N95-11045

LONG-TERM OZONE AND TEMPERATURE CORRELATIONS ABOVE SANAE, ANTARCTICA

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ABSTRACT

A significant decline in Antarctic total column ozone and upper air temperatures[1] has been observed in recent years. Furthermore, high correlations between monthly mean values of ozone and stratospheric temperature have been measured above Syowa, Antarctica[2]. For the observations reported here, data from TOMS (Total Ozone Mapping Spectrometer) aboard the Nimbus 7 satellite, have been used to examine the 1980 to 1990 decrease in total column ozone above the South African Antarctic base of SANAE (70°18' S, 2°21' W). The cooling of the Antarctic stratosphere above SANAE during this period has been investigated by examining upper air temperatures at the 150, 100, 70, 50 and 30 hPa levels obtained from daily radiosonde balloon launches. Furthermore, these two data sets have been used to examine long-term, medium-term and short-term correlations between total column ozone and the temperatures at each of the five levels. The trend in SANAE total column ozone has been found to be -4.9 DU/year, while upper air temperatures have been found to decrease at around 0.3 °C/year. An analysis of monthly average SANAE total column ozone, has shown the decrease to be most severe during the month of September with a trend of -7.7 DU/year. A strong correlation (r^2 = 0.92) has been found between yearly average total column ozone and temperature at the 100 hPa level. Daily ozone and temperature correlations show high values from September to November, at a time when the polar vortex is breaking down.

INTRODUCTION

A significant decline in Antarctic total column ozone and upper air temperatures[1] has been observed in recent years. Furthermore, high correlations between monthly mean values of ozone and stratospheric temperature have been measured above Syowa, Antarctica[2]. For the observations reported here, ozone data were obtained from TOMS (Total Ozone Mapping Spectrometer) aboard the sun-synchronous Nimbus 7 satellite. This experiment provides, on a daily basis, the global distribution of total column ozone. For each day in the period 1980 to 1990, total column ozone data have been extracted from this data set for the South African Antarctic base of SANAE (70°18' S, 2°21' W). Version 6 TOMS data have been used for each year except 1989 where version 5 data have been used. However, an algorithm based on comparisons between version 5 and version 6 TOMS data in 1987 and 1988, has been used to normalise the 1989 data with respect to the other years of data. Monthly averages of these daily values have been used to investigate the decrease in SANAE total column ozone over this period and the months for which this decrease has been most severe. Yearly averages have been used to quantify the general long-term decline in SANAE total column ozone.

The cooling of the Antarctic stratosphere above SANAE during this period has been investigated by examining upper air temperatures at the 150, 100, 70, 50 and 30 hPa levels obtained from the midnight radiosonde balloon launches performed by the South African Weather Bureau.

Furthermore daily correlations between SANAE total column ozone and upper air temperatures have been investigated. Daily correlation coefficients at the 150, 100, 70 and 50 hPa levels, in a 31 running window, have been computed for each day of 1980 to 1990.

OBSERVATIONS AND DISCUSSION

Monthly average SANAE upper air temperatures

Monthly averages of daily upper air temperatures, at 150, 100, 70, 50 and 30 hPa, have been calculated for each year from 1980 to 1990. Figure 1 shows the data for the 150 hPa level. Only the even numbered years have been shown for clarity. Monthly average 150 hPa temperatures during January, February and March, appear to have decreased over the 11 year period, with a *minimum* during the years 1984 to 1986. During the winter months of June to September, a decrease in temperature from 1980 to 1990 is noticeable. The long-term cooling observed during November and December over the 11 year period, is

