Comparing the year 2016 Total Ozone Column measurements at Uccle and Diekirch

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Abstract:

The total ozone column measurements made during the year 2016 at Uccle (WOUDC station 053) and Diekirch (WOUDC station 412) are compared, using only direct sun (DS) measurements.

The Uccle measurements were made by two different Brewer instruments, the Diekirch measurements by two different broadband Microtops II instruments. The Diekirch readings follow the heavily changing Uccle data in a quite satisfying manner. The 159 same day measurements used for the comparison suggest to apply a **calibration multiplier of 1.034** to the Microtops readings to make them comparable to the Uccle measurements. This calibration factor has remained very similar since 2011.

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1. The Diekirch Microtops II measurements.

Most of the 184 daily measurements during the year 2016 were made using the Microtops II broadband sun photometer from Solar Light Co., serial number 5375 (operator Francis Massen, location Bettendorf)). 68 measurements were made with the Microtops II, serial 3012 (operator Mike Zimmer, location Schieren). The two locations being very close to Diekirch (distance less than 10 km, practically same altitude), Diekirch is taken as the representative point of measurement. Several comparisons suggested to apply a multiplier of 0.9422 to the readings of instrument #3012, to make them comparable with those of instrument #5375. So the Diekirch data series has been homogenized as representative of instrument #5375. Only the "O3(corr)" readings which combine the three spectral channels are used in this report. Out of these 184 measurements, 159 are usable for a comparison of same-day, direct sun measurements with Uccle.
The Diekirch TOC raw data are available at the data archive of meteoLCD [**ref. 2**], the "O3(corr)" readings at the WOUDC side **[ref. 1**]

