Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2020-173-AC1, 2020

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.

Zhihao Shi et al.

hu_jianlin@126.com

Received and published: 12 June 2020

Referee #2 The authors here have studied the effect of perturbation of meteorology on PM2.5 and O3 concentration across China. Overall, the manuscript was well written, method is sound, results are valid. I would recommend it to be published after addressing the following issues.

1. The authors here conduct the sensitivity analysis by perturbing the value of one meteorological parameter and keeping value of others constant. In real world when a meteorological parameter changes, a corresponding change in other parameters also takes place. This will affect the entire results.

Responses: For 'real world' meteorology changes, climate/weather forecasting models are usually utilized to predict how an entire set of meteorological parameters will change under certain scenarios and to estimate the impacts on air quality. Despite the large uncertainties in predicting 'real world' climate changes, another problem with this method is that it is impossible to isolate the effects of individual meteorological parameters. Sensitivity studies are commonly used to achieve this objective by perturbing one parameter at a time and keeping other parameters unchanged. This method may not reflect 'real world' changes, but can provide information that the first method cannot provide, and this method has been applied in several studies, such as Dawson et al. (2007a), Dawson (2007b), and Horne et al. (2017).

2. Even if we assume that the authors are trying to only depict the sensitivity of PM2.5 and O3 on perturbation of meteorological parameters, the above said knowledge won't be handy to the authorities when trying to implement emission control in such scenarios. Since perturbation of one meteorological parameter will result in corresponding change in other parameters and since the current simulation is only based on assumption that only one parameter will change at any given time, the results from current sensitivity analysis won't be of any use.

Responses: The results are useful for implementing emission controls in several aspects. First, the results help identify the major meteorological factors to which PM2.5 and O3 have the largest sensitivities. For example, our results indicate that in July O3 is very sensitive to temperature but not so sensitive to PBL height in Beijing. Therefore, additional emission controls would be needed if temperature is predicted to increase in future, but not necessary if PBL height is predicted to increase (while temperature is predicted no significant increase). Second, the results show that the PM2.5 sensitivities to these meteorological parameters are mainly through secondary components (SO42-, NO3-, NH4+, and SOA). Therefore, more emission controls on the precursors of the secondary components would be needed in future to overcome the adverse impacts of meteorological condition changes on PM2.5. Third, this study aims to isolate

the effects of individual meteorological parameters on air quality. It is very straightforward to quantify the combined effects of changes in several meteorological parameters. As an example, we conducted an additional simulation to test the impact of all perturbations (T+1.0K, WS-10%, AH+10%, PBLH-20%, CLW+10%, and PCP+10%) on O3 and PM2.5 in January and July, and the results was shown in Fig.S8 in the revised manuscript.

3. Solar radiation apart from temperature is also one of the main factors affecting O3 why haven't the authors studied sensitivity of O3 concentration to change in solar radiation.

Responses: Solar radiation affects photolysis rates. In CMAQ, the photolysis rates are calculated in-line. First the clear-sky photolysis rates are calculated using the clear-sky actinic flux. Then photolysis rates are corrected to account for the effects of cloud and particle extinction. The actinic flux is calculated in real time as a function of time of day, longitude, latitude, altitude, and season, therefore is not perturbed in this study.

4. The authors doesn't mention on what basis they change the meteorological parameters i.e. on what basis is the magnitude of change in parameters considered.

Responses: The magnitude ranges of perturbations are based on IPCC AR5 report and the study of Dawson et al. (2007) and the references therein. For each parameter, three positive and three negative perturbations were then designed within its range to have a more comprehensive examination on the sensitivity of PM2.5 and O3 to this parameter. We add the above information in the method section.

5. Line 179-182, the authors discuss regarding effect of Temperature on Ozone in Ozone forming regime. Any references to suggest that the said areas in China are in ozone forming or ozone consumption regimes?

Responses: The net O3 formation areas and the net O3 loss areas are classified based on the O3 concentrations (shown Fig. 2). The background O3 is about 35 ppb,

therefore, areas with O3 concentrations over 35 ppb is the net O3 formation areas, and areas with O3 concentrations less than 35 ppb is the net O3 loss areas. We added the explanation in the revised manuscript.

6. In Figures S8-S13, the authors estimate the quantitative sensitivity of O3 and PM2.5 concentrations to change in individual meteorological parameters by linear fitting of the changes. The authors should also report the corresponding R-squared, slope and significance values, it would help to understand the rate of change of PM2.5 or O3 per change in meteorological parameters and if at all the rate of change is statistically significant.

Responses: Thanks for your suggestion. We added these metrics in Fig. S8-S13.

7. Does the authors perturb meteorology parameters only for China in the domain? As per spatial variation figures, the domain also constitutes parts of south-east Asia?

Responses: 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. We have added above explanation in the method section.

References

Dawson, J., Adams, P., Pandis, S., 2007a. Sensitivity of PM 2.5 to climate in the Eastern US: a modeling case study. Atmospheric chemistry and physics 7, 4295-4309. Dawson, J.P., Adams, P.J., Pandis, S.N., 2007b. Sensitivity of ozone to summertime climate in the eastern USA: A modeling case study. Atmospheric environment 41, 1494-1511. Horne, J.R., Dabdub, D., 2017. Impact of global climate change on ozone, particulate matter, and secondary organic aerosol concentrations in California: A model perturbation analysis. Atmospheric Environment 153, 1-17 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.

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2020-173, 2020.