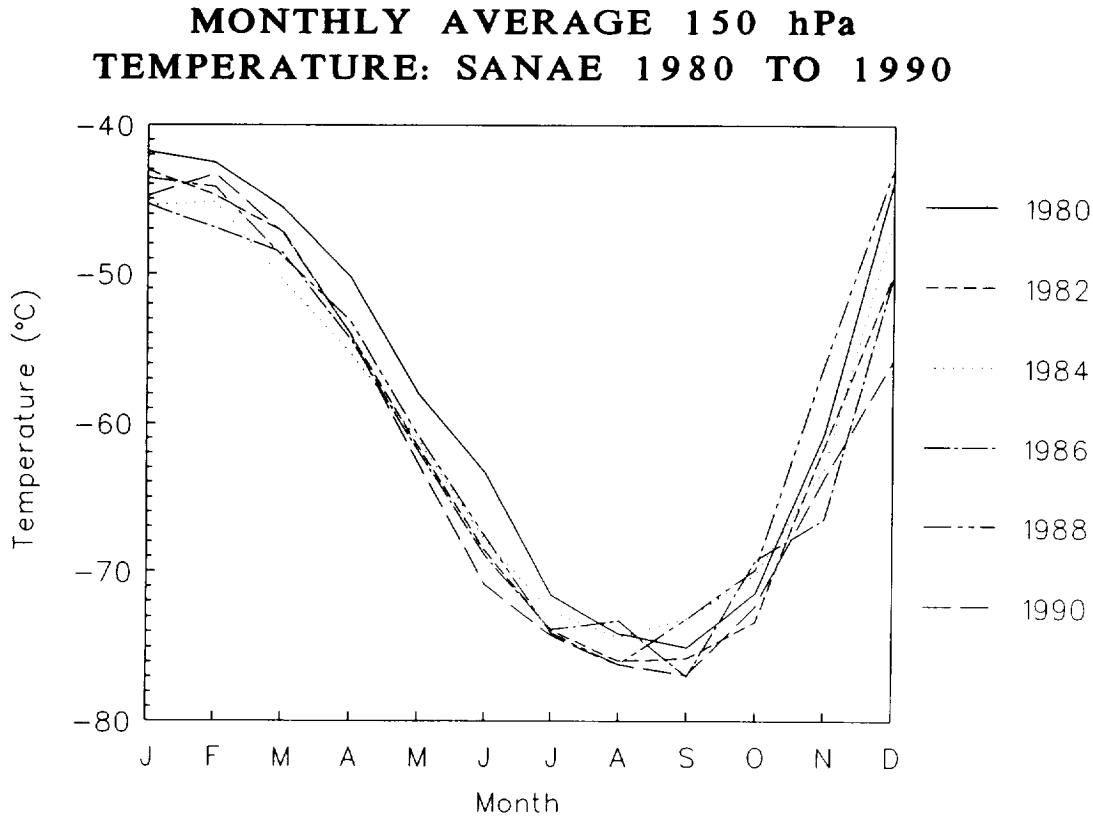

Figure 1: Monthly average SANAE 150 hPa temperatures: 1980 to 1990

interrupted by an unusually high monthly average temperatures in 1988 where an early final warming occurred. It has been reported[3] that the Antarctic atmosphere in 1988 was strongly perturbed by planetary wave activity resulting in an early circumpolar vortex breakdown.

The data set shown in Figure 1 together with similar data sets for the other levels, have been used to determine linear trends in the monthly average temperatures for each month at each height. Statistically significant results indicate that monthly average temperatures have decreased by between 0 and 0.6 °C/year from 150 to 50 hPa during the first 7 months of the year, and by between 0.6 and 1.0 °C/year from 150 to 70 hPa during December.

Monthly average SANAE total column ozone

Figure 2 shows the monthly average SANAE total column ozone from 1980 to 1990. Again, only even numbered years have been shown for clarity. No data are available for June since SANAE is in the polar night during this month and TOMS can make no measurements. Figure 2 shows a clear decline in monthly average SANAE total ozone. The high values seen early in the period are absent in later years. Attention is drawn to the high total column ozone during the last four months of 1988. This correlates well with the unusually high temperatures observed during the same period as seen in Figure 1. Note in Figure 2 the very low values of below 250 DU observed in September and October in recent years. Linear trends in monthly average SANAE total column ozone show that the long term decrease has been more pronounced in the post-winter months, with a maximum trend of -7.7 DU/year in September. This compares with a value of -2.1 DU/year over the January months.

Yearly average SANAE total column ozone and upper air temperatures

Figure 3 shows the yearly average SANAE temperatures at the 50, 70, 100 and 150 hPa levels together with the yearly average SANAE total column ozone. The 30 hPa level was excluded since much of these data were missing and interpolation resulted in unrealistically high values. Figure 3 shows a very good correlation between yearly average total column ozone and upper air temperatures as demonstrated by the ozone and temperature correlation coefficients (r values) listed below:

