Climate Change, Global warming, depletion of Ozone

Climate change science is a legitimate branch of science dealing with the Earth that is being greatly impacted and thus greatly changed by humankind .

What is climate change?

- Climate change is a global phenomena.

Climate change can be defined as a change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels.

- Examples include the melting of ice caps at the South Pole and North Pole.

- NASA's definition of climate change says it is "a broad range of global phenomena created predominantly by burning fossil fuels, which add heat-trapping gases to Earth's atmosphere. These phenomena include the increased temperature trends described by global warming, but also encompass changes such as sea-level rise; ice mass loss in Greenland, Antarctica, the Arctic and mountain glaciers worldwide; shifts in flower/plant blooming; and extreme weather events."

- According to US Geological Survey, global warming is just one aspect of climate change. In fact, they say that global warming refers to the rise in global temperatures mainly due to the increasing concentrations of greenhouse gases in the atmosphere.
- On the other hand, climate change refers to the increasing changes in the measures of climate over a long period of time – including precipitation, temperature, and wind patterns.

What is Global Warming?

- An increase in the average temperature of the Earth's atmosphere and oceans

- Global temperature on both land and sea increased by 0.6 ± 0.2 °C over the past century

- Volume of atmospheric carbon dioxide increased from 280 parts per million in 1800 to 367 in 2000, a 31% increase over 200 years

- Global mean surface temperatures have increased 0.5-1.0°F since the late 19th century

- The snow cover in the Northern Hemisphere and floating ice in the Arctic Ocean have decreased

- Sea level has risen 4-8 inches over the past century
- Global surface temp. could rise 1-4.5°F (0.6-2.5°C) in the next fifty years, and 2.2-10°F (1.4-5.8°C) in the next century

What causes it?

- Human Impacts- Atmospheric greenhouse gases trap some of the outgoing energy, retaining heat.
- Natural Impacts- Change in sun's energy output, Volcanoes, Water Vapor Clouds.
- Greenhouse Gases -
- CO_2 , Methane, Nitrous oxide, Fluorinated compounds (hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride)
- Since industrial revolution, atmospheric concentrations of carbon dioxide increased 30%, methane more than doubled, nitrous oxide risen by 15%.
- These increases have enhanced the heat-trapping capability of the earth's atmosphere

Greenhouse Gas Emissions

- Combustion of fossil fuels?

➢ coal-burning power plants, automobile exhausts, factory smokestacks, other waste vents of the human environment contribute 22 billion tons of carbon dioxide and other greenhouse gases each year

➢ Animal agriculture, manure, natural gas, rice paddies, landfills, coal, and other anthropogenic sources contribute about 450 million tons of methane each year

➢ Atmospheric concentrations of CO_2 and CH_4 have increased by 31% and 149% respectively above pre-industrial levels since 1750

Greenhouse Gas Emissions

- Power Plants

40% of carbon dioxide emissions stem from the burning of fossil fuels for the purpose of electricity generation

- Cars

20% of carbon dioxide emissions comes from the burning of gasoline in internal-combustion engines of cars and light trucks with poor gas mileage contribute the most to global warming

- Trucks

Another 13% of carbon dioxide emissions come from trucks used mostly for commercial purposes

- Airplanes

Aviation causes 3.5 percent of global warming, and the figure could rise to 15 percent by 2050

- Carbon Dioxide from Buildings

Buildings structure account for about 12% of carbon dioxide emissions

Methane

- Methane is more than 20 times as effective as CO_2 at trapping heat in the atmosphere.
- 2004 Levels of atmospheric methane have risen 145% in the last 100 years.
- Derived from sources such as rice paddies, bacteria in bogs and fossil fuel production .
- In flooded fields, anaerobic conditions develop and the organic matter in the soil decomposes

Nitrous oxide

- Naturally produced by oceans and rainforests,
- man-made sources-nylon and nitric acid production, the use of fertilizers in agriculture, cars with catalytic converters and the burning of organic matter

Deforestation

Responsible for 25% of all carbon emissions entering the atmosphere by the burning and cutting of about 34 million acres of trees each year.

