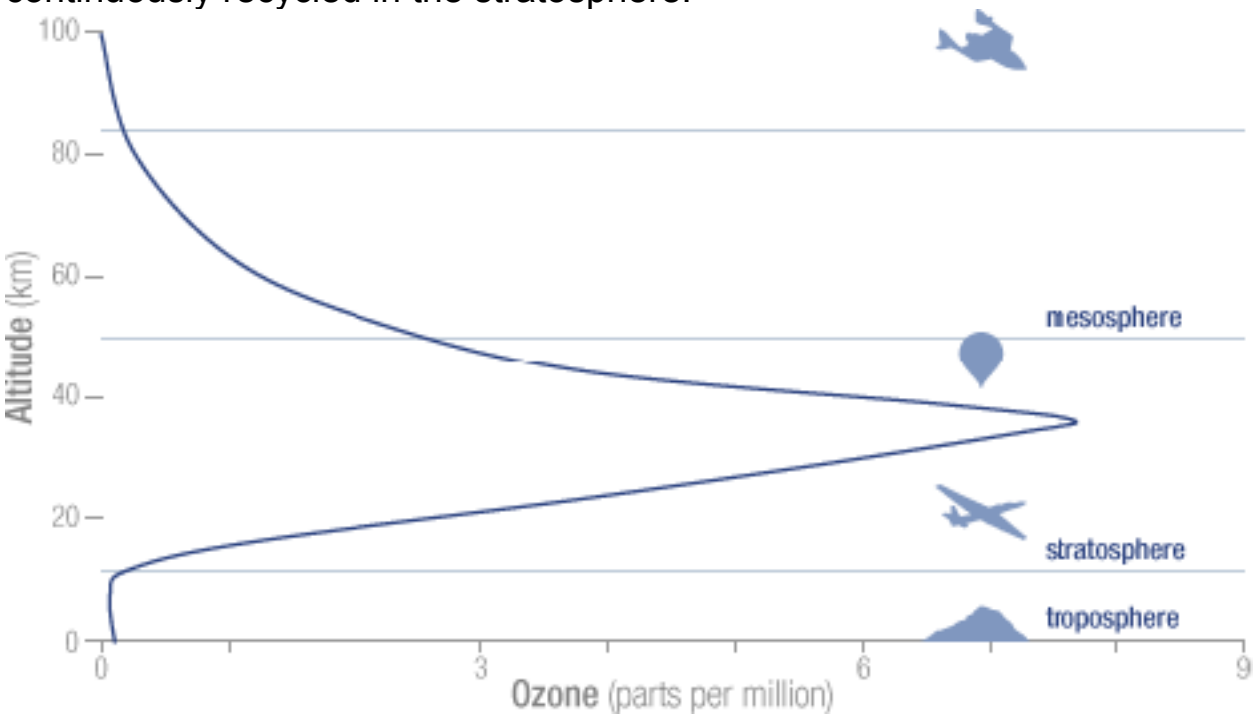
Content

The layer of the Earth's atmosphere that surrounds us is called the troposphere. The next layer up between 10 and 50 km is called the stratosphere and it is here where the ozone layer (which accounts for 90% of Earth's ozone) can be found. Ozone is a naturally occurring gas that is continuously recycled in the stratosphere.

