

Introduction to Climate Change

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Key concepts, causes, impacts, and responses

1. What Is Climate Change?

Term	Definition
Climate	Long-term (30-year average) patterns of temperature, precipitation, wind, etc., for a region or the globe.
Weather	Short-term atmospheric conditions (hours to days).
Climate Change	A statistically significant shift in average climate conditions or their variability over decades to centuries, caused by natural processes, human activities, or a combination of both.
Global Warming	The observed rise in Earth's average surface temperature, primarily due to increased concentrations of greenhouse gases (GHGs).

2. The Science Behind Climate Change

2.1 The Greenhouse Effect

- Solar radiation** reaches Earth – some is reflected, most is absorbed by the surface.
- The warm surface emits infrared (IR) radiation.
- Greenhouse gases (CO₂, CH₄, N₂O, water vapor, etc.) absorb and re-emit IR, trapping heat in the lower atmosphere.
- This natural “blanket” keeps the planet ~15°C warmer than it would be without it.

2.2 Why the Climate Is Warming Now

Driver	Mechanism	Current Trend
Carbon Dioxide (CO ₂)	Fossil-fuel combustion, cement production, land-use change	↑ ~50% since pre-industrial (→ 415ppm in 2023)

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Driver	Mechanism	Current Trend
Methane (CH₄)	Agriculture (rice, ruminants), fossil fuel extraction, waste	↑ ~150% since pre-industrial (↑ 1,900 ppb)
Nitrous Oxide (N₂O)	Fertilizer use, industrial processes	↑ ~20% since pre-industrial
Aerosols	Particulate matter from combustion, dust	Can cool (reflect sunlight) or warm (absorb heat); net effect currently negative but decreasing with air quality regulations

2.3 Climate Feedbacks

- **Positive feedbacks** amplify warming (e.g., ice albedo loss, permafrost thaw releasing CH₄).
- **Negative feedbacks** dampen warming (e.g., increased cloud albedo, enhanced plant growth).
- Overall, Earth system models indicate net positive feedback, leading to further warming if GHG emissions continue.

3. Evidence of Climate Change

Indicator	Observed Change (1880-2020)	Data Sources
Global mean surface temperature	+1.1°C relative to pre-industrial	NASA GISS, NOAA, HadCRUT
Ocean heat content	↑ ~25% in upper 2 km	Argo floats, IPCC
Sea level rise	+20 cm (average)	Satellite altimetry, tide gauges
Arctic sea ice extent	↓ ~40% (summer minimum)	NSIDC
Glacial mass balance	Net loss of ~10% of global ice volume	GRACE, field surveys
Extreme events	Increased frequency/intensity of heatwaves, heavy precipitation, droughts	EM-DAT, IPCC AR6

4. Impacts of Climate Change

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4.1 Environmental Impacts

- **Ecosystem shifts** – species migrate poleward/upward; coral bleaching; forest die?back.
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