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Illuminating heterogeneous anisotropic upper mantle: testing a new anisotropic teleseismic body-wave tomography code - part II: Inversion mode

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Considering only isotropic wave propagation and neglecting anisotropy in teleseismic tomography studies is a simplification obviously incongruous with current understanding of the mantle-lithosphere plate dynamics. Furthermore, in solely isotropic high-resolution tomography results, potentially significant artefacts (i.e. amplitude and/or geometry distortions of 3D velocity heterogeneities) may result from such neglect. Therefore, we have undertaken to develop a code for anisotropic teleseismic tomography (AniTomo), which will allow us to invert the relative P-wave travel time residuals simultaneously for coupled isotropic-anisotropic P-wave velocity models of the upper mantle. To accomplish that, we have modified frequently-used isotropic teleseismic tomography code Telinv (e.g., Weiland et al., JGR, 1995; Lippitsch, JGR, 2003; Karousova et al., GJI, 2013). Apart from isotropic velocity heterogeneities, a weak hexagonal anisotropy is assumed as well to be responsible for the observed P-wave travel-time residuals. Moreover, no limitations to orientation of the symmetry axis are prescribed in the code. We allow a search for anisotropy oriented generally in 3D, which represents a unique approach among recent trials that otherwise incorporate only azimuthal anisotopy into the body-wave tomography. The presented code for retrieving anisotropy in 3D thus enables its direct applications to datasets from tectonically diverse regions.

In this contribution, we outline the theoretical background of the AniTomo anisotropic tomography code. We parameterize the mantle lithosphere and asthenosphere with an orthogonal grid of nodes with various values of isotropic velocities, as well as of strength and orientation of anisotropy in 3D, which is defined by azimuth and inclination of either fast or slow symmetry axis of the hexagonal approximation of the media. Careful testing of the new code on synthetics, concentrating on code functionality, strength and weaknesses, is a necessary step before AniTomo is applied to real datasets. We examine various aspects coming along with anisotropic tomography such as setting a starting anisotropic model and parameters controlling the inversion, and particularly influence of a ray coverage on resolvability of individual anisotropic parameters. Synthetic testing also allows investigation of the well-known trade-off between effects of P-wave anisotropy and isotropic heterogeneities. Therefore, the target synthetic models are designed to represent schematically different heterogeneous anisotropic structures of the upper mantle. Testing inversion mode of the AniTomo code, considering an azimuthally quasi-equal distribution of rays and teleseismic P-wave incidences, shows that a separation of seismic anisotropy and isotropic velocity heterogeneities is plausible and that the correct orientation of the symmetry axes in a model can be found within three iterations for well-tuned damping factors.