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Optimization of the Mellor-Yamada scheme in the meso-scale model WRF for offshore wind conditions based on measurements and large eddy simulations.

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Measurements of offshore wind data are necessary to determine wind resources and inflow conditions in order to decide if a site is eligible for the production of wind energy. However, offshore measurements are very costly and thus information on wind conditions far from the coast are insufficiently available. Furthermore, it is necessary to know the atmospheric conditions of a site as good as possible for the development and design of future wind energy converters.

The hub heights of currently installed wind turbines in the North Sea are around 90 m, the upper tip heights are around 150 m. Since the wind speed measurements of present met masts do not go beyond much more than 100 m (e.g. FINO1 103 m) there is a gap in the knowledge concerning the wind conditions in the North Sea in heights above 100 m. After further improvement and validation meso-scale models can be a helpful mean to fill these knowledge gaps.

In this study we use the LES model PALM [1] to create a detailed data set of flows in the offshore atmospheric boundary layer. The data set contains information on all relevant turbulent variables for different atmospheric stabilities, e.g. covariances of velocity components and temperature, and is used to determine the constants in the Mellor-Yamada model. This leads to constants of which some are similar and some are rather different from those of the original model [2] (MYJ) and of Nakanishi [3] (MYNN) which are currently used in the WRF model. Furthermore the results suggest not to use constant values for the parameterization of the pressure redistribution term but functions of the atmospheric stability.

The adapted model is compared to current PBL-schemes in WRF. As reference we use mast measurements up to 100 m above the North Sea.

[1] Maronga, Björn, et al. "The Parallelized Large-Eddy Simulation Model (PALM) version 4.0 for atmospheric and oceanic flows: model formulation, recent developments, and future perspectives." Geoscientific Model Development Discussions 8 (2015), Nr. 2, S. 1539-1637 (2015).
[2] Mellor, George L., and Tetsuji Yamada. "Development of a turbulence closure model for geophysical fluid problems." Reviews of Geophysics 20.4 (1982): 851-875.
[3] Nakanishi, Mikio. "Improvement of the Mellor–Yamada turbulence closure model based on large-eddy simulation data." Boundary-Layer Meteorology 99.3 (2001): 349-378.