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The influence of heat flux boundary conditions on convection and dynamo in a rapidly rotating sphere

Kumiko Hori[1*], Johannes Wicht[1], Ulrich R. Christensen[1]

[1]Max-Planck Institute

Present geodynamo is driven by a mixture of secular cooling and of latent heat and light core constituents emanating from a growing inner core. The early dynamos of Earth and Mars, however, functioned without an inner core were thus exclusively driven by secular cooling. Dynamo simulations model secular cooling by internal heat sources and the inner core-related driving by bottom sources. We explore how the different combination of thermal (compositional) boundary conditions and source distributions affects non-magnetic convection and dynamo simulations.

The impact of the outer boundary condition is only large when the convection is mainly driven by internal sources. When bottom sources dominate, the lower boundary condition becomes more important. In both cases, a fixed flux condition promotes larger convective scales than a fixed temperature (composition) condition. A magnetic field can further increase the flow scale in the dynamo cases. The roll of magnetic field in the effect of the boundary conditions is understood from a linear stability analysis of magnetoconvection. The result suggests that the thermal outer boundary condition plays an important role for the early dynamos in Earth and Mars more than for the present geodynamo.