Prediction of wake effects on wind farm power production using a RANS approach. Part II. Offshore: Case studies from the UPWIND project

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Abstract summary

The estimation of power losses due to wind turbine wakes is crucial to understanding overall wind farm economics. This is especially true for large offshore wind farms, as it represents the primary source of losses in available power, given the regular arrangement of rotors, their generally larger diameter and the lower ambient turbulence level, all of which conspire to dramatically affect wake expansion and, consequently, the power deficit. Simulation of wake effects in offshore wind farms (in reasonable computational time) is currently feasible using CFD tools. An elliptic CFD model based on the actuator disk method and various RANS turbulence closure schemes is tested and validated using power ratios extracted from Horns Rev and Nysted wind farms, collected as part of the EU-funded UPWIND project. The primary focus of the present work is on turbulence modeling, as turbulent mixing is the main mechanism for flow recovery inside wind farms. A higher-order approach, based on the anisotropic RSM model, is tested to better take into account the imbalance in the length scales inside and outside of the wake, not well reproduced by current two-equation closure schemes.

NUMERICAL MODEL

A non-uniform flow is modelled in a computational domain representing the surface boundary layer in which the Monin-Obukov theory is solved from the Reynolds Average Navier Stokes equations and the turbulent transport terms from the k-ε method and the RSM model.

RESULTS FOR HORNS REV: Analysis on Vinf estimation

RESULTS FOR NYSTED: Analysis on turbulence modeling

CONCLUSIONS

Two critical aspects for the simulation of big offshore wind farms based on RANS models coupled to the actuator disk technique have been assessed: the method to estimate the reference wind speed and turbulence modeling. For the case run at Horns Rev, the method proposed by [2] for the estimation of the reference wind speed improves the results in comparison to the standard procedure of selecting the value 2D upstream of each rotor disk. For the case run at Nysted, the use of a higher order turbulence closure scheme also improves the results making this option a promising alternative. Further work will consist of generating a parabolic solver based on the open CFD code OpenFOAM for offshore wind farms, combining both methods and validating the model for more cases.

References

8) Cabezón D., Sanzo J., Marull J., Crespo A., “CFD modelling of the interaction between the Surface Boundary Layer and rotor wake: Comparison of results obtained with different turbulence models and mesh strategies”. EWEC 2009, Marseille (France)

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