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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Cloud phase identification of low-level Arctic clouds from airborne spectral radiation measurements: test of three approaches" *by* A. Ehrlich et al.

Anonymous Referee #2

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This paper presents aircraft in situ and remote sensing measurements of low-level clouds consisting of liquid and/or ice particles. Three methods of identifying cloud phase from spectral measurements are identified and analyzed through sensitivity studies and comparison to in situ data. The ability to accurately identify cloud phase from remote sensing measurements would be very useful for both remote sensing and climate model evaluation, thus the results are of interest to ACP readers. I recommend the paper for publication after response to the following comments.

General comments

1) It is not clear how the determination that clouds were ice, liquid or mixed phase was

made for the discussion of Figures 2 and 3.

In particular, in Section 3.1, give the ranges of particles that the FSSP and CPI can measure, to help determine how this discrimination is made. Is the 'ice layer' determined only from the fact that the CPI measured particles here and the asymmetry parameter is lower? Is there any evidence that this layer consists only of ice particles and has no liquid water? By what instrument were the precipitating ice particles down to 500m observed? Also, it would be nice to put the profile of in situ measurements in Figure 2 into context. Was it the only in situ profile taken on these days during the experiment or the only one in a mixed phase portion of the cloud? What part of the flight track in Figure 1 does it correspond to?

In Section 3.3, how were the periods of mixed phase, pure ice, and pure liquid plotted in Figure 3 identified? And how were the optical depths for each cloud calculated? What are the error bars on the plots? Were multiple reflectance measurements averaged over some flight track/time period for the plot? Do the areas of ice, liquid, mixed phase correspond to particular elements of the flight track or MODIS image in Figure 1?

2) The definition of 'mixed phase' cloud throughout the paper is unclear. Please define what you mean by mixed phase cloud - is it defined as cloud with ice and water in the same layer, or ice and water in the same column? In the sensitivity studies presented in Figure 4, how is the 'Mixed' cloud calculated? Is it a liquid layer above an ice layer or liquid/ice particles in the same layer? What is the ratio of ice and water mass in the mixed layer?

3) For the ice scattering calculations, columns were used. Is there any evidence that low-level Arctic ice/mixed-phase clouds contain columns? How sensitive are the ice indices to the habit assumption used?

4) Section 5.1. The authors mention that to achieve reliable information on cloud phase, a priori knowledge about ice crystal effective diameter and optical depth are needed (as shown in the sensitivity studies), but do not discuss what the typical uncertainties on

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such measurements are. Also, there is the problem that visible optical depth retrievals are very sensitive to the scattering phase function assumed in the retrieval. Given that the instruments used have visible and near-IR channels (which are sensitive to optical depth and particle size, respectively), a retrieval of optical depth and effective diameter could be performed along with the phase retrieval. This would allow a more sophisticated sensitivity study, which would include the actual errors likely in retrieval of optical depth and particle size. One question I am left with after reading the paper is, given the large variability in Is and Ip with particle size and optical depth (for tau $<$ 10), and the likely uncertainty in those values, what fraction of the mass (or optical depth) of a mixed phase cloud would have to be water for the cloud to be clearly distinguished from a pure ice cloud?

5) The paper should be proofread by a native English speaker for grammar and punctuation before publication.

Specific/technical comments:

1. Define SMART when first mentioned (p. 15905, line 1).

2. Section 4.2, 2nd paragraph. Are these tau and Deff the same values discussed at the beginning of section 4 and used in the sensitivity study for Is? If so, do not repeat them here.

3. In discussion in Section 5.1 about optically thin clouds, I believe that Is and Ip have been mixed up as Ip shows values much closer to liquid values for thin ice clouds than Is does.

4.p. 15913, What is the explanation for the fact that R for wavelengths $<$ 1300 nm is different for mixed phase and pure ice clouds in the simulations, while in the observations they are the same?

5. What particle size is used for the cloud simulations shown in Fig 4?

6.Section 5.2; sensitivity to vertical distribution. How sensitive are the values of Is and

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Interactive Comment

Ip (or their relative magnitudes) to the choice of ice and liquid Deff? If a smaller ice Deff were chosen, would you still be able to identify the cloud as mixed phase?

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 15901, 2008.