Review of “Microphysical and thermodynamic phase analyses of Arctic low-level clouds measured above the sea ice and the open ocean in spring and summer”, by Manuel Moser, Christiane Voigt, Tina Jurkat-Witschas, Valerian Hahn, Guillaume Mioche, Olivier Jourdan, Régis Dupuy, Christophe Gourbeyre, Alfons Schwarzenboeck, Johannes Lucke, Yvonne Boose, Mario Mech, Stephan Borrmann, André Ehrlich, Andreas Herber, Christof Lüpkes, and Manfred Wendisch, acp-2023-44.

Response to reviewer 1

Dear reviewer,
We are very grateful for your valuable feedback and suggestions which helped us to improve the manuscript. The manuscript has been thoroughly revised and point-by-point responses have been prepared. Please find below our replies, highlighted in blue, along with your suggestions. The revised manuscript is also provided with tracked-changes for clarity.

<u>General comments:</u>

Line 159. “filtering”. Change to “identification and removal of shattered particle artifacts”

Has been changed. Additionally, we have added the new reference for SODA2.

191-192. The Brown and Francis (1995) m(D) relationship has been shown to underestimate ice water content. (https://doi.org/10.1175/2010JAS3507.1, 10.1175/JAMC-D-22-0057.1). Could you possibly use a second m(D) relationship as well that would be more accurate?

Thank you for the advice, we agree, the BF method is no longer up to date. Therefore, for the calculation of the CWC, we now use your suggested values (a = 0.00528 and b = 2.1). A direct comparison of the calculated CWCs shows that the new CWC is slightly higher than the old one:

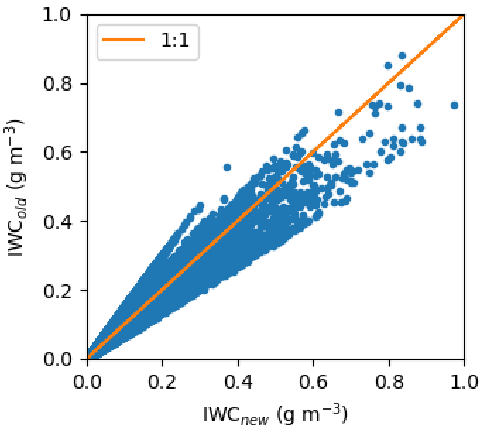

Figure 1. Correlation of IWC calculated with mass dimension parameters given by Brown and Francis (1995) vs. new suggested IWC calculation.

We have adjusted all CWC-values in the manuscript and clarified which parameters for the mass-dimension relationship are used. Note that the definition of a cloud segment in Section 3.1 changes as it is defined by a CWC threshold. This changes for example the values in Table 3 minimally.

In Figures 4 and 5, it might be good to put on the right side of each panel the approximate mean temperature with altitude.

We have added the median temperature including the 25th and 75th percentile in Fig. 4 and 5.

Figure 4. I'd separate liquid and ice water contents.

Figure 4 is used to give a quick overview of the measured data, but for absolute values Table 3 and Fig. 5 are more suitable. We appreciate your suggestion to split the microphysics between ice and liquid water, so we have added additional rows in Table 3 in the manuscript that presents the values for liquid particles (assuming particles < 50 µm) and ice particles (assuming particles > 50µm). Corresponding plots following Figure 5 are given here:

