Rupture Dynamics and Ground Motion from the Salt Lake City Segment of the Wasatch Fault Zone
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We study dynamic rupture and ground motion from dip-slip faults in regions that have high-seismic hazard, such as the Wasatch fault zone, Utah. Previous numerical simulations have modeled deterministic ground motion along segments of this fault in the heavily populated regions near Salt Lake City but were restricted to low frequencies (~1 Hz). We seek to better understand the rupture process and assess broadband ground motions and variability from the Wasatch Fault Zone by extending deterministic ground motion prediction to higher frequencies (up to ~5 Hz). We perform simulations along a dipping normal fault (40 x 20 km along strike and width, respectively) with characteristics derived from geologic observations to generate a suite of ruptures > Mw 6.5. This approach utilizes dynamic simulations (fully physics-based models, where the initial stress drop and friction law are imposed) using a summation by parts (SBP) method. The simulations include rough-fault topography following a self-similar fractal distribution (over length scales from ~100 m to the size of the fault) in addition to off-fault plasticity. Energy losses from heat and other mechanisms, modeled as anelastic attenuation, are also included, as well as free-surface topography, which can significantly affect ground motion patterns. We compare the effect of material structure and both rate and state and slip-weakening friction laws have on rupture propagation. The simulations show reduced slip and moment release in the near surface with the inclusion of plasticity, better agreeing with observations of shallow slip deficit. Long-wavelength fault geometry imparts a non-uniform stress distribution along both dip and strike, influencing the preferred rupture direction and hypocenter location, potentially important for seismic hazard estimation.