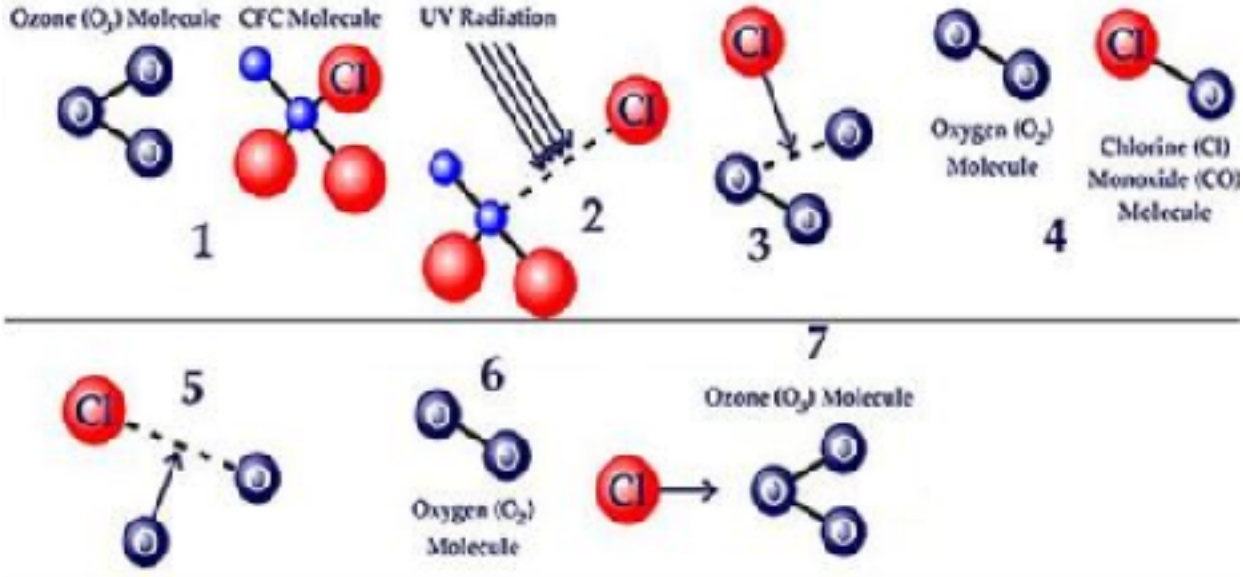


The concentration of ozone varies with altitude. Peak concentration of 8 molecules of ozone per million molecules in the atmosphere occur between an altitude of 30 and 35 kilometers. Image courtesy of NASA.

The ozone layer is important because it filters the Sun's ultraviolet (UV) radiation, and the effect of a thinning of the ozone layer is a greater amount of UV radiation reaching the Earth. The greater quantities of UV light may result in a greater incidence of skin cancer, cataracts, and weakened immune systems.

Measuring Ozone:
The Dobson Unit (DU) is the unit of measure for the amount of total ozone. Ozone is spread in the upper stratosphere where the air pressures and temperature are greatly reduced. If all of the ozone in a column of air were brought to a standard temperature and pressure then the column would be 0.3 cm thick, and the total ozone would be 0.3 atm-cm. A Dobson Unit is defined to be 0.001 atm-cm and the 0.3 value would therefore become 300 DU.

Ozone Depletion:
Ozone depletion is caused by the release of chlorofluorocarbons (CFCs), and hydrochlorofluorocarbons (HCFCs), which were used widely in refrigeration and aerosol canisters. Other ozone depleting substances (ODS) including methyl bromide (used as a pesticide) and halons (used in fire extinguishers) have also been a concern.
CFCs are heavier than air but in two to five years they slowly move up through the atmosphere and when in the stratosphere, UV radiation from the Sun causes them to dissociate and release the chlorine atoms. The chlorine atoms react with the ozone (O_3) producing O_2 and ClO. The ClO may then react with an unstable O atom releasing the Cl to break apart another ozone molecule. One chlorine atom may break apart more than 100 000 ozone molecules before it leaves the stratosphere.



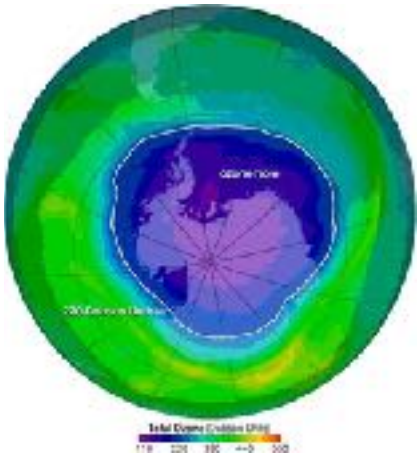


Image courtesy of NASA.

Ozone Holes:
The ozone hole in the Southern hemisphere is more prominent during the spring when reactions between chlorine and bromine cause the ozone to be destroyed at a rapid pace, forming an "ozone hole". The area itself is not a hole but an area where the amount of ozone is greatly diminished compared to the rest of the Earth.
The ozone hole over Antarctica is easily visible in the coloured concentration of ozone map of Earth. The atmosphere over Antarctica has a measured ozone value of approximately 110 DU, which is 220 DU lower than other areas around the Earth.

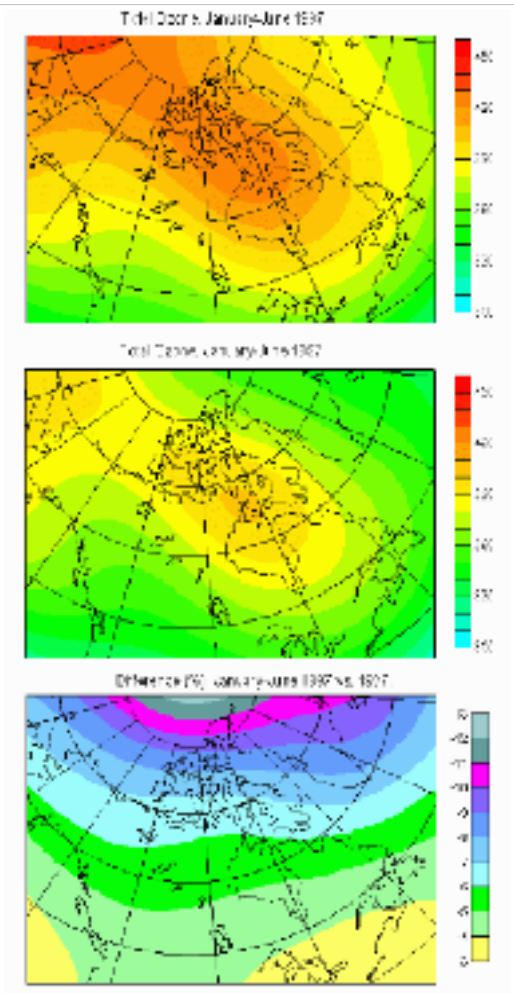


Image courtesy of Environment Canada.

