Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS034-06 Room:105 Time:May 23 09:45-10:00

Crustal structure in Japan inferred from receiver functions and comparison with those of travel time tomography

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Investigation on the crustal structure and configurations of the subducting plates is the key to understanding the stress and strain concentration process. Recently, many researchers have elucidated crustal structures in the Japansese Islands from travel time tomography analyses. However, they show different features in some areas. In this study, we estimated the seismic velocity structure and seismic velocity discontinuities of the crust and uppermost mantle beneath the Japanese Islands by using receiver function analyses, and compared them with existing results of seismic velocity structures estimated from travel time tomography.

We first searched for the best-correlated velocity structure model between an observed receiver function at each station and synthetic ones by using a grid search method. Synthetic receiver functions were calculated from many assumed one-dimensional velocity structures that consist of four layers with positive velocity steps. Observed receiver functions were stacked without considering backazimuth or epicentral distance. We further constructed the vertical cross-sections of depth-converted receiver function images transformed the lapse time of time series to depth by using the estimated structure models. Receiver function amplitudes were projected and stacked at each cross-section. Telemetric seismographic network data covered on the Japanese Islands and several temporal dense seismographic stations are used. We selected events with magnitudes greater or equal to 5.0 and epicentral distances between 30 and 90 degrees based on USGS catalogues.

As a result, we clarify spatial distributions of the crustal S-wave velocities. Average S-wave velocities from the ground surface to 5 km deep indicate thick low-velocity layers in several plain and basin areas. Although the velocities are slower than those of tomography models, the spatial patterns are corresponding with basement depth models. The velocity perturbations in the crust are consistent with tomography models. There are low-velocity zones corresponding to volcanoes in the upper crust and around the crust-mantle boundary. In the lower crust, our results show low-velocity structures in the Niigata-Kobe Tectonic Zone. From depth-converted cross-sections, we can detect the upper boundary and the oceanic Moho of the subducting plates that dipped toward northwest. High velocities near the southern coastline of the Japanese Islands correspond to the oceanic Moho of the subducting Philippine Sea plate. We also estimated the tops of the mantle depths in the overriding plate from the velocity discontinuities of layered structures and depth-converted cross-sections of receiver function images. It is deep beneath the mountain region of the land area and becomes shallow toward the surrounding seas in most part of the Japanese Islands. The tendency of depth changes is consistent to the patterns of the Moho discontinuity proposed previously, but the depths are deeper than those results in several regions. We will be able to resolve detailed whole structures by considering difference of both images.

Keywords: Receiver function analysis, Crustal structure, the Japanese Islands