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DISTRIBUTION OF OZONE BETWEEN 60 DEGREES NORTH AND 60 DEGREES SOUTH

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ABSTRACT

The distribution of total column ozone is investigated, using data from the TOMS (Total Ozone Mapping Spectrometer) experiment aboard the US Nimbus 7 satellite. The region of interest extends from 60° North to 60° South, encircling the earth. Data for several years have been used in order to assess the long-term variations in the distribution of total column ozone. First results are presented on the seasonal variability of total column ozone in each hemisphere. The effects of the seasons are strongest at the highest latitudes but can still be discerned at the equator. While the variations are similar in the two hemispheres, ozone levels in the north are larger than in the south. Strong similarities are also found in the drift patterns of total column ozone in the two hemispheres. These drift patterns are compared to meteorological phenomena. We find an almost stationary ozone distribution for low latitudes at all seasons. At middle latitudes the ozone distribution drifts eastward in both hemispheres and this drift shows a seasonal variation. At very high latitudes (70° and higher) during spring in the southern hemisphere the ozone distribution is once again almost stationary, indicating that these regions are inside the polar vortex.

1. INTRODUCTION

Since 1978 the TOMS instrument onboard the US Nimbus 7 satellite has been measuring daily values of total column ozone. In this paper, we report on the variation of total column ozone in 1985 and 1986, at low and middle latitudes in both hemispheres.

TOMS provides a daily value of total column ozone for each of the global grid points, which are separated by 1° in latitude and by 1.25° in longitude. Note that this implies a time difference between neighbouring data points of 24 hours at worst.

The ozone distribution for both hemispheres in September 1985 is shown in Figure 1, in the form of Hovmoeller plots. Figure 1(a) shows the summer pattern in the northern hemisphere and Figure 1(b) the winter pattern in the southern hemisphere. Each large square represents one month's worth of data averaged over a 15° latitude strip extending around the earth. The day of the month increases downward on the ordinate. Blocks inside each large square represent total column ozone for one day, averaged over 15° of latitude and 10° of longitude. Four large squares are shown for each hemisphere, numbered 1 to 4, indicating average ozone values for the latitude strips 0° to 15°, 15° to 30°, 30° to 45° and 45° to 60°, respectively.

2. OBSERVATIONS

Plots similar to Figure 1 have been produced, for all months in 1985 and 1986, for both hemispheres. Both years show very similar behaviour. From these plots the following conclusions have been made.

The ozone values in the northern hemisphere are always higher than in the southern hemisphere.

The values of total column ozone increase with increasing latitude.

The values of ozone appear to be higher in the winter hemisphere than in the summer hemisphere.

In order to determine the zonal bulk drift speed local maxima of ozone were traced. From plots similar to Figure 1 the average bulk drift speed could then be deduced.

Figure 2 shows, for 1985 and 1986, the calculated monthly bulk drift speeds (m s^{-1}) in the four latitude zones for both hemispheres. Eastward drift is shown as positive. Both hemispheres show a rather similar behaviour of the drift

