JOHNS HOPKINS
Center for Environmental & Applied Fluid Mechanics

SPRING 2020 SPECIAL CEAFM SEMINAR

“On the Structure of Turbulence in Wind Turbine Wakes: Insights Gained by Numerical Simulations and Experiments”

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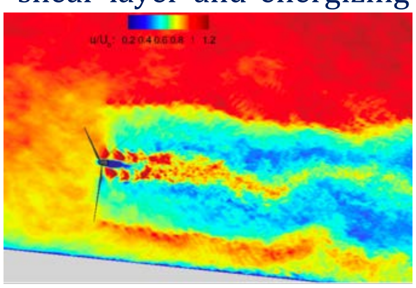
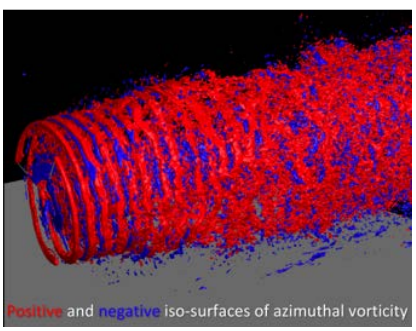
Recent high-fidelity large-eddy simulations (LES) coupled with laboratory and field scale experiments have yielded new insights into the rich dynamics of wind turbine wakes and elucidated the impact of near-wake phenomena to far wake meandering. The hub vortex has been shown to undergo spiral vortex breakdown undergoing low frequency oscillations and lateral expansion ultimately interacting with the turbine tip shear layer and energizing the intensity of wake meandering several rotor diameters downwind. Large-scale snow PIV and LES of utility scale turbines have further uncovered a previously unknown centrifugal instability mode of the turbine tip shear layer, which manifests itself in the form of a second set of spiral vortices with vorticity of opposite sign relative to the spiral tip vortices. Standard actuator disk or line models widely used today to parameterize wind turbines in wind farm simulations are not able to capture such phenomena and especially the instability of the hub vortex. To mitigate this limitation, we have developed a new class of actuator surface models that incorporate the turbine nacelle and are able to capture the correct coherent dynamics of the near wake and their impact on far wake meandering. I will present this new class of models, demonstrate their improved predictive capabilities, and discuss implications for large scale simulations of real-life wind farms. I will also present a new computational framework that paves the way for simulation-based control co-design of utility scale offshore wind farms incorporating floating platform dynamics and a range of wind turbine control strategies.





Monday, February 3, 2020 (Special Day)
3:00 PM, Latrobe Hall 106 (Special Location)