Surface-wave phase speed distribution beneath the Japanese islands: A two-station approach

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Seismic surface waves provide us with useful information on three-dimensional heterogeneous and anisotropic structures in the crust and uppermost mantle. To investigate the local-scale heterogeneity using surface waves, a two-station method or a multiple station method has been widely used to estimate local phase speed dispersion as a function of frequency. With the recent deployment of high-density broad-band seismic networks, it is now possible to reconstruct a high-resolution local seismic model working with such conventional methods of surface wave analysis. In this study, we apply a classical but straightforward two-station method to the F-net broad-band seismic network (NIED) in Japan, and try to reconstruct phase speed distribution in the period range between 20 and 150 seconds.

In this study, we used F-net broad-band seismic stations as well as several stations in Japan, which are affiliated with the global seismic network. We chose seismic events with moment magnitude greater than 6.0 and depth shallower than 100 km. Prior to waveform processing, the response characteristics of all the seismograms are corrected with those of an STS-1 broad-band seismometer. Surface-wave arrivals are automatically picked depending on the epicentral distance based on appropriate group speed ranges (Rayleigh: 2.6-3.1 km/s; Love: 3.0-5.5 km/s). Phase spectra for seismograms are then calculated, and are applied to two-station phase speed measurements. We have chosen two-station pairs with the following criteria: the difference in azimuth from a source is less than 0.5 degrees, and the distance between two-stations are longer than 50 km. An average station interval of F-net is less than 100 km, which is suited to estimate the local phase speed dispersion between two stations down to a relatively short period of 20 seconds (whose wavelength corresponds to about 70 km for the Rayleigh wave case).

Preliminary results of Rayleigh-wave phase speed distributions at periods shorter than 50 s show a prominent slow anomaly in central Japan (the Chubu region), which is likely to be related to a thick continental crust beneath this region. In the south-western part of Japan, we can see high phase speed anomalies corresponding to the subducting Philippine-Sea plate and a slow anomaly related to mantle wedge in the period range between 20 and 70 seconds. In the eastern Japan, large-scale high speed anomalies corresponding to the subducting Pacific plate can also be identified.

The results of this study suggest that local phase speed dispersion curves are well retrieved by the simple two-station method with the dense F-net broad-band seismic network. In this study, we have employed the classical two-station method based on a great-circle path approximation. This approach may need to be improved based on a quantitative evaluation of the effects of off-great-circle propagation. In particular, such effects should be of importance in the period range shorter than 30 seconds at which surface waves are affected strongly by the heterogeneous crustal structure.