Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS26-P28 Room:Convention Hall Time:May 20 17:15-18:30

Two-dimensional Velocity Structure Inversion Using the Voxel FEM

GUO, Yujia[1*], KOKETSU Kazuki[1]

[1]Earthquake Research Institute, The University of Tokyo

In order to clarify the characteristics and mechanism of strong ground motions, it is essential to evaluate the effects of not only the source process of an earthquake but also the velocity structure where seismic waves propagate. In particular, the heterogeneity and anelastic attenuation of a velocity structure are thought to cause seismic waveforms to vary significantly. Therefore, we must reconstruct a reliable velocity structure model whose heterogeneity and anelastic attenuation are sufficiently reflected. In this study, we propose a new method to determine a two-dimensional velocity structure with heterogeneity and anelasticity, by performing a waveform inversion for P-SV wave propagation.

In the forward procedure, we use the voxel finite-element method (FEM) (Koketsu et al., 2004). A voxel mesh can be generated easily and fast, thus it is possible to compute seismograms by the use of almost the same amount of memory and time as a finite difference method (FDM). To each rectangular mesh, we apply the Glalerkin scheme and use shape functions for the first-order element. We discretize in the time domain with central and backward-difference schemes for the term of acceleration and velocity, respectively. In this two-dimensional problem, a seismic source should be a line source. Consequently, we transform approximately the line source into a point source, using the approach of Hikima (2007).

For the purpose of fulfilling broadband attenuation, we introduce Rayleigh damping (Ikegami 2009), which is the linear combination of stiffness-proportional damping and mass-proportional damping. This enables the required constant-Q spectra to be satisfied for P and SV-wave.

Because of nonlinearity of the inversion problem presented here, which is constrained least-squares optimization problem, it is solved iteratively so that its regional optimum solutions satisfy Karush-Kuhn-Tucker (KKT) condition. Our optimization approach is based on that of Askan (2006) and Askan et al.(2007). For calculating partial differential seismograms, we perform partial differentiation directly for optimality system and forward procedure simultaneously. We use the reduced optimization space approach which is feasible for the large-scale problem we consider. We choose the step length by solving the first-order minimization problem, called line search technique. We then determine the search direction with the Newton-CG method, where the Newton direction is found by making the Gauss-Newton approximation and employing the conjugate gradient (CG) method. In order to overcome multiple local minima, we use the multi-grid algorithm, in which we repeat the inversion procedure by initially solving the solution on a coarse material grid and then utilizing the solution as an initial guess for the next finer grid.

In this presentation, we show the detail of methodology of our work and the result of numerical experiment with it.

Keywords: Velocity structure, Attenuation, Finite-element method (FEM), Inversion