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Atmospheric Measurement Techniques Discussions

AMTD

3, C1741–C1749, 2010

Interactive Comment

Interactive comment on "Ceilometer-lidar inter-comparison: backscatter coefficient retrieval and signal-to-noise ratio determination" *by* B. Heese et al.

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We would like to thank referee #1 for his/her useful comments. We have answered the specific comments below and provide more details for the reader's comprehension.

Answers to specific comments:

1 Introduction, p 3909, lines 17-20: the 2 km-distance between the ceilometer and the PollyXT could have an impact on backscatter profiles comparison due to very local updraft structures building up during the afternoon convection (probably present in Apr and May). Anyway, the very close profiles shown in figure 2 suggest that this doesn't

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happen or that the averaging process smooth out the local effects.

Answer: Indeed, all comparisons made did show very close profiles. This is also due to the at least 1 hour temporal averaging. But when comparing the temporal development of both measurements, as in Figure 1, same small scale structures in aerosol can be seen in both plots, although with a certain time delay. When averaging over some hours of measurement this time delay is smoothed out.

3 Data evaluation p 3912, lines 1-4: explain better how you retrieve the extinction directly.

Answer: The Raman method for the derivation of the extinction and backscatter coefficients is described in the reference Ansmann et al. (1990) and even in (lidar) textbooks. We find it too extensive to be repeated it here in detail. For a better understanding I emphasize that only the Raman signal is necessary for the calculation of the extinction coefficient.

new text: During night-time the lidar data can be evaluated by the Raman method (Ansmann et al., 1990) using also the signal from the Nitrogen Raman channel at the 607 nm. In contrast to the Fernald-Klett method here the extinction coefficient profile results directly from the measured Raman signal - without any prior assumptions.

p 3912, lines 11-13: a piece of information is lacking here about which ceilometer is being compared to the lidar in Figure 2.

Answer: In this case it is not relevant which ceilometer data were used, but only the fact that the choice of the reference height results in different backscatter values. For clarification, the used ceilometer type, CHM or CHX, is now indicated in the legend of all plots and a explained I the text

modified text: The instrument type CHM15k (CHM) is the standard instrument with a complete overlap at about 1500 m and a measurement range of 15 km. A new version of the instrument, the CHM15k-X (CHX) has a 4-times wider field-of-view and improved optics facilitating a complete overlap at 150 m..

p 3913, lines 2-5: the statement is not clearly expressed, please rephrase it. How do you get to 20% and 50% error? over- under-estimation?

Answer: For the first there is a ".," typo in this sentence. This has been corrected. Concerning the error estimation it is based on the height of the captured aerosol layer. In the case presented here the aerosol layer reaches up to 4-5 km and the part of the profile that has to be extrapolated is1 km deep. Thus the estimated error is about 20%. If the boundary layer top is lower, the error is increasing proportionally.

Corrected text: The extrapolation invokes indeed a certain error which can be estimated to about 20% in the cases with a high aerosol layer top of about 4-5 km height, as presented in this paper. In other cases when the BLT is lower or even inside the overlap region the error is increasing proportionally.

p 3913, line 6: I guess this is sliding average, please clarify.

Answer: The averaging was done by a Savitzky-Golay filter. The main advantage of this approach is that it tends to preserve features of the distribution such as relative maxima, minima and width, which are usually 'flattened' by other adjacent averaging techniques (like moving averages, for example).

new text: The vertical smoothing of all lidar and ceilometer profiles was done by a by a sliding polynomial filter which preserves the characteristic structure of the profiles. For the ceilometer twice the number of rangebins was chosen than for the lidar resulting in the same averaging length of 330 m for both instruments.

4.1 Daytime case p 3913, lines 16-19: Again, which ceilometer is being compared to the lidar in Figure 2?

Answer: The one in Leipzig-Holzhausen. CHM is now indicated in the plot, and new text is added for clarification: …and the particle backscatter profile derived from the ceilometer measurement of the CHM type instrument placed at the DWD regional center.

4.2 Night-time case p 3914, lines 24-28: backscatter wavelength independence within clouds is used to adjust the signal from the two instruments. Fig. 3 doesn't allow a clear visualization of the cirrus cloud; please extend the axis limits to allow the entire cirrus to fit in. The authors should explain more clearly how this adjustment/calibration works and what the effect on the presented data is. It seems that this auto-calibration might have an impact on the obtained backscatter coefficients.

