Response to Reviewer #1 of acp-2016-831

Dear Reviewer,

Thank you very much for taking your time to review our paper.
I am returning herewith a manuscript revised according to reviewers' comments.
I hope that the manuscript is now acceptable for publication in *ACP*.

[RC]: Referee comment in *Italic*
[AC]: Author comment

General Comment:

[RC] *This manuscript sheds light on the overestimate of aerosol effects on liquid water path simulated by GCMs. I particularly like the two-dimensional dependence on stability and reflectivity illustrated in Figure 4. The figures effectively illustrate the key points. The writing is generally lucid and concise. Only minor revision is needed before publication.*
[AC] We would like to thank the referee #1 for his/her very positive comments. The reply and corrections on individual issues are below.

Minor Comments:

[RC1] *Page 2, line 22. Replace "hydrometeor" with "geometric".*
[AC1] We have modified.

[RC2] *Page 5, lines 30-31. Couldn't the S_{conv} bias also be due to insufficient vertical resolution or biased cloud geometric thickness?*
[AC2] The model vertical resolution in this study is 20 layers (sigma-pressure coordinate system: 0.995, 0.980, 0.950, 0.900, 0.830, 0.745, 0.650, 0.549, 0.454, 0.369, 0.295, 0.230, 0.175, 0.124, 0.085, 0.060, 0.045, 0.035, 0.025, and 0.008), which is finer near the surface. The modeled cloud geometric thickness is well represented quantitatively compared with observations (Fig. R1), but there are some biases quantitatively. This mainly stems from insufficient vertical resolution in model than CloudSat whose output is fine (~240 m by oversampling). It further causes biases in vertically integrated conversion rate P_{conv}, and also S_{conv}.

We add this issue in the revised version as follows: "Besides this, S_{conv} can also be biased from the error of cloud geometric thickness due to insufficient vertical resolution in GCMs. In addition to the microphysical aspects mentioned above, biases in macrophysical structure are also related to model performances, which will be discussed later (cf. Sect. 3.3).".

[RC3] *Page 6, line 4. "The response of cloud liquid water to aerosol perturbations determines the cloud lifetime". I think you mean cloud lifetime effect, although cloud fraction changes are also involved.*
[AC3] This sentence has been modified as follows: "The response of cloud liquid water to aerosol perturbations determines the cloud lifetime via the modification of cloud fraction (Albrecht, 1989), and is thus related to global hydrological cycles as well as radiation budget (e.g., Trenberth et al., 2009; Wood, 2012).".

[RC4] *Page 8, line 32 – page 9, line 1. You might note that the overestimate in S_{conv} at low LWP might be partly due to insufficient dependence of autoconversion on LWP. See, e.g., Wood, JAS (2005).*
[AC4] Yes, the dependence of autoconversion rate upon LWP and N_c (i.e., ¥alpha and ¥beta in Eq. 1)

is also important issue. In this case, since Fig. 1b shows S_{conv} behavior as a function of LWP, the bias in S_{conv} relates to the dependence on N_c rather than LWP. MIROC uses Berry (1968) autoconversion scheme, which is parameterized as ¥alpha = 3 and ¥beta = 1, and this microphysical dependency is consistent with Wood (2005) who suggested that ¥alpha ~ 2.8–3.0 and ¥beta ~ 1.4–1.5. However, it is also true that the dependence of autoconversion rate on LWP and N_c remains a controversial issue in several literatures (e.g., Suzuki et al., 2013, 2015; Gettelman, 2015).

We slightly have modified the sentence as follows: "Moreover, the model overestimates S_{conv} around low LWPs compared with A-Train satellite retrievals due to uncertainties in process rates parameterization (Wood, 2005).".

[RC5] *Page 9, line 12. Replace "the assumption" with "assumptions".*
[AC5] We have modified.

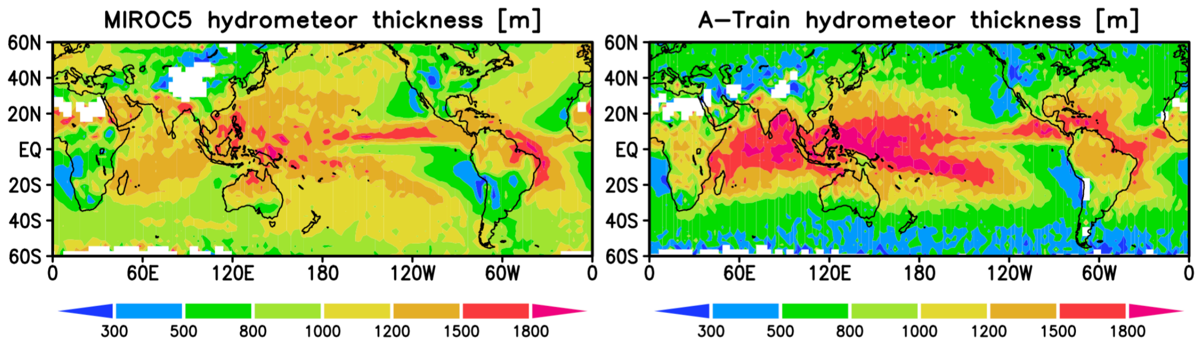

Figure R1. The (left) simulated and (right) satellite observed cloud geometric/hydrometeor thickness.

Thank you very much for reviewing our paper.

Sincerely yours,

Takuro Michibata

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