



**Western Region Technical Attachment
No. 92-27
August 25, 1992**

DISAPPEARING OZONE

John Slemmer - WRH Summer Aid

[Editor's note: The following information was summarized from NASA and NCAR bulletins, an article in the November 1, 1991 issue of Science magazine, and an article in WMO Bulletin, Vol 41, No 2, April 1992.]

Introduction

The Earth's ozone layer, a natural barrier against harmful ultraviolet (UV) radiation, has been rapidly disappearing in just the last several years. The ozone is actually being irreversibly converted into another chemical form: oxygen atoms and oxygen gas. CFCs (chlorofluorocarbons) have been blamed by the scientific community for the ozone's destruction ever since the large hole in the ozone was discovered over the Antarctic in 1985; reductions of 50 percent of normal were found. As time has progressed, a gradual drop has occurred since the 1985 levels; the lowest being this past winter in the Antarctic. CFCs are being blamed because they are thought to contribute the most to the decrease.

Chemical Destruction Processes

The normal ozone-producing chemical process begins with UV radiation breaking the three oxygen molecule (ozone or O₃) into oxygen gas and a single oxygen atom. Ozone is then produced through the separation and recombination of oxygen molecules with single oxygen atoms. However, CFCs can interrupt this process because the chlorine component of this molecule combines with oxygen atoms to form a chlorine oxide molecule, which is eventually separated by UV radiation. Further depletion of available oxygen atoms occurs when chlorine oxide and oxygen atoms form chlorine and oxygen gas. This results in fewer oxygen atoms to recombine with oxygen gas and make ozone again (see Figure 1).

This ozone-destroying process can repeat approximately 100,000 times before the chlorine atom becomes locked in a reservoir compound. Hydrogen atoms and nitrogen oxide molecules combine with chlorine to become reservoir compounds. These reservoir compounds cannot be broken by UV energy. Winds aloft transport these molecules to the poles where concentrations are the greatest.

During the Antarctic winter, when the temperatures in the upper polar atmosphere become extremely cold, the reservoir compounds attach themselves to ice crystals. A photochemical reaction takes place after the Antarctic winter, as sunlight reappears in the region, which causes the chlorine to separate from the reservoir compounds. This allows the ozone decaying process to enhance itself in this region.

The Arctic has not experienced a similar reduction to the Antarctic, because of generally warmer temperatures and fewer stratospheric ice clouds. However, chlorine oxide measurements have shown levels three times as high as the Antarctic during the winter season. During the greatest periods of breakdown of the polar vortex in the Northern Hemisphere (spring/summer), the mid-latitudes acquire higher amounts of chlorine oxides because of the increase in circulation over the region, and the southward spread of air from within the polar vortex.

Other chemical ozone destruction processes exist, including a natural hydrogen process, and others triggered by man-made chemicals such as nitrogen oxide (from the exhaust of high altitude aircraft) and halons (most frequently found in fire extinguishers). These sources of ozone destruction contribute only marginally to today's large decreases.

Volcanic eruptions further add to ozone-decaying chemical reactions on a global scale. Sulfur dioxide, which is the main component of volcanic debris, may facilitate chemical reactions analogous to the ones occurring with the stratospheric ice clouds at the poles. Mount Pinatubo, one of the largest eruption this century, emitted roughly 15-20 million tons of sulfur dioxide around the globe within four weeks. Additionally, the emission of hydrogen chloride from volcanic eruptions further aids the ozone-depleting process.

Scientists feared that this past winter's ozone loss in the northern mid-latitudes would be about 5-10 percent due to the predicted chemical reactions that could have occurred with sulfur oxide emissions from the Pinatubo eruption. Fortunately, North America had a mild winter, which may have played a role in preventing the occurrence of a significant ozone decrease.

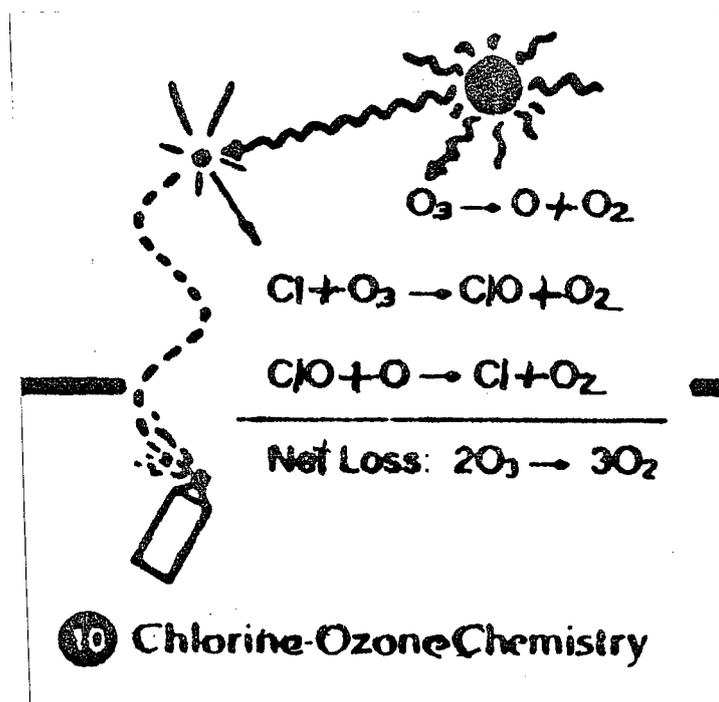


Figure 1

Recent Measurements

Measurements taken last fall over the Antarctic show a continued downward trend in ozone concentrations, with the greatest observed decrease as of yet. NASA has determined that in the period 1969-1986, the Northern Hemisphere above 40° N had a total reduction in ozone levels of five percent in the winter/spring seasons. During the decade of the 1980s, ozone depletion was a total of three percent in the northern mid-latitudes, while Buenos Aires and Sydney had losses of five percent. The EPA estimates that 20,000 people get skin cancer for every one percent decrease of ozone.

Aircraft took readings this past winter in the troposphere over the mid-latitudes of the Northern Hemisphere to ascertain the concentration of ozone-destroying molecules. Chlorine oxide amounts increased to their highest level ever observed (1.5 ppb) as the cold arctic air began to make its way southward. Greatly increased levels of chlorine oxide were found as far south as 22° N.

All the recent figures have heightened worldwide concern for what the effects will be and what can be done to control this problem. The main contributors to CFC accumulation in 1989 were insulation, air conditioners, refrigerators, and industrial cleaning. DuPont, AT&T, and other major contributing corporations have vowed to halt production of CFCs by the end of the century. Recent bills passed by Congress over increased concern for faster and more acute elimination of ozone have coerced these companies to entirely eliminate these chemicals by 1996.

Conclusion

The most extreme losses of ozone continue to occur at the Antarctic, yet recent evidence suggests that all areas of the planet are highly susceptible to this problem. The Antarctic seems to have the most intense loss because of special conditions related to the polar vortex and extremely cold temperatures. It is feared that the destruction will continue to intensify as ozone-destroying agents continue to increase on a global scale. Developing countries do not yet have the technology, nor can they afford to pursue alternative sources. CFCs will continue to be used by major corporations in the U.S. and other developed countries while alternative sources are gradually phased in.

Even though CFC emissions on a global scale will eventually be reduced, it is believed that the molecules already in the atmosphere will remain chemically "active" for another 50 to 100 years. Therefore, the threat of a continued decay in the Earth's ozone layer could last through most of the 21st century.