Criterion for the dominance of scattered Rayleigh waves in coda envelopes at low frequencies

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(1) Introduction

Recent wide distributions of broadband seismometers make us possible to explore the inhomogeneous structure of the Earth by using seismic waves. By using coda waves and their envelope shapes, we can estimate stochastic features of small-scale heterogeneities. However, since the target of theoretical modeling of coda wave envelopes of regional earthquakes has been concentrated at frequency bands above 1Hz, the period band between 0.1Hz to 1Hz has been a missing band of coda wave analysis. Although there are several reports that indicate the contribution of scattered surface waves to coda waves in that frequency range, there still is not exist a model which explains the characteristics of coda waves constituted by surface waves as a function of medium heterogeneity. At last SSJ meeting, we evaluate the contribution of scattered Rayleigh waves to coda envelopes through a theoretical formulation of the MS envelope of three-component elastic waves based on the Born approximation in randomly inhomogeneous media of a half space. In this study, we consider the criterion for the dominance of scattered Rayleigh waves based on above result.

(2) Envelope synthesis based on the single scattering model

First, we briefly summarize the envelope synthesis. We consider a localized randomly inhomogeneous cube with extent L in a half space. Here we assume that the scale L is larger than the scale length of the inhomogeneity and wavelength. Scattered waves generated by incident plane waves are evaluated by applying the Born approximation. Representing the wave field as a summation of body waves and Rayleigh waves, we can introduce the scattering of Rayleigh waves and conversion scattering between body and Rayleigh waves. For the synthesis of MS envelopes of elastic waves for a source radiation from a point, we divide the whole medium into many cubes with dimension L. Under the assumption of incoherency of scattered waves originated from different cubes, ensemble averages of MS envelopes of vector elastic waves in randomly inhomogeneous half space could be calculated by summing up the contribution of scattered waves' power from many cubes distributed all over the half space.

We simulate MS envelopes for a strike-slip type event of M=5 at 10km depth in exponential type random media whose correlation length is 2km and RMS of fractional fluctuation of velocity is 10%, where the background medium is characterized by P wave velocity 7km/s, P/S velocity ratio 1.73 and mass density 2.7g/cmˆ3. At a receiver located at the epicentral distance of 50km, we compare three-component MS envelopes. Although S-to-S (SS) scattered waves are dominant at a high frequency band at 2Hz, Rayleigh-to-Rayleigh (RR) scattered waves with slow attenuation with increasing lapse time become dominant at low frequencies at 0.125Hz.

(3) Dominant lapse time of scattered Rayleigh waves

Though this model gives a strict estimation of envelope shapes within a valid range of single scattering approximation, it is convenient to have a criterion to judge whether scattered Rayleigh waves are dominant. Here, we compare the sum of three-component MS envelope of SS scattered waves and RR scattered waves based on the assumption of collocated source and receiver. As a criterion for the dominance of scattered Rayleigh waves in coda waves, we define a dominant lapse time as lapse time when scattered Rayleigh waves become dominant over scattered S waves in coda envelope. Calculated dominant lapse times for several source mechanisms and depth becomes smaller as frequency becomes lower and the focal depth becomes shallower. For example, the dominant lapse time is 10ˆ5s at 1Hz in the medium and source characterized above. This large lapse time means that scattered Rayleigh waves do not contribute to coda waves at this frequency band. However, the dominant lapse time decreases down to 20s at 0.2Hz, which implies the strong contribution of Rayleigh waves.