Development of a method of visualization of abrupt changes in slip-rate and rupture velocity toward better understanding of high-frequency radiation on a fault.

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High-frequency waves are thought to be generated by abrupt changes of slip-rate or rupture velocity on a fault during an earthquake rupture based on theoretical studies (e.g. Spudich and Frazer, 1984, BSSA). Finite-fault inversion of seismic waveforms is a tool to estimate spatiotemporal distribution of slip-rate function. Slip-rate function is composed of some basis functions at each subfault which an assumed fault is divided into in a reticular pattern. Back Projection (BP) (Ishii et al., 2005, Nature) and Hybrid BP (HBP) (Yagi et al., 2012, EPSL) methods are techniques for tracking high-frequency radiation sources and have been used to discuss the detailed source process by comparison with slip distribution resolved by waveform inversion. However, the physical meaning of the BP/HBP images is ambiguous, and the quantitative evaluation of the high-frequency radiation has been difficult solely by the BP/HBP methods. In order to reveal what rupture behavior generates high-frequency radiation, we proposed a method to image acceleration and deceleration of slip and rupture from spatiotemporal distribution of slip-rate function resolved by waveform inversion. We derived a representative slip-rate as a maximum value of slip-rate function and a representative rupture time at each sub-fault, and then calculated spatial gradients of the slip-rates and the rupture time to derive acceleration and deceleration of slip and rupture front, respectively. We used the slip-rate function which was obtained by the waveform inversion introducing uncertainty of Green’s function (Yagi and Fukahata, 2011, GJI), where the high-frequency components of observed waveform were well reproduced compared to the conventional scheme because the waveform inversion can get a slip-rate functions which have a number of basis functions. We applied the developed method to the slip-rate functions of the M_W 7.9 2015 Gorkha, Nepal and the M_W 8.8 2010 Maule, Chile, earthquakes, which were presented in Yagi & Okuwaki (2015, GRL) and Pulido et al. (2011, EPS), respectively. For both the two earthquakes, the results showed that the rapid acceleration of slip was found at the edge of the large slip area facing to the hypocenter, while rapid deceleration of slip was found at the edge across the large slip area. The results also showed that the rapid deceleration of rupture was observed just before the rupture front penetrates into and escaped out of the large slip area. The estimated areas of rapid acceleration and deceleration are consistent with the spatial distribution of intense high-frequency radiation sources tracked by HBP methods (Yagi & Okuwaki, 2015, GRL; Okuwaki et al., 2014, Sci. Rep.). Our developed method well distinguished the behavior of slip evolution related to the generation of high-frequency waves, that is, spatiotemplrally separated slip and rupture front acceleration/deceleration, which has not been evaluated by the BP/HBP methods alone.

Keywords: High frequency, Waveform inversion, Slip rate, Rupture velocity, 2015 Gorkha, Nepal, earthquake, 2010 Maule, Chile, earthquake

