#16019

Karlsruhe Institute of Technology

Inst. of Meteorol. + Climate Research
Atmospheric Environmental Research

KIT-Campus Alpin
IMK-IFU: Atmospheric Environmental Research

WIPAFF

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag
grant number: FKZ 0325783

Meteorological issues of large offshore wind parks

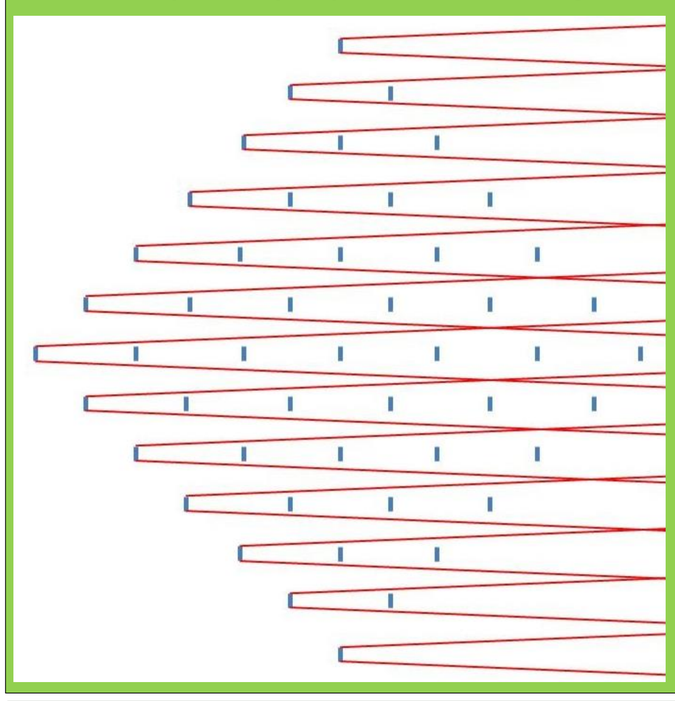
Stefan Emeis
Karlsruhe Institute of Technology, stefan.emeis@kit.edu

Keywords: Deep Array Effects – Offshore Park Wakes – Extreme Wind Speed - Cut-Off Wind Speed – Turbine Shut-Down

Synopsis: 1169 wind turbines in 20 wind parks with an installed power of 5.387 GW were operated in the German Bight on a small area of roughly 200 km by 130 km = 26000 km² at the end of June 2018[1]. This raises, amongst others issues, three questions:

(1) have ‚deep array effects' to be considered?
(2) do park wakes influence other wind parks?
(3) what happens, if the cut-off wind speed is reached?

Deep array effects (DAE): Wake interaction within wind parks depends on the park configuration, meteorology and outer conditions. DAE means nonlinear interaction which is stronger than simple superposition of single wakes.



Wake interaction within an offshore wind park (WDC = 0.04). For approaching flow parallel to the turbine rows, onset of DAE can be expected from the Nth turbine in a row onwards:

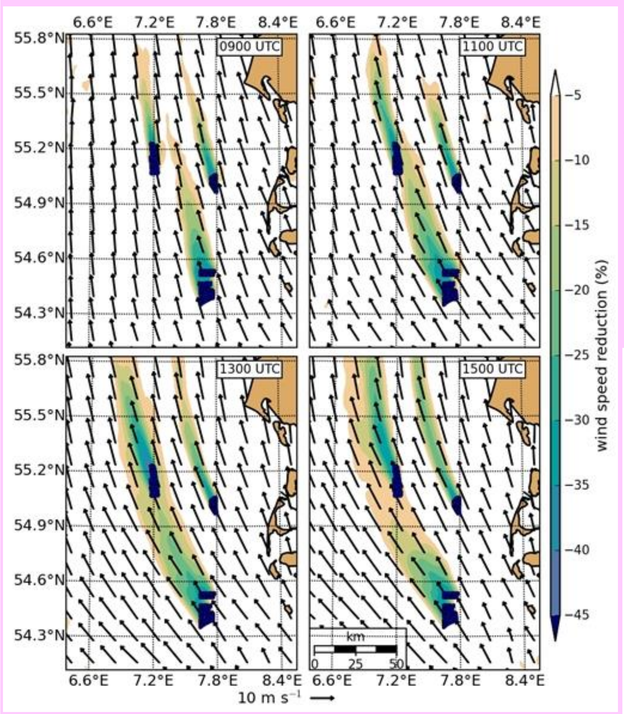
N = 1 + 0,4 *(1/WDC) * (Y/X)

