# Low frequency (f≤ 1Hz) ground motion simulations of 10 events in the 2010-2011 Canterbury earthquake sequence

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## 1. Background and Objective

This poster presents initial results from low frequency ($f$≤1Hz) ground motion simulations of the 2010-2011 Canterbury, New Zealand earthquakes. The 10 most significant earthquake events in the sequence, based on magnitude (Mw4.7-7.1) and proximity to the Christchurch urban area were considered as shown in Figure 1a.

A 3D velocity model is currently under development for the Canterbury region (Lee et al. 2014), however in these set of analyses a 1D velocity structure was considered, as shown in Figure 1b. Ground motions were simulated using staggered grid finite differences (Graves 1996).

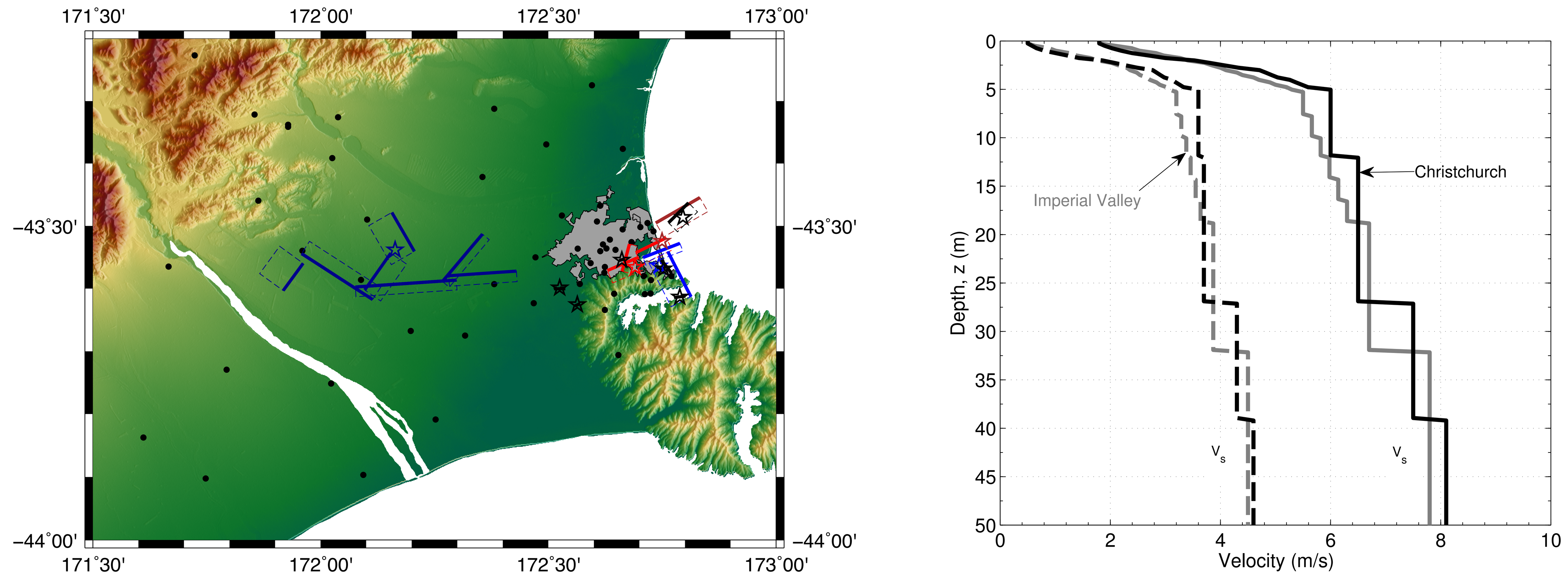


**Figure 1: (a) The Canterbury, New Zealand region with the 10 events considered and regional distribution of strong motion stations; and (b) the 1D velocity model considered for Christchurch**

## 2. Source rupture generation

The four largest events (4 Sept 2010, 22 Feb 2011, 13 June 2011 2:20pm, 23 Dec 2011 2:18pm) use source geometry informed from the source inversion studies of Beavan et al. (2010, 2012), while the remaining six events (*Mw4.7-5.8)* use source geometry based on magnitude-geometry scaling relationships (as well as being alternatively modeled as point sources). Even in the case of ruptures with finite fault inversions, comparisons were made with predicted source dimensions from empirical scaling relationships, because the magnitude-geometry coupling has a significant affect on the implied average slip amplitude, and hence ground motion intensity.

The slip distribution from finite fault inversions were not utilized (i.e. the 'scenario EQ' method of GP10 was utilized) in order to avoid circular reasoning in the predicted ground motions.

The kinematic rupture description of the finite sources is based on an updated version of the Graves and Pitarka (2010) rupture generator (GP14.3; Graves and Pitarka 2014) currently implemented on version 14.3 of the SCEC Broadband Platform. Figure 2 illustrates examples of the slip distributions for four events.

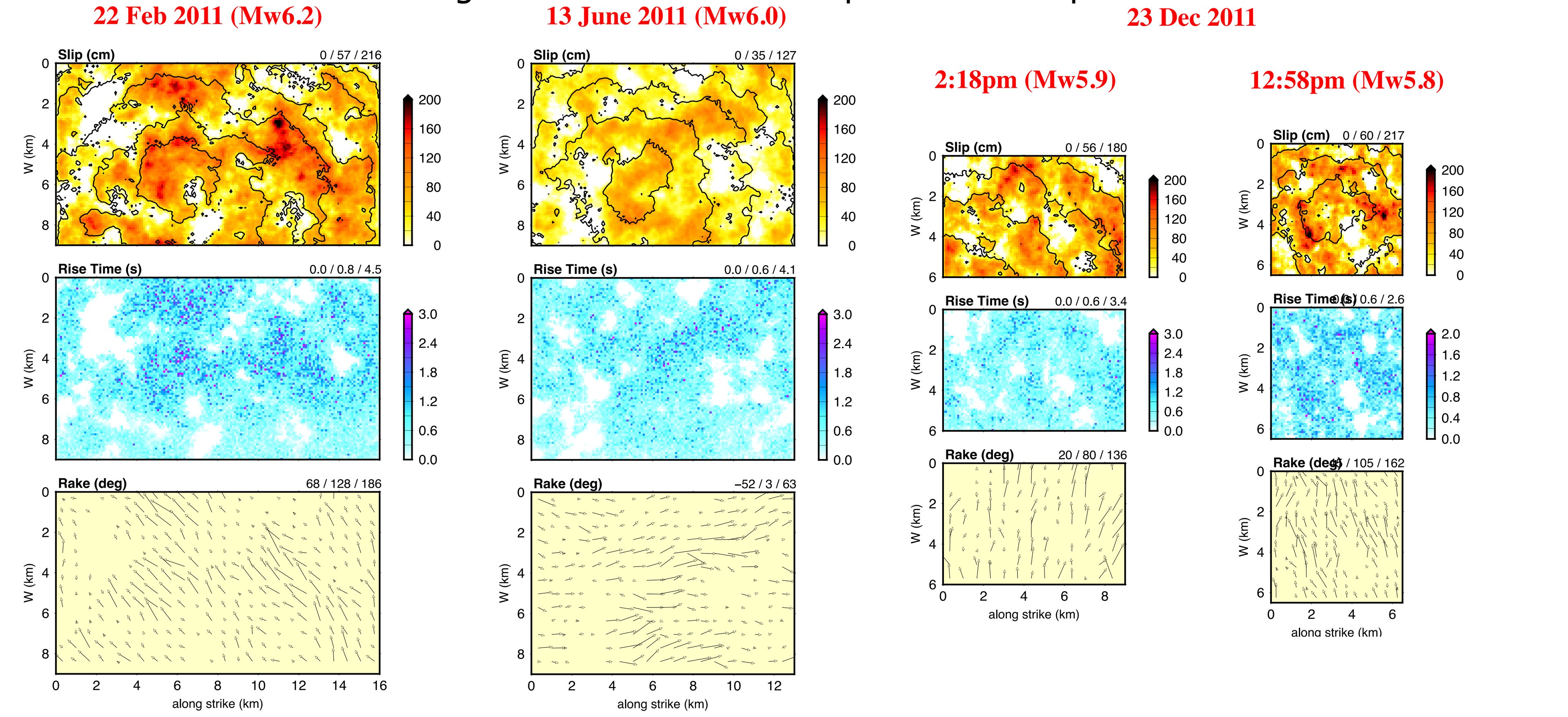


**Figure 2: Examples of simulated seismic sources using the GP14.3 rupture generator**

## 3. Velocity time series

Figure 3 illustrates comparisons between observed and simulated velocity time series at a set of 5 stations for the 4 Sept 2010 and 22 Feb 2011 earthquakes. Despite the simplicity of the 1D velocity model, it can be seen that at a resonable proportion of strong motions that amplitude and duration of ground motion is well captured. At several stations there is a clear under-prediction of surface waves amplitudes in the 2-5sec period range.

