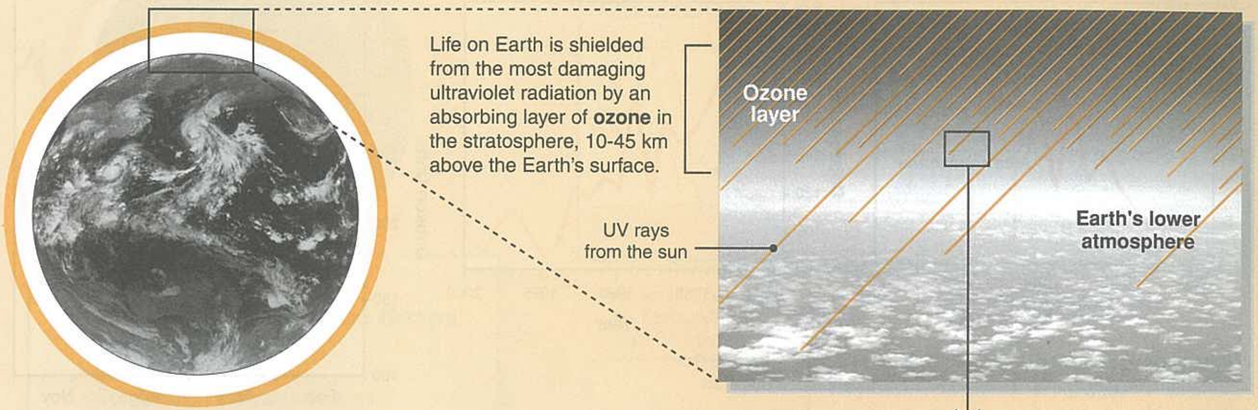
Stratospheric Ozone Depletion

In a band of the upper stratosphere, 17-26 km above the Earth's surface, exists a thin veil of renewable **ozone** (O_3). This ozone absorbs about 99% of the harmful incoming UV radiation from the sun and prevents it from reaching the Earth's surface. Apart from health problems, such as increasingly severe sunburns, increase in skin cancers, and more cataracts of the eye (in both humans and other animals), an increase in UV-B radiation is likely to cause immune system suppression in animals, lower crop yields, a decline in the productivity of forests and surface dwelling plankton, more smog, and changes in the global climate. Ozone is being depleted by a handful of human-produced chemicals (ozone depleting compounds or ODCs). The problem of **ozone depletion** was first detected in 1984. Researchers discovered that ozone in the upper stratosphere over Antarctica is destroyed during the Antarctic spring and early summer (September–December). Rather than a "hole", it is more a thinning, where ozone levels typically decrease by 50% to 100%. In 2000, the extent of the hole above Antarctica was the largest ever, but depletion levels were slightly less than 1999. Severe ozone loss has also been observed over the Arctic. During the winter of 1999-2000, Arctic ozone levels were depleted by 60% at an altitude of 18 km, up from around 45% in the previous winter. The primary cause for ozone depletion appears to be the increased use of chemicals such as chloro-fluoro-carbons (**CFCs**). Since 1987, nations have cut their consumption of ozone-depleting substances by 70%, although the phaseout is not complete and there is a significant black market in CFCs. **Free chlorine** in the stratosphere peaked around 1999 and is projected to decline for more than a century. Ozone loss is projected to diminish gradually until around 2050 when the polar ozone holes will return to 1975 levels. It will take another 100-200 years for full recovery to pre-1950 levels.



Sources of ozone depleting chemicals

The chemicals below drift up to the stratosphere, where ultraviolet radiation causes release of free chlorine, a highly reactive chemical.

