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Global Seismic Tomography as an alternative to restricted-array tomography ?

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Over the years teleseismic tomography has developed to be a sophisticated method to study the Earth's upper mantle on a scale-length of several tens of kilometers, mostly with data recorded at temporary, dense networks. Using teleseismic arrival time data from such passive experiments to invert for three-dimensional velocity variations in the subsurface, one faces some inherent problems, including limited resolution at depth, artefacts due to a plane-wave approximation at the bottom of the model volume and a resulting velocity model that is not directly related to the chosen reference (starting) model.

Simultaneous, global inversion of such dense regional arrival time and global P-wave travel time data (reported to ISC and NEIC) provides an opportunity to overcome these specific problems. Calculation of the entire ray path using a 3D ray tracing algorithm and a non-linear iterative inversion scheme allow to localize heterogeneities in the entire Earth's mantle and to improve resolution in the target region at depth. Application of a variable parameterization scheme provides not only a high-resolution model of the study region but additionally allows to include a priori constrained structures such as a crustal model derived from independent studies. Implicit correction of the traveltime residuals for crustal structure in combination with the combined data set of regional and global travel time data enhances resolution, even at depths greater than could be resolved by regionally recorded teleseismic data alone.

Similar inversion strategies reach back to 1992, when Fukao et al. first used a global inversion scheme for a regional tomographic study of the Western Pacific. Since then, several authors followed and further developed this approach although by applying

ISC- and NEIC-data only. Such global tomographic inversions were computationally very expensive in the past. For the presented study however, focussing at the Eastern Carpathians and Southeastern Europe, the time-consuming, three-dimensional ray tracing of more than 600.000 rays through a global mantle model with more than 400.000 model parameters is calculated on a 6-processor SGI Origin 3200 in less than 4 hours. With the LSQR inversion taking only some 10-15 minutes, the entire process of non-linear, iterative inversion can be thus done in less than a week, yielding not only a high-resolution image of the upper mantle in the study region (with a scale-length comparable to pure teleseismic tomography), but also revealing a comprehensive overview of the target region in its large scale geodynamical context.