Lecture 11: Ozone Hole Depletion

- Ozone Production and Destruction
- Catalytic Cycle
- Polar Stratospheric Clouds
- CFC and Ozone Depletion

Ozone Production and Destruction

(from *The Earth System*)

The Chapman Mechanism of Ozone Production and Destruction

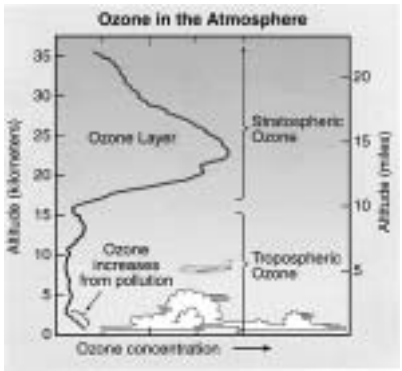
Photodissociation (or photolysis)

*Reaction**		*Rate*
1) $O_2 + UV\ photon \rightarrow O + O$	production	Slow
2) $O + O_2 + M \rightarrow O_3 + M$	production	Fast
3) $O_3 + photon \rightarrow O_2 + O$	destruction	Fast
4) $O + O_3 \rightarrow 2\,O_2$	destruction	Slow

visible light

destroy O3 permanently

Ozone Distribution

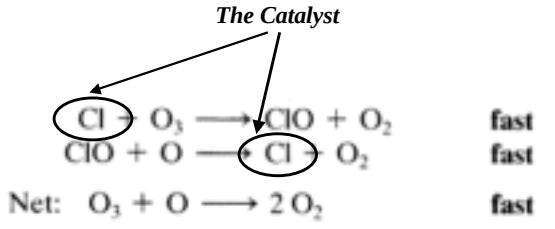


(from WMO Report 2003)

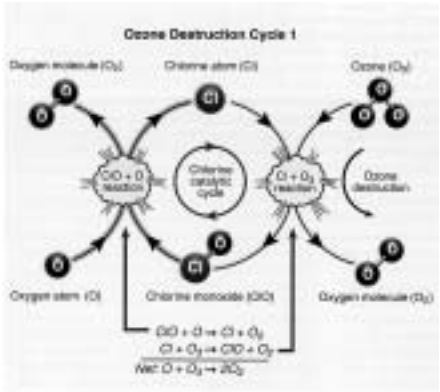
Other Ozone Destruction Processes

- Other atmospheric trace constituents, such as nitrous oxide (N2O), water vapor, and freons, can also be photolyzed. They produce highly reactive radicals that keep ozone abundances lower than they would otherwise be.
- These radicals include: nitric oxide (NO), atomic chlorine (Cl), bromine (Br) radicals, and hydroxyl (OH) radicals.
- These radicals can destroy stratospheric ozone through ***"catalytic cycles".***

The Chlorine Catalytic Cycle

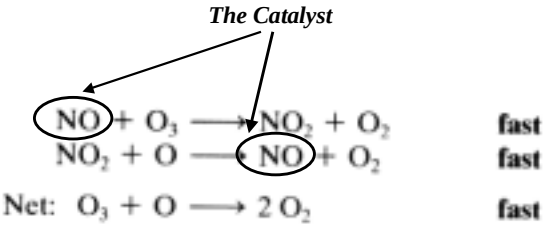


The Chlorine Catalytic Cycle



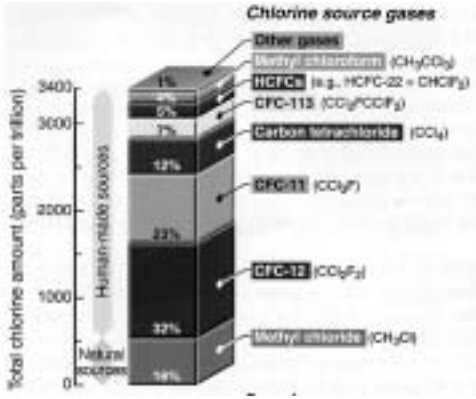
(from *WMO Report 2003*)

The Nitrogen Catalytic Cycle



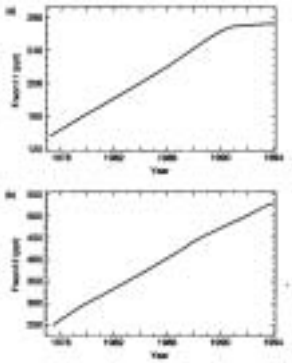
(from *The Earth System*)

Chlorine Sources



(from *WMO Report 2003*)

Man-Made Sources for CFCs



(from *The Earth System*)

- There are two kinds of CFCs: freon-11 (CCl_3F) and freon-12 (CCl_2F_2).
- Freon-11 has been used:
  (1) as a propellant in spray cans
  (2) as a blowing agent for producing foams
  (3) to clean semiconductor chips.
- Freon-12 has been used as
  (1) a refrigerant
  (2) working fluid in most car air conditioners.

Polar Stratospheric Clouds (PSCs)

(Sweden, January 2000; from NASA website)

- In winter the polar stratosphere is so cold (-80°C or below) that certain trace atmospheric constituents can condense.
- These clouds are called "polar stratospheric clouds" (PSCs).

How PSCs Affect Ozone Hole

- The ice crystals in the polar stratospheric clouds provide surface for the ozone depletion surface to occur more easily.
- On these cloud surfaces, certain forms of chlorine that do not react with ozone are converted into forms that do.
- Polar stratospheric clouds set up the stage for massive destruction of ozone to happen when sunlight returns in the spring.

Two Factors for the Ozone Hole

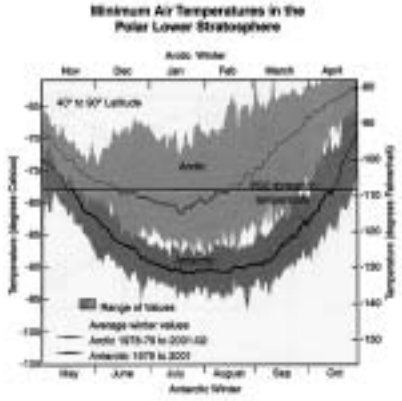
- Very Cold temperature

  To form polar stratospheric clouds (PSCs)

- Return of the Sunlight

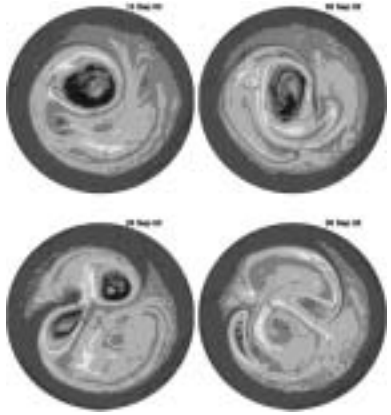
  To start the ozone depletion reaction

Why No Ozone Hole in Artic?



(from WMO Report 2003)

The Polar Vortex



- The wintertime circulation over the South Pole is characterized by a gigantic whirlpool of cold and dense air, called the polar vortex.
- The cold and dense cold air in the middle of the vortex is subsiding.
- The sinking air carries cloud particles along with it.
- Remove odd nitrogen from the stratosphere.
- Very little ozone and odd nitrogen can be brought into the south pole.

The 1997 Ozone Hole