

Estimation of scattering and intrinsic absorption parameters using envelopes of ambient seismic noise cross-correlation functions

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Estimation of scattering and intrinsic absorption parameters is important, because they reflect heterogeneity structures of subsurface. Scattering and intrinsic absorption parameters of S waves have been estimated by using seismogram envelopes of natural earthquakes (e.g., Carcole and Sato, 2010) or active shots (e.g., Yamamoto and Sato, 2010). In recent years, spatial changes of seismic velocity or seismic scattering property have been estimated by using sensitivity kernels (e.g., Obermann *et al.* 2013a; Obermann *et al.* 2014) in seismic interferometry analyses. Scattering and intrinsic absorption parameters are necessary to calculate sensitivity kernels. We need to estimate those of Rayleigh waves to calculate sensitivity kernels in seismic interferometry analyses, because Rayleigh waves are dominant in ambient seismic noise cross-correlation functions (CCFs) for many cases. Therefore, we estimated parameters of scattering and intrinsic absorption of Rayleigh waves using envelopes of CCFs. Seismic interferometry was applied to ambient seismic noise records in 1 - 2 Hz and 2 - 4 Hz recorded at 6 JMA stations for the period from 1 January 2015 to 31 March 2015. Adopting temporal flattening technique (Weaver, 2011a), we calculated daily CCFs (ZZ, ZR, RZ, ZT, TZ), and stacked them as following procedures: We simply averaged causal and acausal part of ZZ, and averaged causal part of ZR (ZT) and acausal part of RZ (TZ). Then, we stacked these averaged daily CCFs, and calculated mean squared envelopes by smoothing squared amplitude with 2 s (1 - 2 Hz) or 1 s (2 - 4 Hz) long time windows. Parameters of scattering and intrinsic absorption were estimated by modeling the space-time distribution of energy density calculated from CCFs with 2D radiative transfer theory. The best-fit parameters were as follows: Mean free path of Rayleigh waves was 1.6 km at 1 - 2 Hz and 2.4 km at 2 - 4 Hz, and parameters of intrinsic absorption b ($b = Q_i^{-1} \omega$) were 0.1 s^{-1} at 1 - 2 Hz and 0.1 s^{-1} at 2 - 4 Hz. To validate seismic interferometry approach, we also estimated these parameters using active shot records at Sakurajima volcano. Since the source is located near the ground surface (about 60 m depth), we can directly compare the results with those of using CCFs that may represent the waveforms from a source at one borehole station to the other one. Mean free path of Rayleigh waves was estimated as 1.2 km at 1 - 2 Hz and 2.0 km at 2 - 4 Hz, and values of b were estimated as 0.1 s^{-1} at 1 - 2 Hz and 0.15 s^{-1} at 2 - 4 Hz. They are almost consistent with those of using CCFs. This confirms that we can estimate parameters of scattering and intrinsic absorption of Rayleigh waves by using envelopes of ambient seismic noise CCFs without active sources.

Keywords: seismic interferometry, parameters of scattering and intrinsic absorption