Geophysical Research Abstracts
Vol. 21, EGU2019-13101, 2019
EGU General Assembly 2019

A new length scale model for the planetary boundary layer based on LES

Cem Berk Senel (1,2), Orkun Temel (1), Sara Porchetta (1,3), and Jeroen van Beeck (1)

(1) von Karman Institute for Fluid Dynamics, Sint-Genesius-Rode, Belgium (cem.berk.senel@vki.ac.be), (2) Université Libre de Bruxelles, Ecole Polytechnique de Bruxelles, Bruxelles, Belgium, (3) KU Leuven, Department of Earth and Environmental Sciences, Leuven, Belgium

The planetary boundary layer (PBL) is the lowest part of the atmosphere ranging from hundreds of meters at night up to a few kilometers during the day, this phenomena is caused by the dynamics of the atmospheric stability. The PBL contains large eddies produced by the instability of the mean flow and small eddies that dissipate the turbulent kinetic energy particularly near the planetary surface. In the present study, we conduct three-dimensional, time-dependent large-eddy simulations (LES) of the PBL over the Høvsøre Test Centre for Large Wind Turbines in Denmark. We investigate the effects of the atmospheric stability on the PBL physics under different stability conditions (i.e. convective ($L_{MO} = -142m$), neutral ($L_{MO} = 3910m$) and stable ($L_{MO} = 108m$) boundary layer). Large-eddy simulations are performed at high-resolutions using the SOWFA ABLSolver (Churchfield et al., 2010) which is an open source finite volume solver based on OpenFOAM. In order to implement the proper initial and boundary conditions for different atmospheric stability classes, the Høvsøre meteorological mast measurements reaching beyond the surface layer are used (Gryning et al., 2007). On this framework, the turbulence kinetic energy (TKE) budget, mean and higher order statistics, instantaneous contours, coherent structures and the time- and streamwise averaged energy spectra are investigated in detail. All the simulations display the Kolmogorov spectral -5/3 slope within the inertial subrange to ensure the reliability of the LES. Wind speed profiles obtained from LES agree well with the wind speed measurements in Høvsøre. The effect of the LES grid-resolution is examined along the wavenumber space from the grey-zone turbulence region (Wyngaard, 2004) towards the high resolutions. Besides all these, an excessive emphasis is put on the length scale – dissipation relation along the boundary layer. In this context, we propose a new length scale model based on our LES experiments by comparing state-of-the-art models. Thanks to this generic formulation, a new PBL scheme will be built up to improve the representation of the mesoscale atmospheric simulations.

1. Churchfield, M. J., Vijayakumar, G., Brasseur, J. G., Moriarty, P. J. (2010). Wind energy-related atmospheric boundary layer large-eddy simulation using OpenFOAM (No. NREL/CP-500-48905). National Renewable Energy Lab.(NREL), Golden, CO (United States).
2. Gryning, S. E., Batchvarova, E., Brümmer, B., Jørgensen, H., Larsen, S. (2007). On the extension of the wind profile over homogeneous terrain beyond the surface boundary layer. Boundary-Layer Met., 124(2), 251-268.
3. Wyngaard, J. C. (2004). Toward numerical modeling in the "Terra Incognita". Journal of the atmospheric sciences, 61(14), 1816-1826.