Seismic ambient noise interferometry applied to dense OBS array of off Ibaraki region

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Off Ibaraki region is located at the southern end of the focal area of the 2011 off the Pacific coast of Tohoku Earthquake (Tohoku Earthquake). A dense network of 32 ocean bottom seismometers (OBSs) was deployed at this region with a station interval of about 6 km from October 2010 (11 OBSs started from February 2010) to October 2011. A large number (> 10,000) of aftershocks following the 2011 Tohoku earthquake were detected by this network. However, precise determination of these hypocenters and focal mechanisms is challenging due to uncertainties of seismic properties of thick sediment layers beneath the seafloor. The P-wave velocity structure has been reasonably constrained by active-source seismic surveys (Mochizuki et al., 2008), but the S-wave velocity structure is still unrevealed despite its importance.
To constrain the S-wave velocity of the shallower portion, we apply the ambient noise interferometry to the short-period OBS data in this study. After dividing the data into ten-minute segments, we deconvolve the data with instrumental response function, remove trends, and discard data dominated by seismic events. Then, we apply a one-bit normalization and spectrum whitening. Finally, we calculate cross-correlations for vertical-vertical, radial-radial, and transverse-transverse components to retrieve Green's functions.
We measure average phase velocity in the array using spatial auto-correlation method (Aki, 1957; Nishida et al., 2008). The phase velocities of the fundamental Rayleigh, the first-higher Rayleigh, and the fundamental Love modes are 0.5 to 2.5 km/s (in the frequency range of 0.1 to 0.3 Hz), 0.8 to 1.5 km/s (0.17 to 0.3 Hz), and 0.5 to 2.0 km/s (0.25 to 0.1 Hz), respectively. Next, we infer the 1-D average S-velocity isotropic structure by non-linear inversion, whose sensitivity is mainly ~5 km. The results show ~1000 m thick sediment with S-wave velocity of 300–1000 m/s immediately beneath the seafloor. At last, we apply band-pass filter with frequency range of 0.125 Hz and measure travel-time anomaly of the phase velocity in each frequency range, following Nagaoka et al. (2012). We apply non-linear inversion (Rawlinson & Sambridge, 2003) and find low-velocity anomalies in the deeper of the northern part and in the shallower of the center part.

Keywords: ambient noise interferometry, sedimental layer, S-velocity structure