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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Sensitivity of $PM_{2.5}$ to climate in the Eastern U.S.: a modeling case study" *by* J. P. Dawson et al.

J. P. Dawson et al.

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Major concern:

The abstract has been amended to address these concerns. We have deemphasized the possibility of using a correction and just mention the magnitude of the discrepancy between the two results (sum of individual perturbations and combined perturbation case). Short of simulating many binary, ternary, etc. interaction effects among the meteorological parameters, it would be very difficult to determine why the combined change is smaller than the summed individual changes.

Specific comments:

1. *Second paragraph on page 6490: Additional studies that examined the effect of climate change on ozone should be cited.*

These references have now been added.

2. *Line 10 on Page 6492: Simulation period of about a week seems a little too short to me. Predicted aerosol distributions and concentrations and default weather system can have large influence on your results. Why not doing the simulation for the whole month of July or January?*

Month-long simulations would be more complete, but they would also require triple the computational time of the simulations in this study. Given that over 75 simulations were required for this study; computational resources precluded the use of longer simulation periods. The robustness of our conclusions has been tested by performing selected longer simulations for certain perturbations and the results were generally consistent.

3. *Page 6492: Why does the model have 14 vertical layers in July and 16 layers in January? Since the sensitivity to mixing height was investigated by changing mixing height by one model layer, how does this difference in vertical layers influence results from the sensitivity study?*

Different resolutions were necessary for the better meteorological simulation of the two periods. The additional January layers were above the July layers, so there was simply a larger domain in January, rather than a more highly resolved one.

4. *Line 5 on Page 6492: Is SOA from isoprene included in the SOA scheme?*

Isoprene is not part of the SOA scheme in this model; however, the lumped monoterpene species is part of SOA formation. This has now been explained in the relevant paragraph. Isoprene SOA is included in later versions of PMCAMx (see for example Lane and Pandis, Eviron. Sci. Technol.. 2007, 41, 3984-3990).

5. *Lines 18-19 on Page 6492: Biogenic emissions were assumed not to change with perturbations in meteorology in this work. Because biogenic emissions increase with temperature, SOA is underestimated in the simulation examining the sensitivity of July PM2.5 to temperature. A test with biogenic emission increasing by 25 percent in your*

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sensitivity run might help you to know the bias caused by your assumption.

The role of biogenics will be discussed in future work, largely dealing with GCM-predicted future meteorology. This simplification is now acknowledged explicitly in the paragraph.

6. *Top of Page 6494: It is described that average concentration was 40 micrograms per cubic meter in the New York area, due largely to primary organics. In July, the highest average concentrations were in the Midwest, especially the Chicago area; this was largely due to high sulfate concentrations. Are these predictions representative of the conditions in the eastern US? Should the highest PM2.5 concentrations be located over eastern US in summer?*

PM2.5 concentrations are usually higher in the Midwestern US during the summer because of higher sulfate levels. The model has been evaluated for these exact time periods, so we do know that the model represents these specific time periods well. A reference to the evaluation work of Karydis et al. (2007) has been added.

7. *Figure 2: Why isn't BC shown? How did you calculate PM2.5 mass based on predicted ions, SOA and POA?*

BC was included in the simulation and is included in the total PM2.5 concentrations. We did not show it as one of the important species because of its inertness. PM2.5 mass is the sum of sulfate, nitrate, ammonium, SOA, POA, BC, seasalt, and crustal material. The last three of these were not discussed in great detail due to space limitations– only as part of total PM2.5.

8. *Section 3.1: Why sulfate increases with temperature in summer but is insensitive to temperature in winter (Figure 3)? Give quantitatively how sulfate production (gas-phase and aqueous-phase) changes with temperature in January and July.*

There are multiple factors at play here. In the summer gas-phase oxidation plays a more important role and the reaction of SO2 with OH accelerates with increasing tem-

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perature. In winter, when aqueous chemistry dominates, the solubility of SO2 into the aqueous phase decreases as temperature increases, while the oxidation rate increases with temperature. It is this combination of reaction pathways and temperature dependences that causes the difference.

9. *Figure 3: why did the authors select different temperature perturbations for January and July? A perturbation of +1.5 K is shown for July but not for January.*

After the July simulations were completed, it became apparent that the +1.5 K simulation did not give much additional information. Because of this, this case was not simulated in January.

10. *Section 3.2: The effect of changing wind speed is expected to have different effects over different areas; over an area with a convergence of mass fluxes, increasing wind speed would increase aerosol concentrations, while over an area with a divergence of mass fluxes, increasing wind speed would reduce aerosol concentrations. Why increased wind speed generally leads to reductions in PM concentrations in this work?*

The average concentrations reported are for land cells. Since winds are predominantly from west to east over most of the Eastern US, increasing wind speeds will carry PM away from land and out to sea. This is now noted in the paper.

11. *Page 6497: Is SOA as sensitive to water vapor as nitrate aerosol?*

There is no direct connection between SOA and water vapor in the model so the modeled SOA is not sensitive to water vapor. This is in general consistent with observations of the nighttime behavior of these two species: nitrate concentrations increase as temperature decreases and relative humidity increases while there is little change of the organic aerosol levels.

12. *Table 2: What do you mean by expected changes in meteorological fields? Model predictions? It says in the table caption that (Major sensitivities in bold) but no bold letters are found in the table.*

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The “expected changes” are predicted by climate models; these are the footnotes in the table. This is now noted in the relevant paragraph. The bold type appears on the pdf file.

13. *Figure 10: How are non-sulfate aerosols influenced by changing cloudy areas?*

These changes were quite minor, as can be seen in the paper, so it was decided not to devote a significant amount of space to this topic. There can be indirect effects on other species, such as changes in sulfate resulting in changes in ammonium, which then result in changes in nitrate. Also, changes in photochemistry could affect oxidation of organics and, therefore, SOA formation.

14. *Sections 3.7 and 3.8: Sensitivity of PM concentrations to precipitation rate (or to precipitation area) relies on the locations with precipitation. Small change in precipitation over heavily polluted area would have a large effect on PM2.5 concentrations. Sentences such as “ with the strongest effect in areas receiving light to moderate rainfall and in their downwind areas.” (Lines 20-21 on Page 6501) are correct only when examining percentage changes in concentrations. Please clarify in the text.*

This has now been clarified in the text.

15. *Lines 2-4 on Page 6501: It is stated that “Since convective storms tend to be shortlived, changes in precipitation rate help them more fully wash out aerosols”. What fractions of aerosol mass are washed out by convective and large-scale precipitation, respectively, over the eastern US in January and July in the base case?*

This cannot be easily determined in this modeling framework because PMCAMx does not distinguish between convective and large-scale precipitation.

16. *Figure 13: What are the data points?*

This has now been explained in the caption. Each point represents an average concentration in one grid cell.

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17. *Section 5: Describe in the text how you calculated sensitivity mean and predicted effect mean in Table 5.*

This is now summarized in the first paragraph of the section.

18. *Conclusions: Since this study is based on a regional simulation over eastern US for a short time period, conclusions drawn from this study may depend on predicted aerosols and default weather system in the model. This should be mentioned in the conclusion section.*

This is now mentioned in the conclusions.

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