

# Global Effects of Climate Change



## Introduction to the lecture

- Global effects of climate change lecture introduce the concept of global climate change effects on the atmosphere.
- This lecture provides an overview of fossil fuel impacts on the level of carbon dioxide, ozone depletion in the stratosphere, bad and good ozone, origin of good and bad ozone, causes of ozone depletion, idea on ozone reserve in the stratosphere.

## Introduction to the lecture

➤ It also focuses on the relation between greenhouse effects and climate change over geological periods, basic information on climate change, overview of greenhouse gases i.e. CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, fluorinated gas, ratio of greenhouse gas emission, source of greenhouse gas, trends in global emission, emission by country and basic concept of causes of climate change.



## Aim and Learning outcomes

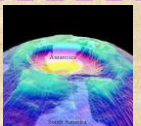
- The aim is to bring in to consideration the global climate change in relation to greenhouse gases and its impacts on the stratosphere.
- On completion of lecture "Global effects of climate change" students will be able to:
  - To understand the influence of human being on the global atmosphere and climate.
  - Understand the depletion of ozone in the Stratosphere "a hole in the sky".
  - Know the mechanism of global climate change caused by greenhouse gases.

## Talk outline

### Introduction



### Ozone Depletion in the Stratosphere



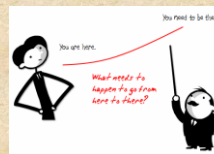
### Greenhouse Effect and Climate Change



## Learning Objectives



➤ To understand the influence of human being on the global atmosphere and climate



- Depletion of ozone in the Stratosphere "a hole in the sky"
- Global climate change caused by greenhouse gases

## Introduction - What to do??



- To **reduce** the rate at which we emit **carbon dioxide** into atmosphere
- As we know that **production** of CO<sub>2</sub> is **controlled** by burning **fossil fuels**
- Is it possible to **cut the rate** of production of energy from fossil fuels ?
- Is it possible to **reduce the use** of fossil fuels to reduce CO<sub>2</sub> in the atmosphere ?



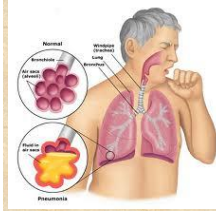
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## Ozone Depletion in the Stratosphere



### Ozone:

- Ozone (O<sub>3</sub>), a **colorless** and highly reactive gas, is a major ingredient of photochemical smog
- Causes **coughing and breathing** problems, lung and heart diseases, reduces resistance to colds and pneumonia, and irritates the eyes, nose, and throat

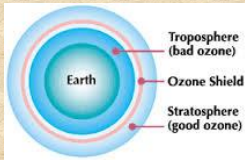


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## Ozone Depletion - Ozone



- **Damages plants**, rubber in tires, fabrics, and paints
- Ozone in the troposphere near ground level is often referred to as **"bad" ozone**, while ozone in the stratosphere as **"good" ozone**.

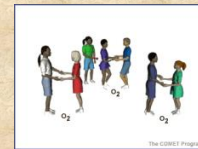


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## Ozone Depletion – why good and bad



- Essentially, ozone (O<sub>3</sub>) is an **unstable and highly reactive** form of oxygen. The ozone molecule is made up of three oxygen **atoms** that are bound together, whereas the oxygen we breathe (O<sub>2</sub>) contains only two oxygen atoms
- From a human perspective, ozone is both **helpful and harmful**, both good and bad



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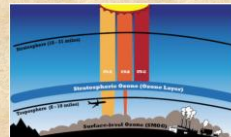
## Ozone Depletion – Good Ozone



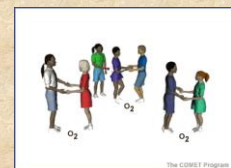
- **Small concentrations** of ozone occur naturally in the stratosphere, which is part of the Earth's upper atmosphere.
- At that level, ozone helps to protect life on Earth by **absorbing ultraviolet** radiation from the sun, particularly **UVB radiation**
- can **cause skin cancer**, damage **crops**, and destroy some types of **marine life**

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## Ozone Depletion – Origin Good Ozone

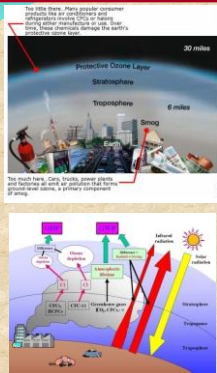


- Ozone is created in the stratosphere when ultraviolet light from the sun splits an oxygen molecule into two single oxygen atoms.
- Each of those oxygen atoms then binds with an oxygen molecule to form an ozone molecule.



