Particle motion of S-wave coda in terms of energy partitioning

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Recently, coda wave interferometry has been applied for passive monitoring of temporal changes in the Earth. In terms of the applicability of the coda wave interferometry, renewed attention is paid to the nature of coda waves. It is an important issue whether single scattering or multiple scattering is dominant in S coda part. In a multiple scattering regime, equilibrium between conversion scatterings can be expected, which leads to the stabilization of S-to-P energy ratio. Shapiro et al. (2000) observed such stabilization from dense array records in Mexico, and interpreted that the multiple scattering is dominant in S coda. On the other hand, particle motion may also be useful to detect the equilibrium state, because isotropic incidence of waves is expected in the state. In this view, a polarization analysis of S coda is conducted.

Two stations of IWTH13 and IWTH17 in the Kik-net are chosen, which show small variation of seismic velocity with depth in well-log data. As a quantitative measure of particle motion, energy partitioning ratio (EPR) to three orthogonal directions of motion is calculated for the mean squared velocity envelopes in a 2-16 Hz band and in a S-coda time window with lapse time of 40-80sec at both surface and subsurface receivers,. Total number of events used is 29 for IWTH13, and 27 for IWTH17.

The EPR first reflects the source radiation pattern at the direct S-wave part, but tends to fluctuate around an average value after about 1.5 times of S-wave travel time. The EPR averaged in the time window and over events is as follows.

Subsurface at IWTH13: 0.323+-0.022 for EW, 0.329+-0.025 for NS, 0.348+-0.033 for UD.
Subsurface at IWTH17: 0.338+-0.027 for EW, 0.325+-0.027 for NS, 0.337+-0.027 for UD.
Surface at IWTH13: 0.388+-0.019 for EW, 0.425+-0.031 for NS, 0.187+-0.030 for UD.
Surface at IWTH17: 0.422+-0.023 for EW, 0.393+-0.027 for NS, 0.185+-0.031 for UD.

According to the results, equal partitioning of energy is realized at subsurface receivers of the two stations. Hoshiba et al. (2002) already noticed that similar characteristics can be found at subsurface receivers of the Kik-net. On the other hand, the EPR at the surface receivers is different from that at the subsurface receivers. In this study, a theoretical calculation is performed to explain the results at the surface receivers. For a Poisson solid in an equilibrium state, S-to-P energy ratio is about 10.4. Under an assumption that P, SV, and SH plane waves with this energy ratio are isotropically incident on the free surface in a homogeneous half space, the EPR becomes 0.41 for two horizontal components and 0.18 for vertical component. Contribution from surface waves is not incorporated in the calculation. These values show a good agreement with our observation. This shows that two stations used in this study can be modeled by a homogeneous half space, and that contribution from surface waves is negligible in the frequency range of 2-16Hz. And this agreement also implies that the assumption on the S-to-P energy ratio is reasonable. Generally speaking, the EPR can be affected by subsurface velocity structures. For example, low velocity layers reduce the EPR for vertical component, because body waves are incident on the surface with smaller incident angles. So, the EPR may be a measure for the shallow velocity structure if contamination by surface waves can be neglected.

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