Development of a double gaussian wake model

Understanding the intra wind farm flow has historically been driven by the need for estimating the annual energy production. The task was addressed with a combination of simplified, static engineering wake [1] and embedding background flow models [2]. Due to its low computational cost this bottom-up concept has been widely adopted and especially the individual description of the wake allowed for continuous development and improvement of its modeling [3]. One of the most popular wake models is the Gaussian model, developed by [4].

However, due to their low-fidelity nature, substantial uncertainties are commonly expected. This is especially true in the near wake region, where the wake has not yet reached a self-similar state. Particularly for German wind energy sites, this is a pressing issue. Here, the inter-turbine spacing is often very small due to the available areas and permitting reasons. At the same time many turbines are going to be replaced in the coming years. For this reason the single Gaussian model has been extended to a double Gaussian model by [5] and [6]. This new description offers an improved modeling of the near wake region.

Computational Fluid Dynamics (CFD) has proven to be a reliable tool in the study of wind farm flows. Multiple studies have showed a good agreement between numerical results and wind tunnel experiments [7,8]. A version of the open-source code SOWFA by NREL that has been developed by TUM, will be used as simulation tool for this project. SOWFA couples an LES solver implemented in OpenFOAM with the blade element momentum (BEM) code FAST. [9] The coupling occurs with the actuator line method (ALM) [10].
The goal of this thesis is to improve the existing double Gaussian formulation through setting up and analyzing LES simulations. For the LES Simulations the student would investigate:
- different inflow conditions (i.e. turbulence)
- different wind turbine conditions (tip speed ratio, pitch angles, yaw angles)
- different nacelle/tower shapes (requires a minimum experience with 3D CAD drawing)

The student would use a Unix platform to run simulations with the CPU cluster “SuperMUC-NG”.

After the simulations have been run, the velocity distribution in the near wake can be analyzed. Then, the student should test different shape functions, for fitting the velocity distribution. These should be then transferred into a new description of the wake model. In the end, the improved double Gaussian model needs to be tuned and validated also with wind tunnel data.

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References: