Wind Energ. Sci. Discuss., referee comment RC1
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Comment on wes-2022-94

Joseph Saverin (Referee)

Referee comment on "A simple vortex model applied to an idealized rotor in sheared inflow" by Mac Gaunaa et al., Wind Energ. Sci. Discuss., https://doi.org/10.5194/wes-2022-94-RC1, 2022

General Comments:

This paper presents a simplified vortex model for the analysis of influence on local power coefficient and wake behaviour of a sheared inflow. The paper begins by describing some contradicting results in the literature regarding the influence of sheared inflow on global power generation and wake behaviour as predicted by medium and high order numerical methods. The paper presents a relatively detailed description of an analytical model based on the treatment of the wake as a set of disjoint wake regions separated by infinitely thin vortex sheets. The analysis shows that a number of the results predicted by classical 1D momentum theory can be reproduced within this theory and thus certainly has scientific significance.

It is concluded that the results from 1D momentum theory as used within a BEM approach be applied locally and that global corrections such as average disc loading and induction should be avoided. It is furthermore concluded that, according to the herein presented theory, there should be no cross-shear deflection of the wake.

The reviewer finds that the conclusions made regarding model inconsistencies by applying rotor-averaged corrections are correct, and that under the assumptions of the model, no wake deflection should occur. In this sense this simpified theory represents a fundamental contribution to numerical treatments of wind turbine rotor and wake aerodynamics. Emphasis should be placed on the fact that this analysis is valid for an idealized rotor & conditions (for example the statement made in the abstract that locally 1D momentum theory is valid for non-uniformly loaded rotors may be somewhat ambitious). As with classical 1D momentum theory, underlying the simplified vortex model presented here are numerous physical assumptions. The vortex cylinder treament for example assumes a semi-infinite, inviscid vortex sheet. The analogies between the model types are certainly valuable, and as with classical 1D momentum theory, there is a suitable area of application for this theory.

Specific Comments:

- Perhaps more emphasis should be placed on the model assumptions, in order to ensure that the theory is correctly applied in future works.

- Is the wake sheet suggested in Section 3.3 consistent with regards to Helmholtz's theorems?

- Suggest to use a different term than *cylindrical* to decribe disjoint wake regions. The theory has been applied to cylindrical sections in the literature, however in the work here this is applied to general "extrusions" of areas in the rotor plane.

- There appears to be an averaging across a full revolution required for the derivation of equation (8). Does this contradict the approach that distinct wake regions have distinct convection velocities?

Technical Corrections:

There are a small number of typographical errors in the manuscript which are highlighted in the attached .pdf file.

Please also note the supplement to this comment:
https://wes.copernicus.org/preprints/wes-2022-94/wes-2022-94-RC1-supplement.pdf