

# Ground Motion Aspects of the 22 February 2011 Christchurch Earthquake Related to the Canterbury Television (CTV)

Brendon Bradley<sup>1,2</sup>

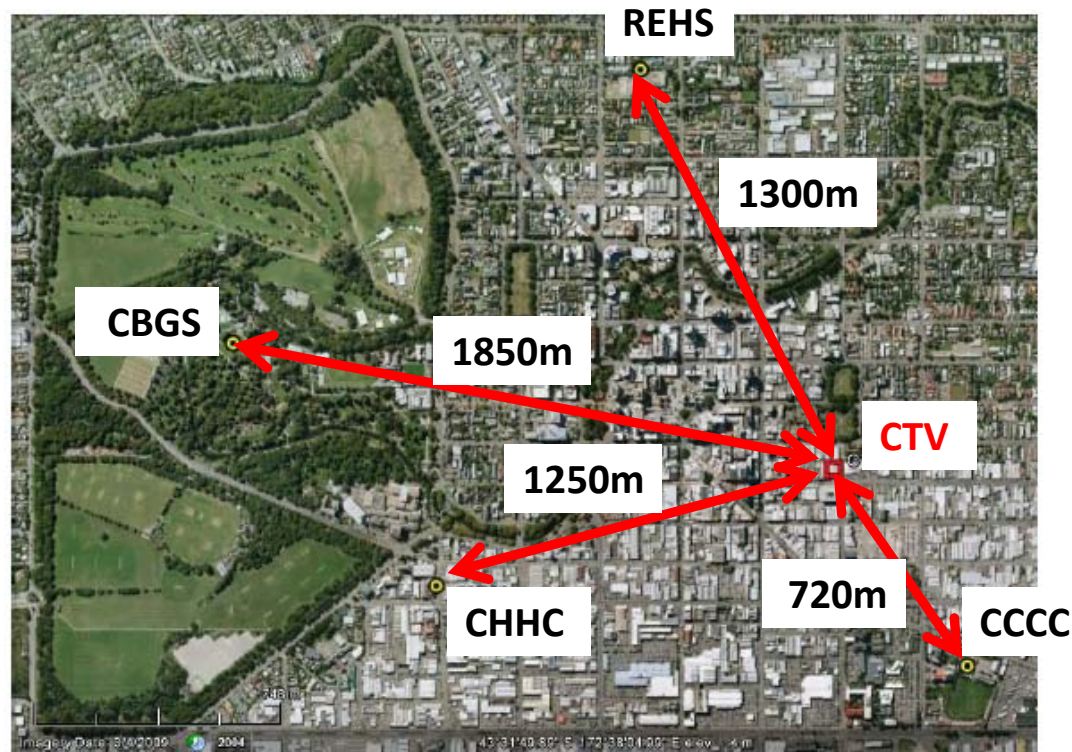
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Resources Engineering, University of Canterbury

B. Bradley

## Recordings in proximity to the CTV site

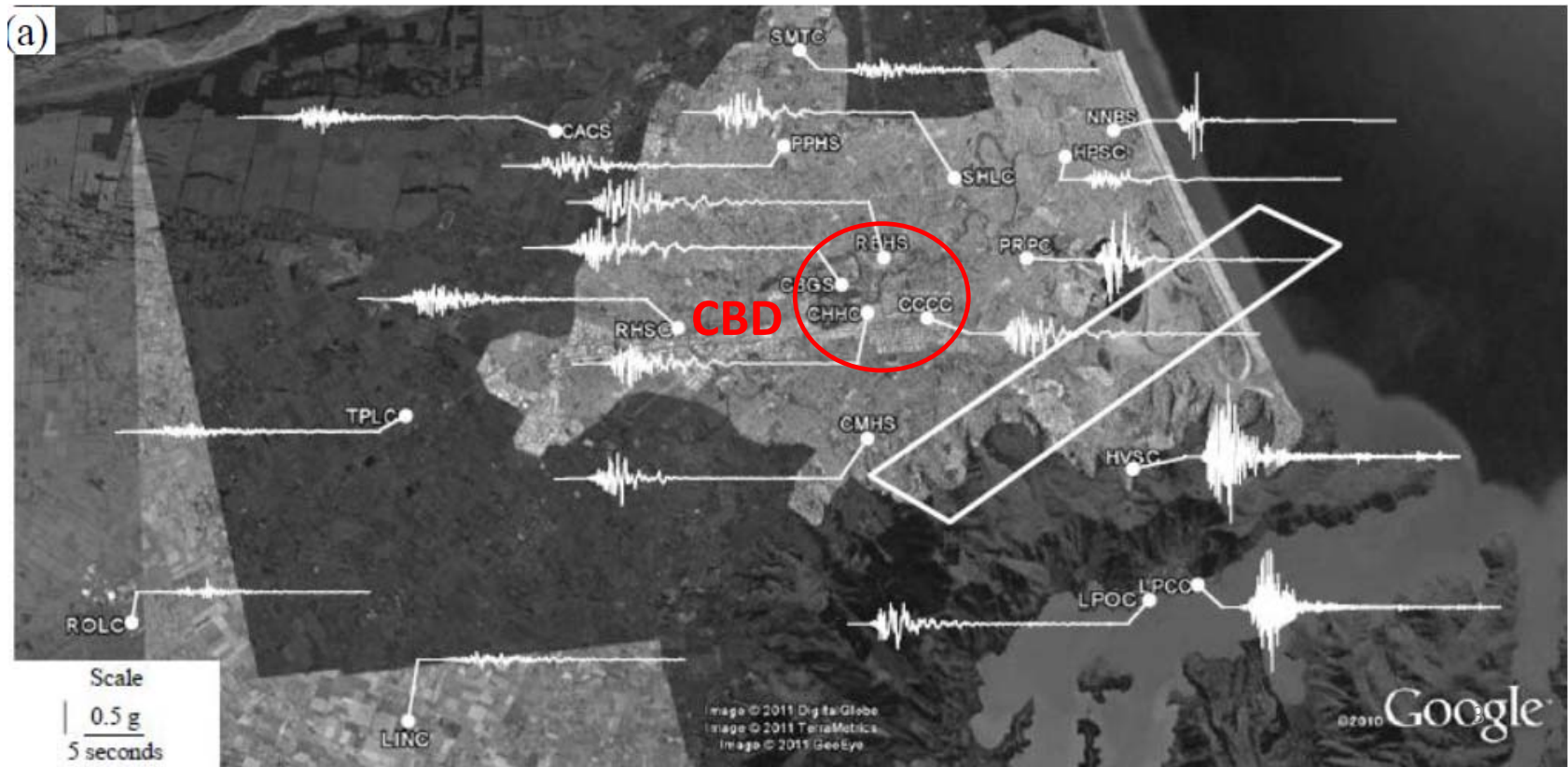
- No ground motion recordings at the CTV site during the major Canterbury earthquakes
- However, 4 ground motion instruments in the vicinity of the CTV site



