Slip Patterns on Heterogeneous Fault Interfaces Governed by Rate and State Friction Model

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Observations show that both seismic and aseismic fault slip on SAF display significant variability. Even repeating sequences exhibit significant variations in their moment and recurrence time. Similarly, the creeping segment of the SAF may be accumulating its slip unsteadily, as suggested by surface creep meters and inversions of GPS data. These behaviors may be pointing to heterogeneity of fault properties and motivate us to explore the consequences of fault heterogeneity on the resulting slip patterns through simulations. We focus on rate-and-state interfaces that mix seismogenic velocity-weakening (VW) and velocity-strengthening (VS) patches. Both slow and rapid slip events could occur on such interfaces, depending on the fractional area, connectivity, strength contrast of VW patches with respect to the surrounding VS region and the size of the VW patches with respect to the nucleation size.

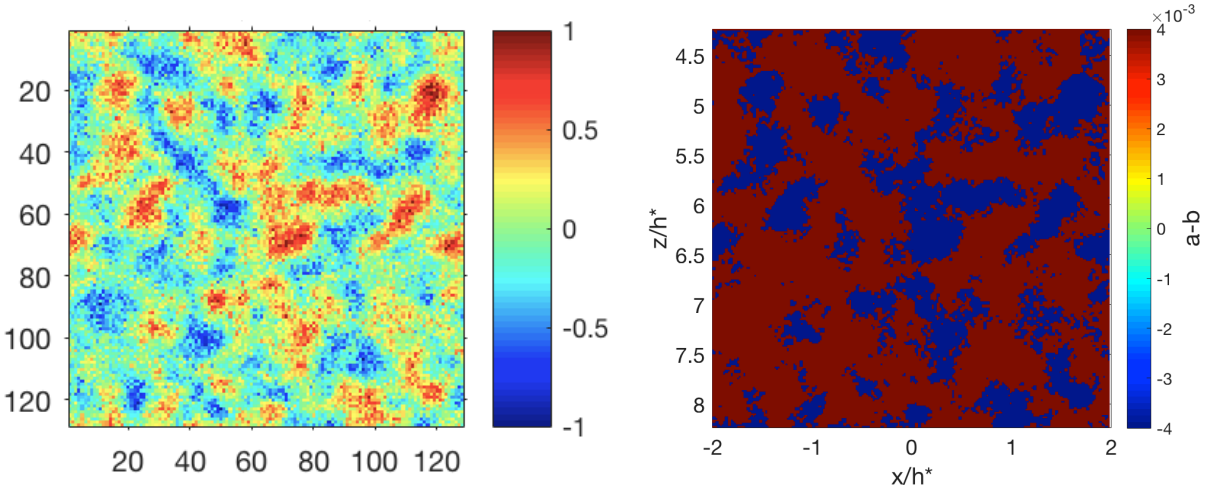

Figure 1: (a) Example of a correlated 2D fractal distribution over a domain spanning 128x128 cells. (b) Rate and state frictional property distribution produced via thresholding.

We study a variety of distributions of rate-and-state frictional parameters, starting with simple patterns with well-defined length scales, like checkerboard patterns of varying heterogeneity, to more realistic, fractal-like distributions (Figure 1a,b), using 3D numerical simulations of a 2D fault embedded in a homogeneous elastic space, with an efficient and rigorous numerical procedure for elastodynamic analysis of earthquake sequences on slowly loaded faults [Lapusta and Liu, JGR, 2009]. We observe the complexities in slip patterns emerging upon the gradual variation of the underlying frictional property distribution. Overall, our goal is to understand how local heterogeneities in friction properties translate into large-scale behaviors, both in terms of stability and slip patterns.