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Effect of thermal boundary condition on dynamos driven by internal heating

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We numerically investigate magnetohydrodynamic dynamos driven by purely-internal heating, which probably operated in the cores of early Earth and Mars where an inner core did not (yet) exist. Previous models of internally-heated dynamos differed in the size of the inner core, which was retained for pratical reasons, and in the thermal condition on the outer boundary, which was either fixed temperature or fixed heat flux. Dipole-dominated magnetic fields have been reported in some studies and multipolar fields in others. It is not clear what controls the selection of different field pattern. Here we systematically investigate the effects of the thermal boundary condition and inner core size on the morphologies of the magnetic field. We find that dipole-dominated and strong fields are generated with the heat-flux condition, whereas weaker and non-dipolar fields are generated when temperature is fixed. The size of the inner core has only a small influence. With the fixed heat-flux condition convection cells are of larger scale than with fixed temperature and the mean zonal and meridional flows are enhanced. Since the solid mantle of terrestrial planets imposes a heat-flux rather than a temperature condition on the core, our result support a dipole-dominated field for early Earth and Mars.