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Little Earth Experiment: A model to study the flow in the Earth's Tangent Cylinder

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We present a new experimental set-up developed to model the flow in the Earth's Tangent Cylinder (TC). This flow is known to have important consequences for the Earth's magnetic field and the drift of its north pole. For the first time, our experiment allows to reproduce the interplay between the magnetic, Coriolis and buoyancy forces inside a transparent electrically conducting liquid in an Earth-like geometry. The novelty of our experiment lies in the study of convection in a hemisphere heated on the inside and cooled on the outside, filled with sulphuric acid and permeated by a large magnetic field. The experimental apparatus can provide data at Ekman number E (ratio of the viscous force to the Coriolis force) of the order of 10^{-4} to 10^{-5}, Elsasser number Λ (ratio of the Lorentz force to the Coriolis force) of the order of 0.1 to 1 and Rayleigh number (ratio of buoyancy to viscous forces) in the range of the critical Rayleigh number Ra_c to $20 \times Ra_c$. With the help of particle image velocimetry (PIV) and thermal measurement, we compare the onset of convection and supercritical flow regimes between a purely hydrodynamic system and a magnetohydrodynamic system. For cases without magnetic field, we recover well-established scaling for the onset of convection under rotation; moreover, we obtain thermal wind scalings for supercritical flows. With magnetic field, we study the thermal behaviour by measurement of the Nusselt number and the Rayleigh number as well as magnetoconvective patterns inside the TC.