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Earthquake scaling and near-source ground-motions from multi-cycle earthquake simulation (with heterogeneity in rate-and-state friction)

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This study analyzes catalogs of moderate-to-large earthquakes obtained in 3-D elastic continuous fault modeling governed by rate- and state-dependent friction. As a proxy for geometrical irregularities of the fault, we parameterize the frictional response of the system by including spatial distributions of the critical slip distance L. Fault zones at different evolutionarys stages are then characterized by variable range-of-size-scales present in the L-distibution.

Our earthquake-cycle simulations return large sets of model quakes whose source parameters show remarkable similarities when compared against observed earthquake source parameters. We investigate earthquake scaling relations on bulk source properties, and examine the characteristics of distributed slip on the fault plane. In particular, slip of large events (M > 6.5) is highly variable on the fault, while ruptures tend to start at the edges of asperities (regions of large slip), consistent with imaged finite-source rupture models.

Our investigations also show that the catalog of simulated source models provides a useful resource to generate physically self-consistent scenario earthquakes for near-source ground-motion prediction. Combined with the pseudo-dynamic source characterization to model the temporal rupture evolution, we use our event catalog to calculate near-field seismograms for a suite of scenario earthquakes. Using a heterogeneity-spectrum characterization based on the fault-segmentation data from the North Anatolian Fault, we generate source models for simulation-based ground-shaking maps in the Marmara Region near Istanbul. The large repository of physics-based near-source synthetics helps to investigate ground-motion variability for earthquake-engineering purposes, but is also usful for seismic hazard assessment.