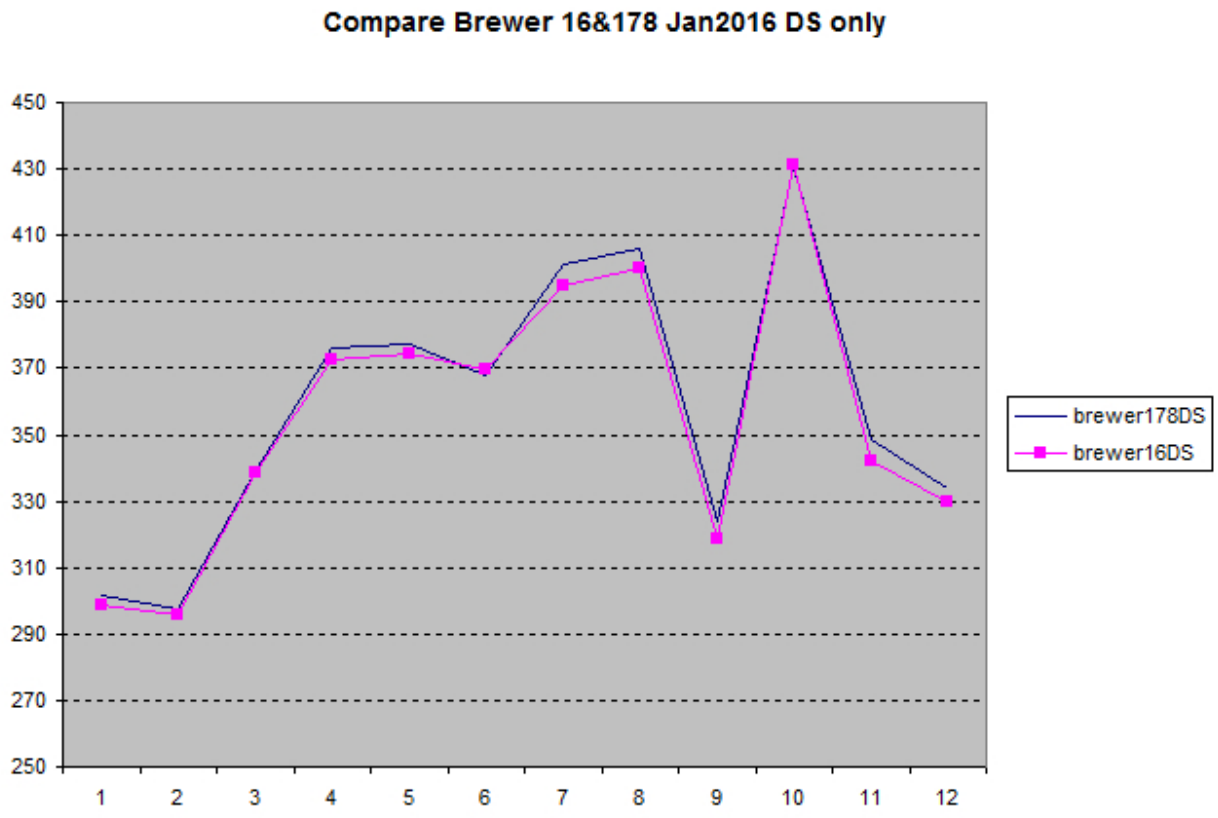

Fig.1. Brewer 16 and 178 direct sun measurements during January 2016

2. The Uccle measurements.

Uccle measures TOC using two different Brewer instruments (Brewer 16 and Brewer 178, [**ref. 1**]); overlapping measurements are available only for January 2016. A comparison of the 12 simultaneous measurements shows that the readings are very close, with Brewer 16 being constantly lower than Brewer 178, as shown by the following plot (fig.1):

An xy-plot (fig.2) suggests a calibration multiplier of 0.9914 to apply to the #178 readings to make them comparable to those of Brewer 16:

As this number is practically equal to 1, we will use in the comparison both Uccle instruments without any distinction (but checking the validity of this restriction by using only the Brewer 16 measurements in a separate comparison).