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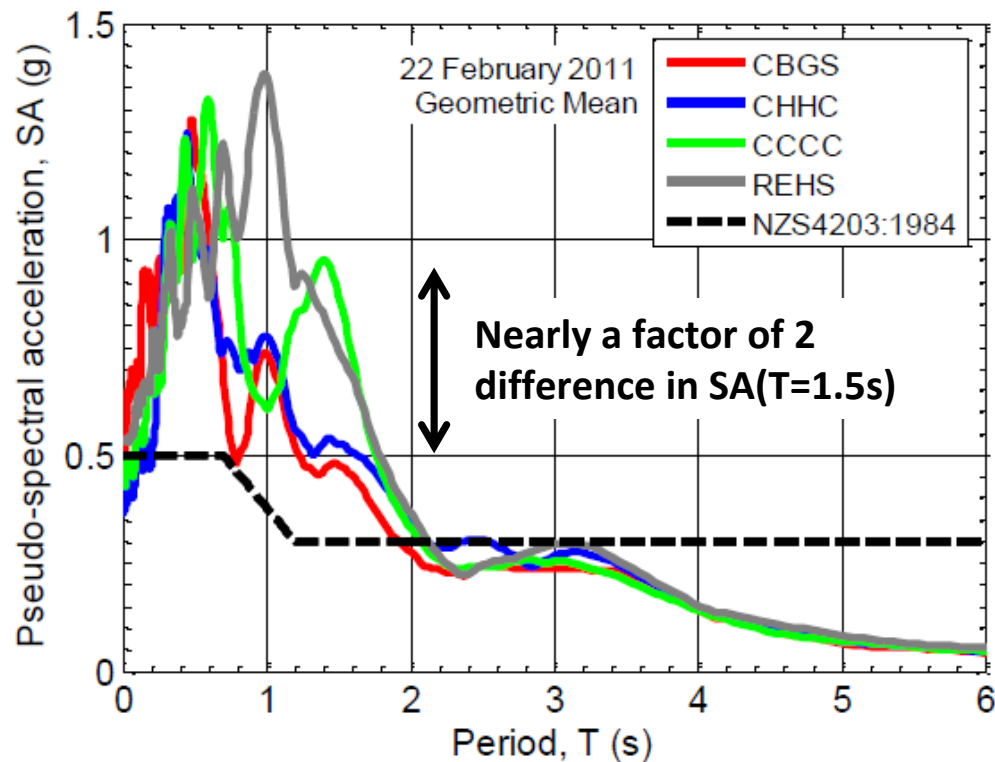
## Recordings in proximity to the CTV site

- There is significant spatial variability in ground motion intensity over short distances, particularly for high frequencies



## Recordings in proximity to the CTV site

- Variability at high frequencies (i.e. short vibration periods) evident in response spectra comparison of the four ground motion recordings



