Numerical simulations of thermo-chemically driven convection and geodynamos

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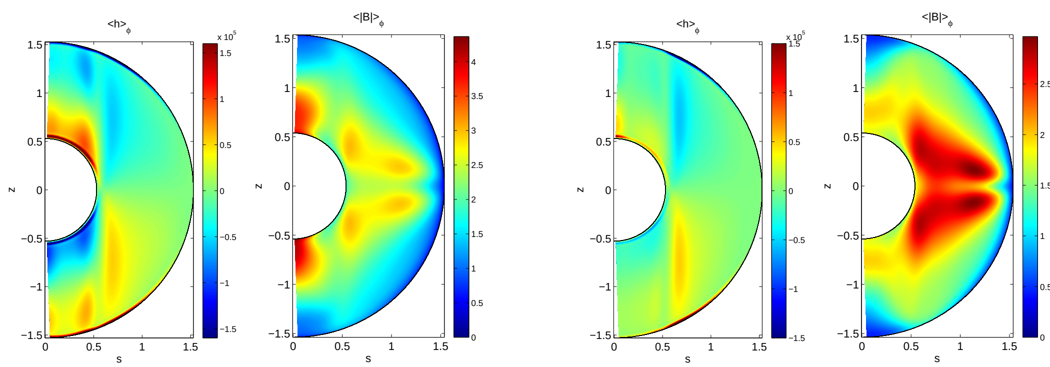
Our numerical study focuses on convection and magnetic field generation in a rotating spherical shell with the objective to model combined thermal and compositional convection as proposed for the Earth's core. Since the core of the Earth is cooling, a thermal gradient is established, which can drive thermal convection. Simultaneously, the advancing solidification of the inner core releases latent heat and increases the concentration of the light constituents of the liquid phase, e.g., sulphur, oxygen, and silicon, at the inner core boundary [Fearn, 1998]. Thus, buoyancy is created by both thermal and chemical heterogeneities. Typically, the molecular diffusivities of both driving components differ by some orders of magnitude [Braginsky and Roberts, 1995] indicating that one has to consider two separate transport equations in the numerical solution. In our double-diffusive convection model, we assume that the thermal diffusivity κ_T exceeds the compositional one κ_C by a factor of ten (κ_T/κ_C=10). The core mantle boundary is supposed to be impermeable for the light component. The freezing inner core, however, provides a certain flux of light material at the inner core boundary. Therefore, appropriate Neumann boundary conditions are implemented in the numerical scheme. The ratio of thermal to chemical forcing in the Earth's core is still rather uncertain. As a joint action of both buoyancy sources is most likely we investigated core convection in a range of varying thermal to chemical forcing ratios. We find that the patterns of spatial flow structures like differential rotation and helicity depend significantly on the particular driving scenario (see fig. 1(a) and 1(c)). Additionally, we compare our results to equivalent simulations with Dirichlet boundary conditions thus assessing the influence of the different types of boundary conditions on the convective flow. Furthermore, we investigated the effect of different thermo-chemical driving scenarios on the process of magnetic field generation of the MHD geodynamo. It turns out that the distribution of magnetic energy inside and outside the tangent cylinder depends significantly on the thermal to chemical forcing ratio (see fig. 1(b) and 1(d)).



(a) (b) (c) (d)

Figure 1: *Temporally and azimuthally averaged helicity $h = \vec{u} \cdot (\nabla \times \vec{u})$ and total magnetic field $|\vec{B}|$ of two simulations with different driving scenarios. Predominantly chemically driven: (a) and (b). Chemical and thermal driving of equal strength: (c) and (d).*

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