Effects of Global Warming

Negative Effects:

- Rising Sea Level
- Change of precipitation and local climate conditions; acid rain
- Alteration of forests and crop yields
- Expansions of deserts into existing rangelands
- More intense rainstorms
- Destabilization of Ocean currents

Positive Effects

- Can stimulate plant growth in places where CO_2 and temperature are the limiting factors (preventing photorespiration which can destroy existing sugars).

- Melting Arctic ice may open the Northwest Passage in summer, which would cut 5,000 nautical miles from shipping routes between Europe and Asia

Assignment

How global warming can be minimized: Alternatives, Renewable Energy Sources

Discuss briefly.

What is global warming potential?

- It is a measure of how much heat a greenhouse gas traps in the atmosphere up to a specific time horizon, relative to carbon dioxide.
- It compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide and is expressed as a factor of carbon dioxide.
- The GWP depends on the following factors:

- the absorption of infrared radiation by a given species
- the spectral location of its absorbing wavelengths
- the atmospheric lifetime of the species

Thus, a high GWP correlates with a large infrared absorption and a long atmospheric lifetime.

Kyoto Protocol (1997)

- The Kyoto Protocol is an international treaty which extends the 1992 United Nations Framework Convention on Climate Change (UNFCCC) that commits state parties to reduce greenhouse gas emissions.
- It was adopted in Kyoto, Japan, on 11 December 1997 and entered into force on 16 February 2005.
- There are currently 192 parties.
- Developed countries agreed to specific targets for cutting their emissions of greenhouse gases.

- The Kyoto Protocol applies to the six greenhouse gases listed in Annex A: Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulphur hexafluoride (SF_6)
- Industrialized countries committed to an overall reduction of emissions of greenhouse gases to 5.2% below 1990 levels for the period 2008 – 2012.
- Objective is the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

The Paris Agreement

- The Paris Agreement is an agreement within the United Nations Framework Convention on Climate Change (UNFCCC), dealing with greenhouse-gas-emissions mitigation, adaptation, and finance, signed in 2016.

- As of February 2020, all UNFCCC members have signed the agreement, 189 have become party to it, and the only significant emitters which are not parties are Iran and Turkey.

- The Paris Agreement builds upon the Convention and for the first time brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so.

- The Paris Agreement central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.

- Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change.

What is the difference between Kyoto protocol and Paris agreement?

- Fundamentally, both were global agreements to address climate change.
- Kyoto put the burden on developed nations, and gave a "pass" to developing nations. For this reason it was never ratified by the US Senate. For it to be at all effective, it must include all nations.
- Indeed, most growth in GHG emissions are coming from developing nations.

- This was the fundamental difference, and the difference which made Paris even more widely adopted. The US agreed to Paris because all nations must do their part, with no exception for developing nations. What made this possible was redefining “do their part” to mean voluntary goals set by each participant, so a developing nation could simply set an easier goal, but still be on board with a collective effort. The idea was to gradually increase the goals in future commitments, with peer pressure, once developing nations realize that participation is not hard and goals are achievable.

Ozone layer

- The layer of life-protecting ozone found at the top of the stratosphere.
- Concentrations of stratospheric ozone represent a balance, established over eons, between creative and destructive forces and this balance, or dynamic equilibrium, has been changed by human activity.

- Ozone is formed in the earth's stratosphere and is critical to life on earth.

- There is compelling scientific evidence that ozone is destroyed in the stratosphere and that some human-released chemicals are speeding up the breakdown of ozone in the atmosphere.

