RUPTURE DYNAMICS AT THE INTERFACE BETWEEN A COMPLIANT LAYER AND STIFFER UNDERLYING HALF-SPACE

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We examined the sliding dynamics of a frictional interface between elastic solids. Our objective is to quantify sliding stability and rupture styles for a thin layer over half-space geometry with rate-and-state friction. This arises in many contexts, ranging from shallowing dipping subduction zones to ice streams (in particular, the Whillans Ice Plain (WIP), which advances via slow slip events). Specifically, we study the influence of layer thickness (H) on conditions for steady sliding vs. slow slip cycles vs. fast slip cycles, using both linear stability analysis and earthquake cycle simulations on a 2D anti-plane shear sliding of a compliant layer over a stiffer half-space.

Steady sliding with velocity-weakening rate-and-state friction is linearly unstable above a critical wavelength (Lc). For thin layers, such as the WIP, Lc is proportional to the square-root of H. But, as H is increased, Lc becomes independent of H and approaches to the well-known solution for sliding between two half-spaces.

The stability analysis provides insight into more complex situations, such as the nonlinear earthquake cycle dynamics of a nominally velocity-strengthening interface containing a velocity-weakening patch of width W. For small W, the patch slides steadily with the rest of the interface, and for large W the patch fails in fast earthquakes. Between these two limits, the patch exhibits slow slip events. We use our cycle simulations to map sliding style as a function of H and W, finding a trend that is consistent with the stability analysis. Overall this study demonstrates how the decreasing elastic stiffness associated with small layer thickness reduces the critical wavelength for instability, with important implications for rupture dynamics in thin layer geometries.