Using a cylindrical vortex model to assess the induction zone in front of aligned and yawed rotors

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Abstract

The knowledge of the induction zone in front of a rotor has regained interest in the last decade. Simley compared lidar measurements with Computational Fluid Dynamics (CFD) simulations [7]. A better knowledge of the induction zone can improve control strategies. In recent work, the possibility that the wind turbine influences the turbulence characteristics in the induction zone has been investigated [3]. Based on analyses of the turbulence spectrum, it appeared that the approximation that the turbulence characteristics remained unaffected by the turbine was fair upstream of the turbine. The standards recommend a distance of 2.5 diameters to locate a meteorological mast and measure the representative free-stream velocity [5]. The possible effect of the turbine induction at this location can be quantified as mentioned in previous work by the authors [1]. More references will follow in the paper.

The current paper uses the cylindrical rotor model of Joukowski [6] to investigate the induction zone. The model received recent interest by the authors for aligned [1] and yawed conditions [2], where closed form expressions or respectively semi-empirical expressions can be obtained for the entire flow field. A superposition of such models can add further details to the flow [4].

The paper will briefly present the analytical models to assess the velocity field upstream of the rotor. Results will be compared to Actuator disk simulations in aligned and yawed conditions. The typical induction for different operating conditions ($C_T - \lambda$) will be presented with focus on the effect at $2.5D$ upstream of the turbine. If time allows, results will be compared to lidar measurements which are currently being postprocessed.

Preliminary results are shown in Figure 1.

References

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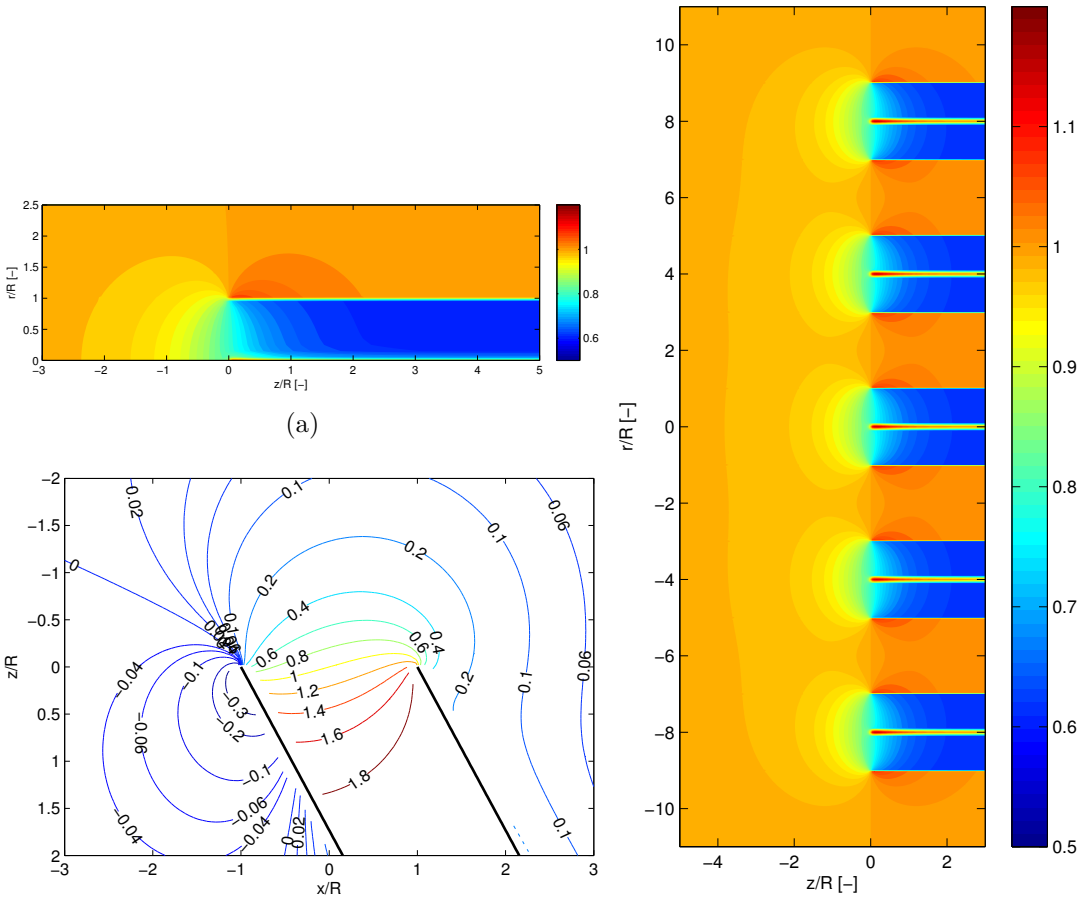

Figure 1: (a) Induction for a superposition of vortex cylinders without wake rotation- (b) Induction for a yawed vortex cylinder - (c) Induction for several rotors, using a superposition of cylinders and including wake rotation.

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