Geophysical Research Abstracts
Vol. 17, EGU2015-7275, 2015
EGU General Assembly 2015

The western Mediterranean subduction system – Insight from full-waveform inversion

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We present a new 3D model of anisotropic S- and P-velocity from the surface to 1,300 km depth beneath the western Mediterranean region.

The construction of our model is based on the combination of spectral-element simulations of anisotropic, visco-elastic wave propagation with adjoint techniques. Spectral-element simulations provide highly accurate synthetic seismograms for nearly arbitrarily heterogeneous media, thereby reducing artefacts related to simplifications of the forward model. Adjoint techniques allow us to compute sensitivity kernels efficiently, which is essential for iterative gradient-based optimisation.

Our model of the western Mediterranean is embedded in a larger Eurasian model. While we model and invert waves at periods from 30 to 200 s within Eurasia, we use a broader band from 12 to 200 s for the smaller western Mediterranean submodel. This multi-scale strategy allows us to simultaneously invert for crustal and mantle structure. Benefits of this approach include the absence of crustal corrections, and more reliably imaged anisotropy.

The majority of seismic data used in our full-waveform inversion were recorded by IberArray and other temporary networks, as well as permanent regional networks, thus providing excellent coverage of the Iberian Peninsula, northernmost Africa, and the western Mediterranean basin. For the inversion we use those parts of the seismograms where observed and synthetic waveforms are sufficiently similar to allow for the meaningful measurement of time- and frequency-dependent phase differences.

In our final model we quantify resolution with the help of second-order adjoints that can be used to compute direction- and position-dependent resolution lengths, as well as inter-parameter tradeoffs. The model reveals a complex system of high-velocity anomalies that may be interpreted as signatures of subducted Tethyan slabs. While subducting slabs beneath the eastern Mediterranean region may penetrate into the lower mantle, western Mediterranean slabs appear to stagnate around 660 km depth.