Calibration of 3D upper mantle structure in Eurasia using regional and teleseismic full waveform seismic data

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Starting model from 2D kernels

This radially anisotropic model, which covers the large Eurasian region, has been developed using the Path Average Approximation (PAVA) and the Nonlinear Asymptotic Coupling Theory (NACT - Li and Romanowicz, 1995). These approaches consider the 1D (PAVA) and 2D (NACT) sensitivity of waveforms to structure in the vertical plane along the great-circle path between the source and the receiver. The isotropic S-velocity structure (left) is parametrized laterally in level 6 spherical splines, which correspond to lateral resolution of ~200 km, and imaged anomalies are with respect to PREM. The radial anisotropic parameter $\xi (=v_{sh}/v_{sv})^2$ (center), which is less well constrained, is parametrized in level 5 splines, which have resolution of 400 km, and plotted anomalies are relative to isotropy (saturation level is given in %). Several tectonic features are clearly imaged in our model: slow back-arc basins (Japan and South China Sea), fast subducting slabs (e.g. Mariana, Japan and Philippine subduction zones), fast continental platforms (e.g. Eastern European Platform, Deccan province) and slow upwelling regions (Red Sea and Afar).

Preliminary models from 3D kernels

We are refining the above model in a smaller subregion between longitudes 90 and 145 degrees E, and latitudes 15 and 40 degrees N using a subset of the original dataset (vertical component records from 180 events where the source-receiver paths are contained within the larger Eurasian region). We utilize a more accurate theoretical approach that accounts for the 3D sensitivity of the waveform to velocity structure. 3D waveform sensitivity kernels are calculated using 2 different normal-mode based implementations of the Born (single scattering) approximation. The first approach maps the effect of structure into linear perturbations to the amplitude of the reference seismogram (Capdeville, 2005). The 3D sensitivity of this approach provides a great improvement over previous approaches which neglect off-path sensitivity for some complex paths (Synthetics, left). For some relatively simple paths through strong anomalies, however, a linear amplitude perturbation approach can be outperformed by an approach that instead perturbs the phase of the reference seismogram such as PAVA (Synthetics, right), which is nonlinear in amplitude. For this reason, we chose to also explore a Born implementation where the effect of the average structure along the great-circle path is treated as a perturbation to the phase of the seismogram as in PAVA, while the effects of 3D sensitivity including off-path sensitivity are included as a linear amplitude perturbation. We developed 2 preliminary "low resolution" isotropic velocity models (level 5 spherical splines) of the subregion using these 2 Born implementations (Models, 4 bottom panels). Structure outside the subregion is modeled using NACT in both cases. Good agreement is observed between the models, which are also consistent with results obtained using the NACT approximation (Models, top 2 panels).