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Development of a New Multiphysics Framework for Large Wind Farm Simulations.

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ABSTRACT

As the size of modern wind farms is continuously increasing, the research community is paying more attention on far-field wake recovery, wake/wake interaction between adjacent wind farms and on the flow region upstream the plant, where flow deceleration is the result of pressure perturbations triggered by atmospheric gravity waves. The latter live above the boundary layer and are generated by its interaction with the wind farm. These effects are not yet clearly understood, hence not included in state-of-the-art engineering models. Therefore, wind farm annual energy production is frequently underestimated. This work presents an efficient, highly parallel numerical framework that enables large eddy simulations of arbitrary-large wind farms, accounting for the impact of atmospheric boundary layer stability, free-stream turbulence, and thermal stratification. Wind turbines can be modeled with sophisticated actuator disk/line models, allowing data acquisition of turbine data samples in the same fashion as real-world SCADA (System Control and Data Acquisition) systems. Additionally, the proposed framework can model complex terrain using a sharp interface immersed boundary method. High fidelity simulations are crucial to understand the above mentioned physics for enhancing engineering models used in wind energy industry and this new open source framework allows the user to achieve the desired versatility within it.