Atmospheric Measurement Techniques Discussions

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Comment on amt-2020-504

Anonymous Referee #2

Referee comment on "Estimating the optical extinction of liquid water clouds in the cloud base region" by Karolina Sarna et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2020-504-RC2, 2021

The paper proposes a methodology to retrieve profiles of the cloud extinction coefficient in the base region of liquid-water clouds by using an elastic backscatter lidar. The approach is based on the Klett-Fernald solution. In this method, a boundary condition (reference value) and the assumption on the extinction-to-backscatter ratio are needed. To apply this solution, multiple scattering and resolution effects on the lidar return signals are corrected via a simple parameterization based on the linear depolarization ratio, which can be measured with the lidar system. The problem of inverting signals in the presence of liquid-water clouds is not new. However, with respect to aerosol-cloud-interaction research, a trustworthy retrieval of the optical properties in liquid-water clouds from lidar signals, as explained in the manuscript, could be very useful.

The manuscript needs major revisions. Many mistakes must be corrected in the mathematical expressions. There are also numerous very short explanations and the structure is partly unclear.

Specific comments:

Equations 2-5:

The presentation of Eqs.2–5 needs to be improved. It was hard to follow and check the derivations because of a few errors, such as alpha'_m in Eq. 3 should be jus alpha', and the term S/z^2 should *be S*z^2* in Eq. 4, which according to my calculations would be redundant (or it is in Eq. 3).

It would be easier to follow, when the expression on page 3 line 11:*S is the extinction-to-backscatter ratio (S = alpha (z)/beta_(z) here assumed to be range independent within the cloud) and for the water clouds and wavelengths in the range from 200 to 1064 nm it is around 16 sr (Yorks et al., 2011)....* would be placed right before Eq. 2 and by adding to Eq. 2 =S (beta_c + beta_m).

Finally, to my opinion, to obtain Eq.6, the apparent (i.e., multiple-scattering influenced) lidar ratio is needed in the Klett method (not the single-scattering lidar ratio, 18sr), and this quantity varies with multiple scattering impact and thus changes with height. Please clarify this, and state this clearly…. How did you overcome this effect?

Section 3:

Please provide more information of the computed scenes! Which form do the vertical profiles have? How many values of the extinction coefficient did you test?

Later on in Section 4.4, you report that the accuracy of ’ for the whole data set was 95%. What is the data set?

Section 4.1.1

In Figure 2, what is the reason for the large negative extinction value (Klett) at 190 m height? Juts provide more information to better understand the problem.

To my opinion, the normalization of the signal is a major potential drawback of the method, i.e., to accurately determine’ to initialize the inversion. This need to be discussed in more detail, e.g., what is the influence of the selection of the normalization range? What do you get when you vary it from the cloud base up to the limit (where SNR < 20)?

I am concerned about this, because Eq.(7) is only valid if the extinction coefficient remains constant with height, which is not the case in the clouds that you considered (with an increasing extinction coefficient profile). Usually the aerosol-free troposphere is used as boundary condition. And this is precisely the biggest problem in attempts to invert lidar signals within clouds, the lack of a boundary condition because of the complete attenuation of the laser light throughout the cloud. I am surprised that you got good results applying Eq. (7)

Page 4, line 28: Should it be … ATB(z)=P’(z)z^2? You have P(z)z^2 … without prime?

Page 5, line 31: multiple scattering signal instead of multiple signal?

It should be written somewhere that you refer to single scattering + multiple scattering when you ‘talk’ about multiple scattering signals.

Fig.4: Why do you use here the optical thickness? The blue solid line in Fig.4 should be the same as the black line in Fig.2, right? But I do not see that!

Why is alpha in units of (m-1 sr) and not (m-1)? … in Figs.2,4,6 (in Fig.6,both axes).

Fig.4 top line … Retrieval

Fig.6 : Why did you divide the presentation into four different optical thickness classes? I think all results could be shown in ONE figure. Furthermore, more explanations and a detailed description of the dataset would be helpful. Please state in the figure caption explicitly: What is n, what is E, what is A.

From my point of view, the only (really) new aspect presented in this paper is the so-called resolution correction presented in the Appendix A. So, the question arises: Is the Appendix the best place for this important aspect? I would include it in the main paper body.

To continue, it was not easy to follow the developments in the Appendix. There are many mistakes in the middle part that need to be corrected.

Eq. A3: I think the whole expression should be divided by z?

Eq. A4, A5 and A6: C should large…. not c?

Eq. A6: Remove C/2, …. just B_i=1/2 (Bi,1+B_i,2) (without C)

Page 10, Line 16: … ratio … instead of … difference… , and … illustrated….

I do not understand: What is the impact of such assumptions (A8 and A9)? Please, provide more details.

Eq. A8: Minus instead of plus? …tau(z+…) – tau(z), and also … tau(z-…) – tau(z)?

Eq. A10: Middle term 1 – (…) ? and then the term on the right there is one alpha instead of alpha’

Eq. A11: There is a minus 1 missing on the numerator, and also in Eq. A12