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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Droplet number prediction uncertainties from CCN: an integrated assessment using observations and a global adjoint model" *by* R. H. Moore et al.

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Responses to Reviewer #2

We thank the reviewer for their detailed comments and contributions to the paper. Responses to the italicized reviewer comments are shown below.

General Comments

The title. This study does not "predict" droplet number, but diagnose (calculate) it from aerosol (CCN) number and size and updraft. There are no other sources and sinks for the droplet number. I would suggest changing the title to "Droplet number uncertainties

associated with CCN: an assessment using observations and a global adjoint model"

This is a good point. Change made.

This study aims to quantify the uncertainty of droplet number from CCN number uncertainty in observation estimations by using $\Delta Nd/Nd = (\partial Nd/\partial Na)(Na/Nd)(\Delta Nccn/Nccn)$. *However, it is unclear if the Na from the model is the same thing as Nccn from the individual observation? Or Na has the same sensitivity to Nd as CCN?*

This is a very good point. As implemented here, N_{CCN} scales directly with N_a through the CCN spectrum; the cloud droplet sensitivity with respect to N_{CCN} and N_a is interchangeably used.

Specific Comments

1. Abstract. There are many sentences which are unclear to me. "Published CCN closure prediction uncertainties" is awkward. Change to "Published CCN closure uncertainties". "CCN-active aerosol number concentrations" is awkward. Change to "number concentrations of aerosols which are active as CCN". "most of the anthropogenic indirect forcing is concentrated over the continents". How do you know that? The objective of this study is to quantify the droplet number uncertainty from CCN uncertainty. However there are no quantitative numbers given for droplet number uncertainty in the abstract.

Thank you for pointing these issues. We have made the requested wording changes and added text related to the droplet number uncertainty. The greatest anthropogenic aerosol increases have been observed over the continents due to the close proximity to emissions sources, while continental clouds are more strongly forced.

2. P20487. L10-13. Please explain the reason of reduced uncertainty of Nd compared to CCN.

Increasing aerosol number promotes competition of aerosol for water vapor during droplet formation. This results in a supersaturation reduction, hence a sublinear re-

sponse of droplet number to aerosol (e.g., Sotiropoulou et al., GRL, 2006).

3. The title of section 2.1 "CCN prediction uncertainty measurements" is awkward. Change to "CCN uncertainties due to mixing state and composition in the measurements".

We have modified the section title.

4. P20490. L1-2. The statement is not generally true for large-scale models. Many large scale models are now predicting the aerosol mixing state, composition and size distribution.

This point is well taken; most global models however invoke at least one of the simplifying assumptions used in the different CCN closure "scenarios" examined here. The goal then is to quantify the associated Nd prediction uncertainty.

5. P20490. L22-24. This sentence is confusing. "Most studies tend toward overprediction with the external mixing. . . lower. . . than. . . internal mixing"

We will rewrite the sentence to make it clearer.

6. P20491. L19. "offline parameterization" of what?

This has been corrected to explicitly refer to the droplet activation parameterization

7. P20492. L14. What do you mean "analytical precision"?

The adjoint computes the analytical derivative of the model calculations, which is more precise than, e.g., a forward-difference perturbation.

8. P20493. L2. "observations" of what?

This has been corrected to explicitly refer to observations of cloud droplet number

9. P20493. Section 3.1, first paragraph. What is the size range of Na? Is Na the number for all aerosols predicted in the model? Are Na and Nd concentrations at surface? What is Smax? How do you derive the global geometric mean aerosol concentration?

Size distributions are prescribed in the model following Karydis et al., (2011) and references therein. N_a is indeed the total modeled aerosol number concentration. All model results are computed at the surface layer. s_{max} is now reported in Table 3. Geometric mean concentrations are computed from the area-weighted average of all model grid cells.

10. P20494. L15. "inflection point of the sigmoidal fit function". This is unclear to me.

The inflection point is reported as a single parameter in describing where the logarithmic sensitivity of cloud droplet number to aerosol number decreases below 0.5

11. P20495. L17. "moisture flux (e.g., liquid water content)". Chang "liquid water content" to "water vapor mixing ratio".

Done.

*12. P20496. L8. I don't know how you get 1/12*Nd when A=0.5 in Equation 1.*

We apologize for this oversight. The typo has been fixed.

13. P20496. L25. It is confusing "simplified forms of Kohler theory".

This has been clarified to say "simplifying assumptions in Kohler theory".

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 20483, 2012.