Atmos. Meas. Tech. Discuss., 3, C1750–C1759, 2010
www.atmos-meas-tech-discuss.net/3/C1750/2010/

Atmospheric Measurement Techniques Discussions

AMTD

3, C1750–C1759, 2010

Interactive Comment

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

B. Heese et al.

heese@tropos.de

Received and published: 19 October 2010

We would like to thank the reviewer for his/her useful comments.

Before we answer the specific comments below we would like to answer the general comments of the reviewer concerning the representativeness of the study.

This study is based on the observations of the lidar and ceilometer during half of the year 2009, plus the 3 weeks comparison campaign EARLI09. To clarify the available data basis we have added a paragraph to the 'Introduction'; see new text below. The goal of the paper is to investigate the retrieval possibilities of particle backscatter profiles from ceilometer data. To retrieve these backscatter profiles an aerosol free layer is needed where the reference value for the backscatter coefficient can be set. This means that the ceilometer should also be able to measure the molecular signal and not only noise when no aerosol is present at higher altitudes. Whether it is possible to detect the molecular signal can be determined by the signal-to-noise ratio. This ratio is depending on the possible received signal - which is of course higher for aerosol layers - but it is also depending on the signal background. To demonstrate that all depends on the detection of the molecular signal and thus on the SNR it is sufficient to show one representative example of a high and a low background case. The two examples in the paper show what we can expect from the ceilometer during daytime and during night-time. However, another night-time case is shown in a companion paper by Flentje et al. (2010) and several examples have been given in the official report of the study to the German Meteorological Service, for whom the study has been performed. The results from the other cases do in principle not differ from those shown here so that we did not consider it necessary to show and discuss more of them. A paragraph has been added to the conclusion section; see below

No statistical study has been carried out since for that not many cloud free cases were available. Although we cannot proof the results by their statistical significance, we nevertheless think that this study is a useful contribution to the discussion on the capabilities and limits of ceilometers. Due to their comparatively low costs and easy appliance the number of ceilometers in use will increase and the scientific community should be able to assess their abilities.

new text in "Introduction" p. 3909 from line 19: For the study daily ceilometer data from January to June 2009 were available from the instrument placed in Leipzig-Holzhausen. The number of comparison cases was generally determined by cloud free conditions and simultaneously measured profiles from one of IfTs multi-wavelengths aerosol lidars, the portable Raman lidar system PollyXT. The normal measurement schedule of the lidar is daily 2 times 3 hours: from midnight to 0300 UTC and from noon to 1500 UTC lidar. Clear sky conditions that lasted for some hours were indeed not numerous during the lidar observation times and in total 10 cases were chosen for the study. An example of a daytime measurement from these comparisons will be shown.

p.3910 from line 3: This was done in the frame of the ceilometer lidar comparison (CLIC) study. Three weeks of data were available, but again, due to the weather conditions the number of useful measurement days was limited. The best inter-comparison day of EARLI09 was May 25, 2009. On this day three time periods from the ceilometer and lidar measurements were compared and the example of the night-time measurement will be shown in this paper.

p. 3917 "Conclusions" from line 11: In this paper we show that the retrieval of particle backscatter profiles from ceilometer data is depending on the received signal compared to the background noise and the decrease of their ratio with height. A reference value for the backscatter coefficient must be set in the retrieval algorithm. This can only be done if the ceilometer is able to measure any molecular signal and not only noise when no aerosol is present at higher altitudes. That this is a critical point has been demonstrated by presenting two representative examples for high and a low background signals.

Specific comments:

Abstract p. 3908 ln. 3 Inter- Comparison => Inter-Comparison (and use this one throughout manuscript)

Answer: Since I learned now that an "Inter-Comparison" is performed between instruments of the same type and "Comparisons" are performed between different instruments we will use only Ceilometer Lidar Comparison throughout the whole paper.

