**Review of "Extending the Dynamic Wake Meandering Model in HAWC2Farm: Lillgrund Wind Farm Case Study and Validation", manuscript id: wes-2023-14**

Reviewer: Vasilis Pettas, University of Stuttgart

**Summary**

The manuscript presents the mid-fidelity wind farm simulator HAWC2Farm. It discusses the structure of the code and the basic principles of the modules (i.e. the individual turbine aeroelastic simulations, the collective wind fields and the superposition of the wake effects based on an extended version of the DWM) with a focus on wake-related aerodynamics. Moreover, a case study using measurements from the Lillgrund site is shown to validate the tool.

**General Comments**

The topic of the manuscript is relevant and nicely timed for the wind energy community as wind farm control and simulation is an important research topic currently under development. Mid-fidelity simulation tools that can capture in detail the aeroelastic response of each individual turbine both in terms of loads and power is a crucial step towards this goal.

The manuscript has a clear structure, is coherent, and in general well written while the topic fits the scope of the journal. I have some comments in the direction of the information passed to the reader and explaining a bit more some interesting points mentioned through the manuscript. My main concern is on the validation part which I think requires more quantitative results to serve its purpose. The current results can be considered as a general qualitative agreement with the measurements but they cannot be considered as a validation of the code.

Overall, I believe this is an interesting and relevant manuscript and should be published after a major revision addressing the comments mentioned below.

**Specific comments**

1. l.75 What does the term operating conditions mean in the context of HAWC2 outputs?
2. L 82 Is this recommendation referring to all dimensions of the box or only the rotor plane (YZ plane) here? Especially considering the turbine spacing in a farm this seems quite small.
3. L 86 This is not clear to me. Can you provide more information on how modifying the mean wind speed works? The Mann model (or the Veers for that matter) assumes stationarity for the wind speed. How can this work when the mean value is changed? Moreover, is there a limit in terms of spatial dimensions and duration beyond which these engineering models are not valid?
4. L 132 Can you explain to the uninformed reader what is LAPACK's xgstv routine?
5. L 142-143 This is a generally correct comment regarding implicit and explicit methods. Is it relevant for the levels of discretization used in wind farm simulation applications? I.e. since explicit methods are generally faster is there some recommendation on when they can be used?
6. L144-145 Is this correlated to the choice between implicit and explicit schemes? If so, can these be treated by applying some type of smoothening function to the obtained axial induction profiles? This could speed things up if it allows for an explicit scheme to be applied.
7. L146-147 What does random mean in this case? Are the profiles coming from Hawc2 or just assigning some random values in a range?

8. The study and discussion in section 2.3.1 regarding the choice of the solver are very interesting. Do you have any possible explanation for why this is happening? It seems both solvers behave almost the same until the 25 line but for larger ratios, the explicit solver seems to fail in every case. Can you also comment on the difference in computational time between the two methods?
9. L 165-172 What is the spatial filter shown with blue in figure 4? Is it the spatial averaging mentioned in l167? Clarify and explain briefly how it works.
10. L 232-233 It would be helpful for the community to list and discuss the measures taken to ensure numerical stability. The current statement is vague.
11. L 248-256 I recommend adding a table here stating the turbine names involved in each case and also the scenarios with their duration and scope. This will improve understanding for the reader in a compact manner.
12. L259-262 To understand the process better, add some more information on the lidar measurements (point-wise or rotor-effective speeds, sampling rate, location of measurement compared to the relevant turbine etc.) and the SCADA and load measurements (sampling rate, load sensors of interest etc.). Even if these are mentioned in other publications I think they should be also mentioned here briefly for completeness.
13. L268-269 Is it always the first turbine or the one upstream of the considered one?
14. L275-276 Can you explain why dividing with the standard deviation of the upstream turbine will tackle the problems mentioned here?
15. L289-290 As also discussed in the comments of section 2. Is a single 8-hour Mann box able to reproduce the conditions? I understand that the mean wind speed and probably turbulence and shear seem to be quite constant for the period, but the length and size of the box make me think that it might exceed the capabilities of turbulence boxes and their underlying assumptions. Also, how can short-term fluctuations like the ones between 17-18hr be captured when assuming a single stationary box? Would it make sense to cut the time series in smaller intervals and do multiple simulations or is there some other solution? I think this discussion is also of general interest and should be included here.
16. L291 Can you express TI also in terms of percentage? Same for l357. It will be helpful for readers not familiar with the Mann model formulation.
17. Sec 5.1.1 and 5.2.1 Provide some more information about the simulation that can ensure reproducibility and clarity. Turbulence box sizes and discretization in all directions, simulation time step, turbine model and controller (is it the one from the manufacturer or reversed engineered, etc.), communication interval between the wind farm controller and individual turbines, yaw actuator modelling, etc.
18. Sec 5.1.2 and sec 5.2.2 In the current state the results of all three scenarios are shown and discussed in figures 9, 10 and 13 which show the total time series of the total duration for power, nacelle direction, wind speed, blade root flap-wise moment and tower bottom side-side moment. The plots and discussion are interesting as a general overview of the capabilities of the simulation tool. Nevertheless, there is no quantitative comparison between the simulations and the measurements. This is done only through visual comparison of the long time series. This makes the argument of validation weak as the reader cannot understand at what level the response of each individual turbine is captured by the simulation tool. More quantitative results are required to consider this a validation exercise (especially for cases 1 and 2).

    I recommend: either changing the scope of the paper avoiding referring to validation and keeping these results as a qualitative demonstration of the capabilities of the tool or adding more results that can be used to quantify the accuracy of the tool both in aerodynamic modelling and structural responses. For example, some metrics that can be used are: mean wind speed (or deficit), rotor

speed, power produced, DELs calculation, mean/std of the signal, etc. These can be considered for 10 min blocks throughout the whole duration of each scenario and compared directly with the measurements. This can show how well the outputs of the simulations agree with practical metrics that are used by the wind energy community. I understand that there might be high discrepancies due to model or measurement uncertainties but I strongly believe that validation requires also quantitative measures.

19. L350-351 Could be this attributed to a different shutdown control procedure? The loads seem quite different.
20. Sec 5 or Sec 6: I suggest adding some discussion on the computational time of the simulations. Information on wall time of simulation and scaling of time with increasing size and discretization. I think this is relevant information for the reader to understand the capabilities of the tool and the practical limits of the sizes and iterations that can be considered.
21. Sec6 As per the previous comments on validation, this section needs to be adjusted accordingly. Some strong statements regarding validation are not justified by the results shown.

**Minor corrections**

1. L 45 frozen synthetic turbulence box: rephrase
2. L 128 Equation
3. L 163 reference issue
4. L304 measured wind speed?