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Earthquake nucleation and propagation on rate and state faults: single versus two state variables formulation and evolution by Kato–Tullis law

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ABSTRACT

Earthquake nucleation and propagation has been studied extensively within the framework of single rate and state formulation with either the aging or the slip evolution laws. In this presentation we report on our ongoing work on simulating earthquake cycles on faults described by the two state variables formulation of the rate and state law. Beside the slip and aging evolution law we also consider the composite state law proposed by Kato and Tullis [2001]. The two state formulation has been found to provide a closer description of the observed relaxations following jumps over a wide range of sliding speeds. Gu and Rice (1984) have also shown through a quasi-static stability analysis that the two state formulation may lead to chaotic vibrations for a range of wavenumbers and slip rates. Meanwhile, compared to the slip and aging laws, the composite law matches better the observations in both the slide-hold-slide experiments and the velocity stepping tests. We use the Spectral Boundary Integral Equation method [Lapusta et al., 2000] to simulate ruptures on 2D antiplane faults embedded in an elastic full space. We show that nucleation using the composite law is very similar to nucleation using slip law. There are differences in the cycle simulation results between the two laws, however. The two state variables formulation, compared with the single state one, is found to lead to a richer dynamic response with more complex instability patterns. Our investigation will enable us to quantitatively determine the influence of using different friction and evolution laws on the details of the different phases of the seismic cycle.