Rupture Velocities of Large Deep-Focus Earthquakes Surrounding Japan

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Rupture velocity is an important parameter in understanding the physics of the earthquake source, and many studies estimated rupture velocities of shallow and deep earthquakes. For shallow earthquakes, not only seismic waveform data but also geodetic or surface displacement data are frequently available, so that they can be constraints for the estimation of source parameters including rupture velocity. These data are not available for deep-focus earthquakes, and lack of closely observed data makes it more difficult to accurately estimate earthquake source parameters.

To estimate rupture velocities of deep-focus earthquakes surrounding Japan, we first carried out teleseismic waveform inversions using empirical Green function method, for rupture velocities of 0.5 ˜6 km/s on both nodal planes obtained by Harvard CMT solutions. Next, forward modeling of regional data (F-net and Hi-net) was performed with each slip distribution obtained by teleseismic inversions, also using empirical Green function method. Then we estimated the rupture velocity when the synthetics calculated by forward modeling best explain the observed regional data. Both for teleseismic inversions and forward modeling of regional data, we varied grid size for the change of rupture velocity, so that the number of inversion parameters can be constant. Our new method, that varies grid size and uses both teleseismic and regional data, provides better resolution to estimate the rupture velocity.

Using this method we were able to estimate the rupture velocities of three deep-focus earthquakes surrounding Japan. The estimated rupture velocities for the three events are about 1 ˜2 km/s, which are equivalent to 20 ˜40 % of shear wave velocity. These values of rupture velocity are quite slow, compared to typical values for shallow earthquakes (70 ˜80 % of shear wave velocity).