Numerical simulation of dynamic earthquake triggering based on rate- and state-dependent friction law

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Dieterich (1994) represented time to instability as a function of slip velocity assuming single spring-block system based on rate- and state-dependent friction law (RSF), and denoted that increase of the slip velocity due to static stress change triggers earthquakes. We extend this model to the case of dynamic stress change, noting that increment of logarithm of slip velocity is proportional to difference between static stress change and state variable (frictional strength) change. When fault strength is decreased by dynamic stress change due to seismic waves, earthquake occurrence could be advanced, resulting in delayed dynamic triggering even if no static stress change occurs.
We conducted numerical simulations of earthquake triggering assuming a circular asperity obeying RSF law revised by Nagata et al. (2012). In a situation where earthquakes repeatedly occur, we apply dynamic stress disturbance of sinusoidal variation at a certain time. The dynamic stress change causes increase of slip velocity following the RSF law, and resultant slip weakens the frictional strength. This leads to dynamic earthquake triggering depending on the amplitude of the disturbance. When the stress disturbance is sufficiently large, earthquake occurs during the period of stress oscillating. This might correspond to dynamic triggered earthquakes during passage of seismic waves. When static stress is also increased, smaller dynamic disturbance can trigger earthquakes with a shorter delay. Even if static stress change is negative, a certain amplitude of dynamic stress change can trigger earthquakes.
Figure 1 shows relation between the time to instability and the increase of logarithm of the slip velocity at the center of the asperity. Red, blue, and green circles denote triggering due to static stress change, dynamic stress change, and both stress change, respectively.

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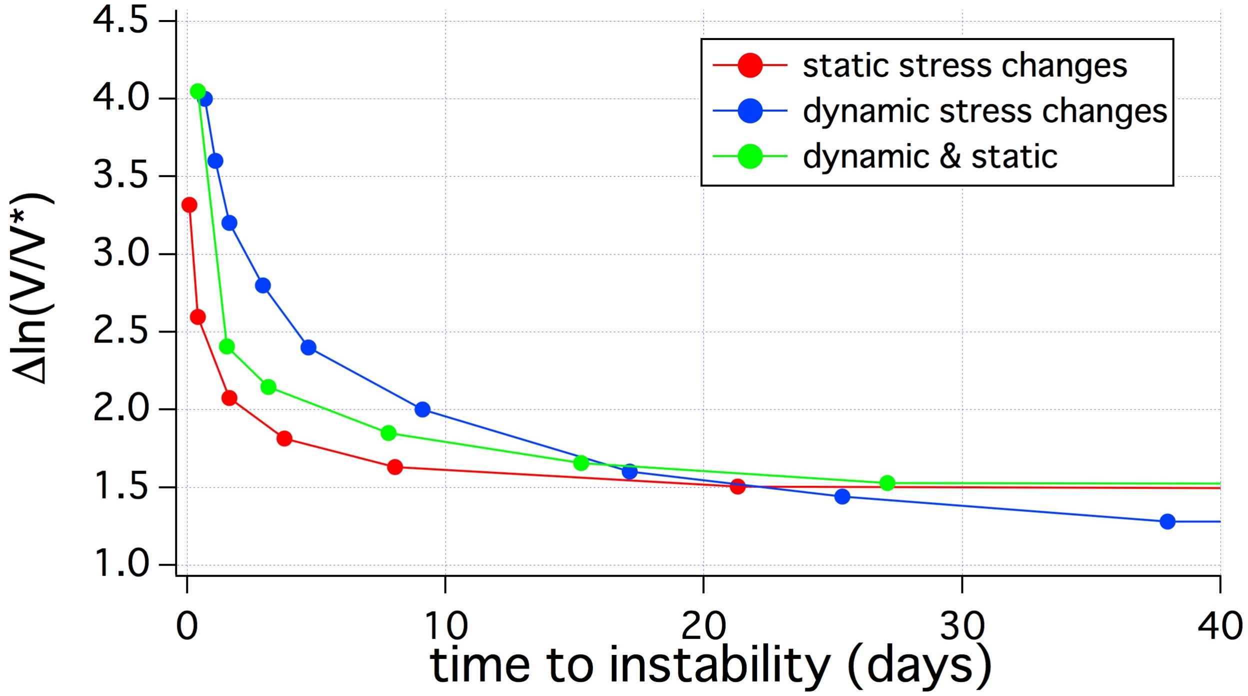
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Δln(V/V*)
0
10
20
30
40
time to instability (days)
static stress changes
dynamic stress changes
dynamic & static

Fig.1