Anisotropic shear velocity models of the North American upper mantle based on waveform inversion and numerical wavefield computations.

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The Earthscope TA deployment across the continental US now has reached the eastern part of the US, providing the opportunity for high-resolution 3D seismic velocity imaging of both lithosphere and asthenosphere across the entire north-American continent (NA). Previously (Yuan et al., 2014), we presented a 3D radially anisotropic shear wave (Vs) model of North America (NA) lithospheric mantle based on full waveform tomography, combining teleseismic and regional distance data sampling the NA. Regional wavefield computations were performed numerically, using a regional Spectral Element code (RegSEM, Cupillard et al., 2012), while teleseismic computations were performed approximately, using non-linear asymptotic coupling theory (NACT, Li and Romanowicz, 1995). For both datasets, the inversion was performed iteratively; using a Gauss-Newton scheme, with kernels computed using either NACT or the surface wave, path average approximation (PAVA), depending on the source-station distance.

We here present a new radially anisotropic lithospheric/asthenospheric model of Vs for NA based entirely on SEM-based numerical waveforms from an augmented dataset of 155 regional events and 70 teleseismic events. The forward wavefield computations are performed using RegSEM down to 40s, starting from our most recent whole mantle 3D radially anisotropic Vs model (SEMUCB-wm1, French and Romanowicz, 2014). To model teleseismic wavefields within our regional computational domain, we developed a new modeling technique which allows us to replace a distant source by virtual sources at the boundary of the computational domain (Masson et al., 2014). Computing virtual sources requires one global simulation per teleseismic events.

We then compare two models obtained: one using NACT/PAVA kernels as in our previous work, and another using hybrid kernels, where the Hessian is computed using NACT/PAVA, but the gradient is computed numerically from the adjoint wavefield, providing more accurate kernels while preserving the fast convergence properties of the Gauss-Newton inversion scheme.

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