Answer: The explanation of this procedure was maybe misleading. Since the choice of the right reference height and value is a critical point in the lidar and ceilometer BSC derivation, we mention a convenient calibration method using cirrus clouds.

new text: Inside the cirrus cloud the backscatter coefficient is independent of the wavelength of the measured signal. Therefore, at these heights the backscattered signal at 1064 nm must have the same value as for the two other lidar wavelengths (not shown). With this knowledge the reference value can be set to a common value so that the backscatter coefficient has the same value for all signals at the three wavelengths inside the cloud. Below the cloud the backscatter coefficient profile at each wavelength is again different from the others. This approach is a further proof for the correctness of the lidars backscatter coefficient calculated at 1064 nm. In the case of the night-time measurement on 25 May 2009 the reference value chosen inside the cloud was 8 Mm-1sr-1 at a reference height of 12 km. For the data retrieval of the PollyXTs signals this adjustment was done for both the particle backscatter profiles from the elastic wavelength and the Raman particle backscatter profile.

p 3915, line 1: in which way the above-mentioned adjustment proves the correctness of the retrieved BSCs?

see answer above.

p 3915, lines 8-10: any explanation about why the BSC of the ceilometer is lower?

new text: However, the particle backscatter coefficient profile calculated from the ceilometer is a bit lower than the lidar profiles, especially between 2 km and 4 km height. This results in a slightly lower calculated AOD of 0.101. The AOD calculated from the elastic lidar profile is 0.108 and compares very well to the values of 0.109 calculated from the Raman profile. These differences result from the more the noisier ceilometer signal making the calibration of the ceilometer signal more difficult. However, the shape of the profiles is clearly in good agreement.

5 Signal-to-noise ratio p 3916, equation (2): please explain how Psig and Pbg are obtained.

new text: The background signal Pbg is calculated from the uppermost rangebins, where the lidar or ceilometer signal Psig is assumed to be negligible. The lidar or ceilometer signal Psig is then obtained by subtracting the background signal from the total signal Ptot.

p 3916, lines 13-14: a vertical line at SNR=1 should be added to Fig 4 to allow a more straightforward visualization of the “clean” and “noisy” part of the signal.

new Figures 2-5!

Technical corrections: p 3911, line 1: should be 8.4 μm; corrected. p 3915, line 1: proof; corrected. p 3917, line 4: SNR is greater than 1 up to 8.5 (rather than 6.5); right, corrected.

new text: Here, the SNR is greater than 2 up to 6.5 km, which is the dust layer top. Above this height the SNR decreases slowly and stays above 1 up 8.5 km, even for a 30 min mean profile. In the range of the cirrus cloud where the signal gets rapidly higher the SNR is increasing again above 1.

Interactive comment on Atmos. Meas. Tech. Discuss., 3, 3907, 2010.

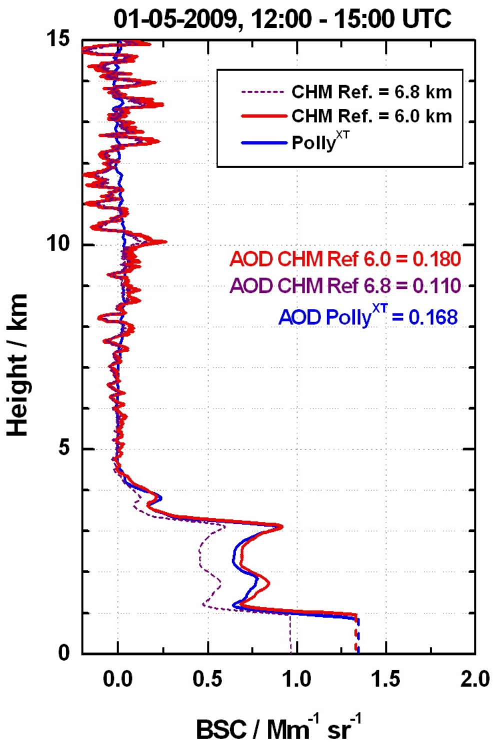

Fig. 1. Daytime particle backscatter coefficient profiles derived from the CHM ceilometer data from DWD in Holzhausen (in red) and lidar data (in blue). The mean AOD measurement from the AERONET ...

