First of all, we appreciate the editor's comments and suggestions. In response to them, we have made relevant revisions to the manuscript. Listed below are our answers and the changes made to the manuscript according to those comments and suggestions. Each comment of the editor (black) below is followed by our response (blue).

Dear authors,

Thank you for revising your manuscript according to the referee's comments and for thoroughly responding to their various concerns. I recognize that this required significant effort on your part, and I am pleased to note that the manuscript is now much improved. Adding and discussing observations in comparison to your modeling results was particularly important.

Both referees have provided additional comments based on your responses, and I would ask you to review these and further revise your manuscript accordingly. In particular, I would like to emphasize two specific points from these comments:

- Representation of the mixed phase in the model compared to the observation: Your assumptions do not seem to align with current literature based on observations. This should, at a minimum, be acknowledged and discussed in the manuscript.

A discussion, which is about the assumption adopted by the model used here for the mixing of droplets and ice crystals, is given in Section 4.4 in the revised manuscript:

- Relationship between IWC/LWC and ICNC/CDNC: This is a significant highlight of your paper, yet it is not clearly represented in any figures. As suggested by the referee, a visual representation of the relationship (e.g., one ratio as a function of the other) could be very useful.

We believe that Table 4 shows the relation between ICNC/CDNC and IWC/LWC well. Hence, based on Table 4, Figure 11 with ICNC/CDNC for x-axis and IWC/LWC for y-axis is added.

Additionally, I would like to provide a few more comments:

- The title of the manuscript is becoming too long and should be made more concise for better impact and readability. Please refer to our Guidelines for Authors (https://www.atmospheric-chemistry-and-physics.net/policies/guidelines_for_authors.html).

The title is changed in a way that the title is shorter yet more succinct, following this comment and a comment by one of the reviewers. In the new title, we put the emphasis on the fact that this study examines the role of a microphysical factor, which is ICNC/CDNC, in the development of mixed-phase stratocumulus clouds and their interactions with aerosols.

Similarly, your conclusion has also increased in length, and I suggest adapting it to provide a more concise summary for the readers. Again, please refer to the guidelines. This could for instance be achieved by moving some content to your "discussion" section, which is comparatively shorter than the conclusion.

Some text in “Summary and Conclusion” in the old manuscript is moved to “Discussion”. For this, Section 4.3 is created. See text for details.

- The "data availability" section should include a statement about where the data you used can be accessed (https://www.atmospheric-chemistry-and-physics.net/policies/data_policy.html). You mention that the data processed on your private computer system is private, but you have also utilized publicly available data. An access statement for this original data should be provided, particularly for CloudNet, and perhaps for the reanalysis and CCN data (if it is not based on publicly available data, please state so in that section).

The corresponding section is revised as follows:

(LL1015-1023 on p34)

Our private computer system stores private data such as the model code and output, and the CCN data. Upon approval from funding sources, the data will be opened to the public. Projects related to this paper have not been finished, thus, the sources prevent the data from being open to the public currently. However, if information on the data is needed, contact the corresponding author Seoung Soo Lee (slee1247@umd.edu).

The Cloudnet and reanalysis data used in this study are publicly available. The Cloudnet data are obtainable at “https://cloudnet.fmi.fi/search/data”, while the reanalysis data can be obtained by contacting Met Office via “https://www.metoffice.gov.uk/about-us/contact”

- As mentioned earlier, comparisons to observations are a crucial aspect of your work. However, I still find that insufficient details are provided regarding these observations. For example,

how many CloudNet stations are available in your simulated region,

There is only one station in the simulated region. This is indicated as follows:

(LL244-246 on p9)

These clouds are observed by a ground station which is a part of the Cloudnet observation network and marked by a dot in Figure 1.

and where are they located (this could be useful to include in Fig 1)?

The location of the station is indicated in Figure 1.

What is the spatial resolution of the retrievals? Are they continuously available accross your simulation or are there discontinuities?

For the retrieval of IWC and IWP, the spatial resolution of ~ 10 m in the vertical direction is used. The CloudNet data, including IWC and IWP data, are provided in a continuous way with a time resolution of 30 seconds. To indicate this, the following is added:

(LL253-256 on p9)

The retrieval of IWC is performed by using radar reflectivity and lidar backscatter in the Cloudnet observation with a spatial resolution of ~10 m in the vertical direction and a temporal resolution of 30 seconds as described in Donovan et al. (2001), Donovan and Lammeren (2001), Donovan (2003) and Tinel et al. (2005).

