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Power spectral density of slip distribution and slip rate function

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In view of energetics, earthquake faulting is a physical process that part of cumulated strain (i.e., potential) energy is converted into radiated (i.e., kinetic) energy. We have revealed that the potential energy and kinetic energy can be represented by quite similar spectral integrals although the former is with respect to spatial wavenumber and the latter is with respect to frequency[1]. In other words, power spectral densities (PSD) of the potential energy, which is correlated to slip distribution[2], and kinetic energy, which is correlated to slip rate function, are related to each other. This seems to be reasonable qualitatively because shorter wavelength components of the slip distribution should generate higher frequency contents of the seismic wave. To investigate this relationship quantitatively, we model spatio-temporal distribution of slip rate function on the fault and show that PSD of slip distribution and PSD of slip rate function should have the similar form. In our model, the distribution of slip rate function is represented as spatial distribution of peak slip velocity multiplied by a characteristic slip rate function that arises when the rupture front arrives at each point; this is an extension of the Haskell model. We find that the PSDs are proportional to a PSD of distribution of the peak slip velocity even if the distribution is quite heterogeneous and rupture velocity has perturbation in space. This suggests that the PSD of the slip distribution, which is hardly analyzed due to poor resolution of slip inversion analyses, can be roughly estimated by using the PSD of slip rate function of an ideal point source. Additionally, our model of the characterized slip rate function is consistent with a result of dynamic simulation of spontaneous rupture propagation along a rough fault[3]. Hence we suggest a simple method to estimate not only heterogeneity of slip distribution but also roughness of faults.

References

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