Atmos. Meas. Tech. Discuss., 3, C1532–C1538, 2010
www.atmos-meas-tech-discuss.net/3/C1532/2010/

Atmospheric Measurement Techniques Discussions

Interactive comment on "Aerosol Optical Depth measurements at 340 nm with a Brewer spectrophotometer and comparison with Cimel observations at Uccle, Belgium" *by* V. De Bock et al.

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Received and published: 22 September 2010

We would like to thank the reviewer for his/her useful comments on the revised manuscript and for the suggestions concerning future work.

Before we answer the general and specific comments, we would like to point out some changes that we have made. First, we have made a new comparison between the AOD values of the Brewer and Cimel instruments (both at 320 and 340nm), using AERONET

level 2.0 data (instead of the level 1.5 data which was used for the original manuscript). Second, we have extended the analysis period to include measurements until the end of August 2010.

ANSWER TO GENERAL COMMENTS:

We are definitely aware of the fact that the cloud screening method is not yet perfect. Currently, we are working on the development of a better screening method and we will reanalyze our results as soon as the new method is validated. We will add a special section on the comparison of the Brewer monthly mean AOD with the Cimel monthly mean AOD values to address your comments on this issue. We will also clarify that our mean values are most likely upper limits, since some individual AOD measurements (that constitute to these mean values) can still be highly biased as a result of the cloud screening technique that still needs some work. The comparison with the Cimel will confirm this. The following paragraph is added to section 4.1 (Comparison between Brewer spectrophotometer and Cimel sunphotometer measurements):

"A comparison is also made between the monthly mean AOD values from the Brewer and Cimel measurements. For some months, the difference between the monthly values is rather high. For example in March 2008, the mean monthly Cimel AOD was 0.16, whereas for the Brewer instrument, the monthly mean was 0.54. For 13 months (out of the analyzed 27 months) the difference between the monthly AOD values of the two instruments is larger than 0.2. The mean monthly AOD values of the Brewer instrument are most likely upper limits, since some individual AOD measurements (that constitute to these values) can still be highly biased as a result of cloud perturbation. This thus causes the large differences in mean monthly values between the two instruments. It also shows that the used cloud screening method needs further improvement."

ANSWER TO SPECIFIC COMMENTS:

Page 2744, Abstract: The intensities at 340 nm due to lower ozone absorption are larger as compared to what? Additionally, it is too general to state that the monthly and

seasonal variability in Brewer AOD's are 'consistent with other studies.' Do you mean consistent with other studies in Europe in amplitude of seasonal variation?

The intensities at 340nm are larger compared to the ones between 306.3 and 320.1nm. We will add this on page 2744.

In the abstract, we replaced the sentence on the consistency with other studies (p2744, lines 14-15):"The analysis of the monthly and seasonal Brewer AODs at Uccle is consistent with other studies reporting on the seasonal variation of AODs in Europe."

Page 2747, line 4-6: Please define the difference between direct sun ozone measurements and sun scan measurements. Is this only a difference in wavelength or are there other differences in the measurement methodology? (Same comment applies to Page 2749 lines 4-7)

The direct sun measurements are performed at 5 specific wavelengths, whereas the sun scan measurements are scans (each with a total duration of 21 seconds) from 335 to 345nm, that are afterwards convoluted with the Cimel band pass function. This is explained in Section 2 of the original manuscript. The following sentence will be added to underline the difference between sun scan measurements and direct sun measurements: page 2747, line 4: "... instead of using the standard direct ozone measurements (which are performed at 5 specific wavelengths) from the Brewer instrument (as in Cheymol and De Backer, 2003), we will use sun scan measurements between 335 and 345nm, convoluted with the band pass function of the Cimel sun photometer at 340 nm, to obtain AOD values at 340nm."

Page 2748, after line 21: You need to state that the accuracy of the AERONET measurements of AOD at 340 nm is 0.02 [Eck et al., 1999].

This was added in the revised manuscript and the reference has been added to the reference list.

Page 2749, line 14: In equation (1) the sec(z) is only an approximation for the optical

air mass. I am surprised that you did not use a more accurate computation such as Kasten and Young (1989). I suggest that you take his into account in future work.

Thank you for the suggestion. This will be taken into account for future work.

Page 2751, line 3: What is the justification for removing data when air mass is above 3? Air mass changes more rapidly in time in the range from 5 to 3 (morning Langley) making it easier to meet the necessary criteria of a temporally stable atmosphere. Many researchers have typically made Langley analyses from air mass 5 to 2 or 5 to 3 using morning data at Mauna Loa, mainly for this reason. By using your criteria of only air mass less than 3 you insure only a small air mass range (since in some seasons the air mass minimum is 2 or higher at Uccle) and also increase the likelihood of atmospheric instability since the time period of the Langley sequence is longer and since atmospheric convection intensifies towards mid-day.

