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Using ground-motion simulations to estimate components of aleatory variability and the level of stress accumulation

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To relax the ergodic assumption in site-specific seismic hazard assessments requires estimates of various components of aleatory variability, including single-site sigma and, for the most sophisticated analyses, single-site-single-path sigma. In many cases the estimation of these quantities from observations is associated with considerable epistemic uncertainty because of the limited number of earthquakes recorded by a single station, and particularly from a single seismic source. Consequently, ground-motion simulations are an attractive alternative to an empirical approach because, in theory, as many waveforms as required to get a robust result can be generated.

In this study a large database of ground motions simulated for the Marmara Sea region of Turkey is created. Part of this database consists of ground velocities simulated at 70 stations from 156 magnitude 5 earthquakes. The peak ground velocities from these waveforms are extracted and analysed to recover estimates of components of ground-motion variability including: within-event single-site, site-to-site, path-to-path and single-site-single-path. The relationships between these components are similar to those obtained empirically. In addition, the influence of azimuthal spread on single-site components is investigated.

The second part of this database comprises simulated waveforms from large (magnitude ~7) earthquakes that are simulated using a dynamic rupture approach assuming different levels of accumulated stress. The peak ground velocities from these waveforms, which are strongly dependent on the assumed stress levels, are compared to predictions from recent ground motion prediction equations that are valid for the Marmara Sea. These comparisons help constrain the accumulated stress along the North Anatolian Fault in this region.