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Thermo-chemical structures in the lower mantle from body wave, surface wave and normal-mode data

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One of the most powerful approaches for understanding the dynamics and evolution of the Earth is to combine results from different branches of Geoscience (e.g. seismology, mineral physics, geodynamics...). In this context, we link tomographic models of wave-speed and density with mineral physics data, to place quantitative constraints on the 3-D thermochemical structure of the lower mantle.

Our tomographic models are an improvement on earlier models in that they satisfy constraints from body wave, surface wave and normal mode data simultaneously, rather than just one of these datasets individually, thereby enhancing the spatial resolution. Further, the seismic structure at a given location is represented as a probability density function, i.e. described by a mean and standard deviation, and thus takes into account the uncertainty and non-uniqueness of the solution.

Variations in seismic velocities alone may not distinguish thermal from chemical variations inside the mantle due to trade-offs in their associated velocities. However, we reduce this trade-off by mapping not only compressional and shear wave-speed anomalies in the lower mantle, but also density, which is obtained independently of the wave-speed models.

Using a thermodynamically self-consistent method to compute seismic velocities for different thermochemical structures, we construct sets of hundreds of thousands of themochemical models, each model chosen at random in a Monte-Carlo procedure within broad thermochemical ranges. Via the Metropolis algorithm, we select a subset of these models which match the probability density functions for P-wavespeed, S-wavespeed and density simultaneously, at each node in our tomographic models.
From these we are able to generate probability density functions for lateral variations in a range of physical parameters including temperature, iron content, and silica content, throughout the lower mantle.