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Complex Crustal Structure Beneath Western Turkey Revealed by 3D Seismic Full Waveform Inversion (FWI)

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We present a 3D radially anisotropic velocity model of the crust and uppermost mantle structure beneath the Sea of Marmara and surroundings based on the full waveform inversion method. The intense seismic activity and crustal deformation are observed in the Northwest Turkey due to transition tectonics between the strike-slip North Anatolian Fault (NAF) and the extensional Aegean region. We have selected and simulated complete waveforms of 62 earthquakes (Mw > 4.0) occurred during 2007-2015, and recorded at ($\Delta < 10^{\circ}$) distances. Three component earthquake data is obtained from broadband seismic stations of Kandilli Observatory and Earthquake Research Center (KOERI, Turkey), Hellenic Unified Seismic Network (HUSN, Greece) and Earthquake Research Center of Turkey (AFAD-DAD). The spectral-element solver of the wave equation, SES3D algorithm, is used to simulate seismic wave propagation in 3D spherical coordinates (Fichtner, 2009). The Large Scale Seismic Inversion Framework (LASIF) workflow tool is also used to perform full seismic waveform inversion (Krischer et al., 2015). The initial 3D Earth model is implemented from the multi-scale seismic tomography study of Fichtner et al. (2013). Discrepancies between the observed and simulated synthetic waveforms are determined using the time-frequency misfits which allows a separation between phase and amplitude information (Fichtner et al., 2008). The conjugate gradient optimization method is used to iteratively update the initial Earth model when minimizing the misfit. The inversion is terminated after 19 iterations since no further advances are observed in updated models. Our analysis revealed shear wave velocity variations of the shallow and deeper crustal structure beneath western Turkey down to depths of $\sim$35-40 km. Low shear wave velocity anomalies are observed in the upper and mid crustal depths beneath major fault zones located in the study region. Low velocity zones also tend to mark the outline of young volcanic areas. Our final 3D Earth model is tested using forward wave simulations of earthquakes ($M \geq 3.7$) that were not used during the inversion process. The comparison of observed and synthetic seismograms, calculated by initial and final models, showed significant improvements in waveform fits at 8-100 sec periods. This study is supported by The Scientific and Technological Research Council of Turkey (TUBITAK Project No: ÇAYDAG-114Y066), and EU–HORIZON-2020: COST Actions: Earth System Science and Environmental Management: ES1401 - Time Dependent Seismology (TIDES).