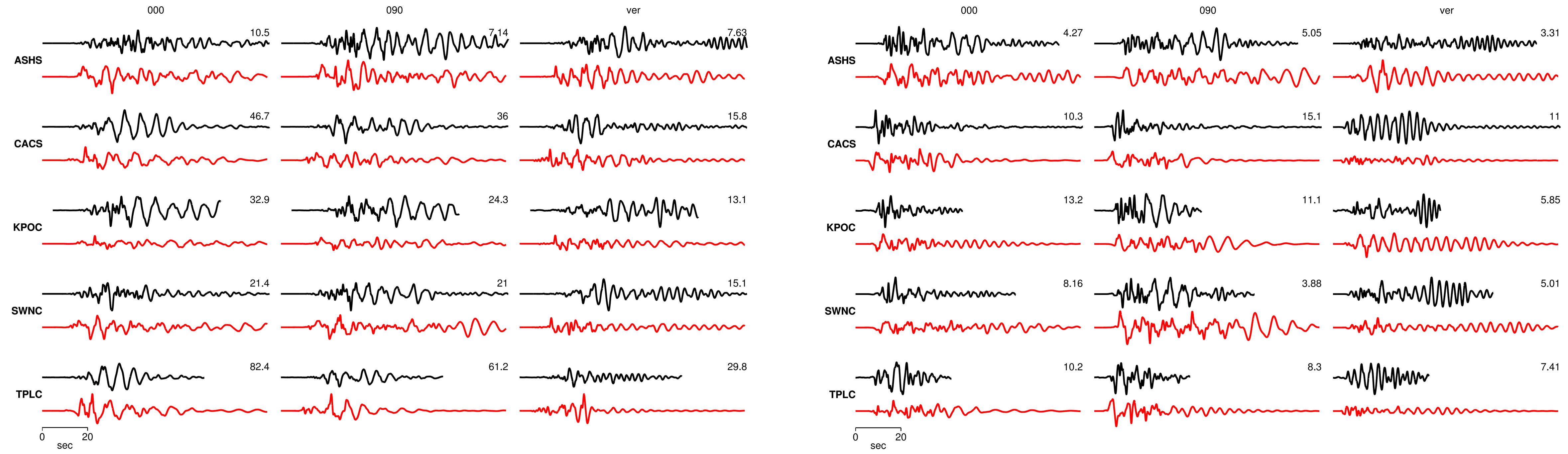


**Figure 3: Comparison of observed and predicted velocity time series: (a) 4 Sept 2010 (Mw7.1); and (b) 22 Feb 2011 (Mw6.2) earthquakes**

## 4. Intensity measures – PGV and low frequency SA

Figures 4 and 5 illustrate the simulated vs. observed PGA and response spectra (SA) intensity measures for the 4 Sept 2010 and 22 Feb 2011 earthquakes. Broadly speaking the PGV amplitudes are well predicted, although the under-prediction at larger Rrup values is evident in the 22 Feb 2011 event (and also apparent for other events not shown here). Figure 5 clearly illustrates a trend of decreasing ln(obs/sim) ratio as vibration period increases. We expect this is a result of the use of a 1D velocity model, as 3D basin-effects are expected to lead to an increase in simulated ground motion amplitudes for T<5s.

