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Volker, Patrick; Badger, Jake; Hahmann, Andrea N.

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Dynamical and statistical-dynamical modelling of wind farm flows with WRF

Patrick J. H. Volker, Jake Volker, and Andrea N. Hahmann
Danish Technical University, Windenergy, Roskilde, Denmark (pvol@dtu.dk)

A pledge to increase the share of renewable energies has led to a focus on offshore wind energy in many western European countries. With an increasing number of offshore wind farms to be installed it becomes important to understand (I) the degree to which wakes from neighbouring wind farms affect the power production of a target wind farm and (II) how large wind farms can get if they are to remain efficient and productive power generators.

The modelling of wind farm wake flows is challenging, since it includes processes from the micro- to mesoscale meteorology. We use the Weather Research and Forecast (WRF) model that allows us to simulate mesoscale features of wind farm wakes. Its limited horizontal resolution – in microscale terms – however, requires flow characteristics, such as single turbine wakes, to be parametrised.

We start by describing the WRF wind farm scheme and the Explicit Wake Parametrisation (EWP) (developed at the Danish Technical University) approach and show that the averaged simulated wake compares well to met mast measurements to the east of the offshore wind farm Horns Rev I. Then, we discuss simulations with “real” initial and boundary forcing. These simulations are especially useful to simulate a time dependent wind farm interaction, because of the model’s ability to account for wake dynamics particularly wake direction. This is shown by examples from Belgian and British wind farms. Finally, we discuss how “idealised” initial and boundary conditions allow – due to a controllable forcing – for a more analytical investigation of the flow field. We show how these simulations can be used to simulate long-term averaged flows and why they are especially suitable to investigate flow fields within wind farms in different wind regimes.