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Imaging density and seismic velocities in the Eastern Mediterranean

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The Mediterranean domain is a tectonically active and geologically complicated region. This is a result of its complex geodynamic evolution which is dominated by convergence between the African and Eurasian plates. Our understanding of it draws from surface geology, modeling and imaging of the subsurface.

Here, we present a seismic waveform tomography of the Eastern Mediterranean. While computationally more expensive than ray-based imaging methods, the advantage of waveform methods lies in their ability to incorporate in a consistent manner all the information in seismograms – not just the arrivals of certain, specified phases. As a result, body and multimode surface waves, source effects, frequency-dependence, wavefront healing, anisotropy and attenuation are naturally and coherently incorporated. This not only allows us to image P- and S-wave velocity jointly for the crust and mantle, but also makes it possible to put constraints on density that ray tomography cannot provide. This is of special interest because heterogeneities in density drive geodynamics, and the combined knowledge of all parameters can help to distinguish between thermal and compositional effects.

Our tomography makes use of a multi-scale approach, initially using only the very lowest frequency signals with periods of 100–150 s and going down to periods of 40 s. The low-frequency data is not only important in order to avoid local minima in the optimisation – also the recovery of density relies crucially on it. As the model is updated and more of the data is explained by it, higher-frequency data is added and more parts of the seismogram are included. Only those parts are used in which data and synthetics are similar enough to allow for meaningful comparison. Resolution of the final model is assessed using a resolution analysis strategy developed by Fichtner & van Leeuwen (JGR, 2015). This helps us to evaluate the effects of smearing and heterogeneous ray coverage in a quantitative manner.

Our work aims to provide a coherent model for the crust and upper mantle in the Eastern Mediterranean that includes seismic velocities, anisotropy and density. Taken together, these parameters may help shed light on the nature of anomalies as slabs, thermal provinces or compositional heterogeneity.