Geophysical Research Abstracts
Vol. 21, EGU2019-18005-2, 2019
EGU General Assembly 2019

Radially and Azimuthally Anisotropic Global Waveform Tomography

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We present new models for the distribution of shear-wave velocity and of its radial and azimuthal anisotropy in the crust and the upper mantle at the global scale. Seismic anisotropy is the consequence of the preferential orientation of structures due to deformation. The reconstruction of both its radial and azimuthal components gives us insight into past and present deformation and flow in the lithosphere and the asthenosphere. The full consideration of anisotropy also enables to accurately determine the isotropic shear-velocity average, and therefore to isolate the effects of thermal or compositional variations from those of anisotropic fabric.

Our models are constrained by a large compilation of waveform fits for more than 750,000 vertical-component and 250,000 transverse-component seismograms. We follow a two-step partitioned inversion procedure that comprises the Automated Multimode Inversion of surface, S, and multiple-S waveforms in a period range from 10 s to 450 s, followed by a 3D tomographic inversion that reconstructs the v_{SH} and v_{SV} velocities and their 2ψ and 4ψ azimuthal dependencies. The joint inversion of vertical and transverse components is regularized in terms of the linear isotropic average $v_S^0 = (v_{SH} + v_{SV})/2$ and radial anisotropy $\delta = v_{SH} - v_{SV}$.

We compare our models with published radially and azimuthally anisotropic models, which show poor mutual agreement on anisotropic structures. We identify different patterns of anisotropy for different tectonic regions, with a clear difference between oceanic and continental regions of different ages. While we observe a consistent negative anisotropy in the first 50 km of oceanic lithosphere, radial anisotropy is positive under continents, with a thick layer of slightly positive anisotropy under cratons and a shallower layer of stronger anisotropy under phanerozoic crust. We observe a remarkable reversal from positive to negative anisotropy between 200 and 260 km depth over the entire globe. The depth at which this reversal occurs depends on the tectonic settings. Synthetic tests help us to assess the robustness of these observations.

This publication has emanated from research supported in part by a research grant from Science Foundation Ireland (SFI) under Grant Number 13/RC/2092 and is co-funded under the European Regional Development Fund.