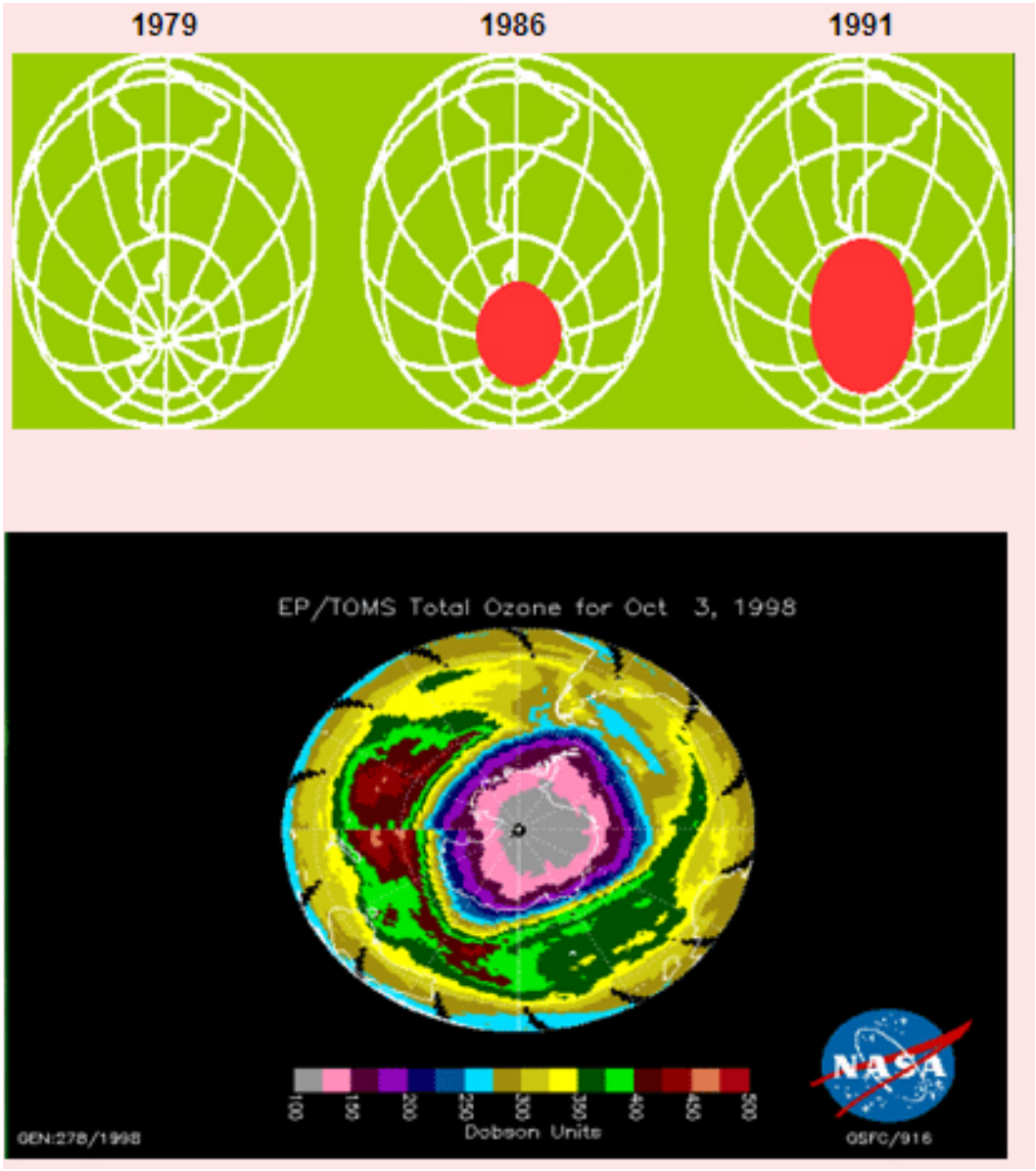
- CFCs, a human-developed compound, are particularly destructive to the breakdown of ozone in the atmosphere.
- Ultraviolet radiation is present in natural outdoor light and can be blocked or filtered by various substances.