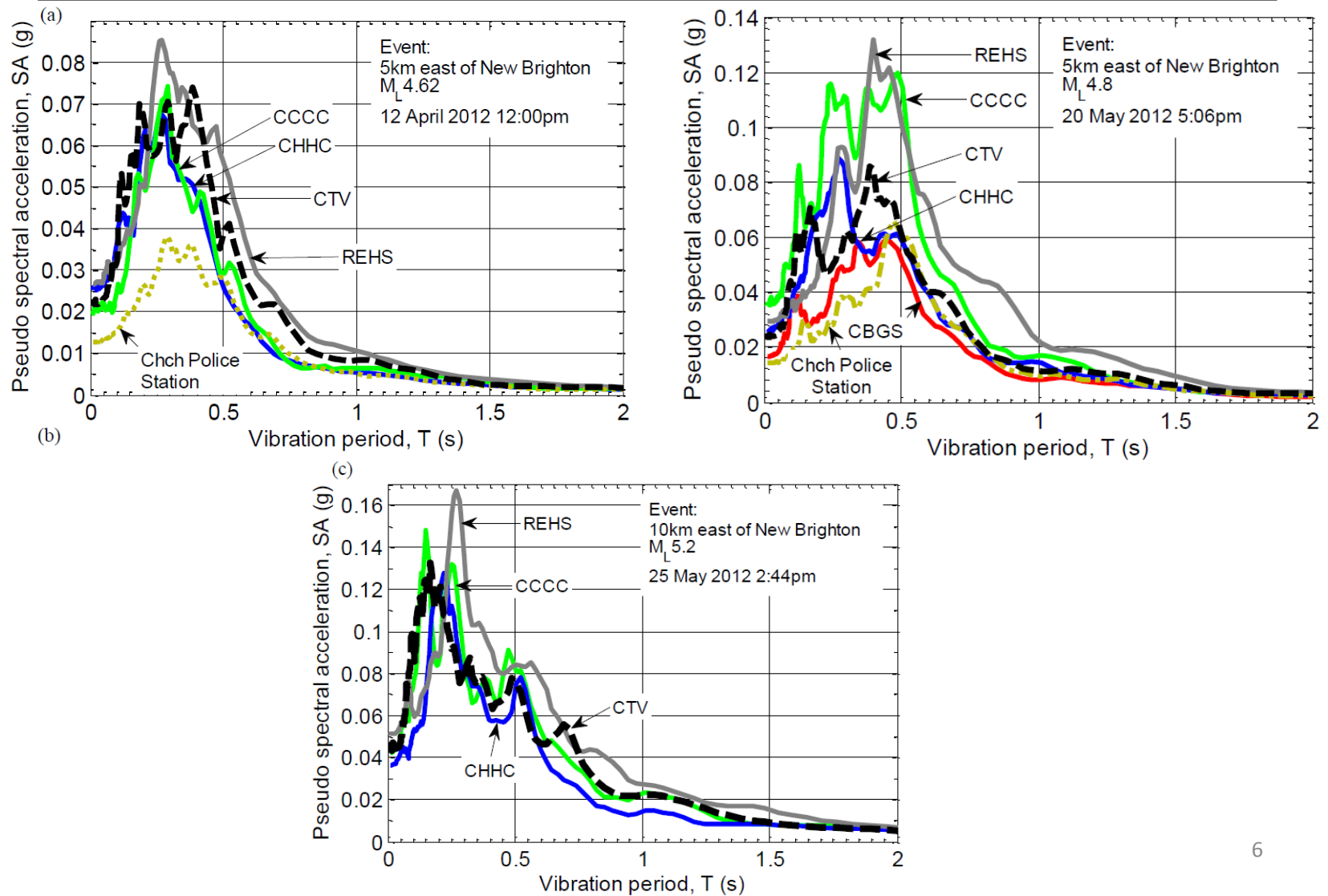
## Instrumentation at the CTV site

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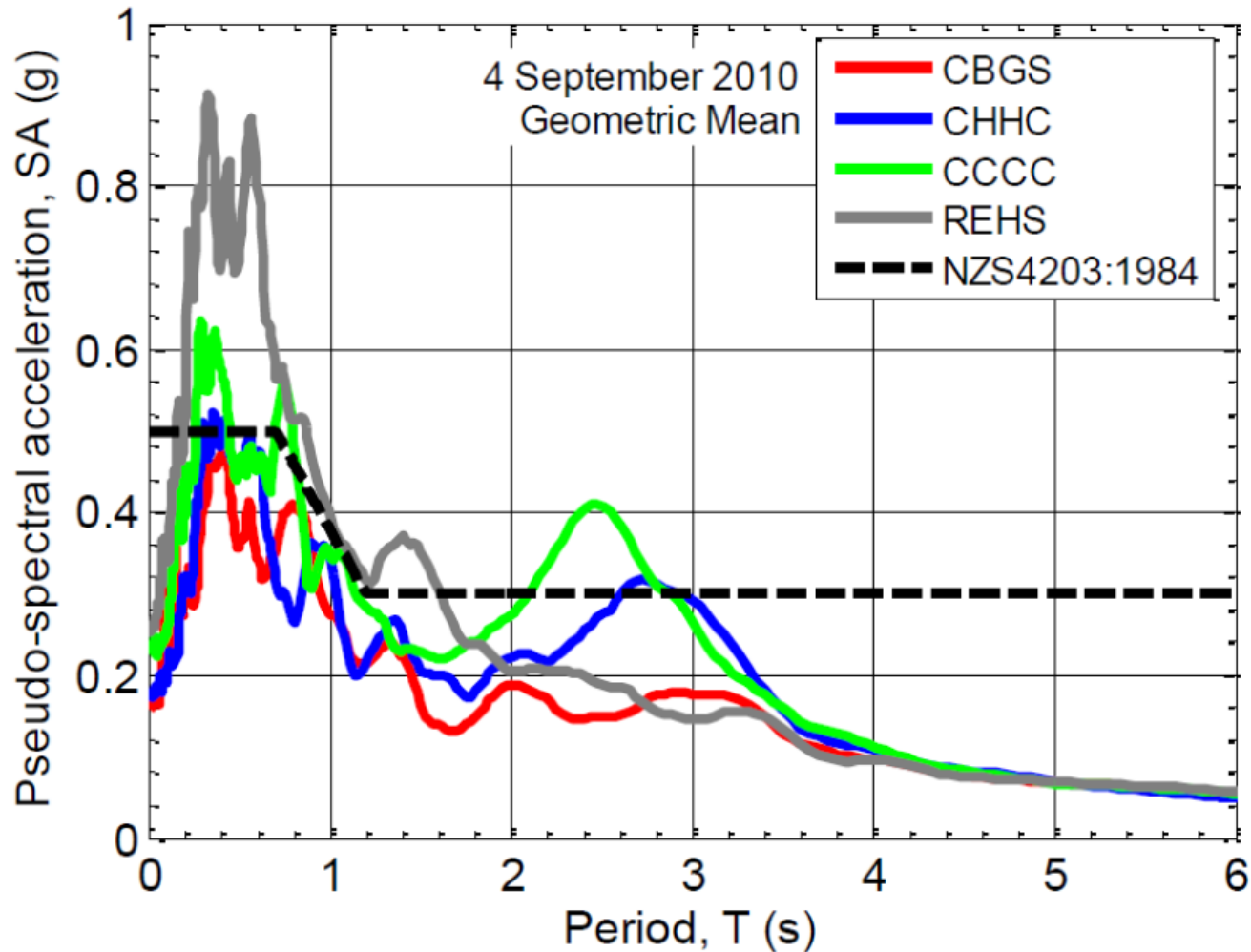
- Instrument deployed at the CTV site in March 2012
- Ground motions observed at the site since March 2012 can be compared with those concurrently observed at the nearby permanent strong motion stations, in order to investigate any potential peculiarities
- Only events  $>M_L 4.0$  were considered (with peak ground acceleration up to 5%g)

B. Bradley

# Instrumentation at the CTV site



B. Bradley 4<sup>th</sup> September 2010 ground motions vs.  
 “design ground motion”



Ground motion response spectra from the 4<sup>th</sup> September 2010 Darfield earthquake (Figure 8 of WIT.BRADLEY.0003.1).

