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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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Reply to comment of anonymous referee #1

We would like to thank the reviewer for his/her useful comments and for the suggestions concerning future research. 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:

1)The reviewer's request to discuss the stability of the calibration functions has been taken into account and more information concerning this topic will be added to the revised manuscript. See also the answer to your specific comment on this issue.

Concerning the justification of the use of the LPM: The stability of the Brewer wavelengths has been examined and the results (which can be found in the following report: Gröbner, J., Blumthaler, M., Kazadzis, S., Bais, A., Webb, A., Schreder, J., Seckmeyer, G. and Rembges, D.: Quality assurance of spectral solar UV measurements: results from 25 UV monitoring sites in Europe, 2002 to 2004, Metrologia 43 S66, 2006, doi:10.1088/0026-1394/43/2/S14 http://iopscience.iop.org/0026-1394/43/2/S14/pdf/0026-1394_43_2_S14.pdf) show that the stability of our Brewer instrument is very good. This means that the LPM can also be used for the sun scan measurements.

2)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. Following the comments of one of the other referees, we included the comparison between the monthly mean AOD values (at 340nm) from the Brewer and Cimel, because there is a large difference between the two. This is most likely the result of cloud-perturbed measurements that are not eliminated from our resulting data set. So we agree that there is still some work to be done on the cloud detection methodology.

3)We will include more information on the elimination of the outliers in paragraph 4.1. See also the answer to your specific comment on this issue.

ANSWER TO SPECIFIC COMMENTS:

2747 what is the brewer measuring wavelength step and scan duration? Is slit function 1 used similar to UV scans?

For the sun scan measurements, the measuring step is 0.5nm and one scan has a total duration of 21 seconds. Slit function 1 has been used similar to UV scans. This information will be added to section 2 (p2747-2748) in a revised manuscript.

2748 line 25. Describe in brief the Langley plot method used here. Is the Langley method derived for the weighted (with the Cimel band pass) direct irradiance or AOD is derived for each wavelength and then you weight? How often the Langley method was used and what was the stability of the ET values over the 3+ year period that is analyzed here?

First the direct irradiances at the different wavelengths (from 335 to 345nm) are weighted with the Cimel band pass filter. Then the Langley method is applied to the weighted irradiance at 340nm. We only applied the Langley method once for the entire period, due to the low number of completely cloud free days. This will be added to section 3 in the revised manuscript. Concerning the stability of the ET values over the analyzed period: The UV lamp tests show that the sensitivity of the instrument is very stable, so the ET of the instrument will be stable as well. We added the following section on page 2752, after line 17 to clarify this: "Since we only apply the Langley Plot Method once for the entire period, the stability of the Calibration Factor of the instrument can not be calculated. However, the UV-lamp tests of the Brewer instrument, showing that the instrument is very stable, indicate that the same is true for the Calibration Factor of the instrument."

2751 It is better not to repeat the Cheymol criteria because DS measurements are not used here. But just to mention the criteria adopted to the sun scans. The non-ozone influence is repeated here. As mentioned, 2nd criterion cannot be adopted. But also I cannot see how the 4th criterion can be adopted since sun scans are measured once

and probably need 1 minute to be performed. Unless 5 repeated observations are taken so that has to be clarified in the text.

We would prefer to keep the Cheymol criteria in the article for the sake of completeness. We will however change the order of the criteria so that it becomes clearer to the readers which new criteria are adaptations of the old ones and which criterion is a completely new one. The fourth Cheymol criterion means that there has to be a minimum of 10 sequences of 5 observations on one day to guarantee that you have enough measurements to use for the LPM. We adopted this to the sun scans by stating that on one day, minimum 10 sun scans need to be performed for that day to be used for the LPM. Following the comment of an other referee, the second criterion (as in the new order, see below) is changed so that a minimum air mass range is used instead of the SZA-range that was used in the original discussion paper.

New order old criteria (p2751, lines 1-10): "This leads to different criteria for the selection of the days on which the LPM can be applied (calibration quality clear days). Cheymol et al. (2009) proposed the following criteria:

1. The individual DS data for which the air mass is above 3 are removed.

2. The range of zenith angles covered by valid DS observations for one day must be at least 20 °.

3. The number of individual DS data must be at least 50 per day (i.e. 10 sequences of 5 observations)

4. The ozone column and its standard deviation are computed on each group of 5 individual DS measurements for each wavelength. Data are accepted if the standard deviation is lower than 2.5DU."

New criteria (p2752, lines 7-15): "This leads to the following set of criteria for the selection of calibration quality clear days (CCD= Criteria Calibration Days) for the determination of the calibration factors with the Langley plot method:

1. The sun scans for which the air mass is above 3 are removed.

2. The range of air masses covered by the sun scans for one day must be at least 1.

3. At least 10 sun scans per day have to remain after applying the first two criteria.

4. The maximum deviation of the individual ratios (of the observed and expected intensities) from the mean ratio for a certain day has to be smaller than 20%."

