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Numerical investigation of frictional heating effect on the earthquake faulting based on the Ruina- and Chester-Higgs- models

Yaqi Gao[1] and Baoping Shi[2]
[1]College of Earth and Planetary Sciences, University of Chinese Academy of Sciences, Beijing, China (gaoyaqi16@mails.ucas.edu.cn)
[2]College of Earth and Planetary Sciences, University of Chinese Academy of Sciences, Beijing, China (bshi@ucas.edu.cn)

Rate- and state-dependent friction laws (RSF laws) are empirical laws derived from laboratory experiments related to rock friction. They have been used to quantitatively describe complex fault friction processes. With a combination of the RSF laws and the McKenzie-Brune frictional heat generation model, we have studied the effects of frictional heating processs on the fault strength variation and temporal evolution of temperature based on the spring-slider-fault system subjected to Ruina and Chester-Higgs RSF laws. The system equations are solved efficiently by Dormand-Prince method with adaptive steps. First, with a comparison to the Ruina- model in which the temperature effect due to frictional heating on frictional strength is neglected, the numerical results show that the fault will be unstable slightly earlier for the Chester-Higgs- model in which the temperature effect due to frictional heating on frictional strength is taken into consideration, which indicates that the rise of temperature caused by frictional heating can lead to a slight time advance of fault instability. Second, by contrast with Ruina- model, the frictional strength will keep a little bit higher for the Chester-Higgs- model when the fault sliding at high speed, indicating that frictional heat can strengthen faults to a certain extent. Third, the simulation results also suggest that, at the same rupture velocity, the temperature change for the Chester-Higgs- model is much smaller than that given by the Ruina- model, indicating that frictional heat can also restrain the sharp rise of temperature on fault surface. In addition, under the same parameters and initial conditions, the seismic occurrence time giving by the Chester-Higgs- model is obviously shorter than that by the Ruina- model, indicating that a significant effect of friction heating generated on entire fault temporal evolution could greatly reduce the seismic recurrence time. Correspondingly, both static stress drop and total slip resulted from the Chester-Higgs- model is also smaller than that from the Ruina- model, respectively.