ACCELERATING FORESHOCKS OF CRUSTAL EARTHQUAKES CONTROLLED BY FRICTIONAL HETEROGENEITIES

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While most earthquakes start abruptly, with no evidence for a nucleation process, accelerating foreshocks within or in the vicinity of the eventual mainshock rupture zone for some moderate to large crustal earthquakes have been documented recently. For example, Tape et al. (2018) reported nucleation signals of crustal earthquakes in the Minto Flats fault zone in central Alaska, manifested by ∼20 seconds of simultaneous high-frequency foreshocks and a very low-frequency earthquake. One potential explanation for such observations is a slow slip front propagating over the fault and triggering foreshocks as it transitions into the mainshock rupture (e.g., Tape et al., 2018). Another explanation may be that accelerating foreshocks represent cascading sequences of fault ruptures due to static and/or dynamic stress changes, without underlying slow slip (e.g., Ellsworth and Bulut, 2018). Here we show that a numerical fault model incorporating full inertial dynamics and rate-and-state friction laws with frictional heterogeneities can reproduce the accelerating foreshocks observed in the Minto Flats fault zone in central Alaska. Our results suggest that a slow physical process, such as slow slip or fluid diffusion, in between small-scale, velocity-weakening asperities is needed to generate accelerating foreshocks. Our results further suggest that the time scale of accelerating foreshock sequences depends on the degree and size of frictional heterogeneities and tectonic loading rates. The model may also explain why the occurrence of accelerating foreshocks is relatively uncommon.