Investigation of crustal waveguides in Japan by waveform modeling

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The retrieval of the crustal structure using a waveform modeling technique is the main objective of this study. The waveform inversion is one of the nonlinear multi-parameter optimization problems that require efficient numerical techniques to solve the nonlinear problem. The micro-genetic (micro-GA) algorithm (Caroll, 1996) is an efficient tool for this purpose. It is used to handle the large parameter space of the velocity model parameters in this study. The micro-GA has the merit of faster convergence than the traditional GA. The Generalized Ray Theory (GRT, Helmberger, 1983) is used for the construction of synthetic seismograms for the specified ray path and the given 1-D velocity model. The GRT is specially used for this purpose for producing faster synthetics with the corresponding phase travel times. To estimate the optimum 1-D velocity model in SW Japan., we used a three-layer velocity model which can effectively explains the local/regional observed waveforms (Abdelwahed and Zhao, 2005). The three layers in the model are: surface layer, upper crust and lower crust. The high-frequency local waveforms are found to be well represented by synthetics which fit the observed waveform well.

The entire processes of the waveform analysis, genetic algorithm, and GRT are compiled into a Windows-based code (Sgraph3.5) in which the genetic search and waveform fitting are performed with high flexibility, providing a comparison plot in every genetic step.

Sensitivity tests are made to study the efficiency of the technique. The focal mechanism test shows the ability of the technique to solve the focal mechanism efficiently for a fixed velocity model. The velocity model test, similarly, shows the successful search of a target velocity model. The application of this technique to the Mid-Niigata earthquake yields a good observed-synthetic fitting for the high-frequency waveforms. The optimized velocity models are in good agreement with the average velocity model in this region. The genetic conversion curves and the well-fitted waveforms prove the reliability of the technique and its applicability to model the local and regional waveforms in Japan efficiently.