For 45° flow N is about half this value.

Existing wake interaction estimates need updates.

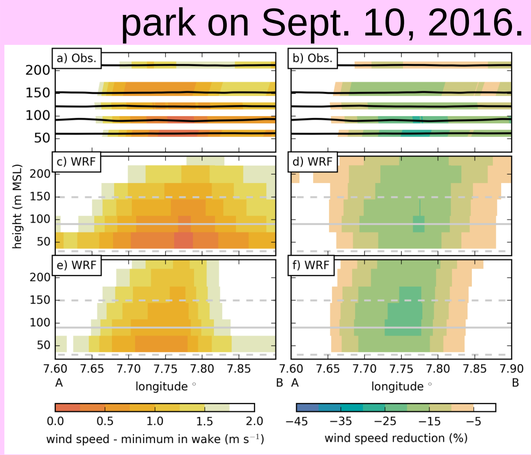
WDC: wake decay constant, Y: longitudinal turbine distance, X: crosswise turbine distance

Offshore wind park wakes: The wind park parameterization in WRF [2] has been evaluated [3] in WIPAFF [4]. It is working well and the exact choice of parameters within the parameterization is less important than the correct simulation of the undisturbed upwind wind conditions. This becomes especially important for wind parks close to shore lines.



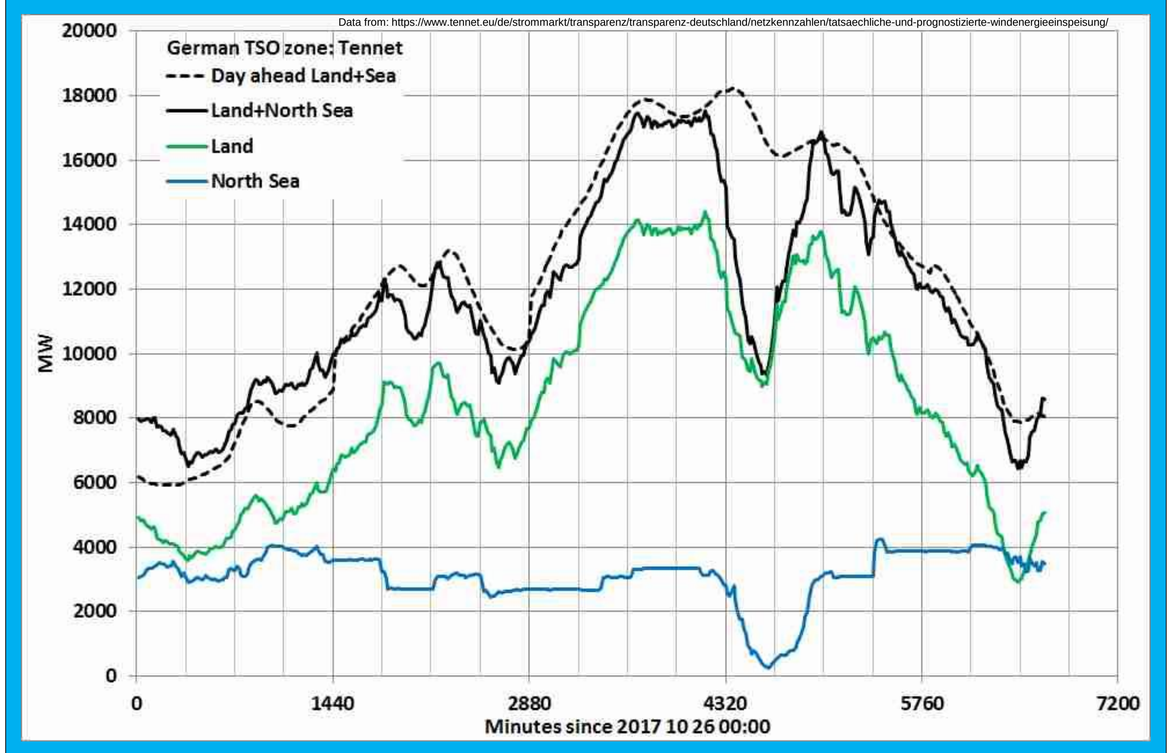
Wake-wake interaction. Weather data of May 3, 2006 together with today's wind farms in a WRF simulation.

