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Quantitative relationship between slow slip propagation speed and frictional properties

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Motivated by recent observations of the migration of slow slip, such as postseismic slip and slow earthquakes, the propagation of tremor and very low-frequency earthquakes, and the expansion of aftershock areas, we develop a new analytical relationship between the migration speed of aseismic slip transients and frictional properties of the fault, modeled by a rate- and state-dependent friction law. The relationship explains the migration speed of slow slip in 3-D numerical model simulations to first order, except near the earth's surface. Based on this relationship, we suggest that lower values of the frictional parameter a-b (which quantifies the velocity-dependence of steady-state friction) and of the effective normal stress σ cause faster propagation for small amount of shear stress loading due to the passage of postseismic slip, while reducing the frictional parameter a (which quantifies the instantaneous velocity-dependence of friction) is more effective at accelerating slow-slip propagation for large amount of shear stress loading. The characteristic slip distance dc is inversely proportional to the migration speed. This relationship should be useful to constrain the frictional properties of faults based on observed migration speeds, independent of rock laboratory experiments, which can then be used in predictive numerical simulations of slow slip phenomena.