(LL262-264 on p9)

The Cloudnet observation data including these IWC, LWC, IWP and LWP data are provided to the public with a temporal resolution of 30 seconds in a continuous manner.

For Fig. 5 and related discussions, have you compared domain-averaged model outputs with the observations from the one or few station(s), or have you co-located the simulations with the observations?

As described in the figure caption, the simulated cloud-top height is averaged over grid points with cloud tops, and cloud-bottom height is averaged over grid points with cloud bottoms in the domain at each time step. As also described in figure caption, the simulated IWP and LWP are averaged over grid points with non-zero IWP and LWP, respectively, in the domain at each time step. These simulated and averaged variables are compared to the counterparts from one Cloudnet station in the domain.

To indicate that observations from one station are used in Figure 5, the following is added in the caption for Figure 5:

Observed and retrieved values are from the ground station as marked in Figure 1.

Additionally, have CloudNet data been used / evaluated before for mixed-phase clouds, Yes, Cloudnet data have been used to evaluate the simulated clouds including mixed-phase clouds as exemplified by studies such as Illingworth et al. (2007) and Hansen et al. (2018). To indicate this, the following is added:

(LL389-391 on p13)

This study adopts the Cloudnet observation, which has been used to assess cloud simulations as in Illingworth et al. (2007) and Hansen et al. (2018), to evaluate the 200_2 run.

Hansen, A., Ament, F., Grutzun, V., and Lammert, A.: Model evaluation by a cloud classification based on multi-sensor observations, Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2018-259, 2018.

Illingworth, A. J., Hogan, R. J., O'Connor, E. J., et al.: Cloudnet - continuous evaluation of cloud profiles in seven operational models using ground-based observations, Bull. Am. Meteorol. Soc., 88, 883-898, 2007.

and do they provide simultaneous ice and liquid cloud properties in a single vertical pixel or only one at a time?

As mentioned in text, LWC and LWP are measured by radiometer, while IWC and IWP are retrieved based on the measurement by radar and lidar. Radiometer measures LWC with a time resolution of 30 seconds and a spatial resolution of ~50 m in the vertical direction, while the IWC retrieval is performed with a time resolution of 30 seconds and a spatial resolution of ~10 m in the vertical direction. Here, in the Cloudnet data, the IWC-retrieval resolution is used as a master grid on to which LWC dataset are interpolated for comparisons between IWC and LWC at a specific spatial location.

Due to the use of the identical temporal resolution, ice and liquid cloud properties are considered provided simultaneously. However, due to the use of the higher spatial resolution for ice cloud properties than for liquid cloud properties, ice cloud properties are provided in more vertical pixels than liquid cloud properties, and in general, there is inconsistency between the location of pixels where ice properties are retrieved and that where liquid properties are measured before the interpolation is performed. However, since high resolutions finer than 100 m are used for both the measurement of liquid properties and the retrieval of ice properties, we believe that the discrepancy in the location between ice and liquid properties is minimal.

To deliver points here, the related text is revised as follows:

(LL251-264 on p9)

In the Cloudnet observation, particularly, LWC is measured by radiometer with a spatial resolution of ~50 m in the vertical direction and a temporal resolution of 30 seconds. The retrieval of IWC is performed by using radar reflectivity and lidar backscatter in the Cloudnet observation with a spatial resolution of ~10 m in the vertical direction and a temporal resolution of 30 seconds as described in Donovan et al. (2001), Donovan and Lammeren (2001), Donovan (2003) and Tinel et al. (2005). In the retrieval, the lidar signal and radar reflectivity profiles are combined and inverted using a combined lidar/radar equation as a function of the light extinction coefficient and radar reflectivity. The combined equation is detailed in Donovan and Lammeren (2001). In the Cloudnet data, LWC data with the coarser spatial resolution than IWC data are interpolated to observation locations of IWC data, and IWP and LWP data are obtained from these IWC and interpolated LWC data, respectively. The Cloudnet observation data including these IWC, LWC, IWP and LWP data are provided to the public with a temporal resolution of 30 seconds in a continuous manner. This study utilizes these publicized Cloudnet data.

