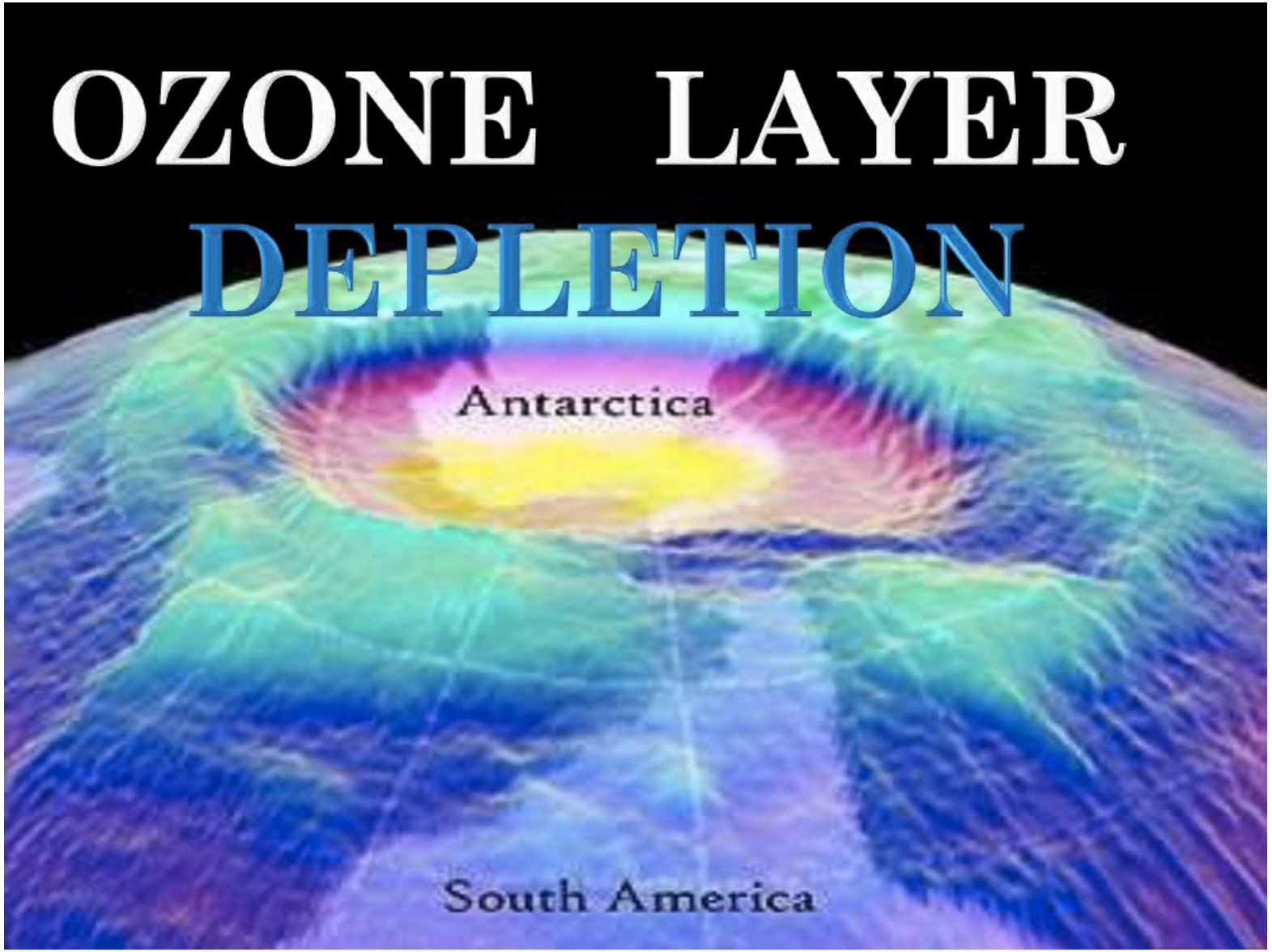
Lecture 12: Ozone Layer Depletion

Lydia R. Leonardo, DrPH
Professor Emeritus, UP Manila
Director, UE Office of Research Coordination
Professorial Lecturer, UP Diliman


OZONE LAYER
DEPLETION
Antarctica
South America

The Ozone Layer

Naturally occurring protective shield in the stratosphere, 25 km into space which absorbs the sun's ultraviolet radiation, preventing it from reaching the earth's surface

Protects life on earth from the dangerous UV radiation from the sun

In the 1970s, scientists discovered that chemicals called chlorofluorocarbons or CFCs which are used in refrigerants and aerosol spray posed a threat to the ozone layer.

