

Introduction to Climate Change

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(A concise, easy-to-read overview for students and anyone new to the topic)

1. What Is Climate Change?

Term	Definition
Climate	Long-term patterns of temperature, precipitation, wind, and other atmospheric variables (typically averaged over 30+ years).
Weather	Short-term atmospheric conditions (hours to days).
Climate Change	A measurable shift in the average state of the climate system, or its variability, over periods ranging from decades to millions of years.
Global Warming	The specific aspect of climate change that refers to the rise in Earth's average surface temperature, primarily due to human activities.

2. Why Is the Climate Changing Now?

2.1 Natural Drivers (historical background)

- **Solar variability** – changes in the Sun's output.
- **Volcanic eruptions** – inject aerosols that temporarily cool the planet.
- **Orbital cycles (Milankovitch cycles)** – affect the distribution of sunlight.
- **Land-use changes** – natural shifts in vegetation and surface albedo.

2.2 Anthropogenic (human-caused) Drivers

Source	Main Greenhouse Gases (GHGs)	Typical Emissions
Fossil-fuel combustion	CO ₂ , CH ₄ , N ₂ O	Power plants, transport, industry
Agriculture & livestock	CH ₄ , N ₂ O	Enteric fermentation, rice paddies, fertilizer use
Deforestation & land-use change	CO ₂	Forest clearing, soil disturbance

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Source	Main Greenhouse Gases (GHGs)	Typical Emissions
Industrial processes	HFCs, PFCs, SF ₆	Refrigerants, electronics, metal production

Result: Concentrations of CO₂ have risen from ~280 ppm pre-industrial to >420 ppm today, trapping more infrared radiation and warming the planet.

3. The Greenhouse Effect – How It Works

1. **Solar radiation** (short-wave) reaches Earth's surface and is absorbed.
2. The surface re-emits energy as **long-wave infrared radiation**.
3. Greenhouse gases absorb and re-emit part of this infrared radiation, sending some back toward the surface → **warming**.

Key gases: CO₂, CH₄, N₂O, water vapor (feedback), and synthetic gases (HFCs, etc.).

4. Observed Impacts (What the Data Show)

Indicator	Recent Trend (last 50 yr)	Typical Consequence
Global mean surface temperature	+1.2°C relative to 1850-1900	Heatwaves, altered ecosystems
Sea level	+20 cm (global average)	Coastal flooding, saltwater intrusion
Arctic sea ice extent	~13% per decade	Habitat loss, albedo feedback
Ocean heat content	~30% increase in upper 200m	Coral bleaching, marine species shift
Extreme weather events	↑ frequency/intensity of heatwaves, heavy precipitation, droughts	Economic losses, human health risks
Phenology (timing of biological events)	Earlier flowering, migration	Mismatch in food webs

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5. Climate Feedbacks

| Feedback Type | Positive (amplifying) | Negative (dampening) | |-----