TURBULENT ROTATING CONVECTION TO THE EXTREME

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The interplay of buoyancy and rotation is observed in many geophysical and astrophysical flows. These flows are characterized by extreme parameter values: very high Rayleigh numbers Ra and very small Ekman numbers $E = \nu/2\Omega H^2$, where ν is kinematic viscosity, Ω is angular velocity and H is the height of the flowing fluid layer. In many of these systems the effects of rotation are dominant, the so-called geostrophic regime of turbulent rotating convection named after the dominant geostrophic balance of Coriolis and pressure gradient forces.

We want to study geostrophic rotating Rayleigh–Bénard convection as a simple model for these natural flows. However, when studying flow and heat transfer in the geostrophic regime we are faced with some practical difficulties. The combination of high Ra and low E necessitates the use of very fine meshes in direct numerical simulations. Experimentally, the main challenge is to achieve low E values while minimizing centrifugal acceleration that perturbs this density-driven flow. Making taller setups helps, though Ra may then grow by so much that buoyancy takes over and the constraint of rotation-dominated flow can no longer be met.

After carefully balancing these experimental constraints, we have come to the design of TROCONVEX (figure 1), a tall, slender convection setup capable of covering an unprecedentedly large part of the geostrophic regime of rotating convection. The sidewall of the convection cell consists of four segments, allowing us to use four different cell heights between 0.8 and 4 m. Water is used as the working fluid. Ekman numbers as small as 5×10^{-9} can be reached with Rayleigh numbers that allow us to cover large parts of the rotation-dominated range.

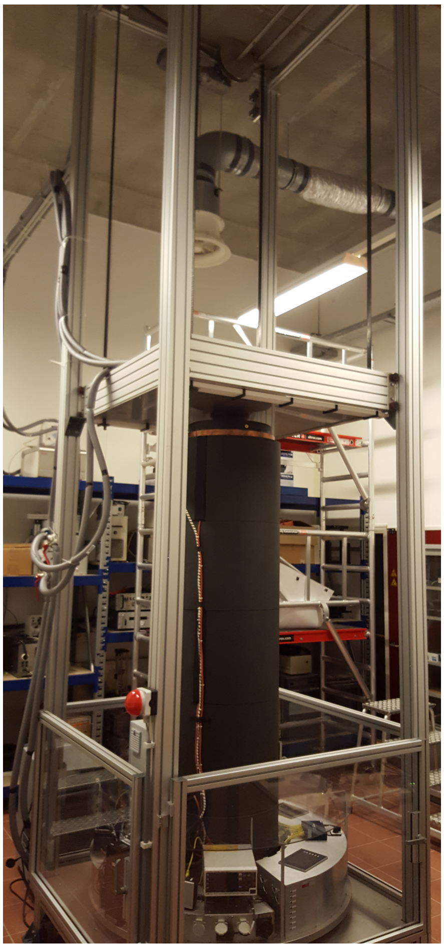

Figure 1: TROCONVEX at $H = 2$ m.

In this presentation we will report on the first heat transfer measurements carried out with this new device. Additionally, we can compare to accompanying direct numerical simulations at moderate parameter values. These simulations provide additional information on the various flow regimes occurring in geostrophic convection and how these regimes are reflected in the heat transfer scaling.

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