# B. Bradley 4<sup>th</sup> September 2010 ground motions vs. "design ground motion"

- Seismic hazard deaggregation – SA(T=1.0s)

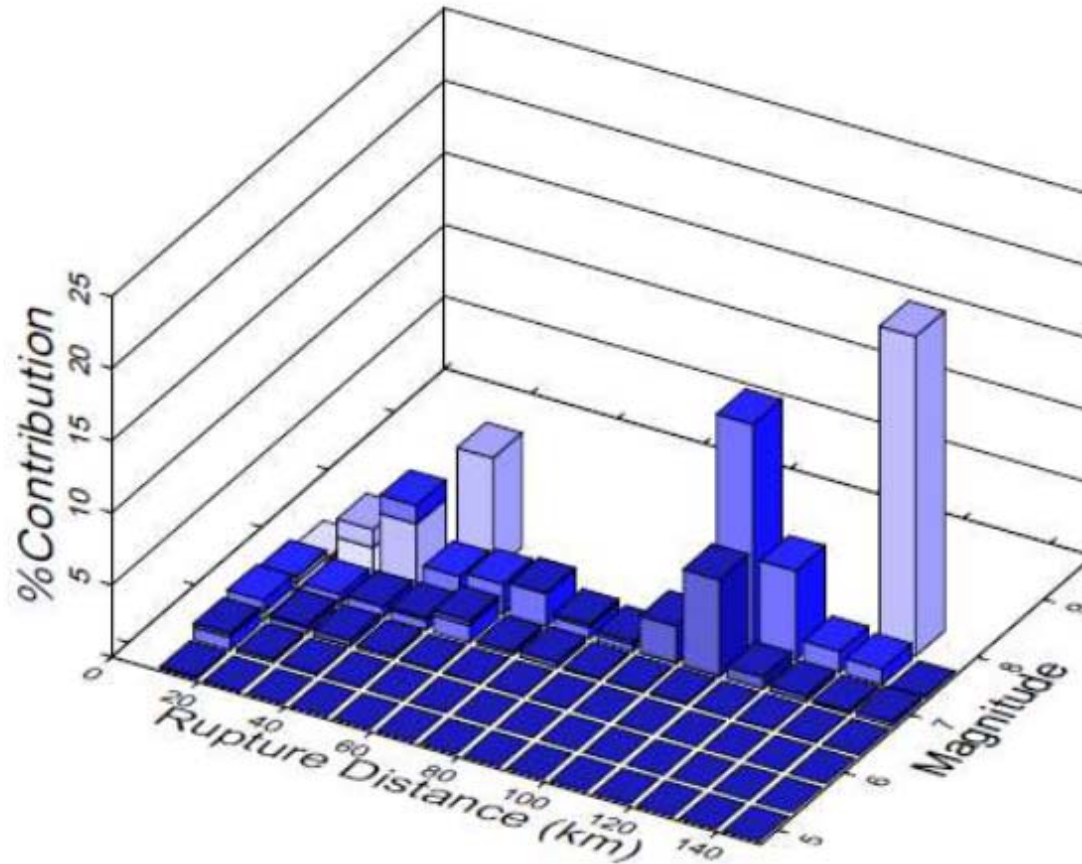


Figure: Contribution of various earthquake sources to the total seismic hazard in central Christchurch. The mean magnitude is  $M_w 7.37$ .



# B. Bradley 4<sup>th</sup> September 2010 ground motions vs. “design ground motion”

- Ground motion durations from the Darfield earthquake were larger than predicted

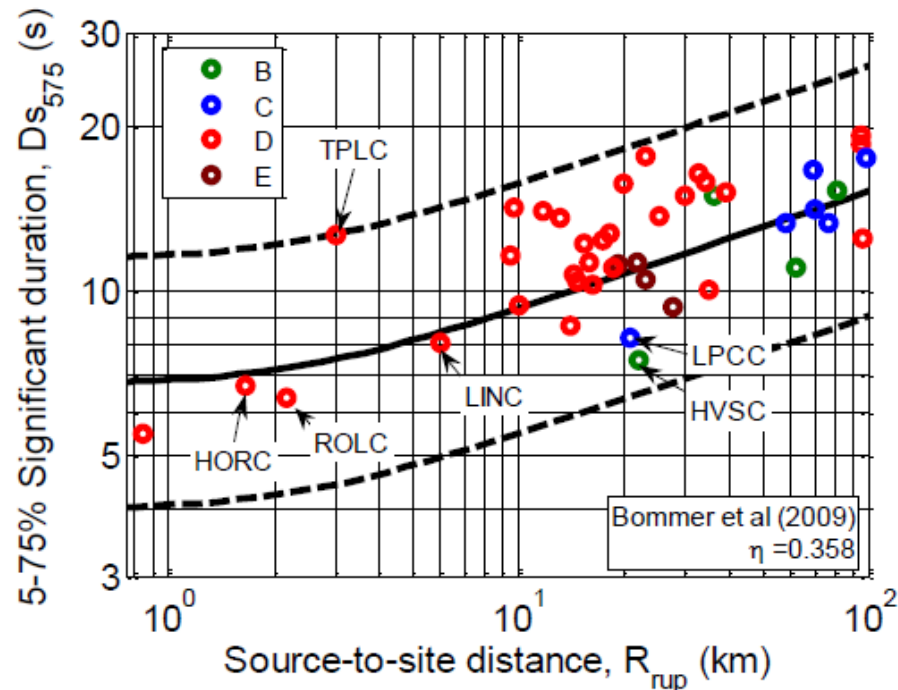


Figure: Comparison of 5-75% significant durations observed in the 4<sup>th</sup> September 2010 Darfield earthquake and empirical prediction (Figure 18a of Bradley (2012)).

# Comparison with ground motions from the Alpine fault in Christchurch

- Ground motions in Christchurch from an inferred Alpine fault earthquake (Mw8.1; R130km) will be similar to those in Tokyo from the Tohoku earthquake (Mw9.0; R110km).

