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Investigation of the impact of atmospheric stability on the flow conditions in the offshore wind farm alpha ventus by the means of large-eddy simulations

G. Steinfeld, B. Witha, H. Ambroise, E. Stütz, and D. Heinemann

Carl-von-Ossietzky-Universität Oldenburg, ForWind - Center for wind energy research, Energy Meteorology, Oldenburg, Germany (gerald.steinfeld@forwind.de)

According to the European Wind Energy Association, 400 GW of wind power will be installed in Europe in 2030, out of which 150 GW will be located offshore. Many wind turbines will be installed in the Southern North Sea region within clusters of wind farms. For finding the optimal layout of wind farms and clusters of wind farms with regard to an optimal yield to cost ratio, a deeper knowledge on intra and inter wind farm wake effects is required, as the region downstream, in the wake of an operating wind turbine is characterized by a deficit of the wind velocity and an increase of the turbulence intensity.
Recent studies on wake effects inside Horns Rev wind farm reveal that atmospheric stability has an influence on the wind farm efficiency. Larger power output to rated power ratios are observed in convective situations. Wake measurements with a far-range lidar have also shown that atmospheric stability has a huge impact on the wake characteristics.
In this study, we used the large-eddy simulation model PALM and an implemented actuator disc model in order to simulate the intra wind farm flow in the offshore wind farm alpha ventus under a set of atmospheric conditions. By using a stationary model domain with turbulent inflow instead of cyclic boundary conditions, a single wind farm instead of an infinite series of wind farms is simulated. The results of the simulations that underline the importance of the atmospheric stability for the wind farm flow are compared with measurements in the wind farm and its nearby meteorological met mast FINO1.
The systematic analysis of wind farm flows with the means of LES can deliver valuable information for the development of new parameterizations in engineering wake models that are used for planning the layout of new wind farms.