Simultaneous estimation of source, path, and site spectra from the S-net strong-motion records in the Japan Trench area

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We analyzed the strong-motion data recorded by S-net, which is a seafloor network of 150 observatories with seismometers and pressure gauges, covering the whole of the Japan Trench and the southern part of the Kurile Trench. The network has been in operation since 2016 (Aoi et al. 2020). The spectral inversion technique was used to separate the source, path, and site spectra from the strong-motion records in the least-square sense. To reduce the effect of the trade-off between the source and site terms in the inversion, theoretical site amplification factors estimated at two KiK-net stations were used. Strong-motion records with high S/N ratios from about 600 earthquakes having magnitudes between 3.5 and 7.0, and focal depths < 70 km, were used. Magnitude-dependent S-wave time windows of lengths 8 to 20 s were used, and zeroes were padded to compute the Fourier spectra with uniform frequencies. To avoid nonlinear site response and contamination of the records by rotations during strong motions, records having vector peak accelerations < 50 gals were only used. In our previous study (Dhakal et al. 2022), we determined the source, path, and site spectra from the mean spectra of two horizontal components. In the present study, we obtained the results from the single horizontal-component records aligned parallel to the long axes of the sensor houses, the cylindrical pressure vessels. Records from a few KiK-net stations, where site amplification factors were estimated reasonably well from surface and borehole records, were also employed in the spectral inversion to check whether the site amplification factors from the inversion were acceptable. We obtained the following results from the analysis. The obtained site spectra at the selected KiK-net sites matched well with the empirical site amplification factors derived at the sites based on the surface-to-borehole spectral ratios of the observed records. The path-averaged quality factors for the S wave were generally comparable with those reported in the previous studies. The source spectra obtained using the single horizontal component records (X components) and two horizontal component records were essentially the same. We fitted the source spectra with the omega-square source model by searching the corner frequency and flat level of the source spectra. From the flat levels of the source spectra, seismic moments and then moment magnitudes were estimated. We found that the estimated magnitudes generally matched well with the F-net catalog magnitudes. Also, the Brune-type stress drops varied with tectonic types and increased with focal depths, consistent with the previous studies using global and regional datasets (e.g., Allmann and Shearer 2009; Nakano et al. 2015). At several S-net sites close to the coast, the site factors were comparable to the theoretical amplification factors computed from the J-SHIS subsurface model. Even though the site factors estimated using the X-component records only and the two horizontal components were largely similar, they were different at many unburied sites at certain frequencies over about 4 Hz. Spurious site spectra, related to the resonance of the cylindrical pressure vessels, were present when using the two horizontal components (Sawazaki and Nakamura 2020). The spurious spectra between about 4 and 10 Hz, which were mainly from the Y components, were subdued when using the X-component records only. However, we recommend that the amplitude of the records should be used cautiously at frequencies higher than about 4 Hz.

