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Mantle-driven geodynamo features - effects of post-Perovskite phase transition

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Exploring the impact of the heterogeneous lower mantle on the geodynamo requires knowledge of the heat flux anomaly across the core-mantle boundary. Most studies so far used a purely thermal interpretation of seismic shear wave anomalies to assign heterogeneous heat flux boundary conditions on numerical dynamo models, ignoring phase transition or compositional origins. A recent study of mantle convection (Nakagawa and Tackley, 2008) provides guidelines to include such non-thermal effects. Here we construct maps of heat flux across the core-mantle boundary based on a lower mantle tomography model (Masters et al., 2000) with a combined thermal and post-Perovskite phase transition interpretation. We impose these patterns as outer boundary conditions on numerical dynamo simulations and study the impact of accounting for post-Perovskite effects on the long-term time-average properties of the dynamo. We then compare our results with geophysical observations. We find in all cases that surface downwellings associated with cyclones concentrate intense non-axisymmetric magnetic flux at high-latitudes, the surface flow contains a large anticlockwise vortex at mid-latitudes of the southern hemisphere, and the inner boundary buoyancy flux is dominated by a Y20 pattern. Boundary-driven time-average surface flow with some equatorial asymmetry is organized in the shell by quasi-axial convective rolls that extract more buoyancy from low-latitudes of the inner-boundary. These positive inner boundary buoyancy flux structures are found at low-latitudes of the northern hemisphere, in some places due to cyclonic flow at mid-latitudes of the southern hemisphere connecting with higher latitude cyclonic flow in the northern hemisphere. Accounting for post-Perovskite effects improves the recovery of several geodynamo observations, including the Atlantic/Pacific hemispherical dichotomy in core flow activity, the single intense paleomagnetic field structure in the southern hemisphere, and possibly the m = 1 dominant mode of inner-core seismic heterogeneity.