Towards the detection of the mantle-reflected P wave

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The seismic interferometry is the technique which extracts the Green’s function between a station pair by calculating the cross-correlation function (CCF) of random wavefield in a pair of station (e.g. Snieder et al., 2013). The seismic interferometry requires the isotropic and homogeneous source distribution. A microseism, which is excited by ocean swell activities, is a typical example of a random wavefield. Because a microseism is dominated by the surface wave, the seismic interferometry of microseism is suitable for estimating the velocity structure of the crust and upper mantle (e.g. Shapiro et al., 2005). However, recent studies tried to extract the body wave as well as the surface wave by the seismic interferometry. For example, some groups reported reflected P wave at the 410/660 km discontinuities (P410P/P660P) (Poli et al., 2012, Feng et al., 2013), though these studies used the continental stations. The purpose of this study is to extract the P410P/P660P and estimate the depth of discontinuities beneath Japan by application of the seismic interferometry to the vertical motion of Hi-sensitivity Seismograph Network Japan (Hi-net).

The procedures of calculation the CCF are as follows: The dataset in this study is the vertical components of 240 Hi-net stations in Southwest Japan (2007-2018). We down-sampled the original 100 Hz data to 2 Hz. We took the difference between waveforms on two successive days at the same station instead of using the original waveform to suppress the effect of the logger noise (Takagi et al., 2015) on the CCF (Takagi et al., 2019). Next, the 1-day-length waveform was split into 1024-second-length segments, and selected based on the mean square amplitude in 0.05-0.1 Hz and 0.1-0.2 Hz. Then, we calculated CCFs for every pair of station by stacking over all the selected segments with spectral whitening from 0.1 to 1.0 Hz.

Then we calculated the 4th root vespagram (Rost and Thomas 2002) using the CCFs. The vespagram showed the P410P in the 0-300 km offset and the P660P in the 50-100 km offset, with P660P weaker than P410P.

Finally, we applied the Common Middle Point (CMP) stacking to estimate the depth of discontinuity from the extracted P wave (e.g. Stein and Wysession, 2003). Station pairs with the shorter offset than 500 km were categorized into groups according to the location of the reflection point. We applied the CMP stacking with a reference model (JMA2001, Ueno et al., 2002) for each group assuming that the discontinuity depth is constant within the group. We estimated the 410 km discontinuity only, and found the lateral variation on the depth of discontinuity, especially the elevation in the group whose reflection points in 33°-36°N 134°-135°E. The pattern of the discontinuity depth is consistent with those of previous studies using earthquakes (Tonegawa et al., 2005, Tono et al., 2005).

We estimated the depth of 410 km discontinuity beneath Southwest Japan by the seismic interferometry in this study. In future studies, we will expand the study area to Northeast Japan and will estimate the depth of 660 km discontinuity.

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