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Heterogeneity beneath Japan as inferred from energy partitioning of P-wave and implication for seismic radial anisotropy

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Seismic radial anisotropy is generally attributed to horizontal layering (especially with thin fluid layer and fluid-filled cracks) and/or large-scale deformation in the lower crust and upper mantle, and it has been extensively studied by surface wave analyses in order to elucidate geodynamical processes and fluid circulation. However, use of surface waves having long wavelength makes it rather difficult to discriminate between solid-fluid layering and TI anisotropy of the media. On the other hand, it is also known that the short-wavelength heterogeneity in the crust and upper mantle causes the scattering phenomena of high-frequency seismic waves such as the excitation of transverse component of teleseismic P-wave.

In this study, by systematically analyzing the excitation of transverse component of P-wave observed at NIED Hi-net stations, we map spatial variation of the heterogeneity beneath Japanese island and examine the detectability of radial anisotropy. We also compute the wave scattering in anisotropic random media using the finite difference method, and study the dependence of excitation of transverse component to the propagation direction.

In the data processing, for each frequency band, we calculate the energy partition of direct P-wave into the transverse component at each station. After averaging over events with different incident azimuthal direction and incident angle, spatial variation of the normalized transverse energy shows consistent feature with the tomographic image and spatial variation of coda-Q. This result suggests that the observation of energy partition is a good measure to characterize the structural heterogeneity. On the other hand, the normalized transverse energy also shows dependence to the incident angle, which cannot be explained by wave propagation in simple isotropic random media. To understand the cause of the angular dependence of the normalized transverse energy, we conducted finite difference modeling of the wave scattering due to anisotropic random media and examine the effects of incident angle. The results of numerical modeling indicate that the observed characteristic can be explained by oblique propagation of P wave into anisotropic random media having longer correlation distance in horizontal directions. These results imply that it may be possible to have new insight into the cause of radial anisotropy, deformation field, and fluid distribution beneath Japanese island.

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Keywords: Seismic wave propagation, Seismic wave scattering, Geofluid