1 Introduction p.3909 ln. 13 Unfortunately, along with this manuscript there are not many studies done on a retrieval of optical properties using the CHM15k(-X) ceilome-

AMTD

3, C1750–C1759, 2010

ters. Hence, it is worth a citation here the conference paper which discusses one of such approaches: Stachlewska, I. S. and Markowicz, K. M.: On forward Klett's inversion of ceilometer signals, 25thILRC International Laser Radar Conference, 5-9 July 2010, St. Petersburg, Russia, 2010

new text: A study on the retrieval of the boundary layer aerosol by the Jenoptik ceilometer was presented recently by Stachlewska and Markowicz (2010). A self-calibration method using the instrumental constant is presented that allows an independent calibration of the obtained backscatter profile.

p. 3910 ln. 6 More details on the CLIC campaign should be given. How many observations were taken? What was duration of the campaign? Where was it performed? I guess it was a few days during EARLI 09, or is there more to it?

Answer: There was no CLiC campaign, but a CLiC study. Ceilometer CHM data from six month in 2009 were made available by the DWD and CHX data were taken only during the EARLI09 campaign. Due to often cloudy conditions in 2009 only 10 cases the DWD ceilometer data were evaluated. One is shown here, another, indeed, in Flentje et al. (2010) From the EARLI09 campaign the golden day of the campaign was chosen for the CLiC study. On page 3909 line 20-24 is described, from which time period data were available for the CLiC study.

new text in introduction p. 3910 from line 3. (see also answers to general remarks above) This was done in the frame of the ceilometer lidar comparison (CLIC) study. Three weeks of data were available, but again, due to the weather conditions the number of useful measurement days was limited. The best inter-comparison day of EARLI09 was May 25, 2009. On this day three time periods from the ceilometer and lidar measurements were compared and the example of the night-time measurement will be shown in this paper.

2 Instruments p. 3910 l. 16-17 Does the PollyXT fulfill 'the requirements of the EARLINET lidar'? Please check this statement. To my knowledge, accordingly to Dr. G.

Pappalardo (priv. com. 2009), there is no such thing as requirement for EARLINET lidar.

Answer: You are right. We just wanted to emphasize that PollyXT is a quality assured EARLINET lidar. I mixed it up with the requirements for an EARLINET reference lidar: mobile, 3+2+1 Raman lidar. See also http://earlinet.eu/ The reference lidar systems are expected to measure at the three "standard" backscatter and two Raman wavelengths and must be mobile.

new text: With this configuration, PollyXT is a mobile, state-of-the-art 3 backscatter + 2 extinction + 1 depolarization lidar.

p. 3911 ln. 1 84 micro J ? Corrected to 8.4 micro J

3 Data evaluation p. 3911 ln. 21 Was any overlap correction on the ceilometer and lidar signals performed and if so, add information on how was it done.

Answer: No, the comparison of any overlap correction was not subject to this study. The overlap region was left out and the profiles were extrapolated to the ground.

p. 3912 ln. 1 - 4 As Referee 3# pointed out please add more details on Raman retrieval. How where the Raman profiles averaged in time and space? What method was used for smoothing?

Answer: Please see corresponding answers to Referee #1 and #3

p.3913 ln.1 1 km of incomplete overlap of lidar or ceilometer?

Answer: Both.

new text: To calculate the resulting AOD from the lidars and ceilometers extinction profiles, . . .

p.3913 ln.2 As Referee #1 mentioned more on error estimation is needed. What about error of using AOD of photometer at 1020 nm and AOD of ceilometer / lidar at 1064 nm

AMTD

3, C1750–C1759, 2010

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

in the daytime measurement? What about a difference in daytime – night-time errors due to the use of a different optical path of the ceilometer/ lidar and photometer AOD which is a constrain on retrieval?