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## Ozone Depletion – Origin Good Ozone



- Depletion of stratospheric ozone poses serious health risks for humans and environmental hazards for the planet, and
- many nations have banned or limited the use of chemicals that contribute to ozone depletion.

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## Ozone Depletion – Origin bad Ozone



- Ozone is created in the stratosphere when Ozone is also found much nearer the ground, in the troposphere, the lowest level of Earth's atmosphere.
- Unlike the ozone that occurs naturally in the stratosphere, troposphere ozone is man-made,
- an indirect result of air pollution created by automobile exhaust and emissions from factories and power plants.

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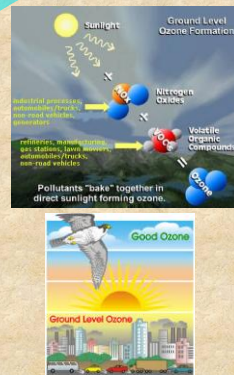
## Ozone Depletion – Origin bad Ozone



- When gasoline and coal are burned, nitrogen oxide gases (NOx) and volatile organic compounds (VOC) are released into the air.
- During the warm, sunny days of spring, summer and early fall, NOx and VOC are more likely to combine with oxygen and form ozone.

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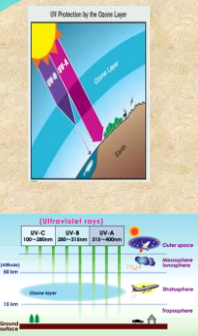
## Ozone Depletion – Origin bad Ozone



- During those seasons, high concentrations of ozone are often formed during the heat of the afternoon and early evening, and are likely to dissipate later in the evening as the air cools.

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## Ozone Depletion



- A layer of ozone in the lower stratosphere keeps about 95% of the sun's harmful ultraviolet (UV-A and UV-B) radiation from reaching the earth's surface.
- Measurements show considerable seasonal depletion (thinning) of ozone concentrations in the stratosphere above Antarctica and the Arctic and a lower overall ozone thinning everywhere

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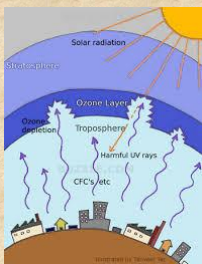
## Ozone Depletion



- Ozone depletion in the stratosphere poses a serious threat to humans, other animals, and some primary producers (mostly plants) that use sunlight to support the earth's food webs

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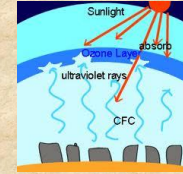
## Ozone Depletion - Rate



- 1956-1968 the ozone concentration was constant about 300 Dobson Unit (mill atmosphere-centimeter of ozone)
- In 1984 ----- 200 Dobson
- In 1991 ----- 150 Dobson
- Measure by satellites and high altitude air craft

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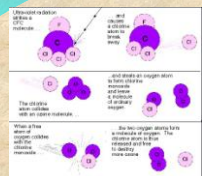
## Ozone Depletion



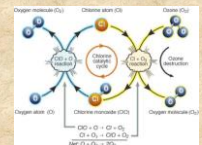
- Ozone is depleting due to the injection of CFC (chlorofluorocarbons) gas into the atmosphere
- More widely used Ferron-11, 12, CFC13, CFC12
- These chemicals used in the air conditioner, refrigerator etc
- CFC – are triples from 1970-1980

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## Ozone Depletion



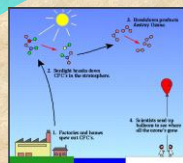
- These CFCs can be **transported high**
- **Disassociate** CFCs into free chlorine and other molecules – free chlorine can act as a catalyst  
 $Cl + O_3 \rightarrow ClO + O_2$   
 $ClO + O \rightarrow Cl + O_2$



- The process **continue** again and again

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## Ozone Depletion



- Chlorine atom can destroy 100000 O3 molecules
- Bromine also leads to destruct O3 layer – 25 % sharing
- Extensive cloud system transport catalyst to destruct ozone layer
- Cloud system carry aerosol, nitric acid, water vapor etc
- Small fraction Cl destroy O3 rapidly

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## Ozone Depletion - Hypothesis



- It had been thought that the ozone layer in troposphere will move up and cover the deficiency of stratosphere
- **BUT NO !!!!!**

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## Why should we worry about ozone depletion?



