A SCEC CyberShake Physics-Based Probabilistic Seismic Hazard Model for California

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The Southern California Earthquake Center (SCEC) has developed CyberShake, a simulation platform that performs physics-based probabilistic seismic hazard analysis (PSHA) using 3D deterministic wave propagation simulations. The CyberShake PSHA calculations begin by simulating time- and space-varying Strain Green Tensors. An earthquake rupture forecast (ERF) is then extended by varying hypocenters and slip on finite faults, generating hundreds of thousands of events per site of interest. Seismic reciprocity is used to calculate synthetic seismograms for each event at each site, which are processed to obtain intensity measures (IMs) such as RotD50 spectral acceleration. These IMs are combined with ERF probabilities to produce hazard curves. PSHA results from hundreds of locations across a region are interpolated to produce hazard maps.

In 2018, SCEC initiated CyberShake Study 18.8, whose goal is to produce a physics-based PSHA hazard model for a large Northern California region that includes the San Francisco Bay Area. PSHA calculations up to 1 Hz for 869 locations in Central and Northern California were performed on the NCSA Blue Waters and ORNL Titan supercomputers. To support simulation volumes that included most of California, we tiled three separate 3D community velocity models (SCEC-CCA-06, USGS Bay Area 08.3.0, and SCEC-CVM-S4.26.M01) into a composite statewide model and applied smoothing around interfaces to minimize unrealistic reflections and refractions. To improve representation of near-surface velocity structure in the tomographically-derived models, we inserted a geotechnical layer (GTL) in the top 300 meters by applying the Ely (2010) method, assuming Vs30 values from the Wills (2015) map.

This computational effort enabled the calculation of a continuous physics-based PSHA map for a large portion of California, obtained by combining results from multiple CyberShake studies.