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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Sensitivity Analysis of the Surface Ozone and Fine Particulate Matter to Meteorological Parameters in China" *by* Zhihao Shi et al.

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The paper discusses the sensitivity of surface ozone and PM2.5 in China to meteorological parameters. The information presented in the paper is useful to understand the interaction between pollution and meteorology, and regional difference in the sensitivity of emission control measures. I'd recommend the publication of the paper if the following comments are addressed: (1) The method description is very brief, and the details in implementation may affect the interpretation of the results. In particular, I see one difficulty in this type of sensitivity simulation that a simple perturbation of individual parameters may lead to unphysical meteorological fields. For example, increas-

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ing/decreasing T by 1 K under some conditions may turn saturated/unsaturated air into unsaturated/saturated, but since only T is perturbed, no cloud is dissipated/formed in response to changing T. Another example, a simple perturbation of wind speed may generate a wind field that violates the physics, and is inconsistent with the pressure field that feeds into the air quality simulation, which may lead to spurious sensitivities in the result. Even more difficult is to perturb wind direction, though I notice the authors did not assess the wind direction sensitivity. In general, I'd like to see if and how this type of issues is handled by the authors. The current method description is too brief to tell the exact implementation. Other useful details to include are if the perturbations are done for the entire atmosphere or only in the boundary layer, if they are done for the whole day uniformly or only in the daytime.

Responses: To clarify how we perturb the meteorological parameters, we added the following sentences in the method section:

"All perturbations were implemented uniformly in space on the modeling domain and in time through the modeling periods. The perturbations on temperature, wind speed, and absolute humidity were made in all layers. To separate the effects of individual meteorological parameters, only one parameter was changed in each case while all other parameters were kept unchanged. Therefore, cloud dissipating or forming in response to changing temperature was not considered in the simulations. When perturbing horizontal wind speed, to avoid unphysical situations that mass would not be conserved, the vertical wind speed was adjusted in the vertical transport calculation based on the air density changes to conserve mass."

(2) The responses of emissions to meteorological parameters are not included in the assessment. The responses of emissions to meteorology is a significant contributor to the overall meteorological sensitivity of ozone and PM2.5. To name a few, the effect of T on biogenic emissions, the effect of T on soil NOx emissions, the cloud cover/convection on lightning NOx emissions, the effect of T on power plant NOx emissions (high T leads to higher electricity demand in summer). Because emissions are

held unchanged in the simulations, these effects are not included, which makes the analysis incomplete and less informative. This caveat needs to be discussed in the paper.

Responses: Thanks for the comments. In the method section, we added the following sentences:

"It is worthwhile to note that some meteorological parameters could have significant impacts on emissions, such as the effect of T on biogenic VOC and soil NOx emissions, the cloud cover/convection on lightning NOx emissions, the effect of T on power plant NOx emissions (high T leads to higher electricity demand in summer), which would affect air quality. Therefore, the sensitivities in this study only include the 'direct' effects of individual meteorological parameters on air quality. A full evaluation of the impacts of climate/weather changes on air quality should consider effects of the emissions changes."

(3) Evaluation against observations. The O3-T slope from model simulations is often found to be much lower than that derived from observations, suggesting that model tends to underestimate the sensitivity of O3 to meteorology. The current paper provides no evaluations of how good the model in use could reproduce the observed chemical-met relationship. Note this evaluation is different from evaluation of chemical concentrations, and is perhaps more relevant for the current work.

Responses: Thank you for your valuable advice. We conducted the evaluation of the O3-T relationship, following the method in Rasmussen et al. (2012). We have no O3 observations in January (O3 observations became available from March 2013 in China), so we only evaluated the results in July in the five cities as in the manuscript. We found that CMAQ overestimated the O3-T relationship (CMAQ: 2.4 ppb/K vs. observation: 0.8 ppb/K, shown in Figure S1). Please note that we only have 1 month data and we use daily MDA8 O3 and daily maximum temperature in the evaluation, while a much more meaningful evaluation should be performed to use monthly aver-

aged MDA8 O3 and monthly average temperature over a long-term period. We added above evaluation and discussion in the revised manuscript.

(4) In abstract and elsewhere (such as Line 282), the authors compare the different sensitivities. For instance, the paper says in Line 282 that "the sensitivity of O3 to T is obviously higher than that of WS, AH, and PBLH". This is to compare apples to oranges, because these sensitivities are in different units! The delta concentrations of O3 or PM2.5 from two simulations apparently depend on how much you perturb, and it is meaningless to compare which one is bigger unless the perturbations are carefully defined to relate to the variations of individual parameters.

Responses: We modified the descriptions about the comparison among different meteorological parameters because of the different unit problem.

References

Rasmussen, D., et al., 2012. Surface ozone-temperature relationships in the eastern US: A monthly climatology for evaluating chemistry-climate models. Atmospheric Environment. 47, 142-153.

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