

Simultaneous inversion of mantle properties and initial conditions using an adjoint of mantle convection

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Through the assimilation of present day mantle seismic structure, adjoint methods can be used to constrain the structure of the mantle at earlier times. However, the application to geophysical problems is restricted through both the high computational expense from repeated iteration between forward and adjoint models and the need to know mantle properties (such as viscosity and the absolute magnitude of temperature or density) *a priori*. We propose that an optimal first guess to the initial condition can be obtained through a simple backward integration (SBI) of the governing equations thus lessening the computational expense.

Mantle viscosity and the effective Rayleigh number are crucial for mantle convection models, neither of which is exactly known. We place additional constraints on these basic mantle properties when the convection-induced dynamic topography on Earth's surface is considered within an adjoint inverse method. We considered both one-layer and two-layer viscosity in regional models. For the one layer model, the magnitude of dynamic topography is controlled by the temperature scaling while the rate of change of topography is controlled by the absolute value of viscosity. For the two-layer case, the rate of change of topography constrains upper mantle viscosity, while the magnitude of dynamic topography determines the temperature scaling (lower mantle viscosity) when upper-mantle (lower-mantle) density anomaly dominates the flow field. For both cases, we show that the theory can constrain mantle properties with errors arising through the adjoint recovery of the initial condition.

The adjoint algorithm was created by modifying *CitcomS Version 2.0*, obtained from the Computational Infrastructure for Geodynamics (CIG).

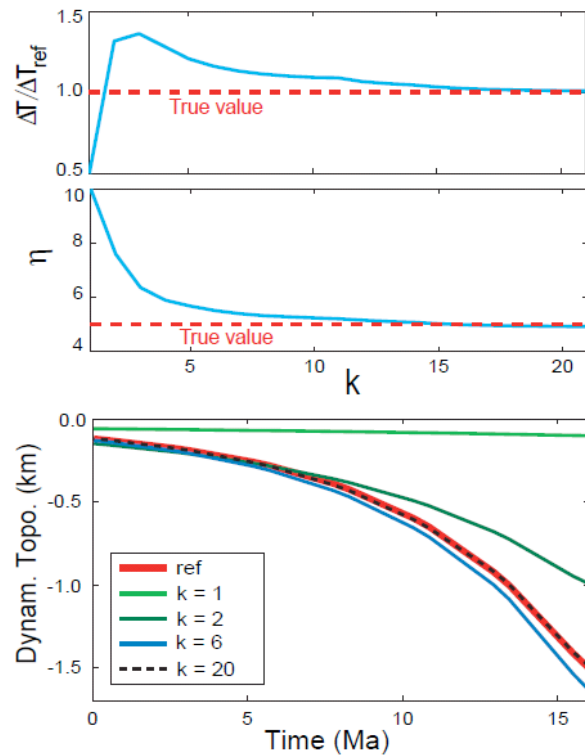


Figure (right) shows the dynamic topography constraints on mantle viscosity and density anomaly for a 1-layer viscosity mantle, where k represents the inverse iteration.

Reference: Liu, L., and M. Gurnis, Simultaneous inversion of mantle properties and initial conditions using an adjoint of mantle convection, *Journal of Geophysical Research*, **113**, B08405, doi:10.1029/2008JB005594, 2008.