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Receiver Function image of the 410 and 660km seismic velocity discontinuities beneath the Japan Islands

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In the Japan Islands, several short-period and broadband seismic networks have recently been installed and are still under construction at present, which realize one of the highest densities of station spacing in the world. Among these networks, we apply Receiver Function (RF) analyses to teleseismic P-wave coda portions observed at 63 J-array and 64 F-net broadband stations and investigate the detailed structure of the upper mantle velocity discontinuities. We examine the observed waveforms from the teleseismic events with the magnitudes greater than 5.5, which occurred during a period from 1996 to 2000. We discard almost 30,000 RFs with low signal-to-noise ratios, and finally keep a total of 5555 RFs from 153 events. Since such numbers of data and stations used in this study are largely augmented comparing with those in the previous RF analyses around the Japan Islands such as Li et al. (2000), we can reveal the far more detailed upper mantle structure.

RFs are conventionally constructed through frequency domain division of radial components by vertical ones with a water level of 0.01. The low-pass Gaussian filter of 0.3 Hz is also applied. Assuming the phases in RFs are produced by Ps converted ones at depths, we transform the time domain RFs to the depth domain ones using a reference velocity model of iasp91. This process may be called migration. Then, SVD filtering is applied to the depth domain RFs. We keep largest 6 eigenimages to construct SVD-filtered RFs. Finally, we construct 2-D stacked RF images projected on cross-sections along several profiles to see the detailed velocity discontinuity structure.

Beneath the Japan Islands, the Pacific plate (PAC) is subducting westwards from the Japan trench to a depth of 600 km, while the Philippine Sea plate (PHS) is subducting from the Nankai trough to a depth of 60-80 km in southwest Japan. Beneath the whole Japan Islands, the dipping positive RF amplitude traces can be recognized to a depth of 150 km or more, which coincide with the distribution of deep earthquakes occurring within PAC. In southwest Japan, however, we cannot clearly see the RF image of the descending PHS. In the deeper upper mantle, the remarkable positive RF traces corresponding to the 410 and 660km velocity discontinuities are recognized clearly all over the Japan Islands, while the 510 km discontinuity can not be seen except for a limited region in northeast Japan. The 410 and 660 km discontinuities are undulated due to the subducting cold PAC slab. Beneath central to southwest Japan with the highest density of conversion points of these phases, RF images remarkably delineate that the 410 km velocity discontinuity is locally elevated by about 80 km within the subducting PAC. Also, RF images indicate that the 660 km discontinuity is undulated by the stagnation of the subducting PAC, whose existence is suggested by the travel time tomography studies beneath the Japan Islands. Concretely, the 660 km discontinuity is gradually downwarped westwards toward the PAC in a larger spatial scale, whose deepest depth is about 690km.

Thus, this RF study determines the detailed structure of the upper mantle seismic discontinuity inside and outside the subducting plate, which provides important data for estimating the detailed temperature distribution at subduction zone due to the high-density seismic networks.