How Much Can We Hope to Resolve Acceleration and Deceleration of Earthquake Rupture Evolution?

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Acceleration (ACC) and deceleration (DEC) of earthquake rupture evolution are critical phenomenon for understanding the earthquake source physics, which are realized when rupture is advanced by cascade triggering and when rupture front is disturbed by geometric/inhomogeneous barriers. Theoretical studies suggest that abrupt change of rupture evolution can enhance high-frequency (HF) radiation, and it is possible to track ACC and DEC with backprojection (BP) technique since it has been widely used for imaging HF radiation sources.

Here we explored a resolvability of ACC and DEC with the BP technique. Conventionally, it was difficult to distinguish ACC and DEC from the BP image, since the image were usually composed of the normalized intensity of the stacked signal of only positive values (in a range of 0–1). We propose new implementation of the hybrid BP (HBP) method; one of the variants of BP technique developed to enhance depth resolution by using theoretically calculated Green's functions (GFs) and to mitigate the dummy imaging of depth phases in BP method. An explicit use of GFs enables us to extract the physical unit from the signal intensity as either velocity or acceleration. We stack the cross-correlation functions of the velocity waveforms and displacement GFs filtered in 0.5–2.0 Hz for all the stations and project them onto the fault, which will correspond to the time derivative of slip rate; ACC and DEC, for the positive and negative values of stacked signals, respectively.

We performed numerical test by using the synthetic waveforms generated with the boxcar slip-rate function of variable source duration and various configurations of source locations, and we also performed the real application for the 2008 Wenchuan China, 2015 Gorkha Nepal, 2015 Iquique Chile, 2015 Hindu-Kush Afghanistan earthquakes. Results showed that ACC and DEC were well resolved by the HBP method, only if the sources were isolated in both time and space, but if they were closely distributed, it was difficult to distinguish ACC and DEC from the image. In a real configuration of sources, they do not always separate each other, and the radiation phases of ACC and DEC may easily be canceled out in HF waveforms, especially for the later phases. Thus practically, it would be difficult to rigorously resolve ACC and DEC with the BP technique.

Keywords: earthquake source rupture process, rupture imaging technique, acceleration and deceleration of rupture evolution, backprojection, high-frequency waveform

