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Comparison of wind turbine wake numerical simulation with scanning lidar measurements

Introduction

Wind turbines wake can have an impact of 10 to 20 % on the production of an offshore wind farm. Therefore an accurate modeling of these wakes remains an important but still difficult issue for the estimation of the annual energy production. Good quality data sets are required to validate this modeling and to define what is the best compromise between the modeling refinement and the required computation time. Scanning Lidar system has been recently considered as a valuable tool for realization of cost efficient wind resource assessment. This kind of device may offer more complete measurement data than traditional meteorological masts sensors. Furthermore, scanning Lidar can cover a larger spatial extent measuring wind fields up to a range of a few kilometers. This aspect is very useful for offshore wind turbines, especially for measuring wind speed inside the farm and thus characterizing the wake effect.

Approach

The objective of this work is to use scanning lidar measurements for a detailed characterization of the wake effect inside a wind farm and to compare with a numerical modeling this effect. Although the final objective is to carry out the comparison at an offshore site, it is first performed on a flat onshore site in order to be able to focus on the wake of a single row of turbines. Numerical simulations of wind turbine wakes have been performed with an open source in-house computational fluid dynamics (CFD) tool "Code_Saturne".

Main body of abstract

The main objective of the present work is to compare numerical simulations of wake effect with scanning lidar measurements for 8 wind turbines located in France. A four month campaign (from end of January to beginning of May 2015) has been carried out focusing on capturing wakes from the wind turbines for various wind and atmospheric conditions. Measurements from a WINDCUBE 200S scanning lidar, WINDCUBE V2 and other in-situ sensors such as sonic anemometers, vanes and cups located on a meteorological mast were used for inter-comparison of wind measurements. The CFD model solves numerically the 3D Reynolds Averaged Navier Stokes (RANS) equations using the turbulence model "standard k-ε" with a 1.3 million cells mesh. The wind turbines have been modeled by a homogeneous model without rotation based on the actuator disk concept. The comparison of the wind fields between Scanning Lidar raw measurements and reconstructed wind speed measurements with the CFD model results will be presented. The results from two predominant wind direction sectors of interest (North East and South West) will be analyzed. In the case of North East wind, the meteorological mast is located in the wake of the wind turbines, thereby giving a reference measurement to compare with the model and the scanning lidar. One of the challenges is to define a relevant method to compare instantaneous wind speed measurements (four scans per

hour for a given elevation) from the Lidar to a mean wind speed value (obtained from averaged Navier Stokes equations).

Conclusion

The presentation will give the results and conclusions of the comparison, including lessons learned from the field deployment. Comparison of radial wind speed as well as statistical metrics between the CFD model and scanning Lidar measurements will be shown.

Learning objectives

1. Details of the open source CFD model “Code_Saturne”
2. How to compare CFD model and scanning lidar measurements
3. Does a CFD model with an actuator disk modeling represent realistically the wind field downstream a row of wind turbines ?