Answer: For a more accurate comparison we used the now available AERONET level 2.0 data and interpolated the sun photometer AOD to 1064 nm. It is now 0.140 (before 0.147@1020) on May 1, 2009 and 0.117 (before 0.119@1020) on May 25, 2009. This error is thus only 1-2%. The remaining differences in AOD are in the order of 10-20%. These deviations can be attributed to contributions from the different optical path and the evening to night-time difference in AOD. See also answer to p. 3914 ln. 10 below.

new text in chapter "Data evaluation": This sun photometer measures the radiance at eight channels ranging from 340 nm to 1640 nm. For the comparison with the lidars' and the ceilometers' AOD the AERONET level 2.0 data of all channels were interpolated and the value at 1064 nm was used.

4 Ceilometer-lidar inter-comparison p. 3913 ln. 7 Ceilometer lidar => Ceilometer-lidar (and use this one throughout manuscript)

Answer: Ceilometer lidar comparison (CLiC) is now used throughout the text. See also answer to Referee #1

p. 3913 ln. 16 Please state here once again were the lidar the sun-photometer and the ceilometer were based. Where they apart (and what instruments) in as distance of 2 km for the daytime case? Where they together at one site for the night-time case? This must be clear here.

Answer: The AOD measurements are taken by IfTs AERONET instrument standing right aside the lidar and ceilometer at IfT. Of course, the distance to the DWD ceilometer is still 2 km. Of course, the same uncertainties are valid for the comparison between the AOD from the photometer and the DWD ceilometer as for the comparison between the lidar and the DWD ceilometer.

AMTD

3, C1750–C1759, 2010

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

See also comment below to p. 3914 ln. 10 and added new text.

p. 3913 ln. 16 Please comment on how much / little representative for the atmospheric variability are presented here profiles which were obtained with such a long averaging (over 3 h).

Answer: For the comparison the profiles were averaged over 3 h mainly due to the availability of the lidar data. The "normal" operation mode for the lidar is 3 hours measurement during daytime and 3 hours during night-time. During special campaigns (like EARLI09) there may be differing measurement times. We used all available data during daytime for better visual inspection of the profiles. Because of the better representativeness for the atmospheric variability the SNR was calculated for 30 minutes profiles only.

p. 3914 ln. 5 Reference for FLEXPART is missing, e.g. Stohl, A., Hittenberger, M., and Wottowa, G.: Validation of the Lagrangian particle dispersion model FLEXPART against large scale tracer experiments, Appl. Optics, 32, 24, 4245–4263, doi:1016/S1352-2310(98)00184-8,1998.

Answer: Included

p. 3914 ln. 10 More information on the obtained AOD photometer value is necessary. Is this value calculated also over the 3h period? How did you eliminated the passing or sub-visible clouds, if they where on the photometer's sight of view?

Answer: The AOD value is also calculated over the same 3 h period. In the submitted paper we used the AOD values from the AERONET version 1.5 cloud screened values. New AOD AERONET level 2.0 values were now available and have been interpolated to 1064 nm. See also Answers to Referee #3.

new text: On 1 May 2009 the AOD derived from the ceilometer profile is 0.180 and the one from the lidar profile was calculated to 0.168. The independent measurement of the AOD by IfTs sun photometer interpolated to 1064 nm over the same time period

AMTD

3, C1750–C1759, 2010

yields a value of 0.140. These are differences in the order of 20%, which may be explained by the distance between the measurement sites as well as to the extrapolation of the extinction profile to the ground with a constant value. Differences in this range were to be expected considering the different measurement sites. However, the shape of the particle backscatter profiles from both instruments compare quite well.

p. 3914 ln. 22- 27 Is the described calibration in cirrus heard of or invention of the authors? Please clearly indicate you contribution or give a reference.

Answer: No, this is a common method in multi-wavelength lidar retrieval since the backscatter of cirrus particles in not wavelength dependent. See also the detailed answer to Referee #1.

p. 3914 ln. 27 (and also in Figs. 2 and 3) what is this unit Mm-1 ?

