

## NUMERICAL SIMULATIONS OF WIND TURBINES AND WINDFARMS

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### ABSTRACT

The numerical simulation and prediction of flows around wind turbines and wind farms are difficult. This difficulty is caused, on the one hand, by the rotating blades, which leads to unsteady flow features and dynamic effects, and to the high Reynolds number turbulent atmospheric flow in which these devices operate. Both the blade movement and the high turbulence lead to costly numerical simulations. Large eddy simulations (LES) of farms are common in academia [1] and have helped to study energy extraction or wake interactions. The choice of simulation approach depends on the desired level of accuracy, with large eddy simulation being the preferred method for capturing the most detailed information. However, when conducting parameter studies, (unsteady) RANS is required, while more analytical approaches are pursued to increase the physical understanding of the flow.

Various simplified techniques exist to mimic the effect of rotating blades (e.g., actuator discs or actuator lines [2]), which are used to reduce cost. These techniques impose sectional forces on the fluid (calculated/measured for 2D airfoils) to mimic the effect of individual blades (actuator line) or, if azimuthally averaged, mimic the entire rotor (actuator disc). These techniques can efficiently replicate the effect of the energy extracted from the flow and flow swirls arising from rotors in the far field but face limitations when detailed flow features need

to be considered for fine design or aeroacoustic predictions since some effects are neglected (e.g. trailing edges, 3D effects on lift/drag, dynamic stall).

This colloquium will unite wind turbine and wind farm simulation experts to explore cutting-edge simulation strategies. In addition, we will discuss how the valuable insights gained from these simulations can be leveraged to enhance low-order and analytical models, driving meaningful advancements in our understanding of the fluid mechanics of wind turbines and wind farms. With active wind energy research communities across Europe, North and South America, and China, we anticipate a diverse and engaging group of participants worldwide to join us in this colloquium.

### REFERENCES

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