# Revision of 40 years of ozone measurements in Uccle, Belgium


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## 1 Data

The Royal Meteorological Institute at Uccle (Belgium, 50°48' N, 4°21' E, 100 m asl) has a long tradition of ozone observations. The ozone data on which the time series analysis described in this poster is based, are:

- total ozone column measurements with either a Dobson or Brewer spectrophotometers since mid 1971,
- vertical ozone profiles obtained with radiosondes (three times a week) since January 1969.

## 2 Aims

- to update the observed ozone trends above Uccle,
- to make a time series analysis of the vertical distribution of ozone layers **relative to the tropopause**.

## 3 Total ozone

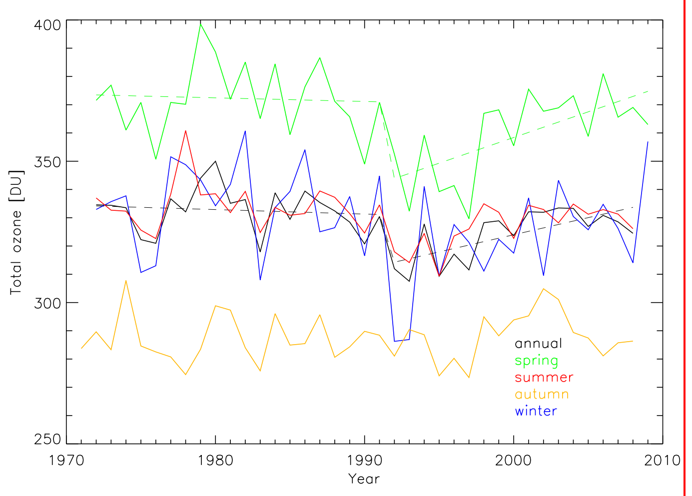


**Figure 1.** Annual and seasonal means of total ozone column measurements with the Dobson or Brewer spectrophotometers at Uccle.

Overall, since 1971 the total ozone column above Uccle decreased at a rate of $-0.79 \pm 0.43\,\%$/decade. This decrease is largest and most significant in spring ($-0.92 \pm 0.59\,\%$), whereas in autumn no trend is observed.

However, as should be clear from Fig. 1, the time series can be divided in periods representing different trends. As a matter of fact, the total ozone column above Uccle

- decreased slightly from 1971 until 1991,
- reached its minimum in the years 1992–1993 (especially in the winter), enhanced by the volcanic eruption of Pinatubo in June 1991,
- starts to increase again from the second half of the 1990s as a result of the protocol of Montreal.

This double trend is again most pronounced in the spring time series and is absent during autumn.

## 4 Vertical distribution of ozone

The mentioned total ozone trends can be resolved vertically by using the vertical ozone profiles observed with radiosondes. Above Uccle, tropospheric ozone increases at a rate of about $3.5\,\%$/decade (see Fig. 2), while stratospheric ozone decreases at $-2.5\,\%$/decade. These trends are significant at the $2\sigma$ level.

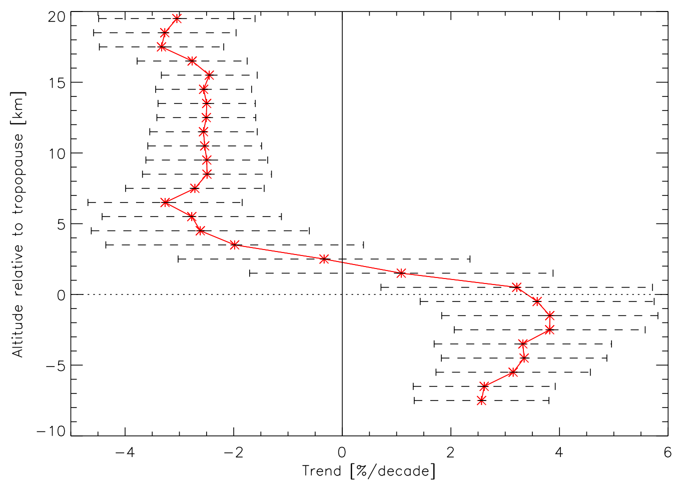


**Figure 2.** Vertical profile of ozone trends based on radiosonde data. The trends were estimated using linear regression to the total ozone content of layers of a thickness of 1 km, with the height scale relative to the tropopause. The $2\sigma$ error bars are shown.

In order to study the changeover between the negative and positive ozone trends, which occurs in the Upper Troposphere Lower Stratosphere (UTLS), we show in Fig. 3 the trends resulting from a linear regression on the monthly mean ozone partial pressures obtained during the 40 years of observations. It appears that from February to June the changeover is sharp and located at the tropopause. From July to January, the positive trends in the troposphere extend into the lower stratosphere.

