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Moho discontinuity beneath the Japanese Islands inferred from grid search analysis of receiver functions

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Information on seismic velocity and seismic velocity discontinuities is important to clarify the characteristics of the seismogenic zone. In particular, investigation on the crustal structure and the crustal thickness is the key to understanding the stress concentration and strain accumulation process. Recent travel time inversion analyses have elucidated 3D velocity structures in the whole areas in the Japanese Islands. However, very few studies have paid attention to velocity discontinuities due to the limitation of spatial resolution. A receiver function analysis can extract velocity discontinuities at any depth. In this study, we applied the grid search analysis of receiver functions to estimate the depths of Moho discontinuity beneath the Japanese Islands.

We first searched for the best-correlated velocity structure model between an observed receiver function at each station and synthetic ones for 10 seconds from the direct P arrival. Synthetic receiver functions were calculated from many assumed one-dimensional velocity structures that consist of a sediment layer and one or two velocity discontinuities from the ground surface to the depths of 50 km. We considered only the positive S-wave velocity steps. Observed receiver functions were stacked without considering backazimuth or epicentral distance. 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 catalogue.

As a result, we clarify spatial changes of the depths of Moho discontinuity. They tend to increase in mountain regions and become shallow toward the surrounding areas with some undulations in most part of the Japanese Islands. This grid search analysis extracts the oceanic Moho of subducting plates in some areas near the Pacific coastline and beneath the south western Japan. This result suggests that velocity gaps of the subducting plates are larger than that of the overriding plate. We also show the Itoigawa-Shizuoka Tectonic Line (ISTL) is the boundary of the velocity structure in the Japanese Islands. The uppermost mantle along the ISTL shows relatively low P-wave velocities compared to the neighborhood areas. The southwestern Japan side is covered in the relatively high velocity and low Vp/Vs in the crust. On the other hand, the northeastern Japan side has heterogeneities of velocity perturbations. Low S-wave velocity and high-Vp/Vs areas exist just beneath the Moho discontinuity. This may be the reason the depths of Moho discontinuity interpreted from depth-converted receiver functions are deeper than the estimation from tomographic imaging and travel time of the refracted seismic waves in several areas.