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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Airborne observations of a subvisible midlevel Arctic ice cloud: microphysical and radiative characterization" *by* A. Lampert et al.

A. Lampert et al.

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1 Introduction

We would like to thank the reviewer, and acknowledge the useful comments. They encouraged us to explain the difficulty of estimating the lidar ratio. In this regard a third independent method to derive LR is included in the revised manuscript as described below. The suggestions to use more conventional abbreviations were considered. The detailed replies to the reviewer's comments are given below.

2 Comment 1

In the paper, the authors derive three different values of lidar ratio. First, the authors reproduce in-situ nephelometer observations of scattering using a model, the best agreement is found for small spherical particles and rough hexagonal crystals leading to a lidar ratio of 27 sr (Sect. 3.2). Then, a value of 21 sr (standard for cirrus clouds) is used to perform radiative transfer simulations (Sect. 4.1); since results of the simulation agree well with observations the authors conclude it is an accurate estimate. Finally, solving the Klett equation (Sect. 4.2) leads to a lidar ratio of 15 (+/- 10). In the end, the authors conclude the overall lidar ratio of the subvisible cirrus cloud is 21 (+/- 6). While I appreciate the efforts the authors went through to retrieve this parameter, I don't understand 1) why the authors did not use the value retrieved in the first step as input for the radiative transfer simulations of the second step, and 2) how the final value and its uncertainty were derived from the three values?

The idea of comparing simulations with different LR to the measurements of I_downwelling was very helpful and overlaps with a comment of Referee 3. In the revised manuscript, we do not compare the simulated time series of I_downwelling, but performed a retrieval of tau. Consequently the different estimates of tau are compared. The results do not differ significantly to the comparison shown in the first manuscript. However, using the tau; retrieved from the radiation measurements in combination with AMALi provided a third independent method to derive an estimate of LR. In the revised manuscript, this method is considered in the discussion of the LR. In the revised manuscript, we explain in detail why we used different methods to find the appropriate lidar ratio. Section 4.3 begins with the following paragraph:

The lidar ratio is crucial for determining the extinction coefficient and the cloud optical depth tau from lidar measurements (cf. Eq. 2 and 3). As the extinction coefficient and the cloud optical depth are proportional to the lidar ratio, the two quantities are strongly influenced by the error of the lidar ratio. Therefore, three independent methods of determining the lidar ratio are applied and compared in the following.

We end Sect. 4.3 with the following concluding subsection:

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In summary, we determined the effective lidar ratio and its error bar by three independent methods (evaluation of PN data, transmittance method applied to lidar data , and combination of cloud optical thickness derived from albedometer and integrated lidar backscatter) in order to estimate the value and the accuracy of this parameter. A LR of 27 (+/- 7) sr was obtained from the PN data, 15 (+/- 10) sr from the transmittance method, and 20 (+/- 10) sr from the combined albedometer and lidar data. The mean lidar ratio calculated from these three values by error propagation amounts to 21 sr. The error bar was estimated according to the following considerations: A lidar ratio in the range of 20 to 25 sr is within the error bars of all measurements. We also included the mean values of the LR obtained by the in situ retrieval and the transmittance method in the range of the LR. As an overall lidar ratio, we propose 21 (+/- 6) sr. This value is in reasonable agreement with other LR values for cirrus clouds in the literature (Ansmann et al., 1992, Chen et al., 2002, Cadet et al., 2005, Giannakaki et al., 2007).

3 Comment 2

I was also unfamiliar with the following abbreviations: LR for lidar ratio (I would expect S, as in e.g. Chen et al. 2002), BSR for the backscattering ratio (according to the definition of Eq. 1, it is the value I've known as Scattering Ratio or SR).

The abbreviation LR for lidar ratio is also used by e.g. Cadet et al. (2003). We prefer this abbreviation as it appears more intuitive than the letter S used by Chen et al. (2002). Furthermore, S is ambiguous as it is used for the logarithm of the range-corrected lidar signal, e.g. by Klett (1985). The term Scattering Ratio can refer to scattering under different angles, while BSR refers only to the backscatter angle (180°). From AMALi only information about the scattering at an angle of 180° is available. Therefore we propose to keep the expression BSR (backscattering ratio) to avoid confusion.

4 Technical Correction

Technical corrections - p. 597, l.17: "solar zenith angels"

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Discussion Paper

This is corrected in the revised manuscript.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 595, 2009.

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