

# Introduction to Climate Change

## Introduction to Climate Change – Study Notes

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### 1. What Is Climate Change?

- **Definition** – Long-term alteration of temperature, precipitation, wind patterns, and other aspects of the Earth's climate system.
  - **Distinction from Weather** – Weather = short-term atmospheric conditions (hours/days). Climate = average of weather over decades/centuries.
  - **Key Components**
    - **Atmospheric composition** (greenhouse gases, aerosols)
    - **Energy balance** (incoming solar radiation vs. outgoing infrared radiation)
    - **Feedback mechanisms** (water/vapor, ice/albedo, carbon cycle)
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### 2. Drivers of Climate Change

| Category                          | Main Factors                                                                                                                                                                                                                    | Example Sources                                           |
|-----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|
| <b>Natural</b>                    | <ul style="list-style-type: none"><li>• Volcanic eruptions (ash, SO<sub>2</sub>)</li><li>• Solar variability</li><li>• Orbital cycles (Milankovitch)</li></ul>                                                                  | Volcanoes, sunspot cycles, Earth's tilt                   |
| <b>Anthropogenic (Human-made)</b> | <ul style="list-style-type: none"><li>• Greenhouse gas emissions (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O)</li><li>• Land-use change (deforestation, urbanization)</li><li>• Aerosols (sulfates, black carbon)</li></ul> | Fossil-fuel combustion, agriculture, industrial processes |

*Current scientific consensus: >99% of the observed warming since the mid-20th century is attributable to human activities.*

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### 3. The Greenhouse Effect

1. **Solar radiation** reaches Earth as short-wave (visible) energy.
2. Surface absorbs energy and re-emits it as long-wave (infrared) radiation.

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- Greenhouse gases (GHGs) **absorb and re-emit** part of this infrared radiation, trapping heat in the lower atmosphere.
- Result:** Global average surface temperature rises.

## Major GHGs (by radiative forcing, 2020):

- CO<sub>2</sub> (1.68 W/m<sup>2</sup>) – fossil fuels, cement, land-use change
- CH<sub>4</sub> (0.48 W/m<sup>2</sup>) – livestock, rice paddies, fossil-fuel extraction
- N<sub>2</sub>O (0.17 W/m<sup>2</sup>) – agriculture, industrial processes
- Fluorinated gases (0.20 W/m<sup>2</sup>) – refrigerants, electronics

## 4. Evidence of Climate Change

| Indicator                  | Observed Trend (1880-2023)                                       | Data Sources                            |
|----------------------------|------------------------------------------------------------------|-----------------------------------------|
| Global surface temperature | +1.1°C relative to pre-industrial                                | NASA GISS, NOAA, HadCRUT                |
| Ocean heat content         | ~230% in upper 200m                                              | Argo floats                             |
| Sea-level rise             | +210mm (1900-2023)                                               | Satellite altimetry, tide gauges        |
| Arctic sea-ice extent      | ~13% per decade                                                  | NSIDC                                   |
| Glacier mass balance       | Net loss on all continents                                       | GLIMS, World Glacier Monitoring Service |
| Extreme events             | frequency/intensity of heatwaves, heavy precipitation, wildfires | IPCC, EM-DAT                            |

## 5. Impacts of Climate Change

### 1. Physical Environment

- Melting ice sheets → sea-level rise, coastal flooding
- Ocean acidification (CO<sub>2</sub>) → coral bleaching, shell-forming organism stress
- Shifts in ecosystems and species ranges