Quantitative relationship between aseismic slip propagation speed and frictional properties

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Recent observations show evidence of propagation of postseismic slip, whose propagation speed may contain information about the mechanical properties of faults. Here, we develop a new analytical relationship between the propagation speed of aseismic slip transients and fault frictional properties, modeled by a rate- and state-dependent friction law. The relationship explains the propagation speed of afterslip in 3-D numerical simulations to first order. Based on this relationship, we identify systematic dependencies of afterslip propagation speed on effective normal stress σ and frictional properties (the coefficients *a* and *a-b* which quantify the instantaneous and the steady-state velocity-dependence of friction, respectively, and the characteristic slip distance d_c of fault state evolution). Lower values of the parameter $A=a\sigma$ cause faster propagation in areas where the passage of the postseismic slip front induces large shear stress changes $\Delta\tau$ compared to *A*, which are typically located near the mainshock rupture. In areas where $\Delta\tau/A$ is small, typically more distant from the mainshock, afterslip propagation speed is more sensitive to $(a-b)\sigma$. The propagation speed is proportional to initial slip velocity and inversely proportional to d_c. The relationship developed here should be useful to constrain the frictional properties of faults based on observed propagation speeds, independently of rock laboratory experiments, which can then be used in predictive numerical simulations of aseismic slip phenomena.

Keywords: rate- and state-dependent friction, effective normal stress, stress perturbation