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Frequency dependence properties of seismic wave scattering and attenuation at the Kanto basin

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Introduction

It is well known that high-frequency seismic wavefield shows complicated propagation features caused by the seismic wave scattering due to small-scale heterogeneities along propagation path. In the shallow low-velocity layer, basin structures, the strength of scattering may be much stronger than it in deeper layers, i.e., crust and mantle.

In this study, to understand propagation characteristics of high-frequency seismic waves in shallow low-velocity basin structures, we estimate the scattering and intrinsic attenuation properties at Kanto basin by using coda envelope analysis.

Method

We used the waveform data recorded by K-NET/KiK-net and F-net seismic array in Kanto area, Japan, during earthquakes with Mw 4.5-5.5. We apply a set of band-pass filter with 1-2, 2-4, 4-8 and 8-16 Hz to three-component seismograms. Then we calculate mean square (MS) envelopes of sum of three-component seismograms for each frequency band. By the grid search analysis technique, observed MS envelopes were compared with calculated ME envelopes based on direct-simulation Monte Carole (DSMC) proposed by Yoshimoto (2000) in order to estimate scattering coefficient g_0 and intrinsic attenuation Q_I^{-1} in the medium.

To achieve precise estimation of parameters in the basin, first, we estimate the parameters in the crust and mantle using waveform data recorded at F-net. Then, using these parameters in the crust and mantle, we estimate scattering coefficient g_0 and intrinsic attenuation Q_I^{-1} in the Kanto basin using K-NET/KiK-net records.

Estimation results of scattering properties at Kanto basin

The values of estimated scattering coefficient and intrinsic attenuation in the crust are g_0 = 2.51x10-3, Q_I^{-1} = 5.74x10^{-3} for 1-2 Hz, g_0 = 2.93x10^{-3}, Q_I^{-1} = 3.35x10^{-3} for 2-4 Hz, g_0 = 3.98x10^{-3}, Q_I^{-1} = 2.28x10^{-3} for 4-8 Hz and g_0 = 5.41x10^{-3}, Q_I^{-1} = 1.33x10^{-3} for 8-16 Hz. Estimated scattering coefficients are smaller than these estimated by multi lapse-time window analysis (e.g., Fehler et al., 1992; Yoshimoto and Okada, 2009), while intrinsic attenuation values are comparable with them.

We estimated scattering coefficients and intrinsic attenuation in the Kanto basin derived from K-NET/KiK-net records. The values of estimated scattering coefficient and intrinsic attenuation in the basin are g_0 = 0.126, Q_I^{-1} = 6.71x10^{-3} for 1-2 Hz, g_0 = 0.0708, Q_I^{-1} = 5.96x10^{-3} for 2-4 Hz, g_0 = 0.126, Q_I^{-1} = 6.68x10^{-3} for 4-8 Hz and g_0 = 0.0891, Q_I^{-1} = 6.48x10^{-3} for 8-16 Hz. The estimated parameters for all frequency bands in the basin are larger than them in the crust. Estimated scattering coefficients in the basin are intermediate values between volcanic area and lithosphere (e.g., Sato et al., 2012). The values of total attenuation of S wave (Q_S^{-1} = Q_{Scat}^{-1}+Q_I^{-1}) are 2.68x10^{-2} for 1-2 Hz, 1.16x10^{-2} for 2-4 Hz, 1.17x10^{-2} for 4-8 Hz and 6.48x10^{-3} for 8-16 Hz. These results are good corresponding to estimation results by Kinoshita and Ohike (2002).

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Keywords: Seismic wave scattering, basin structure, intrinsic attenuation