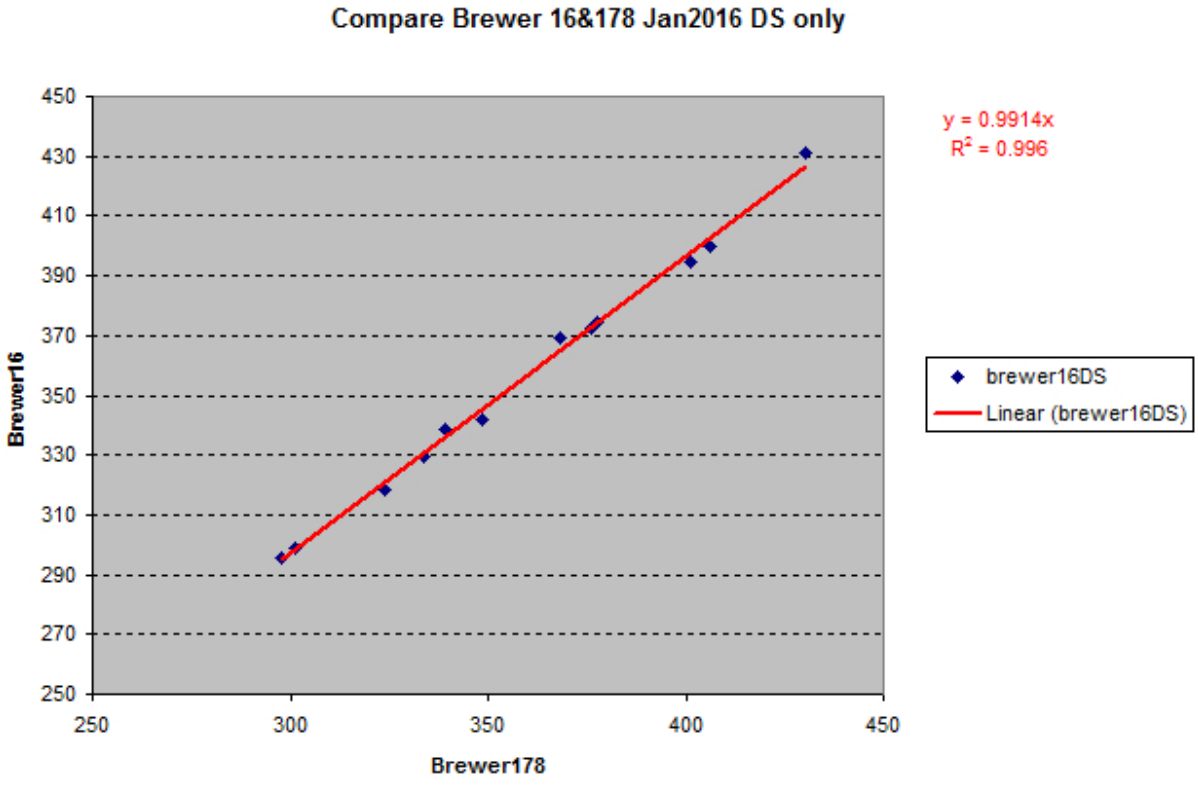

Fig 2. Brewer 16 versus Brewer 178 for the preceding measurements.

The Uccle data series runs as shown in the following table:

period	instrument	number of data points
8 Jan - 29 Jun	Brewer 16	80
1 Jul - 25 Sep	Brewer 178	54
3 Oct - 16 Oct	Brewer 16	8
1 Nov - 30 Nov	Brewer 178	9
3 Dec - 24 Dec	Brewer 16	8

3. Comparing all DS measurements from Uccle with the same day measurements at Diekirch

The mean +/- standard_deviation of the TOC in DU (Dobson unit) are the following, using the 159 same day measurements (with no restriction concerning the time of the day):

	average	**stdev**
UCCLE	331.7	41.3
DIEKIRCH	320.9	44.3

The following plot (fig.3) shows the two data series (the x axis corresponds to the number in the series, going from January to December, but does not represent equidistant time intervals):

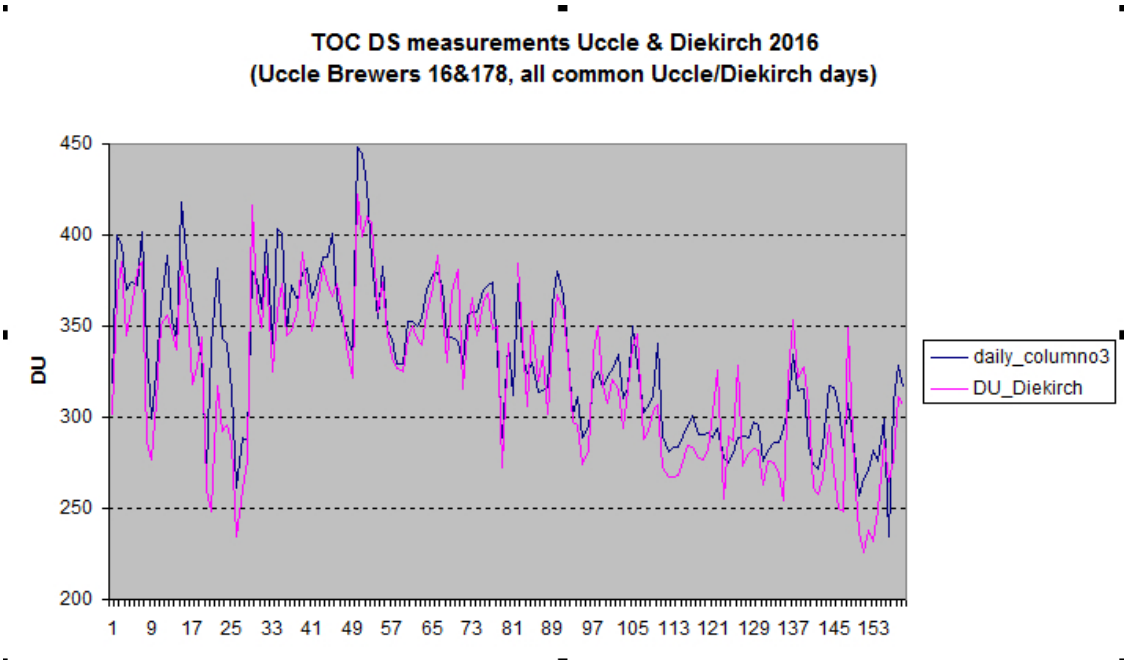

Fig.3. Uccle combined Brewer 16&178 and same day Diekirch TOC.

