

Title : Lidar-based wake tracking for closed-loop wind farm control

Dear reviewer,

We really appreciate your comments and have tried to adopt and consider all of them. Please find below a point-to-point reply. Further, in the supplementary material, a latexdiff is given.

Thank you very much for your effort!

Best

Steffen on behalf of the authors.

Summary review : *The work seems to be innovative and of value to the scientific community, but the manuscript is extremely hard to follow because of the wording / order of statements. The writing needs to be overhauled so that it can be more accessible. Below some specific suggestions are made to improve clarity.*

We have considered all of your points, see below, and tried to give more structure. We highly appreciate your effort!

Page	Lines	Comment	Reply
1	8	issues in the wind farm as opposed to...? the individual turbine?	Rephrased to clarify
	15	Or > and	Changed
	19	In relation to wind turbine control, the same two goals are valid for wind farm control > The same two goals are valid for both wind turbine and wind farm control	Thanks for the suggestion. We adopted it.
	20	These goals were addressed in research with different approaches unclear whether you are talking about previous research or your own, please reword it	We shortened the sentence and rephrased.
2	1	In > at	Thanks
	4-5	the barrier is not necessarily a lack of devices, but their cost, logistics, etc?	In the past, there wasn't a measurement device available to measure flow at different locations remotely like a lidar can do. But you are right about the other barriers. We have added them.
	6-8	weird sentence, I suggest rewording similar to Lidar can be a useful tool to address the measurement problem in wind farm applications, while bearing in mind the instrument limitations and the	Thanks!

		assumptions required to extract the information and exploit the lidar measurement data.	
	9	It aims to enable closed-loop wake redirection	Thanks.
	12	Incomplete sentence?	Sorry about that. We have corrected it.
Introduction		Since you are going into so much detail and level of simplicity when you put things in context in the introduction (e.g. flow is modeled by Navier Stokes), you should also briefly explain difference between open vs closed loop control, and why focus on one vs the other. Also, introduction makes it sound like no one else has looked into this before (closed loop wake redirection), is this the case? If so that's fine otherwise you should refer to their work.	Thank you for the advice. Since my background is control engineering I have assumed a lot. I tried to add a paragraph which briefly explains the advantage of closed-loop wake redirection vs. open-loop. We do not know a publication about lidar-based closed-loop wake redirection at the moment.
Figure 1		Remove a	Thanks!
	20	Exist > exists There isn't a > there is no	Thank you. I have changed.
	21	which is a concept based on time averaged profiles of the wake behind a turbine.	Thanks.
	22	Give a time scale for these averages Having averaged the flow something like a > the language is too informal, reword something like "Averaging the flow yields a (double) Gaussian function for the velocity deficit profile in the horizontal and vertical directions..."	We tried to be more specific, thank you for your suggestion.
	23-24	taking a different method of defining the shape, the wake center position could be at a different position although the flow would be the same > also needs rewording, suggestion something like "when different methods are used to define the shape, wake center estimates may be vary under the same flow conditions"	Thank you.
	24-25	Thus, there isn't a unique wake center definition. This makes a comparison difficult and needs to be considered when comparing results. Suggestion... The absence of a unique wake center definition must be considered when	Thank you clarifying. We took you suggestion.

		comparing results as it precludes direct comparisons (across different studies?).	
	27-28	Considering the task of lidar-based wake tracking then this includes first a reference definition of the wake center and second an estimation method which is used to get the closest estimation of the wake center from the lidar measurement data.	We rephrased it. Thanks.
	30	Which want to > to	Thanks.
3	2-3	Estimate verb repetition...	We shortened the sentence to be more clear.
	5	you repeat over and over again "a redirecting" which sounds really off -- either remove "a" or change to a better noun, e.g. redirection	We changed to redirection.
	7	compensates > compensates for	Thanks.
	8	can be > is , which is due > due	Thanks.
	9	first, the measurement problem is addressed. the measurement problem is addressed first.	Thanks.
	11-12	Keep in same paragraph!	Sorry for that.
	14	The in the following described tasks ??	We removed parts to state more clearly.
4	3	As described before, first a reference is needed to be defined. As previously mentioned, it is first necessary to define a reference. (still sounds like an incomplete sentence, a reference what?)	We changed to be more precisely.
	3-4	Can you be a bit less concise here? Unclear what the Vollmer work is. Example: The minimum wind power method proposed by Vollmer et al. (2016) is adopted here to identify the wake shape/center.....	We rephrased and adopted your suggestion.
	4	Is all the work 2D? Not yet very clear until this point	It depends on the method. In our point of view the wake center definition is also not 2D, since all directions are present.
	9	which is every second > sampled at 1 Hz frequency?	Thanks.
	9-10	In addition to Vollmer et al. (2016) You mean in addition to using the method proposed by Vollmer?	We rephrased to be clearer.
	10	with different time constants	Same here.

