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Reply on RC1

Goutam Choudhury and Matthias Tesche

Author comment on "Estimating cloud condensation nuclei concentrations from CALIPSO lidar measurements" by Goutam Choudhury and Matthias Tesche, Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2021-358-AC1>, 2021

We thank Dr Aristeidis Georgoulis for his time and effort in reviewing our manuscript. We found his comments to be very helpful in enhancing the quality of our article. Following are our point-by-point replies to his comments. Referee comments are given in black, our answers are given in blue.

- Page 1 / line 8: As a general comment, try to keep either present or past tense (but not both) in the text. For example, rephrase "...We have studied the sensitivity of the thus derived CCN concentration to the effect of variations of the initial size distributions..." to "...the sensitivity of the derived CCN concentrations to variations of the initial size distributions is also examined...".

Thank you for pointing this out. We have modified the sentence in the updated manuscript.

- Page 1 / line 10: Similarly, rephrase "... We have also compared our results with the POLIPHON and found comparable results for extinction coefficients larger than 0.05 km⁻¹..." to "...Our results are comparable to results obtained using the POLIPHON method for extinction coefficients larger than 0.05 km⁻¹...".

Thank you for your suggestion. We have modified the sentence in the revised manuscript.

- Page 1 / line 19: The IPCC reference should be corrected in the reference list. You may find here (https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Citation.pdf) the proper way of citing the freshly released IPCC report.

Thank you for pointing this out. We have modified the citation in the revised paper.

Comments 4-6:

- Page 2 / line 37: "Lidar sensors provide" instead of "lidar provides". Also, give a definition some lines before when the lidar word appears for the first time.

Thank you for the suggestion. We have changed the statement from "*lidar provides...*" to "*lidar measurements provide...*". The AMT readership is familiar with the acronym lidar. At least, it or its cousin radar are rarely introduced in AMT publications.

- Page 2 / line 46: "a global" instead of "global".

Changed to "*global 3D CCN and INP data sets*".

- Page 3 / line 75: "for altitudes between" instead of "in between altitudes".

Changed.

- Page 3 / line 79: Give a reference for GMAO.

We have added the reference for the GOES-5 model currently used in GMAO as follows:

"Molod, A., Takacs, L., Suarez, M., and Bacmeister, J.: Development of the GEOS-5 atmospheric general circulation model: evolution from MERRA to MERRA2, *Geosci. Model Dev.*, 8, 1339–1356, <https://doi.org/10.5194/gmd-8-1339-2015>, 2015."

- Page 3 /line 93: Please clarify the following sentence: "...Since the changes in lidar ratio from version 2 to version 4 are minor ($\leq 1\%$) for all aerosol types except for clean continental (51%), we believe the aerosol models can still be used in our algorithm. However, for the case of clean continental aerosol subtype, further study is required to estimate the effect of change in lidar ratio on its microphysical properties. Having said that, we do not exclude it from our analysis for the completeness of our algorithm, leaving a scope of future validation study to examine its applicability in estimating the CCN concentrations from CALIPSO..."

It is not very clear what you want to stress here. Maybe some information is missing.

We understand the confusion and are sorry for not having been more clear. The lidar ratio used in the initial versions of the CALIPSO retrieval were provided in the CALIPSO aerosol model. However, the lidar ratios in the current version of the CALIPSO retrieval have been adjusted based on the findings from measurement campaigns. For some aerosol types, these values are no longer connected to the CALIPSO aerosol model. We wanted to emphasize that the changes in the lidar ratios used in the version 4 CALIPSO retrieval are mostly minor compared to earlier used values. We hence conclude that the aerosol microphysical properties from the CALIPSO aerosol model can still be used in our algorithm. To convey the same, we have added the following sentence (line 102-104) to the revised manuscript:

"*Note that the lidar ratios used in version 4 of the CALIPSO retrieval have been adjusted from earlier versions based on the findings from atmospheric measurements (Kim et al., 2018) and don't necessarily connect to the CALIPSO aerosol model.*"

- The methodology is well explained. The same stands for the sensitivity analysis.

Thank you very much for the positive feedback.

