Long-Term Ozone Observations in Uccle

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1 Introduction

At the Royal Meteorological Institute in Uccle (Belgium, 50°48'N, 4°,21'E) routine ozone observations started in 1969. The program consists of daily total ozone observations with spectrophotometers and ozone soundings with balloon borne electro-chemical sensors on Mondays, Wednesdays, and Fridays. During the whole period careful track was kept of the calibration history of the spectrophotometers. As to the ozone soundings, there were some interruptions, but nevertheless it is one of the longest and most complete ozone sounding data sets that exists. Over the time period many changes in the operating procedure and instrumentation occurred. Some of them influenced the performance of the sensors and thus introduced artificial jumps. Recently the data set was homogenised. Comparison with SAGE II satellite ozone profiles shows that there is good agreement in the overlapping altitude range. With this quality assurance, the time series can be used for reliable trend analysis.

2 Total ozone observations

2.1 Instrumentation Total ozone is observed with two instruments:

- Dobson n° 40, in use since 1971, and calibrated in 1971, 1978, 1980, 1986, 1990, 1995, 2000. This instrument appeared to be a very stable instrument. The only problem was the interference of SO_2 during the early observing years, but a correction is applied for this [De Muer *et al.*, 1992].
- Brewer n° 16, in use since 1983, calibrated relative to Dobson n° 40 in 1984, but kept independent afterwards [De Backer and De Muer, 1991]. Calibration checks were performed in 1989 and 1994 with the travelling Brewer standard. The Brewer instrument is also used since 1989 for the observation of UVB irradiation (290-325 nm)
- In September 2001 a new double Brewer (n° 178) is installed for total ozone and UVB/UVA (286-363 nm) observations.

2.2 Comparison of instruments Figure 1 shows that there is a small seasonal cycle in the differences between the Brewer and the Dobson instrument (<2 %), and no significant drift (<0.5 % over almost 19 year).

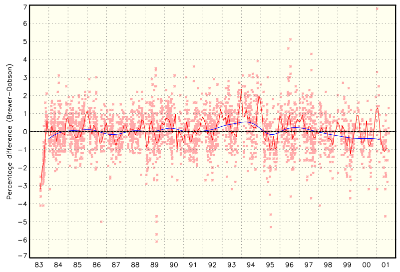

Figure 1. Percentage differences between Brewer and Dobson Direct Sun observations at Uccle (crosses); data are filtered to remove synoptic variations (red line) and to remove seasonal variations (blue line).

2.3 Trend in total ozone Figure 2 shows the time series of total ozone at Uccle, using a filter to remove the variations with frequencies higher than one year. The good agreement between the instruments (after application of the SO_2 correction) may be noticed.

The effect of stratospheric aerosols after major volcanic eruptions (Mt Pinatubo in 1991, El Chichon in 1982) can clearly been seen.
The overall trend is -5.1±0.8 DU or -1.5±0.3 % per decade, for the period 1971-2001.

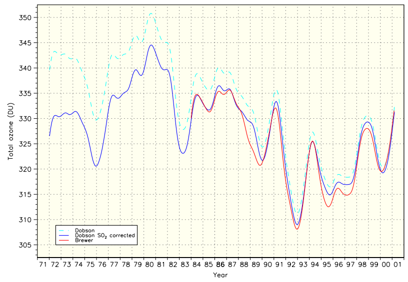

Figure 2. Smoothed time series of total ozone obtained at Uccle with Dobson n° 40 (without an with SO_2 correction), and Brewer n° 16.

3 Ozone profile measurements

3.1 Instrumentation Ozone profiles were measured with Brewer-Mast sondes from 1969 until March 1997. From April 1997 until now, Z-ECC sondes are used. This change is well documented [De Backer *et al.*, 1998]. The main consequence was a change of the procedure for the correction for the change of the pump efficiency. To obtain a homogeneous time series, corrections were made for [De Backer, 1999]:

- the box-temperature which was not measured before 1990;
- the altitude needed to eliminate the effect of the use of different sensors;
- the interference of SO_2 with the ozone measurements, due to the dramatic decrease of SO_2 during the 1970's;
- the different available information on the background current;
- the pump efficiency of the sensor, which changed over the years.

