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Interaction of dynamic rupture with small-scale heterogeneities

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Broadband ground motion simulations, with frequencies up to 10Hz, are important for engineering purposes, in particular for seismic hazard assessment for critical facilities. One problem in such simulations is the generation of high frequency radiation emitted during the dynamic rupture process. Ad-hoc kinematic rupture characterizations can be tweaked through empirical models to radiate over the desired frequency range, but their physical consistency remains questionable. In contrast, for physically self-consistent dynamic rupture modeling, controlled by friction, material parameters and the adopted physical laws, the mechanism that may lead to appropriate high-frequency radiation require heterogeneity in friction, stress, or fault geometry (or even all three quantities) at unknown but small length scales.

Dunham at al. (2011) studied dynamic rupture propagation on rough faults in 2D, and described how fault roughness excites high-frequency radiation. In our study, we focus on the interaction of the dynamic rupture with small-scale heterogeneities on planar faults in 3D. We study effects of the interaction of dynamic rupture with 1) small-scale heterogeneities in the medium (that is, randomized 3D wave speed and density variations), and 2) small-scale heterogeneities in the frictional parameters. Our numerical results show significant variations in rupture velocity or peak slip velocity if small-scale heterogeneities are present. This indicates that the dynamic rupture is sensitive to both types of spatial inhomogeneity. At the same time we observe that the resulting near-source seismic wave fields are not very sensitive to these rupture variations, indicating that wavefront healing effects may "simplify" the complex seismic radiation once the waves propagated several wave-lengths away from the fault.