Answer: M means Mega: Mm = 10 exp(6) m, this abbreviation is commonly used in the lidar community.

p. 3915 ln. 10 (and also Fig. 3) An information on the obtained AOD photometer value is missing. Did you use this value as a constrain for ceilometer retrieval? Were the two instruments placed nearby? Was the ceilometer and lidar tilted to measure into the same direction as photometer? Did you filter the cirrus optical depth out of photometer data? Was the photometer AOD measurement taken during the whole 2h period corresponding to the vertical profiles?

Answer: The AOD measurements are taken by IfTs AERONET instrument standing right aside the lidar and ceilometer at IfT. The sun photometer is not measuring during night-time. Instead the values from the last hour in evening before were used. At that time the cirrus was not present and the value was 0.115. For the AOD of the ceilometer and lidar we integrated only the extinction below the cirrus. See also comment to Figure 3

new text: The AOD measured by the sun photometer in the evening during the last

AMTD

3, C1750–C1759, 2010

hour before sunset when no cirrus war present was 0.115.

p. 3915 ln. 17 please add also here a reference to the AMTD paper of Flentje et al. 2010 with a commentary that another example of a night-time case is discussed in detail therein.

Answer: included

new text: Another example of a night-time case is discussed in detail in Flentje et al. (2010).

p. 3915 ln. 25 It is not trivial to obtain the background for the 1064 nm signal as the ceilometer signals have a short-range SNR. Please give a hint how you did it.

Answer: The background for the ceilometer is calculated as the mean value from the signal measured during the last 1000 m from 14 to 15 km. Although the signal is noisy up there, there is a certain offset to zero in the signal. The mean value is the background signal.

References p.3918 l. 16 correct => Markowicz Remiszewska Stelmaszczyk

Answer: sorry, corrected

p.3919 l. 1 add references => Stachlewska, I. S. and Markowicz, K. M.: On forward Klett's inversion of ceilometer signals, 25thILRC International Laser Radar Conference, 5-9 July 2010, St. Petersburg, Russia, 2010

Answer: done

=> Stohl, A., Hittenberger, M., and Wottowa, G.: Validation of the Lagrangian particle dispersion model FLEXPART against large scale tracer experiments, Appl. Opt., 32, 24, 4245–4263, doi:1016/S1352-2310(98)00184-8,1998.

Answer: done

p. 3919 l. 1 and l. 4 Reference to Pappalardo et al. 2010 needs to be placed alphabet-

AMTD

3, C1750–C1759, 2010

Interactive Comment

ically.

Answer: corrected

Figures Commentary to Fig.2 There is significant difference in ceilometer retrieval below 5 km with w change of the reference height of 6.8 km. An explanation of why this is happening is necessary (in the text). Also in the caption you write that the obtained AOD from the dashed profile is 'too low'. You mean 'too low' with respect to what, the photometers AOD? If so, you must state firmly to what extend you do expect those two values to match, as this is not trivial.

Answer: This example was chosen to show THAT this is happening, if no calibration by AOD is done! The explanation is given in the chapter "Data evaluation" on page 3912 line 7-16.

new part of Figure 2 caption: ... The mean AOD measured by the AERONET sun photometer (level 2.0 data) for this time period interpolated to 1064 nm is 0.140. ...

Commentary to Fig.3 It is not clear here nor in the text how you obtained the AOD from ceilometer / lidar, i.e. did you integrated AOD from profiles with or without the cirrus range? And how the AOD of photometer is obtained, i.e. is it 'contaminated' with this cirrus cloud? There two are necessary to conclude for the AOD comparisons.

Answer: Right, the sun photometer is not measuring during night-time. Instead the latest values from the evening before were used. At that time the cirrus was not present. From the ceilometer we integrated only the extinction below the cirrus. See here new text above and answers to Referee #3.

new figure caption: ... The AOD measured by the AERONET sun photometer during the last sun hour in the evening is 0.115.}

Commentary to Fig.4 and 5 In caption: signal => signals;

Answer: corrected

AMTD

3, C1750–C1759, 2010

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

AMTD
3, C1750–C1759, 2010