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Ozone depletion, worst not yet over

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The ozone depletion which started in late 1970s, reached a maximum level (minimum ozone content) in 1993 and thereafter a partial recovery seemed to have occurred up to 2002. But that was a false signal. From 2003 onwards, there seems to have a relapse and the level has been low even in 2009 implying that a permanent damage might have occurred.

Keywords: Atmospheric ozone, Ozone depletion, Total ozone mapping spectrometer (TOMS)

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1 Introduction

From the moment Farman *et al.*[1] noticed that the total ozone level at the Antarctic station Halley (74°S, 271°W) was declining considerably every year starting probably in 1976. Several researchers confirmed this tendency in the following years. It was soon discovered that the loss was due to chemical destruction of ozone by anthropogenic causes, namely escaping into the atmosphere of chlorofluorocarbon (CFC) compounds from man-made gadgets like refrigerating units, hair sprays, etc. These compounds spread first into the troposphere but eventually reach the stratosphere and destroy O_3 molecules (halogen chemistry) (ref. 2). In 1987, the Montreal Protocol was signed by many nations, which agreed to reduce their emissions of CFCs by 2000 to half of 1987 levels. The recommendation of the Montreal Protocol to make immediate efforts to reduce or eliminate the use of CFC compounds seems to have produced some effect[3-5]. In the polar region, a spring-time circumpolar vortex is formed, ozone is captured inside it and has no connection with outside ozone, so CFCs have enough time to destroy ozone as long as this vortex lasts. In the Antarctic, the vortex is stable for 2-3 months, therefore, the ozone depletion is intense, causing the Antarctic ozone hole. However, ozone changes could also be due to other causes unrelated to the halogen load as such[6-9]. Another important factor affecting Antarctic ozone is the effect of the Quasi-Biennial Oscillation (QBO)[10].

In recent communications[11,12], it was illustrated that the ozone depletion, which started in late 1970s, seems to have reached a maximum level (minimum ozone) near about 1993-1996 and recovery seems to have occurred thereafter up to 2002-2003. But in the succeeding years 2004–2006, there seems to have a relapse. Since ozone level is of great interest to the scientific community, scientists are always eager to know every year, whether the level is showing any indication of recovery. The last data point was for 2006 and the level was low[12]. It would be interesting to check the ozone level as it stands now. In this paper, the latest situation regarding the ozone hole up to the end of 2008 is examined.

2 Data

Data were obtained from the websites, viz. http://www. antarctica.ac. uk/ met/ jds/ ozone/ #data; http://ozonewatch.gsfc .nasa.gov/; and http:// www. csulb.edu/~rodrigue/ geog140/ labs/ozone-hole.html and consisted of ozone minimum values during September-October in the south polar region, ozone hole area near South Pole and Dobson ozone values for the Antarctic location Halley Bay.

3 Results

Figure 1 shows plots for the years 1979-2008. Figure 1(a) shows ozone minimum values as obtained by various satellites (names and intervals mentioned), one daily value per year during September-October. As can be seen, the minimum value was ~200 DU in 1979 but decreased considerably in the next 15 years to reach a minimum of ~90 DU in 1993 (marked by the first vertical line). Thereafter, it oscillated and showed a recovery in 2002 (marked by the second vertical line). However, this proved to be a false signal, as values in the succeeding years 2003-2006 were almost the same (~90 DU) as in 1993. This was termed as a relapse[12] during 2003-2006 (marked by the third vertical line). Presently, there are two more points corresponding to 2007 and 2008 (last circle), which are still low. Thus, the ozone depletion has not yet recovered.

Figure 1(b) shows a plot of the ozone hole area, defined as the region around the South Pole, where the ozone level <220 DU. Starting from an almost zero value in 1979, the area increased enormously to ~25 × 10^6 km^2 in 1993 (about the area of North America) and fluctuated near that value till it decreased appreciably in 2002 (only) to ~15 × 10^6 km^2. However, this was a false signal not because of recovery of the depletion as such but because of other reasons[12]. Thereafter, the area has shown large fluctuations (it was ~20 × 10^6 km^2 in 2004) and was still around ~25 × 10^6 km^2 even in 2008. Thus, no recovery of the ozone hole is indicated. The correlation between the plots (a) and (b) is very high (0.97) indicating that when the depletion is large, the area also becomes large.

Figure 1(c) shows a plot of the minimum total ozone values recorded by a Dobson photo-spectrometer at the location Halley (74°S, 271°W) in the Antarctic Peninsula. All the features are very much alike to those in Fig. 1(a), the correlation between (a) and (c) is very high (0.98).

