

L E T T E R S

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ANTARCTIC OZONE HOLE STATUS - AN UPDATE

1. Ultraviolet (UV) radiations from the Sun in the spectral range 100-280 nm react with the stratospheric atmosphere and oxygen molecules (O₂) and atoms (O) combine to produce ozone (O₃). Since there are destruction processes also, the equilibrium amount is small, only a few per cent of the atmosphere. However, it serves a very vital, useful purpose as it absorbs UV in the spectral range 280-320 nm (termed as UVB), which is very dangerous for terrestrial life and is a cause of skin cancer, etc. Total ozone is measured regularly, earlier by Dobson instrument and now with the Brewer instrument and satellite instrumentation TOMS (total ozone - measuring spectrometer) at several hundred locations, including in the polar regions, for the last several decades.

Farman *et al.* (1985) were the first to notice that the total ozone level at the Antarctic station Halley (74° S, 271° W) was decreasing considerably from year to year, probably from 1976. In the next few years, several workers confirmed this tendency of ozone depletion. It was soon discovered that the loss was due to chemical destruction by anthropogenic causes, namely escaping into the atmosphere of CFC compounds from man-made gadgets like, refrigerating units, hair sprays, etc. These compounds spread into the troposphere but eventually reach the stratosphere and destroy O₃ molecules (halogen chemistry, Anderson *et al.*, 1991). The Montreal Protocol recommended immediate efforts to reduce or eliminate the use of CFC compounds and this seems to have produced some effect (Montzka *et al.*, 1996; Dutton *et al.*, 2003; Schauffler *et al.*, 2003). In the polar regions, a spring-time circumpolar vortex is formed, ozone is captured inside and has no connection with outside ozone; so, CFCs have enough time to destroy ozone until the vortex lasts. In the Antarctic, the vortex is stable for 2-3 months and the ozone depletion is intense, causing the “Antarctic ozone hole”. Incidentally, ozone changes can also be due to other causes unrelated to the halogen load as such. (Shindell *et al.*, 1997, 1998a, b, 1999). Another important factor-affecting Antarctic ozone is the effect of stratospheric wind QBO (Garcia and Solomon, 1987). In an earlier communication (Kane, 2002), it was shown that the ozone depletion, which started in late 1970s, continued till about 1996, after which the level remained steady up to 2002. Using data for another 4 years 2003-2006, Kane (2008) reported that the ozone depletion, which started in late

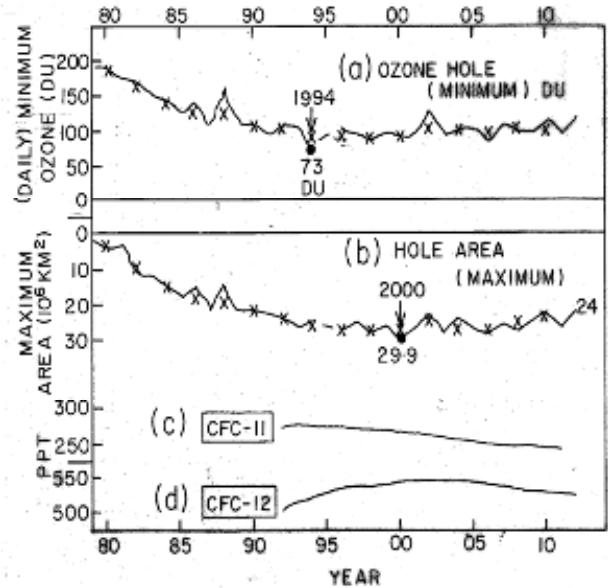


Fig. 1. Plots for 1979 onwards of (a) Antarctic ozone *intensity* minimum (Ozone hole, DU), (b) Ozone hole *area* maximum (million km², note the scale is upside down), full lines, one value per year; crosses, 3-year running means, (c) CFC-11 level, (d) CFC-12 level

1970s seemed to have reached a maximum level (minimum ozone) in 1996 and a recovery seemed to have occurred thereafter up to 2003. But in the succeeding years 2004-2006, there seemed to have occurred a relapse.

In this communication, data up to 2013 are used to examine the present status of the minimum ozone hole level in the Antarctic.

2. *Data* - In the Antarctic, the winter months February-July are dark (no sunshine). Sun appears only in August when the ozone level can be measured. However, the ozone destruction starts soon and during the last week of September to the first week of October, the ozone destruction is largest, recovering thereafter. In this study, the parameters considered are the minimum daily value (Dobson Unit DU) in the Antarctic ozone hole and the maximum hole area (million km²), as seen in TOMS data, one value of each per year, occurring during the last week of September - the first week of October. Also, the levels of CFC 11 and 12, (ppt, part per trillion), the ozone-destroying compounds, are examined. Data were obtained from the Websites <http://ozonewatch.gsfc.nasa.gov/>

meteorology/annual_data.html and <http://www.esrl.noaa.gov/gmd/hats/publicn/elkins/cfcs.html>.

3. *Plots* - Fig. 1 shows the plots for 1979 onwards for ozone hole magnitude (DU) minimum in the top plot, followed by the ozone hole area. The following may be noted:

(i) In the top plot, the minimum ozone level (Full lines: one value per year; Crosses: 3-year running means) was about 200 DU in 1979 but decreased thereafter to 73 DU in 1994. For 1995, no data are available. In 1996, the level was ~100 DU. Since then, the average level seems to have steadied near ~100 DU. In 2002, the level rose to 131, but fell to 91 DU next year. In 2010, the level rose to 118 DU, but fell to 95 DU next year. In 2012, the value rose to 124 DU and in 2013, the value was still high, 118 DU.

(ii) In the second plot, the ozone hole area reached a maximum value of 29.9 million km² (note that the vertical scale is upside down), not in coincidence with the ozone hole minimum value which occurred in 1994, but in 2000, six years later (reason for this delay not known). Since then, there is a tendency of reduction in hole size from ~30 million km², to the present value of ~24 million km² (Reduction 20%). This may be an indicator of a possible partial recovery.

(iii) The lower part shows the evolution of the CFC 11 and 12 compounds. Data are available only for 1992 onwards. The CFC-11 level (ppt) was 275 in 1992 but has steadily reduced to ~230 in 2012 (275 to 230, about 16%). The CFC-12 level (ppt) rose from 500 to 545 in 2003-2004 but has reduced since then to 525 in 2012 (545 to 525, ~4%). Thus, CFC levels are showing a tendency of reduction. As mentioned earlier, the Montreal Protocol recommended immediate efforts to reduce or eliminate the use of CFC compounds and this seems to have produced some effect. Thus, based on the CFC criterion alone, the ozone hole recovery may have started; but what actually happens, only data in the next few years will indicate.

4. *Conclusion* - The Antarctic ozone hole intensity fell from a level of ~200 DU in 1979 to ~75 DU in 1994 and has not recovered much since then. It is hovering around 100 DU, occasionally rising to ~125 DU but falling back again to ~100 DU, thus indicating no recovery. On the other hand, the ozone hole area showed a reduction, from 30 to 24 (20%). Since the CFC compound level is steadily falling in recent years (effect of Montreal agreement), an ozone recovery may be round the corner. The hole intensity does not yet signal a recovery; but the reduction of hole area in recent years does signal a possible tendency of recovery.

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