

Response to the Editor's Comments
(Here the editor's comments are displayed with Italic and bold font)

Dear Colleagues,

*I have taken a close look at the revised manuscript. I am still very concerned about the readability of the manuscript, which is compounded by the significant grammatical and typographical errors. I have consulted with the editorial staff on this matter. While I do understand that ACP will perform a technical edit on this document prior to publication, I am particularly concerned that most readers will be frequently confused by the *meaning of the text*, and that this will obstruct the exchange of information and the transfer of physical insights. This will not serve the authors well.*

My comments below are an attempt to highlight some of the parts of this document that need particular attention. There are likely others that I have not picked up on. Please also note that while I marked these as 'minor revisions', there are some questions that are much more substantive. Until these very important corrections are made, I will not be able to accept the manuscript for publication in ACP.

Graham Feingold

Note 1: Page and line numbers refer to the diff file.

Note 2: I have not attempted to correct the many grammatical errors that unfortunately make the text very hard to follow at times.

We thank your effort in helping us to improve the manuscript. The following are our point-to-point responses to your comments. Certainly, our revisions go beyond these indicated modifications as shown in the manuscript version tracking the revisions. Specifically, the section 4.1 has been merged with 4.2, and 4.3 is now 4.2, both sections, alongside many other parts of the manuscript, have also been largely rewritten to improve the readability as well as to interpret the results more adequately. Several redundant or inadequate paragraphs and statements have also been removed.

Page 1, line 38. Please be clear: remove the word 'can' and make it clear exactly what the model shows.

Done.

Page 2 the first paragraph at the top of page 2 is not clear at all to me. There also are grammatical errors that make it difficult for any reader to follow.

We have removed the sentences containing “positive” and “negative contribution” here (and in other places such as Conclusion) to make the paragraph read better, and to reflect what the model shows as suggested in the above comment. It reads now as: “In addition, we find that an excessive atmospheric heating up to 12 K day^{-1} produced by absorbing black carbon aerosols (BC) in our modeled cases lowers the height of cloud top and liquid water path, resulting a weaker extent in vertical development while a higher cloud fraction and delaying intense cloud break-up before later afternoon. While the thinner clouds resulted from such a heating, on the other hand, would break up faster in late afternoon when convection is further strengthened.”

Page 5, line 139 please also refer to Bretherton et al. 2007 GRL, who were the first to identify the impact of cloud droplet sedimentation.

This paragraph is about certain previous modeling efforts using DACCIWA data (now opens with a brief statement to make this more clearly). Nevertheless, your point is received, we have modified the sentence to: “The impact of sedimentation on LLSCs was indicated by previous studies (e.g., Bretherton et al., 2007). This issue has also been addressed in a modeling of DACCIWA case by...”.

Page 8, line 257. You discuss evaporation of this light precipitation. Please expand on the physical chain of events -- otherwise the reader does not gain any physical insights.

It has been modified to: “...by the cooling alongside moistening brought by the evaporation of this light precipitation, which could enhance the liquid water path of the beneath LLSC...”.

Page 9, line 297: you mention a pseudo prognostic approach for supersaturation was developed. What does this mean? For example, the last line at the end of this page discusses the Abdul-Razzak and Ghan parameterization, which is a diagnostic supersaturation calculation. Therefore, I am quite confused about what you mean above, and how exactly S is calculated.

It has been modified as: “...a pseudo-prognostic approach correcting the diagnostically derived...”.

Line 317 on page 9: ‘secondary’ organic aerosol not ‘second’ organic aerosol.

Done.

Page 10. Line 328 – ‘module’ not ‘nodule’.

Done.

Page 10 line 345 you say that the liquid cloud affective radius is computed from the liquid water content. Please be clear that the drop size is equally determined by the drop concentration.

Added “and droplet number concentration”.

Page 10 line 365: you speak about an absorbing layer, but what does the layer absorb? Please be precise in your language.

It has been modified to: “a “sponge layer” is set between 1.8 and 2 km height to absorb wave reflection”.

Page 11 online 382 you mentioned an ‘alarming difference’ please quantify what you mean by ‘alarming’. This is hyperbole.

Changed to “...any significant...”.

Page 12, lines 414 to 424: these lines repeat text that was mentioned on lines 262 to 270.

However, they are inconsistent with the previous text. Please get the numbers straightened out.

The numbers in 414-424 are corrected values of the original measurements (262-271), this was

indicated in Line 271. Nevertheless, the sentence in 415 has been modified to: “derived from the corrected original measurements as described by...”.

Page 13. Line 446 you mentioned ‘limited to only one vertical direction’. Please change this text. I think you mean ‘limited only to the vertical direction’.

Thanks, done.

Page 13, figure: there is a red line at roughly 600 m. This line should not cross the color bar.
This is the tracking version of the manuscript. The figure in P.13 was deleted, that’s why the red line was there to mark its removal. The new figure was displayed in the next page.

Page 18. Please mention that the timing of the surface fluxes is incorrect. In other words, there is a temporal offset in the surface flux relative to the observations.

We assume this was referring to the surface heat fluxes. We have modified the corresponding sentence to: “Between 09:00 and 14:00 UTC, the modeled sensible and latent heat fluxes follow the measured trends though with a clear temporal offset, leading to an overestimate...”.

