Microscopic derivation of rate- and state-dependent friction and its scaling properties

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In this talk, a scaling argument is given for the the length constant in the rate- and state-dependent friction law.
In general, the dynamic friction coefficient is not the single-variable function of the sliding velocity, as friction involves some aging processes such as frictional healing. Therefore, one needs additional variables to describe the behavior of friction coefficient. In the simpleset case, a single “state variable” is introduced to describe an aging process and the friction coefficient is described with the two variables: the sliding velocity and the state variable. This formulation is referred to as the rate- and state-dependent friction (RSF) law. It includes three important parameters and they determine the frictional stability/instability. Thus, it is widely used to understand earthquakes as the frictional instability. Unfortunately, to this date, the RSF is purely empirical and therefore one cannot judge its applicable limit. In addition, it is not clear at all how these important parameters are determined from (or related to) the physical entity of the fault surface.
Because the macroscopic friction force is supported by microscopic junctions of protrusions, any macroscopic friction law should be derived from constitutive laws of such microscopic junctions. With this procedure one can overview the micro-macro correspondence in friction and understand the physical meaning of phenomenological parameters in an macroscopic friction law. Here we carry out this program for the RSF law; i.e., we derive the RSF from constitutive laws of the microscopic junctions. Consequently, the microscopic expressions are given of the RSF parameters such as the relaxation length Dc. The system-size dependence of the relaxation length is discussed.

Keywords: friction law, critical slip distance