On the impact of realistic offshore wind energy exploration scenarios on wind conditions within the German Bight

PO.042

Dörenkämper, Martin[1]; Vollmer, Lukas[1]; Steinfeld, Gerald[2]; Stoevesandt, Bernhard[1]; Heinemann, Detlev[1,2]

[1]Fraunhofer Institute for Wind Energy Systems (IWES), [2]ForWind - University of Oldenburg, Germany

Fraunhofer IWES

Abstract

Offshore wind energy is a rapidly growing energy source. In Germany, the installed offshore wind capacity increased from 1.0 GW to 4.1 GW only within the years 2015-2017. [1]

Limited mesoscale wind farm wake studies exist. Past studies were often either using idealized or unrealistically large wind farms or investigating single flow situations.

In this study, realistic wind farm scenarios taking the as is as well as all planned wind farms within the German Bight into account are simulated using a mesoscale model with a wind farm parametrisation.

The study compares three scenarios and their impact on the wind conditions over the German Bight over a full year of simulations with a horizontal resolution of about 2 km in each scenario. The simulations show a quite strong reduction of the wind resource. However, validations especially for longer time scales are needed.

Objectives

The objectives of this study are:

- to perform one of the first investigations of realistic wind
- to compare different wind farm expansion scenarios and their impact on the wind resource
- to discuss validation strategies for the modelling approach used

Methods

Mesoscale Model Simulations with the widely established WRF model [2] were carried out, taking the existing and planned wind farms in the German Bight into account (Fitch-parametrization [3]). The simulations covered a full year (2011) that was chosen to be representative to the long-term wind conditions above the German Bight.

An offshore-optimized setup was used with an enhanced sea surface temperature dataset and PBL schemes optimized for offshore wind conditions.

The wind time series and wind fields (10-min resolution) provided by the model simulations were statistically evaluated and the scenarios were compared

Methods

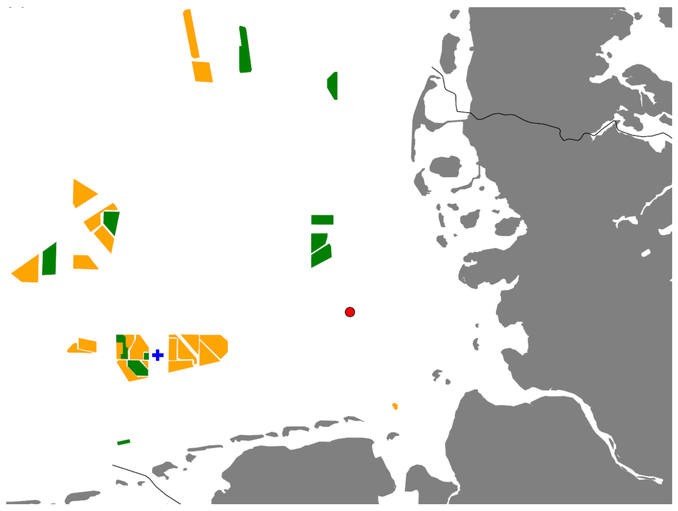

Figure 1: Positions of the wind farms simulated.

Three different scenarios were simulated: a control run with no wind farms [REF], an as-is scenario of the current wind energy expansion 2016 [SC1 - green in Fig. 1] and a future scenario taking all planned wind farms into account [SC2 - yellow+green in Fig. 1].

Results

Figure 2 shows the wind fields at hub height for the scenarios SC1 and SC2. The figure indicates a moderate impact of the wind farm clusters on the wind field in the German Bight in case of the current wind farm expansion.

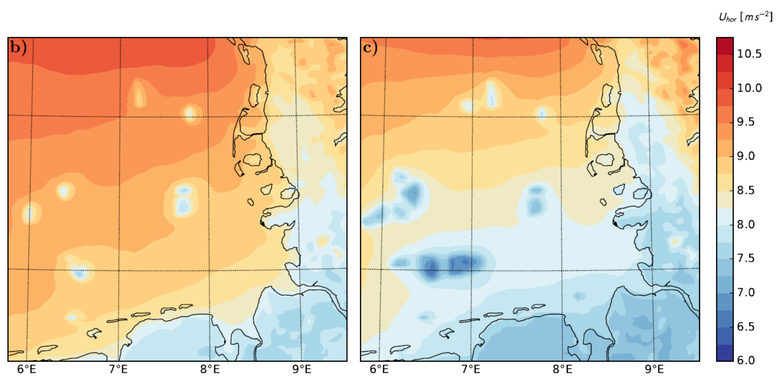

Figure 2: Wind field at hub height for two different scenarios (2016 + >2022) from mesoscale model simulations with a wind farm parametrization.

However, in the scenario with the further wind farm expansion the wind speed reduces to a much stronger extent over large areas of the German Bight.

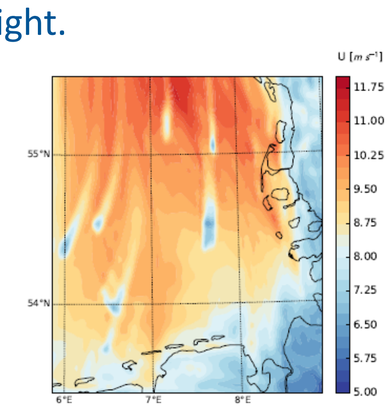

Figure 3: Instantaneous wind field at hub height during southwesterly winds.

Figure 3 shows an instantaneous wind field from the simulations during south-westerly winds. The figure shows a strong turning of the wind due to a nearby pressure system.

Results

Although, these large-scale meteorological effects strongly modify the flow conditions they are typically not accounted for by engineering models.

Validation

The presented results are not properly validated. The modelling approach has been compared for single situations to aircraft measurements and wind farm production data and showed good results (see e.g. [4]).

A validation against long-term wind or production data is missing.

The authors see this approach as a first scientifically sound step towards understanding the future wind resource, but more validation is needed.

The authors aim on validating these simulations with long-term data together with wind farm operators and owners.

Conclusions

A rather strong impact of the wind farms on the wind statistics and the average wind fields is shown.

When large-scale wind farm wake effects, are investigated, the larger scale (e.g. mesoscale) meteorology needs to be taken into account. Frontal passages and the large-scale turning of the wind strongly impact the behaviour of the wakes.

Mesoscale model simulations are a key technology for a future investigation of large-scale wind farm exploration. Future projects will need to focus on a detailed verification of these methods in particular with wind farm production data. If properly validated, the method is well suited for a renewed calculation of the future wind resources, i.e. offshore wind atlases.

References

[1] Wind Europe (2018): The European offshore wind industry - key trends and statistics 2017, *Technical Report,* Wind Europe.

[2] Skamarock et al. 2008: A description of the advanced research WRF version 3, *Technical Report, NCAR Boulder, Colorado.*

[3] Fitch et al. 2012: Local and mesoscale impacts of wind farms as parametrized in a mesoscale NWP Molde, *Mon Weather Rev, doi: 10.1175/MWR-D-11-00352.1*

[4] Siedersleben, et al. 2018: Evaluation of a wind farm parametrization for mesoscale atmospheric flow models with aircraft measurements, *submitted to Meteorol. Z*

Meet us at Hall B6, Booth 464

Wind EUROPE
The global on & offshore conference

windeurope.org/summit2018
#GlobalWind2018

Download the poster