Wind Energ. Sci. Discuss.,
https://doi.org/10.5194/wes-2020-80-RC2, 2020

WIND ENERGY SCIENCE DISCUSSIONS

Interactive comment on "Field experiment for open-loop yaw-based wake steering at a commercial onshore wind farm in Italy" *by* Bart M. Doekemeijer et al.

Anonymous Referee #2

Received and published: 3 August 2020

Dear Authors, your paper presents results from a wake steering experiment considering three-turbine interactions in complex terrain. It is well written and organized. The paper contains a unique wind farm control experiment and the work presented is very important for the wind energy research community. Thanks for working on it! It nicely confirms that there is a large potential for wind farm control, but also still more research is necessary to understand all effects.

In general, the paper could focus more on these effects which are not fully understood. For example in Section 5, line 221, the authors try to interpret the effect, although the uncertainty of the data is very high: you write: "…while negative yaw misalignment

angles even lead to a slight increase in the power production…". However, the difference between both curves for 255-295 deg is similar to the difference between both curves below 230 deg, where both lines should be equal, since WTG 26 is not misaligned. Therefore, the conclusion "that upstream turbines may benefit from nonzero yaw misalignment, already leading to an effective increase in power production at these turbines without considering the phenomenon of wake steering downstream" is hard to follow. Further, it might be that the upstream wind turbine already had a static yaw misalignment and a demanded nonzero yaw misalignment unintendedly aligned the turbine into the wind and thus increased the power. Another example is that for Figure 10, you write "the predictions (no losses due to wake steering for downwind turbines) are largely reflected", but for a quite a large are, there are losses for WTG 11 and 12. Focusing on these effects might help more to improve further wind testing campaigns compared to highlighting (sometimes uncertain) positive effects.

Further, there are several points where more details might help to better understand the work: - Section 3.1: You pointed out that the most important variable of the ambient condition is the wind direction. However, in Figure 4 you compare the wind speed from the lidar to the ones estimated by WTG 24 and 25. Further, Section 3.1 is relatively short. It would be interesting to know (if this information can be shared): * how and on which signals wind speed, wind direction and TI are estimated. * Further, it is not clear in Figure 4 if datapoints are 1 min or 10 min averages. * The lidar position could be included in Figure 3. Was it installed outside of the induction zone (based in standards more than 2.5 D) and was the data set filtered (e.g. sectors with wakes excluded)?

- Section 3.2: More details about the optimization would be helpful: you mentioned that the yaw setpoints have been optimized in steps of 1 m/s, but then they are fixed between 5 and 11 m/s. Are the values based on an average? And maybe you could also use TI=13.5% since in the experiment the lower bound is 12 %.

- Gaussian smoothing kernel: It definitely serves its purpose (reduces sensitivity) and looks fine in general. But at the "most important point", in a full wake situation (e.g. at

225 deg, WTG 26 in wake of WTG E5) in produces a setpoint of zero degree. Some comments of this drawback would be helpful, e.g. wouldn't a hysteresis or similar be more helpful?

- FarmFlow comparison: Results would be interesting, e.g. add line averaged over all wind speeds to Figure 6?

- Implementation: Here, more details than the last sentence in Section 3.2 would be helpful, e.g. * You describe, how the demanded yaw setpoint is derived from the estimated wind speed and wind direction via interpolation in a look-up-table. But it is not clear, if the estimated TI is used and if so, how? Sorry, if I missed it. * Why the controller is toggled every 35 min? * How is the demanded yaw setpoint added to the turbine? As a real setpoint or by having an offset to the measurement signal? How is the signal filtered? * If toggled off, is the turbine yawing instantaneously back or some time due to filtering? * How is the decision based on WTG 24 and 25 transferred to WTG E5 and 26? * Why there was a curtailment?

- Section 5: * Since you have been using the averaged estimates of WTG 24 and 25, wouldn't it be more consistent to use this average also for the postprocessing? * And the yaw angle setpoints are shown. Wouldn't be the yaw misalignment be more interesting, since usually wind turbines don't follow the setpoint instantaneous? Maybe it could help to understand the effect between 295-320 deg. * Figure 9: why is the baseline from Floris not 1.3 as stated in the text for unwaked conditions, e.g. 200-240 deg? * Figure 11: How does the Floris prediction here corresponds to the ones in Figure 6, A1, A2? If there has been a scheduling on TI, one would expect an average. However, close to 310 deg there is a prediction of losses, not present in Figure 6, A1, A2.

- Conclusions: It is not clear, why the "transition regions" lead to poor performance. Are those not only part of the postprocessing? Floris should optimize the yaw angles without this concept.

Minor comments: - l25f: Measurement uncertainties should be also present in wind tunnel experiments. Do you mean that the wind turbines are not measuring the wind direction by themselves? Would be good to specify.

- l87, Figure 2: Predominant wind directions seem to be west and south-east (and not south- west).

- l165, Figure 6: γ has not been introduced. Maybe use yaw setpoint instead?

- l171: Maybe add 285+295 (WTG 31 in wake of WTG E5) to the list.

- Figures 8-11: you mentioned that the wind direction of interest are 200 to 320 deg. However, only 200 to 310 deg are shown.

- l256: It might be better to write "for the three-turbine-interaction", since the third turbine changes.

- l286. plural "s" missing for "these turbines".

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