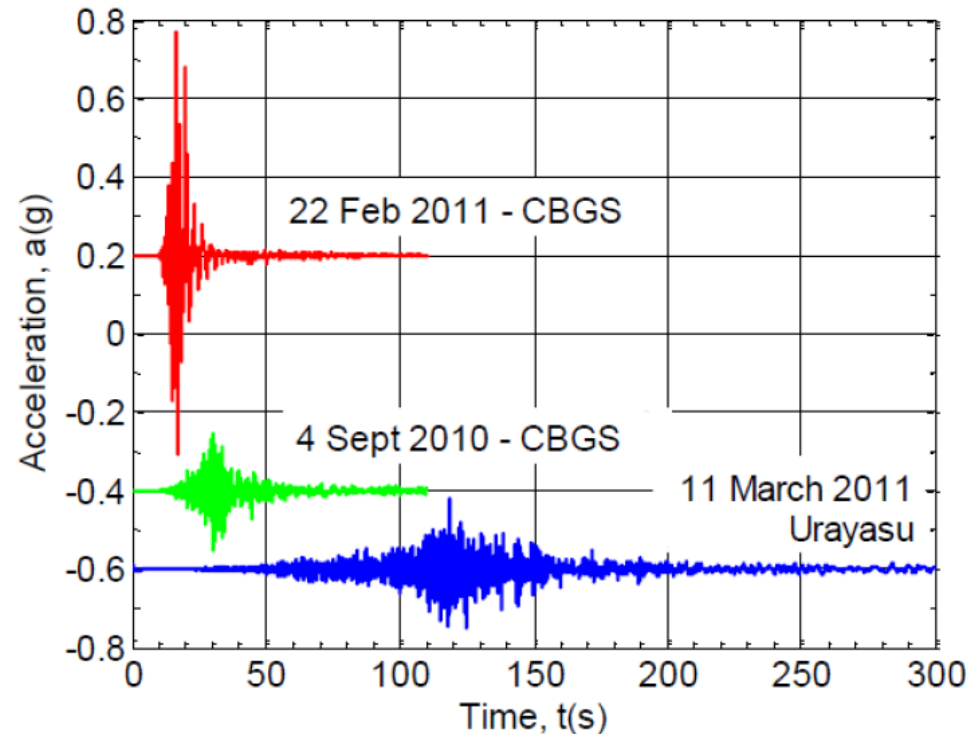


Figure: Comparison of the ground motions recorded at Christchurch Botanic Gardens (CBGS) during the 22 February 2011 Christchurch earthquake and the 4 September 2010 Darfield earthquake with the ground motion recorded in Tokyo Bay (Urayasu) during the 11 March 2011 Tohoku earthquake (Figure 2 of Bradley (2012)).

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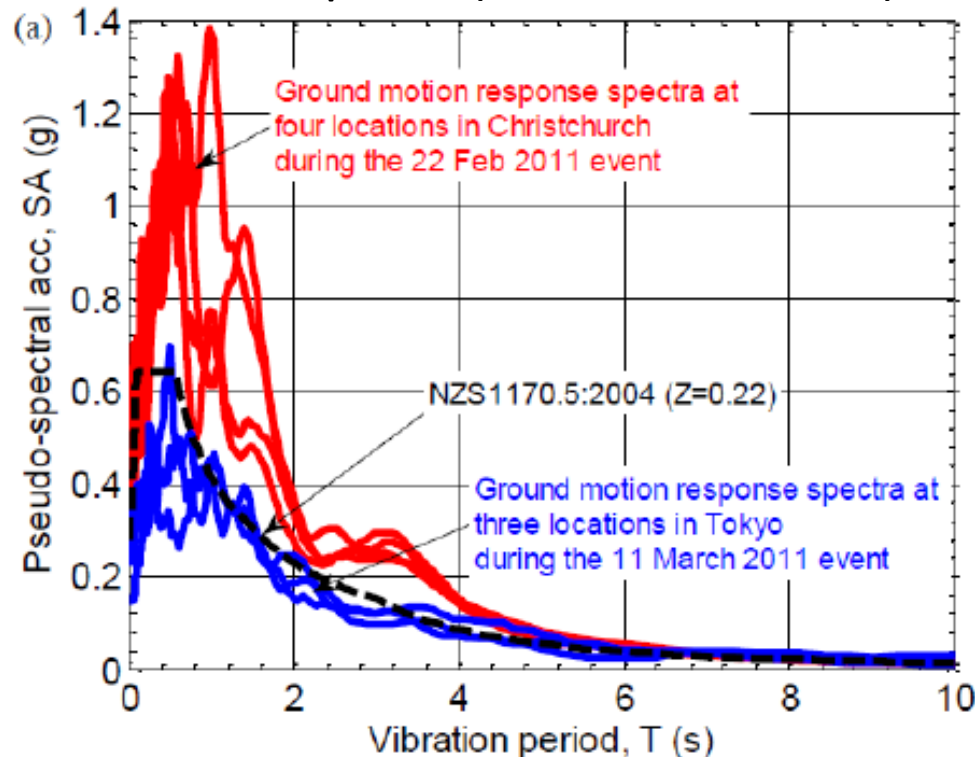


Figure: Comparison of ground motions in the Christchurch CBD with those observed in Tokyo from the 11 March 2011 Tohoku earthquake: (a) The 22 February 2011 Christchurch earthquake; and (b) the 4 September 2010 Darfield earthquake. For reference the site class D seismic design spectra for Christchurch ( $Z=0.22$ ) as per NZS1170.5:2004 is also shown (Figure 3 of (Bradley 2012)).

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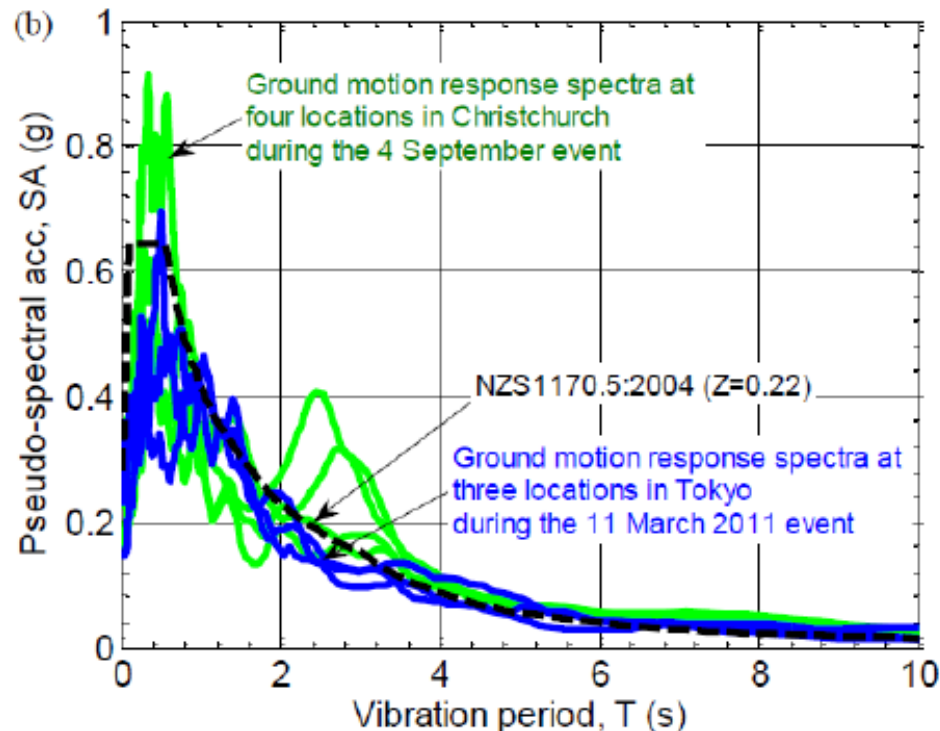


