Direct inversion of 3-D shear wave speed azimuthal and radial anisotropy from surface-wave traveltime data: methodology and applications

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Seismic anisotropy plays a key role in understanding deformation patterns of Earth's material. Surface wave dispersion data have been widely used to invert for azimuthal and radial anisotropy of shear wave speeds in the crust and upper mantle typically based on a 1-D pointwise inversion scheme. Here we present new methods of inverting for 3-D shear wave speed azimuthal and radial anisotropy directly from surface-wave traveltime data with the consideration of period-dependent surface wave raytracing. For the inversion of 3-D azimuthal anisotropy, our new method includes two steps: (1) inversion for the 3-D isotropic Vsv model directly from Rayleigh wave traveltime data (DSurfTomo; Fang et al., 2015, GJI); (2) joint inversion for both 3-D Vsv azimuthal anisotropy and additional 3-D isotropic Vsv perturbation. The joint inversion can significantly mitigate the trade-off between the strong heterogeneity and azimuthal anisotropy. We apply the new method (DAzimSurfTomo) (Liu et al., 2019, JGR) to a regional array in Yunnan, southwestern China using the Rayleigh-wave phase velocity dispersion data in the period band of 5-40 s extracted from ambient noise interferometry. The obtained 3-D model of shear wave speed and azimuthal anisotropy indicates different deformation styles between the crust and upper mantle in southern Yunnan. For the inversion of 3-D radial anisotropy, we presented a new inversion matrix that directly inverts Rayleigh and Love wave traveltime data jointly for 3-D Vsv and radial anisotropy parameters (Vsh/Vsv) simultaneously without intermediate steps (Hu et al., submitted to JGR). The new approach allows for adding the smoothing or model regularization terms directly on the radial anisotropy parameters, which helps to obtain more reliable radial anisotropy structures compared to the previous division approach (Vsh/Vsv) from separate inversion of Vsv and Vsh structures. We apply this new approach (DRadiSurfTomo) to the region around the eastern Himalayan syntaxis using ambient noise dispersion data (5-40s). The obtained 3-D Vs and radial anisotropy models reveals complex distribution of crustal low velocity zones and spatial variation of deformation patterns around the eastern syntaxis region.