Evolution of the Ozone Layer

Initially, the atmosphere was devoid of oxygen. Photosynthetic activities of the blue-green algae added oxygen into the atmosphere and only after that did the evolution of complex multicellular organisms took place.

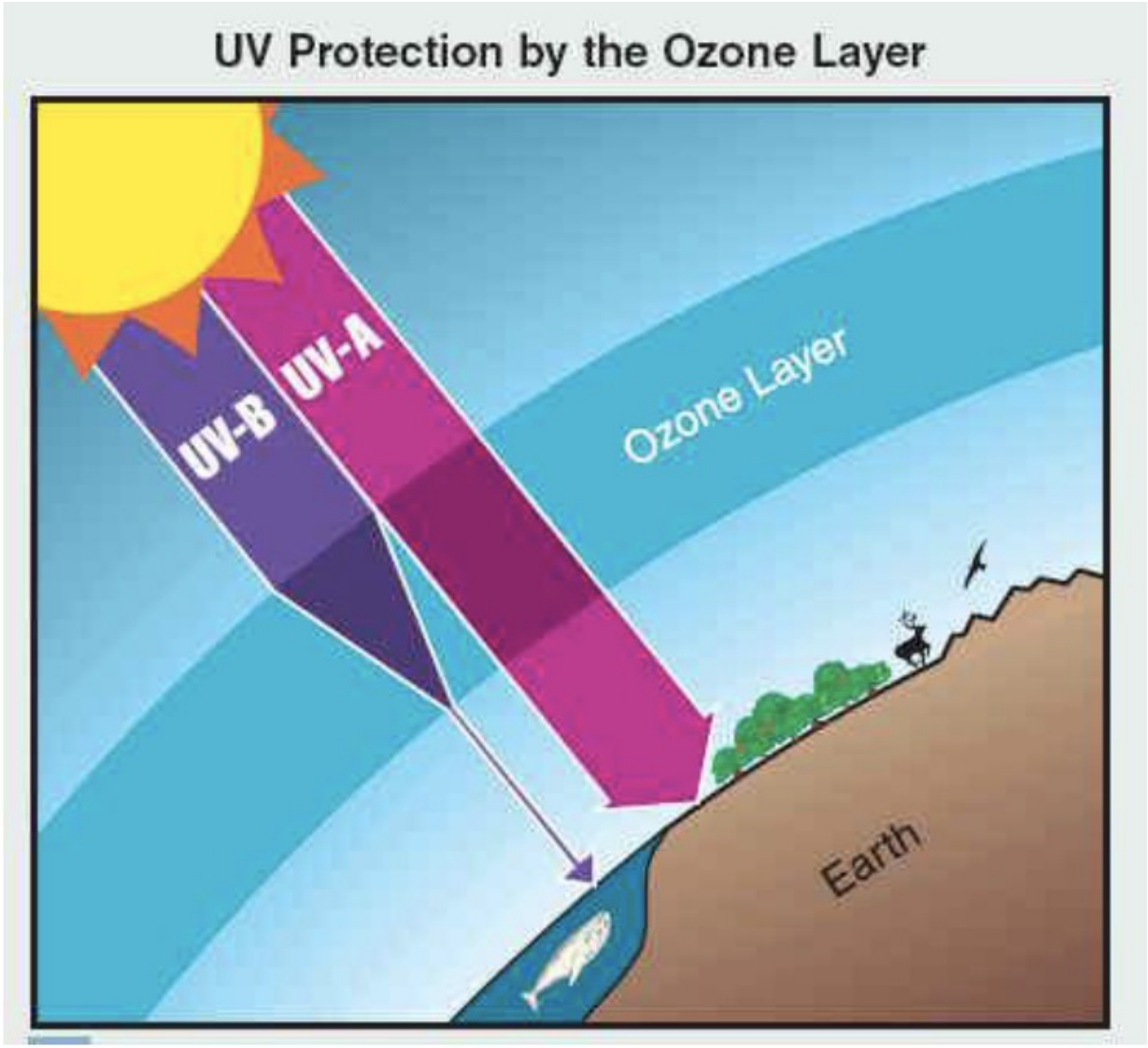
Ozone occurs in the form of a layer in the concentration of 10 ppm in the stratosphere between 16 to 40 kms. At the ground surface, the concentration is very low just around 0.05 ppm.

Ozone in the atmosphere accounts for the 90% of the total ozone present in the atmosphere.

A total of 350,000 tons of ozone are formed and destroyed everyday.

