Velocity Structure of the Iran Region Using Seismic and Gravity Observations

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Iron and Surrounding Area

The recent tectonics of Iran are dominated by continental collision between Arabia and Iran and the subduction of the Indian Ocean plate beneath the Makran. These plate interactions produce a dominant N26°E compressional strain across much of the country. On a broad scale, deformation within Iran is localized within the Zagros, Alborz, and Kopet-Dag mountainous regions, although moderate and deadly seismic activity occurs along the boundaries of the relatively stable Central Iran, Lut, and South Caspian blocks. The region contains some relatively sharp geologic transitions, notably the continental-ocean boundary and the transition from the Arabian plate to the Russian platform northeast of Iran, as well as complexities associated with the Caspian and Black Sea basins. With the exception of the Late-Proterozoic age Arabian Shield, much of the focus area consists of relatively young, Phanerzoic terranes accreted onto the southern Eurasian plate during the closing of the Tethys Ocean.

Data

Seismic body wave travel times

P- and S-arrivals from 3750 earthquakes occurring between 1973 and 2013 are included. Only earthquakes that satisfy the condition of having a secondary azimuthal gap < 180°, calculated over the entire range of epicentral distances are included. The secondary azimuthal gap is the largest azimuth gap that is filled by a single station. Focal depths are color-coded.

Gravity observations

Gravity data are extracted from the global Earth Gravitational Model EGM2008 - publicly released by the U.S. National Geospatial-Intelligence Agency. Free-air gravity anomalies for are shown here. Data are filtered prior to the joint inversion to remove long-wavelength features.

Surface wave dispersion curves

Rayleigh wave group velocities are measured from vertical-component data. 2D frequency-dependent tomographic inversions result in velocity maps for frequencies between 10-34 Hz. These maps are sampled at the grid nodes used for the joint inversion, and these resulting dispersion curves are used as input.

Results

Vp model

Checkerboard Tests

Tradeoff analysis

Based on checkerboard tests with different anomaly sizes and velocity perturbations, we conclude that we can robustly resolve 5 layers in the crust and upper mantle with a horizontal grid parameterization of 1 x 1 degrees.

Work in progress

Can multiparameter tomography improve travel time predictions and source locations?

The first-order goal of tomography is to derive improved models of Earth structure. The nature of “improvements” is not easy to judge, however. Here, we try to address the question: “Can multi-parameter tomography address crustal heterogeneities and areas of limited coverage, and improve travel time predictions?” The implication of this question is that improvements in theoretical travel times calculated from a model based on multi-parameter tomography could lead to improved location accuracy. We consider the extent to which relocating the events in the joint inversion moves them away from the starting locations. We present two versions of this test, one based on an inversion of travel-time data only, and the second being a joint inversion of travel-time and gravity data.

Code optimization

Ray tracing using the finite-difference method employed in our code JointTomFoD is computationally expensive for a region the size of Iran. A new version of the code using a modified pseudo-bending ray-tracer is currently being implemented, which will sell a thorough and robust testing of regularization parameters and relative data weighting.

Adding surface waves & gravity

Dispersion curves resulting from recent surface wave analyses are currently being incorporated in the joint inversion. These are expected to greatly improve shear-wave velocity recovery and help constrain deeper portions of the velocity model. Below depths sampled by body waves from the deepest regional seismicity.

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