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Abstract No.

Comparison of wake flow, power and load measurements from three mid-fidelity wake models based on the DWM approach

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In this study we compare the performance of three mid-fidelity wake models based on the Dynamic Wake Meandering (DWM) model. The original DWM model (Larsen et al., 2008) developed at DTU has shown to be a promising approach for estimating both power and, when coupled to an aeroelastic solver, loads in a wind farm. It is now a well-established model in the wind energy community and has recently been included in the new edition of the IEC code as a recommended practice. The DWM model is based on the assumption that the quasi-steady wake deficit, obtained from a thin shear-layer approximation of the Navier-Stokes equations, meanders as a passive tracer by the large-scale structures in the incoming wind. Another core element of the DWM model is the wake added turbulence; an increase of the turbulence level in the turbine wake relative to the ambient, caused by the breakdown of tip vortices and from the shear of the velocity deficit.

Since the introduction of the DWM model, several improvements have been suggested and other wake models based on the main DWM ideas have been developed. FAST.Farm (Jonkman et al., 2017) developed at NREL, and WIFET Farm Simulator developed at IFE (Hanssen-Bauer et al., 2020) are two such wake models, and are compared against the original DWM model in this study. The comparison is carried out by testing the three models on different farm configurations. Figure 1 and 2 shows preliminary results of the flow field through two such farm configurations. In figure 1, four NREL 5MW reference turbines are aligned with 7.5D spacing resulting in fully waked conditions. In figure 2, the inflow angle has changed and the turbines experience partially waked conditions. A third example of a farm setup, two turbines side-by-side, is investigated to compare how the DWM models handle the merging of these turbine wakes. To focus on the wake modelling, the difference in inflow models is eliminated by feeding all the DWM models with the same Large Eddy Simulation (LES) precursor-generated inflow for the comparison. As a reference to the three DWM models, LES with turbines modeled as actuator lines were performed for some of the inflow and farm configurations simulated by the DWM models.

Despite the similarities between the wake models, this comparison shows differences in simulated wake flow, and turbine power and loads. Variations in model implementation when it comes to treating e.g. wake added turbulence, wake summation and merging, eddy viscosity closure and wake transport velocity are addressed, and their impact on the results are discussed. The results of this comparison will help quantify simulation uncertainty as it pertains to model implementation. In addition, we identify strengths and weaknesses of current mid-fidelity wake modeling strategies. From these results, we suggest priorities for future model developments so that robust and low-uncertainty model implementations can be used in wind farm design.

Keywords: ”DWM” ”turbine wakes” ”wind farm” ”wake merging” ”turbine loads”

Images:
Link: https://s3-eu-west-1.amazonaws.com/static.vcongress.de/cms/forwind/paper/59ab4063-a2ab-4230-a9cd-df5be1236f42.png
Description: Figure 2: Preliminary results of the flow field through a farm with turbines in partially waked conditions

Link: https://s3-eu-west-1.amazonaws.com/static.vcongress.de/cms/forwind/paper/f669be49-06d4-4639-9836-7780ba4bc152.png
Description: Figure 1: Preliminary results of the flow field through a farm with turbines in fully waked conditions

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