Incorporating long-period (T>1 s) ground motions from 3D simulations into the U.S. National Seismic Hazard Model

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With the introduction of additional periods into the design spectrum of U.S. building codes, future U.S. National Seismic Hazard Models (NSHMs) must consider the effects of longer period (T>1 s) earthquake ground motions. These longer period effects are highly sensitive to the presence of sedimentary basins, which are included in most current ground motion models (GMMs) used in the western U.S. through proxy parameters for sediment thickness (i.e., depths to 1 and 2.5 km/s horizons, Z1 and Z2.5, respectively). Observations and 3D earthquake simulations, however, indicate that the ground motions at sites within sedimentary basins are often far more complicated than can be predicted by a single explanatory variable.

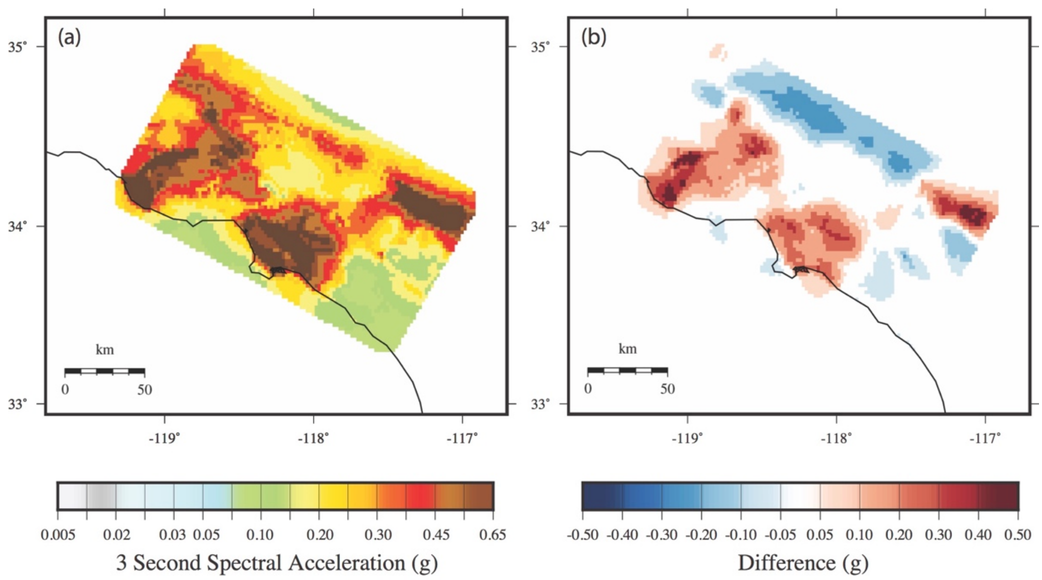

Figure 1: Seismic hazard sensitivity testing from the incorporation of basin amplifications from 3D simulations into U.S. National Seismic Hazard Model. (a) PSA, T=3 s, with 2 percent probability of exceedance in 50 years, computed from the empirical-simulation-based ground motion model. (b) Difference in PSA, T=3 s, between the empirical-simulation-based ground motion model and the empirical ground motion model.

We present initial results from the incorporation of long-period (T>1 s) basin effects into the NSHM using basin amplification products derived from the Southern California Earthquake Center (SCEC) CyberShake simulations. The current investigation focuses only on the basin amplifications and attempt to minimize the effects of the absolute ground motion level, the finite-source features, and the path effects from the 3D simulations. This presentation focuses on integration of basin amplifications from 3D simulations in southern California with the empirical GMM from Boore et al. (2014), which is part of the NGA-West-2 project. The resulting ground motion model is an empirical-simulation-based hybrid, which represents empirically constrained ground motion levels, magnitude, and distance scaling, but with laterally varying and period-dependent basin amplifications specified by the 3D simulations.

To validate the joint empirical-simulation-based GMM, we compare the site amplifications predicted from the model with a previously compiled database of amplifications computed from small- to moderate-sized earthquakes in the southern California region (Thompson and Wald, 2016). Comparison of the observed and predicted amplifications indicates laterally varying reductions in misfit, with good average fits at 2 s period and slightly diminished fits at longer periods.

We assess the effect of modifying the median ground motion predictions by computing probabilistic seismic hazard curves for sites within the CyberShake simulation domain using the full seismic source characterization of the 2014 U.S. National Seismic Hazard Model Hazard (Petersen et al., 2015) and the empirical-simulation ground motion model. We currently use the ground motion (aleatory) variability from the Boore et al. (2014) model for the probabilistic ground motions. Seismic hazard maps at multiple periods (T=2, 3, 5 s), and with 2 percent probability of exceedance in 50 years, are compared with similar calculations using the empirical ground motion model, only. The empirical GMPEs use the laterally varying values of Vs30, Z1, and Z2.5 from the SCEC Community Velocity Model S4.26 (Lee et al., 2014) and represent best-available regional information about the seismic velocity structure. The hazard calculations indicate that the resulting probabilistic ground motions can be more than 50 percent higher than what is predicted by the empirical GMMs. These effects are greatest in the deepest parts of the Los Angeles and Ventura basins and indicate that hazard in deep basins of southern California may be higher than current forecasts using empirical GMPEs indicate.