Criticality of Self-similar Earthquake Rupture Propagation against Energetic Barrier

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Earthquake rupture starts from a tiny fracture and sometimes grow into a very large event, affected by perturbation due to multi-scale heterogeneity on fault system. In statistical average, this process is approximated by a self-similar crack propagation in space and time [Meier et al., 2016], which is terminated by some energetic barrier. To discuss the condition of the rupture growth to energetic perturbation, we show the results of simple numerical simulations, in which a self-similar crack with a constant rupture velocity encounters energetic barrier in 2-D anti-plane and in-plane fault using full-dynamic BIE method. The critical ratio γ_c of fracture energies inside and outside of the region of self-similar propagation is a single monotonically increasing function of the rupture velocity v_i alone (Fig. 1), and it is almost explained by analytical approximation: $\gamma_c(v_i) = 1/1 - v_i$. The exponential increase of this ratio with the propagation velocity may explain why there has been no report of earthquakes propagating at a very small velocity < $0.1v_s$.

The simulation can also be interpreted as dynamic nucleation process for the barrier region. The size of critical dynamic nucleus $R_C^{dyn.}$ depends on the rupture velocity and is smaller than the static size $R_C^{sta.}$ by up to about 25%, which may not be significant difference.

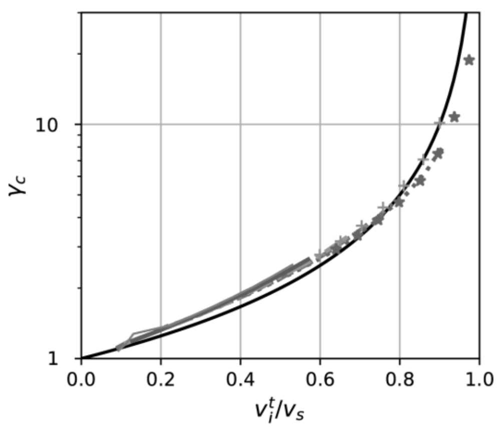

Figure 1. Critical ratio γ_c plotted against rupture velocity v_i prior to cascading process. Black Solid line indicates analytical approximation and others indicate results of numerical simulation in various parameter settings. v_s is shear wave velocity.

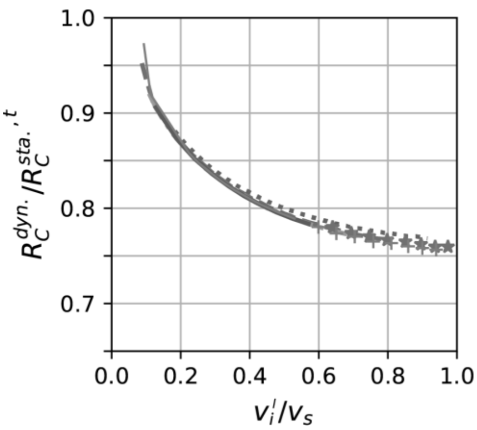

Figure 2. Ratio of $R_C^{dyn.}/R_C^{sta.}$ plotted against rupture velocity v_i prior to cascading process. Different symbols denote the results of different parameter settings.