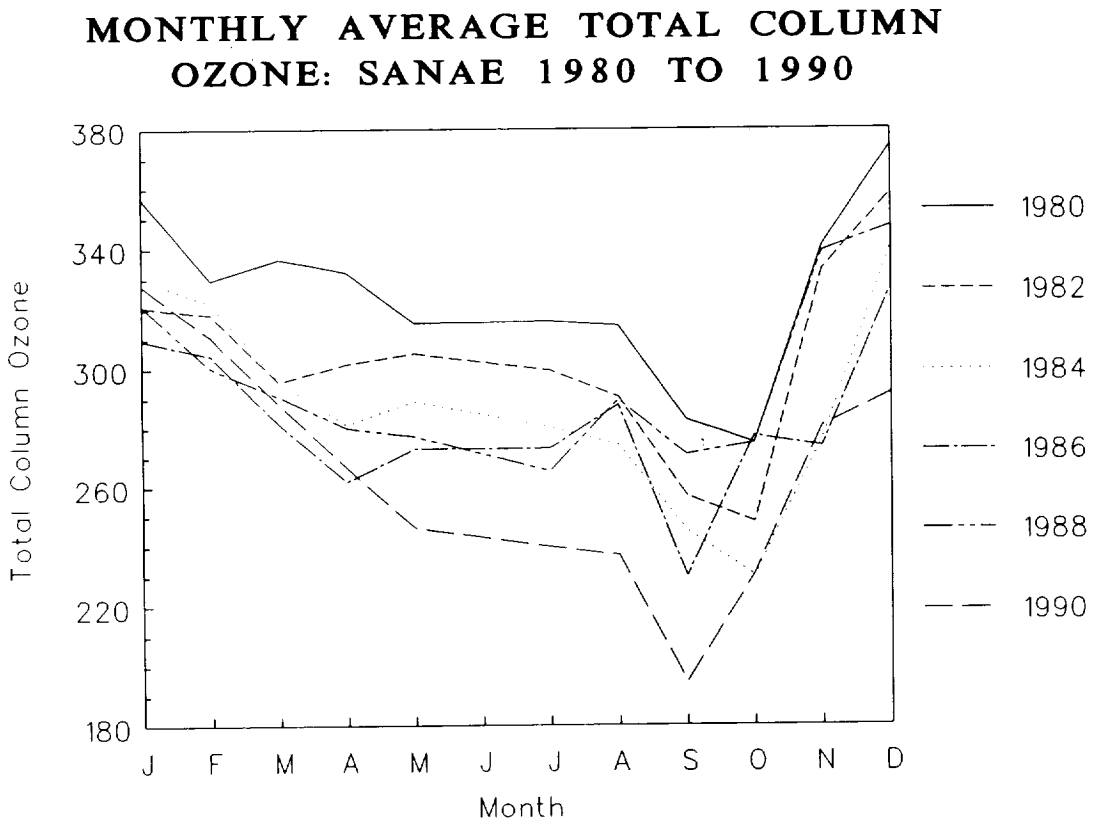

Figure 2: Monthly average SANAE total column ozone: 1980 to 1990

50 hPa : 0.80
70 hPa : 0.89
100 hPa : 0.96
150 hPa : 0.93

The highest ozone and temperature correlation is achieved at the 100 hPa level. Furthermore, linear fits to each of the curves shown in Figure 3 reveal the following trends:

50 hPa : -0.33 °C/year
70 hPa : -0.29 °C/year
100 hPa : -0.34 °C/year
150 hPa : 0.26 °C/year
Ozone : -4.9 DU/year

This analysis suggests that the long-term decrease in total column ozone over SANAE is closely followed by a decrease in upper air temperatures between 150 and 50 hPa.

Daily total column ozone and upper air temperature correlations

Correlation coefficients have been computed between profiles of SANAE total column ozone and temperatures at the 150, 100, 70, 50 and 30 hPa levels for each day of the period 1980 to 1990. A sliding window of width 31 days, sets the length of the profiles examined and results in 1 correlation coefficient for each level per day. Figure 4 gives an example of the daily ozone and temperature correlation coefficients for 1990. It can be seen that the best ozone and temperature correlations are generally observed at the 100 hPa level between day 270 and 310 where r^2 values exceed 0.7. The results from all years indicate that the highest ozone and temperature correlations are observed at the 100 hPa level around the month of November of each year. Correlation coefficients (r values) in excess of 0.95 are reached on occasion. Qualitatively it appears that the best correlations between total column ozone and upper air temperatures, are obtained during the time of the vortex breakdown. However this requires further investigation.

ACKNOWLEDGEMENTS

For access to the TOMS total column ozone data we wish to thank Dr. R.D. McPeters and Dr. A.J. Krueger (NASA/GSFC) members of the TOMS Nimbus Experiment and Ozone Processing teams; and the National Space Science Data Center through the World Center-A for Rockets and Satellites.

