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Low-frequency seismic wave simulation with tuned 1-D structure

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High-quality seismograms recorded by nation-wide seismic network, Hi-net, provide a good opportunity for examining our understanding of earthquake related phenomena, or the performance of the quantitative modeling. The purpose of this study is to examine the performance of 1-D velocity structure models for simulating low-frequency (0.02 - 0.05 Hz) seismic wavefield. We investigated the performance of the conventional 1-D velocity structure model which is used for the estimation of CMT solution in Japan, and a new 1-D velocity model we proposed in this study.

First, we proposed a new 1-D velocity model based on the dispersion relations for Rayleigh and Love waves. The dispersion relations were obtained by the array analysis of Hi-net records of huge teleseismic events ($M > 8.0$). Although the conventional model fails to reproduce the observed dispersion relations, a new model which is characterized by 4 % decrease in S-wave velocities in crust and 2 % decrease in mantle can reproduce the observed dispersion relation well in the frequency range of 0.01 Hz - 0.1 Hz for both Rayleigh and Love waves.

Then, we confirmed the superiority of the new model in the point of the performance of simulating low-frequency (0.02 - 0.05 Hz) seismic-wave propagation over Japan from large earthquakes ($6.0 < M < 6.8$). We confirmed that the new velocity model was able to simulate the observed seismograms better than the conventional velocity model for many earthquakes. The new model, in particular, can simulate better the travel times of surface waves for long epicentral distance ($>\tilde{}$ 400 km). Furthermore, the centroid times obtained by the new model are systematically ($\tilde{}$ 2 sec) earlier than those by the conventional model.

Through this study, we proposed a new 1-D velocity model, which have better performance for simulating low-frequency seismic waves than the conventional model. The performance of the simulation is significantly improved for many cases but not for all the earthquakes we analyzed. For example, when the surface waves passing through Hida Mountains, the central part of Japan, we cannot well simulate the seismograms. To overcome this limitation, it would be important to extend the velocity model to have spatial varying Moho.

Keywords: Seismic wave, Simulation