Chloro-fluoro-carbons (CFCs)
- Propellants for aerosol cans
- Coolants in air-conditioners
- Coolants (freon) in refrigerators
- Styrofoam insulation/packaging
- Medical sterilizers

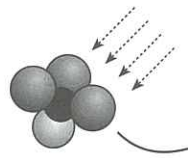
Halons
- Used in many fire extinguishers

Methyl bromide
- Used as a fumigant in agriculture

Methyl chloroform
- Used to degrease metals

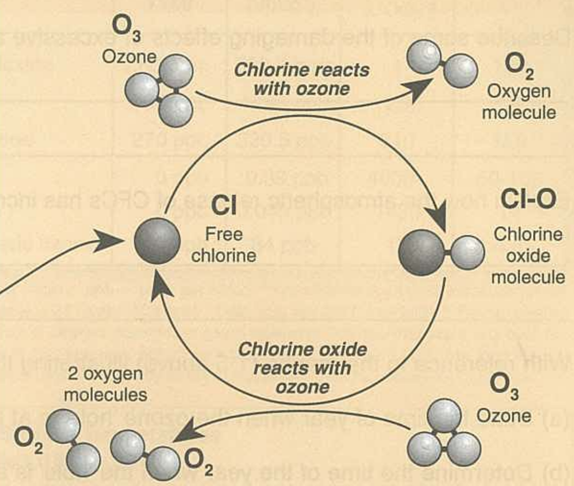
Carbon tetrachloride
- Used in many industrial processes

UV light hits a CFC molecule and releases a chlorine atom

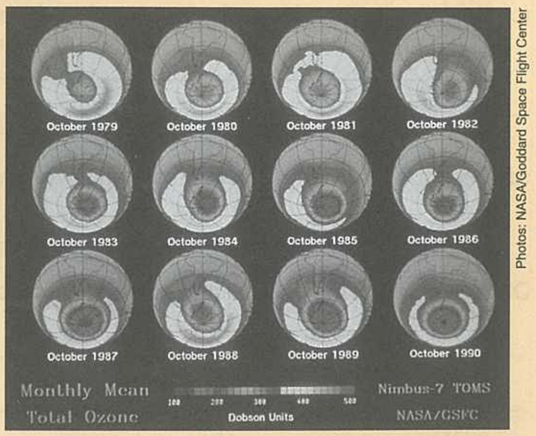


$C.Cl_3F$
Chlorofluorocarbon (CFC)

The destruction of ozone by free chlorine



A large 'hole' in the ozone layer develops over Antarctica each summer, dropping the ozone well below its normal level. The size and intensity of the hole is growing each year, as can be seen in the satellite photos on the right. In recent years, a similar hole has developed over the Arctic.



Photos: NASA/Goddard Space Flight Center

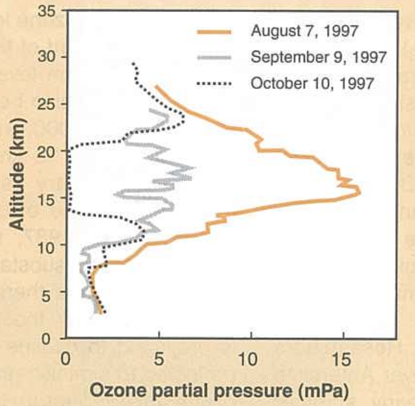
Dobson Unit (DU): A measurement of **column ozone** levels (the ozone between the Earth's surface and outer space). In the tropics, ozone levels are typically between 250 and 300 DU year-round. In temperate regions, seasonal variations can produce large swings in ozone levels. These variations occur even in the absence of ozone depletion. **Ozone depletion** refers to reductions in ozone below normal levels after accounting for seasonal cycles and other natural effects. For a graphical explanation, see NASA's TOMS site: ***http://toms.gsfc.nasa.gov/teacher/basics/dobson.html***

Characteristics of the ozone 'hole'

