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Numerical simulation of cascade and pre-slip rupture models

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It is commonly stated that the cascade rupture model implies that it is impossible to predict earthquakes whereas the pre-slip rupture model allows us to predict a large earthquake (Ellsworth and Beroza, 1995). What is the physical difference between these two rupture models? It is still difficult to judge the two models from precise analyses of seismic waveforms. As proposed in many previous studies, pre-slip rupture models has been numerically reproduced by a quasi-static nucleation phase and a following dynamic rupture stage. This is the inevitable result from the energy balance around crack tips. In the case where characteristic slip-weakening distance, often noted as Dc, is proportional to earthquake size, larger earthquakes naturally require a larger nucleation process, which should be detectable. On the other hand, the cascade rupture model is based on the idea that all the earthquakes of any size begin in the same way, and that the following rupture process is random with no existence of a characteristic distance such as Dc. However this has hardly been studied theoretically or numerically. Therefore we have numerically simulated a cascade rupture using a boundary integral equation method with a renormalization technique, by keeping a scale-dependent characteristic distance Dc. These simulations are deterministic. Our idea is very similar to that of the pre-slip rupture model, but introducing "spatial heterogeneity in multi-scales" allows us to reproduce cascade rupture propagation. The obtained earthquake size-frequency relation follows the well-known log-log distribution.