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Imaging 3D variations of upper-mantle anisotropy from teleseismic full-waveform inversion

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Upper-mantle seismic anisotropy provides direct constraints on the distribution and localisation of finite deformation and mantle dynamics. To date, the most frequent technique used to infer lateral variations of seismic anisotropy relies on the analysis of the birefringence of SKS waves. Owing to their near vertical propagation, these waves are commonly thought to provide no vertical resolution and are thus not generally considered for 3D imaging of seismic anisotropy. However, the depth resolution can be improved by considering finite-frequency effects and the full-complexity of seismic waveforms.
Recent developments in computational seismology have provided opportunities for cheap generation of complete synthetic seismograms for propagations at lithospheric scale, opening the way for full waveform inversion of teleseismic records. Modelling of teleseismic waveforms is tackled by means of an hybrid technique based on the spectral-elements method. Full-waveform inversion (FWI) is formulated as a non-linear local optimisation problem minimizing the sample to sample waveform difference between recorded and modelled seismograms.
In the current study, we extend this methodology to anisotropic media of arbitrary symmetry. Modelling and inversion are performed considering a parametrization characterized in terms of density and the 21 coefficients of the fourth-order elasticity tensor (triclinic symmetry). In our approach, no a priori assumption is made on the symmetry class or on the orientation of symmetry axes. The consideration of a particular parametrization (e.g. hexagonal) is only introduced at the end, after convergence of the inversion. The final elasticity tensors are decomposed by projection onto higher and higher symmetry classes using the theory of Browaeys and Chevrot (2004). The ability of the proposed methodology to recover both vertical and lateral variation of anisotropic parameters is investigated through simple synthetic experiments, considering various experimental settings and types of incident body waves (S, SKS and P waves).