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Earthquake triggering by static and dynamic stress changes

In this study we aim to understand the effect of static and dynamic stress changes in promoting earthquake failures on secondary faults. Toward this goal we solve the equation of motion of a spring slider dynamic system including inertia and using rate - and state - dependent constitutive laws. We separately investigate the dynamic response of this fault analog system to a sudden stress change represented either as a stress step or as a stress pulse, which are used to model permanent (static) and transient (dynamic) stress perturbations. The induced earthquake failure does not occur immediately at the application of the coseismic stress change, but it is delayed in time: we define this time interval as the triggering delay. For a given stress perturbation, we analyze the dependence of triggering delays on different system conditions and constitutive parameters. Our results clearly show that the effects of static and dynamic stress changes are quite different. While a static stress change is able to advance as well as to delay an induced instability depending on its sign, a dynamic stress pulse is only able to promote a nearly instantaneous failure, provided that its amplitude is positive and large enough with respect to the direct effect of friction. In other words, dynamic stress changes can only cause nearly instantaneous failures, without any relevant triggering delay. These results should be considered in interpreting the seismicity rate changes caused by large earthquakes at least as long as seismic events are interpreted as sliding instabilities obeying rate - and state - dependent friction laws.