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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Understanding the contributions of aerosol properties and parameterization discrepancies to droplet number variability in a Global Climate Model" *by* R. Morales Betancourt and A. Nenes

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We thank the reviewer for the positive feedback and for raising important comments that have lead to improvements in the paper. The reviewer's comments are in italics, followed by our responses.

General comments

1. The two main topics (listed above) are not very well connected in the manuscript (for

example, if I understood correctly, adjoint sensitivities are calculated only for PD emissions, and only one parameterization scheme is used when discussing about changes in CDNC due to changing primary organics emissions between PI and PD emissions). The authors should bring out more clearly the connections between these two topics, and make sure that the reader can keep track of which parameterization and emission schemes are used when presenting the results (text, tables and figures).

These two concerns are now addressed in the manuscript and more detailed answers are provided below. Adjoint sensitivities were calculated for both PD and PI simulations. However, in computing changes between PD and PI emissions, only sensitivities at PD are used because the results were found not to vary when sensitivities at PI were utilized. The choice of PD over PI was rather arbitrary but does not affect the outcome of the calculations in any significant manner.

Similarly, the discrepancy in the response to coarse mode aerosol number or the 2-fold difference in the sensitivity to aerosol volume, are both independent of whether the emissions are at PD or PI times.

2. Equation 4, page 31493. If I understood correctly, the first term in the right-hand side of the equation is calculated from the adjoint using PD emissions. Does this "hide" assumption that the corresponding partial derivates of CDNC stay the same in PI and PD scenarios? In any case, the use of the equation should be justified and discussed more explicitly as this is the key to understanding the authors' results regarding the sources of variability CDNC. In particular, two issues: 1) do the corresponding differentials vary between PI and PD emissions? and 2) if so, how it would impact the results?

The assumption is implicit in the equation. This is now clearly stated in the manuscript and the consequences of it discussed. The choice was made because the results were not significantly altered if sensitivities at PI times were used instead of PD, or even if an average between PD and PI times were used. The changes in N_d are dominated by changes in aerosol properties rather than by an increase/decrease in the sensitivities.

3. Section 3.3.1. In the beginning of the section, it is stated that: "Further apportionment of the impacts of aerosol emissions on N_d requires the adjoint of the aerosol module (e.g., Karydis et al., 2012a), which is not yet available for MAM3". I do not argue about the importance of POA, but it should be put in context of relative impacts of various aerosol (and their precursor) emissions that change between PI and PD scenarios. As this is not possible and given the structure of the section 3 (authors seem to pick one particular issue at the end, leaving the reader a bit baffled about its importance) I would advise to omit section 3.3.1 from the manuscript and use it in a further study probing the issue deeper when the adjoint for MAM3 has been developed:

We appreciate the constructive and thoughtful comments on the manuscript. We decided to remove section 3.3.1 from this manuscript and reserve it for a future study.

4. The section 4 could be merged with section 3, as the title of the section states "Quantifying parametric uncertainty with the adjoint approach" while the authors consider a set of parameters related to a single aerosol property (hygroscopicity). Also the choice of +-50% uncertainty in kappa should be justified in more rigorously, now the authors refer only to a single closure study

The section was moved to section 3 according with this comment. The choice of a plus and minus 50% uncertainty was used to represent a large uncertainty range of values that SOA and POM kappa. Other citations were added to support this choice.

Minor and technical comments

1. page 31483, line 3. Please clarify the term "statistical emulator".

This is now expanded in the text. By "statistical emulator" we refer to a Gaussian process emulator, which is a Bayesian approach that uses information from a small number of model runs to predict model output (for a predetermined set of variables) everywhere in the previously chosen uncertainty space.

2. page 31487, first paragraph. Are the results sensitive to the chosen value of α_c?

For α_c between 0.1 and 1, N_d is not strongly sensitive to α_c. The results presented in the paper are therefore not dependent on this parameter. More discussion about this was included in several parts of the modified manuscript.

3. page 31495, line 13. Should be "pre industrial"

The typo is corrected.

4. page 31495, line 14. Should there be total derivative of N_d, instead of partial derivative?

Typo was corrected.

5. page 31498, lines 11-15. Here the authors state that "However, the diverse response observed across parameterizations implies that a physically consistent representation of coarse mode aerosol remains a challenge for activation parameterizations, although a recently developed modification of FN addresses this issue altogether (Morales and Nenes, 2013). Has the referred manuscript been published yet? If not, please describe briefly how the issue has been addressed in the referred work.

We included a more detailed explanation of this in the modified manuscript. The referred paper has been submitted to GMDD; we will provide a copy of the submitted PDF for the reviewers, as it is not yet available online.

6. page 31499, line 18. Should here read "parameters" for example, rather than "sectors"?

This typo is now corrected.

7. page 31499, lines 22-25. While I admire the authors' work, I would be cautious when using adjectives such as "powerful : : :. information" or "unprecedented" here.

The phrasing in the Conclusions section was modified.

8. Table 2, third row, first column. Should be "ARG-PD-PIa". Also, the authors should

use consistent acronym for "pre-industrial" as both “PI” and “PIa” are used now.

The typo was corrected, and the use of acronyms across the entire manuscript was modified. The use of “PIa” was eliminated in favor of “PI”

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