Obviously the Diekirch data are nearly always lower than those of Uccle; nevertheless the sudden TOC spikes are synchronous and well apparent in both data series. The next XY plot gives the Diekirch data (y variable) versus the Uccle data (x variable). The linear regression forced through the origin suggests to apply a multiplier of 1/0.9668 = 1.034 to the Microtops measurements to make them comparable to the Brewer readings. R^2 (which tells us how much of the variance between the two series is explained by the linear regression) is practically 0.80, which is an acceptable value.

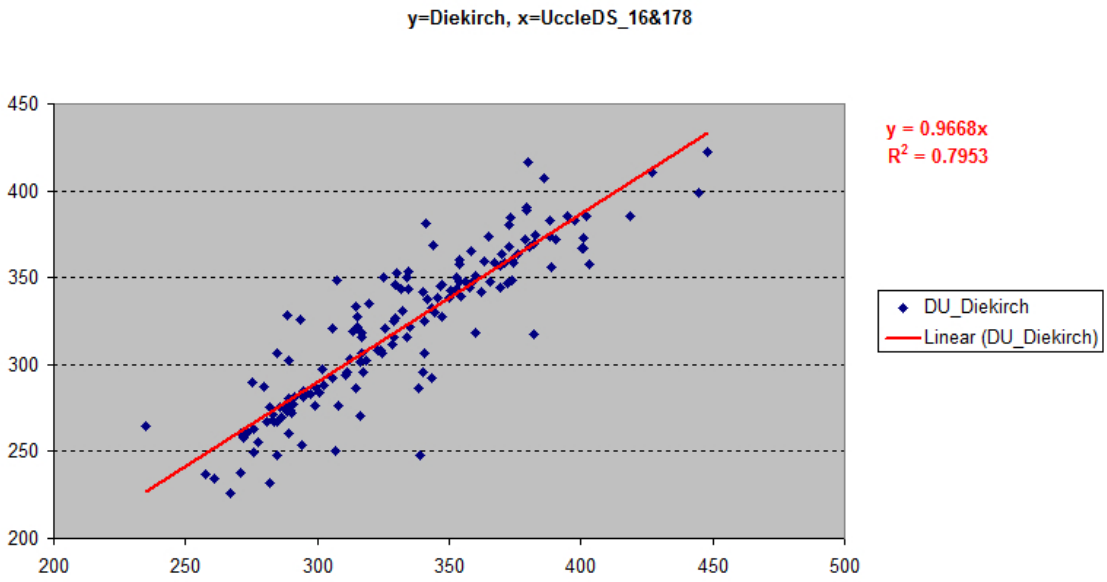

Fig.4. Diekirch versus all same day DS Uccle measurements

Clearly there is quite a lot of spread, and a few points (as for instance the [339, 249]) could probably be considered as distinctive outliers. One should not ignore that the meteorological conditions between Diekirch and Uccle (distance ~170 km) usually are not identical.

Just to situate this spread, check the following figure 5 from the 2005 intercomparison **[ref. 4]** which included also satellite born instruments.

Here $R^2 = (GOF)^2 = 0.81$ for the intercomparison of Uccle with the satellite flown TOMS instrument.

In the next chapter we will restrict the common measurements to one single Brewer and check measurements made at a similar time of the day.

