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Investigation of Dynamic and Static Effects on Earthquake Triggering Using Different Rate and State Friction Laws and Marmara Simulation

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The clock of an earthquake can be advanced due to dynamic and static changes when a triggering signal is applied to a stress-loading fault. While static effects decrease rapidly with distance, dynamic effects can reach thousands of kilometers away. Therefore, earthquake triggering is traditionally associated to static stress changes at local distances and to dynamic effects at greater scales. However, static and dynamic effects near the triggering signal are often nested, thus identifying which effect dominates, becomes unclear. So far, earthquake triggering has been tested using different rate-and-state friction (RSF) laws utilizing alternative views of friction without much comparison. In this study, the analogy of an earthquake is simulated using single degree of freedom spring-block systems governed with three different RSF laws, namely “Dieterich”, “Ruina” and “Perrin”. First, the fault systems are evolved until they reach a stable limit cycle and then static, dynamic and their combination are applied as triggering signals. During synthetic simulations, effects of the triggering signal parameters (onset time, size, duration and frequency) and the fault system parameters (fault stiffness, characteristic slip distance, direct velocity and time dependent state effects) are tested separately. Our results indicate that earthquake triggering is controlled mainly by the onset time, size and duration of the triggering signal but not much sensitive to the signal frequency. In terms of fault system parameters, the fault stiffness and the direct velocity effect are the critical parameters in triggering processes. Among the tested RSF laws, “Ruina” law is more sensitive than “Dieterich” law to both static and dynamic changes and “Perrin” is apparently the most sensitive law to dynamic changes. Especially, when the triggering onset time is close to an unperturbed failure time (future earthquake), dynamic changes result the largest clock advancement, otherwise, static stress changes are substantially more effective. In the next step, realistic models will be established to simulate the effect of the recent (26 September 2019) Marmara earthquake with Mw=5.7 on the locked Kumburgaz fault segment of the North Anatolian Fault Zone. The triggering earthquake will be simulated by combining the static stress change computed via Coulomb law and the dynamic effects using ground motions recorded at broadband seismic stations within similar distances. Outcomes will help us to better understand the effects of static and dynamic changes on the seismic cycle of the Kumburgaz fault segment, which is expected to break soon with a possibly big earthquake causing damage at the metropolitan area

of Istanbul in Turkey.