**Review: Improving Wind and Power Predictions via Four-Dimensional Data Assimilation in the WRF Model: Case Study of Storms in February 2022 at Belgian Offshore Wind Farms**

The authors consider a very interesting and important topic: improving wind predictions during extreme events. The authors perform numerical simulations of historical storms in the North Sea that impacted wind turbine clusters. The authors show that employing observational nudging and representing wind turbines using mesoscale wind farm parameterizations improves the model skill in replicating past events. They test sensitivity to nudging parameters in their simulations. The study is interesting and well-written; however, I have major concerns about numerous aspects in the manuscript.

I believe that the most novel aspect of the manuscript is not being fully addressed and most of the paper shows results that are expected based on the methodology. I believe the authors could explore further the importance of having observations that are within multiple advective timescales upstream of the location of interest to improve 6-hr ahead and day-ahead forecasts.

**Major Comments:**

1. The motivation and the results are not connected:

The motivation of this paper, as outlined in the abstract and introduction, is to improve day-ahead and 6-hr ahead forecasting during extreme events. However, the work presented in the paper is not related to forecasting, rather replicating past events by using observational nudging. As the authors clearly explain in the introduction (Lines 44-67), they are nudging the simulations towards the observed state. Therefore, it is not clear how nudging the simulations will improve day/6-hr ahead forecasts, where nudging cannot be performed because the future state of the atmosphere is not known.

The authors briefly investigate how nudging can improve forecasted winds at one location in Sect 3.2 in their "cyclic configuration" (see Major Comment #3 for additional comments on the cyclic approach). However, the authors show their cyclic approach is only useful for 1-hr ahead predictions (depends on the advecting time scale). Furthermore, their cyclic approach also requires observations to repeatedly correct the simulations towards the observed state.

2. Results and methods are not new.

Most of the results are expected based on the methodology and are not new. It is expected that nudging the simulations towards an observed state will improve their skill in representing atmospheric conditions near the observations. It is not clear how observational nudging at every time step will improve forecasts of extreme events.

3. Cyclic configuration:

It is not clear how the cyclic approach that the authors describe in Sect. 3.2 can be used to improve day-ahead or 6-hr ahead forecasts. How is this approach realistic for day-ahead forecasts if you are repeatedly nudging the simulations in a "future" state. The most novel (and most important from my perspective) aspect of Sect. 3.2 is to show that nudging the simulations for a period of time using upstream observations can be useful for forecasting, but only for timescales shorter than the advective time scale.

4. Nudging using SCADA data from waked turbines:

Nudging the WFP simulations using wind speed data from waked turbines modifies both the background flow and wake propagation. However, the authors do not address this in the paper. For instance, as shown in Fig. 8, the simulations without nudging do not capture the observed wind speed and direction during the storm events. And, as shown in Fig. 5, it is likely that the front-row turbines are being waked during the storm event. Thus, nudging the WFP simulations will modify the propagation of wind farm wakes upstream of the turbine locations and artificially change the wake recovery. In a similar manner, nudging the WFP simulations using data from waked turbines inside the wind farm will artificially change wake recovery. Please comment on the limitations of nudging the simulations using data from waked turbines, having in mind that you are not resolving individual turbine wakes with dx=2km.

5. Use of predictions/forecasting throughout the text.

The authors repeatedly use "predictions" or "forecasting" when referring to performing simulations with observational nudging. Please modify this throughout the entire manuscript given that a prediction/forecast refers to estimating a future unknown event, while the authors are nudging simulations using observations.

**Minor Comments:**

1. Line 24 (and rest of text): "Extreme events" is too broad. Please clarify what types of extreme events you are referring to. Some extreme events can occur for winds slower than cut-off (freezing events); others typically don't (e.g., tropical cyclones). Presumably you are most interested in extreme events in which turbines are still operating.
2. Line 35-36: There is still large uncertainty about representing wind farm wakes in mesoscale models using wind farm parameterizations (Eriksson et al., 2017; Peña et al., 2022; Ali et al., 2023). Also, as noted in the studies you highlighted, accurately representing the atmospheric conditions is one of the most important aspects of accurately modeling wind farm wakes. Please mention the uncertainties surrounding mesoscale wind farm parameterizations.

3. Line 116/ Table 1: Please include the value of \alpha (coefficient regulating added TKE in Fitch WFP) used in the simulations.
4. Line 139: Are these lidars vertical profilers? What is their scanning method (DBS, VAD, …)
5. Line 140: Please show which turbines from the Belgian-Dutch cluster are you using to extract wind speed and power for nudging. (maybe highlight them in Fig. 2)
6. Line 144-145: Are the lidars retrieving data from each beam at 1 Hz? or are the full scans being obtained at 1 Hz (unlikely)?
7. Line 159: Please include basic information on EPL lidar.
8. Sect. 2.3: Please clarify how you define the start and end of each storm.
9. Fig. 7, 11, 12, 13: It is expected that nudging will reduce the MAE at the nudging location. Thus, showing the MAE for the nudging locations is misleading.

**References**

Ali, K., Schultz, D. M., Revell, A., Stallard, T., and Ouro, P.: Assessment of Five Wind-Farm Parameterizations in the Weather Research and Forecasting Model: A Case Study of Wind Farms in the North Sea, Monthly Weather Review, 151, 2333–2359, https://doi.org/10.1175/MWR-D-23-0006.1, 2023.

Eriksson, O., Baltscheffsky, M., Breton, S.-P., Söderberg, S., and Ivanell, S.: The Long distance wake behind Horns Rev I studied using large eddy simulations and a wind turbine parameterization in WRF, J. Phys.: Conf. Ser., 854, 012012, https://doi.org/10.1088/1742-6596/854/1/012012, 2017.

Peña, A., Mirocha, J. D., and Van Der Laan, M. P.: Evaluation of the Fitch Wind-Farm Wake Parameterization with Large-Eddy Simulations of Wakes Using the Weather Research and Forecasting Model, Monthly Weather Review, 150, 3051–3064, https://doi.org/10.1175/MWR-D-22-0118.1, 2022.