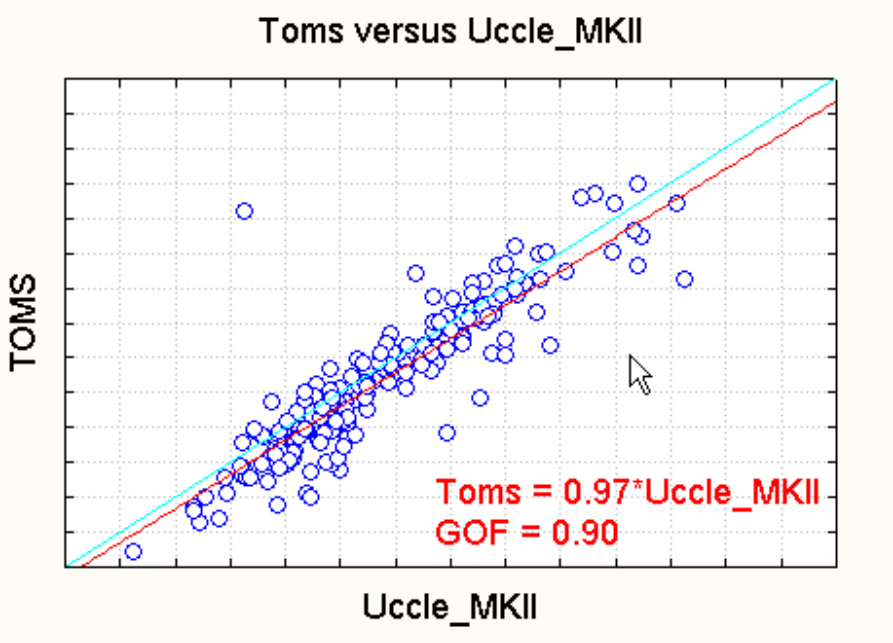

Fig.5. Comparison between TOMS and Uccle TOC measurements during 2005

4. Comparison using only the DS Brewer 16 measurements.

Restricting the comparison to Brewer 16 only data leaves, as shown in the preceding table, only 96 data points; the summer period from July to September being absent.

The XY plot shows a nearly identical slope of the regression line and practically the same R^2; so the decision to use both Brewer series in common can be justified.

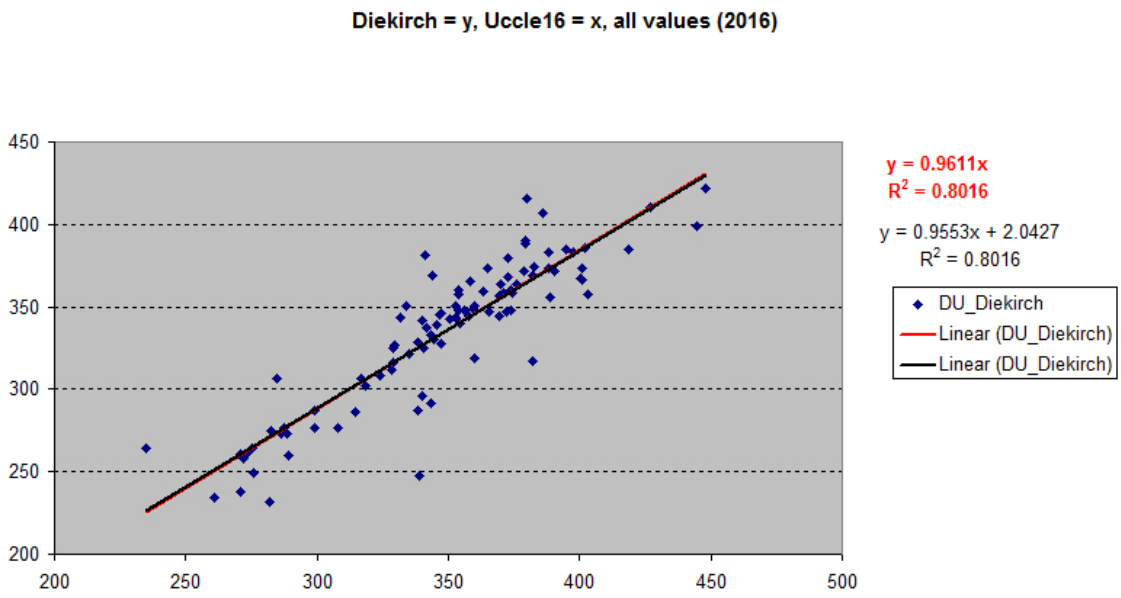

Fig.6. Diekirch versus all same day DS Uccle Brewer 16 only measurements

5. Comparison using only readings made at close times.

The TOC at a given location varies (slightly) with the time of the day. At Diekirch, a series of measurements is done once a day (usually close to 11:00 or 12:00 UTC, weather conditions permitting), and the mean of these measurements kept as definitive result. (All original raw measurements are still available at the data archive of meteoLCD). Uccle makes a varying number of measurements during the day, and this number can vary from 1 to 25. The WOUDC data base gives the ending time and the mean time (=[end-begin]/2). Let us restrict the comparison to readings made at Diekirch not earlier or later than 1 hour of this Uccle mean time (i.e. abs(Diekirch_time - Uccle_meantime) < 1). This leaves 93 common data points:

With this restriction.the R^2 factor is slightly higher, but the slope of the linear regression line remains very close to 0.96.