Canada's Ozone:

The upper map to the left shows average ozone levels over Canada for January-June 1987, while the middle map shows the same information for January-June 1997. The percentage differences between the two periods are plotted in the lower map, which shows declines ranging from 3% over southern Canada, about 4% over the Prairies, and up to 12% in the high Arctic. The maps have been constructed from both ground-based and satellite measurements.

Effects of Ozone Depletion:
The ozone layer acts a natural filter absorbing most of the Sun's UV rays, but what happens when the ozone layer is decreased and loses its ability to absorb the UV rays? There are three categories of UV radiation. UVA and UVB can both cause health problems including skin cancer; however, UVA is a low energy UV ray and has minimal biological effects. UVB, a higher energy ray, causes the most damage to living organisms and UVC is absorbed by oxygen in the atmosphere and never reaches the Earth.

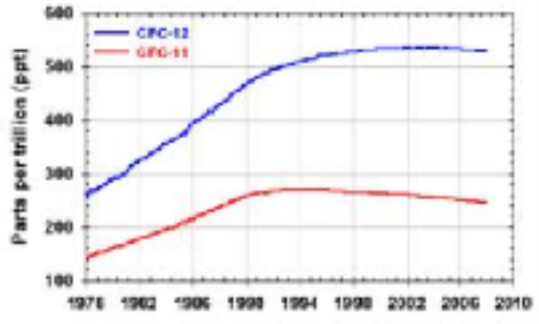
UV radiation may alter DNA and cause skin cancer. Tans and sunburns are examples of UV radiation causing skin damage. There are three main types of skin cancer, basal cell carcinoma, squamous cell carcinoma, and malignant melanoma. The squamous and basal cell carcinomas represent most cases in Canada and rarely cause death because they don't spread to other areas of the body. Scientists predict that a 10% depletion of ozone will result in a 26% increase in the number of skin cell carcinoma cases. Melanoma is the least common form and the most serious because the cancer cells can spread to other parts of the body.

UVB radiation can also damage several parts of the eye. Cataracts are a clouding of the eye's lens and the leading cause of permanent blindness worldwide. It is expected that with a 10% thinning of the ozone layer, there will be an increase of nearly two million new cases of cataracts per year globally. "Snow blindness" is a concern in the northern snowy regions as the white surface reflects sunlight and results in overexposure of the eye to UVB radiation.

Recent research has shown that UV light not only causes cancer and affects our eyes but that it also affects our ability to fight off disease. Our immune system is the first line of defence against bacteria and germs, and recent research has shown that some viruses may be activated by exposure to UV, corresponding with a decrease in our immune response.

Fighting the Battle:
Canada was one of the original countries involved in the signing of the Montreal Protocol on September 16, 1987 that was a significant step in global politics and the protection of Earth's natural systems. Research had indicated that the ozone layer was decreasing and the suspected cause was a group of ozone depleting substances, in particular the CFCs. The

mechanism of ozone destruction was not clear, but there was a general global agreement that called for the reduction and eventual phase-out of CFCs and other ODSs. Progress in this movement has been outstanding and in Canada production of CFCs, which had peaked in 1986 at 21 kilotonnes, was reduced to 0 by 1995. The total Canadian ODS production in 1997 was 1 kilotonne.



Measurements of ozone depleting substances in the Arctic (ppb). Image courtesy of U.S. NOAA

CFCs are no longer being produced and evidence is shown in the levelling out and decreasing concentrations of CFC11 and CFC12. (CFC11 and CFC12 are two different types of chlorofluorocarbons used in different commercial applications.) However the concentrations may persist for many years to come, as the lifespan of CFCs in the atmosphere may range from 50 to over 1000 years.

Will the Ozone Layer Recover?

Progress has been made with the elimination of CFCs and other ozone depleting substances and even though there is a delay in the declining concentrations in the atmosphere, the ozone layer is expected to recover. Various estimates have been made between 50 and 100 years due to the uncertainty of the lifespan of the ODSs in the atmosphere and the other mechanisms that may play a factor in the destruction of the ozone and also in the regeneration of the ozone.