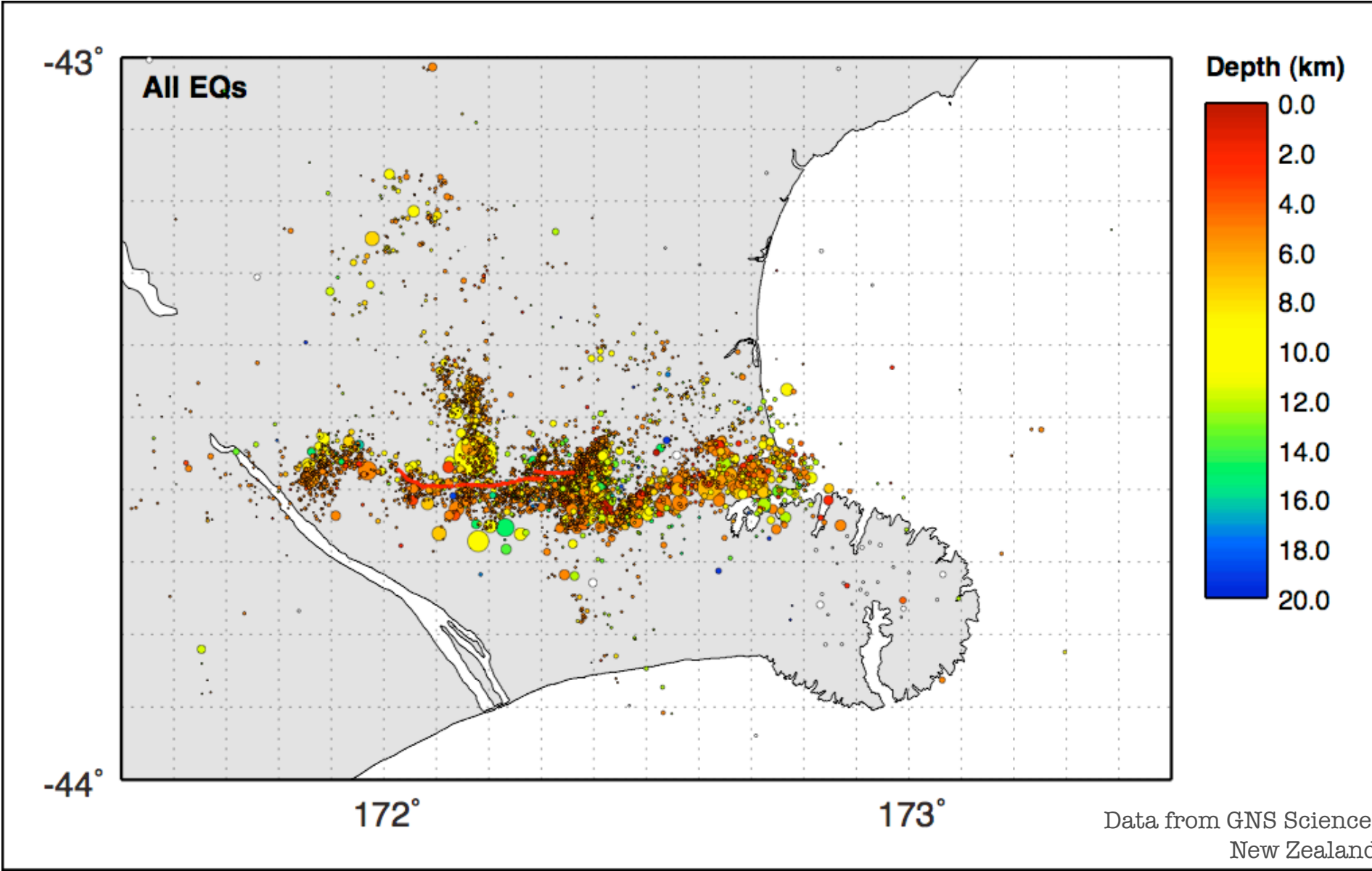
The figures on the left compare preliminary ground motions for stations in the Christchurch region observing both the Christchurch and Darfield earthquakes.

Figures courtesy of Brendon Bradley; data from GNS Science, New Zealand.

