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Interactive comment on "Local turbulence parameterization improves the Jensen wake model and its implementation for power optimization of an operating wind farm" *by* Thomas Duc et al.

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Dear authors,

Thanks for a nice paper, which I read with great interest ! I am listing some comments below, I hope some at least can be useful.

Apologies if the comments are not perfectly neat and well written. Some may just be incorrect or irrelevant, I hope you won't mind if that is the case.

Very interesting paper, much work has been put into this, well done.

All the best, Rémi Gandoin

1. Introduction

"in some cases wake effects are still persistent at significant distances downstream": maybe quantify "significant"

"maximize their own power production": this is true only for the constant TSR control region, right ?

"Two different strategies are mainly considered": in this paper ? or in general in the literature ?

"either the upwind turbines are curtailed": does this mean that the ouput power is set to a constant value, or that the power is just decreased compared to the original control settings ?

"small gains in power production are indeed possible": using the first or the second strategy, or both ?

"high variability with incoming wind conditions": - does this mean that they can have positive and negative effect on park production ? or only positive effect but with some (how much ?) variability ? - what is meant by "wind conditions" (speed, direction, temporal/spatial scale) ?

"where wind conditions are fluctuating constantly and significantly": same as above

"Very few full scale field tests have been realized to investigate this question": can you refer to these few, if there are publications available ?

"uncertainties remain high": can you specificy whether you refer to accuracy and/or precision ?

"La Sole du Moulin Vieux (SMV)": 7 x Senvion MM82/2050 ? maybe refer to Figure 1.

"and was dedicated to axial induction control strategy": what does this mean (in a few words) ?

"high level of curtailment": see my question about defining curtailment above.

"could be observed": how ?

"combined power production": you mean the sum of all WTG production ?

"part of the lost power": can this be quantified ?

"the best settings": which parameters are changing ?

"as a function of wind speed and wind direction": measured by the nacelle anemometry ?

"Jensen model": reference ?

"local measurement of turbulence intensity": how ?

"The resulting wake deficit appears to be more consistent with observed data": can you quantify ?

"the original model": you mean the k-parameter value of 0.075 as in http://orbit.dtu.dk/fedora/objects/orbit:66401/datastreams/file_f7da8eb2-e49c-4dc9-9ee5-72846f40ef34/content ?

"Figure 1. Layout of SMV wind farm and location of wind measurement devices. Inter distances between the wind turbines are expressed in rotor diameters": please specify that D=82m. Could we worth showing a bigger area, maybe {49.816789°;2.753916°} to {49.868842°;2.843664°};

"red arrows indicate the main wind direction ": maybe add that these are °N. How wide are the wind-directional bins ? How is the wind direction defined ?

Section 2

"SCADA data": 10-minute ?

Section 3.1

"where U0 is the incoming wind speed at the upstream wind turbine, Uw the velocity in the wake and R the radius of the upstream rotor.2": ,and C_T the Thrust Coefficient corresponding to U0.

"its inaccuracy": which one ?

"local turbulence intensity": see my question above regarding how you measure this.

Section 3.2

General comments: - you may also want to refer to Section 2.4 of (Lissaman, 1976): https://drive.google.com/drive/folders/1tI2p3W1qRj2GsYkt6RI6VITJMpQh7PMc.
- if the wake expansion factor changes within the wind farm, could this be visible on high-resolution wake measurements reported in http://iopscience.iop.org/article/10.1088/1742-6596/1037/7/072008/pdf ? If k=0.9*TI_WTG then, based on Figure 7, the first wake "cone" should expand with an larger angle than the one for the rows downstream, have I understood correctly ?

"This empirical constant is supposed to vary from one wind farm to another": reference ?

"or vice versa": why is that ?

Section 3.3

"Four months of second-wise SCADA data": you mean 1-Hz ?

"Figure 3": - could you use a function using "density scatter plots" in Matlab and plot the mean and median binned values as well? - the plot NWS vs Met mast shows less scatter than the plot NWS vs LiDAR: could you also show Met mast vs LiDAR (there maybe 10-minute time offset) ?

Section 4.1

Ggeneral comments: - have you considered using the M2 mast dataset measurements for Horns Rev 1? - have you considered a wider wind directional bin ? As I remember, Gaumond showed that using narrow bins, led to bias in the validation, since the model is "steady state" and will consider the turbines always aligned. A workaround is to run a model simulation every 0.5° and then weight the results using a gaussian distribution of the wind directions.

"modified Jensen model": maybe only semantics here, but it seems to me that you are only tuning the input k parameter and not changing the model.

"Region II": can you highlight this region in Figure 5 and Figure 2 ?

"Figure 6": - could you state that "TI" is the TI measured using the Nacelle Anemometer (and not the ambient TI) ? - could you add a curve which uses k_w=0.4TI_ambient, as suggested in the Sexbierum paper ? - the TI value of 12 % for the first WTG at HR1 seem large, for offshore conditions - see typical values in https://pcwg.org/proceedings/2014-10-06/06-Turbulence-Intensity-measmnts-offshore-4-PC-verification-wind-res-assmt-R-RiveraLamatA-D-Pollack-Dong.pptx - can you show a histogram of the corresponding wind speeds ? - for (b): do you see a difference between nightime and daytime ?

"was clearly overestimating the power deficit for the wind farm of Horns Rev-I, as it 10 gives narrower wake growth within the wind farm": it depends actually, see http://www.eera-dtoc.eu/wp-content/uploads/files/Nygaard_Systematic_quantification_of_wake_model_uncertainty_offsh The stability conditions may well differ significantly between the different studies, for the same wind farm, since people use different datasets for model validation.

"Figure 7": - the value of TI for the first WTG at HR1 is 8 %, is was 12% in Figure 6 - can you explain why this is ? - same as for Figure 6: could you state that "TI" is the TI measured using the Nacelle Anemometer (and not the ambient TI) ? - same as for Figure 6: could you add a curve which uses k_w=0.4TI_ambient, as suggested in the

Sexbierum paper ?

Section 5.1

About eq. (5): once the WTG is curtailed, will this relationship hold ? See for instance Figure 1 of http://iopscience.iop.org/article/10.1088/1742-6596/1037/3/032039/pdf (I don't have the answer).

Section 5.2

"The reason for this increase was related the presence of the motorway": could it be the large warehouse located at 330°, 2km upstream of the mast ? Could you make a plot on nighttime and on daytime ?

Section 5.3

"as the upstream wind turbine is down-regulated, the wake added TI emitted by this turbine is reduced": because it is a function of CT, and CT is reduced ? The TI_added is also a function of the downstream distance, see chap 3 of http://orbit.dtu.dk/fedora/objects/orbit:79899/datastreams/file_269c3f19-0001-4e41-b754-b5b322a826cb/content.

Table 1: could you also show the relative power values, for a given wind speed bin (for instance 7 m/s) ?

Section 5.4.1

"It is observed that the maximum gain represents an increase of about 2.5% and is found at 7 m/s when SMV6 is curtailed by 12% (cP decreases from 0.46 to 0.405)":as I understand, in this situation, you reduce C_p by x%, and derive a new C_t using eq. (5). Then, you choose a value of k using eq. (7). Can you then also plot these new and old values of C_t and k, that are used the calculation, in Figure 12 ? Or provide a worked-out example ? It may help the reader understand what goes on in the calculation.

"very stable incoming wind conditions": you mean stable atmosphere ?

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