UNIVERSITY OF TWENTE.

Physics of Fluids

MAX-PLANCK-GESELLSCHAFT

The impact of atmospheric conditions on wind farm wakes

The number of wind farms is expanding due to the increasing demand for renewable energy. Especially in offshore regions, several wind farms are constructed in the direct vicinity of other wind farms. Depending on the wind farm size and layout and the prevailing atmospheric conditions, the wakes of the individual wind turbines might merge and form a wind wake [1, 2, 3, 4]. Wind farm wakes have been measured up to 55 km downstream of a wind farm [2,5], emphasizing the importance of studying the interaction between wind farms. In contrast to field measurements, numerical simulations provide the ability to study the flow under well-controlled and reproducible conditions. The simulations allow for a better physical understanding of the development of wind farm wakes and how atmospheric flow conditions affect this process. Large Eddy Simulations (LES) have been shown to accurately capture wake interaction in different atmospheric conditions [6,7]. LES resolve large-scale flow features in an atmospheric boundary layer, and small-scale turbulence is parameterized using a sub-grid scale model. In this study, we will use LES to study the wake behind wind farms of different sizes. Inflow conditions will be changed systematically, and their influence on the size and strength of the wind farm wake will be documented. Finally, the results will be used to validate and optimize prevailing engineering models that are used to predict the recovery of wind farm wakes. The optimization of engineering models is essential for the sustainable planning of new wind farms in the vicinity of existing wind farms.

This study will be part of the wind farm project in the Physics of Fluids group of the University of Twente in the Netherlands (https://pof.tnw.utwente.nl/). The project will be performed under the supervision of Richard Stevens (Assoc. Professor) [8]. For further information see https://stevensrjam.github.io/Website/.

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Figure 1: Visualization of Large Eddy Simulations of a wind farm by Srinidhi N. Gadde [9]

[1] Nygaard NG. Wakes in very large wind farms and the effect of neighbouring wind farms. J Phys Conf Ser 2014;524:012162.
[2] Schneemann J, Rott A, Dörenkämper M, Steinfeld G, Kühn M. Cluster wakes impact on a far-distant offshore wind farm's power. Wind Energy Science 2020;5(1):29–49.
[3] Platis A, Hundhausen M, Mauz M, Siedersleben S, Lampert A, Bärfuss K, et al. Evaluation of a simple analytical model for offshore wind farm wake recovery by in situ data and Weather Research and Forecasting simulations. Wind Energy 2020;24:212–228.
[4] Maas O, Raasch S. Wake properties and power output of very large wind farms for different meteorological conditions
[5] Cañadillas B, Foreman R, Barth V, Siedersleben S, Lampert A, Platis A, et al. Offshore wind farm wake recovery: Airborne measurements and its representation in engineering models. Wind Energy 2020;23(5):1249–1265
[6] Calaf M, Meneveau C, Meyers J. Large eddy simulations of fully developed wind-turbine array boundary layers. Phys Fluids 2010;22:015110.
[7] Gadde SN, Stevens RJAM. Interaction between low-level jets and wind farms in a stable atmospheric boundary layer. Phys Rev Fluids 2021;6:014603.
[8] Stieren A, and Stevens RJAM. Evaluating wind farm wakes in large eddy simulations and engineering models. J. Phys. Conf. Ser. 2021; Vol. 1934.
[9] Gadde SN, Large eddy simulations of stratified atmospheric boundary layers and wind farms 2021, Enschede: University of Twente. (PhD Thesis)