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マルチモード表面波による上部マントル鉛直異方性の制約
Constraining radial anisotropy in the upper mantle with multi-mode surface waves

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The radial anisotropy of shear waves represents the differences in the propagation speeds between vertically polarized shear waves (SV) and the horizontally polarized ones (SH), and can be a key to the understanding of the dynamic processes in the upper mantle. Seismic surface waves are the most powerful tool to determine the spatial distribution of the radial anisotropy. Some recent studies have revealed the existence of a layer with strong radial anisotropy (with SH >SV) beneath the lithosphere; e.g., under the Pacific plate (Nettles & Dziewonski, 2008, JGR) and the Australian continent (Yoshizawa, 2014, PEPI). This is, however, not always the case and there are also some studies on radial anisotropy that do not show such a clear layer with SH>SV beneath the lithosphere. These differences may be related to the differences in model parameterization.

For the inversions of multi-mode phase speeds of Rayleigh and Love waves for radial anisotropy of shear waves, we can use either set of model parameters for the representation of the anisotropic S velocity; i.e., (A) SV velocity (Vsv) and SH velocity (Vsh), or (B) SV velocity (Vsv) and radial anisotropic parameter ξ =(Vsh/Vsv)^2. The choice of model parameters for inversion is arbitrary, but, through synthetic experiments, we have confirmed that this difference causes non-negligible effects on the reconstruction of radial anisotropic properties of shear waves. This is mainly caused by the differences in the sensitivity kernels of Love-wave phase speeds to Vsv, Vsh and ξ.

For the set of parameters (B) [Vsv, ξ], Love waves always have the largest sensitivity to Vsv with suppressed sensitivity to ξ, and the kernel shapes for both Vsv and ξ are nearly identical. On the other hand, for the parameterization with (A) [Vsv, Vsh], Love wave phase speeds are controlled primarily by the kernels for Vsh, which have the largest sensitivity to Love wave phase speeds with little influence from Vsv, which can be better (and independently) constrained by Rayleigh waves.

Such intrinsic differences in the sensitivities of surface waves can lead to the different results in the estimation of radial anisotropy. Our synthetic experiments suggest that the parameterization with [Vsv, Vsh] would be preferable particularly when the radial anisotropy with SH>SV is caused by anomalously slow SV velocity, which is consistent with the recent anisotropy models reported in the fast moving Pacific and Australian plates. We have also found that the strong dependence of the retrieved anisotropy on the initial model, when we use [Vsv, ξ] as model parameters.
Keywords: radial anisotropy, surface waves, upper mantle, lithosphere, asthenosphere