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Large-scale shear velocity structure of the upper mantle beneath Europe and surrounding regions

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The automated multimode waveform inversion technique developed by Lebedev et al., (2005) was applied to available data of broadband stations in Europe and surrounding regions. The Automated Multimode Inversion Method (AMI) foots on an inversion technique originally invented by Nolet (1991) which he called partitioned waveform inversion. It performs a fitting of the complete waveform starting from the S-wave onset to the surface wave.
Assuming that the location and focal mechanism of a considered earthquake are known, the first basic step is to consider each available seismogram separately and to to derive from it linear constrains, which are later used to construct the 3D-model.
Inversion parameters are variations of shear velocity in the mantle and Moho depth.
The theoretical background of AMI is the pure-path approximation which assumes propagation of waves in and around the vertical plane containing source and receiver. AMI extends the partitioned waveform inversion to a completely automated procedure with automated data quality checks and an automated assessment of the quality of fit obtain when determining the linear constrains from the observed seismogram. In this way, large volumes of data can be efficiently inverted for 3D-mantle structure.

We collected all available data for the years from 1990 to 2007 from permanent stations in and around Europe via the data centers of ORFEUS, GEOFON and IRIS. In addition, we incorporated data from temporary experiments like ETSE array, SVEKALAPKO, TOR and the Eifel plume project. Just recently we were also able to add the data recorded by the EGELADOS network from the GEOFON data archive. In this way, a huge data set of about 500.000 seismograms came about from which about 65.000 1D-models could be constructed. The reduction of usable seismograms is caused by (1) mislocation or/and errors in the CMT solutions, (2) the rigorous automatic quality checks implemented in AMI, and (3) the elimination of seismograms for which violations of the pure-path approximations are apparent, e.g. data from stations on nodal planes of the focal mechanism or data containing too high a level of coda. Since AMI expects wave trains of shear and surface waves separated in time, paths shorter than 100 km are discarded.

The resulting models exhibit an overwhelming detail in relation to the size of the region considered in the inversion. The well detailed models of shear wave velocity for Europe and surroundings shows that the most prominent features are an extremely sharp demarcation of the East European platform from Western Europe, and a narrow high velocity regions follow the Hellenic arc and the Ionian trench toward the north. A high velocity zone beneath the Western alps can be imaged, whereas a low velocity zones are found at depths around 150 km in the back-arc of the Hellenic Subduction Zone. This high velocity anomaly can be observed continuously from the Alpine arc to the Middle East.