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Numerical modelling of the upper mantle anisotropy beneath a migrating strike-slip plate boundary: the San Andreas Fault system

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We performed forward modelling of seismic anisotropy beneath a migrating strike-slip plate boundary to: (1) test if such a geodynamic context might explain teleseismic shear-wave splitting data in the vicinity of the central part of the San Andreas Fault, and (2) constrain the power of such data to unravel vertical and lateral variations in deformation patterns in the upper mantle. The modelling involves five steps: (1) thermo-mechanical modelling, using a finite-element code, of the deformation field, (2) viscoplastic self-consistent modelling of the resulting olivine and pyroxene crystal preferred orientations, (3) calculation of the elastic tensors for different domains of the finite elements (FE) model, (4) forward modelling of seismic wave propagation through the model using ray theory, finite-frequency theory, and a full wave approach, and (5) performing splitting measurements on the synthetic seismograms. SKS splitting data in central California are best fitted by a model with a hotter geotherm within 60 km of the plate boundary accounting for the opening of an asthenospheric window due to the northward migration of the Mendocino Triple Junction. The westward motion of the plate boundary cannot however explain the rotation of fast polarisations east of the San Andreas Fault in central California. Comparison between modelled and measured individual shear-wave splitting also implies that the homogeneity of the 2-layer models accounting for the observations in the vicinity of the San Andreas Fault indicates a sharp transition between lithospheric and asthenospheric deformations beneath this plate boundary. The ability of different synthetic approaches to localize horizontally and vertically the plate boundary-related deformation differs significantly. Splitting data on ray theory synthetics closely follow variations in olivine crystal preferred orientations in the model. In contrast, splitting analysis on full-wave synthetics, which should be more representative of actual long period SKS waves, results in smooth lateral variations of the anisotropy; the location and width of the plate boundary may only be retrieved by comparing fast polarisation profiles obtained using a multichannel analysis on waves with different periods.