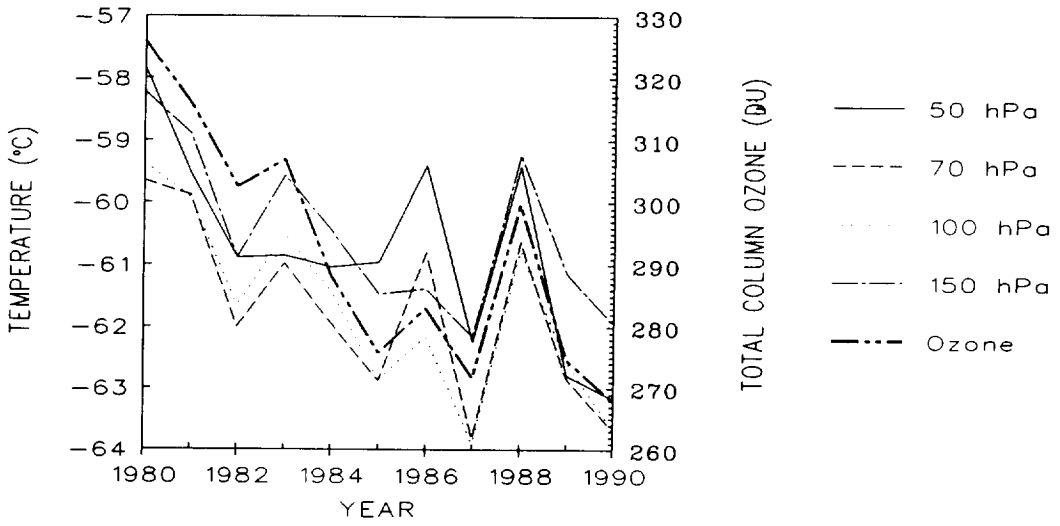

Figure 3: Yearly average SANAE temperatures at the 50, 70, 100 and 150 hPa levels and yearly average SANAE total column ozone: 1980 to 1990

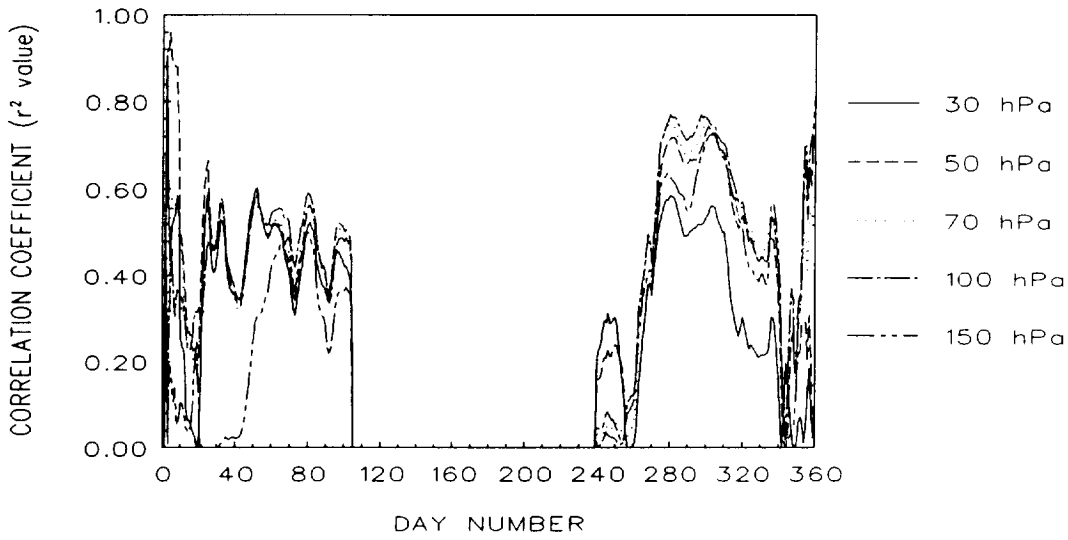

Figure 4: The 1990 daily total column ozone and 150, 100, 70, 50 and 30 hPa temperature correlation coefficients for SANAE

REFERENCES

1) Chubachi S., On the cooling of stratospheric temperature at Syowa, Antarctica, *Geophysical Research Letters*, **13**, no. 12, 1221 to 1223, November 1986.

2) Sekiguchi Y., Antarctic ozone change correlated to the stratospheric temperature field, *Geophysical Research Letters*, **13**, no. 12, 1202 to 1205, November 1986.

3) Schoeberl M.R., R.S. Stolarski and A.J. Krueger, The 1988 Antarctic ozone depletion: comparison with previous year depletions, *Geophysical Research Letters*, **16**, no. 5, 377 to 380, May 1989.