

Interactive comment on “Ground-based remote sensing of thin clouds in the Arctic” by T. J. Garrett and C. Zhao

Anonymous Referee #1

Received and published: 31 December 2012

This manuscript presents a method to retrieve cloud phase, effective radius, optical thickness, number concentration and water path from ground-based thermal interferometer measurements (combined with a lot of other auxiliary data). The method seems unique and a useful addition to the available techniques. Unfortunately, in my opinion the paper cannot be accepted in its present form and many corrections should be made, as detailed below. Most are minor but there are many and will require major revisions to the manuscript to be addressed.

General comments:

My only major comment is that the retrieval results are not evaluated sufficiently. The authors applied their method to data of probably the best-observed measurements

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site in the Arctic. Only a comparison of the retrieved LWP to MWR data is provided, whereas independent estimates of the other retrieval products are very likely available in the ARM database. In my opinion, this paper needs to provide a more adequately evaluation of the new method before it can be accepted.

My other general comment is that in the way described in the present manuscript the method seems rather complicated and uses a lot of auxiliary data other than interferometer measurements. In my view, this considerably limits the applicability of the method. The necessity of the auxiliary data is not (adequately) mentioned in the abstract, introduction and conclusions. Please list all auxiliary data needed for the method in the introduction, abstract and conclusions to make its limitations clear.

Specific comments:

*Section 2.1:

Page 8657: Line 9: Mie theory is used throughout the paper for both liquid and ice. This is probably fine for the wavelengths considered, but a brief discussion and possibly a relevant reference would be informative.

Line 12: Figures 3 and 9 are swapped. The x-axis in the figure is effective radius, although radius r is used in the text. Please make this consistent. Are the Mie calculations integrated over a size distribution? Please mention this in the text.

Figure 4: Please use the same y-axis scale on all figures for easy comparison.

Figure 5: The caption mentions ‘percent difference’, but the right figure seems to give the fractional difference. Also the caption mentions dashed lines, but it is unclear to me in the left figure which lines correspond to 5 and 10 micron effective radius. In both plots there are ‘5 micron’ labels, and in the right there is a ‘50 micron’ label, but it is unclear where they point to.

*Section 2.2:

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Figure 6: please explain in the text how the boundaries are determined. In the text the quantity χ is given, which is used later in the results discussion. I suggest changing the figure to show this ratio since in the results of the case study also χ values are shown.

The clouds for which the phase cannot be determined are labeled 'uncertain' here. In the rest of the paper, the authors sometimes speak of 'mixed-phase clouds'. Are the clouds labeled 'uncertain' the same as 'mixed-phase clouds'? Please clarify and be consistent throughout the paper.

*Section 2.3:

Equation 3: Where are the required N and ΔZ obtained from? Please clarify in the text.

*Section 2.4:

To me it is unclear why the transmittances in the P and R branches are calculated, but not in the Q branch. Moreover, I would assume it is only necessary to calculate the transmittance in the micro window that is used. This procedure seems to be overly complicated and needs to be clarified.

Figure 8: Please separate the two top "panels" for clarity.

Page 8662, line 2: "Other sources than ozone. . ." Please give examples here.

Page 8662, line 4: This first sentence is incomplete.

*Section 2.5:

Equation 9: Probably the absolute difference is meant here. Please add absolute brackets or such.

Page 8663, line 17: Please change "droplet size distribution" to "particle size distribution"

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*Section 3:

Table 1: Change "ROSE-GOME" to "ERS-GOME"

*Section 3.2:

Page 8666, line 5-7: The Burrows et al. reference is a reference for the GOME instrument, not for the ozone profiles. Please move it forward, just after "ERS-GOME". Is the Lapaoalo et al. reference the correct reference for the GOME dataset used here? Then please add it where the Burrows et al. reference is currently. I also suggest adding the source where this data was obtained from in the acknowledgements.

Line 10: I am surprised that the time resolution mentioned for the GOME retrievals is 6 hours since it is polar orbiting. Is this because the target is in the far North and orbit swaths overlap? Moreover, as far as I know, no retrievals are possible in the local winter, since there is little light (extreme solar zenith angles). The authors do give results for the whole year. Please clarify this.

Page 8666, line 24: For clarity add 'temperature' in front of 'profiles'

Line 26: For clarity I suggest changing "Other trace gases" to "Trace gases other than ozone"

Page 8667, line 1: "Associated uncertainties". Please clarify which uncertainties you refer to (i.e. in which quantities).

*Section 4:

Figure 10: The caption of the figure should be more informative. It was unclear to me what the contours and colors in this figure mean. I guess the labels indicate percent differences as I make up out of the text. Also, the contours seem to end at $\tau=14$ for no apparent reason.

Page 8668, line 4: "Sect. 4" should be "Sect. 3" if I'm correct. Line 27: remove the "and" before "38%"

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*Section 5.1:

Figure 11 and 12: It is unclear what the different contours indicate.

Page 8670, line 3: Please add “additional” before “uncertainties”.

*Section 5.2:

Figure 13: In the caption of this figure it says that only the 14% with differences above 0.1 micron are plotted. This is probably a typo since in the figure itself and in the text this number is 0.01 micron. Please change the last word of the caption (‘circles’) into ‘Symbols’. Please also add to the caption that the symbols indicate PWV. In the legend add hyphens between the range values (e.g., 0.5-1).

*Section 5.3:

As indicated in my major comment above, I think this case study should include some independent data to compare the results with.

Figure 15: I suggest not showing the cloud boundaries on a log scale, but on a linear scale. Also, I suggest using colors to separate ice, liquid and ‘uncertain’ retrievals, since the diamonds and open circles are hard to distinguish.

*Section 5.4:

The results shown in figure 16 appear to be a wonderful, useful dataset. It would be very informative to mention whether the dataset is available or what the future plans are for this dataset.

Figure 16: I suggest using more distinct colors than cyan, blue and black. In the caption there is a bracket missing after “(liquid. . . “. Also the y-axis label for number concentration is confusing in this way and can be interpreted as $\text{cm}^{-3} \text{ l}^{-1}$.

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