Aerosol Optical Depth measurements at 340 nm with a Brewer spectrophotometer and comparison with Cimel sunphotometer observations at Uccle, Belgium

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1 Objectives

- Presentation of a new method for the retrieval of Aerosol Optical Depth (AOD) values at 340 nm using sun scan measurements from the Brewer spectrophotometer
- Comparison between the retrieved AOD values from Brewer#178 and the AOD values from the Cimel sunphotometer
- Analysis of the seasonal and monthly AOD variability at Uccle

2 Instruments and locations

In this study, measurements of the Brewer spectrophotometer and the Cimel sunphotometer are used. Both instruments are located in Uccle, Belgium (50°48'N, 4°21'E, 100 m a.s.l.) and are approximately 100 m apart.

- The Brewer#178 spectrophotometer is a double monochromator, originally developed to measure ozone at 5 specific wavelengths (320.1 nm being the largest). For the retrieval of the AOD values at 340 nm, sun scan measurements are performed between 335 nm and 345 nm. The obtained spectral data are convoluted with the band pass function of the Cimel sunphotometer filter.
- The Cimel sunphotometer is an automatic sun-sky scanning filter radiometer that computes the AOD at 340, 380, 440, 500, 675, 870 and 1020 nm. The instrument is part of the AERONET network.

3 AOD retrieval method

The Langley Plot Method (LPM) (as described in Cheymol & De Backer, 2003) is used for the retrieval of the AOD values from the Brewer sun scan measurements.

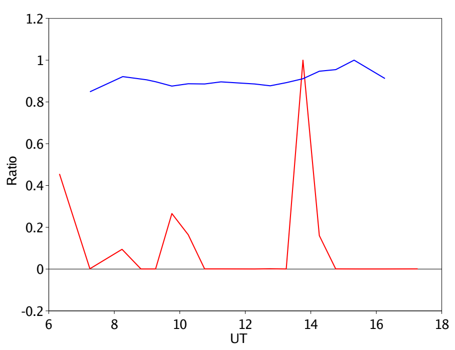

Figure 1. Ratio of the observed and expected irradiance for a cloudless (5 August 2007; in blue) and a cloudy (20 July 2008; in red) day at Uccle.

The LPM can only be applied on cloudless days and for the selection of these days, the following criteria are used:

- The sun scans for which the airmass is above 3 are removed.
- The range of air masses covered by the sun scans for one day must be at least 1.
- At least 10 sun scans per day have to remain after applying the first two criteria.
- The maximum deviation of the individual ratios (of the observed and expected irradiance) from the mean ratio for a certain day has to be smaller than 20%. (Fig.1)

Now one AOD and one Calibration Factor are calculated for each cloudless day. The average of these calibration factors will be used as mean calibration coefficient of the instrument. With this coefficient, the AOD can now be calculated for each individual clear sky observation.
A set of criteria to select the individual clear sky AOD values (from all the calculated AOD values), is defined:

- A direct sun observation must be available for each individual AOD measurement within a time period of 5 minutes.
- Each individual AOD value must be lower than 2. Larger values are removed from the results.

4 Comparison with Cimel sunphotometer observations

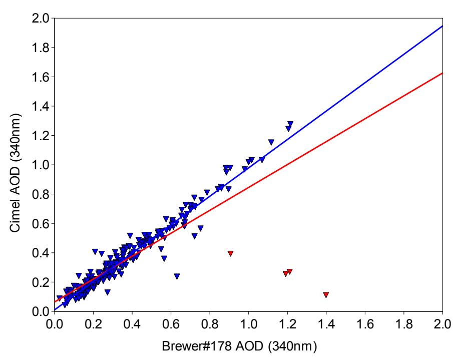

Figure 2. Comparison of the Brewer and Cimel AOD at 340 nm. The red $(f(x) = 0.781x + 0.065)$ and blue $(f(x) = 0.968 + 0.011)$ curve represent respectively the regression line of all the data and of the data without the outliers.

