Response to Referee's Comments:

We would like to thank the Editor and the Referee for the time and efforts handling and reviewing our manuscript. The constructive comments and suggestions were very helpful to improve the manuscript.

The Referee's original comments are formatted in black, while our point-by-point responses are formatted in **blue** font. All the corresponding revisions in the revised manuscript are indicated in **red**.

Reviewer #2:

Within the manuscript, the authors retrieve cloud properties from ICON simulations of a deep convective cloud day over central Europe using a satellite forward operator and remote sensing retrieval algorithms. They test the influence of lower and higher concentrations of ice-nucleating particles (INPs) on the liquid-to-ice partitioning in-cloud and at cloud top as well as how different initial thermodynamic states influence the cloud microphysics. The authors convincingly show that microphysical and thermodynamic adjustments to the model setup can be equally important for the simulated cloud microphysics. Overall, the high INP and high convective available potential energy (CAPE) scenarios show the best match with satellite observations from SEVIRI.

The manuscript reads exceptionally well with an easy-to-follow structure. From a methodological side, particular emphasize is given to the use of a satellite forward operator for a more 'apples-to-apples' comparison between the ICON model output and the satellite observations. In remapping the ICON output to the SEVIRI resolution before applying the satellite operator, the authors can disentangle the effects of remapping and of the satellite operator on the simulated cloud microphysics.

I want to emphasize that it has been a great pleasure to read the manuscript, and I recommend it for publication after only very minor revisions. I structured my review into general and specific comments below, before I will give some hints for technical corrections.

We would like to thank the reviewer for the helpful comments and suggestions and for recognizing the contributions made by this work.

General Comments

(1) It looks to me that Figures 6 and 7 are identical and the authors may have accidentally placed the same figure twice into the manuscript? I cannot identify any difference within the two figures. However, based on the text, it sounds like this is an important figure with a very interesting interpretation, so I suggest to double-check Fig. 7 if it indeed shows cloud top.

Unfortunately, we inserted a wrong figure. In the revised manuscript the correct figure has been inserted for Fig. 7, which shows the supercooled liquid mass fraction at the cloud top. The text is correct and describes cloud liquid mass fraction at the cloud top. Sorry for the mistake.

(2) In Figure 3 you compare the spatial distributions of liquid water path, ice water path, and cloud optical thickness for the CTRL case and the CLAAS-2 satellite product. It shows clear discrepancies between the ICON output and the satellite observations in terms of intensity and spatial coverage. The authors state that, as Geiss et al. (2021) reported, the primary source of these deviations stem mainly from model assumptions on subgrid scale clouds. However, as you find a much better match between the model and satellite observations for the high INP case (with SEVIRI_ML), it would be interesting to reproduce Figure 3 for the high INP case and compare it to the satellite observations and see if you find a better match with the LWP/IWP/COT maps.

Thank you very much for your constructive comments. The SEVIRI_ML retrieval software suite is however limited to neural networks for cloud mask, cloud phase, cloud top temperature, cloud top pressure, and cloud base height. A manuscript on the

SEVIRI_ML is under preparing and the code is available on github: https://github.com/danielphilipp/seviri_ml. Thus, the SEVIRI_ML does not provide any LWP/IWP/COT products. Therefore, figures of LWP/IWP/COT can unfortunately not be produced for SEVIRI_ML.

Specific Comments

Line 102: I cannot completely follow the line of argumentation here. With respect to which parameter does the frequency distribution of ice water fraction have a U-shape? Please clarify this.

Using aircraft observations, the ice water fraction of mixed-phase clouds was analyzed in the work by Korolev et al. (2003). They found that the ice water fraction (IWF) has a minimum in the range 0.1 < IWF < 0.9, and two maxima for IWF < 0.1 and IWF > 0.9. Thus, the probability distributions of IWF have a U-shape, with two maxima at the two ends and minimum in the middle, which is shown in Figure 5a in the paper of Korolev et al. (2003). To clarify, we revised the sentence to "……*Aircraft-based observations of mixed-phase clouds properties reveal that the frequency distribution of the ice water fraction has a U-shape with two explicit maxima, one for ice water fraction smaller than 0.1 and the other for ice water fraction larger than 0.9, and the frequency of occurrence of mixed-phase clouds is approximately constant when the ice water fraction is in the range between 0.2 and 0.5*……" in lines 104 to 109 the revised manuscript.

Korolev, A., McFarquhar, G., Field, P. R., Franklin, C., Lawson, P., Wang, Z., Williams, E., Abel, S. J., Axisa, D., Borrmann, S., Crosier, J., Fugal, J., Krämer, M., Lohmann, U., Schlenczek, O., Schnaiter, M., Wendisch, M. (2017). Mixed-phase clouds: Progress and challenges. Meteorological Monographs, 58: 5.1-5.50.

Figure 6: As the color bars are the same for Figs. 6a-d and 6e-h, respectively, I suggest to just show one color bar each and rather have a y-axis title at each individual panel, as right now it is a bit confusing with w (m/s) corresponding to the color bar but not to

the y-axis title for the panels on the right column. In addition, could you explain what you mean with normalized counts in panels 6e to 6h? The normalization is a bit unclear to me.