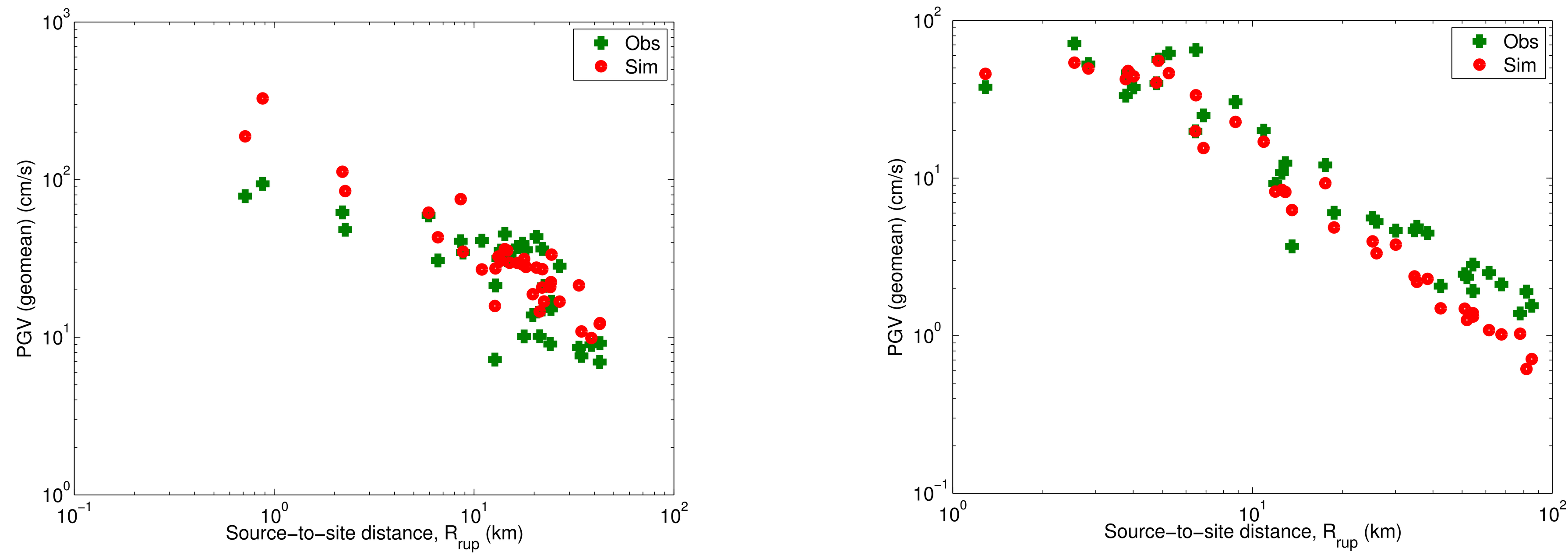


**Figure 4: Comparison of observed and predicted peak ground velocity: (a) 4 Sept 2010 (Mw7.1); and (b) 22 Feb 2011 (Mw6.2) earthquakes**

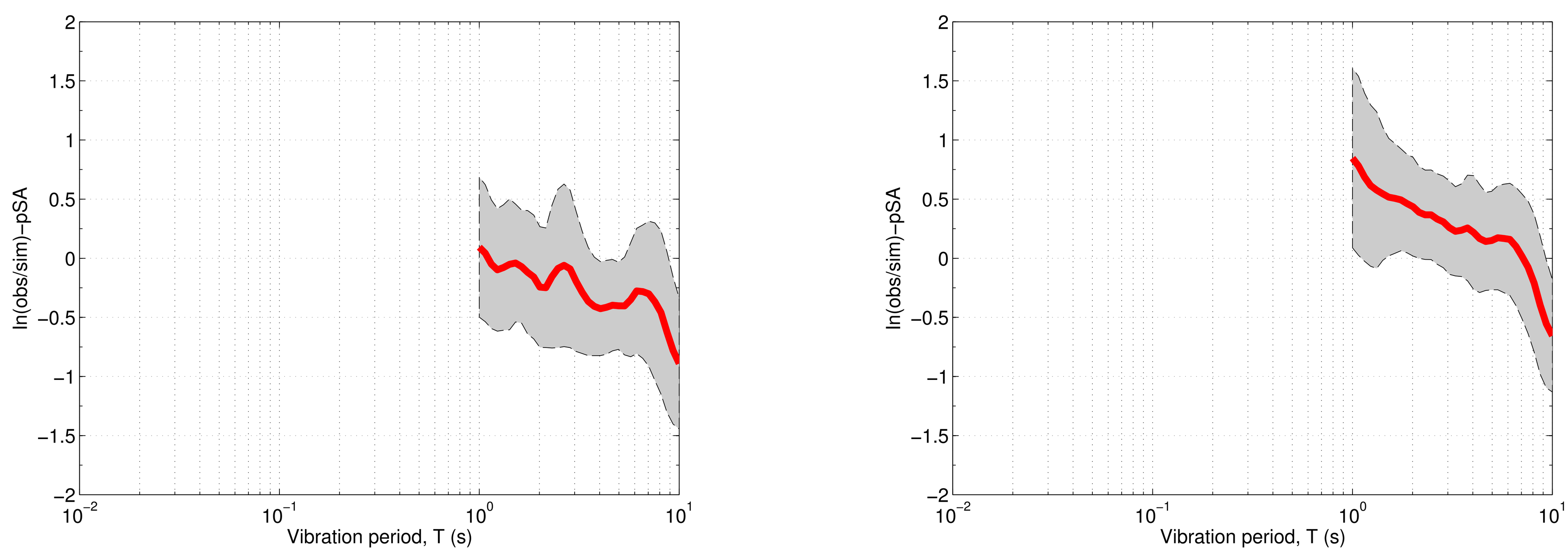


**Figure 5: Ratio of observed and simulated response spectra: (a) 4 Sept 2010 (Mw7.1); and 22 Feb 2011 (Mw6.2) earthquakes**