Aerosol Optical Depth retrieval from Brewer spectrophotometers at Uccle, Belgium

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1 INTRODUCTION

Two Brewer spectrophotometer instruments are installed on the roof of the RMIB building at Uccle, Belgium (50°48'N, 4°21'E, 100m asl):

- **Brewer#016:** single monochromator; installed in 1984; Direct Sun (DS) measurements
- **Brewer#178:** double monochromator; installed in 2001; DS and Sun Scan (SS) measurements

2 METHOD

2.1 AOD retrieval method

Both the DS and SS measurements can be used to retrieve Aerosol Optical Depth (AOD) values, using the methods described in Cheymol and De Backer, 2003 (for DS measurements) and De Bock et al. 2010 (for SS measurements). The retrieval is based on the Langley Plot Method where one Calibration Factor (CF) and one AOD (A) value are determined for selected cloudless days. The average CF is calculated from the individual CF values. This value is then used to retrieve the AOD value for each individual DS or SS measurement (Figure 1).

Langley Plot Method

- The **signal** received by the Brewer (**S(λ)**) follows Beer's law:

$$S(\lambda) = K(\lambda)\, I_o(\lambda)\, \exp[- \mu\alpha(\lambda,T)\Omega - m\beta(\lambda)P/P_{std} - \delta(\lambda)\sec(z_a)]$$

While passing through the atmosphere, the direct beam at the top of the atmosphere is subject to absorption and scattering through 3 different physical phenomena:

(a) absorption by ozone

(b) scattering by air molecules

(c) extinction by aerosol particles

- Taking the logarithm of Beer's law:

$$\ln[S(\lambda)] + \mu\alpha(\lambda,T)\Omega + m\beta(\lambda)P/Pstd = \ln [K(\lambda)\, Io(\lambda)] - \delta(\lambda)\sec(z_a)$$

$$Y = CF - A * X$$

Figure 1. AOD retrieval method.

2.2 Cloud screening method

An automatic cloud screening method has been developed to remove the measurements that are perturbed by clouds (Figure 2). The advantage of this method is that we no longer need to use an upper limit above which AOD values are discarded.

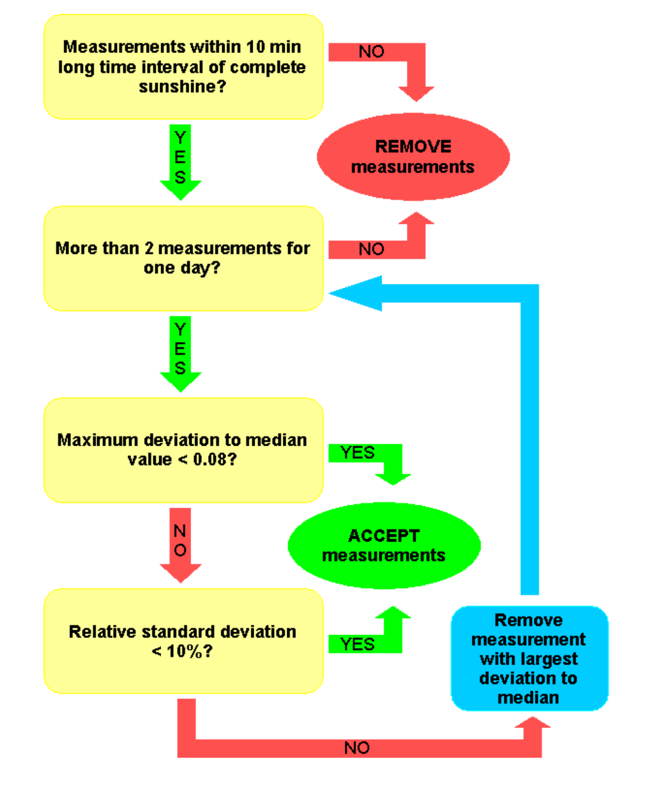

Figure 2. Cloud screening method.