Ozone Layer Depletion: Historical Perspective

- The ozone 'hole', it is really not a hole but rather a thinning of the ozone layer in the stratosphere. We will use the term 'hole' in reference to the seasonal thinning of the ozone layer.
- The appearance of a hole in the earth's ozone layer over Antarctica, first detected in 1976.
- 1974: Rowland & Molina theorize CFCs destroy stratospheric ozone molecules

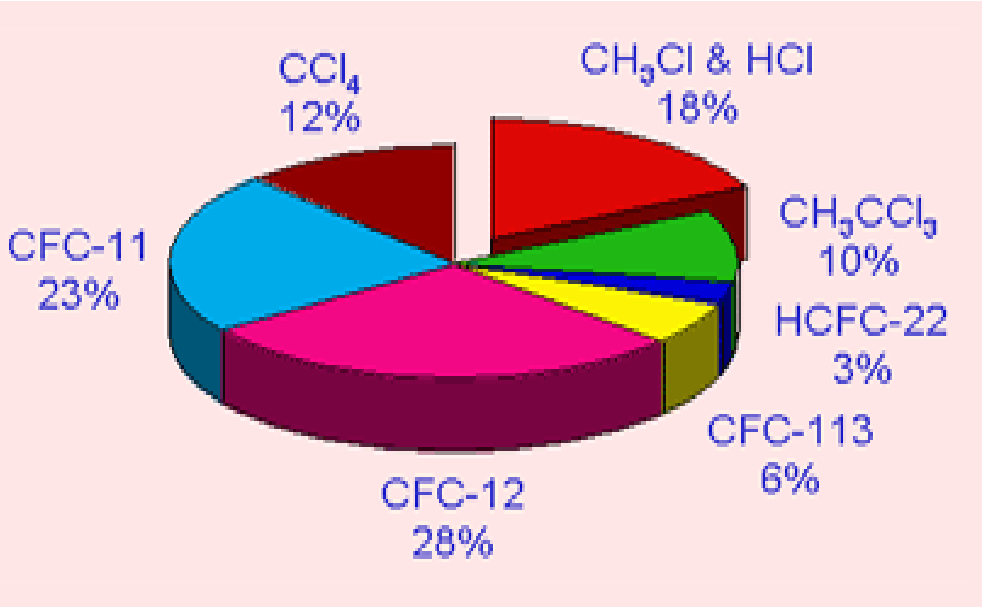
- 1975: Harvard papers predict that CFCs deplete Earth's ozone layer
- 1985: Ozone holes found over Antarctic
- 1988: Ozone layer thinning over North Pole
- 1993: Thinning over mid-latitudes of the Northern Hemisphere
- 1997: Low values of total ozone occur in Arctic as well as Antarctic

Antarctic Ozone Hole Progression



Ozone Layer Depleting Chemicals

- chlorofluorocarbons (CFCs)
- carbon tetrachloride (CCl_4)
- methyl chloroform (CH_3CCl_3)
- hydrochloric acid (HCl)
- methyl chloride (CH_3Cl)
- methyl bromide(CH_3Br)



CFCs

- CFCs are inert, nonreactive, nontoxic, nonflammable.
- Human-made CFCs used in:

- Refrigeration
- air conditioning
- foam blowing
- cleaning electronic components
- Solvents

Ozone Depleting Process

- Ozone can be destroyed by a number of free radical catalysts; the most important are the hydroxyl radical (OH·), nitric oxide radical (NO·), chlorine radical (Cl·) and bromine radical (Br·).
- The dot is a notation to indicate that each species has an unpaired electron and is thus extremely reactive.
- All of these have both natural and man-made sources
- Most of the OH· and NO· in the stratosphere is naturally occurring, but human activity has drastically increased the levels of chlorine and bromine.
- These elements are found in stable organic compounds, especially chlorofluorocarbons, which can travel to the stratosphere without being destroyed in the troposphere due to their low reactivity. Once in the stratosphere, the Cl and Br atoms are released from the parent compounds by the action of ultraviolet light.

$CFCl_3$+ electromagnetic radiation → Cl· + ·$CFCl_2$

- Ozone is a highly reactive molecule that easily reduces to the more stable oxygen form with the assistance of a catalyst.
- Cl and Br atoms destroy ozone molecules through a variety of catalytic cycles.
- In the simplest example of such a cycle,[a chlorine atom reacts with an ozone molecule(O_3), taking an oxygen atom to form chlorine monoxide (ClO) and leaving an oxygen molecule (O_2).
- The ClO can react with a second molecule of ozone, releasing the chlorine atom and yielding two molecules of oxygen.

