M. Cocco, A. Bizzarri, E. Tinti

Physical interpretation of the breakdown process using a rate - and state - dependent friction law

We study the dynamic traction and the slip velocity evolution within the cohesive zone during the propagation of a dynamic rupture using rate and state dependent constitutive laws. We solve the elasto - dynamic equation for a 2 - D in - plane crack using a Finite Difference algorithm. We show that rate and state constitutive laws allow a quantitative description of the dynamic rupture growth. We confirm the findings of previous study that slip weakening is a characteristic behavior of rate and state friction. Our simulations show that the state variable evolution controls the slip acceleration and the slip weakening behavior. These modeling results help understanding the physical interpretation of the breakdown process and the weakening mechanisms. 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. Because the adopted analytical expression for the state variable evolution controls the slip velocity time histories, we test different evolution laws to investigate slip duration and the healing mechanisms. We show that the classic slowness or slip laws do not yield fast re - strengthening or self - healing, although they appropriately describe rupture initiation, propagation and the long - term re - strengthening during the interseismic period. Self-healing rupture mode, yielding to short slip durations, has been obtained for homogeneous faults by modifying the evolution law introducing a fast re - strengthening 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.