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A new high-resolution and probabilistic shear-wave velocity model of the European crust and uppermost mantle derived from ambient noise tomography

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Taking advantage of the large number of seismic stations installed in Europe, in particular in the greater Alpine region with the AlpArray experiment (http://www.alparray.ethz.ch/home/), we derive a new high-resolution 3-D shear-wave velocity model of the European crust and uppermost mantle from ambient noise tomography. The correlation of four years of continuous vertical-component seismic recordings from 1293 broadband stations (10 W-35 E, 30 N-75 N) provides Rayleigh wave group velocity dispersion data in the period band 5-150 s at more than 0.8 million virtual source-receiver pairs. Two-dimensional Rayleigh wave group velocity maps are estimated using adaptive parameterization to accommodate the strong heterogeneity of path coverage. A probabilistic 3-D shear-wave velocity model, including probability densities for the depth of layer boundaries and S-wave velocity values, is obtained by non-linear Bayesian inversion. A weighted average of the probabilistic model is then used as starting model for the linear inversion step, providing the final Vs model.

The resulting crustal S-wave velocity model is validated by forward numerical simulation. The misfits of group arrival time are mostly less than 1 s for Rayleigh waves propagating 100 km in a simple geological context (e.g., Northern Germany) and 2 s in a complex geological context (e.g., Western Alps). The resulting model of uppermost mantle is comparable with published models derived from earthquake-based tomography even at 150km depth, which is unusual for ambient noise tomography. The resulting Moho depth is validated by comparison with controlled-source (CSS) and receiver-function sections across the Alpine belt. Although surface wave tomography is weakly sensitive to layer boundaries, the obtained probability density of interface depth displays striking similarities with reference sections.

Our probabilistic and final shear wave velocity models have the potential to become new reference models of the European crust, both for crustal structure probing and geophysical studies including waveform modeling or full waveform inversion.