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PHYSICAL INTERPRETATION OF THE BREAKDOWN PROCESS DURING THE PROPAGATION OF A DYNAMIC CRACK GOVERNED BY RATE AND STATE FRICTION

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We study the dynamic traction and the slip velocity evolution within the cohesive zone during the propagation of a spontaneous rupture using rate and state dependent constitutive laws. We model the shear stress degradation near the tip of a propagating dynamic rupture (i.e. the breakdown zone) by solving the elasto-dynamic equation for 2-D (in-plane) and 3-D faults adopting Finite Difference numerical approaches. We investigate the behavior of total dynamic traction as a function of slip (slip-weakening curves) and slip velocity (i.e., phase diagrams) and we propose a scaling law between the two different length-scale parameters (d_o and L). We compare the time histories of slip velocity, state variable and total dynamic traction to investigate the temporal evolution of slip acceleration and stress drop during the breakdown time. We show that the adopted constitutive parameters a, b and L affect the traction dependence on slip. We present the results of several numerical simulations to unravel the dependence of the equivalent slip weakening distance on the constitutive parameters, and we propose analytical relations to interpret our numerical results. Our simulations show that the state variable evolution controls the slip acceleration and the slip weakening behavior, and therefore the absorbed fracture energy. We test different evolution laws to investigate slip duration and the healing mechanisms. We find that the slowness or slip laws do not yield fast restrengthening or self-healing. Self-healing rupture mode, yielding to short slip durations, has been obtained for homogeneous faults by modifying the evolution law introducing a fast restrengthening of dynamic traction immediately after the weakening phase. In this study, we discuss how the direct effect of friction and the friction behavior at high slip rates affect the weakening and healing mechanisms.

Our modeling results aim to contribute to the physical interpretation of the breakdown process.