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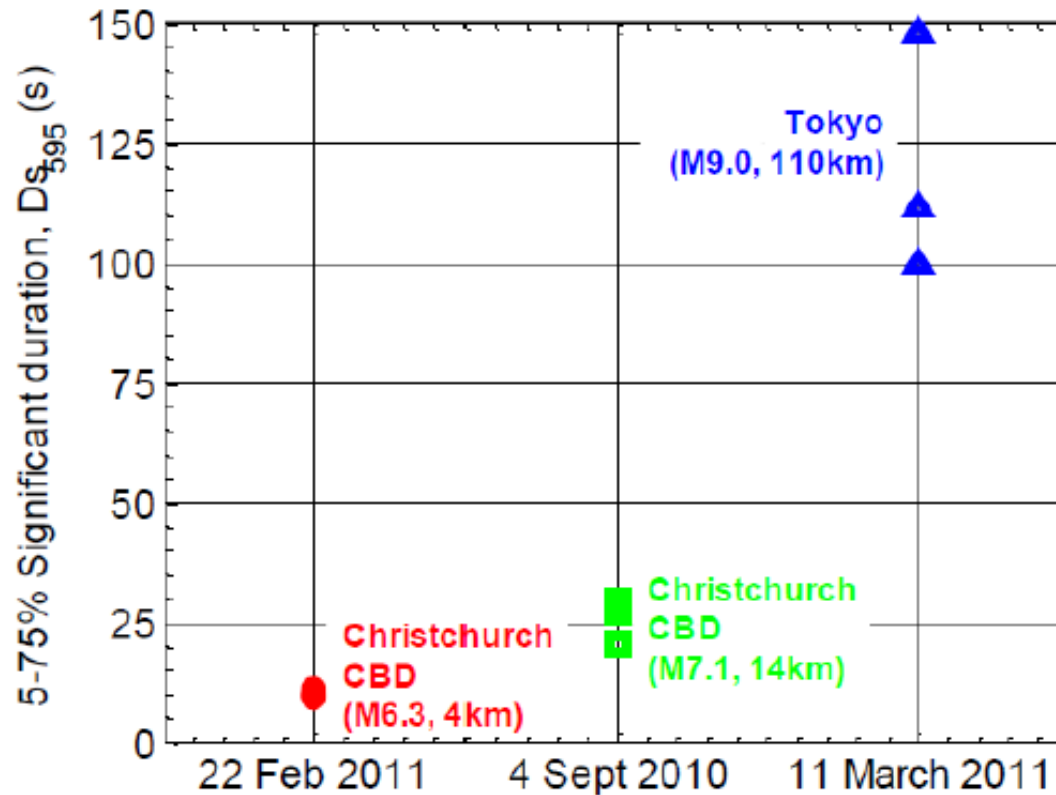


Figure: Comparison of the significant duration (5-95% definition) of ground motions in the three different events (Figure 3 of (Bradley 2012)).

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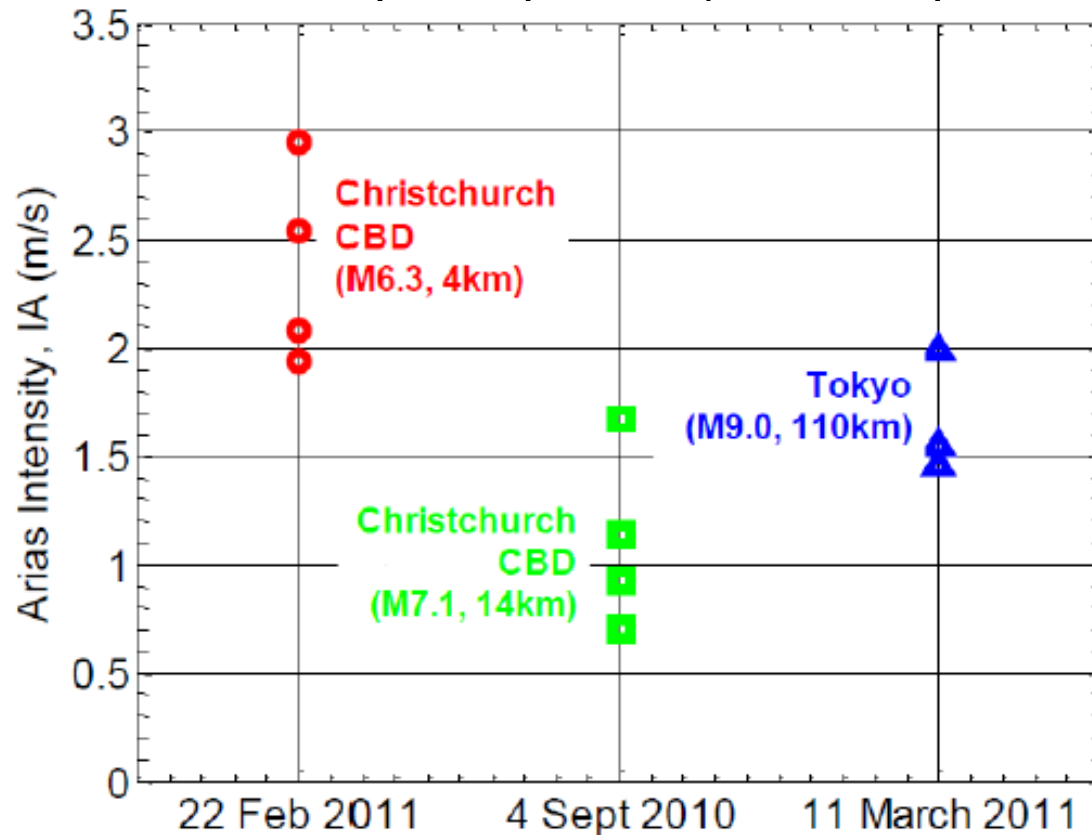


Figure: Comparison of the Arias intensity of ground motions in the three different events (Figure 3 of (Bradley 2012)).

