Review of **Validation of the actuator disc approach using small scale model wind turbines** by Nikolaos Simisiroglou et al.

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The article presents a verification and a validation of an actuator disk model using a grid refinement study and measurements of small scale wind turbines in several configurations, respectively. The influence of different force distributions and turbulence models are discussed.

Main comments

You have chosen to separate the presentation of the results from the discussion of the results. I think it makes more sense to combine the results section with the discussion section and call it Results and Discussion. Then you can introduce a figure or table and directly discuss it, which is more natural to read. You could also make subsections in this section, e.g. a subsection about the grid study, a subsection about the validation with measurements, etc.

The proposed Actuator Disk (AD) method could be described in more detail, see specific comments below.

The results of the grid study show that your AD method does not converge monotonically for the investigated grid sizes. I think it is important to convince the reader that your AD method converges monotonically with grid size and I suggest that you redo this study based on the specific comments below.

Specific comments

1. Page 1, Abstract: In the abstract you have mentioned that the method has a low computational effort; however, the article lacks the results to show this. In addition, you have mentioned that a grid spacing of 40 cells per rotor diameter is sufficient, but this means that you need quite a lot of cells for wind farm simulations. Other RANS AD modelers would use 8 or 10 cells over a rotor diameter in wind farm simulations, where the grid spacing is based on a grid study.

2. Page 2, line 28: It would be worth to mention that a constant pressure drop resembles a uniformly distributed thrust force. Do you have any idea why this was chosen in the model wind turbine design? Real modern wind turbines have non-uniform thrust distributions.

3. Page 3, line 1: You mention that the blockage ratio including the tower is 12%. If I calculate this ratio (without the tower) I get: $0.447^2\pi/(2.701h(x = 3.66)) = 12.8\%$, where I have assumed that the height h of the wind tunnel is increasing linearly with downstream distance x: $h(x) = 0.05/11.150x + 1.801$; $h(x = 3.66) = 1.817$ m. Maybe I misunderstood something?

4. Section 2.1: You could mention the Reynolds number of the experiments.

5. Pages 5-6, AD method:

(a) You use a reference to define your AD method, but I think it would be useful to present the complete method here since the article is focused on the validation of your AD method.

(b) Eq. 8: How is the axial induction factor α_i calculated? Do you use $\alpha_i = \frac{1}{2}(1-\sqrt{1-C_T})$, implying that α_i is always a constant? If that is the case I would remove the index i and just write α.

(c) If you use $\alpha_i = \frac{1}{2}(1-\sqrt{1-C_T})$, are you aware that this relation can result in an overpredicted thrust and power? See for example the results of the AD induction method in van der Laan et al. [2]. How do you solve this issue in your AD method?

(d) If α_i is a constant and the inflow is uniform then the undistributed thrust distribution would always be the same as the uniformly distributed thrust, or do I miss something here? In other words, what is the difference in force distribution between Cases A and B in Table 4?

(e) Table 2: The Trapeze distribution is not defined for $0 < r < 0.2R$, what do you use in this region? It would be helpful to plot the different distributions.

6. Page 7-8, grid study:

   (a) Figure 2 shows that the wake solution is highly grid dependent. Based on these results it is difficult to state which grid is fine enough. You probably need to run a finer grid level to show grid convergence. This is also confirmed by the percentage of oscillating convergence at $x = 10R$ (45%) as listed Table 5. It probably means that your results are not yet in the range where the solution is monotonically converging with grid size.

   (b) Table 5, $\overline{p}$: From the grid study you have calculated an average order of accuracy of 3.58 and 5.92 at $x = 2R$ and $x = 10R$, respectively. How do you explain that the order of accuracy is so high considering the fact that you use a second order numerical scheme (central difference scheme)? You could try to also include a fourth grid level and perform a mixed order analysis as used in Réthoré et al. [1] or in van der Laan et al. (2015).

   (c) Currently the grid study only covers one doubling of the coarsest grid. It would be more useful to look at bigger range of grid sizes, e.g. 5, 10, 20 and 40 or 10, 20, 40 and 80 cells over a rotor diameter.

   (d) How is the total thrust force behaving with grid size? If the total thrust force is oscillating with grid size it might be the reason why the results of the grid study are unsatisfactory.

   (e) Which turbulence model is used in the grid study? You could choose to perform a more basic grid study of your AD method by simulating an AD in a laminar flow (e.g. Re=100) without wind tunnel wall, such that you do not need a turbulence model.

7. Page 10, Figure 4: You could normalize the velocity contours with the freestream velocity at hub height.

8. Page 11, Figure 6: Is the thrust coefficient different for each thrust force distribution (as shown for the double wind turbines cases in Table 8)? If this is the case, it is difficult to isolate the influence of the thrust distribution on the wake flow. Ideally one could keep the the total thrust force constant and only change the distribution.

9. Page 13, Lines 1-2: Based on Figure 5b, it does not seem that the k-ε model predicts similar k levels compared to the measurements, since it produces 2-7 times smaller k levels at $r = \pm R$.

10. Page 16, Lines 5-10 and Table 6. I think a 10% difference in thrust coefficient is quite a lot, especially for the upstream wind turbine.

11. Page 17, Lines 4-5: Maybe you should note that the uniformly distributed thrust might not be the best one if a real size wind turbine is modeled that typically has a non-uniform thrust distribution.

References

[1] Réthoré, P.-E., van der Laan, M. P., Troldborg, N., Zahle, F., and Sørensen, N. N. Verification and validation of an actuator disc model. *Wind Energy*, 17:919–937, 2014.

[2] van der Laan, M. P., Sørensen, N. N., Réthoré, P.-E., Mann, J., Kelly, M. C., and Troldborg, N. The k-ε-f_p model applied to double wind turbine wakes using different actuator disk force methods. *Wind Energy*, 18(12):2223–2240, December 2015.