Refined rate and state friction law and its application to simulated earthquake nucleation

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In recent years, it was pointed out that the possibility that some slow slips correspond to rupture nucleations of megathrust earthquakes [Kato et al., 2012; Ruiz, 2014]. Therefore, in order to discuss the relationship between the slow earthquake and the megathrust earthquake, how the fault slowly starts to slip is an important focus.
This rupture initiation is governed by the rate and state friction law (the RSF law). However, two conventional formulations of RSF law (the aging law & slip law) is contradicting two representative experiments of low-speed friction experiments (the velocity step test & slide-hold-slide test). As a result, there has been a large uncertainty in the picture of rupture nucleations asserted by low-speed friction experiments [Ampuero & Rubin, 2008]. Moreover, the well-known compromise between two laws called the composite law [Kato & Tullis, 2001] also has a point that is inconsistent with the experime. Still, the formulation of RSF law, and thus the experimentally suggested understanding of the low-speed fault behavior, remains problematic.
In this presentation, we formulate an RSF law properly and use it to perform the rupture nucleations, for discussing the picutre of the earthquake-triggering by slow slips reported in the study of the megathrust earthquake [e.g. Kato et al, 2012]. First of the presentation, we briefly report an formulation which clears all the conflicts between three conventional laws and two representative experiments. We call this formulation activation law. Second, we uset it to simulate the rupture nucleation with the same setting as in the previous study [Ampuero & Rubin, 2008]. As a result, it was suggested that the rupture that occurs during nucleation is the pulse-like one asserted by the slip law rather than the crack-like one asserted by the aging law. Moreover, although the shear-stress-weakening effect [Nagata et al., 2012] is known to inhibit the nucleation from migrating [Kame et al., 2012], our result indicates that the rupture migrates in the physically reasonable parameter range of the stress weakening effect. The result of this research is consistent with the interpretation of the previous study [Kato et al., 2012] that propagation of the slow slip before the 2011 Tohoku earthquake to the initial rupture point corresponds to the migration of the rupture nucleation of the Tohoku earthquake. From now on, more precise observation may be able to capture migration of pulse rupture nucleation.

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