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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Aerosol vertical distribution and optical properties over M'Bour (16.96° W; 14.39° N), Senegal from 2006 to 2008" *by* J.-F. Léon et al.

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Abstract: line 4: world (not word)

Done .

Page 1, right column, lower part: winter transport is also observed by Tesche et al. (JGR, 2009) during the SAMUM campaign.

We have mentioned this article in the main introduction. Page 1, we have added the following sentence :
The wintertime transport has also been observed from Lidar sounding in Cape Verde in January 2008 (Tesche et al., 2008).

Page 2, left column, lower part: Heese and Wiegner (JGR 2008) performed Raman lidar observations during AMMA (lidar ratio observations). Should be mentioned, because lidar ratio estimates are required in the lidar data inversion presented here.

Yes. We have mentioned this article in the main introduction.

Page 2, right column, and page 3: Lidar ratio is discussed. Again, the results of Heese and Wiegner should be included in the discussion here.

The discussion on the lidar ratio is in section 3.4 page 6. The paper by Heese and Wiegner (2008) is already mentioned in this section.

Page 3, text following Eq.(4): the method applied is the one of Fernald (Appl. Opt. 1984). The original Klett method (1981) ignores Rayleigh scattering, i.e., assumes particle scattering only.

You are perfectly right. However most of the authors doing lidar inversion named this method the Klett's method. We have modified the sentence as following :
β_{aer} *is retrieved from the attenuated lidar backscattering coefficient following Fernald (1981) method (also known as Klett (1981) method).*

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Page 3, right column: iterative procedure. . .. .! Please explain in detail!

We have clarified this point in the text by modifying the text page 3:
We have used the aerosol optical thickness measured by the Sun photometer as a constrain to fix the effective lidar ratio. The lidar-derived aerosol optical thickness is indeed a monotonic function of the lidar ratio used in the inversion (Pelon et al., 2002; Chazette et al., 2002). The aerosol optical depth is estimated from the lidar derived extinction profile using Eq 8. The extinction profile is derived following an iterative procedure based on a simple dichotomy where the lidar ratio can vary between 10 to 100 sr. The procedure ends when τ_{aer} *for a given effective lidar ratio is close (*$\pm$*10%) to the aerosol optical depth given by the Sun photometer. The profile is not inverted when the dichotomy procedure does not converge within a few (8 maximum) steps.*

Page 3, right column: In this context: It is dangerous to compare the optical depth derived from the lidar profile and the optical depth obtained from sun photometry. How did you overcome the overlap problem? How large is the remaining uncertainty of the overlap correction?

We use Sun photometer AOT as a constrain for the lidar extinction profile retrieval. This is a way to overpass the problem linked to the choice of the lidar ratio (the true lidar ratio profile is unknown) and to have coherent observations between both optical measurements. The overlap function is estimated using the procedure explained by Pelon et al. (2008). We performed horizontal observations for clear (low optical depth) conditions and the overlap function is derived using the slope method (Kunz and de Leeuw, 1993). The overlap function is complete (100%) at 2 km. The correction remains large up to 600 m (20% of overlap). We now give the associated uncertainties in our retrievals in the main text (see our answer to your next remark).

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Page 4, left column: R-min is at 225 m? ..and the overlap is completed at around 3 km, as I expect for a CIMEL MPL lidar. So, please quantify the uncertainty in the results introduced by the overlap correction uncertainty. The overlap configuration can change dramatically as a function of ambient temperature. . ..

As mentioned previously, the overlap is completed at 2 km. We did not observe any change in the overlap function due to temperature variation for our lidar system in Africa as well as in Northern Europe. The overall uncertainty in the lidar derived extinction profile and AOT depends on the aerosol vertical distribution and the lidar ratio profile. As we assume a constant lidar ratio as function of the altitude, the error in the retrieved extinction can be very large. We have added in the text the following discussion:

The main sources of uncertainties in the retrieval come from the unknown lidar ratio profile, the uncertainty in the reference signal $S(R_0)$, the error in the overlap function and the missing first 255 m. The effective lidar ratio used in the iterative procedure is found to be on average 20% lower than the Sun photometer derived one. The effective lidar ratio is affected by the choice of the reference signal (Chazette, 2002). The reference signal uncertainty depends on signal to noise ratio at the given altitude (which depends on the transmission below that altitude) and on the possible occurance of residual aerosols or clouds. In the bottom layer, the uncertainty in the overlap function is the primary source of error. The overlap function is estimated using the procedure explained by Pelon et al., (2008). We performed horizontal observations for clear (low optical depth) conditions and the overlap function is derived using the slope method (Kunz and de Leeuw, 1993). The overlap function is complete (100%) at 2 km. The correction remains large (20% of overlap) up to 600 m and the error is about 10% above 600 m while it is up to 50% close to the ground. The missing first 225 m introduces a positive bias in the retrieved extinction profile that depends on the aerosol vertical distribution and is on average 10%.

