Revista Brasileira de Geofísica; 1987, *Vol. 5, 49-52*

doi: 10.22564/rbgf.v5i1.1063

ANTARCTIC OZONE DECLINE AND OZONE MEASUREMENTS IN BRAZIL

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Recent satellite and ground-based observations of decline of atmospheric ozone in Antarctic region during southern spring (September-November) have attracted world-wide attention of scientists due to possible global environmental implications. Measurements of the total atmospheric ozone started at our Institute at Cachoeira Paulista (22.7°S, 45.0°W), SP, using a Dobson spectrophotometer in 1974. In 1978, another station was added at Natal (5.8°S, 35.2°W), RN, in collaboration with the National Oceanic and Atmospheric Administration, Boulder, U.S.A. Both the stations carry out regular total ozone measurements and with Huancayo (12.0°S, 75.3°W), Peru, and Buenos Aires (34.5°S, 58.7°W), Argentina, are the only four stations in the South America. In this paper, a comparison of the monthly ozone values in Brazil in relation to other South American and Antarctic stations is presented. It is shown that the Antarctic ozone decline does not extend to the middle and low latitudes.

Recentes observações de um buraco na camada de ozônio atmosférico da região Antártica durante a primavera, feitas com satélites e com equipamentos instalados em terra, atraíram a atenção geral de cientistas devido às possíveis implicações ambientais. As medidas de ozônio atmosférico total começaram neste Instituto em Cachoeira Paulista (22,7° sul, 45,0° oeste), SP, usando um Espectrofotômetro Dobson, em 1974. Em 1978, outra estação foi estabelecida em Natal (5,8° sul, 35,2° oeste), RN, em colaboração com a "National Oceanic and Atmospheric Administration", Boulder, U.S.A. Ambas as estações realizam medidas regulares de ozônio total e com Huancayo (12,0° sul, 75,3° oeste), Perú e Buenos Aires (34,5° sul, 58,7° oeste), Argentina, são as únicas quatro estações na América do Sul. Neste trabalho, um estudo comparativo das medidas mensais de ozônio no Brasil em relação a outras estações sul-americanas e Antártica é apresentado. É mostrado que o buraco na camada de ozônio observado na Antártica não se estende para regiões de média e baixa latitudes.

INTRODUCTION

The Antarctic ozone decline reported by Farman et al. (1985) has attracted considerable attention of the scientific community, as well as the general public due to possible environmental implications. They suggested that the declines are caused by the release of man-made chlorofluorocarbons (CFCs) into the atmosphere. An impression seems to be spreading that the effect may be global. The above authors observed a dramatic decrease in the total ozone measurements made with a Dobson spectrophotometer at the British Antarctic Survey Station at Halley Bay (76°S, 27°W), especially for the month of October, since 1976, which continued up to 1985 (Gardiner & Shanklin, 1986). Similar changes were noted at Syowa (69°S, 40°E), as also at the South Pole (Chubachi & Kajiwara, 1986; Komhyr et al., 1986; Bojkov, 1986a,b). Farman et al. (1985) pointed out that the total ozone data at Argentine Island (65°S, 64°W) showed changes similar to those seen at Halley Bay, but much smaller in magnitude. Also, the large deficiencies of total ozone in spring (southern) recovered by February of the following year. Stolarski et al. (1986) confirmed the southern spring total ozone decline in the Antarctic region from the measurements obtained by the Total Ozone Mapping Spectrometer (TOMS) and Solar Backscatter Ultraviolet (SBUV) instruments onboard the polar orbiting Nimbus-7 satellite. However, for October 1986, the ozone values at several Antarctic locations seem to be 15-30% higher than those in October 1985 (Bojkov, private communication). As the polar vortex breakdown in 1986 occurred two weeks earlier than in 1985, the circulation processes seem to play a very important role.

A special issue of Geophysical Research Letters (Vol. 13, Nº 12, November supplement, 1986) contains more than 40 papers related to the observations and theoretical models of the Antarctic spring ozone decline. In an overview, Schoeberl &

Krueger (1986) point out that no clear link between man-made pollutants and ozone decline over Antarctic has been established. Also there are strong suggestions for the important role of circulation processes.

The observations of the Antarctic spring ozone decline have a special importance for investigators in Brazil; because the satellite measurements over Antarctic indicate that the lowest values of total ozone are found between 0° and 90°W longitude. In this paper, a comparison of the ground-based ozone measurements in Brazil, in relation to other South American and Antarctic stations is presented and discussed.

