TITLE: Dynamic rupture on faults with heterogeneous strength due to non-uniform normal stress: The effect of stress redistribution by prior events

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ABSTRACT In dynamic rupture simulations, spatial distributions of fault strength and initial shear stress both strongly influence the results but are often assigned independently. However, simulations of multiple earthquake cycles show that the two distributions are related due to prior slip (e.g., Lapusta and Liu, JGR, 2009). Accounting for stress redistribution due to prior slip may be crucial for determining the true effect of fault heterogeneity on rupture propagation and hence on ground motion.

We investigate the long-term behaviors of faults with heterogeneous fault strength due to spatially variable and time-independent effective normal stress, which could relate to heterogeneity of fault property (compact patch) or approximate the stress state of nonplanar fault (wavy or self-similar profile). In our models, a planar fault segment governed by Dieterich-Ruina rate-and-state friction law undergoes both seismic and aseismic slip under slow tectonic loading. We simulate multiple earthquake cycles while accounting for inertial effects during seismic events using the approach of Lapusta and Liu (2009). In many of these scenarios, initial shear stress are assigned uniformly over most of the fault, as often done in simulations of single dynamic events in the presence of heterogeneity of fault strength.

In each simulation, comparison between the first simulated earthquake and subsequent events shows that shear stress redistribution over time partially compensates for the heterogeneity in fault strength and reaches equilibrium state over many earthquake cycles, showing an evolving and yet persistent mismatch between fault strength and stress. Rupture patterns, including rupture speed, slip rate and final slip, change with the evolution of such mismatch and develop into long-term behavior depending on the degree of fault heterogeneity. We hope to study and quantify the evolution of this mismatch and its dependence on fault heterogeneity. This will help provide physical constraints on initial distributions of shear stress consistent with assumed fault strength for earthquake simulations on a well-developed fault. In addition, we incorporate thermal pressurization into the simulation and study the effect of dynamic weakening on such stress redistribution.