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Interactive comment

Interactive comment on "Control-oriented Linear Dynamic Wind Farm Flow and Operation Model" *by* Jonas Kazda and Nicolaos Antonio Cutululis

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Authors' response

We would like to thank the reviewer for his/her comments and the time spent with the review. Please find our response below. The attached paper includes revisions for Anonymous Reviewer #2 and Anonymous Reviewer #3 with changes highlighted in yellow and green, respectively.

I agree with the comments of the first reviewer.

Authors' response

We would be grateful, if the reviewer could also view our response to mentioned Anonymous Referee #1, since we unfortunately have to disagree with a range of comments of that reviewer.

The subject of this paper is relevant and the simplification of the wind farm flow model is essential for control purposes. Nevertheless the presentation of this development is confusing and misses several crucial points and details that are necessary to understand it. In particular the description of the flow model and the Kalman filter design need to be deeply revised.

Authors' response

We would like to thank the reviewer for his/her support of this work. All questions regarding the model and Kalman filter are addressed in the following.

1) Fig 1) is supposed to show the combination of "multiple sub-models" but only two modules appear. Pset, Pout and uinl are not defined.

Authors' response

We would kindly ask the reviewer to consider that Figure 1 *"... shows the model's system structure, which consists of a flow model and a turbine power model ..."*. More details on the system structure and the definitions of figure quantities are already included in the revised paper attached to the author response for Anonymous Referee

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#1.

2) How eq. (4) is obtained from eq (3)?

Authors' response

More details on the derivation of mentioned Eq. 4 are already included in the revised paper attached to the author response for Anonymous Referee #1. The description now reads as.

"The partial derivates of the wake deficit model (Eq. 5 and Eq. 6) are used in the linearized wake deficit model (Eq. 4), which is employed in the wake superposition model (Eq. 2). After converting the wake superposition model to state space form and joining all wake interaction processes, the total wind farm flow model can be written as ..."

3) As I understand from eq. (4), the state of the model is the union of the delays and the equilibrium points, the input is the power and the output is the present wind speed at rotor.

a. The equilibrium (or linearization) points should be constant, so they cannot be a part of state (actually, they should be a set of values of all the state components)

Authors' response

The linearisation point is constant, as can be seen from the total system description in formerly Eq. 4, that is now Eq. 7. The linearisation point does not change with the time update or data update of the state vector.

b. The power seems to be mostly an output, so why it is defined as an input?

Authors' response

The modelled system is the wind farm and wind farm flow. Turbine power is both an input and output of the modelled system that is turbine power set-point and turbine power output, respectively.

c. "u" denotes at same time: the wind speed, the model output in eqs (5) and (7), and the model input in (6).
d. In the eq. (6) and (7) is u(n) the same variable? If yes, I don't understand the link between eqs (4) and (6).

Authors' response

We thank the reviewer for the comment. The definition of variables is updated in the revised paper attached to the author response for Anonymous Referee #1.

4) The structure of the Kalman Filter is a little bit weird. As the starting system is non-linear and it is linearized (with a frequency that is not indicated) around the operating point, it seems to be an Extend Kalman Filter (in that case the equilibrium point can be dynamic, see point 3a). Nevertheless, the EKF use a the non-linear model for the prediction, when here the linear model is used, which is typical of Kalman (non-extend) Filter.

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Authors' response

The Dynamic Flow Predictor models wind farm flow and operation using a linear state space system, as described in section 2.1.2. The matrix update, also termed gain scheduling in literature, is employed to choose the linear system matrices according to the current operating conditions. The update frequency depends on the update law, which is defined in section 2.2.3. The Kalman filter, as described in section 2.2, is an ordinary Kalman filter, as can be seen from the shown equations.

An extended Kalman filter would use a non-linear wind farm model to update the states. The model of the Dynamic Flow Predictor is, however, linear and thus the employed Kalman filter cannot be an extended Kalman filter.

5) y_{meas}, the measurement used for the Kalman filter, should be the model output (so wind speed at rotor). So why C_u is not equal to C_{meas}?

Authors' response

C_{meas} can be equal to C_u. However, when flow measurements are available also at other locations than at the turbines, such as from remote sensing, then this is not the case.

6) In eq. (10) y should be yhat and x should be xhat.

Authors' response

We thank the reviewer for the comment. The variables are updated in the attached revised paper.

Please also note the supplement to this comment:
https://www.wind-energ-sci-discuss.net/wes-2018-29/wes-2018-29-AC2-supplement.pdf

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