OZONE DATA

Regular measurements of total ozone were started in Brazil in May 1974, when the Dobson spectrophotometer nº 114 was installed by this Institute at Cachoeira Paulista (22.7°S, 45.0°W). In November 1978, another observing station was started at Natal (5.8°S, 35.2°W). The National Oceanic and Atmospheric Administration (NOAA), Boulder, U.S.A., loaned the Dobson spectrophotometer nº 93 to be operated at Natal in a bilateral collaborative project. These two stations, with Huancayo (12.0°S, 75.3°W) Peru, and Buenos Aires (34.5°S, 58.7°W) Argentina, are the only four stations in the South American continent, where regular measurements of total ozone are carried out. The Dobson spectrophotometers operating at these four stations are regularly intercalibrated as part of the activity sponsored by the World Meteorological Organization (WMO).

Sahai et al. (1982) presented the salient features of the total ozone measurements carried out at Cachoeira Paulista (1974-81) and Natal (1978-81) and their comparison with other low and mid-latitude observing stations elsewhere. Ozone data presented for Huancayo and Buenos Aires were obtained from "Ozone Data for the World", published by the Canadian Meteorological Service. Halley Bay total ozone data are from Farman et al. (1985) and Gardiner & Shanklin (1986).

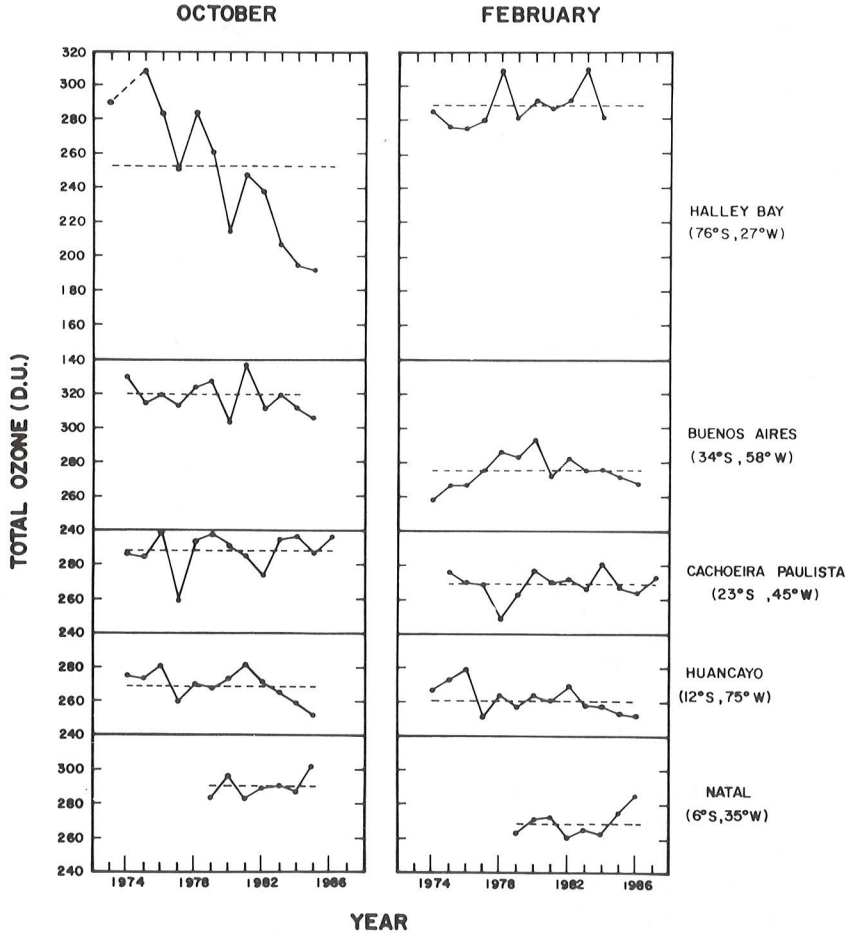

Figure 1 – Monthly mean total ozone amounts (in D.U.) at Halley Bay, Buenos Aires, Cachoeira Paulista, Huancayo and Natal. One thousand Dobson Units (D.U.) is equivalent to one centimeter of pure ozone at standard pressures and temperatures. The dashed lines are the mean value for the period studied. Left half – October; Right half – February.

