Seismic amplitude fluctuations in small-scale random velocity heterogeneous crust

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Introduction

The amplitudes of high-frequency (> 1 Hz) seismic waves during local earthquakes show large fluctuations, even at similar hypocentral distances. The cause of this observation could be interpreted by the composite effects of local site amplifications, source radiation pattern, and seismic wave scattering due to small-scale random velocity heterogeneity in the crust (e.g., Hoshiba, 2000). Yoshimoto et al. (2015) quantitatively estimated the contribution of scattering effect on *P*-wave amplitude fluctuations during crustal earthquakes using seismograms recorded from Hi-net and demonstrated that the observed features could be explained by their scattering model. However, the characteristics of *S*-wave amplitude fluctuations, which are crucial to the improvement of ground-motion prediction equations, are still unclear. In this study, to quantify the scattering effects on both *P*- and *S*-wave amplitude fluctuations, we investigated the frequency and distance changes in *S*-wave amplitude fluctuations, as well as *P*-wave amplitude fluctuations.

Data and Methods

We analyzed velocity seismograms recorded at Hi-net stations during 23 shallow strike-slip crustal earthquakes that occurred in Chugoku region, southwestern Japan. The frequency bands used in our analysis were 1-2, 2-4 and 4-8 Hz. Based on the coda-normalization method of Kobayashi et al. (2015), we analyzed the seismograms recorded at hypocentral distances less than 75 km and evaluated the maximum *P*- and *S*-wave amplitudes normalized by the averaged *S*-wave coda amplitude at lapse time of 60-70 s. Hereafter, we simply refer to the measured maximum *P*- and *S*-wave amplitudes as "*P*-wave amplitude" and "*S*-wave amplitude", respectively. To minimize the effects of source radiation pattern, we only adopted the data with large radiation pattern coefficient (>0.7) expected form CMT solutions in the homogeneous medium (Aki and Richards, 2002, Ch. 4).

Observed seismic amplitude fluctuations

S-wave amplitude fluctuations at frequencies lower than 2-4 Hz gradually increased with increasing hypocentral distance, showing about 10 times difference between the smallest and the largest *S*-wave amplitudes at hypocentral distance of about 70 km. On the other hand, high-frequency (4-8 Hz) ones rapidly increased with increasing hypocentral distance, showing 10 times difference even at hypocentral distance of about 30 km and the saturation of this trend at large distances (>30 km). We also observed very similar characteristics of *P*-wave amplitude fluctuations compared to those reported by Yoshimoto et al. (2015).

Comparing between *P*- and *S*-wave amplitude fluctuations, we found that the characteristics of the frequency and distance changes in amplitude fluctuations for *P* and *S* waves are similar. This result suggests that, as well as *P*-wave amplitude fluctuations, observed *S*-wave amplitude fluctuations were caused by the effects of scattering due to small-scale random velocity heterogeneity in the crust.

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Keywords: Amplitude fluctuation, Ground-motion prediction, Small-scale random velocity heterogeneity, Seismic wave propagation, Seismic scattering

