A Technique for Simplified Estimation of the Small Event's Seismic Moment Using KiK-net Records

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In order to estimate seismic moment of earthquakes we usually use waveform inversion or spectral inversion. Recently, it becomes possible to download these data simply from the F-net website of the NIED. However, for many relatively small earthquakes there are no seismic moment estimations there. The aim of this study is to propose simple method to estimate seismic moment of small earthquakes using abandon set of records of the dense KiK-net network. In this way we expect to get seismic moment estimations for small earthquakes that were not processed by F-net.

If effect of the site amplification is negligible, it is possible to calculate source spectrum simply by correcting observation spectrum for the path effect. If we assume that effect of site amplification is negligible for the down-hole KiK-net sites and then try to estimate seismic moments from the source spectra, it is easy to find that they are systematically larger than that of the F-net estimations. Here, to avoid effect of fictitious spectral amplification, we propose to estimate and apply correction coefficient to the 'source spectra' extracted from the KiK-net records and then to fit them to the theoretical source spectrum (Boore, 1983) calculated using the F-net seismic moment values. Here, we additionally adjusted corner frequency by fitting both spectra in high-frequency range. Effects of the specific site amplifications and the source radiation pattern are eliminated by the averaging of the 'source spectra' of the same earthquake estimated at many sites. For testing of the proposed methodology we use records of M3.0-5.5 earthquakes in Kinki region (N33.5-N35.5, E134.5-136.5) that have F-net estimations of the seismic moments. Segments of records from 1sec before S-arrival having 10.24sec lengths are used. In order to calculate path effect, we applied average (for the path between source and site) values of S-wave velocity and density, 3.6km/s, 2.7t/m^3 respectively, and Q-value valid for the earthquakes in upper crust in the Kinki region after Petukhin et al., 2003 (Q(f)=86.0f$^{0.82}$).

Results of the estimations using above method show that for most of earthquakes, correction coefficient has the same value 0.6. That is, it is possible to estimate seismic moment accurately simply by applying correction coefficient 0.6 to the 'source spectra' of the KiK-net records. However, this correction is applicable for records having hypocenter distance less than 80km; at larger distances amplitudes have tendency to become larger.

The nature of the correction applied can be explained by the effect of seismic impedance. Because seismic impedance gradually decreases from the source depth to the surface, amplitudes of seismic waves radiated from the source gradually increases during their propagation to the observation site. Such amplification ratio is approximated by the square root of the impedance ratio of media around source and site. Assuming that average values of S-wave velocity and density around site are 2.0km/s and 2.5t/m^3 respectively, and those around source are 3.8km/s and 2.9t/m^3, square root of impedance ratio is 0.67, which is close to the 0.6 value estimated empirically. This suggests that the correction coefficient doesn't depend on the earthquake source and can be estimated as the impedance ratio of the media around source and under site.

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