Vertical cross-section through a wake 5 km behind a wind park on Sept. 10, 2016.

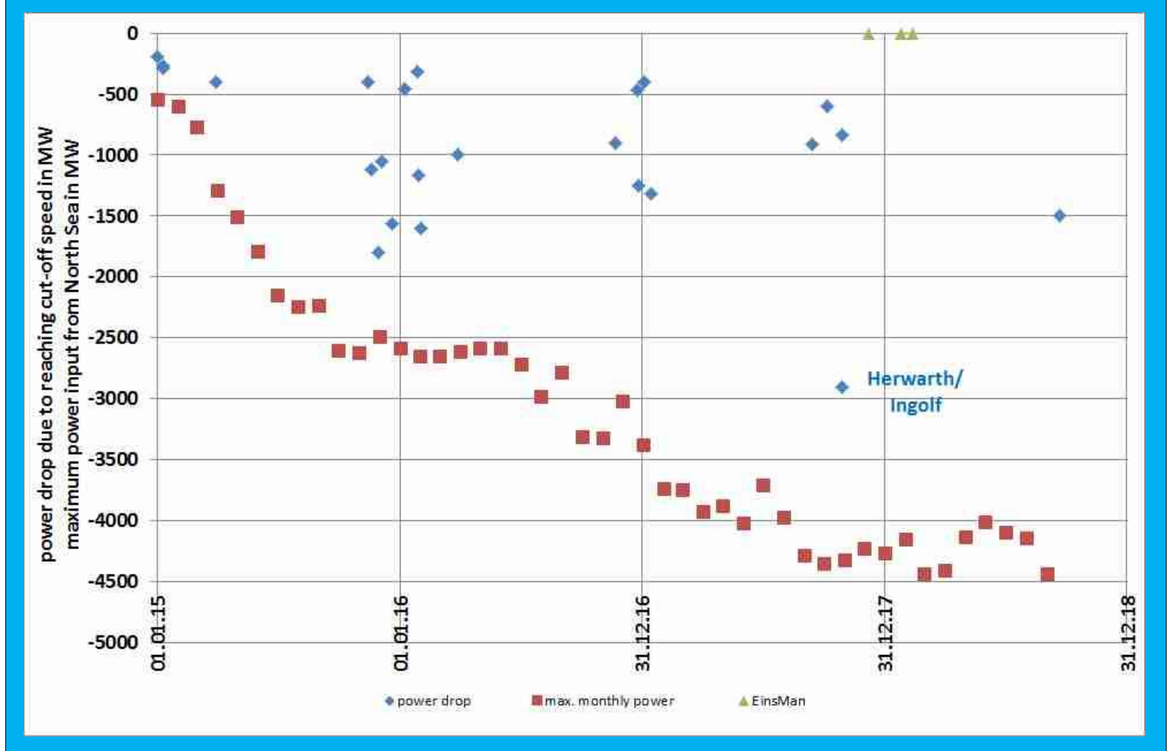


WRF simulations and plots by Simon Siedersleben, IMK-IFU, KIT, aircraft observations behind offshore parks by TU Braunschweig

