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Full seismic waveform tomography for the Iranian plateau

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We present initial results of an ongoing study where we aim to constrain 3-D crustal and upper-mantle structure of the Iranian plateau. Our study area was formed by the convergence of the Arabian and Eurasian plates, which resulted in a continental collision zone (Zagros,Caucasus, Albors, Kopet-Dag and Talesh) and the Makran subduction zone. Since Iran has high potential to host large earthquakes, a 3-D model is essential for accurate assessment of earthquake-induced hazards. It furthermore presents a good opportunity to study in more detail the geometry of subducted slabs, the nature of continental convergence in the Zagros, as well as Moho depth variations.

The extent of our model is between 25°N and 40°N in latitude and 42°E and 63°E in longitude. We use 83 broadband seismic stations of the Iranian seismological center (IRSC) and International Institute of Earthquake Engineering and Seismology (IIEES), and 146 earthquakes with magnitude Mw>4.5 that occurred in the region between 2012 and 2017.

To obtain a detailed tomography model of the area, we use full-waveform inversion which has the ability to incorporate all types of waves recorded in the seismogram, including body waves as well as fundamental- and higher-mode surface waves. For the forward problem solution we use our newly developed spectral-element solver Salvus, which allows us to simulate wavefields in highly heterogeneous, attenuating and anisotropic media, while respecting surface topography. For data management and workflow organisation, we employ the Large-Scale Inversion Framework (LASIF), modified to operate with the Adaptable Seismic Data Format (ASDF), which facilitates simulations on large HPC clusters.

As a first step, we generate a mesh appropriate for the region. For this we use the Salvus mesher, which automatically honours topography and tries to optimise the mesh for spectral-element simulations. The subsequent optimisation problem is solved using an iterative approach which employs adjoint methods to calculate the gradient and uses steepest descent and conjugate-gradient methods to minimize the objective function. Each iteration of such an approach is expected to bring the model closer to the true model.