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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Classification of Arctic multilayer clouds using radiosoundings and radar data" *by* Maiken Vassel et al.

Anonymous Referee #1

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Review of "Classification of Arctic multilayer clouds using radiosoundings and radar data" by Vessel et al.

Recommendation: Might be acceptable for publication after mandatory revision

This paper analyzes a year of data collected by a radar and radiosoundings at Ny-Alesund and attempts to determine the frequency of occurrence of multi-layer clouds, and in the case of multi-layer clouds whether the cloud layer underneath is seeded by the cloud above. The subject matter is timely because the Arctic is currently warming quicker than other parts of the planet, yet models have a difficult time accurately predicting the amount of warming. Better knowledge of the properties of arctic clouds, and on what controls them, is necessary in order to improve these predictions: any paper that hence contributes to our data base on the phases, heights and geometrical char-

acteristics of clouds is beneficial. The paper is well written and the presented analysis easy to understand.

Nevertheless, I fear that the paper as currently written is quite misleading. There are so many uncertainties and problems with the analysis (which, in their defense, the authors do a good job of identifying) that I fear the results that come out of the paper are not terribly useful. However, I think if the data were presented in an alternate way the study could be of potential use and hence I am recommending major revision rather than rejection.

Step 1 of their analysis uses the radiosonde data to identify the presence of multi-layer clouds. However, even though the probability of detection of the multi-layer clouds is 99% with this method, the false alarm rate of 58% "reveals that about half of the MLC detected by radiosounding is no MLC by radar." Thus, it seems that the paper should be reworded to emphasize that the use of the radiosonde data on its own does not reliably identify the occurrence of MLCs, but can be used in combination with radar data to give information on the presence of MLCs. The authors acknowledge the unreliability of the radiosonde data on their own to identify MLCs as they state "even if the layers above and below are supersaturated with respect to ice, the lack of suitable IN can prevent ice cloud formation." They also stated that "the results obtained by the radiosonde profiles disagree with actual MLC occurrence observed by the radar."

The second major problem with the analysis presented is the reliance on the chosen ice crystal size to calculate which of the upper layers of MLCs is seeding a lower layer. As stated by the authors "varying the initial ice crystal size has a large, non-linear impact on the distribution between seeding and non-seeding subsaturated layers." Further, their calculations substantially underestimate the variance that the size of the seeding ice crystal size might have. In several studies of in-situ measurements of mixed-phase clouds, the ice crystal sizes have been much larger than the 150 micrometer size assumed in the calculations here. Further, the calculations assume a hexagaonal plate which is not representative of the shapes of ice crystals in mixed-phase clouds. For

example, Korolev et al. (1998) found that over 98% of ice crystals in mixed-phase arctic clouds had irregular shapes. Thus, the uncertainties will be much larger than those stated, and the stated uncertainties are already huge. And, the base size of 100 micrometers is probably much smaller than the size of particles that will be emanating from the upper layer.

Another potential problem could be the lack of colocation between the radiosondes (which can drift large distances in the background wind) and the radar, which is again noted by the authors: "horizontal drift of the radiosonde away from the radar and inaccuracies due to time averaging of the radar data can explain contradictions between radiosounding and radar." Was any effort made to consider the advection of air parcels measured by the radiosondes so that the radar data at an appropriate time could be used in the analysis (provided that the air parcel was within the radar view volume at some time)?

MORE DETAILED COMMENTS:

Abstract: At first reading, I was confused that the 9% and 23% of the cases mentioned because it did not add to 100%. Perhaps mention that other cases (of the 8 categories) are included to avoid confusion.

Page 1, Line 24: I find trying to differentiate between the terms multilayered clouds and multilayer clouds (MLC) very confusing! To me, that is the exact same word.

Page 3, line 6: Do you expect any diurnal cycle in the cloud properties that would mean that the derived statistics are not representative of the Arctic as a whole?

Page 3, line 10: I think data is plural, so it should be "data are" rather than "data is"

Page 3, line 28: What statistical test was applied to show that the results did not change significantly?

Page 7, line 9: Why is only the lowermost 100 m considered?

Page 10, line 11: Vali (200x?) has recommended that ice nucleating particles (INPs) rather than ice nuclei (IN) be used in order to standardize terminology. Recommend that you use INP rather than IN.

Page 15, line 1: The cloud layers can slope up and down frequently (in relatively short distances or times) and that can have a big impact on averaging. Was this taken into account?

Page 17, line 3: Perhaps I am not looking in the right place, but I cannot find the supplement being referred to in this statement.

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