Practical developments of ambient noise cross-correlation analysis for the array records in oceanic basin regions

*Akiko Takeo[1]

1. Earthquake Research Institutute, the University of Tokyo

The ambient noise cross-correlation method is a useful tool to extract wave propagations from continuous seismograms. In oceanic basin regions, this method has been used to measure phase and group velocities of surface waves, to determine crustal and uppermost-mantle shear-wave velocity structure, and finally to discuss evolution and dynamics of oceanic plates. This presentation summarizes the technical efforts to obtain azimuthal and radial anisotropy in the oceanic uppermost mantle by ERI-JAMSTEC groups (Takeo et al. 2013 JGR; 2016 JGR; 2018 G3) as well as by ERI-US collaboration (Takeo et al. 2014 GJI) in difference oceanic regions. The dataset for each region is about 2-year three-component seismograms of broadband ocean bottom seismometers (OBSs) at about 10 stations within an array of 500–1000 km. The period range of the analysis is 5–30 s.

The largest difference between land and OBS ambient noise analysis is the presence of multi-mode Rayleigh waves for the OBS data due to the existence of the water layer. At a period shorter than about 20 s, the phase velocities of fundamental-mode Rayleigh wave (0S mode) suddenly drops and the first-higher mode Rayleigh wave (1S mode) resembles 0S mode without the water layer. These 0S, 1S and sometimes higher modes have energy concentration either in the ocean layer (ocean mode) or in the shallow solid layer (solid mode), are called generalized Rayleigh waves or Rayleigh-Scholte wave, and can be seen in the ambient noise. When the interstation distance is short and the separation of these modes is unclear, waveform fitting of multi-mode is required for the phase-velocity measurement (Takeo et al. 2014). It should be noted that the ocean mode is stronger in the vertical and pressure components, whereas the solid mode is stronger in the horizontal components.

To measure phase velocities with accuracies of ~1% and estimate anisotropic structure, several minor effects typical in OBS data should be also considered. (1) The strong “local noise”, which is uncorrelated even with the nearest station and whose amplitude strongly varies with stations, affects the amplitude of cross spectrum and should be evaluated when 1-bit normalization or spectrum whitening is applied (Takeo et al. 2013). (2) Clock, instrumental response, variation in the water depth needs to be corrected (Takeo et al. 2014). (3) Although this is not typical for OBS data but even stronger for land data, the effect of inhomogeneous source distribution can be corrected (Takeo et al. 2016).

The effect of first-higher mode Love wave (1T mode) is an unsolved problem for future work. Since the crust is thin and the low-velocity zone (LVZ) is thick beneath oceanic basins, the energy of fundamental mode Love wave (0T mode) leaks into the LVZ (Takeo et al. 2015 SSJ meeting). As a result, both 0T and 1T modes are excited by force at the surface and can be seen in the ambient noise. The separation is, however, almost impossible because phase and group velocities of these two modes are very close. Additional theoretical calculations show that the bias of 1T mode to the phase-velocity measurement of 0T mode is up to ~3%, depending on the thickness of the crust and the LVZ.

After all these treatments of multi-mode surface waves and corrections and combining the measurements with those from the teleseismic surface waves at longer periods, we are or will be able to determine shear-wave velocity in the crust and uppermost mantle including azimuthal anisotropy (Takeo et al. 2016;

2018) and radial anisotropy in the future.

Keywords: Seismic Interferometry, Oceanic Basin, Uppermost Mantle

