

We thank the reviewer for the careful and thoughtful review. Our responses are outlined in bold and italics below.

General Comments:

This paper presents a new technique for retrieving the properties of thin (greybody) Arctic clouds. In general, the paper is well written and well thought out. I would have liked to see more than one case represented as a case study (maybe a campaign or a month?). Having said that, the article is generally in good shape and should be accepted in AMT after some revisions are made (see below).

One intercomparison between retrievals from our method and retrievals from a method developed by Dong and Mace (2003) has been added into the paper. This comparison is for thin clouds (LWP between 20 and 40 g/m²) during periods with sunlight, including the months between May and September. It shows that our retrieved liquid re, N, and optical depth are roughly consistent with those from Dong and Mace (2003).

- Figures 3 and 9 are switched in the manuscript

Fixed

- Why bother with (a)-(g) in section 2.1 and Figure 3? Maybe use color instead in the figure, since (a)-(g) are not really referenced in the text at all.

This was done to be consistent with Mahesh et al. (2001) who identified these as candidate micro-windows where water vapor absorption is particularly small that can be selected from for the purpose of cloud retrievals. This point is now made more clear in the text.

- Should the second microwindow be 860.5 cm⁻¹ or 862.5 cm⁻¹? The text says one thing, while Figure 3 has a different number.

It is 862.5 cm⁻¹.

- What do the dashed and solid lines represent in Figure 6? This doesn't appear to be discussed in either the text or the figure caption.

The color scheme in the figure has been re-drafted and the caption modified for clarity.

- In your discussion of phase in section 2.5 (page 8662, lines 20-21 and page 8663, line 8), is this now the microphysical phase, or the radiative phase? Please clarify. **The reference to mixed-phased clouds was a mistake, and reference to it has been removed.**

- How representative are the measurements from the four flights covered by Garret et al., (2004)? Why not use additional results from campaigns such as ISDAC, ARCPAC, ARCTAS, AMISA and M-PACE?

The value mentioned was derived from an analysis of data from four field campaigns (not flights), which we feel is sufficient. Neither of us were direct participants in any of the more recent field campaigns mentioned, but the lead author (at one time) had ready access to all data from the Hobbs group having been a former student there.

- You state that values for the standard log-normal deviation (sigma) for ice crystals is not necessarily all that different than the liquid value. Is this true even at larger sizes? Or do the liquid and ice hydrometeors generally have comparable size distributions?

This is a valid question. As the reviewer may know, the community's perspective on in situ measurements of ice crystal size distributions is in flux. The best approach in our opinion is to treat ice crystal size distributions as more uncertain, which is what we have done, and propagate errors accordingly.

- Since "cloud base" in a mixed-phase environment can mean several things, please clarify what is meant by "bases" on page 8665, line 11. Is this the bottom of a liquid-containing layer? Or a certain level of extinction? How does snow-fall/precipitation play into this estimate?

The ceilometer does not detect below cloud precipitation that the radar identifies. This distinction has been added.

- What is the impact of assuming multilayer clouds with ice crystals in between are one single cloud layer on your retrievals (page 8665, lines 17-19)?

The text has been elaborated to read

That we have assumed clouds that are microphysically homogeneous in the vertical may mean that additional errors are associated with true clouds. Retrievals based on cloud transmissivity of downwelling atmospheric radiation will tend to be biased by the microphysics at cloud top since this is near where radiative attenuation is a maximum; retrievals based on cloud thermal emission will be biased by properties at cloud base. Because the retrievals here are based on both emission and transmission, derived properties are expected to represent some radiative average of the vertical profile.

- What is your basis for assuming 15% uncertainty in tropospheric water vapor measurements and 5% uncertainty in upper-level temperature profiles?

Are these the upper-level temperature profiles from ERA-40?

Both estimates of uncertainty are very conservative since they do not affect the final retrieval uncertainty a great deal. 15% is greater than the 10% that NOAA advertises, and 5% corresponds with about 15K.

- I don't follow how the 45%/6% and 11%/73% splits of phase determination at 273 and 238 K result in an estimate of 15% in phase misclassification. Please elaborate on how this number was derived.

The number has been changed to “about 10%”. We would hesitate to be more precise.

- The ice number concentrations in Figure 16 seem high to me, though I suppose they’re representing cirrus (and diamond dust?) clouds.

Yes, but the cirrus cloud in the January 13 case study has concentrations more consistent with those measured by aircraft.

We have added a paragraph that reads

When ice clouds are present, they have crystal concentrations that are about two orders of magnitude lower than liquid droplet concentrations, and effective radii that are about four times 25 as large. While we lack any direct point for intercomparison, in-situ aircraft observations of ice crystal concentrations from the Arctic tend to be lower than those we observe (e.g. Jouan et al., 2012). One reason for the discrepancy could be that post-analysis of in-situ ice crystal concentration measurements used an algorithm that removed particles with unusually short inter-arrival times at airborne probes. Assuming this algorithm was appropriately applied, another possibility is that the retrieval method discussed here is in error because it is limited to clouds (not below- cloud precipitation) with effective radii smaller than 50 μm : if ice crystal effective radii are in fact larger than 50 μm , then retrieved ice crystal number concentrations would be erroneously high.

Technical Corrections:

- Page 8655, Line 27: Remove “and extend” from this sentence, since later on in the sentence you state “and is extended here to Arctic ice and liquid clouds”.

Done

- Page 8656, Line 23: Remove “values of”

Done

- Please increase the size of Figure labels.

Done