THE VERTICAL DISTRIBUTION OF OZONE AT PRETORIA FROM JULY 1990 TO JUNE 1991 AND ITS CHANGES

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ABSTRACT

Total ozone and the vertical distribution of ozone were measured at Pretoria between 1965 and 1968. Total ozone measurements recommenced in Pretoria in August 1989, and measurements of the vertical distribution of ozone near Pretoria recommenced in July 1990. Relative to the earlier data, mean monthly total ozone values are significantly higher in all months, with a mean annual relative increase of 12%. The recent profiles show a significant increase in the mean monthly concentration of ozone in the lowest 12 km. Concurrent to this increase a relative decrease in ozone concentration is shown between 12 and 42 km.

The increased ozone concentration in the lower troposphere may be related to urbanization and the increase in ozone-forming nitrogen oxides over the last two decades. It is suggested that the decreased ozone concentration in the stratosphere and upper troposphere is evidence of the global decrease in the mid-latitudes of the Southern Hemisphere.

INTRODUCTION

Pretoria is situated at 25°44'S and 28°11'E, at an elevation of about 1500 m above sea level, in South Africa's Transvaal province, the industrial and financial nucleus of the country where 60% of the approximate 30 million strong nation live and work.

In April 1964 total ozone was measured above Pretoria using a Dobson spectrophotometer and in May 1965 measurements of the Umkehr effect commenced, providing measures of the vertical distribution of ozone. Both of these measurements continued on a regular basis until February 1972. In 1989 the Dobson spectrophotometer was refurbished and calibrated at the NOAA laboratory in Boulder and measurements of total ozone resumed again in Pretoria in August 1989. In June 1990 the Dobson was relocated to the Irene Weather Office, 20 km south of Pretoria, where Umkehr measurements commenced in July 1990 and these were supported in October 1990 by weekly ozonesonde soundings.

BACKGROUND OZONE PROFILES

From the period May 1965 to December 1968, 645 Umkehr profiles were computed and averaged to obtain mean monthly vertical ozone profiles (Zunckel et al, 1992). These profiles showed ozone concentrations to increase steadily with height from partial pressure values of less than 1 mPa near ground level to values of about

14 mPa between 24 and 30 km altitude. Above this level the concentration decreases again to values approaching zero above 54 km altitude.

Large variability in ozone concentration in the vicinity of the tropopause suggests an interaction between the troposphere and stratosphere and a possible source of stratospheric ozone into the troposphere. Small variability in ozone concentration and a systematic decrease in concentration downward from the stratosphere suggests that sources of tropospheric ozone, other than stratospheric, were not significant.

These early ozone data are considered fundamental and represent the ozone situation over the central parts of South Africa before the main onset of stratospheric ozone depletion, and before large-scale industrialization and urbanization in the Pretoria area. They provide an ideal background against which current and future ozone values may be compared

CURRENT OZONE PROFILES

For the 12-month period July 1990 to June 1991, 75 Umkehr profiles were computed and averaged to obtain mean monthly vertical ozone profiles. These current profiles show ozone concentration to increase with height from partial pressure values of between 2 and 3 mPa near ground level to values of between 13 and 14 mPa in the layer between altitudes of 24 and 30 km. Above this level ozone concentration decreases towards zero above 54 km asl.

Large variability in concentration exists in the vicinity of the tropopause and in the layer from ground level to an altitude of 6 km, suggesting a stratospheric source of tropospheric ozone as well as a source of ozone near ground level.

COMPARISON OF OZONE PROFILES

Annual mean total ozone during the earlier period was 259 DU and the corresponding mean for the current period is 290 DU (Bruintjes et al, 1990). This represents a relative increase in total ozone of 12%. In investigating the apparent increase in total ozone, mean monthly values of ozone concentration in nine layers from ground level up to an altitude of 54 km at 6 km intervals were examined. The relative changes in each layer are listed in Table 1, from layer 1 extending from ground level to 6 km altitude up to layer 9 extending from 48 to 54 km altitude.

TROPOSPHERIC OZONE

The significant increase in tropospheric ozone can largely be attributed to a steady increase in electricity production in coal fired power stations within a 200 km arc to the east and southeast of Pretoria and a steady increase in the number of motor vehicles on Pretoria's roads. Motor vehicle numbers have quadrupled in Pretoria since 1966 and the national electricity, mostly in coal fired stations, has increased by five fold since 1965. These increases imply an increase in the concentration of ozone precursor gases in the troposphere and an increase in tropospheric ozone concentration.

Table 1: The mean annual change in ozone concentration in the nine atmospheric layers.

Layer	Background (mPa)	Current (mPa)	Percentage change
1	0.4	2.7	575
2	2.1	3.2	52
3	4.8	4.1	-15
4	10.3	9.4	-9
5	14.1	13.4	-5
6	9.4	9.1	-3
7	4.7	4.4	-6
8	1.90	1.87	-
9	0.55	0.59	-

STRATOSPHERIC OZONE

Since conditions suited to chlorine destruction of ozone do not readily occur in the relatively warm Pretoria stratosphere it is felt that the most feasible explanation for the relative decreases in concentration found in the stratosphere can largely be attributed to dilution. Air above Pretoria that is relatively rich in ozone may be diluted by ozone-poorer Antarctic air after the break down of the polar vortex in late spring.

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