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Quantitative relationship between aseismic slip propagation speed and frictional properties

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Recent observations show evidence of the propagation of slow slip transients, including postseismic slip as a slow earthquake family, and expanding aftershock areas. Here, we develop a new analytical relationship between the propagation speed of aseismic slip transients and frictional properties of the fault, modeled by a rate- and state-dependent friction law. The relationship explains the propagation speed of slow slip in 3-D numerical simulations to first order, except near the earth's surface. Based on this relationship, we identify systematic dependencies of slow slip 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 dc of fault state evolution). Lower values of the parameter A=aσ cause faster propagation in areas where the passage of the postseismic slip front induces large shear stress changes $\Delta\tau$ compared to A. In areas where $\Delta\tau$/A is small, slow-slip propagation speed is more sensitive to (a-b)σ. The propagation speed is inversely proportional to dc. 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.