RESULTS

Fig. 1 shows a plot of the monthly means of the total ozone during the months of October (left half of Fig. 1) and February (right half) at Halley Bay, Buenos Aires, Cachoeira Paulista, Huancayo and Natal. The dashed lines indicate the mean value for the period studied for each station. It can be seen that unlike Halley Bay, which shows a decrease of 100 D.U. (1 Dobson Unit = 1 milli-atm cm) from 1976 to 1985, none of the other stations studied show a decreasing trend in the October (southern spring) total ozone during recent years. Some small year-to-year changes are seen at these stations. In contrast, the February data are more or less similar at all the stations, including Halley Bay. Also, a comparison of the February data with those of October shows larger values for October at Buenos Aires, Cachoeira Paulista and Natal, while Huancayo does not show an increase in October. This is in accordance with the annual variations at these stations discussed by Sahai et al. (1982). It may be mentioned here that in October, the circum-polar vortex is dominant and does not permit an exchange between the low level of polar ozone and the relatively high level of middle latitude ozone. In February, there is almost free meridional exchange. Thus, differences in behaviour of October and February ozone values are expected (Bojkov, 1986b). The comparison of total ozone data obtained at South American stations with that of Halley Bay does not indicate any extension of the Antarctic spring ozone decline towards the South American continent. Also, Schoeberl et al (1986) and Stolarski & Schoeberl (1986), using TOMS satellite data for Octobers during 1979-1985, show that the total ozone distribution in the Southern Hemisphere has very low values at the poles, a steep gradient rising away from the pole with a peak at about 50°S, decreasing again toward the equator. This distribution is in contrast to that observed in autumn (March-April), when the total ozone distribution is flat. This clearly indicates that the spring decline in the Antarctic region does not extend to the South American continent.

CONCLUSION AND DISCUSSIONS

From the simple analysis presented here, it may be concluded that the spring ozone decline is confined mainly to the Antarctic region.

As discussed in considerable details in the various articles in the special issue of Geophysical Research Letters (November supplement, 1986), three types of mechanism are invoked for explaning the ozone decline. The first one is the photochemical destruction, due to chlorine catalysis (Farman et al., 1985), heterogeneous reaction processes (Solomon et al., 1986) and synergistic reactions of chlorine and bromine (McElroy et al., 1986). Cronn et al. (1986) have shown that the amount of chlorofluorocarbon compounds increased continuously (~5%/year) during 1982-85 at the South Pole. This would support the hypothesis of ozone decline by these compounds. However, it is not clear why these compounds do not produce a similar effect in locations where modern civilization ensures a large proportion of such compounds (Watson et al., 1986). The second mechanism proposed for ozone decline suggests an upwelling of the atmosphere each spring, when sunlight strikes the stratospheric aerosol layer (Tung et al., 1986). An interesting observation is the very good correlation between the polar ozone decline and a sizable decline in stratospheric temperatures in the polar region. Thus, a considerable role of dynamic processes is envisaged (Mahlman & Fels, 1986; Bojkov, 1986b). A third mechanism proposes that polar ozone decline is a natural phenomenon associated with the sunspot cycle and with an increase in the natural level of NO and other odd nitrogen compounds (Callis & Natarajan, 1986). Both the second and third mechanisms suggested have some limitations, as discussed by Schoeberl & Krueger (1986).

The observed decrease in total ozone in the Antarctic during the last decade may have been caused by dynamical or photochemical processes or some combination of both. As pointed by Bowman (1986), a return of ozone values to early levels would contradict the chemical hypothesis. Continued low ozone values, especially if they persist in both hemispheres, will support chemical depletion mechanisms and make dynamical explanation less likely. In a recent communication, Krueger et al. (1987) have reported that the TOMS observation of total ozone in the 1986 Antarctic spring shows a value about 30 D.U. (~16%) above the 1985 minimum. Also, the October 1986 values for South Pole, Halley Bay and Syowa are 14%, 28% and 37% higher (respectively) than their October 1985 values (Bojkov, private communication). This possibly indicates reversal of the downtrend. However, the implications of these for the middle and low-latitudes (where no decline is seen) are not quite clear. Continued efforts to model and monitor from the ground and from satellites will be important for future studies.

ACKNOWLEDGEMENTS

Thanks are due to Dr. Luiz Gylvan Meira Filho for his keen interest and valuable support to the development of the Atmospheric Ozone Program at this Institute. Thanks are due to Dr. R.D. Bojkov for supplying us the October 1986 Antarctic ozone values and for valuable suggestions. Dr. R.S. Stolarski,

NASA/GSFC, sent us a preprint describing TOMS observations for the 1986 Antarctic spring, which is gratefully acknowledged. The present work was partially supported by the Brazilian Fund for Science and Technology (FNDCT), under contract FINEP-537/CT.

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Versão original recebida em Jul./87
Versão final, em Out./87