P-wave energy partition observed in Chugoku-Shikoku area

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Introduction

High-frequency seismic wavefield is significantly different from low-frequency wavefield due to the wave scattering caused by small-scale heterogeneities in the curst and mantle. For example, Nishimura et al. (2002) and Kubanza et al. (2007) reported that, in high frequencies, P-waves amplitudes are observed in transverse (T) component and this feature reflects the inhomogeneity in the media.

In order to estimate small-scale heterogeneities in the crust, we examine P-wave amplitudes in T component derived from shallow crustal earthquakes and analyze frequency- and distance-dependent properties of P-wave amplitudes in T component.

Data and Method

We use the Hi-net waveform data derived from shallow crustal earthquakes with M_{JMA} 2.0-4.0 in Chugoku-Shikoku area, Japan. Analytical methods are following; we apply band-pass filter into each waveform with 2-4, 4-8, 8-16, 16-32 Hz and synthesize root-mean-square (rms) envelope of three components by using Hilbert transform. We measure the envelope duration tq of rms envelope at each frequency band. The envelope duration tq is defined as the lag time between P-onset and the time when rms envelope decays to half of the maximum P-wave amplitude. Mean P-wave energies of each component are calculated for tq+1 sec window from 1sec prior to P-wave onset and then energy partition (EP) is evaluated as the ratio mean energy of T component over that of all components. In this study, we analyze 2138 waveform data from 22 small earthquakes at this region.

Result

The EP increases with increasing hypocentral distance and frequency. The value in the cases of 8-16 Hz and 16-32 Hz, especially, asymptotically reaches to 0.33 at distance of larger than 150 km, indicating that energy of each component is almost same. These characteristics of distant dependence indicate that the main cause of P-wave EP is propagating path effect through heterogeneous crust. In addition, EP of high-frequency components is more rapidly increasing, indicating that the effect of seismic wave scattering caused by small-scale heterogeneity in the crust is dominant factor.

Numerical Simulation

In order to confirm main cause of observed features of P-wave energy partition is seismic-wave scattering, we conduct a 3-D FDM simulation using stochastic random media. The model of 3-D FDM simulation covers a zone 204.8 km by 102.4 km by 51.2 km, which has been descretized with uniform grid size 0.05 km into 4096 by 2048 by 1024 grid points. In order to conduct such large scale 3-D simulations, we use a parallel FDM simulation technique [Furumura and Chen, 2004]. The FDM simulation uses a staggered-grid 4th-order scheme in space and a conventional 2nd-order scheme in time. The heterogeneous model of small-scale heterogeneity in the crust, was constructed by velocity fluctuation written as, $V(x) = V_0[1+g(x)]$ where V0 is the average velocity and g(x) is a random velocity fluctuation. The fluctuation g(x) is statistically characterized by the correlation length a and the rms value e. Here, we use exponential-type auto-correlation function to characterize the property of g(x) and average background velocities of P-wave and S-wave are V_P = 5.8 km and V_S = 3.36 km, respectively. We employ a point source which radiates P-wave isotropically.

In the case of correlation distance a = 5km, e = 0.05, simulation result reproduces observed features of P-wave energy partition, such as distance and frequency dependence.

We plan to conduct additional simulation using different heterogeneous structures. We also plan to analyze the data in other regions.

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