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Construction of the seismic wave-speed model by adjoint tomography beneath the Japanese metropolitan area

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The Japanese metropolitan area has high risks of earthquakes and volcanoes associated with convergent tectonic plates. It is important to clarify detail three-dimensional structure for understanding tectonics and predicting strong motion. Classical tomographic studies based on ray theory have revealed seismotectonics and volcanic tectonics in the region, however it is unknown whether their models reproduce observed seismograms. In the present study, we construct new seismic wave-speed model by using waveform inversion. Adjoint tomography and the spectral element method (SEM) were used in the inversion (e.g. Tape et al. 2009; Peter et al. 2011). We used broadband seismograms obtained at NIED F-net stations for 140 earthquakes occurred beneath the Kanto district. We selected four frequency bands between 5 and 30 sec and used from the seismograms of longer period bands for the inversion. Tomographic iteration was conducted until obtaining the minimized misfit between data and synthetics. Our SEM model has 16 million grid points that covers the metropolitan area of the Kanto district. The model parameters were the Vp and Vs of the grid points, and density and attenuation were updated to new values depending on new Vs in each iteration. The initial model was assumed the tomographic model (Matsubara and Obara 2011) based on ray theory. The source parameters were basically used from F-net catalog, while the centroid times were inferred from comparison between data and synthetics. We simulated the forward and adjoint wavefields of each event and obtained Vp and Vs misfit kernels from their interaction. Large computation was conducted on K computer, RIKEN. We obtained final model (m16) after 16 iterations in the present study. For the waveform improvement, it is clearly shown that m16 is better than the initial model, and the seismograms especially improved in the frequency bands of longer than 8 sec and changed better for seismograms of the events occurred at deeper than a depth of 30 km. We found distinct low wave-speed patterns in S-wave structure. One of the patterns extends in the E-W direction around a depth of 40 km. This zone was interpreted as the serpentinized mantle above the Philippine Sea slab (e.g. Kamiya and Kobayashi 2000). We also obtained the low wave-speed zone around the depth of 5 km. It seems this area extends along the Median tectonic line and this area is correspond to the sedimentary layer. We thank the NIED for providing seismic data, and also thank the researchers for providing the SPECFEM Cartesian program package.