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Slip stabilization, a counterintuitive slip response to a sudden buildup of loading stress, predicted by a revised rate

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Motivated by the existing discrepancies between the model predictions of Dieterich (1994) and the observed aftershock seismicity, we re-examined aftershock triggering on faults obeying the recently revised RSF incorporated with a newly noticed stress-weakening effect (Nagata et al., 2012) that seems eventually free from contradictions with laboratory friction experiments. Time-to-instability analysis, which is necessary as a specific nucleation model to get on the original theoretical framework of Dieterich's aftershock modeling, was numerically conducted to derive the resultant aftershock sequences obeying the revised RSF. It was found that certain improvements towards common observations, in terms of raised seismicity and shortened delay before Omori decay. However, the improvements were far too small to resolve the huge quantitative gap in the characteristic stress (direct effect coefficient 'a' times 'normal stress') between laboratory values and what is inferred from observed aftershock sequences. On the other hand, through many numerical simulations of slip response to a stress step imposed at different timings in the seismic cycle, we noticed a counterintuitive behavior of the revised RSF. When a sufficiently large stress step is imposed at a timing somewhat before entering self-accelerating stage of the seismic cycle, the timing of earthquake can be delayed rather than advanced. In this case, the earthquake will occur after several oscillatory cycles resembling slow slip events, which might be usable as a marker for a fault at a certain stage in the seismic cycle. This behavior itself is a potentially important finding in earthquake mechanics and a laboratory confirmation of the counterintuitive response of a frictional fault to a stress step, which is an unintended prediction by the revised RSF, is desired in the near future.

Reference

Kame, N., Fujita, S., Nakatani, M. and Kusakabe, T., Effects of a revised rate- and state-dependent friction law on aftershock triggering model, Tectonophysics (2012), http://dx.doi.org/10.1016/j.tecto.2012.11.028