3 STABILITY OF CALIBRATION FACTORS

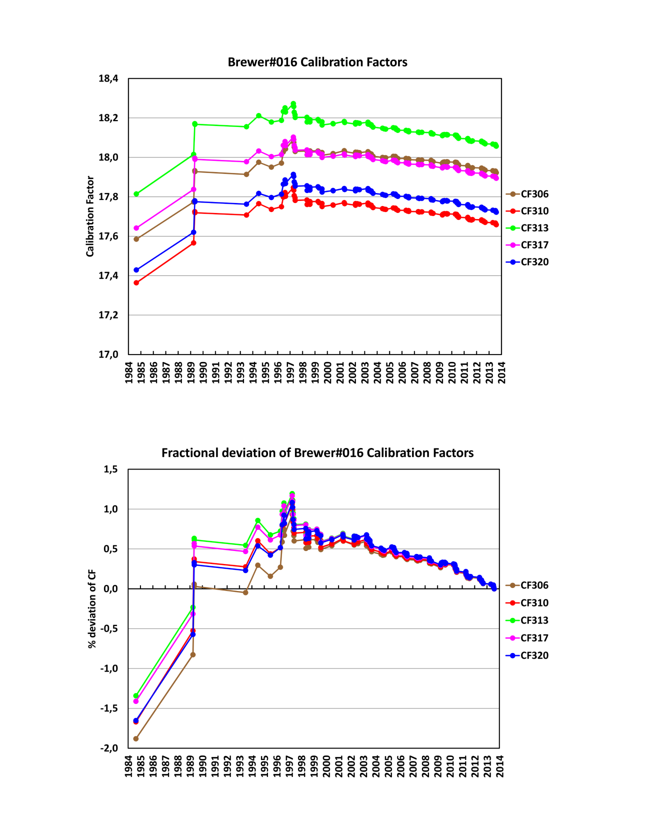

Figure 3. Stability of Brewer#016 Calibration Factors.

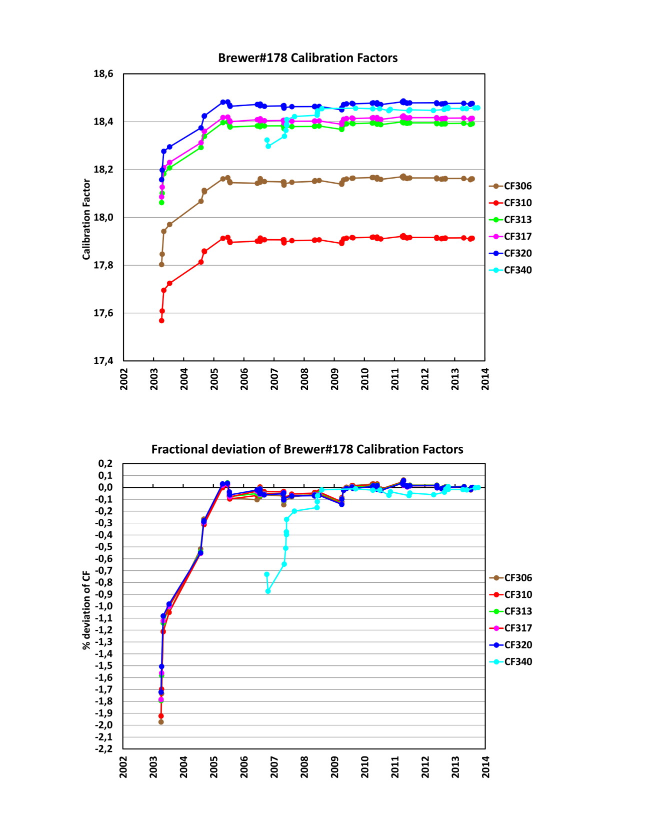

Figure 4. Stability of Brewer#178 Calibration Factors.