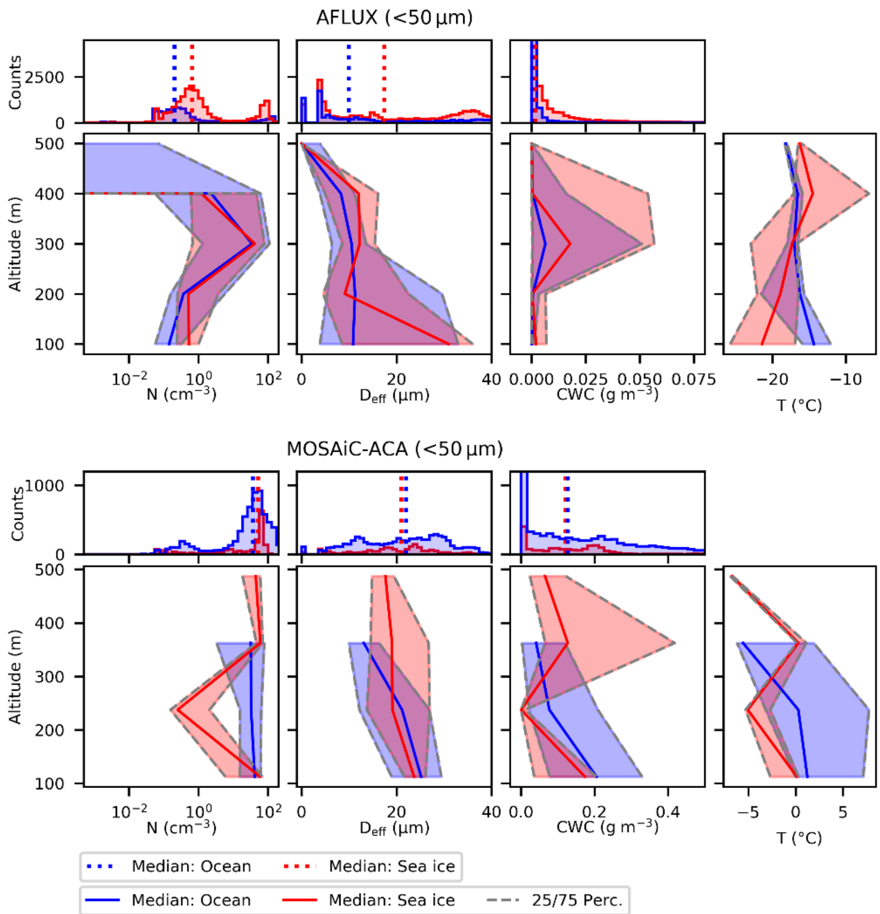

Figure 2. Similar Figure as presented in Fig. 5 in the manuscript, but calculated for particles <50µm only (assumed as liquid droplets).