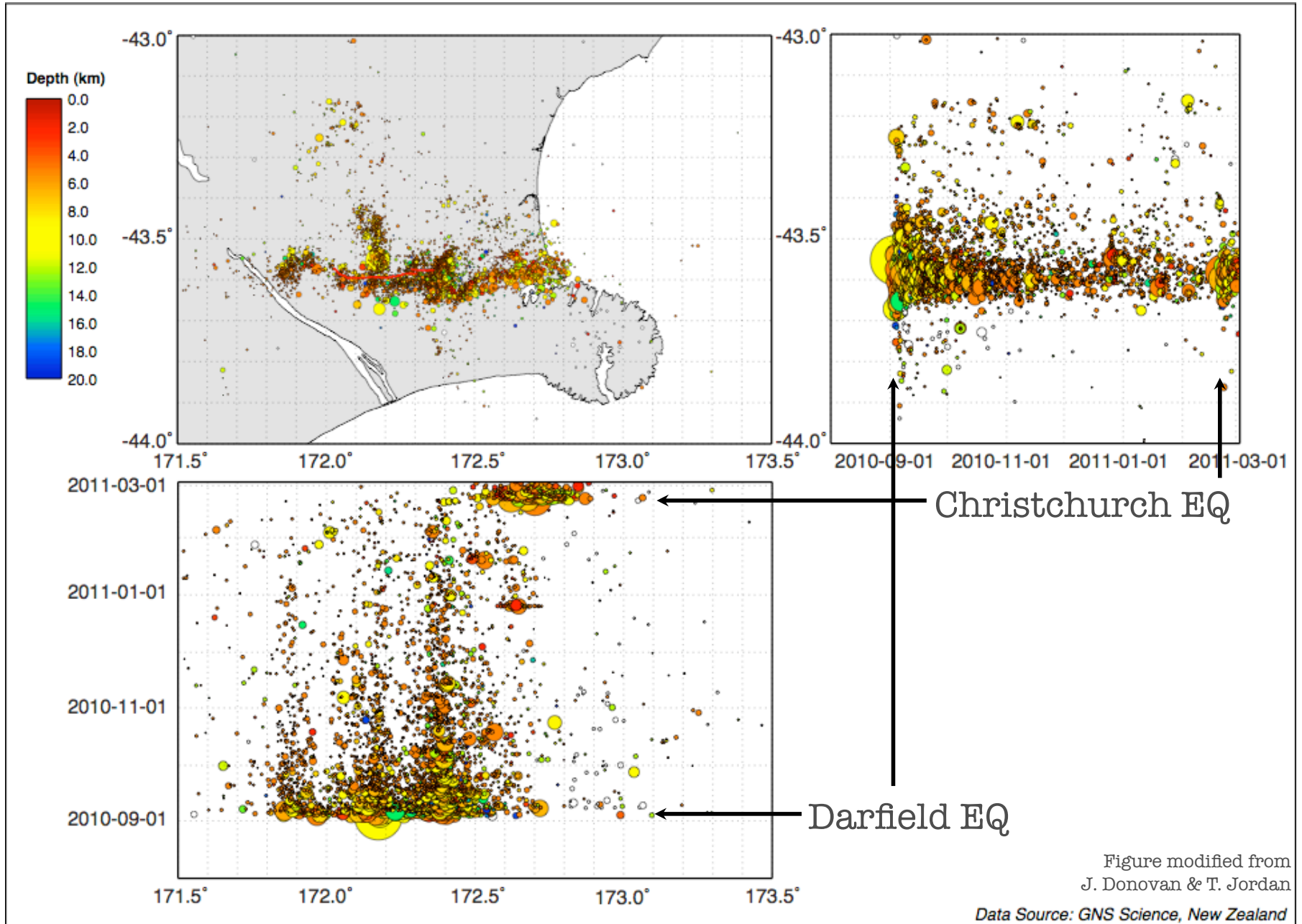
Darfield Earthquake Aftershock Sequence,
09/03/10 - 02/20/11 (prior to the Christchurch earthquake).