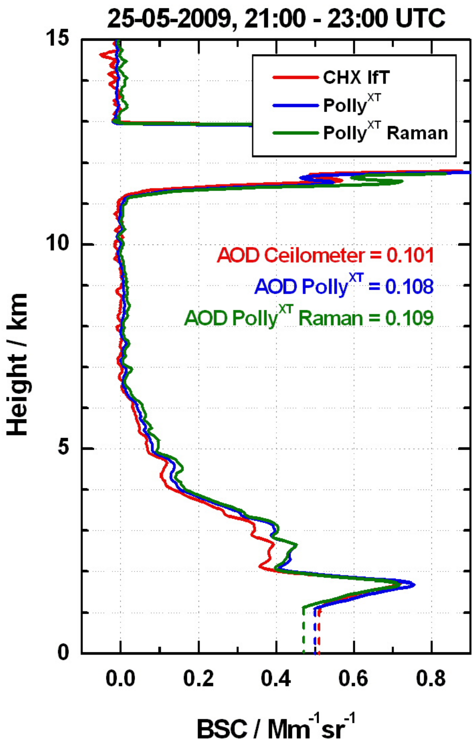

Fig. 2. Particle backscatter coefficient profiles derived from CHX ceilometer data at IfT (in red), lidar data (in blue), and Raman lidar data (in green). The AOD measured by the AERONET sun photometer ...

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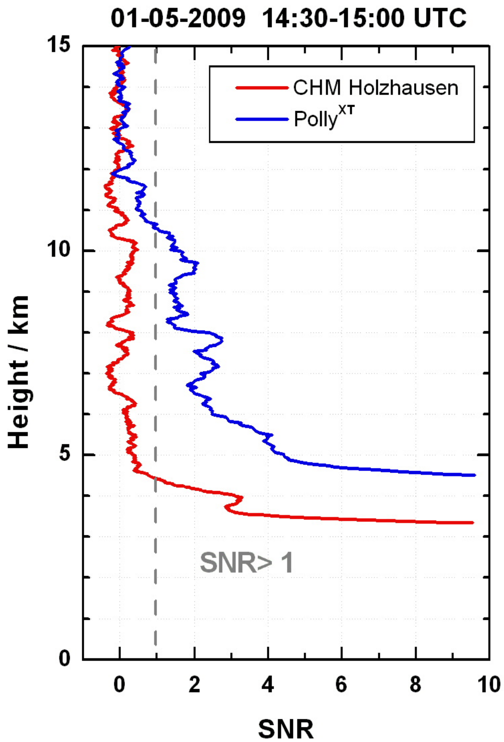

Fig. 3. SNR of 30 min mean CHM ceilometer and lidar signals on 1 May 2009 during daytime.

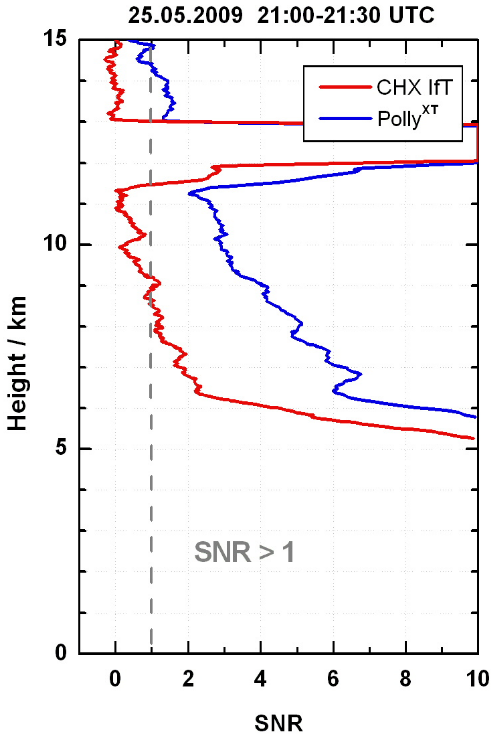

Fig. 4. SNR of 30 min mean CHX ceilometer and lidar signals on 25 May 2009 during night-time.