As a consequence we may conclude that a comparison can rightfully be made using all available Uccle same day DS measurements, regardless of the Brewer instrument or the time of measurements.

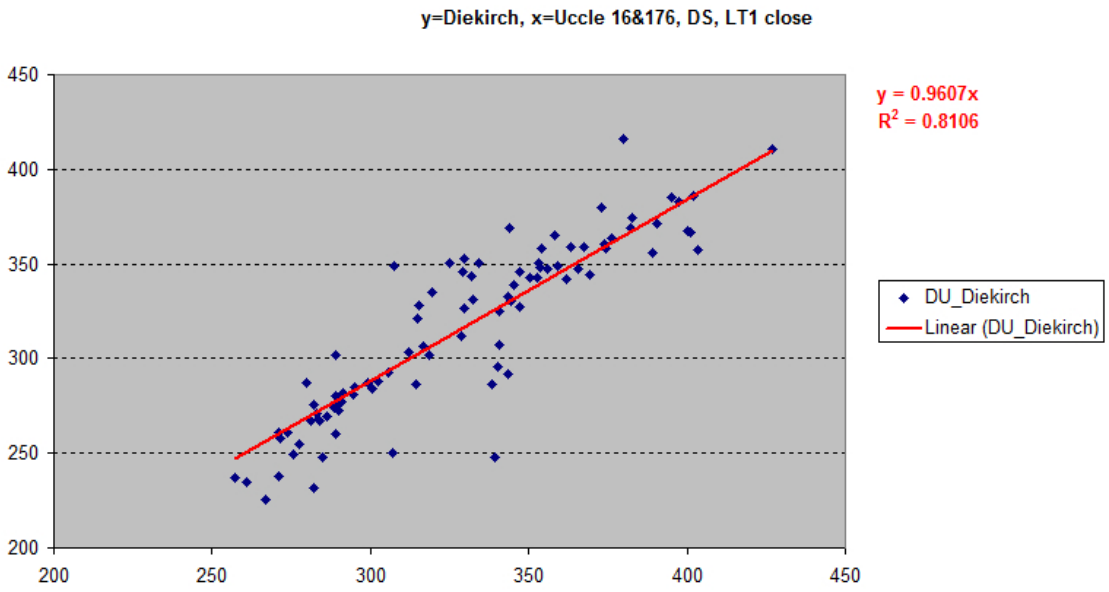

Fig.7. Diekirch versus all same day DS Uccle Brewer measurements, where measuring time differs less than 1 hour.

6. Conclusion

The calibration factors, rounded to 3 decimals, found in the last years are the following **[ref.3]**::

2011	1.060	Brewer 178
2012	1.029	Brewer 16
2014	1.044	Brewer 178
2015	1.033	Brewer 178
2016	**1.034**	**Brewer 16 & 178**

The R^2 is always close to or higher than 0.8. These numbers show that the Microtops #5375 has not changed much since at least 2012, and that its readings can be used with confidence as a possible supplement to the vastly more expensive Brewer instrument.

7. References

1 http://www.woudc.org/data/explore.php (Uccle: choose Total Ozone, daily observations, station 053, year 2016; Diekirch: choose Total Ozone, daily observations, station 412, year 2016)

2 data archive of meteoLCD: http://meteo.lcd.lu/data/index.html

3. http://meteo.lcd.lu/papers/ozone/uccle/index.html

4. http://meteo.lcd.lu/papers/ozone/uccle/2005/uccle_2005.html

An Excel file with all relevant data can be found at
http://meteo.lcd.lu/data/dobson/UCCLE/2016/uccle_2016_DS_Brewer16178.xls