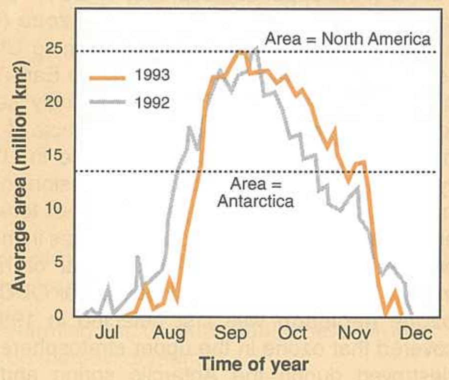
The ozone 'hole' (stratospheric ozone depletion) can be characterized using several measures. The five graphs on this page show how the size and intensity of the hole varies through the course of a year, as well as how the phenomenon has progressed over the last two decades. An explanation of the unit used to measure ozone concentration (Dobson units) is given on the opposite page. Graphs 2 and 5 illustrate readings taken between the South Pole (90° south) and 40° latitude.

Data supplied by NASA's Goddard Space Flight Center and the National Oceanic and Atmospheric Administration (NOAA) in the USA.

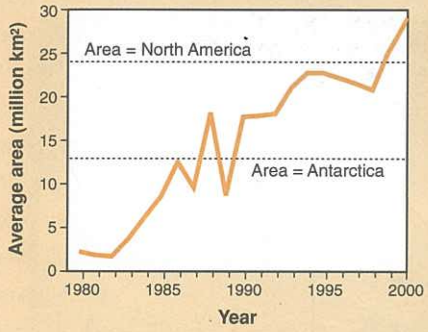
Graph 1: Ozone hole altitude profile



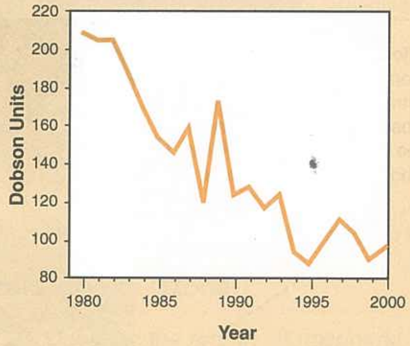
Graph 2: Antarctic ozone hole area (<220 DU, 40° – 90° South)



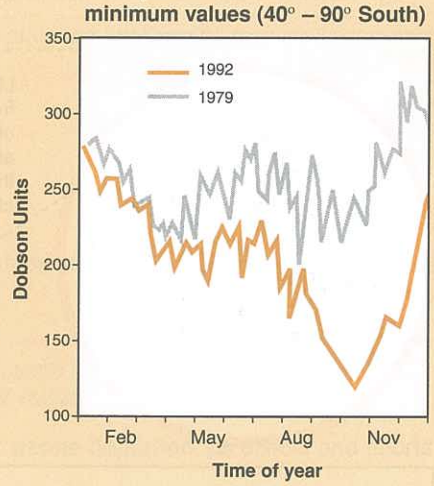
Graph 3: Change in area of the Antarctic ozone hole*



Graph 4: Antarctic ozone hole minimum values* (60° – 90° S)



Graph 5: Antarctic ozone hole minimum values (40° – 90° South)



* Date range in which samples were collected in each year: 7 Sep–13 Oct
The ozone 'hole' is defined as region with less than 220 Dobson units

Sources: NASA Goddard Space Flight Center; NOAA / CMDL

1. Describe some of the damaging effects of excessive amounts of ultraviolet radiation on living organisms:

2. Explain how the atmospheric release of CFCs has increased the penetration of UV radiation reaching the Earth's surface:

3. With reference to the graphs (1-5 above) illustrating the characteristics of the stratospheric ozone depletion problem:

   (a) State the time of year when the ozone 'hole' is at its greatest geographic extent:

   (b) Determine the time of the year when the 'hole' is at its most depleted (thinnest):

   (c) Describe the trend over the last two decades of changes to the abundance of stratospheric ozone over Antarctica:

   (d) Describe the changes in stratospheric ozone with altitude between August and October 1997 in Graph 1 (above):

4. Discuss some of the political and commercial problems associated with reducing the use of ozone depleting chemicals: