Gaussian-beam receiver function synthetics in a 3-D heterogeneous medium

Kazuro Hirahara[1]; Takashi Tonegawa[2]; Takuo Shibutani[3]

[1] Geophysics, Sciences, Kyoto Univ.; [2] Grad. Sch. Env. Studies, Nagoya Univ.; [3] DPRI, Kyoto Univ.

We have constructed receiver functions (RFs) observed at high-density broadband and short-period stations installed over the Japan Islands to execute successfully the mapping of the velocity discontinuities in the crust and the upper mantle; namely the mapping of the Moho beneath the Japan Islands, the slab top and the oceanic crust of the Pacific and the Philippine Sea slabs, and the lower boundary of the Pacific slab, 410 and 660 km velocity discontinuities. The mapping, however, depends on the assumed reference velocity model, in which a layered model and only radial RFs (RRFs) are employed. Actually, the transverse RFs (TRFs) have considerable amplitudes due to Ps converted phases at the inclined interfaces of the oceanic crust and slab. There have been few studies in which such TRFs are also used. RF tomography which combines the travel time tomography and the RF analyses aims at obtaining the 3-D velocity structure including velocity discontinuities. In RF tomography, iterative forward modeling of RFs is necessary and the fast computation techniques for synthesizing RFs in a 3-D heterogeneous medium including velocity discontinuities. Owing to the recent advancement of computer power, relatively short-period waveforms can be synthesized with SEM and FDM. However, iterative synthesizing of RFs which is needed in RF tomography is still formidable.

Here, we extend a computer code GBM3D developed by Sekiguchi (1992) to calculate RFs with Gaussian-Beam method (GBM). The original code can treat only the waves emitted from the source in the model space and the plane waves incident vertically at the bottom of the modeling space. Therefore, we extend to synthesize teleseismic waveforms with arbitral incident angles in the followings. As in the original code, we assume the 3-D heterogeneous velocity, Q and density structure in each layer which are interpolated by 3-D cubic spline functions and the layer boundaries are represented by 2-D ones. We set the dense grids at the bottom of the modeling space and calculate the slowness vectors and travel times at the grids from a teleseismic source, assuming a 1-D earth model outside of the modeling space. From each grid, we execute kinematic and dynamic ray-tracings for a variety of phases converted or reflected at velocity discontinuities, and sum up beams with Gaussian weights to synthesize 3-component waveforms at stations. It has been pointed out that GBM has the several tuning parameters and seems to be less reliable in some cases. For the almost vertical incident teleseismic waves, the synthetic waveforms are stable if ray beams with enough density are summed. Then RRFs and TRFs are calculated from the synthetic waveforms.