All these aspects should be further described and discussed to enhance the relevance of the model-observation comparisons.

Overall, both referees have suggested that minor revisions are needed. Considering that I am also providing my own list of comments in addition, I will request reconsideration of the manuscript after (moderate) major revisions. Please note that these revisions are primarily aimed at further clarifying your manuscript.

Kind regards,
Odran Sourdeval

First of all, we appreciate the reviewer’s comments and suggestions. In response to them, we have made relevant revisions to the manuscript. Listed below are our answers and the changes made to the manuscript according to those comments and suggestions. Each comment of the reviewer (black) below is followed by our response (blue).

I thank the authors for the changes they made to the manuscript, which improved the article, especially in the presentation of the results. As mentioned in my previous review, I think the paper is suitable for publication in ACP. However, I have minor comments that I would like the authors to address before the article is published.

I am still concerned about the representation of the mixed phase in the model compared to the observation. I do not understand what the authors mean by ice and liquid pockets in the sentence: “pockets of ice particles and those of liquid particles are mixed together”. What is the size of the pockets considered? Usually, in models, ice and liquid hydrometeors are homogeneously mixed in mixed phase clouds. My problem is that this is not what observations show, as in Coopman and Tan (2023), Tan and Storelvmo (2016), Korolev and Milbrandt (2022), D'Alessandro et al. (2021), D'Alessandro et al. (2023), Schima et al. (2022). The different representation of homogeneously mixed hydrometeors or the presence of pockets has an impact on the microphysical processes (e.g., WBF...). Therefore, it should be highlighted in the article that the representation of mixed-phase clouds considered in the model of the study has hypotheses that do not agree with observations (the study that the authors refer to Lee et al. (2021) is also from models).

Coopman, Q., & Tan, I. (2023). Characterization of the Spatial Distribution of the Thermodynamic Phase Within Mixed-Phase Clouds Using Satellite Observations. Geophysical Research Letters, 50(24), e2023GL104977.

Korolev, A., & Milbrandt, J. (2022). How are mixed-phase clouds mixed?. Geophysical Research Letters, 49(18), e2022GL099578.

D'Alessandro, J. J., McFarquhar, G. M., Wu, W., Stith, J. L., Jensen, J. B., & Rauber, R. M. (2021). Characterizing the occurrence and spatial heterogeneity of liquid, ice, and mixed phase low-level clouds over the Southern Ocean using in situ observations acquired during SOCRATES. Journal of Geophysical Research: Atmospheres, 126(11), e2020JD034482.

D’Alessandro, J. J., & McFarquhar, G. M. (2023). Impacts of drop clustering and entrainment-mixing on mixed phase shallow cloud properties over the Southern Ocean: Results from SOCRATES. Journal of Geophysical Research: Atmospheres, 128(15), e2023JD038622.

Schima, J., McFarquhar, G., Romatschke, U., Vivekanandan, J., D’Alessandro, J., Haggerty, J., ... & Schnaiter, M. (2022). Characterization of Southern Ocean boundary layer clouds using airborne radar, lidar, and in situ cloud data: Results from SOCRATES. Journal of

Geophysical Research: Atmospheres, 127(21), e2022JD037277.

Tan, I., & Storelvmo, T. (2016). Sensitivity study on the influence of cloud microphysical parameters on mixed-phase cloud thermodynamic phase partitioning in CAM5. Journal of the Atmospheric Sciences, 73(2), 709-728.

To highlight that “the representation of mixed-phase clouds considered in the model of the study has hypotheses that do not agree with observations (the study that the authors refer to Lee et al. (2021) is also from models)”, Section 4.4 is added in the revised manuscript.

Regarding my first specific comment, I suggest that the difference between stratiform and convective clouds be clarified and changed: “When mixed-phase stratiform clouds are associated with convective clouds, they can form even in the tropical region.” to “When mixed-phase clouds are associated with convective clouds, they can form even in the tropical region.”

Done.

I thank the authors for their efforts to remove the brackets, as mentioned in my previous review, but they should be careful that the sentences remain coherent. For example, the three repetitions of "respectively" in lines 122, 123, 124 make reading too difficult.

