Master / Bachelor Thesis or Study Project

Chair of Numerical Fluid and Gas Dynamics · Scientific Computing Lab, Energy Innovation Center (EIZ)
Brandenburg University of Technology (BTU), Cottbus, Germany

Turbulent thermal convection in cylindrical and spherical shells: Assessing wall-curvature effects with a stochastic turbulence model

Synopsis – Thermal convection denotes a flow that is driven by buoyancy forces due to an unstable temperature stratification [1]. The flow is turbulent and exhibits convective boundary layers when buoyancy and inertial forces are much larger than viscous forces. Cylindrical confinement is common in technical flows (like heat exchangers or precipitators), but it shares many similarities with spherical confinement, which is more relevant for geophysical flows (like in Earth's mantle and outer core, or in the solar thermocline). In both cases, wall curvature modifies the boundary-layer structure and, hence, the scaling properties of the heat and momentum transfer [2]. High-fidelity numerical models are needed for detailed analysis and prediction. This is commonly achieved only by fine-structure resolving direct numerical simulation (DNS) [2]. Here, a reduced-order stochastic approach is taken based on the one-dimensional turbulence (ODT) model. ODT has been extended recently to cylindrical and spherical geometry [3], for which it not only aims to capture radial fluxes but also radial buoyancy effects [4]. This model will be used for extrapolation and assessment of theoretical scaling laws.

[1] Chillà & Schumacher (2012) *Eur. Phys. J. E* **35**:58 — [2] Gastine, Wicht & Aurnou (2015) *J. Fluid Mech.* **778**:721 — [3] Lignell *et al.* (2018) *Theor. Comput. Fluid Dyn.* **32**:495 — [4] Klein, Schmidt & Lignell (2018) *Proc. Conf. Model. Fluid Flow (CMFF'18)*, ISBN: 978-963313297-5

Modes

- **a) Master Thesis (1 semester):** Model application and calibration; data analysis
- **b) Study Project (2 semesters):** Same as a), but for additional configurations / control parameters
- **c) Study Project and Master Thesis (3 semesters):** Same as b), but with additional analysis

Tasks

- Review of relevant literature
- Visualization, post-processing, and analysis of simulation data
- Comparison with relevant reference data
- Numerical simulations with the stochastic one-dimensional turbulence model

Desired skills

- Solid knowledge of fluid mechanics, geophysical flows, boundary layers, or related topics
- Affinity to programming (preferably Python, Matlab, C/C++, or Fortran)
- Scientific attitude (curiosity, self-motivation, and critical reasoning)
- Experience with data analysis, numerical simulation and modeling, or CFD is an asset

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