- More biologically damaging UV-A and UV-B radiation will reach the earth's surface.
- Causes problems with human health, crop yields, forest productivity, climate change, wildlife populations, air pollution, and degradation of outdoor materials.

## We can reverse stratospheric ozone depletion

- In 1987, representatives of 36 nations met in Montreal, Canada, and developed the Montreal Protocol to cut emissions of CFCs.
- In 1992, adopted the Copenhagen Protocol-out of key ozone-depleting chemicals signed by 195 countries.
- The ozone protocols set an important step by using prevention to solve a serious environmental problem.

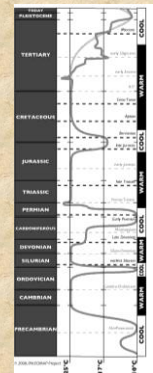
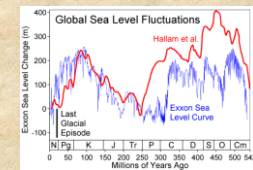
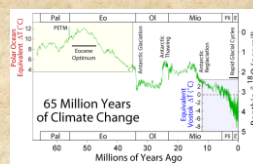
## Three big ideas

- All countries need to step up efforts to control and prevent outdoor and indoor air pollution.
- Reducing the projected harmful effects of rapid climate disruption during this century requires emergency action to increase energy efficiency, sharply reduce greenhouse gas emissions, rely more on renewable energy resources, and slow population growth.
- We need to continue phasing out the use of chemicals that have reduced ozone levels in the stratosphere and allowed more harmful ultraviolet radiation to reach the earth's surface.

## Greenhouse effect and climate change



## Climate change over geological period (past)



## Climate change basic information

**Climate change is happening** - Our earth is warming



- Earth's average **temperature** has **risen** by 1.4°F over the past century,
- **Rise** another 2 to 11.5°F over the next **hundred years**.
- **Small changes** in the average temperature of the planet can translate to large and potentially **dangerous shifts** in climate and weather.

## Climate change basic information

**evidence is clear**



- Rising **global temperatures** have been accompanied by **changes** in weather and climate
- Changes in rainfall, resulting in more **floods, droughts, or intense rain**, as well as more frequent and severe **heat waves**.
- Oceans are warming and becoming more acidic, ice caps are melting, and **sea levels are rising**

## Climate change basic information

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### Humans are largely responsible for recent climate change



- Over the past century, human activities have released **large amounts of carbon dioxide** and other greenhouse gases into the atmosphere.
- The majority of greenhouse gases come **from burning fossil fuels** to produce energy,
- Although deforestation, industrial processes, and some agricultural practices also **emit gases into the atmosphere.**

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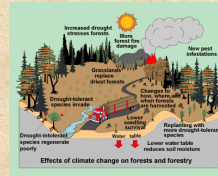
## Climate change basic information

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### Cont'd.....



- **Greenhouse gases** act like a **blanket** around Earth,
- **Trapping energy** in the atmosphere and causing it to warm.
- This **phenomenon** is called the **greenhouse effect**

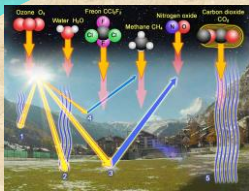


- However, the buildup of greenhouse gases can change Earth's climate and result in **dangerous effects to human health and welfare** and to **ecosystems.**

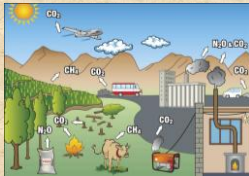
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## Overview of Greenhouse Gases

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- Gases that **trap heat** in the atmosphere are called greenhouse gases--- **Carbon dioxide, methane, Nitrous oxide, Fluorinated gases**

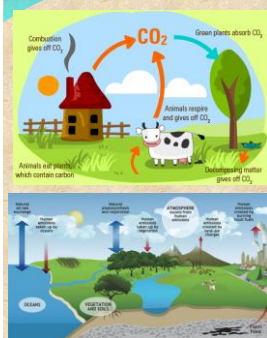


- Important role-**emissions and removals** of the main greenhouse gases to and from the atmosphere

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## Overview of Greenhouse Gases - CO2

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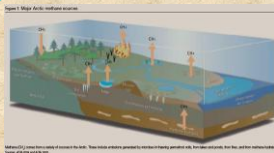


