

Dataset description

Turbulent Ekman flow with cubic small-scale surface roughness ($Re_D = 1000$, $Ri = 0$)

Direct numerical simulation – Set-up and vertical profiles

Jonathan Kosteletzky ^{1*}[▲], Cedrick Ansorge ^{2*}^{*} Freie Universität Berlin, Institut für Meteorologie[▲] Universität zu Köln, Institut für Geophysik und Meteorologie

May 14, 2024

1 Metadata

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Collection This dataset is part of the collection [Turbulent wall-bounded flow](#)³.

The collection is freely available and hosted by Refubium, the institutional repository of Freie Universität Berlin.

DOI [10.17169/refubium-43215](https://doi.org/10.17169/refubium-43215)

HPC systems The data was generated under the project TrainABL on the supercomputer HAWK at Höchstleistungsrechenzentrum Stuttgart (HLRS, in Germany).

Code The data was generated by the tool-suite for turbulence simulation tLab⁴.

2 The dataset

2.1 Contents

The dataset files, collectively named with grid information and the date of creation of the data on the High-Performance Computing (HPC) system. Each file of the collection contains time-series of statistical data for flow and scalar variables in a self-documented netCDF format and a namelist with the file name dns.ini, which is a plain text file holding the configuration of the tLab code (for documentation, please refer to the open-source code available under github.com/turbulencia/tlab). In the case of heterogeneous surface conditions, an additional netCDF file is provided that describes the geometry of the surface roughness.

2.2 Physical case

This dataset contains 4 simulation cases (ID: **s**, **r1**, **r2**, **r3**), with a similar computational grid, domain size and driven by the same large-scale forcing, but differ in the surface condition. Case **s** has a smooth surface and the rough cases **r1**, **r2**, **r3** feature each 56^2 square

¹j.kosteletzky@posteo.de

²cedrick@posteo.de

³refubium.fu-berlin.de/handle/fub188/42710

⁴github.com/turbulencia/tlab

blocks on the lower domain boundary with a uniform height and width distribution. The mean height of the roughness elements increases from case **r1** via **r2** to **r3**. These simulation cases, conducted with a Reynolds number of $Re_D = 1000$ ($Re_D = DG/\nu$, with the laminar Ekman-layer depth $D = \sqrt{2\nu/f}$, Coriolis parameter f , geostrophic wind G and the kinematic viscosity ν), corresponding to a friction Reynolds number Re_τ of 1408 for the smooth case **s**, delves into the study of the turbulent flow with small-scale surface roughness. Utilizing a computational grid measuring $3072 \times 656 \times 3072$ collocation points with a spatial resolution of $2.3 \times 1.0 \times 2.3$ wall units (smooth case), the domain size is scaled to $L_x = L_z = 0.27 \Lambda$, where $\Lambda = G/f$ is the Rossby radius.

2.3 Variable information

The statistical data is available in self-documented netCDF format, and it contains a wide array of parameters, encompassing vertical profiles of velocity and scalar variables (temperature/buoyancy as active and for some cases also passive scalars), scalar and momentum budget terms, as well as statistical moments up to the fourth order of velocities, scalars, and derivatives. These parameters provide a comprehensive perspective on Ekman flow dynamics. They are organized into distinct groups. Within the subsequent table, you will find numerous variables grouped together, accompanied by their descriptions and associated equations.

In order to fully describe the geometry of the surface roughness, there are horizontal domain slices for each of the rough cases (**r1**, **r2**, **r3**) in netCDF format, that describe the positions and heights of the roughness elements in grid points.