Line 561: you mention supersaturation in an updraft at cloud base. However, supersaturation is based on the Abdu-Razzak and Ghan parameterization so this is not necessarily cloud base supersaturation.

“at cloud base” has been removed.

Page 21, line 573: you mention that the drop concentration reaches 1750 per cc, however figure 7e shows a much smaller concentration of drops.

Thank you! It has been modified to “above 1200” as shown in the figure.

Page 21, line 574 you mention that this high drop concentration is most likely due to the continuous activation of aerosol into cloud droplets. However, you do not discuss the fact that such high drop concentrations would suppress the supersaturation and therefore significantly limit further activation, unless there are significant vertical accelerations. I’m concerned about whether these calculations are correct. Are aerosol particles removed locally from the population once they have been activated? Are they returned after a drop evaporates?

The model does track aerosol population in and out of condensed waters and thus transfers it between the two states accordingly when activation or evaporation occurs. This sentence mostly repeats the previous one. Also, the numbers cited here are domain averaged values. For the first 2 hours of the cloud formation, the explanation is apparently not complete. Therefore, it has been removed.

Page 21 line 585 you discuss the influence of drop concentration on longwave cooling in figure 7h. Please make it clear that the sensitivity only occurs at low liquid water path, and please quote the relevant literature.

The sentence has been modified to: “For LLSCs at this stage with many low LWP blocks, the more numerous the cloud droplets are the stronger the cooling is (e.g., Petters et al., 2012), ...”.

Line 595: what do you mean by ‘proper’ temperature and humidity conditions?

It has been changed to “...needs stable ground temperature and moisture supply”.

Page 22, line 600 what do you mean by ‘settled’?

Removed.

Page 23 line 624 please correct the units to watts per meter squared.

Done.

Line 642. Please remove the word ‘intense’. This is hyperbole. Or alternatively please quantify the surface heating.

Done.

Page 24 line 666, same comment: please remove the word ‘drastically’.

Done.

Page 24, lines 683 the word ‘apparently’ is not clear. Do they or don’t they?

Removed.

Page 27 line 772: you mentioned ‘massive formation of drizzles’ what does massive formation of drizzles mean? Please remove the word massive and quantify as necessary. Perhaps you mean ‘significant drizzle’? Quantification puts things in perspective.

Changed to “significant drizzle”.

Line 776 again I believe you should quote Bretherton et al., 2007.

Added “Consistent with certain previous findings (e.g., Bretherton et al., 2007), in a ...”.

Line 779. You discuss total sedimentation amount. Does your model simulate cloud droplet sedimentation? Most bulk models do not. This is really important because if you are discussing this mechanism of cloud droplet sedimentation, then it is important that you connect the process to the physics in your model.

We have modified “total sedimentation” to “total drizzle sedimentation”, also, we have made it more clearly in the model description (2.3) that the KHKO scheme differentiates cloud droplets from drizzle drops using 25 micron radius as the boundary, the sedimentation of the latter is calculated.

Page 39, 831 please change the word ‘timely’ to ‘temporally’.

Done.

Line 832. Please change the word promotional to proportional.

Done.

Line 840 to 845: please give some insight as to why. Can you advance knowledge?

The sentence has been modified to: “The situation of cloud fraction (CF) is somewhat more complicated. As shown in Table 3 and Fig. A3, CF relation with CDNC varies in different stages. An inverse relation between CF and CDNC generally stands in the earlier and later period of the convection stage. This is primarily due to the faster evaporation of clouds with higher CDNC driven by entrainment in the former period (note the controlling role of CF in determining the

surface incoming solar radiation and thus turbulence in this stage), or by strong convection in the latter. In the middle of the convection stage (13:00-15:00 UTC), the above relation, however, would reverse or become insignificant, owing to a weaker turbulent mixing in polluted cases since the cloud reflectivity becomes the dominant factor in controlling the surface incoming solar radiation as discussed previously. Therefore, an analysis throughout the entire LLSC life cycle is very important to understand the response of CF alongside LWP to aerosol variation. Note that the atmospheric heating caused by absorbing black carbon aerosol is already included in this series of sensitivity simulations, though its impacts on the above result will be discussed later based on another set of sensitivity runs.”

Page 31 line 849. The text reads ‘when dynamical situation is more complicated to maintain a constant liquid water content’. I do not understand what you mean by this and I suspect many readers will not understand either.

Removed.

Line 855. The text reads ‘Our study weights in both size, distribution and chemical composition’. This text is not understandable to me.

It has been modified to: “Our sensitivity simulations utilize different aerosol profiles that reflect the variations in both aerosol concentration and chemical composition based on observations, ...”.

Page 32. The caption for figure 12 has undefined acronyms AODON and AODOFF these are not defined. I suspect these are typographical errors.

Done.

Figure 12 is described in the text on Pg 30 as a comparison between the three different cases: polluted, clean, REFF. So why have you included the ADEON and ADEOFF cases in this figure?

If you want the reader to refer to REFF, polluted, clean including the aerosol coupling (ADEON), then you should provide a separate figure. And you seem to hardly compare the others. I got so confused that I gave up.

Indeed, the figure was used in both 4.2 and 4.3 (now 4.1 and 4.2), partly for the purpose to reduce the number of figures. We have added “Fig. 12, ref. ADEON curves” in the discussions in 4.2 (now 4.1). The discussions comparing ADEON and ADEOFF are in new 4.3, e.g., Line 914-918, among other places.