

Comments on Review 2: Please find below our answers to Reviewers 2's comments (answers highlighted in yellow).

Overview Comments:

This is a very comprehensive analysis of ground-based far infrared observations collected over 9 years at Dome Concordia station in the high interior of East Antarctica. Occurrence frequency of clear skies (67%, annual, Fig. 3), ice cloud (30) and mixed phase clouds (3%, just during warmer months) are derived. For the ice and mixed phase clouds with bases above 500 m (to get away from diamond dust, etc.), optical depths, average cloud temperatures, and ice/water particle sizes are derived from the SACR algorithm. I did not see a discussion here of existing Antarctic measurements for comparison. Then a parameterization for the effective dimension of ice particles in terms of ice water content and average cloud temperature is presented and compared with ice cloud parameterizations from other latitudes (Fig. 14). The obvious next step is to test the impact of the cloud particle parameterization in a regional atmospheric model. I have only minor comments on this very comprehensive and well executed analysis.

We deeply thank the Reviewer for the positive comments on our work.

We decided to limit our research to the analysis of the occurrences, cloud properties and the definition of the ice cloud parameterization. The application of the parameterization to regional models will be performed after the assessment of its accuracy against independent measurements (such as satellite data).

We agree with the Reviewer that the discussion on existing Antarctic measurements in the current version of the manuscript is limited. We have discussed previous measurements in recent papers (such as Maestri et al., 2019 [1] and Di Natale et al., 2022 [2]) cited in the text. In the new version of the manuscript, we will add a few sentences reporting the most significant results of the last years.

[1] Maestri, T., Arosio, C., Rizzi, R., Palchetti, L., Bianchini, G., & Del Guasta, M. (2019). *Antarctic ice cloud identification and properties using downwelling spectral radiance from 100 to 1,400 cm⁻¹*. *Journal of Geophysical Research: Atmospheres*, 124, 4761–4781. <https://doi.org/10.1029/2018JD029205>

[2] Di Natale, G., Turner, D. D., Bianchini, G., Del Guasta, M., Palchetti, L., Bracci, A., Baldini, L., Maestri, T., Cossich, W., Martinazzo, M., and Facheris, L.: Consistency test of precipitating ice cloud retrieval properties obtained from the observations of different instruments operating at Dome C (Antarctica), *Atmos. Meas. Tech.*, 15, 7235–7258, <https://doi.org/10.5194/amt-15-7235-2022>, 2022.

Detailed Comments:

Line 33: Better reference for SOCRATES and related campaigns: McFarquhar, G. M., Bretherton, C. S., Marchand, R., Protat, A., DeMott, P. J., Alexander, S. P., et al. (2021). Observations of clouds, aerosols, precipitation, and surface radiation over the Southern Ocean: An overview of CAPRICORN, MARCUS, MICRE, and SOCRATES. *Bulletin of the American Meteorological Society*, 102(4), E894–E928. <https://doi.org/10.1175/BAMS-D-20-0132>

We thank the Reviewer for this suggestion. We will add the recommended reference.

Line 56: A reference to Mesoscale Convective Systems is out of place for this manuscript focused on Antarctica and Dome Concordia in particular.

We thank the Reviewer for this remark. The reference to Weverberg et al. (2013) was included as one example illustrating the general point that model simulations are highly sensitive to the microphysical parameterization and to the ice particle effective dimension. However, we agree that Mesoscale Convective Systems, absent over the Antarctic continent, are contextually out of place here. We therefore accept the suggestion to remove the reference, also because the point is already supported by the remaining examples (Bozzo et al., 2008; Muskatel et al., 2021).

Table 1: Explain the meaning of these performance metrics.

We will add the following explanation at the end of Section 2.2.2, after the metrics are introduced:

“These metrics provide complementary views of the classification performance. The hit rate measures the probability that a spectrum of a given class is correctly classified, but it does not account for false positives. The threat score addresses this by penalizing both false negatives and false positives. The positive predictive value gives the probability that a spectrum classified as a given class actually belongs to it. Finally, the misclassification ratio, defined for each pair of classes, measures the probability that a spectrum of one class is assigned to another, identifying which classes are most often confused.”

Line 300: 5-8K rather than 3K.

We believe that the indication of 3 K is correct. Please look at Table 2 second column (clear sky) and last column (all-sky). We therefore ask the Reviewer to better clarify her/his comment.

Line 332: Need Schnaiter (2026) in the list of references.

We think that the Reviewer refers to Järvinen and Schnaiter (2026), which is reported in the reference list.

Line 333: Arctic.

Thank you, this will be corrected.

Line 378 (and Appendix C): Reference needed for Mutual Information parameter.

We thank the Reviewer for pointing this out. We agree that a reference for the mutual information was missing. In the revised manuscript we will add two references: one for the theoretical concept of mutual information (Cover and Thomas, Elements of Information Theory, 1991 [3]), and one for the method used to estimate it in this work (mutual_info_regression function, scikit-learn library). The text in Appendix C will be updated accordingly.

[3] Cover, T. M. and Thomas, J. A.: Entropy, Relative Entropy and Mutual Information, chap. 2, John Wiley & Sons, Inc., ISBN 0-471-06259-6, 1991

Lines 480-487: These limitations are well taken, especially the need for validation of these remote sensing results by in situ measurements. Xu et al. (2023) provides some guidance on the spatial representativeness.

We thank the Reviewer for the comment and we will account for the Xu et al. paper for future investigations.