4 Discussions and conclusion

The plots of ozone hole minimum values and the ozone hole area for 1979-2008 indicate that from 1979 to about 1993 (15 years), the depletion developed enormously (more than 50%) and then it remained steady. This gave a false signal of recovery

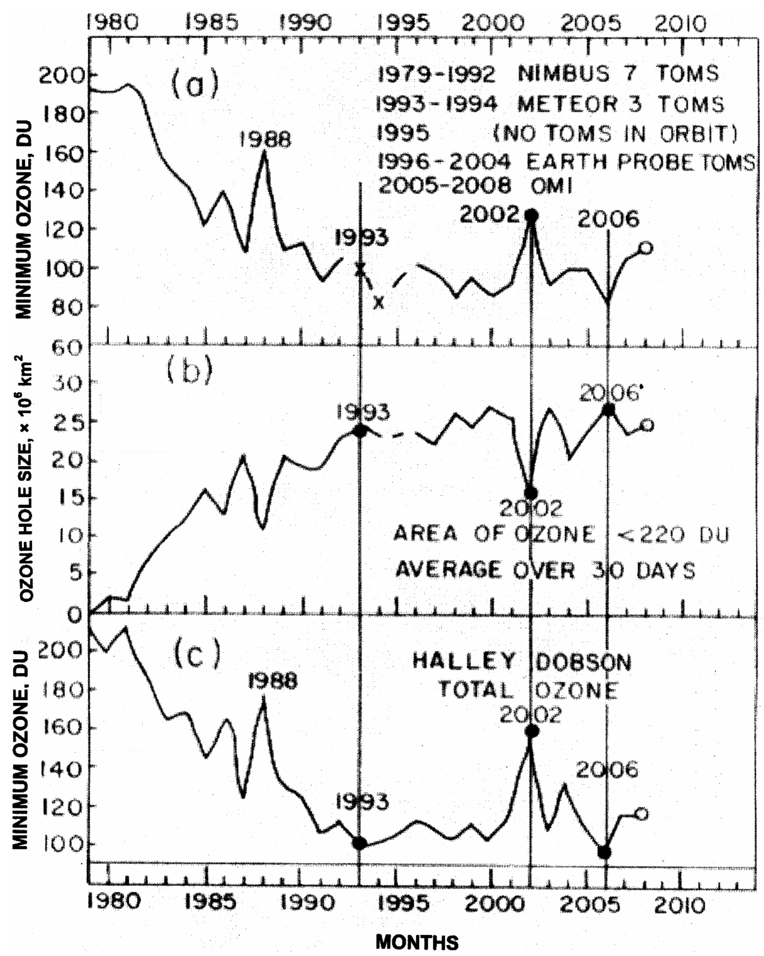

Fig. 1 — Plots for the years 1979-2008: (a) ozone minimum values as obtained by various satellites, one daily value per year during September-October; (b) ozone hole area, defined as the region around the South Pole, where intensity was <220 DU; and (c) minimum total ozone values recorded by a Dobson photo-spectrometer at Halley (74°S, 271°W) in Antarctic Peninsula

in 2002, but the ozone level returned back to the steady low level and remained there till 2008. Thus, there is no recovery, and even any sign of possible recovery has not yet been indicated. From the NASA website http://ozonewatch.gsfc.nasa.gov/, it seems that 2009 ozone hole started developing in the beginning of September, attained a maximum area on 17 September (24×10^6 km^2) and a minimum daily value on 26 September (94 DU) and has started recovering since then. These values are comparable to those of 2008, indicating that the ozone hole occurred in 2009 just as strong as in the previous years, so the depletion continues unabated even in 2009.

This is an alarming situation, as it would imply that a permanent damage has probably occurred. Whereas the Montreal Protocol participants might have taken adequate measures regarding CFCs into the atmosphere, the existing levels of CFCs in the stratosphere are large enough to continue to destroy ozone. Since CFCs are long-lived, no recovery is expected for decades to come.

Incidentally, the danger from ozone depletion and the increased level of UVB causing skin cancer is probably exaggerated and overstated. Firstly, even though the Antarctic ozone depletion is enormous, virtually nobody lives there. Secondly, it lasts for only a few weeks during September-October and recovers almost completely thereafter by December. It may be remembered that because of the large zenith angle for solar radiation falling on Antarctic, the increased UVB level reaching the surface there even with maximum ozone depletion is about the same as that received by equatorial regions normally due to small zenith angles. Thirdly, the ozone depletion in latitudes outside the Antarctic is much lesser. At Arosa (Switzerland) and Boulder (Colorado, USA) in northern mid-latitudes, it was only 7% during 1980-1993, which has recouped now by a few percent[12], though some locations in Europe experienced low ozone levels in November 2001. In low latitudes and at the equator, the depletion effect is negligible and erratic and major variation there is the QBO[13], which existed even before 1980s when the ozone depletion started. This is as far as ozone variations are considered, but their damaging effects are not direct. The damages come through the variations of solar UVB radiation filtering down through the stratospheric ozone layer. This UVB variation is not related simply to the ozone variations and UVB reaching the surface of Earth is largely affected by cloud cover[14,15]. A few weeks of heavy cloud cover can affect tremendously the UVB effect expected at ground. Further, the effect of UVB for cancer incidence is not immediate[16]. It takes decades to evolve. So, one is forced to make intelligent guesses, take actions erring on the safe side, and then hope for the best, allowing for the fact that natural disasters can still occur, mostly unexpected (for example, tsunamis, major earthquakes) and catch us unaware.

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