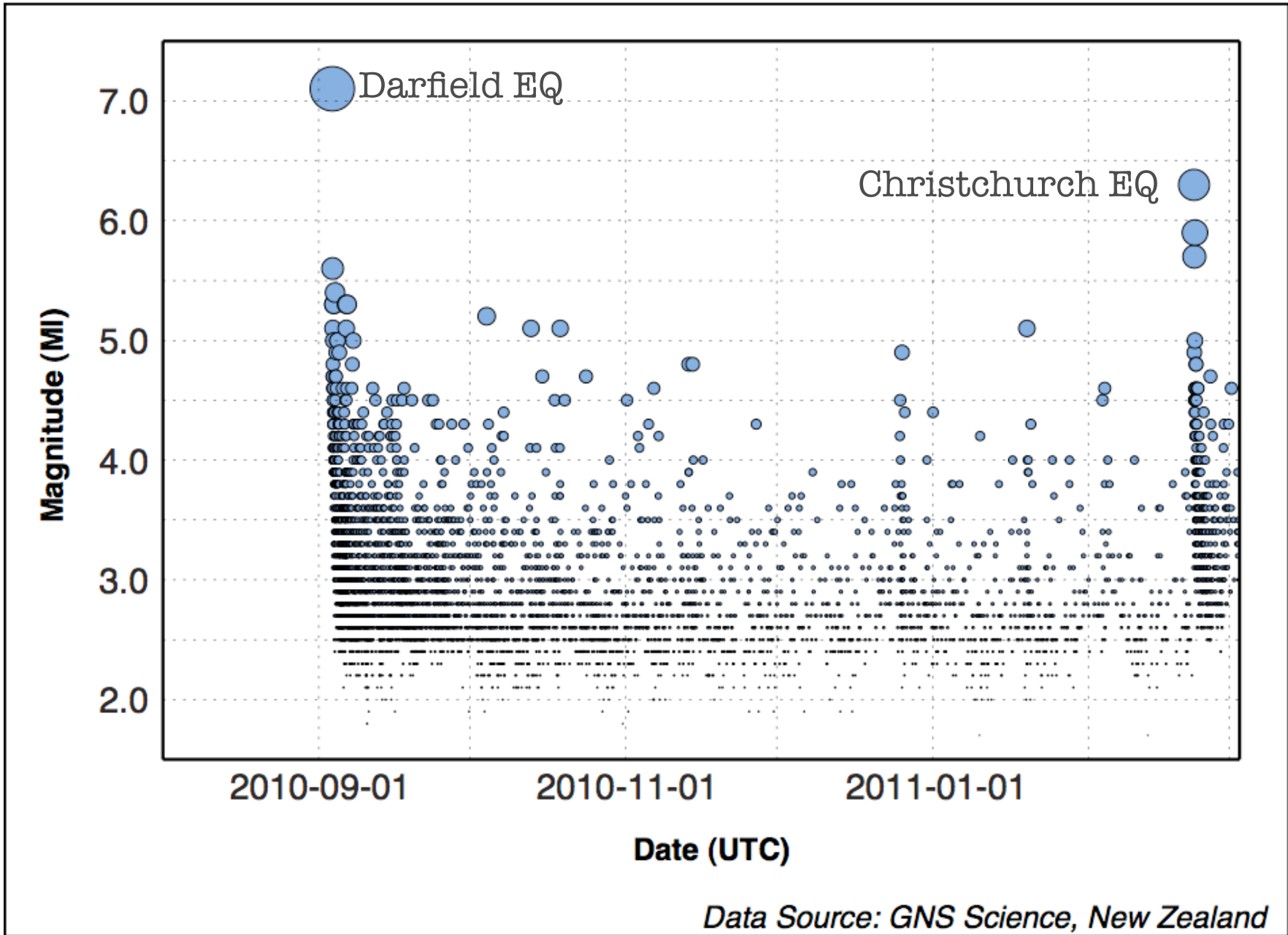
Darfield Earthquake Aftershock Sequence,
09/03/10 - 03/02/11



Darfield Earthquake Aftershock Sequence, Time History



Darfield Earthquake Aftershock Sequence, M:Time History



Darfield Earthquake Aftershock Sequence, Spatial Energy Release

Understanding the precise relationship between the two events involves unraveling the complex faulting history of the Darfield earthquake, and how that network of faults relates to the fault that ruptured on 02/21.

This image projects the energy release of all earthquakes in the sequence onto an E-W profile.

