Summary

This article investigates the impact of wake imingement in wind farms on blade and bearing loads. The authors use FAST.Farm to simulate a deployed wind turbine/farm, and investigate the effect of wakes. They use a two-step strategy, where they utilize a parameteric study to understand how the wake deficit location affects bearing and blade loads. The main conclusion from this study is that for blade loads, the presence of wakes can reduce the fatigue damage for below rated wind sppeds, and increase the loads in above rated wind speeds. And for bearing loads, the relative location of the wake deficit to the rotor has a large effect. Then they extend this to the actual wind farm to understand how the loads vary within the wind farm.

The study provides valuable insight into bearing and blade loads, and how they are affected by wakes. This is specifically relevant for other wind farm design and control studies that are of interest to researchers now. However, there is not sufficient novelty compared to other works on this topic. Additionally, there are severe limitations in how the experiments are designed for this study. The article will only be suitable for publication following major revisions.

Major Comments

Comment 1 – Insufficient novelty

Issue: This article only builds on the previous articles on this topic, and does not add sufficient novel tests or results to warrant this being an independent journal article.
Recommendation: One way this can be addressed is by expanding the design of experiments as will be discussed in the next point.

Comment 2 – Insufficient design of experiment

Issue: The design of experiments for both the parametric study, and the wind farm study are insufficient as they do not cover the range of relevant wind speeds and wind directions. Additionally, the effect of turbulence intensity has not been considered, especially when its effect on fatigue loads has been well studied. Also, the effect of wind shear is not included, and its effect on bearing loads would be relevant to understand. Finally, yaw misalignment will also be important to look at, and understand how it affects the bearing and blade loads.
Recommendation: Both the case studies need to be run for finer discretizations of wind speed and for the second study finer wind direction discretization is required. Additionally, the effect of wind shear, yaw misalignment, and turbulence intensity must be accounted for when possible.

The first study, the 2 turbine setup, will be extended to include the effect of wind shear and turbulence intensity in the context of wake impingements for different wind speeds. For 5 turbulence intensities and 5 shear exponent values, this results in ~3000 simulations. Due to the high number of simulations, it is not feasible to also add yaw misalignment into the parameter study.

The second study, the case study, will incorporate finer discretization of wind speed and wind direction.

Comment 3 – Effect of multiple wakes

Issue: This issue also stems from the lack of finer discretization for wind direction. Within the context of this study, when it has been established that the relative position of the wake has an effect on the bearing loads, then it is imperative to also look at cases when multiple wakes act on a given turbine, and how they can impact the bearing loads.
Recommendation: The current study needs to consider multiple wakes, or provide sufficient justifications for not considering them.

The case study of the complete wind farm does consider the effect of multiple wakes, which will be better represented in a finer discretization of the wind directions.

Adding a third turbine to the parametric study would again increase the parameter space to a size not feasible for the available computational capacities.

Comment 4 – Simulation setup

Issue: The simulation setup, including but not limited to, the number of seeds used, length of the simulation, transient period at the start, simulation time has not been provided.
Recommendation: This information needs to be included.

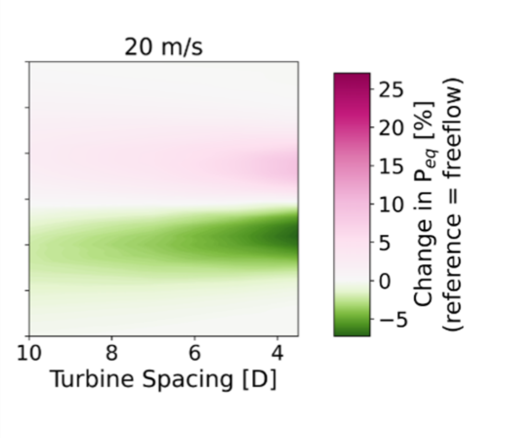
The simulation setup will be described in greater detail to include the here noted information.

Comment 5 – Figures 3 and 4

Issue: There are a couple of design choices with respect to figures 3 and 4 that make these figures unintiutive and hard to follow and possibly misleading:

- The way the figures are presented, it is easy to misunderstand these figures as an aerial view of the wake behind a turbine.
- Why is the turbine spacing shown from right to left, instead of left to right which is the natural reading direction?
- What are the dotted lines in the subfigures in figure 3? Why is the line for the subfigure corresponding to 20 m/s wind only shown for 90 % of the figure? WHy are there only 2 lines for the 8 and 10 m/s cases, but 4 for the 12 and 16 m/s cases?
- For the 12 m/s case in Figure 3a, why is there basically a 0 percent change in the DEL in the region below 4D turbine spacing?
- I find the normalization of the colorbars misleading. For example, when comparing the subfigures for 10 m/s and 16 m/s in Figure 3a, a reader may interpret the magnitude of the damage values as being comparable (but of opposite sign) because the color scales appear visually similar. However, this is not the case. The increase in loads for the 16 m/s case is only about one third of the magnitude of the decrease observed for the 10 m/s case. Because the colorbars are normalized separately, the color mapping suggests comparable magnitudes even though the underlying values differ significantly. This issue is further exacerbated in Figure 4, where the two fields are shown together, making it even more difficult to interpret the relative magnitudes correctly. Consider

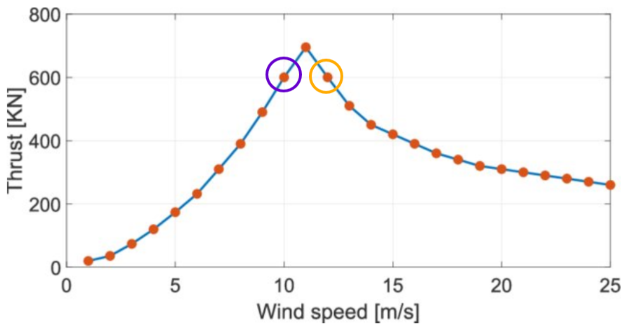
the attached figure, from the figure it looks like the magnitudes are vastly different, but looking at the colorbar, these magnitudes might actually be equal.



Recommendation: Please consider addressing these issues with respect to these figures. Although it might sound nitpicky, I think these changes are essential as Figures 3 and 4 present some core results for the article.

Figures 3 and 4 will be reworked to account for the here given feedback.
Regarding: "For the 12 m/s case in Figure 3a, why is there basically a 0 percent change in the DEL in the region below 4D turbine spacing?"
In these cases, the fatigue loads are very close to those of the reference simulation. The wind speed is reduced enough such that the peak of the thrust curve is passed and a value similar to that in freeflow conditions is reached:

Exemplarily indicated with the purple and orange circles on this thrust curve of another turbine. The purple circle is what we see for the cases below 4D while orange represents the freeflow condition.



For larger turbine spacings, the windspeed reduction is smaller and the thrust closer the maximum, which results in larger fatigue loads.

The dotted lines in Figures 3a and b will be removed and the colorbars will be adapted to have the same scalings between subfigures a and b.