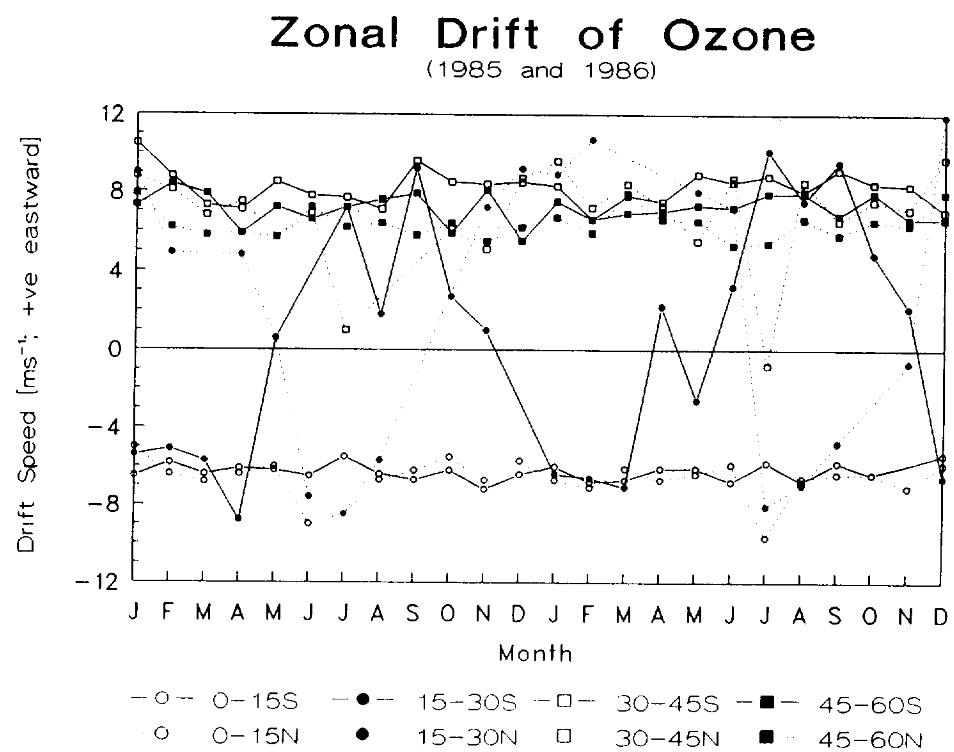

Figure 2. Calculated zonal bulk drift speeds of ozone averaged for each month, for both hemispheres, for the years 1985 and 1986. The key indicates measurements for the four latitude zones in each hemisphere.

speed, but the two hemispheres are out of phase by half a year.

There is a considerable eastward drift at higher latitudes, particularly during the winter months, of the order of 7 to 10 m s^{-1}. This speed tends to be slightly larger in the southern hemisphere than in the northern hemisphere.

The zone of lowest latitudes shows a clear drift, of the order of 6 m s^{-1}.

The intermediate zone (15^{o} to 30^{o}) shows a transition from eastward drift in winter to westward drift in summer. It appears that the year is divided equally into four quadrants, two of which correspond to the transitions and one each to a summer and winter pattern.

3. DISCUSSION

In Figure 1 it is obvious that the annual distribution of total column ozone is, as anticipated, linked to the seasonal change from winter to summer and vice versa. During winter the total column ozone builds up in the polar regions, probably due to the polar vortex which forms in the winter hemisphere.

It is also clear that the drift patterns in the winter hemisphere appear to be stronger and more coherent than in the summer hemisphere. From Figure 2 we see, however, that the main change occurs in the middle region between 15^{o} and 30^{o} in latitude. While the higher and the lower latitudes do not change very much, this region suffers a reversal of its drift pattern. This reversal leads to the more pronounced drift patterns in the winter hemisphere (Figure 1). Due to the eastward flow in the intermediate zone during the winter months the eastward bulk drift of ozone is more noticeable in these months.

This is qualitatively consistent with expectations from statistical data (Murgatroyd, 1969; Randel, 1992) and also from modelling (Geller, 1983). In the lower stratosphere, bulk eastward drift in both hemispheres at higher latitudes is expected. In the winter hemisphere this drift extends down to a latitude of about 10^{o}.

