Fault Roughness Induces Longer Migration of Aseismic Slip Pulse on the Earthquake Nucleation Process

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It has been known that natural faults possess rough profiles with a wide range of spatial scales, which can be described as self-affine fractal with its Hurst exponent being 0.5-1.0 (Candela et al. [2012]). The roughness may play a vital role in earthquake dynamics. Here we examine the effect of fault roughness in the earthquake nucleation process using the rate and state friction law with the slip evolution law. Our numerical results show that the migration distance of aseismic slip pulse during the nucleation process increases with the extent of roughness (Figure 1). The effect of fault roughness on the aseismic slip pulse migration is described by a single parameter known as the roughness drag (Fang & Dunham [2013])

$$\tau^{drag} = \frac{(2\pi)^3 H}{3-2H} G\delta \frac{b_r^2}{\lambda_{min}^{3-2H}},$$

where b_r is the amplitude, λ_{min} is the minimum wavelength, H is the Hurst exponent, G is the shear modulus and δ is the slip amount. We also show that aseismic slip pulse cannot accelerate to dynamic rupture and ceases spontaneously if the roughness drag exceeds the static stress drop. This might be a possible mechanism for slow slip events. We further discuss the physical entity of the minimum wavelength of the roughness profile that causes a significant effect on the slip behavior.

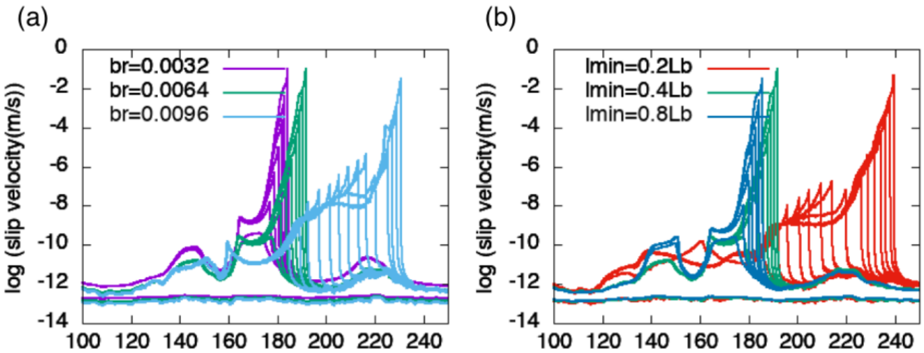

Figure 1. Examples of slip velocity distributions during nucleation. *br* and *lmin* mean the amplitude and minimum wavelength of roughness, respectively.