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Imaging density and seismic velocities in the Eastern Mediterranean

Nienke Blom (1), Alexey Gokhberg (2), and Andreas Fichtner (2)
(1) Universiteit Utrecht, Earth Sciences, Utrecht, Netherlands (n.a.blom@uu.nl), (2) ETH Zürich, Earth Sciences, Zurich, Switzerland (andreas.fichtner@erdw.ethz.ch)

The Mediterranean domain is a geologically complicated region, a result of its complex tectonic and geodynamic evolution. Our understanding of it draws from surface geology, modeling and imaging of the subsurface.
Here, we present the first results of seismic waveform inversion of the Eastern Mediterranean region. While computationally much more expensive than more traditional ray-based imaging methods, the advantage of waveform tomography lies in its 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 additional 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 would help to distinguish between thermal and compositional effects in the subsurface, where no direct measurements can be made.
Our tomography makes use of a multi-scale approach, initially using only the very lowest frequency signals of periods of around 100-150 seconds which corresponds to structures of ∼200 km size in the crust. Slowly, higher-frequency data is added as the model is updated and more of the data is explained by it. Our ultimate aim is to go down to periods of ∼10 seconds, which corresponds to structures of about 15 km size in the crust to ∼25 km in the mantle. Only those parts of the seismograms are used in which data and synthetics are similar enough to allow for meaningful comparison. As iterations progress and synthetics become more similar to the data, more parts of the seismogram can be included. Resolution of the final model is assessed using a resolution analysis strategy developed by Fichtner & van Leeuwen (JGR, 2015), which helps us to assess the effects of 'smearing' and heterogeneous ray coverage and gives an indication of trade-offs between parameters.
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.