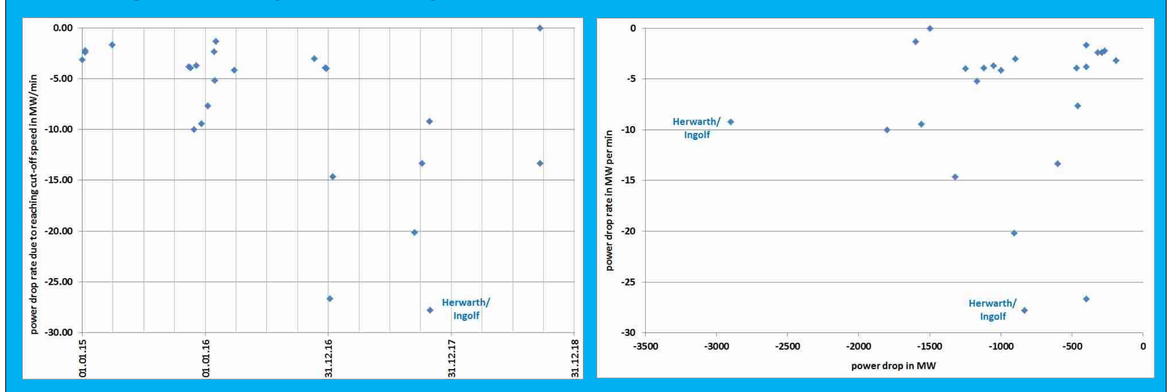
Exceedance of cut-off wind speed: Exceedance of cut-off wind speed leads to sudden shut-downs of offshore wind parks.



Shut-down of onshore and offshore wind parks due to cyclone Herwart/Ingolf on October 28/29, 2017.



Drop in power due to shut-down of wind parks in the North Sea for the years 2015-2018. Further OWPs in the North Sea will rise the risk of even larger drops in power, although feed-in management (EinsMan) reduces such risks.



Left: Drop rate in power due to shut-down of wind parks in the North Sea for the years 2015-2018. Right: Power drop versus drop rate for the years 2015-2018. For Herwart/Ingolf, the maximum drop rate within half an hour and the overall drop are given.

Statistics made on October 4, 2018 using FINO1 and FINO3 data provided by BSH and feed-in data provided by Tennet on the internet. Additional research is needed. Better shut-down procedures are available and should be applied.

References

[1] https://www.windkraft-journal.de/2018/07/19/aktuell-laeuft-der-ausbau-der-offshore-windenergie-bis-2020-nach-plan (read: October 18, 2018)

[2] Fitch, A. C., J. B. Olson, J. K. Lundquist, J. Dudhia, A. K. Gupta, J. Michalakes, and I. Barstad, 2012: Local and Mesoscale Impacts of Wind Farms as Parameterized in a Mesoscale NWP Model. Mon. Wea. Rev., 140 (9), 3017–3038, doi:10.1175/MWR-D-11-00352.1.

[3] Siedersleben, S.K., A. Platis, J.K. Lundquist, A. Lampert, K. Bärfuss, B. Cañadillas, B. Djath, J. Schulz-Stellenfleth, J. Bange, T. Neumann, S. Emeis, 2018: Evaluation of a Wind Farm Parametrization for Mesoscale Atmospheric Flow Models with Aircraft Measurements. Meteorol. Z., published online Sept 28, 2018. DOI: 1010.1127/metz/2018/0900

[4] Platis, A., S.K. Siedersleben, J. Bange, A. Lampert, K. Bärfuss, R. Hankers, B. Cañadillas, R. Foreman, J. Schulz-Stellenfleth, B. Djath, T. Neumann, S. Emeis, 2018: First in situ evidence of wakes in the far field behind offshore wind farms. Scientific Reports, **8**, 2163. DOI: 10.1038/s41598-018-20389-y