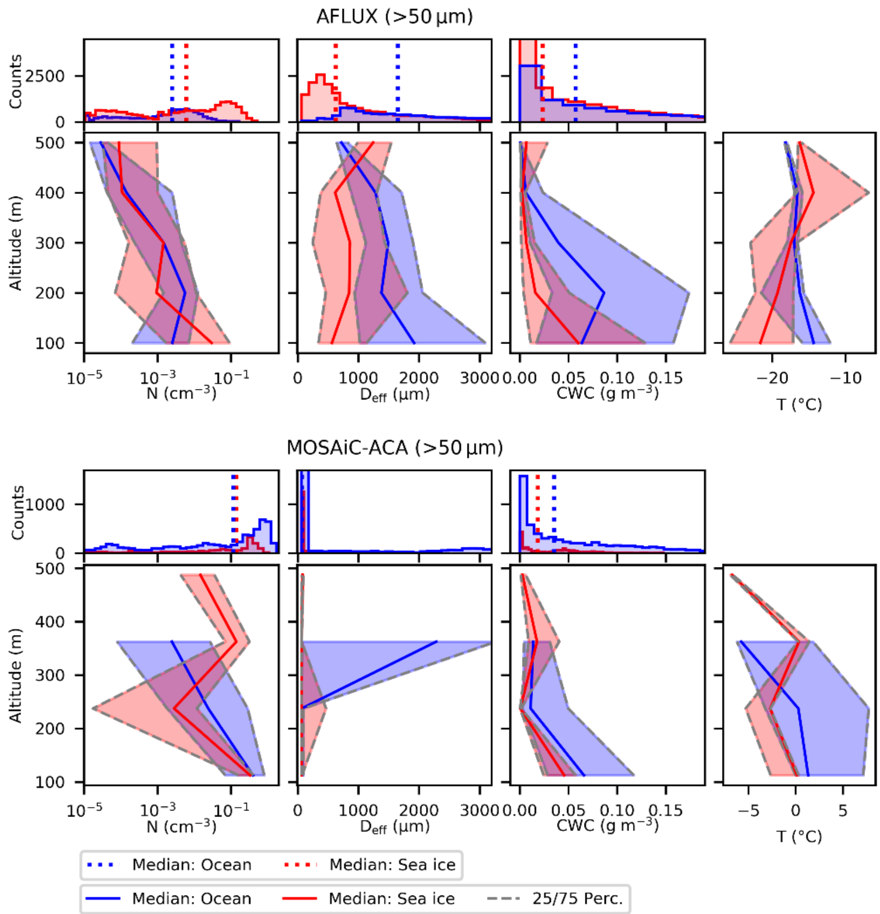

Figure 3. Similar Figure as presented in Fig. 5 in the manuscript, but calculated for particles >50µm only (assumed as ice particles).

In Chapter 3.2 we show how to separate cloud data into liquid, mixed phase and ice regimes. For the respective regimes, we created plots according to Fig. 5 including Tables with their respective microphysical properties and attached them to Appendix in the manuscript (requested by reviewer 2).

Table 3. Separate ice and liquid water contents.

Please see the answer to previous comment.

It might be helpful to modelers to have the PSD parameterized, as a gamma function. Also, show plots of the maximum measured particle diameter for each regime. Is the maximum diameter of the largest probe able to get the actual largest particles? Figure 7 with the PSD suggest that there are larger particles present but not measured.

We much appreciate the idea of adding gamma fits to the particle size distribution to enable analyses with other methods in the future. However fitting gamma distributions over the whole size range is challenging due to the multimodal shape. Therefore, the parameters for the gamma functions are given for the respective size range of each instrument. We have added the gamma functions in Fig. 7 including a Table in Appendix B1 showing the values of the fitted parameters.
We are aware that there may be particles larger than the upper size limit of the PIP in the cloud regimes 1b, 2a, 2b,2c. However, we cover a particle size distribution with values distributed over

more than 13 orders of magnitude. The influence of large particles, which exceed the size range of detection, is negligible in the calculated microphysical properties due to their very low number concentration.
We have added an explanation and the equation of the gamma fit in the manuscript.

246: is the air polluted or do you mean that there are fewer aerosols?

During cold air outbreaks in the Fram Strait airmasses from the central Arctic get transported to lower latitudes. These airmasses are typically exposed to fewer aerosol particles.
We have changed the sentence to: "In spring, cold air outbreaks with strong winds from the central Arctic bring dry air with a low aerosol load."

265: a stronger temperature inversion

Adapted.

Figure 6. This figure would be more interesting if you had two panels with separate panels for CDP and CIP+PIP data.

We have added a Figure in the Appendix similar to Fig. 6 but showing the D_{eff} and N calculated for CDP/CAS, CIP and PIP respectively. Additionally, we show how the previous defined regimes are measured by the individual probes and calculate the proportion of the detected values compared to the combined values in Fig. 6.

366. Right after Arctic. I strongly suggest having a figure with a schematic (pictorial) of the primary findings that would be simple to grasp.

We implemented this idea and added a schematic Figure summarizing the primary findings of this work in Section 4.

232: How is D_{eff} calculated? Does it include both liquid drops and ice particles?

Here the D_{eff} calculation includes both, droplets and ice particles. Now that we distinguish between ice and water in the manuscript and in Table 3, the calculation of D_{eff} is more clear.

Minor Points

Table 2 Year should be 2020, shouldn't it.

This typo was corrected in the manuscript.

231: "to" to "with

Adapted.