Energie-Innovationszentrum Cottbus

Brandenburgische Technische Universität Cottbus - Senftenberg

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

Intermittent turbulence in idealized atmospheric boundary layers with application to wind energy

Synopsis – Turbulence is ubiquitous but complicated, exhibiting transient and intermittent phenomena across a broad range of scales. Many examples are found in the Earth's atmosphere and ocean where steady, sudden, periodic, and chaotic forcings play an important role. In this thesis, idealized rotating boundary layers in response to various forcings will be investigated using a stochastic column model that is based on the so-called one-dimensional turbulence (ODT) model [1]. We consider a fluid above a horizontal wall placed in a rotating frame of reference. A flow is excited relative to this frame by pressure-induced perturbations of the horizontal wind velocity. New insight into the dynamics of such flows have been obtained previously and recently by direct numerical simulation (DNS) [2,3], laboratory experiments [3], and stochastic modeling [5,6] in addition to theoretical analysis. It was found that linear (deterministic) and nonlinear (chaotic/stochastic) dynamics are often of equal importance giving rise to intricate scale interactions in space and time. The goal is to better understand scale interactions and stochastically induced flows in the atmospheric boundary layer for improved prediction of wind energy generation.

[1] Kerstein & Wunsch (2006) *Boundary-Layer Meteorol.* **118**:325 — [2] Salon & Armenio (2011) *J. Fluid Mech.* **684**: 316 — [3] Ghasemi, Klein, Will & Harlander (2018) *J. Fluid Mech.* **853**:111 — [4] Vincze, Fenyvesi, Klein *et al.* (2019) *EPL* **125**:44001 — [5] Ashkenazy, Gildor & Bel (2015) *EPL* **111**:39001 — [6] Klein & Schmidt (2022), accepted for publication in *Adv. Sci. Res., EMS'21 Special Issue*

Modes

- **a) Master / Bachelor Thesis (1 semester):** Data analysis; own simulations for selected cases
- **b) Study Project (2 semesters):** Same as a), but for additional cases
- **c) Study Project and Master Thesis (3 semesters):** Same as b), but with theoretical analysis

Tasks

- Review of relevant literature and theoretical foundations
- Visualization, post-processing, and analysis of numerical simulation data
- Comparison with relevant reference data
- Own numerical simulations with an in-house stochastic solver or theoretical analysis

Desired skills

- Scientific attitude (curiosity, self-motivation, and critical reasoning)
- Solid knowledge of fluid mechanics, boundary layers, atmospheric dynamics, or related topics
- Solid background in mathematics, especially differential equations and statisitics
- Experience with programming (preferably Python, Matlab, C/C++, or Fortran), numerical simulation and modeling, or CFD is an asset

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