- Carbon dioxide **enters** the atmosphere through **burning fossil fuels** (coal, natural gas and oil), solid waste, trees and wood products
- Also as a result of certain chemical reactions e.g., **manufacture of cement**
- Carbon dioxide is **removed** from the atmosphere (or "sequestered") when it is **absorbed by plants** as part of the biological carbon cycle

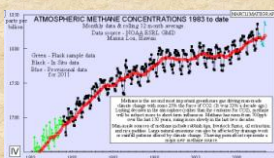
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## Greenhouse Gases - Methane (CH4)

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- Methane is **emitted** during the **production and transport** of coal, natural gas, and oil

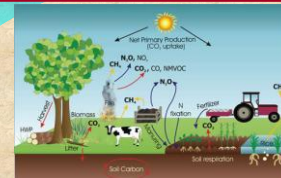


- Methane **emissions** also result from **livestock and other agricultural practices** and by the **decay** of organic waste in municipal solid waste landfills

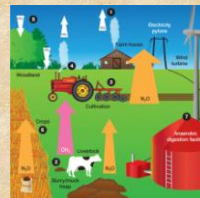
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## Greenhouse Gases - Nitrous Oxide (N2O)

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- Nitrous oxide is **emitted** during agricultural and industrial activities, as well as during **combustion of fossil fuels and solid waste.**



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## Greenhouse Gases – Fluorinated gas

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- Industrial processes, refrigeration, and the use of a variety of consumer products contribute to emissions of F-gases, which include ----- hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF<sub>6</sub>).

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## Greenhouse Gases

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Each gas's effect on climate change depends on three main factors--

1. How much of these gases are in the atmosphere?

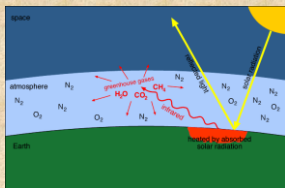


- Concentration, or abundance, is the amount of a particular gas in the air. Larger emissions of greenhouse gases lead to higher concentrations in the atmosphere

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## Greenhouse Gases

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2. How long do they stay in the atmosphere?

- Each of these gases can remain in the atmosphere for different amounts of time, ranging from a few years to thousands of years

3. How strongly do they impact global temperatures?

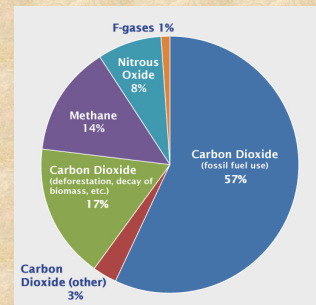
- Some gases are more effective than others at making the planet warmer and "thickening the Earth's blanket."

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## Global Greenhouse Gas Emission - gas

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At the global scale, the key greenhouse gases emitted by human activities are -

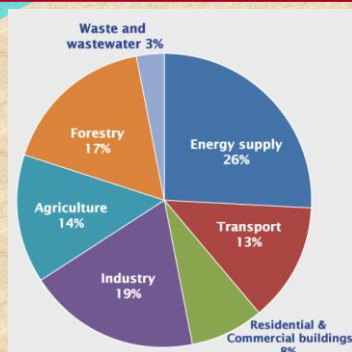


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## Global Greenhouse Gas Emission - source

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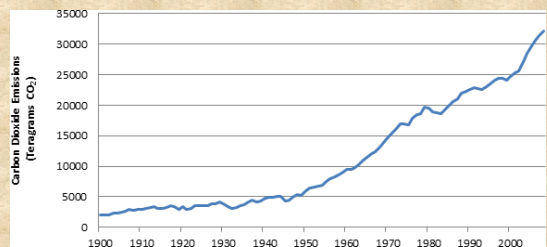


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## Trends in global emission

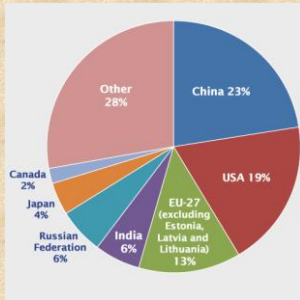
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- Global carbon emissions from fossil fuels have significantly increased since 1900. Emissions increased by over 16 times between 1900 and 2008 and by about 1.5 times between 1990 and 2008.

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## Emission by country



- In 2008, the top carbon dioxide (CO<sub>2</sub>) emitters were China, the United States, the European Union, India, the Russian Federation, Japan, and Canada.
- These data include CO<sub>2</sub> emissions from fossil fuel combustion, as well as cement manufacturing and gas flaring.

