Natural ozone depletion over Antarctica

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Chlorine-catalysed depletion of the stratospheric ozone layer has commanded considerable attention since 1985, when Farman *et al*[1] observed a decrease of 50% in the total column ozone over Antarctica in the austral spring. Here we examine the loss of stratospheric ozone caused by the reaction of ozone with nitric oxide generated by energetic protons, associated with solar flares. During large solar flares in March 1989 satellite observations reveal depletion over the southern polar regions shown in the colour plot of March 21 below[2]. This colour plot uses data obtained from the total ozone mapping spectrometer (TOMS) aboard the Nimbus 7 satellite launched in 1978. The experiment measures the global distribution of total column ozone daily. Each hue of the colour bar in the plot represents 20 DU's the lowest range being 180 to 199 DU. Attention is drawn down to latitude 70° S, in which there is a substantial area covered by blue colours corresponding to low total column ozone.

In March 1989 many large flares produced over 5 500 particles cm^{-2} s^{-1} $ster^{-1}$ of high energy (> 10 MeV) protons. These particles enter the atmosphere at high geomagnetic latitudes (> 60°) and can penetrate to altitude ranges where ozone is most abundant. The protons produce secondary electrons, through collisions with atmospheric particles, which ionize and dissociate molecular nitrogen leading, in turn, to the formation of nitric oxide[3]. The nitric oxide can then play an important part in ozone depletion through the following catalytic reactions:

$$NO + O_3 \rightarrow NO_2 + O_2$$
$$NO_2 + O \rightarrow NO + O_2$$

The total mass decreased by 7,4 x 10^9 kg or about 9% of the total mass of ozone within 70° S. Total column ozone above SANAE dropped by over 50 DU. Depletion in October due to chlorine is much deeper (total column readings as low as 90 DU) and occurs over an area four times as great as that due to solar proton effects.

Other events of high energy protons from solar flares are being investigated, including analysis of northern polar ozone.

REFERENCES

1 FARMAN JC, GARDINER BG & SHANKLIN JD 1985. Large losses of total ozone in Antarctica reveal seasonal ClO_x/NO_x interactions. *Nature* 315: 207-210

2 STEPHENSON JAE & SCOURFIELD MWJ 1991. Importance of energetic solar protons in ozone depletion. *Nature* 352: 137-139

3 CRUTZEN PJ, ISAKSEN SA & REID GC 1975. Solar Proton Events: Stratospheric sources of nitric oxide. *Science* 189: 457-459