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New insights into tomographic image interpretation and upper mantle dynamics by combining geodynamic modelling and seismological methods

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Earth's crust and upper mantle (above 400 km) exhibit strong anisotropic fabrics which reflect the strain history of the rocks and can provide important constraints on mantle dynamics and tectonics. Although the well-established anisotropic structure of Earth's upper mantle, the influence of elastic anisotropy on the seismic tomography remains largely ignored. It is in fact commonplace to neglect the effects of seismic anisotropy in the construction of tomographic models assuming an isotropic Earth. This approximation certainly simplifies the computational approach but can introduce notable imaging artefacts hence errors in the interpretation of the tomographic results.

Here, we want to bring new insights into the 3D upper mantle structure and dynamics by combining geodynamic modelling and seismological methods taking into account seismic anisotropy.

An ideal environment for studying seismic anisotropy and related geodynamic processes is the Central-Western Mediterranean, that, in the last 20-30 million years, has experienced a complex tectonic activity characterized by back-arc extension related to slab retreat in the Liguro-Provençal, Alborean, Algerian and Tyrrhenian basins and episodes of slab break-off, lateral tearing and interactions between slabs.

Firstly, we apply the modelling methodology of Lo Bue et al., 2021 to reproduce the geodynamic evolution of the study region over the last 20-30 Myr. We validate this geodynamic model by comparing seismological synthetics (e.g., SKS splitting) and major tectonic features (i.e., slab and trench geometry) with observations. Next, we use the elastic tensors of the present-day modelled Mediterranean set-up to performed 3D P-wave anisotropic tomography by inverting synthetics delay times as in VanderBeek and Faccenda, 2021 validated through comparison with the geodynamic reference model.

In this work, we attempt to answer some fundamental questions. Compared to Lo Bue et al., 2021 how does using a more complex initial geometry affect the geodynamic modelling result? How well

does P-wave anisotropic tomography recover the isotropic and anisotropic features? By performing purely isotropic inversions, which are the main artefacts introduced in the tomographic image by neglecting seismic anisotropy? How much the vertical smearing effect bias P-wave tomographic models?

References

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