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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Microphysical process rates and global aerosol-cloud interactions" *by* A. Gettelman et al.

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Replies to Anonymous Referee #2

» We thank the reviewer for their time and attention to this manuscript, and for their detailed comments. We have clarified the text in many places as suggested by this and the other reviewers, and redone a few of the figures. Results have been changed by being more consistent with application of pre-microphysics liquid water path, which was not used in the earlier draft for the GCM susceptibility figures 7 and 10. The revised figures are more consistent with previous work. We have eliminated figure 8 from the previous draft, which will help simplify and clarify section 5 as requested by the reviewers: this section will be totally rewritten. We have also added error bars to these

susceptibility figures, which will clarify the significance of the results and differences discussed. We have also investigated further the use of the probability of precipitation (POP) as a metric as suggested, and comments on that are contained below.

We think in the revision, with the comments detailed below, we will have satisfied all the major reviewers' concerns. In particular, we have rewritten section 5 and made the changes suggested by Reviewer #3, which we think will address the broad concerns of this reviewer about readability. We have eliminated a figure (figure 8) from the original draft as part of trying to shorten and clarify the manuscript as suggested by reviewer #3.

Detailed replies to be implemented in the text are contained below. These are incorporated in a revised draft that per ACP policy will be uploaded separately.

This paper discusses the representation of autoconversion and accretion in a GCM and in a process model and as inferred from observations and the implications of this representation for the indirect aerosol effect. The authors show that the sensitivity of autoconversion and accretion with increasing liquid water path in the GCM is different from the process model. The sensitivity studies that were performed couldn't change the functional behaviour but could reduce the indirect aerosol effect by putting more weight on accretion and changing how the accretion is calculated. The new aspect in this study is the help of a process model and observations. The topic is relevant and I recommend the paper for publication after the following comments have been addressed.

Major comments:

p.11791, line 14: Instead of just stating that entrainment processes are important, say what they would do in this context

» Noted.

p. 11793, line 25: Aren't all accretion formulations just functions of q_c and q_r?

» Awkward, sentence changed (intent is to just discuss THIS formulation, not others).

p.11794, lines 19/20: Isn't that obvious that accretion and autoconversion are the main sinks for cloud water?

» Yes, we are just proving it.

Why do they peak at 400 hPa in the west Pacific and continue all the way to 200 hPa? I would have thought that there should be ice only....

» Liquid can be present in the model (particularly from convective detrainment) in small amounts down to -30C. Convective detrainment ice fraction is a linear function of temperature from zero at -10C (all liquid) to 1 at -30C (all ice). Noted in the text.

p.11798, line 7: why is the ratio of accretion to autoconversion largest highest up in the cloud? Shouldn't it increase downward as the rain sediments through the cloud?

» It is probably because there is falling ice precipitation (snow) that melts and then accretes liquid, but it is not autoconversion of liquid. It may also be that the relatively thick vertical layers ($\sim$1km or so in the middle troposphere) mean that accretion is occurring mostly in the same grid boxes as autoconversion. The former is more likely, and has been noted in the text.

p.11799, lines 5-12: What is the purpose of showing autoconversion and accretion vs. AOD? AOD is not relevant, but CCN are, and the particles that dominate CCN are not the same that dominate AOD. I suggest replacing AOD everywhere with CCN.

» Correct, it is not as relevant. But AOD is a convenient column variable that has been used in the past from observations as a proxy for CCN measurements. Using it as a metric improves the ability to compare to observations, and with other model studies that have used it. With that in mind we choose to keep using AOD.

p.11800, lines 2/3: Why don't you limit your analysis to warm clouds so that you get no contribution from ice-phase processes?

» This can only be done in the GCM if regions with no ice processes are selected. The S.E. Pacific is one of these regions, and we note that this is a region where there are warm clouds only: but the results in Figure 5 and 6 are not that different in this region as in others. Noted in the text.

p.11800, line 24: How are the deltas in R and CDN obtained given that all these data are from a present-day simulation?

» As with previous work (Jiang et al, 2010) we use the spatial and temporal variance of these values to generate the variability for the regression fits. We have tried to clarify this a little bit.

p.11800, line 28: Please offer an explanation for the change in susceptibility with increasing LWP

» Noted (from Jiang et al 2010)

p.11800, lines 6/7: What causes the minimum in susceptibility at an LWP=300 g/m2? Why has the reduced autoconversion an increased susceptibility at higher LWP?

» I think this refers to 11805 lines 6/7. We have revised the figure with the microphysically relevant LWP, and this feature of the plots has gone away. We are also rewriting this section in response to reviewers' comments for clarity.

p.11806, line 19: Again, please offer an explanation for the change in susceptibility with increasing LWP

» Rewritten to reflect new figures and for clarity.

p.11806, line 27/28: Why does the GCM have problems capturing the correct form of the accretion/autoconversion behaviour?

» This might be due to the long timesteps in the GCM, and limiters that restrict process rates to the available water. We have noted this in the text, and also noted it is potentially one reason why the dT/4 simulation has higher accretion rates.

Minor comments:

I suggest to always use small letters for autoconversion and accretion

» Done. Except in captions and where the ratio is cited.

p.11796, line 8: blue should be red

» Done

p.11799, line 23: delete one "that"

» Done

p.11800, line 17: 6e should be 6b

» Done (actually line 19 and 6c to 6b)

p.11820: add in the legend that the different curves are obtained from CAM5.

» 'GCM' noted at the top of the caption.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 11789, 2013.