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Short-scale Heterogeneity in the Lowermost Mantle Revealed Through Partition Modeling of Seismic Body Waves

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The existence of both chemical and thermal heterogeneities on a variety of scales in the lowermost mantle has been invoked to explain various types of seismological observations and the Earth's dynamics. Understanding the size and magnitude of these heterogeneities is important in the context of whole mantle dynamics. However, due to inaccurate approximation of data noise and the inadequate definition of the misfit function in the optimization framework, the size of heterogeneities has not been well constrained in present tomographic models of the lowermost mantle. Moreover, we need to be able to clearly see through the core-mantle boundary to properly understand the Earth's core. For example, in order to investigate anisotropy in the inner core, it is important to quantify the contribution to seismic travel times from the Earth's mantle. Furthermore, it is impossible to reconstruct the topography of the Earth's core without a full understanding of mantle heterogeneities. In addition, P-wave velocity maps of the lowermost mantle are rare in comparison to S-wave maps, yet both are needed to properly understand the physical and chemical state of the lowermost mantle.

Here we use a Partition Modeling approach, in which trans-dimensional and hierarchical sampling methods are used to solve the above problems. The advantage of such an inversion method is that the number of model parameters, the size of the velocity cells, and the data noise are treated as unknowns in the problem. In this sense, the approach lets us consider the issue of model parameterization as part of the inversion process. A large ensemble of models is averaged to produce a final solution complete with uncertainty estimates. We map the P-wave velocity structure of the lowermost mantle from a dataset of hand-picked PKPab-df, PKPbc-df, and PcP-P differential travel times. We focus on covering gaps in spatial sampling of the lowermost mantle from PKPab-df and PcP-P of previous studies. Travel time residuals from these different datasets are individually and simultaneously inverted for a map of the P-wave velocity field parameterized in terms of Voronoi cells of variable shapes and number. Our results suggest that much smaller scale structure exists in the lowermost mantle than is predicted by previous seismic studies. The data justifies a scale-length of between 5 and 10 degrees (300 to 600 km) for the P-wave velocity perturbations in the 300 km of the lowermost mantle.