

Proactive Monitoring of Wind Farm Performance Through Wind LiDAR Data and a Reduced Order Model

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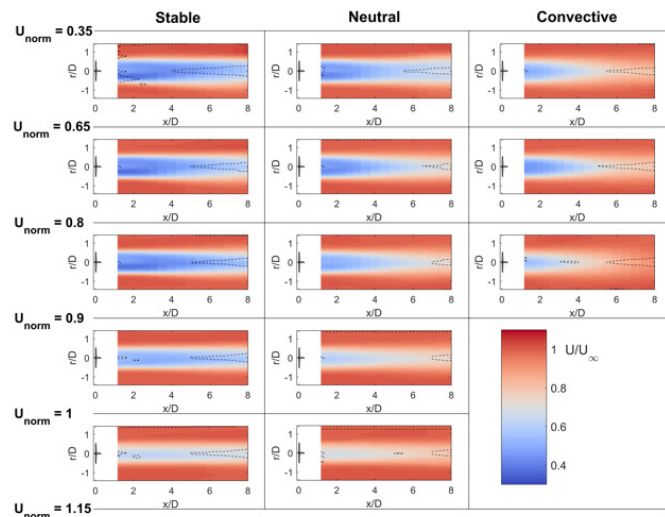
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This project aims to develop a CFD tool for accurate predictions of wind turbine wakes and power capture at the turbine level by reproducing the typical variability during the daily cycle of the atmospheric stability. This CFD tool is based on the Reynolds-averaged Navier-Stokes (RANS) equations, which are solved parabolically in order to reduce the computational costs. Calibration and assessment of this code has been performed by leveraging LiDAR measurements of wind turbine wakes, SCADA and meteorological data collected for a wind farm in North Texas deployed over a relatively flat terrain. For this test case, the CFD tool showed an accuracy of 7% with a confidence level of 90% for estimates of power capture from individual turbines. Among different features, the CFD tool provides a data-driven calibration of the turbulence closure in order to mimic variability in wake recovery due to different regimes of the atmospheric stability. Furthermore, the thrust force over the turbine blades is experimentally estimated by coupling LiDAR data and RANS simulations. The current challenge for this project consists in extending the range of applicability of this CFD tool to wind farms on complex terrain. To this aim, a new LiDAR field campaign is under execution for a wind farm in Colorado. This new experimental dataset will allow us to single out potential weaknesses of the CFD tool in presence of topographic effects and, hopefully, to overcome those through further developments of the tool. Mesoscale simulations with ad-hoc wind farm modeling have been executed for the wind farm in North Texas, showing a good accuracy in predicting the wind field around and within the wind farm, while estimating power capture at the turbine level as well.



Bonded Variability of the wake velocity field for different incoming wind speed and regime of the atmospheric stability.



Deployment of the UTD mobile LiDAR station at a wind farm on complex terrain in Colorado