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## Climate change- Earth climate is Changing



- Earth's climate is changing in ways that affect our weather, oceans, snow, ice, ecosystems, and society
- Natural causes alone cannot explain all of these changes
- Human activities are contributing to climate change, primarily by releasing billions of tons of carbon dioxide (CO<sub>2</sub>) and other heat-trapping gases, known as greenhouse gases, into the atmosphere every year

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## Climate change- Earth climate is Changing



### Natural causes alone cannot explain recent changes



- Natural processes such as changes in the sun's energy, shifts in ocean currents, and others affect Earth's climate.



- However, they do not explain the warming that we have observed over the last half-century.

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## Climate change- Earth climate is Changing



### Human causes can explain these changes



- Emissions of greenhouse gases - come from a variety of human activities



- Burning fossil fuels for heat and energy, clearing forests, fertilizing crops, storing waste in landfills, raising livestock, and producing some kinds of industrial products.

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## Climate change- Earth climate is Changing



Climate will continue to change unless we reduce our emissions



- During the 21st century, global warming is projected to continue and climate changes are likely to intensify
- Scientists have used climate models to project different aspects of future climate, including temperature, precipitation, snow and ice, ocean level, and ocean acidity
- Projected to increase worldwide by 2°F to 11.5°F by 2100. Learn more about the projections of future climate change.

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## Climate change- Causes



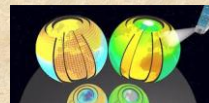
### Earth's temperature is a balancing act

97 out of 100 climate experts think humans are changing global temperature



- Earth's temperature depends on the balance between energy entering and leaving the planet's system .

- When incoming energy from the sun is absorbed by the Earth system, Earth warms.



- When the sun's energy is reflected back into space, Earth avoids warming. When energy is released back into space, Earth cools.

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## Climate change- Causes



### Earth's temperature is a balancing act



- Analyzing a number of indirect measures of climate such as ice cores, tree rings, glacier lengths, pollen remains, and ocean sediments, and by studying changes in Earth's orbit around the sun
- Climate system **varies** naturally over a wide range of time scales.
- Prior to the Industrial Revolution in the 1700s can be explained by natural causes

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## Climate change- Causes



### The Greenhouse Effect causes the atmosphere to retain heat



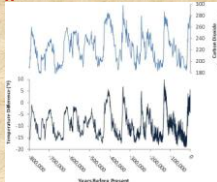
- When **sunlight** reaches Earth's surface, it can either be **reflected back** into space or **absorbed** by Earth
- **Greenhouse gases (GHGs)** like water vapor (H<sub>2</sub>O), carbon dioxide (CO<sub>2</sub>), and methane (CH<sub>4</sub>) **absorb energy**, slowing or preventing the loss of heat to space.
- In this way, GHGs act like a **blanket**, making Earth warmer than it would otherwise be.
- This **process** is commonly known as the "**greenhouse effect**".

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## Climate change- Causes



### The Role of the Greenhouse Effect in the Past



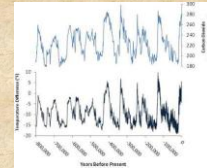
- In the **distant past** (prior to about 10,000 years ago), CO<sub>2</sub> levels tended to track the glacial cycles.
- During warm '**interglacial**' periods, CO<sub>2</sub> levels have been **higher**. During cool '**glacial**' periods, CO<sub>2</sub> levels have been **lower**.
- This is because the **heating or cooling** of Earth's surface can cause changes in **greenhouse gas concentrations**.

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## Climate change- Causes



### The Role of the Greenhouse Effect in the Past



- Estimates of the **Earth's changing carbon dioxide (CO<sub>2</sub>) concentration** (top) and Antarctic temperature (bottom),
- Based on analysis of **ice core** data extending back 800,000 years.
- Until the past century, natural factors caused atmospheric **CO<sub>2</sub> concentrations** to **vary** within a range of about **180 to 300 ppmv**.
- The past century's temperature changes and **rapid CO<sub>2</sub> rise** to 390 ppmv in 2010

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## Climate change- Causes



### The Recent Role of the Greenhouse Effect



- Since the **Industrial Revolution** began around 1750,
- **Human activities** have **contributed** substantially to climate change by adding **CO<sub>2</sub>** and other heat-trapping gases to the atmosphere
- These **greenhouse gas** emissions have **increased** the greenhouse effect and caused Earth's surface **temperature to rise**