		you mean over different running window lengths? over different time intervals? averaging time T?	
	11-12	Therefore, a SOWFA simulation with low turbulence level and a mean wind speed of 8 m/s is used in which the flow field is sampled and every 1 s. Therefore? This is a conclusion from something? Needs rewording...ex: The results presented are for a low turbulence (TI=??) SOWFA simulation under a mean (free stream, hub height?) wind speed of 8 m/s...	Thanks for the comment. We reworded according to you suggestion.
Figure 2		Caption is not descriptive, stand-alone and clear enough. Something like... Time evolution of wake center (meters away from hub? what is negative vs positive?) when different periods T (s) are used to average the flow during the wake center calculation. Why are first 100 s so different? Is this some model spin up, while the wake is still slowly developing? If so, maybe this data should not be part of the analysis, or this should be acknowledged somewhere?	Thanks for the suggestion. We adopted the caption. Yes, it comes from the wake development. I have changed the figure according to your suggestion.
	16	approached > approaches	Thanks.
	17	can first compare to existing quantities. > can first be compared.....	Thanks.
	16-17	like estimation of the rotor-effective wind speed, or estimating u and v wind vector components using lidar measurements like in Schlipf et al. (2012), this whole thing should be in parenthesis to make sentence more readable (e.g., estimation of the rotor-effective wind speed, or of u and v wind vector components as in Schlipf et al. (2012))	You are right. Thank you, we adopted it.
	18	be used predict > be used to predict after line-of-sight velocities can you put (v_los) so that when it shows up in the next figure the reader is already familiarized with your nomenclature / symbology	Thanks.
Figure 3		The general concept of model-based wind field reconstruction: Estimating	Thanks. This makes it more clearer.

		the wind field characteristics by fitting simulated lidar measurement data ($v_{los,s}$) to the measured ones ($v_{los,m}$).	
		The general concept of model-based wind field reconstruction, in which the wind field characteristics are estimated by fitting simulated lidar measurement data ($v_{los,s}$) to measurements ($v_{los,m}$).	
5	16	simulated lidar measurements I am not sure you should call it measurements if they are not measurements!	Thank you. We have changed it here.
	19	What's the "wind field parameter"?	We specified. We meant the model parameter (e.g. wake center, wake decay, wake deficit, etc.)
	20--	This whole paragraph, please rewrite, words and concepts are repeated a lot, very unclear.	We have rewritten.
6	9	horizontal rotation of the wind field you mean the wind direction? Also I'm pretty sure you mean underlying whenever you have underlying	Yes, we mean aligned with the wind direction. Yes, sorry about that!
	13	...and the subscript i represents...?	We explained.
	14	component. Thus, this yields $>$ components, yielding	Thanks.
Figure 5		If the coordinate system follows the wind turbine reference frame, then what do negative wind speed values mean? Also, does it matter at which downstream distance this is? And is there any yaw misalignment here? Unclear	We specified the conditions.
7	4	the deficit is cleared over distance $>$ the momentum deficit recovers?	Yes, thanks.
	8	What is s ?	$s \cdot \Gamma$ gives the solution for the initial wake deficit. There is no meaning for $s \rightarrow$ one could see it as local gain.
	15	what does "impulse dissipation" mean	We meant wake recovery.
8	1	You might want to use D instead of d , or maybe x for the downstream distance, because in equations the little d looks like a derivative, as in Eq 8 I first thought it was derivative of the dissipation. Or maybe just put a	Thanks. The multiplication sign helped.

		multiplication sign there, or the d outside of the fraction multiplying everything...	
	19	by constant you mean steady (constant in time) ?	Mean wind speed is meant
9	7	the model parameter still confused that THE parameter is?	Changed
	12-13	The way you worded this sentence makes the reader think you want to make a point here. If it's just an example (which at least in this section, it is because now the section is over) then say so--for example: An example of an estimation step of the wake tracking from a measurement campaign at the alpha ventus offshore wind farm is shown in Figure 7.	Thanks.
Figure 7		A plot of you don't need to say this is a plot! five distances > five downstream distances is this looking down or upstream?	Thanks ;) We clarified the setup.
	15	has already shown > shows (you haven't discussed Figure 7 at all)	Thanks.
	17	merged to a wind field what does this mean? also use a different symbol in your 7x7, maybe \times wherever it appears in manuscript	We removed the unclear part and used the times symbol.
10	1	$\ln > a t$	Thanks
	4	most far > furthest (wherever it appears in manuscript) the wake parameter , what is this again?	Thanks. We have added some lines before. So the parameter question should be clear.
	6	positions > position there isn't a > there is no	Thank you.
		How did you come up with 0.1 for your dissipation?	It is the result of the model fit.
Figure 8		Time series of model parameters for wake tracking of simulation data? missing a period	We specified the conditions.
11	8	sorry what is "the filtering"? can you be more specific, I don't remember anymore at this point	Removed the sentence, since it isn't necessary here. It is only confusing.
12	5	$A n > a$	Thanks
Figure 9		I assume this is a mistake? I don't understand why it's same caption as	Yes!

		above but results are different!	As mentioned before, we have specified the conditions.
13		Figure 11 is talked about in text before Figure 10 so these should be swapped? Actually seems like Figure 10 never comes up?!	It was mentioned in the text. Before Sect. 6.
	6	the assumptions of a constant thrust coefficient, c_T , is made. the assumption of a constant thrust coefficient is made	Thanks.
14	5	is this so obvious to the community that it doesn't need a reference?	A reference is given.
15	2	what is subscript dem?	A description is added.
	8	using a Smith Predictor. A Smith Predictor uses > using a Smith Predictor, which uses	Thanks.
	21	the sensitivity and the complementary sensitivity As someone not in controls field I don't understand this. It's weird that in some spots you get into such seemingly unnecessary descriptions of things (again, saying the flow is modeled with Navier Stokes for example) but then at other points you assume all your readers will know these concepts? If it's not too difficult, add a line explaining what these concepts mean or refer the reader to some reference. There is a lot of very controls-specific stuff throughout your paper which is fine and great since that's your main topic, but your paper will reach a much broader audience if you make it clearer and more readable to people that do wind research but focus on other aspects, and who may be interested in applying what you've done.	We have added a reference. Sorry about that. It is very difficult to address and assume the right audience. Our assumption was to address someone who has basic knowledge in control theory.
15	12	enable > enables	Thanks
16	5-6	Keep in same paragraph	Changed.
	6	An > a	Thanks!