$Cl\cdot + O_3 \rightarrow ClO + O_2$

- A chlorine atom removes an oxygen atom from an ozone molecule to make a ClO molecule

$ClO + O_3 \rightarrow Cl\cdot + 2O_2$

- This ClO can also remove an oxygen atom from another ozone molecule; the chlorine is free to repeat this two-step cycle

- The overall effect is a decrease in the amount of ozone

- More complicated mechanisms have also been discovered that lead to ozone destruction in the lower stratosphere.

Ozone depletion potential

- ODP of a given substance is defined as the ratio of global loss of ozone due to the given substance to the global loss of ozone due to CFC-11 of the same mass.
- ODP can be estimated from the molecular structure of a given substance. Chlorofluorocarbons have ODPs roughly equal to 1.
- Brominated substances have usually higher ODPs in range 5–15, because of more aggressive bromine reaction with ozone.
- Hydrochlorofluorocarbons have ODPs mostly in range 0.005 - 0.2 due to the presence of the hydrogen which causes them to react readily in the troposphere, therefore reducing their chance to reach the stratosphere where the ozone layer is present.
- Hydrofluorocarbons (HFC) have no chlorine content, so their ODP is essentially zero.

International Response to Ozone Layer Depletion

- 1985: United Nations Environment Program (UNEP)
- 1987: The Montreal Protocol
- 1992: Copenhagen Amendments
- 1998: The Montreal Protocol is affecting stratospheric chemical composition.

International Response to Ozone Layer Depletion

- 1999-2000: Stratospheric ozone layer recovery will be a slow process and extend into the next century.

- Scientific Assessment of Ozone Depletion: 1994 and 1998 (World Meteorological Organization).

- Ozone Depletion Web Page: http://www.epa.gov/ozone

Montreal Protocol

- The **Montreal Protocol** is an international treaty designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion.
- It was agreed on 16th September 1987, and entered into force on 1st January 1989.
- The Montreal Protocol sits under the Vienna Convention for the Protection of the Ozone Layer (the Vienna Convention). The Vienna Convention was adopted in 1985 following international discussion of scientific discoveries in the 1970s and 1980s highlighting the adverse effect of human activity on ozone levels in the stratosphere and the discovery of the 'ozone hole'. Its objectives are to promote cooperation on the adverse effects of human activities on the ozone layer.
- As a result of the international agreement, the ozone hole in Antarctica is slowly recovering.

- The Montreal Protocol targets 96 ozone depleting chemicals in thousands of applications across more than 240 industrial sectors.
- In 2016 the Montreal Protocol also became responsible for setting binding progressive phase down obligations for the 18 main hydrofluorocarbons (HFCs).

- The Montreal Protocol has been further strengthened through six Amendments:

- London 1990
- Copenhagen 1992
- Vienna 1995
- Montreal 1997
- Beijing 1999
- Kigali 2016

Biological Effects of Ultraviolet Radiation

- Sunburn,Premature Aging & PreCancer
- Cancer of Skin

-Basal and Squamous Cell Carcinoma

-Melanoma

- Cataracts
- Photosensitivity
- Immune system changes

- suppression of immune system
- increased incidence of infection
- promotion of cancer growth
- Basal cell carcinoma

- most common, least aggressive, locally destructive

- Squamous cell carcinoma

- more aggressive, can metastasize

- Melanoma

- most aggressive, ~75% of all skin cancer deaths

- The Skin Cancer Epidemic

- melanoma is increasing in incidence faster than any other cancer
- lifetime probability of developing melanoma is 1 in 75
- 100 new cases of melanoma diagnosed per day, ~ one death per hour

- Cataracts of Eyes
- cataracts are when the lens of the eye becomes cloudy
- 20 million cases worldwide
- account for half of blindness in the world

Thank you!