Source scaling for the 2016 Kumamoto, Japan, earthquake sequence using the S-wave coda spectral ratio method

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Source scaling and variation in stress drops play an important role not only in understanding source physics but also in advancing strong ground motion prediction because stress drop is an essential source parameter to control the high frequency ground motion amplitude. We estimated corner frequencies and stress drops for the 2016 Kumamoto earthquake sequence based on the S-wave coda spectral ratio method (Somei et al., 2014) to investigate the source scaling and factor for variation in stress drops.

We analyzed 60 events (M_w 3.3-7.1) including three large earthquakes with M_w≧6.0 in the 2016 Kumamoto earthquake sequence. We collected ground motion records observed at KiK-net and F-net stations located in and around the source areas of the 2016 Kumamoto earthquake sequence. For KiK-net stations, we used acceleration time histories recorded by downhole strong motion sensors. For F-net stations, we used velocity time histories recorded by both strong motion and broadband seismographs. Following the procedures introduced by Somei et al. (2014), the source spectral ratio for one station is obtained by the amplitude spectral ratio of large and small events. For calculating the amplitude spectra, we used the S-wave coda parts at the same lapse time between the event pair as the analyzed time window. In order to guarantee the commonality of decay curves in the time windows between the event pair, we examined the decay ratios of RMS envelopes in S-wave coda for six narrowband frequency ranges. The observed source spectral ratios were well explained by the ω^{-2} source spectral model, and we could estimate the reliable corner frequencies for large and small events by grid search method. For comparisons, we also obtained the source spectral ratios from the observed spectral ratios for direct S-waves. We could clearly see the source spectral ratios derived from S-wave coda are much more stable by station to station than those derived from direct S-waves. This variation in source spectral ratios for direct S-wave had station azimuth dependence due to rupture directivity effect for large event.

Assuming a circular clack fault model (Brune, 1970, 1971), the stress drop could be estimated from seismic moment and corner frequency. Overall, stress drops for all 60 events spanned from 0.07 to 4.85 MPa. The stress drops of the mainshock (2016/04/16,1:25, M_w 7.1) and the averaged value for the other events are 3.63 and 0.81 MPa, respectively. We showed the mainshock has larger stress drop than most of the other events in the 2016 Kumamoto earthquake sequence, which is comparable with the result of Somei et al. (2014). To investigate the factors of variations in stress drops independent of seismic moment, we examined possible correlations between stress drop and some tectonic effects such as regionality, focal mechanism, and source depth. Although there are no obvious correlations of stress drops with regionality and focal mechanism, we could see the dependence of source depth on stress drops for the 2016 Kumamoto earthquake sequence.

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