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Interactive comment on "Design and analysis of a spatially heterogeneous wake" *by* Alayna Farrell et al.

Anonymous Referee #1

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General comments

This paper presents an interesting improvement of the FLORIS wind farm model with the implementation of a method to take into account an heterogeneous atmospheric inflow. The original wind farm model is well described and efforts have been made on the description of the new implementation with plots that are quite useful for the comprehension, but there are still grey areas and it lacks information about the processing of the z-dimension for the complex terrain application: this application is mentioned twice in the introduction and in the conclusion, and the test case is a wind farm in complex terrain, but no information is given on this specific point. While the test case lacks some detailed information about the wind farm and the atmospheric conditions, a comprehensive comparison has been performed between the

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original homogeneous FLORIS and the two presented improvements. An exhaustive presentation of quantitative indicators is given and the authors provide well-detailed explanations and conclusions.
Thus, more explanations should be given on the wind direction change processing and the processing of the vertical dimension should also be addressed if a potential application remains "wind farms in complex terrains". Therefore I suggest a major revision.

Here are some general suggestions:

- In the introduction, the authors could mention other state-of-the-art wake modelling utilities and give more general information on the heterogeneity part with reference to studies on the characterization of heterogeneous conditions, the impact of spatial heterogeneity on power predictions. . .
- About the description of the new implementation, the authors do not mention how they deal with the vertical dimension, especially since they mention in the introduction that a potential application of this new version is wind farms in complex terrains, and the test case is in complex terrains.
- The part addressing the wind direction heterogeneity and the mesh deformation was not very crystal clear for me and needs more details. Maybe a second case without a constant change in wind direction could be interesting.
- About the test case, the authors could give more information about the wind farm (i.e. number and type of turbines, layout/inter-distance), some information about the complexity of the terrain and about the atmospheric measurements at met masts (temporal evolution of wind speed, wind direction and TI for Days A and B, and some information about the stability).

Specific comments

- P1, L19: you could mention a reference on the “accurate results in uniform set of atmospheric conditions”.
- P3, L68: you mention “yaw-misalignment conditions” but the $\cos(\gamma)$ is missing in Equation 3. However, as you don’t consider any yawing strategy in the paper, maybe you could drop the $\cos(\gamma)$ mentions in all equations. Moreover, u should be infinite velocity or without induction zone.
- In Section 2.3 : you could mention the limitations of the Gaussian model (only valid in far wake)
  - P4, L106: you mention a dependence on ambient TI, but it does not appear until Eq 8. You could mention that this dependence is hidden in k with a reference to Eq 8.
  - P4, L114: why do you use quadratic superposition of velocity deficits ? You have an added-TI model and you mention Niayifar and Porté-Agel later: in their paper, they recommend the use of linear superposition of velocity deficit while having an added-TI model.
  - P5, L140: You could nuance this paragraph on turbulence and saturation effect as it is not well understood for now.
  - P6, L145: why is the added-TI model part located in the atmospheric stability section ? Moreover, the equation describing the Crespo model is not correct, it should be $0.73 \times a^{0.8325} \times I_0^{0.0325} \times (\frac{x}{D})^{-0.32}$. You should also mention the validity ranges ($5 < x/D < 15$, $0.07 < I_0 < 0.014$ and $0.1 < a < 0.4$).
- In Section 3:
  - P6, L152: You could specify that the heterogeneous flows are undisturbed atmospheric flows (i.e. without wake effects).

- P6, L158: You could make a reference to Fig 1.a.
- P8, L185: You could name the mentioned algorithms that have been tested for extrapolation, or not mention at all their disadvantages as the explanations are a bit vague and it is difficult to understand what this is about.
- P8, L203: You could mention a reference to Section 3.3. for the processing of wind direction heterogeneity.
- P10, Fig 4 and others: You could name turbines (T1... T6) and make a reference to T6 in the text.
- In general for Section 3.3: this procedure with rotation only works if you have uniform lateral change in wind direction ? Maybe you could choose a more complex case for the wind direction change with a bell behaviour or a S-shape. Moreover, how do you define the centre of rotation ? And how do you deal with wake superposition ?
- P10-11, Fig 5 and 6: You could distinguish rotated grid points for single turbine and rotated grid points for all turbines (you have deformation for this grid).
- In Section 3.4: in this subsection, I can not really say if you deal with heterogeneous ambient/undisturbed TI. It needs some clarification: do you deal with heterogeneous TI the same way you deal with heterogeneous wind speed ? You could add a plot with the corresponding TI in Fig 8.
- In Section 3.5: Have you used an aero-elastic solver for this part ? You could also give an order of magnitude for Λ.
- P14, L276: You could nuance this comment because having an improved Ct should be as important as having an improved Cp as the velocity deficit model relies on Ct.

- In Section 4:

- P14, L281: More information could be given on the wind farm, the layout (min/max inter-distance), the turbines, the complexity of the terrain...
- P16, Figure 11/12: You could give more information on the daily evolution of wind speed, wind direction and TI, and on α_s to have an information about stability.

- In Section 5:
  - P22, L389: You could give an approximate value of the power prediction improvement.

Technical corrections

- In general with the plots on wind direction changes, you could add one or two streamlines, it could help in the understanding.
- P5, L134: Consider removing "For simplicity, k_y and k_z have been set as equal for this model", it has already been mentioned.
- P6, L174: It should be Fig 1.b and not Fig 1.a.
- P7, Fig 1: You could give the title of the colorbox. Is it undisturbed wind speed or wind speed with potential wake effects ?
- P7, L194: Consider writing cos and sin not in italics as for arctan2.
- P13, Eq 12: $\mathrm{d}x$ should be $\mathrm{d}x_i$.
- P17, L323: Consider removing one “the”.
- Tables 1/2: Consider rounding the numbers to integral numbers or with one decimal.

- P22, L378: Consider replacing “cause” by “causes”.
- P22, L390: Consider replacing “show” by “shows”.

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