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Interactive Comment

Interactive comment on "Putting the clouds back in aerosol-cloud interactions" *by* A. Gettelman

Anonymous Referee #2

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This manuscript performed sensitivity tests to examine how different processes contribute to the uncertainties in ACI. Based on the sensitivity results, the author argued that uncertainties in cloud microphysical processes contribute more to the uncertainties in ACI, stronger than uncertainties due to natural aerosol emissions. Given the large uncertainties in ACI and given the large uncertainties in cloud-related processes in climate models, the topic is timely and highly relevant to ACP. The method is generally appropriate. I would recommend the publication of the manuscript after my following comments are addressed.

Major comments:

The main conclusion of the paper is that cloud-related processes contributed more to the uncertainties in ACI than aerosol-related processes (the author used "cloud microphysics" in the abstract seems not accurate, as CLUBB in itself is cloud macrophysics).

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This conclusion may not be a surprise to many of us in the field, as this has been hinted in many previous sensitivity studies (on this aspect, I would suggest the author to add more relevant papers). But the hard part is to provide solid evidence to make an assertive statement on this. One challenge is that whether the sensitivity experiments performed in the manuscript were designed in a way to systematically examine key uncertainties in cloud-related processes. I would suggest the author to add more discussions on this.

Another even bigger challenge associated with these sensitivity tests is whether these experiments are equally realistic. This is less a problem with aerosol-related processes, as the perturbation in aerosol-related processes usually has less impact on the model climatology, but this can be a big issue for cloud-related sensitivity experiments as cloud-related changes can significantly perturb the model climatology. Table 2 documented the anthropogenic radiative forcing from these different tests, but it is not clear how realistic each of these experiments are. To partly address this issue, I would also think the relative change in radiative fluxes may be more relevant than the absolute changes, as cloud radiative forcing may be different across different experiments. Adding how the corresponding fields in present-day simulations in Table 2 can be helpful as well.

I would also suggest the author to use less assertive statement in the abstract and the main text about how cloud-related processes contribute to the uncertainties in ACI, as the current assertive statement may require more evidence that is not supported by the manuscript.

The manuscript includes both off-line microphysical tests and global sensitivity tests. But it seems that the off-line tests do not add much. Removing the off-line tests would have little impact on the main conclusions of the manuscript.

Specific comments:

P. 20777, line 6: Many previous studies have examined how cloud microphysics may affect ACI (e.g., Menon et al., 2002; Rotstayn and Liu, 2005; Penner et al., 2006; Wang et a., 2012).

P. 20777, line 14: Ghan et al (2013) is highly relevant here

P. 20777, lines 18-21: This statement is unclear. It is not clear to me how "the sensitivity of ACI to pre-industrial aerosols" indicates the second part of that statement.

P. 20779, Eq. (1): any reference for Eq. (1)?

P. 20778, Section 2.1: four off-line test cases. It is not clear why these four cases are chosen. Readers also need to refer back to Gettelman and Morrison (2015) to understand these four cases.

P. 20784, line 21-28: Any explanation why the autoconverion changes have different effects in different cases?

P. 20786, Fig. 7: how are cloud top drop number and effective radius calculated? Is this for a particular cloud type, such as warm clouds?

P. 20788, Section 4.4: Many previous studies examined the sensitivity of cloud lifetime effects to autoconversion schemes (e.g., Menon et al., 2002; Rotstayn and Liu, 2005; Penner et al., 2006; Wang et a., 2012).

P. 20792, line 8-11: The explanation here provides little help on why Berg0.1 produces a large increase in ACI compared to the default case.

P 20786, line 20: "in"→ "an"

P 20792, line 20: "can can" → "can"

Menon S, Del Genio AD, Koch D, Tselioudis G (2002) GCM simulations of the aerosol indirect effect: sensitivity to cloud parameterization and aerosol burden. J Atmos Sci 59:692–713. Rotstayn, L. D., and Y. G. Liu (2005), A smaller global estimate of the sec- ond indirect aerosol effect, Geophys. Res. Lett., 32, L05708, doi:10.1029/

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2004GL021922. Penner, J. E., J. Quaas, T. Storelvmo, T. Takemura, O. Boucher, H. Guo, A. Kirkevag, J. E. Kristjansson, and O. Seland (2006), Model intercom- parison of indirect aerosol effects, Atmos. Chem. Phys., 6, 3391–3405, doi:10.5194/acp-6-3391-2006. Wang M., S. Ghan, X. Liu, T. L'Ecuyer, K. Zhang, H. Morrison, M. Ovchinnikov, R. Easter, R. Marchand, D. Chand, Y. Qian, J. Penner, Constraining cloud lifetime effects of aerosols using A-Train Satellite observations. Geophys Res Lett 39, (2012)10.1029/2012GL052204).

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 20775, 2015.