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## Climate change- Causes



### The Main Greenhouse Gases

- Carbon dioxide is the **primary** greenhouse gas that is **contributing** to **recent climate change**
- CO<sub>2</sub> is **absorbed** and emitted naturally as part of the **carbon cycle**, through animal and plant respiration, volcanic eruptions, and **ocean-atmosphere exchange**
- **Human activities**, such as the burning of fossil fuels and changes in land use, **release large amounts of carbon** to the atmosphere, causing **CO<sub>2</sub> concentrations** in the atmosphere to **rise**.

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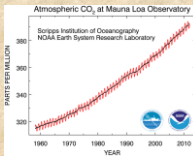
## Climate change- Causes



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### The Main Greenhouse Gases

➤ Atmospheric CO<sub>2</sub> concentrations have **increased by almost 40%** since pre-industrial times



➤ Approximately 280 parts per million by volume (ppmv) in the 18th century to **390 ppmv in 2010**

➤ Some **volcanic eruptions** released large quantities of CO<sub>2</sub> in the distant past

➤ **Human activities** now emit more than 135 times as much CO<sub>2</sub> as volcanoes each year

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## Climate change- Causes



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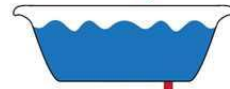
### Carbon Bath tub

#### The Carbon 'Bath tub' and its Components

##### SOURCES OF CARBON = "FAUCET"

- Fossil fuel combustion
- Deforestation

Right now, size of "faucet" is much larger than "drain."



As global temperature increases, size of "drain" decreases.

##### SINKS OF CARBON = "DRAIN"

- Land uptake
- Ocean uptake

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## Climate change- Causes



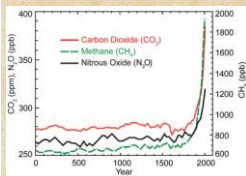
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### The Main Greenhouse Gases- Methane

➤ Methane is produced through both **natural and human activities**

➤ Natural wetlands, agricultural activities, and **fossil fuel extraction** and transport all emit CH<sub>4</sub>

➤ Greenhouse gas (GHG) **concentrations** in the atmosphere over the last 2,000 years.



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## Climate change- Causes



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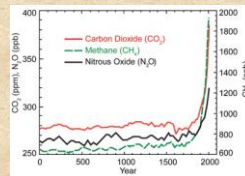
### The Main Greenhouse Gases- Nitrous Oxide

➤ Nitrous oxide is **produced** through **natural and human activities**,

➤ Mainly through **agricultural activities** and natural biological processes.

➤ **Fuel burning** and some other processes also create N<sub>2</sub>O

➤ Concentrations of N<sub>2</sub>O have risen approximately **18%** since the start of the **Industrial Revolution**



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## Climate change- Causes



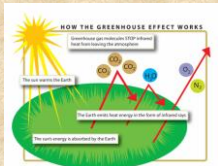
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### Other Greenhouse gases

➤ Water vapor is the most **abundant greenhouse gas** and also the most important in terms of its **contribution** to the natural greenhouse effect,

➤ Some **human activities** can **influence** local water vapor levels.

➤ However, on a global scale, the **concentration of water vapor** is **controlled** by temperature, which **influences** overall rates of **evaporation and precipitation**



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## Climate change- Causes



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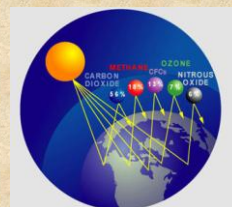
### Other Greenhouse gases

➤ **Tropospheric ozone (O3)**, which also has a short atmospheric lifetime,

➤ Is a potent greenhouse gas

➤ Chemical reactions **create ozone** from emissions of nitrogen oxides and volatile organic compounds

➤ In addition to **trapping heat**, ozone is a pollutant that can cause **respiratory health problems** and damage crops and ecosystems.

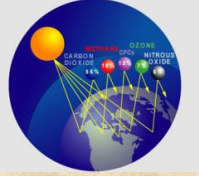


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## Climate change- Causes



### Other Greenhouse gases



- Chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6),
- Together called F-gases, are often used in **coolants, foaming agents, fire extinguishers, solvents, pesticides, and aerosol**
- Unlike water vapor and ozone, these F-gases have a **long atmospheric lifetime**