Evaluating the effectiveness of current 3-D earth models for use in rapid earthquake source characterisation

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Tsunami warning systems typically use only magnitude and location to identify potentially tsunamigenic earthquakes, but slip distribution may also have an influence if the fault rupture length is comparable to the tsunami propagation distance. For example, the M_W 9.3 Sumatra-Andaman earthquake in 2004 had a rupture length of >1200km, so that even coastlines 1000s of km distant from the source could experience tsunami heights sensitive to details of the fault slip.

Slip model inversions typically use waveform calculations that only approximately account for 3D structure, and these often involve a minimum distance for their application, delaying the time in which data can be used to produce a slip model. The purpose of this project is to explore whether this distance threshold can be reduced by using seismograms accurately calculated for 3D earth structure. We compared synthetic surface wave seismograms calculated for a point source representation of the 12 September, 2007 Mw=8.5 earthquake off Sumatra using (a) an asymptotic method accounting for 3D structure via a global phase velocity map, and (b) calculations using SPECFEM3D via the CIG portal. The calculated waveforms were compared with each other via cross-correlation (Figure 1.).

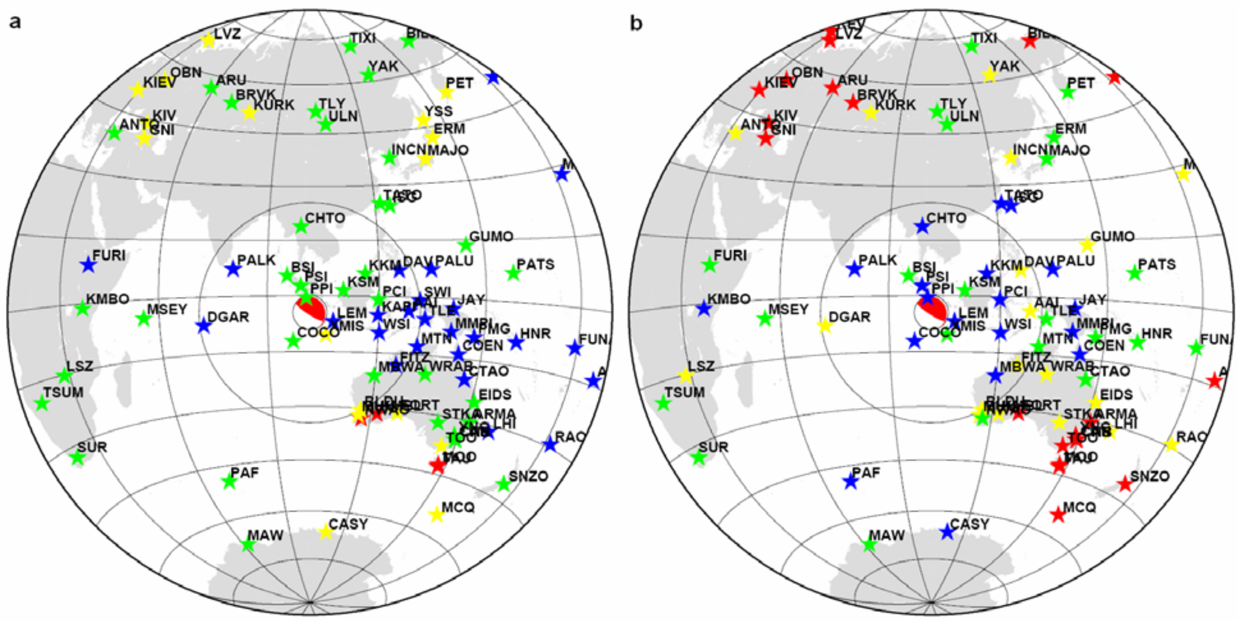

Figure 1. Results of cross correlating point source synthetics from 1D and 3D earth models for the Sumatra event, plotted according to: (a) correlation coefficients (vertical component) of <0.85 (red), 0.85 – 0.90 (yellow), 0.90 – 0.95 (green), 0.95 – 1.00 (blue), (b) correlation coefficients (transverse component).

The results, and similar ones for the 2007 Solomon Islands earthquake, show geographically coherent patterns of low and high correlation. Most of the correlations within the 30º distance threshold, where we expected our use of a phase velocity map might break down, are high. The regions of poorly correlated synthetics are generally at large distance form the source and exhibit some similarity for the two events studied – in particular, some correlations were poor in southern Australia, particularly for the transverse component synthetics.

The results suggest that the effects of 3D structure on the seismic waveform data used for finite fault rupture modelling should be further investigated, especially if its use is to be considered for the Australian stations important for the Australian Tsunami Warning System. Future work will focus on comparing synthetics computed for finite fault models with actual data.