

Introduction to Climate Change

Introduction to Climate Change – Study Notes

1. What Is Climate Change?

- **Definition:** Long-term alteration of temperature, precipitation, wind patterns, and other aspects of the Earth's climate system.
 - **Key Distinction:**
 - *Weather* = short-term atmospheric conditions.
 - *Climate* = average weather over decades to millennia.
 - **Primary Driver (Current Era):** Human activities that increase concentrations of greenhouse gases (GHGs) in the atmosphere.
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2. The Greenhouse Effect – The Core Mechanism

Component	Role in the Atmosphere
Solar Radiation	Short-wave energy from the Sun reaches Earth's surface.
Surface Absorption & Re-emission	Land & oceans absorb energy, then radiate it as long-wave (infrared) radiation.
Greenhouse Gases (GHGs)	CO ₂ , CH ₄ , N ₂ O, water vapor, and others trap a portion of the outgoing infrared radiation, warming the lower atmosphere.
Feedbacks	Processes that amplify (positive) or dampen (negative) the initial warming (e.g., ice-albedo feedback, water-vapor feedback).

3. Major Greenhouse Gases & Sources

Gas	Atmospheric Lifetime	Main Sources
Carbon Dioxide (CO ₂)	100-300 years	Fossil-fuel combustion, cement production, deforestation, land-use change
Methane (CH ₄)	~12 years	Agriculture (ruminants, rice paddies), landfills, natural gas production, wetlands
Nitrous Oxide (N ₂ O)	~114 years	Synthetic fertilizers, industrial processes, manure management

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Gas	Atmospheric Lifetime	Main Sources
Fluorinated Gases (HFCs, PFCs, SF ₆)	10,000+ years	Refrigeration, electronics manufacturing, aluminum production

4. Evidence of Climate Change

1. Temperature Records

- Global mean surface temperature $\uparrow$ $\sim 1.2^\circ\text{C}$ since pre-industrial (1850-1900) baseline.
- Most of the warming occurred since the 1970s.

2. Cryosphere Changes

- Arctic sea ice extent $\downarrow$ $\sim 40\%$ since 1979.
- Glacial retreat worldwide; Greenland ice sheet mass loss $\sim 3.8\text{ mm}$ sea level equivalent per year (2003-2022).

3. Sea Level Rise

- Global mean sea level $\uparrow$ $\sim 210\text{ mm}$ since 1900; rate accelerating to $\sim 3.4\text{ mm/yr}$ (1993-2022).

4. Ocean Changes

- Surface warming $\sim 0.13^\circ\text{C}$ per decade.
- Ocean acidification: pH down ~ 0.1 units ($\sim 30\%$ increase in acidity) since the industrial era.

5. Extreme Weather Trends

- Increased frequency/intensity of heatwaves, heavy precipitation events, and tropical cyclones.
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5. Climate System Feedbacks

Feedback Type	Example	Effect on Warming
Positive	Ice-albedo feedback: melting ice reduces surface reflectivity, absorbing more solar energy.	Amplifies warming
Negative	Planck feedback: as Earth warms, it radiates more infrared energy to space, providing a stabilizing effect.	Dampens warming

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Feedback Type	Example	Effect on Warming
Carbon Cycle Feedback	Permafrost	