The average thickness of the ozone layer in the stratosphere is estimated to be around 300 dobson units. It varies marginally with latitude and season.

The ozone layer is thinnest at the polar regions due to cold conditions and other parameters.


UV Protection by the Ozone Layer
UV-B
UV-A
Ozone Layer
Earth

Causes of Ozone Layer Depletion

CFCs and halons (man-made which are used in air conditioning, refrigeration, aerosols, foam-blowing and modern fire-fighting are the main culprits responsible for the destruction of the ozone layer.

Oxides of nitrogen released from the exhausts of large fleets of supersonic aircrafts are also responsible for the increasing rate of ozone destruction.

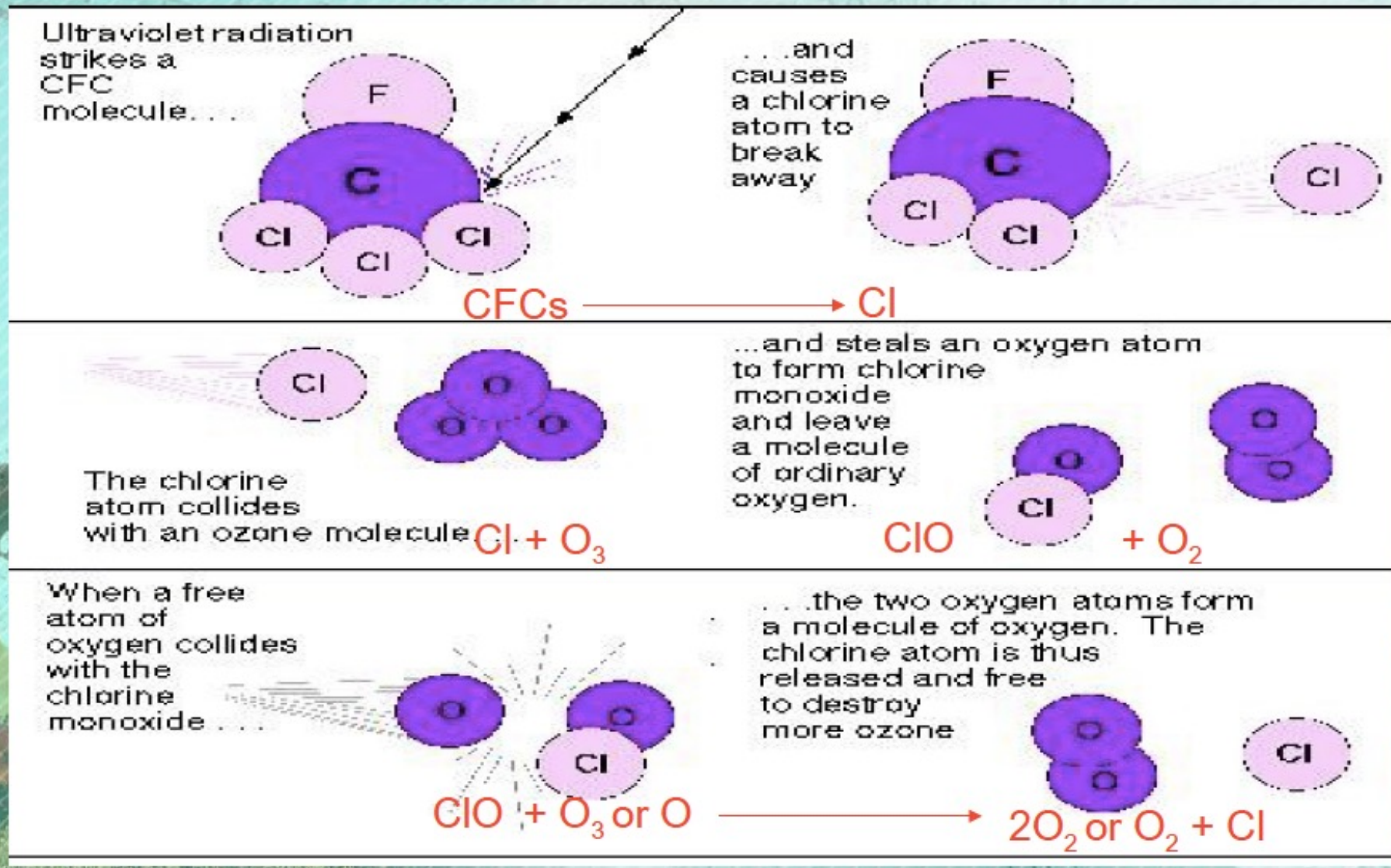
CFCs and halons have a long staying period in the atmosphere. CFC has a residential period between 60 and 110 years where CF_2Cl_2 has residency time of 55 to 400 years.