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Page 5, left column: Please check SAMUM special issue (Tellus B, 2009) for SSA values, too.

We have added the following reference on SSA from the SAMUM 2006 field experiment:

During the SAMUM 2006 experiment (Heintzenberg, 2009) in Morocco, Schladitz et al. (2009) have also reported a dust SSA between 0.89±0.02 and 0.96 ±0.02 for conditions of low and hight dust load, respectively.

Page 6, left column: There is a paper of Mueller et al. (JGR, 2007) on lidar ratios, better to cite that. Check also Tesche et al. (JGR, 2009) for recent lidar ratio observations in smoke/dust plumes during SAMUM.

Thank you for providing additional references. We have introduced the papers of Müller et al. (2007) and Tesche et al. (2009) in the text :
Raman lidar are in the range between 23 to 65 sr for typical atmospheric aerosols (Müller et al., 2007) and can goes up to 100 sr.
and
From multiwavelength aerosol Raman lidar observations in Cape Verde, Tesche et al. (2009) derived a lidar ratio of 77 sr above 1.5 km height in a layer of mixed dust and biomass burning.

Page 6, Figure 7: When lidar ratio is below 50sr (or even 40sr) then there is a large maritime impact? Please explain!

When the lidar ratio is below 50 sr, the Angström exponent is between 0.0 and 0.5, AOT is below 1 and SSA is above 0.9. If we refer to the paper by Müller et al. (2007), the lidar ratio for the marine aerosol in the PBL of the North Atlantic is 23 sr $\pm$ 3. So we expect to have a mixing between dust (lidar ratio between 40 and 60 sr) and marine aerosol. Very few cases are observed with lidar ratio below 30 sr (mostly during the rainy season) that might correspond to rather "pure" marine aerosols.

Page 7, left column, section 4.1.1: Keeping in mind that the overlap is complete at about 3 km, I would not trust extinction values below 1.5km height.

As said previously, the overlap is complete at 2 km. It is true that the extinction might be underestimated at low level. We now clearly mention this point and give an estimate of the uncertainty on the extinction values.

Page 7, right column, sections 4.1.4, 4.2: lidar ratio can vary strongly from layer to layer (in the vertical)

We cannot determine the variation of the lidar ratio as a function of the altitude. This is a strong limitation of a one wavelength backscattering lidar. However, it has been shown that in September, the lidar ratio can significantly vary between the lower and the upper layers. Léon et al. (2003) have found that the lidar ratio in the lower layer is 55 sr while it is 46 sr in the aloft layer.

Page 8, Figure 9: x-axis and y-axis text is too small, other text (months) too, decrease empty space between plots, please.

We have improved this figure by reducing the empty space between the plots and by increasing the labels and legends.

Page 9, left column: regarding lidar ratio profiles, aerosol types, layer heights, please provide more context to AMMA and SAMUM literature (Tellus, JGR), and may be SHADE results, and other observation over the Atlantic (Berthier et al., JGR).

We did not retrieve lidar ratio profiles. Regarding the context, it is given in the discussion with references to the SHADE campaign. We have added the following sentence in section 4.3:
Such vertical structure of the dust transport has also been observed by Berthier et al. (2006) from the LITE spaceborne lidar over the Tropical Atlantic ocean off the western African coast.
and
In Cape Verde, Tesche et al. (2009) have shown that this thick layer is mixed of dust and biomass burning aerosols with a relative contribution to the total extinction of 1/3 and 2/3 respectively.

Page 9, right column: again, world (instead of word).

Done.

Page 10, Figure 11: again, x-axis and y-axis text is too small, other text (SSA. . .) too, decrease empty space between plots, please.

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We have improved the figures according to your recommandations.

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