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Wake deviation of yawed wind turbine by Large-Eddy Simulation

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According to the current energetic and environmental challenges, maximizing the electric power generated in windfarms is a societal concern. New strategies such as involving wind turbine yaw angle seem relevant to reduce wake interaction and associated power losses [1]. Therefore, yawed turbine aerodynamics is modified and remains a challenging investigation topic.

Since experimental data on actual windfarm scales are not affordable and given the constant growth of computational resources, high order numerical simulations tend to be a promising approach [2]. The goal of this study is to evaluate a highly resolved numerical model under yaw condition in a wind tunnel before applying it to actual windfarm. The blade modeling is performed using an Actuator Line Method [3] (ALM), coupled to the low Mach-number massively-parallel finite-volume Large-Eddy Simulation (LES) flow solver on unstructured meshes, called YALES2 [4] [5].

The Blind Test 5 experimental configuration led at NTNU [6], gathering numerous experimental data, is reproduced in this study. After the study of a yawed turbine wake interaction with downstream turbine the study of a single yawed turbine ($+30^o$ and 0^o) will be presented. The computational domain of these cases will be the NTNU wind tunnel, involving a turbulence grid aiming to create a fully turbulent sheared inflow [6]. The grid will be modeled using multiple Actuator Lines (to mimic the turbine blades) with dedicated polars [7] [8]. Each computational case is performed on a unstructured mesh with around 150.10^6 tetrahedra. An instantaneous velocity field of the yawed turbine wake interaction is presented on Figure 1.

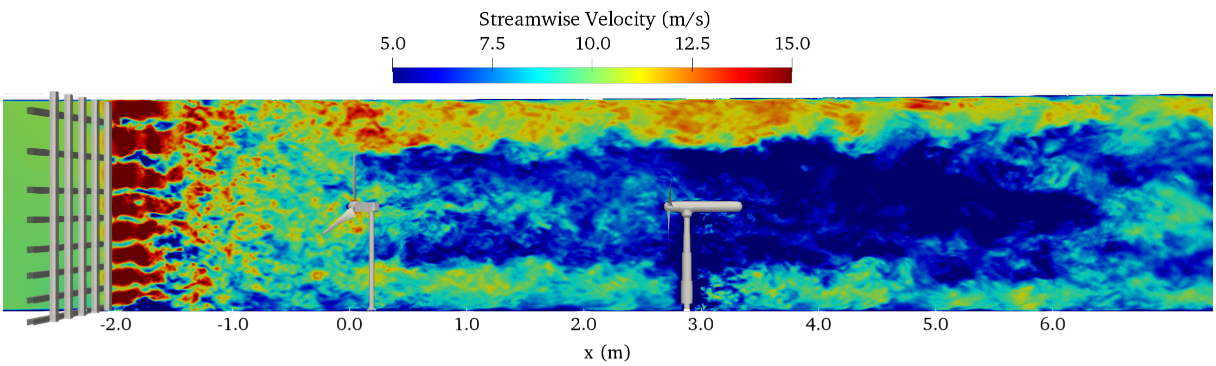

Figure 1: Instantaneous streamwise velocity field of wake interaction between two turbines in the NTNU wind tunnel with unstructured mesh

At first, a comparison of global quantities with experimental data will be led, such as averaged power and thrust coefficient, or yaw moment. This will be followed by local characteristics analysis including velocity and turbulence intensity profiles as well as wake scan downstream of the turbine. As well, a comparison to wake deflection models will be presented. This first validation step will allow to go into a deeper analysis using advanced post processing. A study of the turbulence anisotropy [9] [10] in the wake will be provided, showing the effect of yaw angle on the turbulence anisotropy fields and how tip vortices will impact the close and far wake velocity fluctuations.

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