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Towards consistent seismological models of the core-mantle boundary landscape

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The dynamic topography of the core-mantle boundary (CMB) provides important constraints on dynamic processes in the mantle and core. However, inferences on CMB topography are complicated by the uneven coverage of data with sensitivity to different length scales and strong heterogeneity in the lower mantle. Particularly, a trade-off exists with density variations, which ultimately drive mantle flow and are vital for determining the origin of mantle structures. Here, I review existing models of CMB topography and lower mantle density, focusing on seismological constraints (Koelemeijer, 2020). I develop average models and vote maps with the aim to find model consistencies and discuss what these may teach us about lower mantle structure and dynamics.

While most density models image two areas of dense anomalies beneath Africa and the Pacific, their exact location and relationship to seismic velocity structure differs between studies. CMB topography strongly influences the retrieved density structure, which partially helps to resolve differences between recent studies based on Stoneley modes and tidal measurements. CMB topography models vary both in pattern and amplitude and a discrepancy exists between models based on body-wave and normal-mode data. As existing models typically feature elevated topography below the Large-Low-Velocity Provinces (LLVPs), very dense compositional anomalies may be ruled out as possibility.

To achieve a similar consistency as observed in lower mantle models of S-wave and P-wave velocity, future studies should combine multiple data sets to break existing trade-offs between CMB topography and density. Important considerations in these studies should be the choice of theoretical approximation and parameterisation. Efforts to develop models of CMB topography consistent with both body-wave and normal-mode data should be intensified, which will aid in narrowing down possible explanations for the LLVPs and provide additional insights into mantle dynamics.

Koelemeijer, P. (2020), "Towards consistent seismological models of the core-mantle boundary landscape". Book chapter in revision for AGU monograph "Mantle upwellings and their surface expressions", edited by Marquardt, Cottaar, Ballmer and Konter