The retrieved Brewer AOD values at 340 nm are compared to quasi-simultaneous AOD values (with a maximum time difference of 3 min) from the Cimel sunphotometer for a period from 1 September 2006 to 31 August 2010. After removing the outliers, the correlation, slope and intercept of the regression line are respectively 0.974, $0.968 +/- 0.014$ and $0.011 +/- 0.006$ (Fig.2). This shows that good quality AOD observations can be obtained at 340 nm from Brewer#178 sun scan measurements with the proposed method.

5 Seasonal and monthly variability of AOD at Uccle

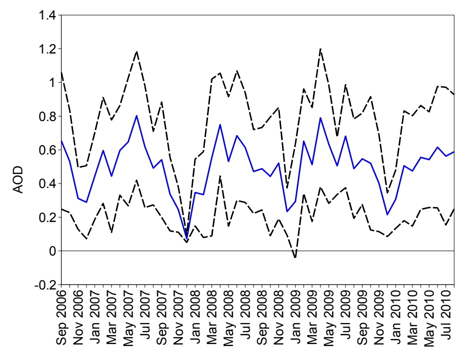

Figure 3. Monthly variation in AOD at 340 nm at Uccle. The blue line is the mean seasonal value, whereas the dashed black lines represent the mean value $+/-$ its standard deviation.

There is a clear seasonal cycle in the observed AOD at Uccle, with higher values in spring and summer and lower values in autumn and winter (Fig. 3 and 4). In winter, more than 60% of the values are lower than 0.4, whereas in summer, only 35% of the values are lower than 0.4.

- Highest values at Uccle: 0.79 +/- 0.38 (June 2007), 0.74 +/- 0.31 (April 2008) and 0.78 +/- 0.41 (April 2009)
- Lowest values at Uccle: 0.07 +/- 0.02 (December 2007), 0.23 +/- 0.14 (December 2008) and 0.21 +/- 0.13 (December 2009)

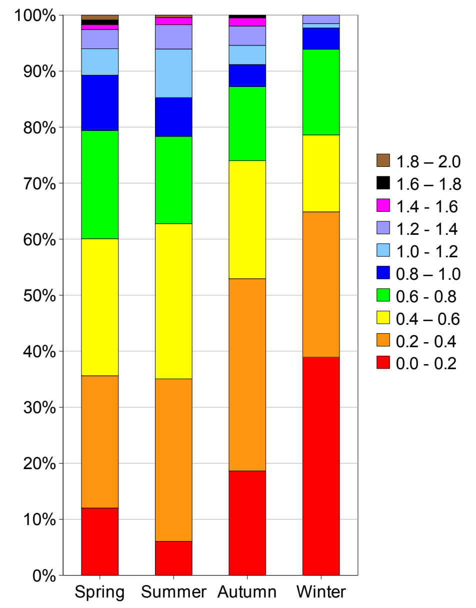

Figure 4. Seasonal frequency distribution of AOD values at 340 nm at Uccle.

6 Conclusions

By using the Langley Plot Method (with adapted criteria for the selection of cloudless days), the AOD can be calculated from sun scan measurements of the Brewer instrument. The sun scan measurements are performed between 335 and 345 nm and are convoluted with the band pass filter of the Cimel sunphotometer at 340 nm.

The comparison of the Brewer AOD measurements to quasi-simultaneous Cimel sunphotometer values shows that good quality AOD observations can be made using Brewer sun scan measurements.

There is a clear seasonal cycle in the observed AOD at Uccle with higher values in spring and summer and lower values in autumn and winter.

7 Outlook

Despite the automatic and manual cloud screening, the influence of scattered clouds on our measurements is still an issue for the calculation of the AOD values and the current cloud screening algorithm has to be improved to further increase the quality and reliability of the data.
The AOD retrieval method will also be used to retrieve the AOD from the Brewer measurements in Antarctica (after installation of the Brewer instrument in austral summer 2010-2011).

References

- Cheymol, A. and De Backer, H.: Retrieval of the aerosol optical depth in the UV-B at Uccle from Brewer ozone measurements over a long time period 1984-2002, J. Geophys. Res., 108, D24, doi:10.1029/2003KD003758, 2003.
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