How Does Frequency-band-limited Backprojection Image Relate to The Actual Slip Behavior?

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Waveform backprojection (BP) has been an effective tool of earthquake-source imaging since its successful application to the 2004 Sumatra-Andaman megathrust. Recently, clarifying physical meaning and inherent bias of the BP image has become an active-research endeavor, following the pioneering work of Fukahata, Yagi and Rivera [2014]. The series of work has revealed that the BP signal intensity has depth-dependent bias, which is not related to slip, but rather is proportional to the amplitude of the Green's function. Another critical finding is that the resolvability of the BP signal is determined by the similarity of the convolution function of the Green's functions and the slip-rate function, which may be controlled by the frequency range applied to the data as well as the true asperity size and its duration.

Here we investigate how the actual slip behavior is resolved in low-frequency (LF; 0.1–0.5 Hz) and high-frequency (HF; 0.5–2.0 Hz) BP images by using the kinematic Hybrid BP (kHBP) method, which is a variant BP technique designed to remove the depth-dependent bias in the original HBP method. We use the linearly-aligned point sources, representing the various asperity length, to generate synthetic waveforms. We assume the triangular slip-rate function of a fixed half-rise time of 2 s on each point source, which is triggered to rupture by constantly propagating rupture front at 3 km/s. The results show that if the asperity length is shorter than the LF band, and the rise and drop points of slip-rate function are close together, the intense LF signal is obtained at the center of the asperity, which results in the complementary distribution of the LF and HF sources. While if the asperity length is long enough (> 12 km) to distinguish the rise and drop points in the LF band, the peak of LF signal is located at a similar point as that of HF signal obtained at the edges of the asperity. The plateau of the source time function where the slip is smoothly propagating may not be favorable to be resolved even by LF BP, suggesting that the LF BP image is not necessary comparable to the inverted slip distribution. The condition where the LF and HF signals are separately located may require a longer rise time than the LF range without dominant smooth slip, which is possibly related to long nucleation process for breaking the asperity.