High-Performance Computing for Physics-Based Seismic Hazard Analysis

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Current applications of probabilistic seismic hazard analysis (PSHA) employ empirical attenuation relationships to model the propagation and attenuation of seismic waves between the source and receiver, but these relationships cannot properly account for 3D structural variations (e.g., basin effects), rupture directivity, and source complexities. A goal of the Southern California Earthquake Center (SCEC) is to use physics-based earthquake simulations to improve PSHA. For this purpose, SCEC is developing a Community Modeling Environment (www.scec.org/CME) that can execute PSHA computational pathways and manage data volumes using the high-performance computing, storage, and networking resources of the national TeraGrid (www.teragrid.org). The computational platforms of the CME vertically integrate hardware, software, and technical expertise (wetware), and they employ advanced workflow management tools to compute and store the large suites of simulations needed to achieve the science objectives. The main objectives are to extend deterministic simulations of strong ground motions above 1 Hz for investigating the upper frequency limit of deterministic ground-motion prediction; improve the resolution of dynamic rupture simulations by an order of magnitude for investigating the effects of realistic friction laws, geologic heterogeneity, and near-fault stress states on seismic radiation; validate and improve the Southern California structural models using full 3D waveform tomography; and compute physics-based PSHA maps and validate them using seismic and paleoseismic data. Specific results that will be presented include ground motion scenarios for large earthquakes in Southern California, full 3D waveform tomography for the Los Angeles region, and simulation-based hazard curves calculated from the uniform California earthquake rupture forecast (UCERF2) of the 2007 Working Group on California Earthquake Probabilities. Plans to achieve the petascale computational capability required for full physics-based PSHA mapping will be discussed.