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High Resolution 3-D Waveform Tomography of the Lithospheric Structure of the Hellenic Subduction Zone

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We present a high-resolution lithospheric shear-wave velocity model of the Hellenic subduction zone obtained by full waveform tomography of the EGELADOS project data. This high quality data was collected with the broadband amphibian seismic network EGELADOS that was deployed all over the southern Aegean from October 2005 to April 2007 providing a sampling of the south Aegean lithosphere with a resolution never reached before.

Because of the strong deformations in the Hellenic subduction zone and the linear approximation in solving the full waveform inverse problem, a special care was taken to guarantee the best possible accuracy of earthquakes parameters and initial reference models. The accurate locations of the selected earthquakes were hence re-estimated and the best moment tensors were selected by computing the misfits between the observed seismograms for one event and a set of synthetics calculated for every value of the fault angles (strike, dip and rake) and hypocenter depths. On the other hand, instead of using an average 1D reference model for the complete region, a 1D path-specific approach permitted to obtain the 1D initial model for each source-receiver pair by waveform fitting using a grid search varying the Moho depth and the average S-wave velocity in the crust. These models were then refined by a 1D inversion and used to calculate the sensitivity kernels for each source-receiver pair. For the inversion, we adopted a special formulation including a correction term which permits to use the path-specific sensitivity kernels in an inversion for 3D velocity perturbations relative to a single 1D reference model constructed from all these 1D initial models.

The inversion was done in frequency domain with a frequency window ranging from 0.03 Hz to 0.1 Hz. For the selected 2695 paths the total number of data values reached 140140. The model was discretized in volume cells with a varying vertical width and a fixed lateral one of approximately 15 km, resulting in 67320 model parameters. Adding the smoothing and damping constraints we solved in total a system of 274780 equations for 67320 unknowns. The 3D tomographic model obtained from the full waveform inversion of the shear-wave velocity resolves in high details the crustal structure of the Hellenic subduction zone and images distinctly the eastern part of the volcanic arc where most of the actual volcanic activity is concentrated. Thinning of the crust in the Gulf of Corinth and many special features of the forearc such as low velocity anomalies throughout its upper 40 km depth are also well imaged. The crustal thickness in the southern Aegean shows strong variations in the whole region with a shallower Moho in the volcanic arc and the Cretan Sea (from 18 km to 25 km) and a thicker one beneath the entire forearc especially in its south-eastern part (from 45 to 50 km).