Geophysical Research Abstracts
Vol. 20, EGU2018-16049, 2018
EGU General Assembly 2018

Relation between seismic and thermal mantle structure including effects of mineralogy and tomographic resolution

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Many geophysical phenomena, such as mantle convection, dynamic topography, geoid undulations, and plate motions, arise as a balance between driving gravitational forces and resisting viscous stresses within the Earth's mantle. A good characterization of the present-day buoyancy field of the mantle would allow for tighter constraints on its viscosity. It is possible to derive an estimate for the present-day buoyancy field of the lower mantle using global seismic tomography models together with thermodynamically self-consistent models of mantle mineralogy. However, given the uncertainties affecting both seismic and mineralogical models, different choices can be made, which lead to different estimates. In addition to the uncertainties and approximations of mineralogy models, the estimation is complicated by the fact that the velocity-to-temperature relation is not bijective: Due to the presence of phase transitions, different temperatures can result in the same seismic velocity.

This study investigates the effects of mantle mineralogy and limited tomographic resolution on the complex relation between thermal and seismic mantle structure. To this end, the thermal structure of a given isochemical mantle circulation model (MCM) is converted to seismic velocities using thermodynamically self-consistent models of mantle mineralogy for a pyrolite composition. Subsequently, the synthetic seismic structure is "tomographically filtered" to account for the low resolving power of seismic structure derived by tomographic inversion. Both filtered and raw synthetic velocity structures are then converted back to thermal structure using unaltered or smoothed thermodynamic tables of mantle mineralogy which, respectively, incorporate or neglect the non-unique relation between seismic velocities and temperature.