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Data assimilation in mantle dynamics

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Modern seismic tomographic images of the Earth's interior facilitate the inference of the complex trajectories of present-day convective flow in the upper mantle. Quantitative reconstruction of both the observed mantle structure and temperature field backwards in time requires a numerical tool for solving the inverse problem of thermal convection at infinite Prandtl number. In this paper we present a variational approach to three-dimensional numerical restoration of thermoconvective mantle flow with temperature-dependent viscosity. This approach is based on a search for the mantle temperature and flow in the geological past by minimising differences between present-day mantle temperature derived from seismic velocities (or their anomalies) and that predicted by forward models of mantle flow for an initial temperature guess. The past mantle temperatures so obtained can be employed as constraints on forward models of mantle dynamics.

To recover strong features of deep mantle plumes in the geological past after they have dissipated due to thermal diffusion, we analyse effects of thermal diffusion on data assimilation of present mantle temperature. Also, we investigate the impact of thermal diffusion on the performance of our data assimilation algorithm. For a given range of Rayleigh number Ra and two values of the viscosity ratio r (between the upper and lower boundaries of the model domain) we show that the restoration process becomes

poorer as *Ra* decreases and *r* increases. We discuss the problems of smoothness of input data for assimilation, recovering discontinuous patterns of mantle temperature in the past, and some other challenges in the data assimilation for thermoconvective flow in the mantle.