3.2 Comparison with SAGE II profiles An additional confirmation for the validity of the homogenisation was obtained by comparison with an independent data set, namely the SAGE II ozone profiles [Lemoine and De Backer, 2001]

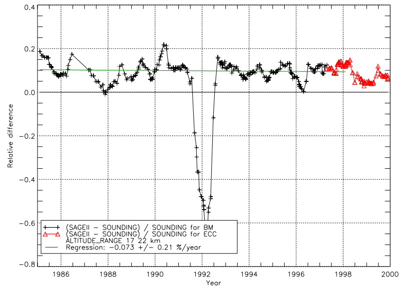

Figure 3a. Relative difference (SAGE II-Sonde/Sonde) at 17-22 km altitude between SAGE II and Uccle Brewer-Mast (black crosses) and ECC (red triangles) ozone soundings as a function of time after homogenisation.

Figure 3a and 3b show the comparison at (17-22 km and at 26-30 km respectively) from 1986 until 2000. The most remarkable difference is seen in the lower levels in 1992, and is caused by the disturbance of the SAGE II observations by the volcanic aerosols of the Mt Pinatubo. It should be noted that the change from Brewer-Mast to Z-ECC type of sensors had no influence on this inter-comparison. The long-term drift between the data sets at each altitude are statistically insignificant.

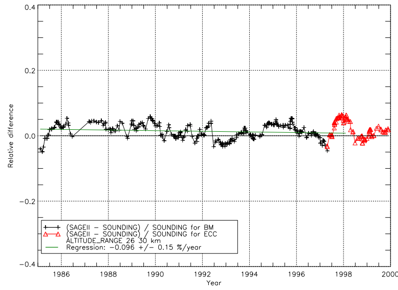

Figure 3b. As Figure 3a, but at 26-30 km.

3.3 Trends in ozone profiles Figure 4 shows a season-height cross section of ozone trends over Uccle. The height is relative to the tropopause: positive values are km above the thermal tropopause, while the negative values are equidistant between tropopause (0) and ground (-10). Since the tropopause is approximately at 10 km, the values can be regarded as km below tropopause. The main features are:

- the trends are positive in almost the whole troposphere;
- the largest trends are found near the ground in April-May;
- in fall there is a significant positive trend in the whole troposphere;
- negative trends dominate in the stratosphere, especially during winter and spring.

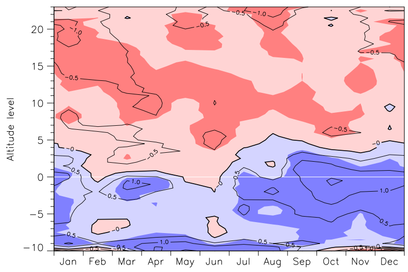

Figure 4. Season-height cross section of ozone trends at Uccle, over the period 1969-2001, in percent per year. The dark colours indicate the zones where the trends are statistically significant. The height scale is relative to the tropopause (see text).

4 Future

The observing program will be continued. When the new Brewer is fully operational the Dobson observations will be phased out. More extended studies of the ozone sounding data set are now being undertaken (especially in the troposphere). The data are also used for the validation of ozone data from satellites (ENVISAT, ERS-2, METOP).

References

- De Backer, Hugo and D. De Muer, Intercomparison of total ozone data measured with Dobson and Brewer ozone spectrophotometers at Uccle (Belgium) from January 1984 to March 1991, including zenith sky observations, *J. Geophys. Res.*, 96, 20711-20719, 1991.
- De Backer, Hugo, D. De Muer and G. De Sadelaer, Comparison of ozone profiles obtained with Brewer-Mast and Z-ECC sensors during simultaneous ascents, *J. Geophys. Res.*, 103, 19641-19648, 1998.
- De Backer, Hugo, Homogenisation of ozone vertical profile measurements at Uccle, *Wetenschappelijke en technische publicatie van het Koninklijk Meteorologisch Instituut van België*, n° 007, ISSN n° D1999/0224/007, Brussel, also available on ftp://ftp.kmi-irm.be/dist/meteo/hugo/publ/1999/o3prof.ps, 1999.
- De Muer, Dirk. and H. De Backer, Revision of 20 Years of Dobson total ozone data at Uccle (Belgium); Fictitious Dobson total ozone trends induced by sulfur dioxide trends, *J. Geophys. Res.*, 97, 5921-5937, 1992.
- Lemoine, René and H. De Backer, Assessment of the Uccle ozone sounding time series quality using SAGE II data, *J. Geophys. Res.*, 106, 14515-14523, 2001.

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Celebrating 10 Years of Atmospheric Research, NDSC Symposium, Arcachon, 24-27 September 2001.