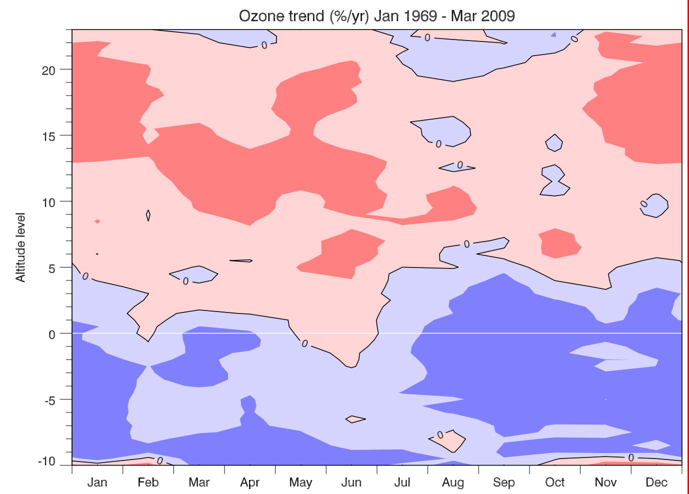


**Figure 3.** Season-height cross section of ozone trends in percent per year at Uccle. The height scale is relative to the tropopause; the negative values are relative heights between the tropopause (0) and the ground level (-10). Areas where the trend is statistically significant at the 95 % level are coloured darker (red for negative and blue for positive trends).

Finally, in Fig. 4, we present the average seasonal vertical profiles for each decade. It should be clear that the largest (and solely) **tropospheric** ozone increase occurs in the 1979–1988 decade. Only during wintertime, the ozone concentrations start to decrease again thereafter (see also Fig. 3 for the surface values).
The largest **stratospheric** ozone decline takes place a decade later, during the 1989–1998 decade, except during autumn. Of course, the Pinatubo eruption also contributes to this decrease. During the last decade, the stratospheric ozone recovers mostly during spring in the lower stratosphere (increased strengths of the secondary ozone peaks).

Yang et al. (2006) attributed this lower-stratospheric ozone recovery to dynamical and transport changes, rather than driven by declining chlorine and bromine. In any case, Fig. 3 seems to exclude cross-tropopause transport in spring, contrary to e.g. the findings in Ordóñez et al. (2007) for Jungfraujoch and Zugspitze. During winter too, lower-stratospheric ozone recovers substantially this last decade, although, as for every other season, the average profile of the first decade (1969–1978) is still out of reach at every altitude.

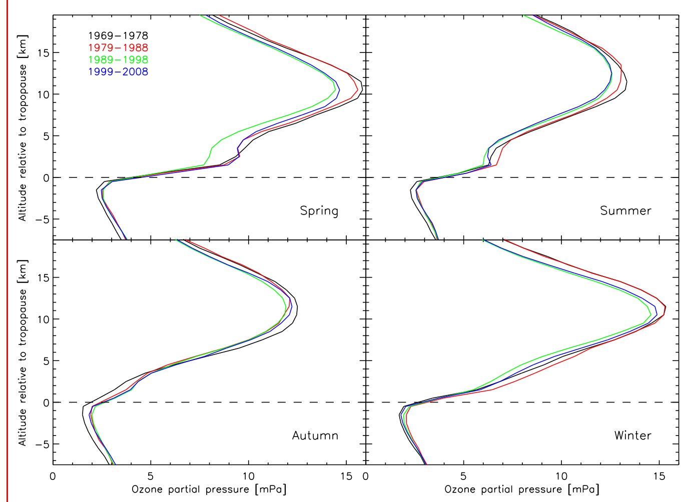


**Figure 4.** Average seasonal vertical ozone profiles for each decade. Once again, the height scale is relative to the tropopause.

## 5 Conclusions and outlook

Above Uccle, since 1969, stratospheric ozone declined at a rate of $-2.5\,\%$/decade, tropospheric ozone concentrations increased at $3.5\,\%$/decade.

Lower-stratospheric ozone recovers since the second half of the 1990s, especially during spring (and winter).

This poster is the onset of a more thorough trend analysis of the ozone concentrations above Uccle, using the Effective Equivalent Stratospheric Chlorine (EESC) function. Correlations with trends of other atmospheric variables will also be investigated.

## References


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This research is conducted within the framework of the Solar-terrestrial Center of Excellence (STCE) and is funded by the Belgian Federal Science Policy Office.



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**European Geosciences Union General Assembly 2009**, Vienna, Austria, 19-24 April 2009.