EMS Annual Meeting Abstracts
Vol. 11, EMS2014-122, 2014
14th EMS / 10th ECAC

Improvement of a wind farm parameterization for mesoscale models based on a parameter study with the large-eddy simulation model PALM

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The utilization of offshore wind resources is intended to play a major role in Germany's future energy system. The current objective is an installation of a capacity of 15 GW by the year 2030. The space actually available for the deployment of offshore wind farms is limited e.g. by ship routes, nature protection areas or areas reserved for fishing leading to plans to place most of the offshore wind farms relatively close together, so that wakes of neighbouring wind farms might have a non-negligible impact on the energy yield of a wind farm. New models are required to come to robust estimates of wind farm wake effects for yield calculations. One approach followed recently is the development of wind farm parameterizations for mesoscale models.

Here, we present results of a large-eddy simulation (LES) study of the flow conditions behind an offshore wind farm. The PArallelized Large-eddy simulation Model (PALM) has been applied. In our PALM runs wind turbines are represented by an actuator disc model. A set of simulations has been carried out in order to study the impact of the wind direction on the wind speed deficit behind the wind farm as well as on the recovery of this wind speed deficit.

The simulations reveal that the specification of the wind turbine density is not sufficient to determine the wind speed deficit behind a wind farm. Based on the LES results an approach has been developed with which the wind farm parameterization implemented in the standard code of WRF has been further developed in order to account for the dependency of the extraction of energy by a wind farm on the wind direction. A parameter being of major importance for the improvement of the wind farm parameterization is the frontal area index, i.e. the share of the total rotor area of the wind farm that is exposed to the ambient flow.