The text pointe out here is revised as follows:

(LL122-125 on p5)

This is because water vapor deposits on the surface of ice crystals, while it condenses on droplets. As a result, ice crystals act as sources of deposition and droplets act as sources of condensation. Consequently, ice crystals act as sources of IWC (or IWP) and droplets act as sources of LWC (or LWP).

Other text involving awkward repetitions of “respectively” is also revised. See text for this revision.

First of all, we appreciate the reviewer's comments and suggestions. In response to them, we have made relevant revisions to the manuscript. Listed below are our answers and the changes made to the manuscript according to those comments and suggestions. Each comment of the reviewer (black) below is followed by our response (blue).

The second review for the manuscript EGUsphere-2023-862 entitled "Examination of varying mixed-phase stratocumulus clouds in terms of their properties, ice processes and aerosol-cloud interactions between polar and midlatitude cases: An attempt to propose a microphysical factor to explain the variation" written by Lee et al..

The authors have adequately improved the manuscript. I suggest a few minor modifications before publishing.

1. Title: almost all contents of this manuscript are focused on the "polar case", instead of "the midlatitude case", with which was dealt by a previous study of the authors. I suggest the phrase "between polar and midlatitude cases" in the title simply to "a polar cloud case".

The title is changed in a way that it is shorter yet more succinct, following this comment and the editor's comment. In the new title, we put the emphasis on the fact that this study examines the role of a microphysical factor, which is ICNC/CDNC, in the development of mixed-phase stratocumulus clouds and their interactions with aerosols. Although as mentioned by the reviewer here, this study mainly talks about a polar case, its goal is to identify the role of the microphysical factor in the variation of cloud properties and their interactions with aerosols between different mixed-phase clouds at different geographical locations. Hence, we believe that as seen in the new title, not putting "polar" or "polar case" in the title makes it better represent this study.

2. I think that the most important result of this manuscript is the strong relationship between IWC/LWC and ICNC/CDNC, which is shown as a list of numbers in Tables 2, 3 and 5. I strongly suggest adding a figure that shows the relationship (e.g., ICNC/CDNC for x axis and IWC/LWC for y axis).

We believe that Table 4 shows the relation between ICNC/CDNC and IWC/LWC well. Hence, based on Table 4, Figure 11 with ICNC/CDNC for x-axis and IWC/LWC for y-axis is added.

3. L497: We cannot know whether pockets of ice particles and those of liquid particles are "mixed together" or "separated in a specific layer" from Figure 4, which just shows the horizontally averaged vertical mass contents profile of ice particles and liquid particles.

This comment is linked to the other reviewer's first comment which is on the mixing of liquid and ice particles. To respond to this comment and the other reviewer's first comment, a discussion about an assumption of the mixing in the model used in this study is given in Section 4.4 in the revised manuscript.

4. L500–507: “higher”, “more”, “higher”, “more”, “higher”, and “more” than what?

To remove confusion from the use of “higher” and “more”, the corresponding text is revised as follows:

(LL516-526 on p17-18)

Thus, as ICNC/CDNC increases in a situation where qv > qsw, it is likely that the portion of water vapor, which is deposited onto ice crystals, increases. This is by stealing water vapor, which is supposed to be condensed onto droplets, from droplets in an air parcel. Here, qv and qsw represent water-vapor pressure and water-vapor saturation pressure for liquid water or droplets, respectively. As ICNC/CDNC increases in a situation where qsi< qv <qsw, the number of ice crystals, which absorb water vapor, increases per a droplet; here, water vapor absorbed by ice crystals includes that which is produced by droplet evaporation, and qsi represents water-vapor saturation pressure for ice water or ice crystals. Thus, as ICNC/CDNC increases, it is likely that the portion of water vapor, which is deposited onto ice crystals in an air parcel, increases as shown in Lee et al. (2021).

5. L507: I expect not only high ICNC/CDNC but also greater capacitance of ice particles than that of liquid drops can impact the more active growth of ice particles by vapor deposition.

To reflect the reviewer’s point here, the following is added:

(LL526-527 on p18)

This is aided by the higher capacitance of ice crystals than that of droplets (Pruppacher and Klett, 1978).

6. Some paragraphs are too long and contain too many ideas so I suggest splitting them into two or more: for example, L479 and L533.

Long paragraphs are split into two or more paragraphs.