- Page 10 / line 299: "The ratio between the CCN concentrations estimated using POLIPHON (CCN_{POLI}) and OMCAM (CCN_{OMCAM}) algorithms for varying extinction coefficients at a supersaturation of 0.15% is shown in Figure 5.". The values compared here are not from G20 but were calculated on an aerosol-type basis from the authors on their own. If I am correct, then the values appearing in Fig. 5 are not RH corrected (RH=0). Please clarify this in the revised manuscript if this is the case.

Thank you for pointing this out. We have modified the sentence in the updated manuscript as follows.

*"The ratio between the CCN concentrations estimated using POLIPHON (CCN_{POLI}) and OMCAM (CCN_{OMCAM}) algorithms for varying extinction coefficients at a supersaturation of 0.15% and **zero relative humidity** is shown in Figure 5."*

- Page 10 / line 310: "This may be either because of different instruments or sample size considered to derive the size distributions used in both the algorithms..." should be rephrased to "This may be due to the different approaches followed and sample size considered to derive the size distributions used in the two algorithms."

Thank you for the suggestion. We have rephrased the statement in the revised manuscript.

- Page 11 / line 316: Please stress that we cannot still say which algorithm performs better. This is why there should be a detailed evaluation of both the algorithms in the future. Is there any advantage/disadvantage that would make any of those two algorithms preferable (e.g. one being faster / or more detailed by means of physics compared to the other, allow direct correction for RH, etc.)? It would be nice to add a couple of lines here.

Thank you for pointing this out. We have already stressed the need for a detailed evaluation of both algorithms (POLIPHON and OMCAM) at the end of Section 4.3. We have also added the following sentences to the updated manuscript to weigh the theoretical advantages and disadvantages of both the algorithms at the end of Section 4.2:

When it comes to ease of application, the POLIPHON method with its simple extinction-to-CCN conversion is more straightforward while the OMCAM algorithm – at present stage – is more complex and computationally expensive. Despite of the complexities, OMCAM incorporates a hygroscopicity correction methodology which is essential for a CALIPSO-based CCN retrieval (Georgoulias et al., 2020). Furthermore, the computation time in the OMCAM algorithm can be drastically reduced by either (i) parameterizing the output CCN concentrations in terms of the type-specific extinction coefficient and RH values or (ii) creating a look-up table of CCN concentrations at different extinction coefficient and RH values for different aerosol subtypes. However, such developments are not within the scope of the present work which focuses on the theoretical description of the OMCAM

algorithm.

- Page 12 / line 365: Replace "such huge difference" with "the large discrepancy".

Thank you for your suggestion. We have modified it accordingly.

- Page 12 / line 379: I suggest removing POLIPHON from the phrase "...Utilizing the aerosol type-specific CCN parameterizations from the POLIPHON method (Mamouri and Ansmann, 2016)...". You may write "Utilizing the aerosol type-specific CCN parameterizations from Mamouri and Ansmann (2016)...".

Thank you for pointing it out. We have modified it in the revised manuscript.

- Page 13 / line 411: You may rephrase "...We have described a novel methodology to retrieve cloud relevant CCN concentrations from CALIPSO measurements illustrating the potential of CALIPSO..." to 'Following the first CALIPSO CCN retrievals from Georgoulas et al. (2020) with the POLIPHON algorithm, in this work we suggest a novel methodology to retrieve cloud relevant CCN concentrations from CALIPSO measurements further illustrating the potential of CALIPSO...'

Thank you for your suggestion. However, we believe that the concluding paragraph of our manuscript should focus only on the present and future aspects of our work. Nevertheless, we have added the following sentence in the Introduction section of our manuscript (lines 51-54) to highlight the first CALIPSO CCN retrieval from Georgoulas et al. (2020).

"Georgoulas et al. (2020) for the first time estimated CCN concentrations from CALIPSO measurements by using the POLIPHON technique and found good agreement with the coincident airborne in-situ measurements taken during the ACEMED-EUFAR (evaluation of CALIPSO's aerosol classification scheme over Eastern Mediterranean) campaign (Tsekeri et al., 2017)."