

Atmos. Chem. Phys. Discuss., referee comment RC1
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Comment on acp-2021-97

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Referee comment on "Ice and mixed-phase cloud statistics on the Antarctic Plateau" by William Cossich et al., Atmos. Chem. Phys. Discuss.,
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Review of ACP-2021-97 "Ice and Mixed-Phase Cloud Statistics on Antarctic Plateau" by Cossich et al.

Based on in-situ measurements, this manuscript documents ice and mixed-phase cloud statistics at the Concordia Station in the Antarctic. Various aspects of cloud statistics are discussed. A comparison with satellite L3 data product is also described.

This is a valuable study. Given the scarcity of in-situ measurements and the need to validate satellite retrievals in the polar regions, such study is also much needed by the observational community. Including far-IR, the portion of spectrum rarely used by other observational studies is another shining point of this study. However, some discussions and depictions in the text are not accurate, which I shall describe below in detail. I recommend acceptance after these issues are addressed.

Major comments:

It is well known that cloud fraction statistics from satellites hinges on multiple factors, such as the size of the field of view, the frequency used in the observation, and the detection method (active vs. passive). Besides, passive remote sensing has significant challenges in distinguishing clouds from snowy or icy surfaces over the polar region. It is good to see the authors attempted to compare REFIR-PAD cloud fraction with satellite L3 products (Figure 10) but to thoroughly and correctly interpret this figure is not trivial at all. The discussions related to Fig. 10 ignore a couple of key points: (1) cloud fraction statistics from satellite L3 products are related to footprint size, and none of the L3 products used here has the same field of view as REFIR-PAD; (2) active sensors usually can give more accurate results than passive sensors in terms of cloud occurrence, but their footprint sizes are so different that no way a real "apple-to-apple" comparison can be made. An enormous amount of effort has to be invested for data subsetting and

collocation in order to make a fair comparison, which cannot be done with the L3 product directly.

Figure 10 is useful and informative, but the interpretation here has to be conservative, with all caveats well described before the discussion. For example, the abstract stated, "A comparison of monthly mean 15 results with cloud occurrences/fractions derived from level 3 satellite products, from passive and active sensors, emphasizes the difficulties of satellite observations in the Antarctic region and highlights the ability of the CIC/REFIR-PAD synergy to identify multiple cloud conditions and studying their variability at different time scales.", which I think is not a fair statement given all the reasons mentioned above.

Other comments:

- Figure 2c, red spectra, I am surprised to see the clear-sky spectrum here has a peak at CO₂ band center ($\sim 667\text{ cm}^{-1}$) as low as 150 K BT. Since this is a surface measurement looking up, the BT at the CO₂ band center should be close to the temperature in the lower troposphere or even in the boundary layer. Thus, it cannot be so low. The cloudy spectra here, as well as the clear-sky spectra in Figure 5, look all reasonable to me. Thus, this 150K BT peak at the CO₂ band center in Figure 2c needs to be examined and explained.
- Line 130: The impact of multiple scattering within liquid clouds on the depolarization ratio can be included as justification for the 15% depolarization threshold.
- Line 154: These classes are not explicitly mentioned in the abstract, please list them there.
- Table 3: Misclassifications are in the hit rate column. Please make it clearer that these are misclassifications through labeling or reformatting the table.
- Figure 7: The caption mentions unclassified spectra, but there does not seem to be any in the figure.
- Line 345: The authors mention that a subset of the long-term data is used for training and testing. Is this different from the training data and testing data mentioned in the preceding text? If so, please state. If not, then please indicate why the algorithm is retrained and reoptimized.