Spatial Correlation of Ground Motions From NGA Data

J. R. Evans[1] and J. W. Baker[2]

[1]U.S. Geological Survey, Menlo Park CA, jrevans@usgs.gov

[2]Stanford Univ., Stanford CA, bakerjw@stanford.edu

Spatial correlation of ground motions is of interest to a variety of stakeholders, for purposes such as estimating potential losses in a region from future earthquakes, or understanding the uncertainty in ShakeMaps. Results from a new study of these spatial correlations are presented here.

The NGA Project flatfile (http://peer.berkeley.edu/nga/flatfile.html) contains the a large set of data from strong motion accelerograms, including peak ground acceleration (PGA) and pseudo spectral velocity (PSV) at a wide range of periods. The inter-station intra-event spatial correlation of these data have not yet been evaluated, which we begin here. For all records in the NGA flatfile which contain sufficiently complete information and are part of an event with more than one recording, we computed intra-event inter-station spatial variance as a function of inter-station separation distance.

To assess spatial variability in observed ground motion intensities, ratios of observed intensities were computed for pairs of recordings. For two recordings from the same event, a ground motion prediction model (Boore et al. 1997) was used to adjust for differences in expected intensities due to differences in source-to-site distance and local site conditions. After adjusting the ratios, this large set of computed ratios was grouped into bins having comparable separation distances. The variance of logarithms of the ratios provides an estimate of the spatial correlation of ground motion intensity at a given distance. The approach was used to compute correlations for PGA and PSV with periods between 0.3 and 1.0 seconds.

The results are similar to previous binned-variance studies (Boore, 1997; Evans, 2001; and Hok and Wald, 2003). The variance of the ratios increases abruptly at small inter-station distances, indicating a decrease in spatial correlation, but are nearly constant (asymptotic) at large distances. The functional form of the results can be approximately fit by an exponential function. All authors show binned variances rising rapidly from zero at 0-km distance to about 60% of their asymptotic variance by just 1 km (σ~0.15 or a 1-σ multiplicative error factor of ~1.5). Asymptotic levels at 60 km are from about 0.27 to 0.29 (1-σ multiplicative errors of ~2). However, there are some differences between the previous and current binned-variance studies. While our distal behavior similar to the earlier studies for PSV, PGA continues a slow ramp a bit above the previous asymptote. This ramp may be caused by increasing sensitivity to radiation patterns, directivity, and systematic errors in ground-motion models when stations are very far from one another. From 0 to 20 km, PGA and PSV are both lower in the current study than in previous studies by about 0.2 to 0.4 (at 20 km, 1-σ multiplicative errors of 2.0 *vs* 1.8 or 1.9 *vs* 1.8).

The results from this work indicate that spatial correlation of ground motions is an important factor to consider for regional loss estimation and ShakeMap interpolation at scales between 0 and 20 km.