2751 line 23. How do the authors compare unitless (not calibrated) direct sun scans measured by the Brewer with TUV model direct sun irradiances?

Both the direct sun scans and the TUV model direct sun irradiances were normalized to their maximum values before the ratio was calculated. Hence, the compared values are both unitless. This will be clarified in the text by adding the following sentence (p2752, after line3): "For the calculation of the ratio, both the observed and the expected intensities are normalized to their maximum."

2751 line 23. I do not agree that the ratio of the sun scans with a constant (real AOD) versus TUV results with a constant AOD have to be constant during the day. For example, in case that TUV input AOD = A and real AOD= 2*A (constant during the day) the Brewer/TUV is solar zenith angle dependent with lower values at high solar angles. Some discussion on the AOD values used as TUV inputs compared to real AOD values have to be included in the text.

It is true that the ratio of the sun scans with a constant (real AOD) versus TUV results with a constant AOD is solar dependent with lower values at high solar angles. But since we define a maximum value of 3 for the air mass, the effect of the above will be limited. As explained in the text, we also use a tolerance of 20% on the value of the ratio, which also takes this into account.

2751 line 25. As mentioned by the authors, ozone is negligible for this comparison.

For the sake of completeness, we mentioned the ozone value used as input for the

TUV model, even though the influence is negligible.

2753 some comments on the removal of the larger than 2 AOD values. You have to mention that you have removed larger than 2 AOD values as measured from the Brewer as the CIMEL has a cloud detection criterion (more or less similar with the Cheymol Brewer DS one). For future work I would suggest the improvement of this criterion by simply using Brewer/TUV ratios for single wavelengths and discard scans that show variability of this ratio during one Brewer sun scan. Or use pyranometer measurements that are high frequency measurements.

Changes have been made to the manuscript (on page 2753, lines 2-6) to clarify the removal of Brewer values larger than 2:

"When the Brewer AODs become larger than 2, there is virtually no agreement with the Cimel measurements. Based on this results, we decided to automatically remove all Brewer AOD values larger than 2 from our results on the assumption that they were influenced by clouds. No Cimel values were removed, since these values are already cloud screened."

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

Table 1: The mentioning of the days has no scientific significance. While a table with the days and the CCF together with a discussion on the instrument calibration stability has to be included. Since sun scans are used in this study there has to be a connection of these CCFs with changes on the UV scan calibration factors of the same instrument too.

Table 1 will be replaced by a new table with the days and the CF of these days. Extra information on the instrument stability was included in section 3 (methods, see comment before (p2752, line 17)).

Figures 3 and 5. Removing the outliers without further discussion on the issues behind these deviations does not help future users of this method to adopt it easily. I would

suggest presenting also outliers that not presented in figure 3 with some discussion on the deviations.

We chose to define a measurement as an outlier measurement, when the difference between the Brewer and Cimel measurement was higher than 0.5. The difference of 0.5 or higher between both instruments drew our attention and made us question these specific Brewer measurements. We looked at the frequency of differences higher than 0.5 and for more than 98% of the compared data, the difference between Brewer and Cimel is smaller than 0.5. For the compared period, there are only 4 Brewer measurements for which the difference with the Cimel value is higher than 0.5. These 4 outliers are all presented in Figure 3. It is thus impossible to present other outliers. For the 4 outliers, we looked at the measured irradiance and plotting this as a function of time revealed that clouds perturbed all these measurements. In the future, when an improved cloud screening algorithm is developed, these outlier measurements should however be automatically removed from the resulting dataset and they will thus no longer be used for comparison with the Cimel measurements.

With respect to your comment, we will add the following sentence on p2754, line 15: "We consider a single point in the scatter plot to be an outlier if the difference in AOD between Brewer and Cimel measurements is bigger than 0.5. This is the case for less than 2% of the compared values which made us question those individual Brewer measurements for which the difference was higher than 0.5."

2755. Does the AOD climatology includes all scans or outliers have been deleted? This has to be clarified.

The AOD climatology doesn't include the outliers. A sentence will be added in the revised manuscript (on page 2755, line 14-15) to clarify this. "The outlier values from the comparison with the Cimel are also not included in the analyzed dataset."

Figure 6 does not provide more information than figures 7 and 8 so it can be deleted for making the discussion straighter. Figure 10 also is out of the scope of this work.

Figures 6 and 10 will be deleted following the comments of the referee.

ANSWER TO TECHNICAL CORRECTIONS:

All the technical corrections have been taken into account.

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