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Slip and Stress Heterogeneity from Finite-Fault Earthquake Source Inversion

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Finite-fault earthquake source inversions are routinely conducted today to estimate the spatio-temporal rupture evolution using seismic and/or geodetic data. Although the uncertainties in these rupture models are still poorly understood and are rarely quantified, the concept of slip and stress heterogeneity is now well established based on such source images. The inversion results reveal large spatial variability of slip during the rupture, which immediately translates into strong heterogeneity of stress drop over the fault plane. Characterizing and quantifying slip and stress heterogeneity of earthquakes are crucial to better understand (and model) the dynamic rupture process, which in turn allows for more reliable simulation of near-source ground motions. However, the evolution of stress heterogeneity on the fault (or fault systems) depends on a variety of seismotectonic processes that act over broad space-time scales, but for which we only have limited data and testable models.

In this presentation I will review slip and stress heterogeneity as seen from published finite-fault rupture models (http://equake-rc.info/SRCMOD), discuss approaches to quantify and parameterize slip variability, and show effects of stress heterogeneity on the dynamics of earthquake ruptures and the associated near-field radiation. I will also review scaling relations and statistics of slip and stress-drop “asperities”, and their implication for earthquake mechanics. The problem of uncertainty quantification in earthquake source inversion – and its bearing on quantifying slip (stress) heterogeneity – will be discussed as well. Ultimately, an improved understanding of the properties of stress heterogeneity should lead to predictive and testable models, based on geophysical observables, that may allow us to anticipate the range of likely rupture behavior for future earthquakes, and hence their expected shaking levels.