Mapping azimuthal anisotropy in the Australasian upper mantle with multi-mode surface waves

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Azimuthal anisotropy in the upper mantle from seismic surface waves provides us with the information of mantle dynamics, such as the present-day mantle flow and the remnant of past deformation in the lithosphere. The Australian plate is currently the fastest-moving tectonic plate including a large continent, encompassed by the intensive seismicity, particularly in its north (Indonesia) and east (Tonga-Kermadec to New Zealand). Thus, the entire continent can be covered by dense ray paths utilizing broad-band seismic stations deployed throughout the continent. This unique tectonic setting of the Australian plate allows us to reconstruct high-resolution tomography models in the Australasian region.

In this study, we construct azimuthally anisotropic phase speed maps of multi-mode surface waves incorporating azimuthal anisotropy, which are then used to construct three-dimensional S wave models with azimuthal anisotropy. We employ the database of path-specific multi-mode phase speeds for the fundamental mode and up to the fourth-higher modes surface waves by Yoshizawa (2014), which has been measured by using the non-linear waveform fitting method (Yoshizawa & Ekstrom, 2010).

The results suggest that the fast-axis of azimuthal anisotropy in the upper mantle is nearly parallel to the absolute plate motion (APM) in the oceanic area, but is more complicated in the continental area. The azimuthal anisotropy beneath the Australian continent above 150 km depth reflects the past deformation frozen in the lithosphere, which is characterized by the E-W oriented anisotropy. However, below 150 km depth, azimuthal anisotropy tends to represent the present-day shear flow in the asthenospheric mantle beneath the cratonic lithosphere, which moves to the north. Beneath the Tasman Sea between New Hebrides Trench and New Zealand, we can see the circular pattern of azimuthal anisotropy, especially at a shallower depth above 200 km.

The thickness of the Australian lithosphere becomes thinner toward the eastern margin of the continent, which is well reflected in the cross-sections of the azimuthally anisotropic S wave model. The agreement between APM and azimuthal anisotropy can be observed at the depth below the lithosphere-asthenosphere transition estimated from the isotropic S wave speed model, indicating the effects of mantle flow under the fast drifting Australian continent.

Keywords: azimuthal anisotropy, surface wave, upper mantle, Australia