They remain inactive in the troposphere 0-15 kms and it takes about 20-40 years for these chemicals to reach the stratosphere.

Destruction of the Ozone Layer

- CFCs bond to the ozone layer and eat it up.
- The destruction of the ozone layer is seen to increase cases of cancer and cataracts.
- Gaps and holes in the ozone layer means entry of UV radiation.
- It also causes damage to certain crops and to plankton thus affecting food chains and food webs.
- Altered ocean ecosystem
- Harmful to flora and fauna especially of Canada
- This in turn causes and increase in carbon dioxide due to the decrease in vegetation.

Depletion of Ozone layer…Chemistry



Slideshare 2019

Where do you find CFCs?

Slideshare 2019

Polar Ozone Hole and Ozone Depleting Substances

- Depletion of the ozone layer has been found to be much more acute in polar regions particularly the Antarctic or south pole compared to other parts of the earth.
- Why ozone depletion greater at poles: due to prolonged cold climate, drop in temperature to -90C during winter and formation of stratospheric clouds

Air turbulence:

- Absence of N_2O (Nitrous oxide) in these areas: under normal conditions N_2O destroys chlorine monoxides and checks ozone depletion.
- In polar regions, N_2O at sub zero temperature freezes into ice droplets or clouds thus ClO free to act on ozone molecules. ClO in turn accumulates and continues destroying the ozone.

Concentration of ozone depleting substances:

- Chlorine in 25 years increased from 0.6 to 2.7 ppb in 1987 and by 2075 the concentration may triple.
- Bromine 1 ppb in 1987 may be 10 ppb by 2075.

Ozone Depletion levels

- 1-2% over all the areas of the globe
- 1.7-3% depletion between 30-60 ^{0} N latitude during 1969-1986 (2.3 to 6.2% in winter)
- 5% depletion beyond 60 ^{0} South latitude
- 5-20% more UV radiations may be received by the earth due to ozone depletion by 2030.

Consequences of Stratospheric Ozone Depletion

- Stratospheric ozone layer is the key life support system.
- Absorbs UV radiation very strongly in 220-320 nm wavelength.
- Depletion of ozone will result in increase in percentage incidence of UV radiations (290-320 nm). It will have profound effect on the DNA leading to mutation and genetic defects.
- Promotes skin cancer (squamous cell carcinoma and malignant melanoma), cataracts and depresses immune system.
- 1% drop in ozone can lead to 4-6% rise in number of skin cancer cases (5 fold increase in Australia during the last 50 years)
- Increase inflow of UV radiations will lower the sea productivity affecting the marine flora and fauna.
- Adverse impact on agricultural crops and natural vegetation.

Montreal Protocol of 1987

- Signed by 35 developed and developing countries
- Limitations were put on the use of CFCs and halons and phasing out of its use was scheduled.
- Proposed freezing of CFC production by 1989 and of halons by 1992
- Proposed the freezing of production of ozone depleting substances at 1986 levels and called for 20% reduction by 1994 and ultimately 50% of 1986 level by 1998
- Targets were later made stringent to phase out these chemicals much earlier after a meeting in London in 1990
- As per the London amendments of the Montreal Protocol, production of these chemicals would be reduced to 50% of 1986 level by 1995; 15% of this level by 1997 and their complete phase out by 2000

Montreal Protocol of 1987

- Protocol granted 10 years grace period to developing countries during which consumption can increase up to 0.3 kg per capita
- UK allowed to expand consumption up to 0.5 kg per capita during the then 5 year plan.
- Allowing import from non-signatory countries for one year
- Allowing trade up to mid 1990s
- Protocol assumed up to 2% ozone depletion by 2075
- According to US Environmental Protection Agency (EPA), even after implementation of the Montreal Protocol , the total concentration of chlorine may increase three folds by 2075.

Montreal Protocol of 1987

- 45% of increase in chlorine from the controlled use of CFCs
- 40% from the compounds not covered by the protocol (methyl chloroform and carbon tetrachloride)
- 15% by non participating countries

Strategies for protecting the stratospheric ozone layer

If all known technical control measures are used, emissions of CFCs and halons can be reduced by 90%

Banning of CFCs

Banning of CC propellants in Canada, Norway, Sweden and USA

Banning land disposal of chlorinated solvents (incineration as disposal and recovery and recycling of the solvents as alternatives)

Prohibition of venting of refrigerants

Thank you.