Unified description of fast and slow earthquakes using velocity strengthening patches

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In a prevalent view, seismicity in subduction zones is governed by the distribution of the frictional properties of the plate interface. Regions with velocity-weakening (VW) friction generate earthquakes, whereas velocity-strengthening (VS) regions creep aseismically. Although most models consider isolated VW regions (patches) from the idea of asperities (e.g. Dublanchet et al., 2013), isolated VS patches also would exist given the frictional properties on faults are inferred to be complex and hierarchical. Therefore, the role of VS patches is to be studied.

Here we perform 3-D numerical simulation of the seismic cycle of faults governed by the rate and state friction law with the aging law. We distribute randomly circular VS patches on a VW background. We mainly focus on the effect of the ratio of VS and VW areas.

In our preliminary simulation, we identified two important effects. First, the VS patches act as the “stability barriers” during dynamic rupture propagation, which makes the rupture process more complicated than a single propagating crack. Rupture decelerates by encountering a stability barrier, followed by reacceleration due to overcoming the barrier. Such a process gives rise to multiple rupture fronts in the slipping area.

Second, dynamic rupture is inhibited by increasing the number of VS patches, and the fault slips aseismically with strong fluctuation in slip velocity. This is because there are no enough VW regions to accelerate the slip to dynamic rupture. Although a similar mechanism for slow earthquakes is proposed by Skarbek et al. (2012) and Yabe & Ide (2017), our 3-D modeling enables detailed studies on the spatiotemporal evolution of slip. In the presentation, we further discuss our results in the context of the dynamic scaling of rupture growth and the phenomenological law of slow earthquakes.

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