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Interactive comment on "Evaluation of the wind farm parameterization in the Weather Research and Forecasting model (version 3.8.1) with meteorological and turbine power data" *by* Joseph C. Y. Lee and Julie K. Lundquist

Anonymous Referee #2

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The manuscript "Evaluation of the wind farm parametrization in the Weather Research and Forecast model (version 3.8.1) with meteorological and turbine data" compares the mesoscale model for different set-ups without wind farm parametrisation against Lidar data and the mesoscale model with and without a wind farm parametrisation against SCADA measurements.

The manuscript has a clear structure and is written well. The estimation of the wind farm power production is challenging and relevant to the wind energy community.

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However, in my opinion the manuscript requires a more profound analysis before it can be published in GMD.

General comment

At least 4 uncertainties in simulating the power production with mesoscale models can be thought of, due to (I) mismatches in wind speed and wind direction (II) errors in simulating the wind speed reduction between grid-cells (III) errors in grid-cell internal wind speed reduction (IV) errors in power production, since turbine positions remain unresolved.

A big challenge in estimating the power production correctly is that the grid-cell averaged wind speed from the mesoscale model is not necessarily equivalent to the local up-stream wind speed of a turbine. Especially, in the presented wind farm layout, where turbines are systematically aligned in the West-East direction, mismatches between simulated and measured power production are expected. For southerly/northerly (and also south-westerly) winds, turbines in the southern/northern most rows all experience free-stream wind conditions and produce accordingly. On the other hand, the model wind speed in each turbine containing grid-cell is reduced due to the drag of all turbines in that grid-cell, leading to a systematically underestimated modelled power production. For easterly/westerly wind directions, the opposite happens and the interaction between turbines is underestimated, since in the model the turbine interaction is only area averaged.

Unfortunately, for the 4 day campaign not all wind directions are observed. However, there are examples that clearly show the challenges. On day 4 with south-westerly winds a large fraction of the turbines experience free-stream conditions, leading to large productions, whereas the modelled power production was systematically too low. For events with southerly winds the situation is more complex, since only the front turbine rows experience free-stream conditions and all other turbines are affected by wind farm internal wakes.

Therefore, a deeper analysis on when and why the model is able/unable to estimate the power production is recommended. First, only events in which the wind speed and wind direction were modelled correctly should be included for the verification. Perhaps, in the scatter plots filled and empty circles could be used to distinguish events that were inside or outside the filter criteria.

One example: since Fig.9 shows that also for events with around 0 m/s bias the power production bias ranges from around -70 to 90 MW, it could be interesting to plot similar to Fig 8a the bias in power production against the modelled wind, but only for events where the wind speed bias was smaller than e.g. 2m/s and the wind direction bias smaller than e.g. 30°. In this plot the colours could be used to indicate the wind direction instead of the days. This would allow see the ability of simulating the power production for different wind directions.

For the above mentioned reasons, I would not agree with the conclusions made from the wind direction sensitivity analysis on p. 8 l. 228, given that the behaviour for the South-Westerly directions is very distinctive from other directions.

I agree that the model's performance is most likely not sensitive to the number of turbines per grid-cell, but is important to find out how sensitive it is to the turbine positions in the grid-cell.

Specific comments

p.2 l.57-59, WEP should be replaced with EWP.

p.4 l.114-123, in this paragraph measurements from the surface flux station are introduced. However, only the power bias against stability (Fig.8d) has been shown without showing the model's ability to simulate stability. For this figure to become more meaningful the model surface layer stability could be compared to that measured.

In the comparison of the TKE, it should be mentioned why the TKE derived from the Lidar measurements are expected to match the completely parametrised model TKE with a 1D production.

Fig. 7c, it is curious that the TKE of ERA12 is larger than that of ERA12WF as well in the night as during the day and that it seems never to be smaller. What would be your explanation for this?

Regarding section 2.2, here the model set-up (namelists) should probably be made available to GMD.

p.5 l.134, the inner domain with a 1 kilometer grid-spacing extends over the whole state of Iowa. This seems a computational expensive solution. What was the motivation for this configuration. Did you perform a sensitivity to the domain size?

In Fig. 3, it would be helpful to indicate the periods in which the 200S lidar and the WC lidar are in the wake of turbines.

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