

Propagation Characteristics Revealed from the Cross-Correlation Analysis of Ambient Seismic Noise at a Long Distance

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Cross-correlation function of multiple scattered waves observed at two points is considered to represent the Green function in an inhomogeneous structure. Our past study showed that Rayleigh waves of about 10s in period were retrieved from the cross-correlation analysis of coda waves in northeastern Japan. In this study, we practice the cross-correlation analysis of ambient seismic noise, and attempt to reveal the propagation characteristics of seismic waves.

Three-component velocity records of ambient seismic noise recorded at stations IYG and TYS of the F-net for 90 days are analyzed. Applying fourth-degree band-pass filters (4-8Hz, 2-4Hz, 1-2Hz, 1-2s, 2-4s, 4-8s, 8-16s, 16-32s) to two records, we calculate cross-correlation functions of filtered trace pair for every time window of 360s in length. Stacking cross-correlation functions for the whole period, we obtain 3x3 pairs of vertical, radial and transverse components. The cross-correlation function of band-pass filtered seismic noise can be interpreted as the Green function in a given frequency band.

While significant wavelets do not systematically appear in the cross-correlation function between the vertical components of two stations for periods smaller than 1s, clear wavelets appear for periods longer than 1s although the distance from IYG to TYS is as long as 82.6km. The propagation velocity of these wavelets show dispersion characteristics: 2.8km/s in 1-2s period and 3.5km/s in 8-16s period. Focusing on the cross-correlation functions near the maximum amplitudes, the phase shift between the cross-correlation calculated from two vertical components and that from vertical and radial components is about 90 degree, so the wavelets we obtained are identified as Rayleigh waves.

We further calculate the cross-correlation functions in 1-2s period for one day records, which are obtained from the 90 days record. Comparing them each other, we find that wavelets near the maximum amplitudes are similar to each other. An averaged travel times of Rayleigh wave stacked from 90 days is 29.38s, and the standard deviation is estimated to be 0.15s. This strongly indicates that our cross-correlation method can estimate travel times of stacked wavelets with high precision.

We are also able to retrieve clear Rayleigh waves having dispersion characteristics in 1-16s period from the cross-correlation analysis of ambient seismic noise at a long distance. These Rayleigh waves are estimated only from ambient noise (that is, no seismic events are necessary), which strongly suggest that our method is very effective for continuously monitoring wave propagation characteristics in the earth medium.

Acknowledgement: We thank the NIED for providing F-net seismograms.