

Introduction to Climate Change

Introduction to Climate Change

(A concise, easy-to-read overview for students or anyone new to the subject)

1. What Is Climate Change?

Term	Meaning
Climate	The long-term (30-year+) average of temperature, precipitation, wind, etc., for a region.
Weather	Short-term atmospheric conditions (hours-days).
Climate Change	A statistically significant shift in the average state of the climate or its variability over periods of decades to millennia.
Global Warming	The observed rise in Earth's average surface temperature, primarily caused by increased greenhouse gases (GHGs).

Key point: Global warming is a *driver* of broader climate change, which includes changes in precipitation patterns, sea-level rise, and extreme-event frequency.

2. The Science Behind Climate Change

2.1 The Greenhouse Effect

- Solar radiation** reaches Earth – some is reflected, most is absorbed.
- The surface re-emits infrared (IR) radiation.
- Greenhouse gases (GHGs) such as CO₂, CH₄, N₂O, and water vapor absorb IR and re-radiate it back, warming the lower atmosphere.

Greenhouse Gas	Primary Sources	Atmospheric Lifetime
CO ₂ (Carbon Dioxide)	Fossil-fuel combustion, cement production, deforestation	Decades to centuries
CH ₄ (Methane)	Agriculture (ruminants), landfills, natural gas systems	~12-years

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Greenhouse Gas	Primary Sources	Atmospheric Lifetime
N ₂ O (Nitrous Oxide)	Fertilizer use, industrial processes	~114 years
Fluorinated gases (e.g., HFCs)	Refrigerants, electronics	10–10,000 years

2.2 Radiative Forcing

- **Definition:** The net change in Earth's energy balance (incoming vs. outgoing radiation) caused by a factor (e.g., GHG concentration).
- Positive forcing → warming; negative forcing → cooling.

The Intergovernmental Panel on Climate Change (IPCC) estimates that human activities have produced a **+2.3 W m⁻²** radiative forcing (2021 data), driving the observed warming.

2.3 Feedback Mechanisms

Feedback	Effect on Climate	Example
Water vapor feedback	Positive	Warmer air holds more vapor → more greenhouse effect.
Ice albedo feedback	Positive	Melting ice reduces reflectivity → more solar absorption.
Carbon cycle feedback	Mixed	Permafrost thaw releases CO ₂ /CH ₄ (positive).
Cloud feedback	Uncertain (both)	Changes in cloud type/altitude affect radiation.

3. Evidence of Climate Change

Indicator	Observed Trend (1900–2020)	Data Source
Global mean surface temperature	+1.1°C ±	NASA GISS, NOAA
Ocean heat content	↑ ~30% in upper 200 m	ARGO floats
Sea level rise	3.3 mm yr ⁻¹ (average)	Satellite altimetry

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Indicator	Observed Trend (1900-2020)	Data Source
Arctic sea-ice extent (Sept)	~13% per decade	NSIDC
Glacial mass loss	Millions of gigatonnes lost	GRACE satellites
Extreme weather frequency		