In the equatorial zone a westward

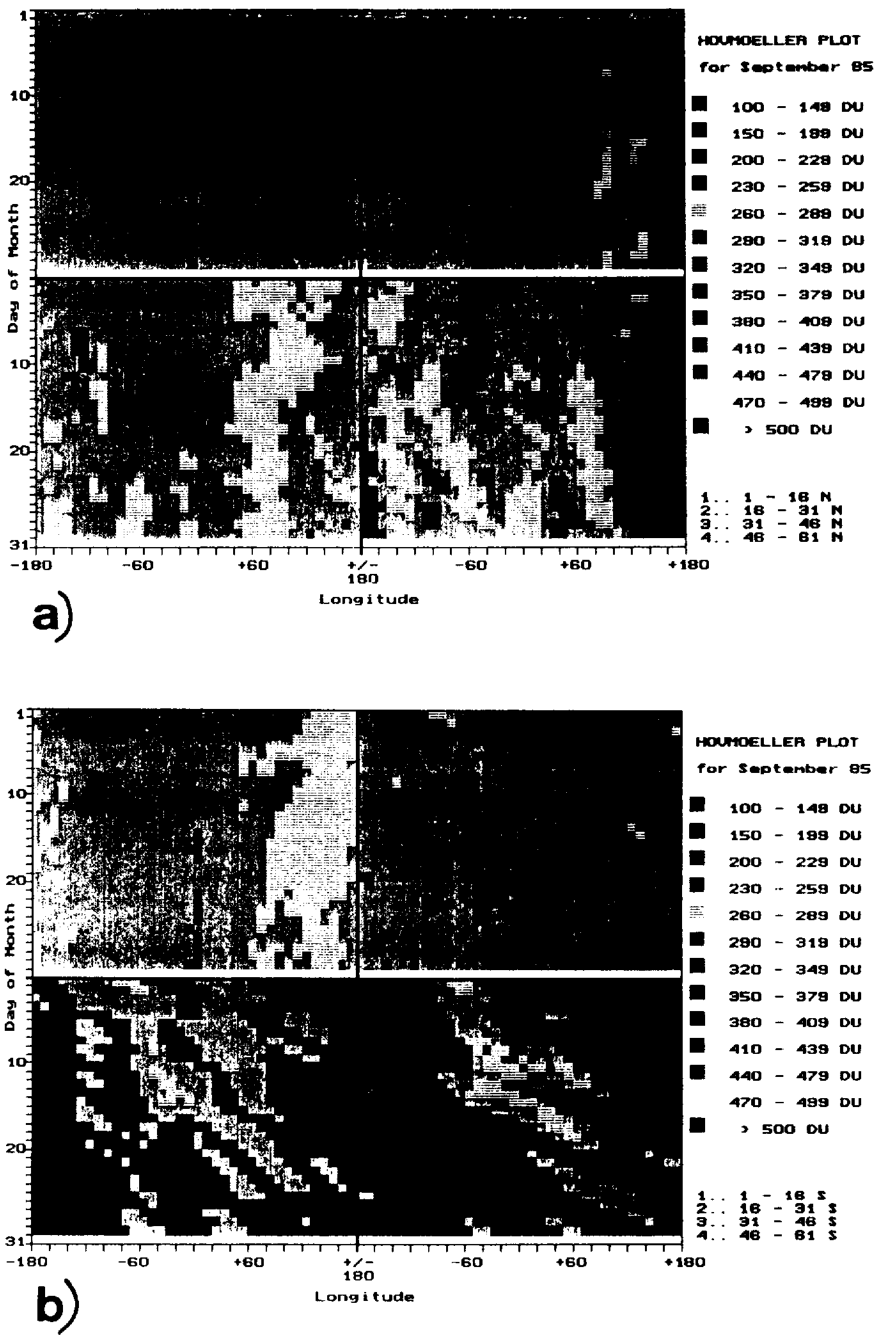

Figure 1. Global disribution of total column ozone in both hemispheres for September 1985. In this figure the northern hemisphere (a) shows the summer pattern and the southern hemisphere (b) shows the winter pattern.

drift prevails at all times, which in the summer hemisphere extends to about 25° in latitude. Hence a reversal of the drift for the zone between 15° and 30° is to be expected.

While the direction of the observed bulk ozone drift agrees with the measured and predicted wind speeds, this is not quite the case for the magnitude of the drift speed. Obviously, more work needs to be done before a good understanding of these dynamic phenomena can be achieved.

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