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European upper mantle tomography: adaptively parameterized models

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We have devised a new algorithm for upper-mantle surface-wave tomography based on adaptive parameterization: i.e. the size of each parameterization pixel depends on the local density of seismic data coverage. The advantage in using this kind of parameterization is that a high resolution can be achieved in regions with dense data coverage while a lower (and cheaper) resolution is kept in regions with low coverage. This way, parameterization is everywhere optimal, both in terms of its computational cost, and of model resolution. This is especially important for data sets with inhomogenous data coverage, as it is usually the case for global seismic databases. The data set we use has an especially good coverage around Switzerland and over central Europe. We focus on periods from 35s to 150s. The final goal of the project is to determine a new model of seismic velocities for the upper mantle underlying Europe and the Mediterranean Basin, of resolution higher than what is currently found in the literature.

Our inversions involve regularization via norm and roughness minimization, and this in turn requires that discrete norm and roughness operators associated with our adaptive grid be precisely defined. The discretization of the roughness damping operator in the case of adaptive parameterizations is not as trivial as it is for the uniform ones; important complications arise from the significant lateral variations in the size of pixels. We chose to first define the roughness operator in a spherical harmonic framework, and subsequently translate it to discrete pixels via a linear transformation. Since the smallest pixels we allow in our parameterization have a size of 0.625°, the spherical-harmonic roughness operator has to be defined up to harmonic degree 899, corresponding to 810.000 harmonic coefficients. This results in considerable computational costs: we conduct the harmonic-pixel transformations on a small Beowulf cluster.

We validate our implementation of adaptive-grid roughness minimization, and present preliminary tomography results in global and European tomography.