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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Tempo-spatial distribution of nitrogen dioxide within and around a large-scale wind farm-a numerical case study" *by* Jingyue Mo et al.

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Responses to the Referee #2's comments

This study presents a modeling work investigating the influence of wind farms on the spatial-temporal variation of the air pollutant. The changes in surface roughness length, and the wind turbine density (the layout of wind turbines) over the wind farm, and potential impacts on NO2 concentrations are especially considered. The impacts of wind farm on air pollution have not yet been addressed in most of previous modeling studies, so this is an interesting and scientifically valuable work, which is worthy of publication in ACP. It is clear and well written, with appropriately illustrated. I have

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Discussion paper

a few, generally minor, questions, mostly with the aim to clarify some aspects of the methodology or the limitations associated with the results presented in this study.

Response: We appreciate Anonymous Referee #2 for his or her comments and the constructive criticisms to our manuscript. We have revised the manuscript following the Referee's comments. Our detailed responses to the Referee's comments and corresponding revisions are presented below

General Comments: 1. Section 2.3, page 5, line 23: "..., we modified the geo-data in the WPS and the LANDUSEF table in WRF-Chem model." Could the author clarify and give a bit more details on what variables are modified in the model and the possible uncertainties related?

Response: To highlight the change in the surface roughness length in the YWF (Yumen Wind Farm) by wind turbine layout, we replaced the land use types and surface roughness lengths defined by LU_INDEX and LANDUSEF variables in the geo-data of the WPS by a land use type scheme which takes into account typical land surface characteristics in northwestern China (Zhang et al., 2015) and estimated effective roughness lengths in the wind farm parameterization. Corresponding changes were made in the revised paper (page 5, line 22).

2. Section 2.4, page 7, the simulated and observed NO2 concentration are compared in Fig. S1, but how is the model performance for reproducing the meteorological fields? The information for meteorological evaluation, especially the wind speed, weed direction, and temperature should be included in the manuscripts. After considering the wind farm parameterization scheme, does the simulated NO2 concentration turn out better or worse when compared the observation?

Response: Since WRF model is an operational weather forecasting model and has been validated extensively, we thought we might not need to verify WRF model performance. Nevertheless, following the Referee's suggestion further efforts were made to evaluate WRF predicted meteorological variables (winds and temperature). We

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compared WRF simulated winds and temperatures from all 4 model scenarios with observed data collected at several meteorological stations within the model domain. Results are presented in the revised Supplementary. Overall the modeled meteorological fields agree well with the monitored data. We did not find that the modeled winds and temperatures after wind farm parameterization become worth when compared with observations. Since the observed hourly wind direction at local weather stations stands for instantaneous wind direction which is often in equilibrium with underlying surface characteristics and subject to turbulence, it is not straightforward to compared measured wind directions with modeled wind directions which are virtually mean wind directions.

3. The authors investigate the impacts of the wind farm on the air quality within and around the wind farm regions by a case study and find that the wind farm would lead to the accumulation of the air pollutants featured by a step change in the concentration at the "edge" of the wind farm. But in winter, I think the prevailing wind are mostly westerly wind over these regions, rather than the case in this study, could the authors give some suggestion that how do NO2 levels might change during polluted episode near city regions with the inclusion of the wind farm scheme? How large-scale wind farm may affect the NO2 levels in Jiuquan or Jiayuguan city? Since the city regions have relative high population density, and it's more worthy of concern in big city. The consequences of the changes induced by the large-scale wind farm parameterize on air quality and their implication on human health near large city should be discussed more, at least in the discussion section.

Response: The Referee raises an interesting question. Westerly wind prevails in the wintertime across the Hexi Corridor. If a large scale wind farm could disturb atmospheric dispersion of an air pollutant and is located near a city, it may influence the temporal-spatial distribution of the pollutant over the city. This would depend on how far the edge effect could extend in the surrounding region of a large scale wind farm. The edge effect of an internal boundary layer can be estimated via a "fetch-height ratio"

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(Garratt, 1994). In micro-meteorology, such the ratio is typically about 1:100 from the rough to smooth surface. In the smooth to rough surface case, the fetch-height ratio is approximately two times greater than that in the rough to smooth case (Garratt, 1994). This suggests that, if the mean obstacle height of the YWF is equivalent to the wind turbine hub height (∼100 m), the fetch over which the edge effect could be extended to would be 10 km. If the westerly wind prevails in winter and knowing that the roughness changes from rough to smooth surface would accelerate the pollutant transport in the downwind edge of the wind farm, we would expect that the eastward transport of air pollutants might influence downwind residential areas, such as Jiuquan and Jiayuguan City in our case (Fig. 1b), located in the downstream of the YWF. However, given that there were no significant emission sources in the upstream of the YWF under the westerly wind regime, the edge effect on the air quality in these two largest cities in the Hexi Corridor was negligible. We have inserted a new paragraph (the last paragraph) in Discussion section to address this question following the Referee's comment (page 14, line 33).

Specific Comments: 1. Organizational suggestion: the simulation runs (S1, S2, S3, S4) are descripted in section 2.3 currently (page 7, line 1-10), but the simulation case (simulation time, locations) is given in section 2.4. Since all the simulations were performed from November 19th to 24th, 2016, I would suggest put the paragraph (currently page 7, line 1-10) into the section 2.4.

Response: This is a good suggestion! We have moved the last paragraph of section 2.3 to section 2.4 (second paragraph)

2. In Figure 2, "40°N" should be "40°00'N", "97°E" should be "97°00'E".

Response: Figure 2 has been revised.

3. Page 9, line 17, "control (S1) run" should be "control run(S1)"

Response: Corrected. Thanks!

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4. Page 9, line 22-23, "(the second model scenario run minus control run)" should be "(S2 minus S1)"ãËŸA ′C

Response: Done!

5. Page 10, line 15, "November 10" should be "November 19".

Response: Corrected. Thanks!

6. Page 10, line 16, "(the third model scenario run minus control run)" should be "(S3 minus S1)". If the simulation runs are named as S1, S2, S3, S4 in the MS, please be consistent throughout the MS.

Response: Done. Thanks!

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