RAL DESIGN & DISCOVERY
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RUTHERFORD APPLETON LABORATORY
SCIENCE AND ENGINEERING RESEARCH COUNCIL

OZONE

The Earth's atmosphere is a very thin layer of gases covering its surface, composed of approximately 80% nitrogen and 20% oxygen. In addition, there are a number of 'trace' gases with very low concentrations which include ozone. Although ozone composes only a very small percentage of the Earth's atmosphere (of the order of a few parts per million by volume) it is nevertheless essential for the existence of life on the planet. Ozone is a molecule made up of three oxygen atoms. 90% of atmospheric ozone resides in the 'ozone layer' between 15 km and 35 km above the Earth's surface.

It is important because:
(1) it absorbs solar ultraviolet (UV) radiation which is potentially damaging to human health and the environment, and
(2) by absorbing solar radiation it warms the atmosphere and plays an important role in determining the atmospheric circulation and hence our climate.

THE OZONE HOLE

Ozone is generated over the equator but is then transported to polar regions, where the largest concentrations usually exist. Recent observations of ozone have highlighted an 'OZONE HOLE', a region of air severely depleted in ozone over the South Pole. Figure 1 shows the distribution of column amounts of ozone in the southern hemisphere on 5th October 1987. Notice that the ozone hole covers much of the Antarctic continent. The hole is formed during late august/september, is present for most of september and october and then subsequently recovers. The depth of the hole has been steadily increasing since the 1970's (see figure 2) although there is much variability from year to year.

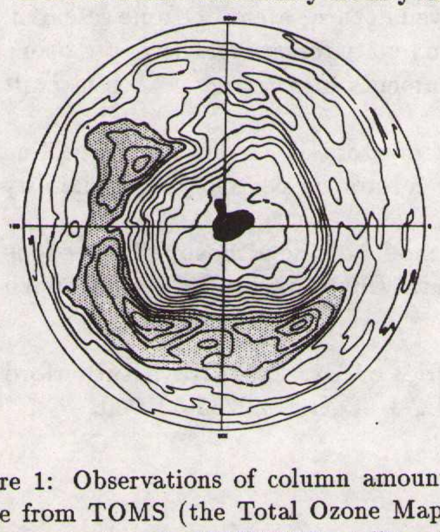

Figure 1: Observations of column amounts of ozone from TOMS (the Total Ozone Mapping Spectrometer) on the NIMBUS 7 satellite, showing that the ozone hole covers much of the Antarctic.

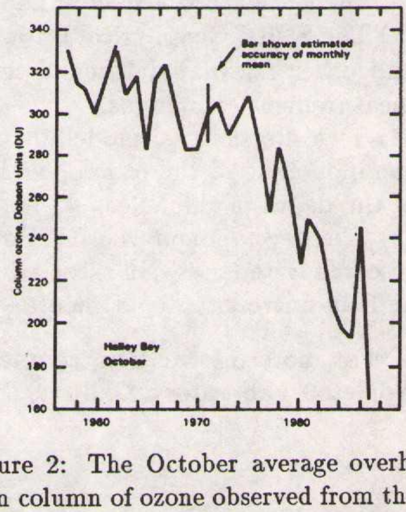

Figure 2: The October average overhead column column of ozone observed from the British Antarctic Survey station at Halley Bay (76 S). A rapid decline has been observed since the mid 1970's.

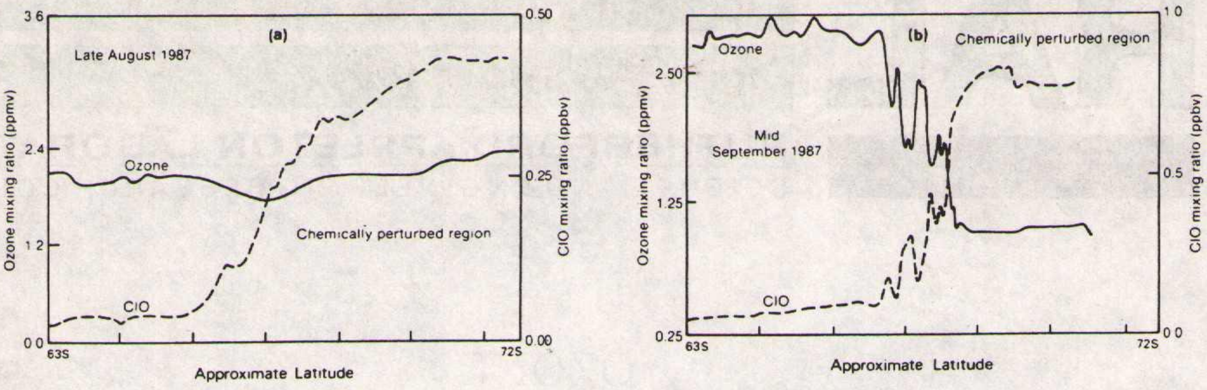

Figure 3: Aircraft observations of ozone and chlorine monoxide at approximately 18 km.

The ozone hole is believed to be due to the increasing amounts of chlorine present in the atmosphere as a result of man's activities (primarily in the form of chlorofluorocarbons (CFCs), used as aerosol propellants, foam-blowing agents, solvents and refrigerants). A recent aircraft measurement campaign over Antarctica has provided compelling evidence for the involvement of chlorine monoxide radicals (ClO) in the destruction of ozone. Figure 3 shows measurements of ozone and ClO (a) during late August, just before the onset of the hole, when ozone has a fairly uniform distribution with latitude, and (b) in mid September, when the depletion of ozone in polar regions is evident. Notice the striking anti-correlation of ozone and ClO.

The ozone hole occurs over the South Pole because of the very cold temperatures there. The formation of 'polar stratospheric clouds', which can only form in the exceedingly cold temperatures, is thought to play an essential part in both the release and maintenance of high concentrations of the reactive chlorine. Whilst the temperatures over the North Pole are not so low, there is now evidence that these clouds can form in northern polar regions and recent aircraft measurements (in winter 1989/90) have indicated that the same chemical destruction of ozone by active chlorine may also be occuring there.

OZONE RESEARCH AT RAL

The Rutherford Appleton Laboratory is involved in three areas of ozone research.
(1) The SERC Geophysical Data Facility gives university researchers access to ozone and other relevant datasets from satellite instruments and recent NASA aircraft measurement campaigns.
(2) Two dimensional modelling of the chemistry of ozone is carried out, including the modelling of the ozone hole itself and research into the year-to-year variability of the depth of the hole.
(3) The development of a full three dimensional model of the atmosphere for ozone research is underway, in association with the Natural Environment Research Council and six university departments.

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