Chapter 26 – Ozone Depletion

Case Study: Epidemic of Skcin Cancers in the US
This case study puts forth the widely believed idea that the increase of skin cancers in the US is correlated with ozone depletion. It also examines the statisctics related to expected increase in cancer (about 2% increase for a 1% decrease in ozone) and shows this this cannot account for the 90% increase in cancers since 1975. Skin cancer, therefore has multiple causes including increased voluntary exposure to uv through tanning.

Ozone Basics

The chemical formula for ozone is O3. It is formed as an angular molecule and is unstable – therefore it reacts well. About 90% of the ozone found in the atmosphere is found in the stratosphere. OZONE IN THE TROPOSPHERE BAD: OZONE IN THE STRATOSPHERE GOOD.

There are three types of ultraviolet light, UVA, UVB, and UVC. UVA has the longest wavelength. It is relatively harmless and much of it reaches earth. UVC can be very harmful, but is filtered by O2, UUVB causes damage to DNA and is filtered by ozone in the stratosphere. When Ozone (O3) absorbs ultraviolet radiation it breaks down into O2 and an atom of O.

Ozone in the atmosphere is measured in "**Dobson Units**" which is equal to 1 ppb.

Ozone depletion

Here's the idea: CFCs emitted in the lower atmosphere by human activity are stable and can persist for up to 100 years. Because of this they can eventually find their way into the stratosphere. Once they are there the UV light will break them apart releasing atomic chlorine (Cl), this chlorine breaks apart ozone, and uv that would have absorbed by breaking that ozone is now allowed to pass to the surface of the earth.
Here are the reactions that deplete ozone

$$Cl + O3 \rightarrow ClO\ O2$$

$$ClO + O \rightarrow Cl + 02$$

One of the reasons this can be so damaging to ozone is that Cl acts as a catalyst, in other words, it is not used up in the reaction. It is thought that one Cl atom can destroy up to 100,000 molecules of ozone.

Uses of CFCs and other ozone depleting chemicals

The major uses of CFCs and other ozone depleting chemicals are in air conditioning, making foams (such as stryrofoam) and in fire extinguishers (table 24.1) . CFCs were once used as a propellant in hair spray, but that has been illegal since the late 1970s.

Chlorine sinks in the stratosphere

There are two main ways that chlorine can be absorbed in the stratosphere and slow its ability to destroy ozone. (1) the ClO that results from the first step in ozone depletion (see first column of theses notes) can combine with N)2 to form ClONO2. (2) Cl may combine with methane to form Hcl (hydrochloric acid) which can rain out, removing the Cl from the stratosphere.

The Antartic Ozone "Hole"

The most pronounced depletion of ozone occurs over the Antartica during Antartic spring (this occurs in April since it is south of the equator). There has been a consistent increase in the

size of the “Hole,” which is really an area of thinning, since the 1970s.

Polar Stratospheric Clouds

These special clouds have a lot to do with why the ozone hole is greater in antartic spring. During winter in antartica, the low amount of sunshine means that the air above the pole gets very cold (below 100 farenheit). At these temperature polar stratospheric clouds can form. When these clouds form the NO2 in the stratosphere gets tied up in the clouds as nitric acid. When these particle get big enough they fall to the earth, this removes the nitric acid (and the NO2 it came from) from the stratosphere. When the sun returns in spring, there is no NO2 to act as a chlorine sink and the rate of ozone depletion is especially high.

Environmental Effects of Ozone Depletion

Increase in skin cancer and cataracts; decrease in primary productivity in the oceans as the increased uv damages the phytoplankton, this can damage the ocean food chain as well as remove the role of ocean phytoplankton as a carbon sink. This may in turn impact global warming. Damage of crops such as corn, wheat, etc… Weakening of immune systems – this may be a particularlyl damaging impact in areas of Africa where AIDS is found in high frequency. Greatest impacts are in New Zealand and in Southern Australia and the tip of South America (Chile).

The Montreal Protocol

The Montreal Protocol is an international agreement to decrease the emissions of CFCs to 50% of 1986 levels. It was signed by 27 nations, including the US and has since grown by 119 countries.

How do we reduce CFCs?

Collection and reuse, as in from refrigerators and automobile air conditioners.

Substitites for CFCs. The main two are **hydrofluorocarbons (HFCs)** and **hydrochlorofluorocarbons (HCFCs)**. HFCs do not contain Cl, the fluorine in them can react similarly to Cl in the stratosphere, but not as effectively, so they damage many less ozone molecules (about 1000 times less). HCFCs containa hydrogen instead of a chlorine, this makes them less persistent, so they break up in the troposphere and the chlorine does not find its way into the stratosphere.