Geophysical Research Abstracts,
Vol. 11, EGU2009-9622, 2009
EGU General Assembly 2009

Synthetic Geoids from Mantle Circulation Models

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The shape of the Earth's geoid provides strong constraints on the internal mantle density structure. Here, we calculate the geoid of 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 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 the 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 recent satellite derived estimates of the Earth's geoid. As expected, the geoid strongly depends on the choice of the radial viscosity structure, which also influences the stability of the Earth's rotational axes. This sensitivity allows us to place additional constraints on the best-fitting viscosity profile. Different ratios of core heating do not significantly influence the structure of the synthetic geoid but do affect its amplitude. Interestingly, we observe rotational stability even in the presence of large amounts of core heating in the mantle circulation model.