We chose to limit the air mass to 3, since at higher air masses, the irradiances (that are measured by the Brewer) become much lower and the instrument becomes much more sensitive to stray light effects. This could thus bias the AOD measurements.

Page 2751, lines 7-8: It is much more important to place a minimum range limit on the optical air mass rather than the solar zenith angle range (SZA), since the same SZA range for different seasons yield different ranges of air mass. Air mass range is really the more important parameter (as compared to SZA) in maintaining the quality control of Langleys.

This is true and we accounted for this comment by changing the 2nd criterion:

Old criterion: "The range of zenith angles covered by the sun scans for one day must be at least 20°."

New criterion: "The range of the air masses covered by the sun scans for one day must be at least 1."

We also added a sentence in the text that explains why we changed this criterion:

“Concerning the 2nd criterion, it has to be mentioned that the same SZA range can yield different ranges of air mass for different seasons. Since air mass range is a more important parameter for the quality control of the Langley Plots, the 2nd criterion was changed so that a minimum range limit was placed on the optical air mass instead of on the SZA range.”

Page 2751, lines 25-27: What default constant AOD value do you assume? Also in line 27 do you mean aerosol optical depth or cloud optical depth?

A default constant AOD value of 0.7777 is used as a standard for polluted air. This is added to page 2751, line 26. In line 27, the text already states that we mean cloud optical depth.

Page 2752, line 10: Again you need to give a justification for selecting the air mass threshold of 3.

See previous answer to this comment.

Page 2752, lines 11-12: Again, same comment as for page 2751, lines 7-8 (see above).

See previous answer to this comment.

Page 2753, lines 4-6: Were there any AERONET Cimel observations (Level 2) with AOD > 2 during the times that Brewer observations were made at Uccle? Page 2753, lines 13-14: Only Level 2.0 AERONET data should be used for publication, since Level 1.5 data may contain observations with instrumental or calibration problems.

Within the period of the Brewer observations, there were no AERONET Cimel level 2.0 AOD observations larger than 2. In the revised manuscript, the comparison is made with Cimel level 2.0 values. It should be noted here that they are only available until may 2009.

Page 2753, lines 17-18: The use of a simple Angstrom exponent to extrapolate to AOD at 320 nm will typically lead to overestimates of AOD at 320 nm since the AOD

spectral variation (in logarithmic coordinates) is often non-linear (see Eck et al., 1999). A second order fit of ln AOD to ln §using the AERONET data from 500, 440, 380, and 340 nm will provide a much more accurate estimate of AOD at 320 nm.

We took this comment into account and recalculated the Cimel AOD at 320nm using the proposed method to get a more accurate estimate. We will also make adjustments to our manuscript to clarify this.

P 2753, lines 15-18: “The AOD values from Brewer#178 at 320nm were also compared to quasi-simultaneous values. A second order fit of ln AOD to ln λ (using the AERONET data from 500, 440, 380 and 340nm) was used to estimate the Cimel AOD values at 320nm.”

Page 2753, lines 23-25: The term ‘cloudless days’ is somewhat misleading, perhaps it would be more accurate to say ‘calibration quality clear days’. Also you state that the mean calibration factor was 18.579 +-0.084, which implies an uncertainty in AOD due to the variability. Please compute the uncertainty in AOD due to this calibration uncertainty. Also do you use the mean value for the entire data record or interpolate in time between calibration dates. Was there any temporal trend in the calibration?

In the revised manuscript, the term ’cloudless days’ will be replaced by ’calibration quality clear days’, as suggested by the referee.

The uncertainty in AOD due to the calibration uncertainty was calculated. The largest difference between the original AOD and the ones calculated with CF+/- STDEV was 0.08, so the uncertainty of our AOD measurements due to the variability in CF is 0.08. This will be added to the revised manuscript.

We used to mean value for the entire data record, because the period was too short. We could not look at the temporal trend in CF, since we only apply the Langley Method once for the entire period (due to the low number of completely cloudless days).

Page 2755, Section 4.2.1: I strongly suggest adding a plot of daily average AOD values

over the entire measurement record.

We made a plot with daily average AOD values, but since this plot doesn't provide more information than can't already be extracted from Fig. 7 and 8, we decided not to include the plot in the revised manuscript. We also want to refer to a comment made by referee 1, who already pointed out that some plots provide the same information and who advised us to remove the plots without new information.

Page 2759, line 1: I think that perhaps 'AOD retrieval method' should be changed to 'AOD calibration method.'

Following the referee comment, we changed 'AOD retrieval method' into 'AOD calibration method' .

Interactive comment on Atmos. Meas. Tech. Discuss., 3, 2743, 2010.