## Vertical ground motions

- Vertical ground motion spectra at short periods are greater than the horizontal spectra near the earthquake source

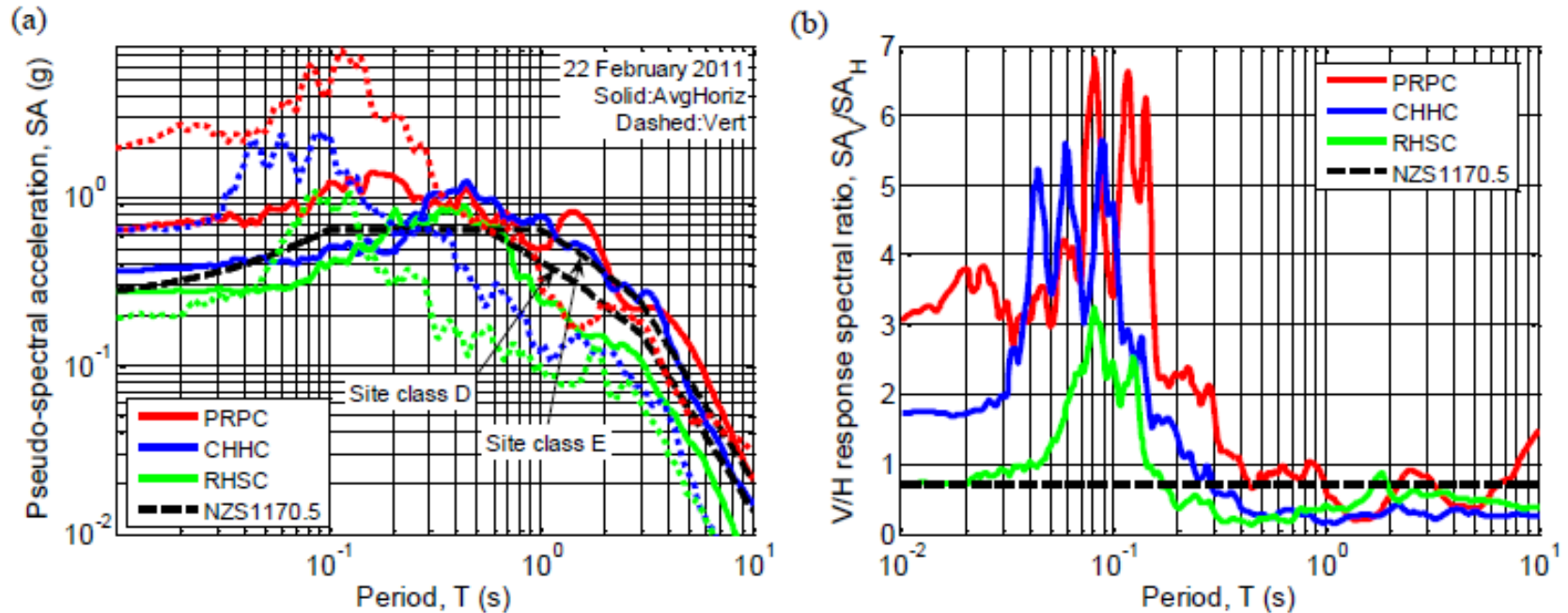
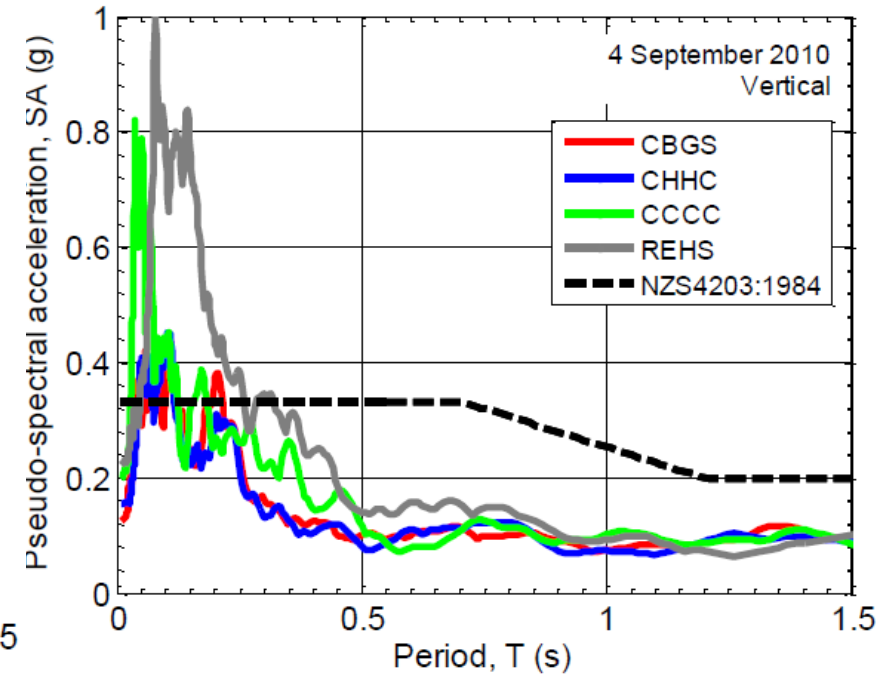
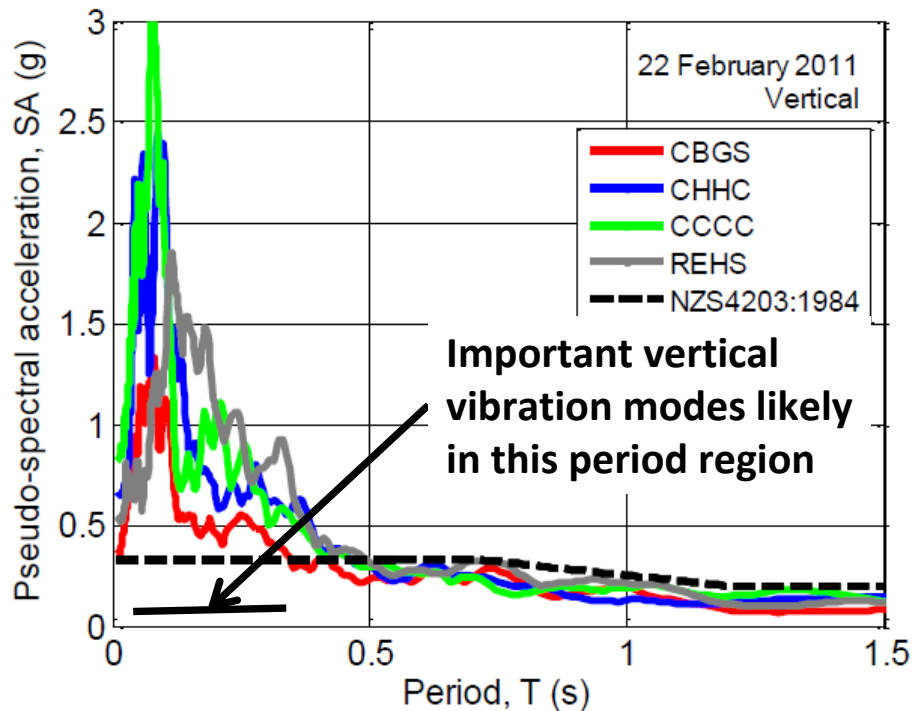


