Investigating Physical Explanations for Path Effects to Reduce Uncertainty in Ground Motion Prediction Equations

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Reducing uncertainty in ground-motion prediction equations (GMPEs) is important for constructing reliable seismic hazard maps, as well as for the safe and cost-efficient design of critical structures. One way to reduce uncertainty is to move from a “global,” average GMPE to a region-specific GMPE. Including information regarding physical or seismological processes into GMPEs may allow a model to be tailored to a particular region, thereby reclassifying some of the aleatory uncertainty as knowable features of the region. We present work on our approach to include path-specific information into GMPEs, and demonstrate the feasibility of this method for future application in GMPEs.

To do this, we employ a database of ~100,000 recordings of earthquakes recorded on four seismic networks including the ANZA network. The ANZA network has been in operation since 1981, resulting in redundancy in source-to-station paths. To obtain a regional GMPE for the Anza region, we inverted the recordings with both simple and mixed effects regressions, and used this GMPE to decompose the residuals between observed and predicted ground motions into source, site and path terms. For each recording, we computed raypaths with the regional tomographic model of Fang et al. (2016). We sampled regional seismic velocity and attenuation models along these raypaths and formed indices representative of the variation in material properties along each recording’s raypath. We then compared these indices with the path terms from our residual decomposition, and find a correlation between the path integral of the gradient of velocity and the path term. We present analyses that may be used to further investigate the effects of material properties on the path effect, and how these relationships may be incorporated into GMPEs. Finally, we demonstrate the resulting reduction in uncertainty from incorporation of this path-specific knowledge, which can result in reduced estimated hazard in certain cases.

Keywords: Path Effect, GMPE, Seismic hazard , ANZA network

