Significant anomalies in high-frequency seismograms for intra-slab earthquakes observed in Kanto area, Japan

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In Kanto-Tokai area in Japan, very complicated high frequency seismograms are frequently observed as it is located above a complicated plate boundary zone between the Pacific plate and the Philippine Sea plate. In this study, we found characteristic high-frequency seismogram anomalies potentially being related to characteristic inhomogeneity in this area.

We analyzed 20 intra-slab earthquakes (M4.4–6.9) occurred within the Pacific slab from October 2004 to April 2016, 227–453 km in focal depth. The datasets are velocity seismograms recorded by 258 NIED Hi-net stations in Kanto-Tokai area. After applying bandpass filters of octave bandwidth ranging from 1 to 16 Hz, characteristic wave packets and their frequency dependence are identified from root mean squared (RMS) envelope seismograms. At a frequency range of 8–16 Hz in Kanto area, we found wave packets preceding the arrival of S waves by about 10–20 s. The wave packets lasted about 10 s and their amplitude was obviously larger than that of the P-coda waves. At lower frequency of 1–2 Hz, we did not find similar packets. These wave packets were not observed for intra-slab shallow earthquakes, less than 200 km in focal depth. The amplitude of the packet at high frequency was always predominant in the vertical component. No strong polarization in the horizontal component RMS envelopes is observed.

Complicated-shape wave packets lasting about ten seconds, without significant pulse of boundary conversion, suggest that a sort of scattered wave packets are generated by the small-scale inhomogeneities. In addition, this cannot be explained by a simple S-to-S scattering because the arrival time of the packet precedes that of the direct S wave. Based on the systematic detection, we found that the wave packet propagated almost along the radial direction from the epicenter with almost the same apparent velocity as that of the S waves. Considering the wave packets arrived earlier than S waves, they are expected to involve mode-conversion such as P-to-S or S-to-P scattering, by characteristic inhomogeneity between the epicenter and seismic stations.

We conducted preliminary numerical simulations of seismic wave propagation with a community velocity model in this area superimposed onto a small-scale stochastic velocity fluctuation. The resultant synthetic waveforms did not explain these peculiar wave packets. Considerable updates especially for small-scale inhomogeneities in the velocity model are expected to contribute to further understandings of seismic wave propagation in the subduction zone.

Keywords: seismic wave propagation, scattering, seismogram envelope, subduction zone, numerical simulation

