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Ambient-noise tomography of the European lithosphere: numerical calculation of sensitivity kernels for nonuniform noise-source distributions.

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Europe is covered very well by seismic instruments, but struck relatively rarely by seismic events. To enhance seismic resolution, it is then essential to exploit the information which comes from
cross-correlation of stacked seismic ambient noise. Julie Verbeke and co-authors have compiled a dense regional database of European station-station surface-wave dispersion using noise-interferometry, resulting in a dramatic growth in seismic coverage with respect to earthquake-based tomography.

This improvement in data coverage can be translated into an enhancement of tomographic resolution only if a sufficiently accurate description of wave propagation is used to formulate the tomographic inverse problem. Jeroen Tromp and co-authors show how adjoint techniques can be applied to ambient-noise data, overcoming the often severe nonuniformity in the geographic distribution of noise “sources”, and the subsequent discrepancies between the recorded noise cross-correlation and the theoretical Green’s function.

We present here the first application of this new method to real ambient-noise data, at the scale of central Europe and at periods of 8s and longer. We present sensitivity kernels relating ambient-noise cross-correlations to crust and lithosphere structure, by forward and adjoint numerical simulations conducted with the spectral-element packages SPECFEM3D_GLOBE (used for reference) and SPECFEM3D_V2.0.0 (better suited for regional-scale applications like ours).

The simulations are applied to our local mesh of the upper mantle, which honours all known seismic discontinuities. We account for the known nonuniformity in the distribution of noise sources
(essentially, noise comes from the oceans), and make use a laterally heterogeneous reference model based on lower-resolution tomography by Boschi and co-workers. The sensitivity functions we compute are at the core of an iterative, nonlinear, gradient-based inversion scheme that will ultimately provide a new tomographic image of Europe. Because of (i) the improvement in the geographic coverage of the data, (ii) the high-frequency content (with respect to teleseismic surface-wave tomography) of the signal we analyze, and (iii) the accuracy in the theoretical and computational derivation of sensitivity functions, we expect the new model to represent an important progress in European upper-mantle tomography.