Crustal structure of the Central Alborz, Iran from inter-event interferometry

Mahsa Afra¹, Taghi Shirzad², Jochen Braunmiller¹, Habib Rahimi³, and Mojtaba Naghavi³
¹University of South Florida, School of Geosciences, United States of America (mahsaafra@mail.usf.edu)
²Institute of Geophysics, Polish Academy of Sciences, Krakow, Poland
³Institute of Geophysics, University of Tehran, Tehran, Iran

Seismic interferometry can be used to turn earthquakes into virtual seismic sensors. Cross-correlation of seismic traces from two earthquakes recorded at the same actual sensor and summation of cross-correlations from many actual sensors result in the (strain) Green's function between the two earthquakes. This simple concept provides an exciting new way for high-resolution imaging of subsurface structures in areas with poor instrument coverage. We test and apply this method to the Central Alborz region of Iran where we can compare results with regular local earthquake tomography. We first extracted the Rayleigh wave group velocities (\(U\)) from the Green's functions and then inverted them for the upper crustal Rayleigh wave maps. We used vertical seismograms from 819 well-located Mw<4 earthquakes with vertical and horizontal location uncertainties of less than 2.5 km recorded between January 2006 and May 2019. The recordings are from seismic stations operated by the Iranian Seismological Center, the International Institute of Earthquake Engineering and Seismology, and the Tehran Disaster Management and Mitigation Organization. Pre-processing of each seismic trace consisted of removing the mean, detrending, instrument response correction, and 1-20 s band-pass filtering. We cross-correlated event-pairs at all available actual sensors and stacked the cross-correlations to obtain the inter-event empirical Green's function (EGF); we used the phase weighted stacking procedure to enhance the signal-to-noise ratio of the EGF. We then applied the classical FTAN method to calculate the group velocities from the Rayleigh wave dispersion measurements. Cross-correlations, stacking and dispersion analysis were performed for all available event-pairs. Finally, we inverted the dispersion measurements to obtain group velocity maps using the Fast Marching Surface-Wave Tomography method. The resulting group velocity maps indicate a thick layer of low velocity material near the junction of the Mosha-North Tehran faults, a low velocity anomaly related to the Damavand Volcano, and abrupt transitions from high to low velocity anomalies associated with the Mosha fault.