The upper panels in Fig. 3 and 4 show the CFs over time for Brewer#016 and Brewer#178 respectively. The lower panels present the deviation (in %) of the CFs with respect to the last CF. This is a way to study the long term stability of the CF of the instruments. It can be seen that over the last 10 years, Brewer#016 CFs have been quite stable, with differences staying lower than 0.5%. There seems to be a drift in the stability of the CFs, but this is something that can be corrected for. The CFs of Brewer#178 are more stable over time. The CFs determined from the DS measurements have been stable around 0.2%, whereas the stability of the CFs from the SS measurements is around 0.1%.
Table 1 shows the response of the AOD values to the changes in CF values.

		Change in CF	Maximum absolute change in AOD	Average absolute change in AOD
320nm	BREWER#016	0,5%	0,08	0,05
	BREWER#178	0,2%	0,04	0,02
340nm	BREWER#178	0,1%	0,02	0,01

Table1. Maximum and average change in AOD caused by changes in Calibration Factors

4 COMPARISON WITH CIMEL AOD VALUES

The AOD values retrieved from the Brewer measurements are compared to co-located, quasi-simultaneous (max. time difference of 3 minutes) Cimel level 2.0 values (http://aeronet.gsfc.nasa.gov/; site: Brussels).
For both Brewer instruments, the AOD values at 320nm (retrieved from the DS measurements) are compared to Cimel values at 320nm (extrapolated from 340nm to 320nm using the Angstrom parameter). The Brewer#178 AOD values at 340nm (retrieved from the SS measurements) are compared to the Cimel values at the same wavelength.

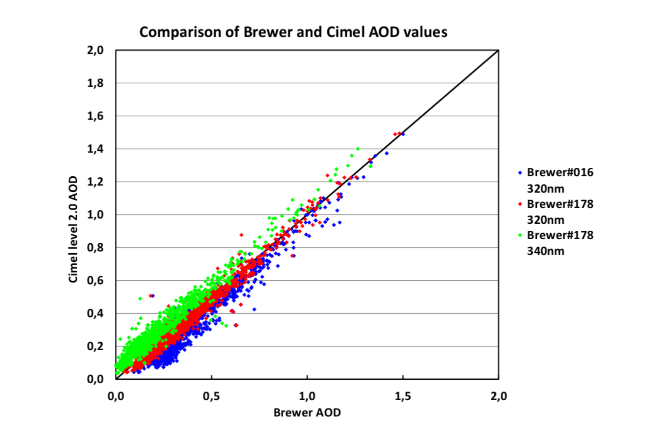

Figure 5. Comparison of quasi-simultaneous Brewer and Cimel AOD values from 2006 until 2013.

		Correlation	Slope	Intercept
320nm	Brewer#016 - Cimel	0,974	1,004+/-0,006	-0,067+/-0,003
	Brewer#178 - Cimel	0,985	1,007+/-0,005	-0,017+/-0,002
340nm	Brewer#178 - Cimel	0,979	0,993+/-0,007	0,073+/-0,002

Table2. Regression coefficients, slope and intercept values between Brewer and Cimel AOD values.

From Figure 5 and Table 2, it is clear that the Brewer AOD values agree very well with the Cimel measurements. For both Brewer DS and SS AOD values, the slope of the regression equation is close to 1. The Brewer AOD values at 320nm are slightly higher than the Cimel values, whereas the opposite is true for the Brewer values at 340nm.

5 CONCLUSIONS

The Calibration Factors of Brewer#016 are stable to within 0.5% over the last years. The associated AOD uncertainty is 0.08 at 320nm.

The stability of the Brewer#178 Calibration Factors seems to be better than Brewer#016. The values are stable to within 0.2% at 320nm and 0.1% at 340nm. This leads to a maximum absolute change in retrieved AOD values of 0.04 at 320nm and 0.02 at 340nm.

Comparing the retrieved Brewer AOD values with the co-located, quasi-simultaneous Cimel level 2.0 data, shows a good agreement between both instruments. This demonstrates that the Brewer AOD retrieval methods using DS and SS measurements generate reliable results.

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References

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