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A hybrid computational Framework for 3D anisotropic full-Waveform inversion at a regional scale

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Seismic anisotropy exists in various depths on Earth. However, computational complexities and limited data coverage often lead many seismic tomographic efforts to neglect it. This isotropic assumption can lead to various misinterpretations, which become more important when the spatial resolution is increased.

In our project, we aim at constructing, through full-waveform inversion, a 3D seismic model of upper mantle anisotropic structure (approximately 500 km depth) below the Tyrrhenian Sea -- a region of great geodynamic interest mainly because of the Calabro-Ionian subduction zone.

Here we present the framework and the forward modelling, based on the joint use of SPECFEM3D and AxiSEM software, for the implementation of the so-called "box tomography" [1]. By this, a 3D, anisotropic, model spans the region that we aim to resolve, whereas the rest of the globe is represented by a 1D model with lower resolution. This methodology allows the inclusion of teleseisms -- thus a much larger dataset than allowed by closed-domain modelling, as we can also use numerous seismic events out of the region of interest recorded by the dense network of stations within it. We show that this approach in fact highly improves the coverage of data, that can be used for inversion.

We use SPECFEM3D for the region of interest and AxiSEM for the global simulation. We process the topography, seismic velocities and anisotropy, in order to construct a realistic 3D input model for the area of interest, that honours the Earth's curvature and transforms the geometry of an a priori model from geographical to Cartesian coordinates, with respect to a point of reference, situated in the middle of the top layer of the constructed mesh. We then process the waveforms, resulting from such forward simulation, with the application of a rotation from the Cartesian coordinates to the geographical ones, in order to perform the inversion with the use of real data of seismic recordings. The forward modelling is then to be used for computation of anisotropic Fréchet kernels and inversion.

[1] Yder Masson, Barbara Romanowicz, Box tomography: localized imaging of remote targets buried in an unknown medium, a step forward for understanding key structures in the deep Earth, Geophysical Journal International, Volume 211, Issue 1, October 2017, Pages 141–163,

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