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# Fine 3D imaging of upper-mantle anisotropy from full-waveform inversion of teleseismic P and S body waves

Stephen Beller and Sébastien Chevrot
CNRS, GET, Toulouse, France (beller.stephen@gmail.com)

In principle, finely resolved images of upper-mantle seismic anisotropy should allow us to constrain the distribution and localization of finite deformation within the lithosphere-asthenosphere system. To date, most seismic inferences about upper-mantle anisotropy come either from the analysis of the birefringence of SKS waves or from surface wave tomography. Despite their popularity, both techniques have their own limitations: the former is characterized by a poor vertical resolution and mostly constrain azimuthal anisotropy while the latter suffers from a poor horizontal resolution.
Recently, new developments in computational seismology have provided opportunities for applying full-waveform inversion (FWI) to records of teleseismic waves for tomographic imaging at lithospheric scale. Teleseismic FWI is formulated as a non-linear local optimization problem which iteratively minimizes the sample-to-sample waveform difference between recorded and modeled seismograms. Affordable modeling of teleseismic waveforms is obtained by a grid injection technique based on the spectral-element method.
In this study, we extend this methodology to anisotropic media of arbitrary symmetry class. Modeling and inversion are performed considering a parametrization of the medium in terms of density and the 21 coefficients of the elasticity tensor (i.e. a triclinic symmetry) which are jointly updated with a preconditioned l-BFGS optimization algorithm. In this approach, no a priori assumption is made on the symmetry class or the symmetry axes orientations. A particular parametrization (e.g. hexagonal) is only introduced at the end – after full convergence of the inversion procedure by decomposition of the final elasticity tensors obtained at each point of the tomographic grid. This decomposition is done by projection onto higher and higher symmetry classes using the theory of Browaeys and Chevrot (2004).
The ability of the proposed methodology to recover anisotropic parameters perturbations is investigated through simple synthetic experiments. We show that (1.) anisotropic FWI of teleseismic body-waves is efficient in recovering both depth and lateral variations of seismic anisotropy parameters, and (2.) the proposed methodology can accurately constrain the 3D orientation – that is the dip and azimuth angles – of the recovered elastic tensors. We further investigate the contribution of incident wave types (P versus SKS waves) over the reconstruction of anisotropic models and review potential trade-offs and leakages between isotropic and anisotropic parameters.