Figure: Vertical ground motion response spectral amplitudes observed: (a)-(b) Example geometric mean horizontal and vertical response spectra and their vertical-to-horizontal ratio; (c)-(e) vertical-to-horizontal response spectral ratios for  $T = 0.0-0.3s$  as a function of distance observed in the 4 September 2010 Darfield and 22 February 2011 Christchurch earthquakes and comparison with the empirical prediction of Bozorgnia and Campbell [45]. (Figure 26 of Bradley (2012)).

## Vertical ground motions

- This was observed in the CBD during both 4/9/2010 and 22/2/2011 earthquakes





# Vertical ground motions

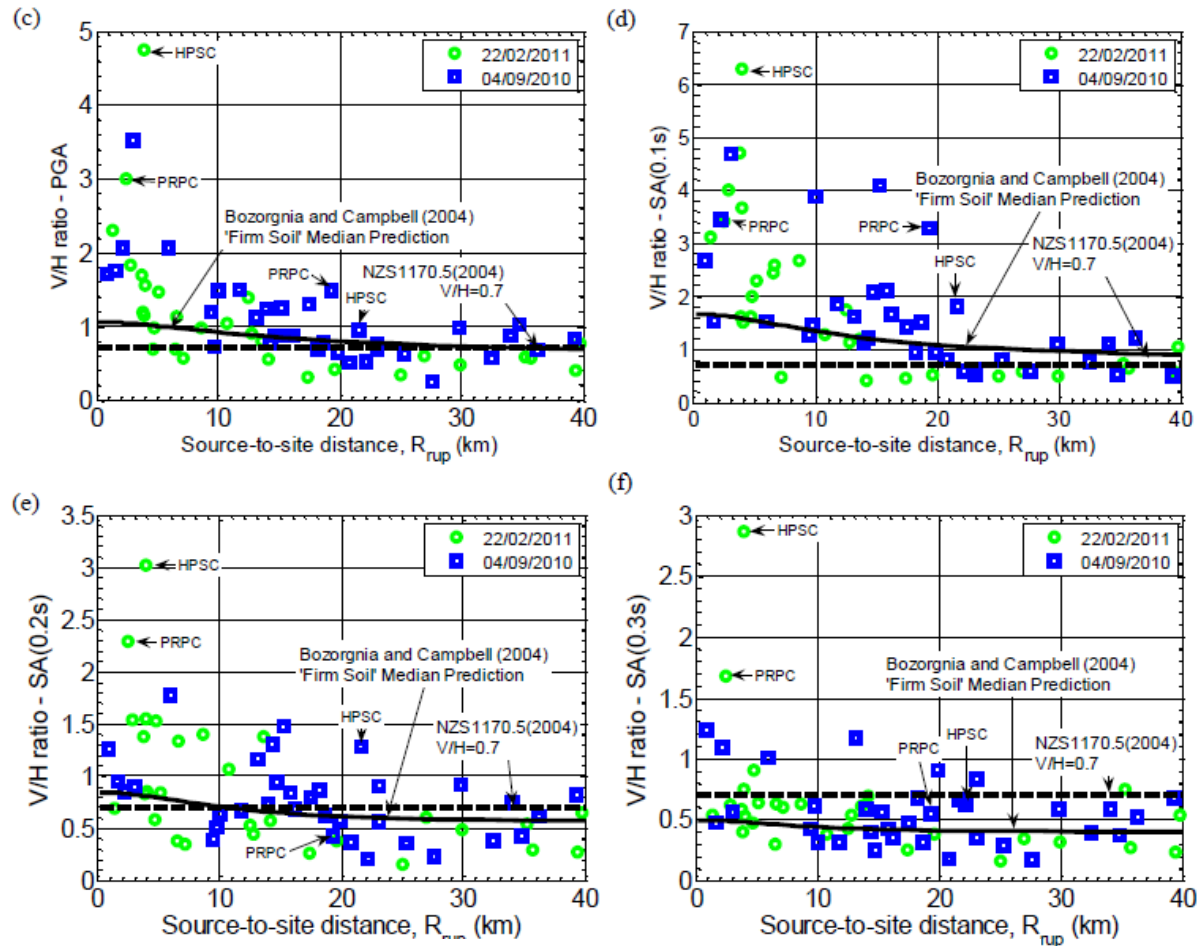


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## Vertical ground motions

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- Numerous structural collapses have been attributed to the effects of vertical ground motions



Fig. 1. Collapsed parking structure of the California State University Northridge [Papazoglou and Elnashai, 1996].