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Evaluation of planetary boundary layer schemes in meso-scale simulations above the North and Baltic Sea

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The development and design of wind energy converters for offshore wind farms require profound knowledge of the wind profile in the lower atmosphere. Especially an accurate and reliable estimation of turbulence, shear and veer are necessary for the prediction of energy production and loads.

Currently existing wind energy turbines in the North Sea have hub heights of around 90 m and upper tip heights around 150 m, which is already higher than the highest measurement masts (e.g. FINO1: 103 m). The next generation of wind turbines will clearly outrange these altitudes, so the interest is to examine the atmosphere's properties above the North Sea up to 300 m. Therefore, besides the Prandtl layer also the Ekman layer has to be taken into account, which implies that changes of the wind direction with height become more relevant. For this investigation we use the Weather Research and Forecasting Model (WRF), a meso-scale numerical weather prediction system.

In this study we compare different planetary boundary layer (PBL) schemes (MYJ, MYNN, QNSE) with the same high quality input from ECMWF used as boundary conditions (ERA-Interim). It was found in previous studies that the quality of the boundary conditions is crucially important for the accuracy of comparisons between different PBL schemes. This is due to the fact that the major source of meso-scale simulation errors is introduced by the driving boundary conditions and not by the different schemes of the meso-scale model itself. Hence, small differences in results from different PBL schemes can be distorted arbitrarily by coarse input data. For instance, ERA-Interim data leads to meso-scale RMSE values of 1.4 m/s at 100 m height above sea surface with mean wind speeds around 10 m/s, whereas other Reanalysis products lead to RMSEs larger than 2 m/s.
Second, we compare our simulations to operational NWP results from the COSMO model (run by the DWD).
In addition to the wind profile, also the turbulent kinetic energy (TKE) and the atmosphere's thermal stability are important to estimate power production and loads. Especially the TKE is in the focus of our research since the Master Length Scale of the closure schemes depends on it.
A third step is the validation of the results using wind measurements around the North Sea. Because the considered heights are much larger than available data from met masts, we use LiDAR observations (light detection and ranging) and prospectively UAVs (unmanned aerial vehicle).