Rapid detection of early aftershocks using high-frequency seismogram envelope: improvement of location estimation of energy radiation point

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Because waveforms of many early aftershocks are overlapped in seismograms, conventional hypocenter determination technique based on the picking of P and S wave arrival times does not work well at the early lapse times after a large earthquake. On the other hand, real-time forecasting of aftershock activity requires sufficient amount of aftershock data in the early lapse times. Sawazaki and Enescu (2014) developed the envelope inversion method that can rapidly detect the energy radiation rate from the early aftershock sequence. In their method, propagation of high-frequency (>1Hz) seismic energy is considered to follow the radiative transfer theory, and the observed seismogram envelopes are regarded as the convolution of energy radiation and propagation processes. To locate the energy radiation point, they compute the sum of squared residual between the observed and the theoretical peak amplitude of the envelopes, and search the minimum residual point at each discrete time step. However, because the theoretical envelope synthesized based on the radiative transfer theory cannot describe both the peak arrival time and the peak amplitude well, the detected energy radiation point frequently has a large error. In this study, I synthesize the theoretical envelope based on the forward scattering approximation that can better describe the peak arrival time and the peak amplitude, and use this in combination with the conventional radiative transfer-based envelope to improve location estimation of the energy radiation point. The hybrid envelope used in this study includes not only S wave but also P wave energies because the amplitude of P wave is sometimes comparable to that of S wave and should not be neglected. I examine seismogram envelopes of 8-16 Hz that are recorded by 13 Hi-net and KiK-net stations located within 70 km from the hypocenter of the 2008 Iwate-Miyagi Nairiku earthquake (M_{JMA}7.2). In total 91 aftershocks which satisfy M_{JMA}>3.4 are detected within half day after the mainshock according to the JMA unified hypocenter catalog. I first perform the conventional detection method that uses the radiative transfer-based envelope, and find that 10 of the 91 aftershocks are located over 20 km apart from the corresponding JMA hypocenters. Next I perform the new detection method that uses the hybrid theoretical envelope, and find that the number of the corresponding aftershocks reduces to one.

Keywords: detection of early aftershocks, analysis of high-frequency envelope

