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Geoids and True Polar Wander from Mantle Circulation Models

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The shape of the Earth's geoid provides strong constraints on the current internal mantle density structure, whereas True Polar Wander provides an effective benchmark for the reliability of the evolution of the Earth's internal density structure in time. Here, we investigate an isochemical high resolution mantle circulation model that solves the dynamical equations governing the behaviour of the mantle flow. Velocity boundary conditions at the top are derived from a model of plate motion history and as an additional condition, the temperature at the CMB is set to obtain various ratios of bottom to internal heating. The resulting thermal fields are transformed into density variations using a published thermodynamically self-consistent mineralogical model. In this forward study of mass transport in the mantle, only a few free parameters remain: the viscosity profile of the mantle, the values of absolute viscosity and the ratio of internal to core heating.

We find that the model geoids correlate well with the derived one from the recent satellite mission GRACE. However, as expected, the geoid strongly depends on the choice of the radial viscosity structure. This sensitivity allows us to place additional constraints on the best-fitting viscosity profile. Different ratios of bottom to internal heating do not significantly influence the structure of the model geoid but do affect its amplitude. Remarkably, even with strong core heating, rotational stability is satisfied and TPW remains within the observed values. So, high CMB temperatures of approximately 4000 K are strongly supported by this study.