Color bars have been changed in Figs 6 and 7 in the revised manuscript. Subplots a-d shared a color bar and subplots e-f shared the other color bar. Panels e-f in Figs 6 and 7 were plotted using Python's library *matplotlib.pyplot.hist2d*. In order to better present the data, the normalization method is used to scale scalar data to the [10^0, 10^4] range before mapping to colors using color map. The scaling factor for each subplot is different and depends on the highest count in each subplot. Thus, the counts shown in the plots are not the real numbers of data points but is the "Normalized Counts".

L489: Could you discuss at this point how much higher the cloud is extending above the mixed-phase temperature range and can you somehow diagnose the sedimentation rate in the model to investigate this statement?

The deep convective clouds simulated in this study have reached the homogeneous freezing temperature. As indicated in Figure 1 below, the cloud-top temperature of convective cores at the mature stage is lower than -65 ˚C and is far beyond the mixed-phase temperature range. Therefore, there are sufficient ice crystals formed via the homogeneous freezing process. Vertical velocity close to the cloud top is smaller than within the cloud that sedimentation of large ice crystals and the Wegener-Bergeron-Findeisen process are expected to be more efficient. Unfortunately, the sedimentation rates were not stored for the simulations and cannot be diagnosed in hindsight.

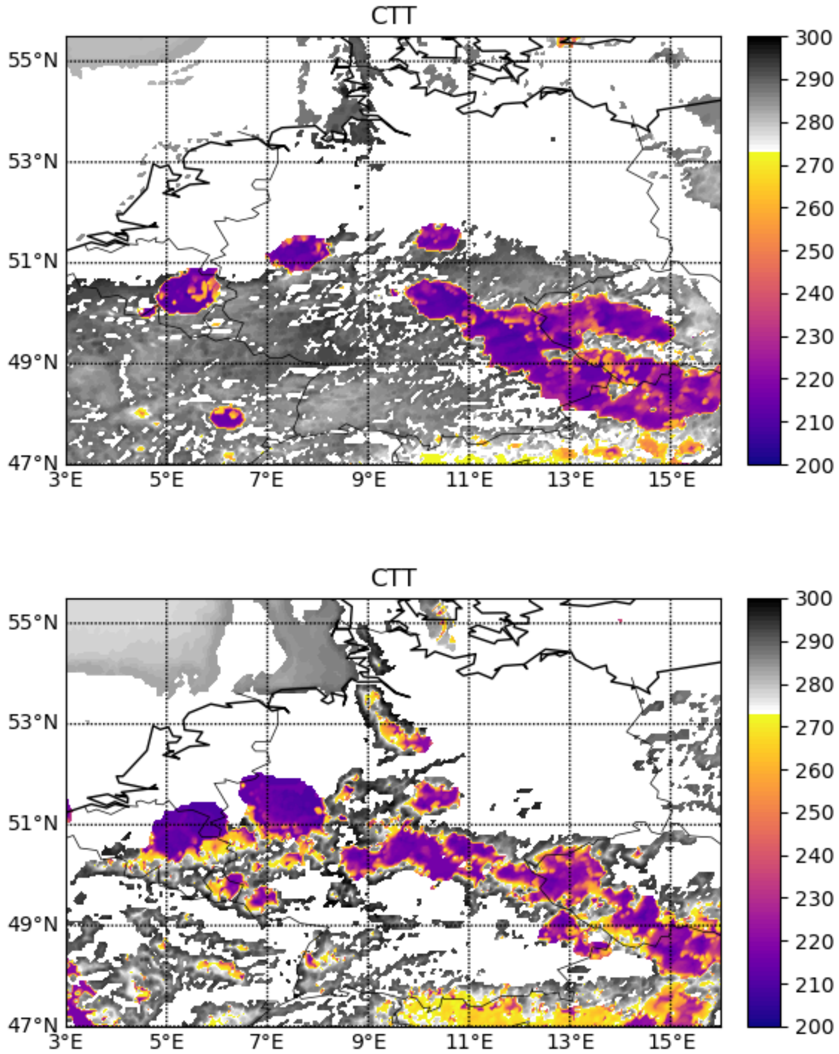

Figure 1 ：Spatial distribution of retrieved cloud-top temperature at 13:00 UTC for the CTRL case (upper) and for the CLAAS-2 product (lower).

L547 and Fig. 8: This is only a suggestion, but as you talk about a temperature shift as compared to Fig. 8c (on the SEVIRI grid), maybe you could move panel e below panel c and move the legend to where panel 8e has been before? Thus, the temperature shift would be immediately clear, and it is a bit easier to compare the shape of the curves.

Fig.8 has been replotted according to your suggestion in the revised manuscript.

Fig. 9: maybe adding a rough estimate where the cloud top height is in these simulations would help to interpret the vertical profiles of vertical velocities.

The cloud top heights are similar in these simulations and a dashed line indicating the cloud top height has been added in Fig 9 in the revised manuscript.

Technical Corrections

L349: cloud water plus cloud ice

Corrected

L434: that is Sect. 3.3, is this the correct reference?

It was a typo and has been changed to section 3.4.

L547: noisier

Corrected

L551: of approximately 1 above -10°C and 0 below approximately -30 °C,

Corrected

L563: as the CAPE increases

Corrected