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Improvement on the simple stacking method based on radial and vertical components receiver functions

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Receiver function is one of an effective method to detect seismic velocity discontinuities. In order to estimate depths of discontinuities based on receiver functions, depth conversion with locally suitable velocity models or velocity inversion method are often used. For Moho depth determination, Zhu and Kanamori (2001) proposed an effective method which sums the amplitudes of receiver function at the calculated arrival times of Ps, PpPs and PsPs+PpSs phases by changing crustal thickness and crustal averaged Poisson's ratio. Suitable parameters are given as the maximum value for the sum of amplitudes. This method is often called as 'the Simple Stacking method'. This method does not require the identification of these phases and many receiver functions can be analyzed at the same time. In order to apply this method to observed receiver functions, however, we have to give an assumed P wave velocity. If the difference between assumed P wave velocity and real structure is 0.1 km/s, estimation error of Moho depth is about 1km. This error results from this analysis technique, so we should discuss how to avoid this.

In this study, we use vertical component receiver functions and propose an improved simple stacking method. Our improved method takes three parameters: thickness, P wave velocity and Poisson's ratio of the crust. Ps, PpPp and PpPs phases on radial components and PpPp on vertical components are used for the analysis. P wave velocity under station can be estimated by using PpPp phases. Vertical receiver function is estimated based on the approach proposed by Langston and Hammer (2001). Using only one receiver function, we cannot get unique parameters. However, this trade-off can be reduced by using plural receiver functions with various incidence angles. To evaluate effectiveness of this improved method, we numerically check using simple one-dimensional two or three layered velocity models. For Ricker wavelet with five incidence angles of from 20 to 40 degrees, we calculated vertical and radial components receiver functions. We use an incidence wave as a source time function. By using the conventional method, estimated Moho depth shows a few kilometers difference from the model structure if P wave velocity fluctuates 0.2km/s. On the contrary, our improved method gives the assumed P wave velocity, Poisson's ratio and depth of major discontinuity (Moho). We apply this method to the waveform observed at N.NKTH and N.SSMH stations of NIED Hi-net. By using the receiver functions of backazimuthal range from 120 to 150 degree, we estimate 6.1 km/s as the crustal P wave velocity, 3.5 km/s as S wave velocity and 25 km as thickness of crust beneath N.NKTH statioin. For the receiver functions observed at N.SSMH station, the P, S wave velocity and thickness of crust is estimated as 6.3km/s, 3.8km/s and 29km, respectively. These results are consistent with the depth-converted receiver functions using seismic velocity estimated by travel time tomography [Shiomi and Matsubara (2004)]. Although we should improve an estimation method for a source time function and should consider a suitable frequency range for analysis to get stable vertical receiver functions, this improved simple stacking method can provide one of important information for underground structure beneath seismograph station.