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Slip - weakening behavior during the propagation of dynamic ruptures obeying rate - and state - dependent friction laws

We model the traction evolution and shear stress degradation near the tip of a propagating dynamic rupture by solving the elasto - dynamic equation for a 2 - D in - plane fault obeying rate - and state - dependent friction laws and adopting a Finite Difference numerical method. Modeling results clearly show that our dynamic solution implies a slip dependence of fault friction, as previously observed either in laboratory experiments or in theoretical models. However, the resulting equivalent slip-weakening distance (d_0^{eq}) is different from the length scale parameter (L) characteristic of the rate and state formulation. We demonstrate that the state variable evolution controls the slip acceleration and the absorbed fracture energy. The adopted constitutive parameters a, b and L affect the traction dependence on slip. We present the results of several numerical simulations, performed after a careful control of the available resolution of the cohesive zone, to unravel the dependence of the equivalent slip - weakening distance on the constitutive parameters. We also propose analytical relations to interpret our numerical results, which point out that the traction evolution within the cohesive zone cannot be prescribed *a priori* in the framework of rate- and state- constitutive laws. In particular, the yield stress and the kinetic friction level depend on particular slip velocity values characteristic of specific stages of the breakdown process. Finally, we discuss how the adopted evolution law affects the slip - weakening curve by comparing the simulations performed with a slip and a slowness law. The former yields smaller equivalent slip - weakening distances than the latter.