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National Aeronautics and  
Space Administration

# GLOBAL CLIMATE CHANGE

NASA's Eyes on the Earth

Home

Key Indicators

Evidence

Causes

Effects

Uncertainties

Solutions

NASA's Role

Missions

Key Websites

Earth Science Week

CLIMATE REEL

CLIMATE KIDS

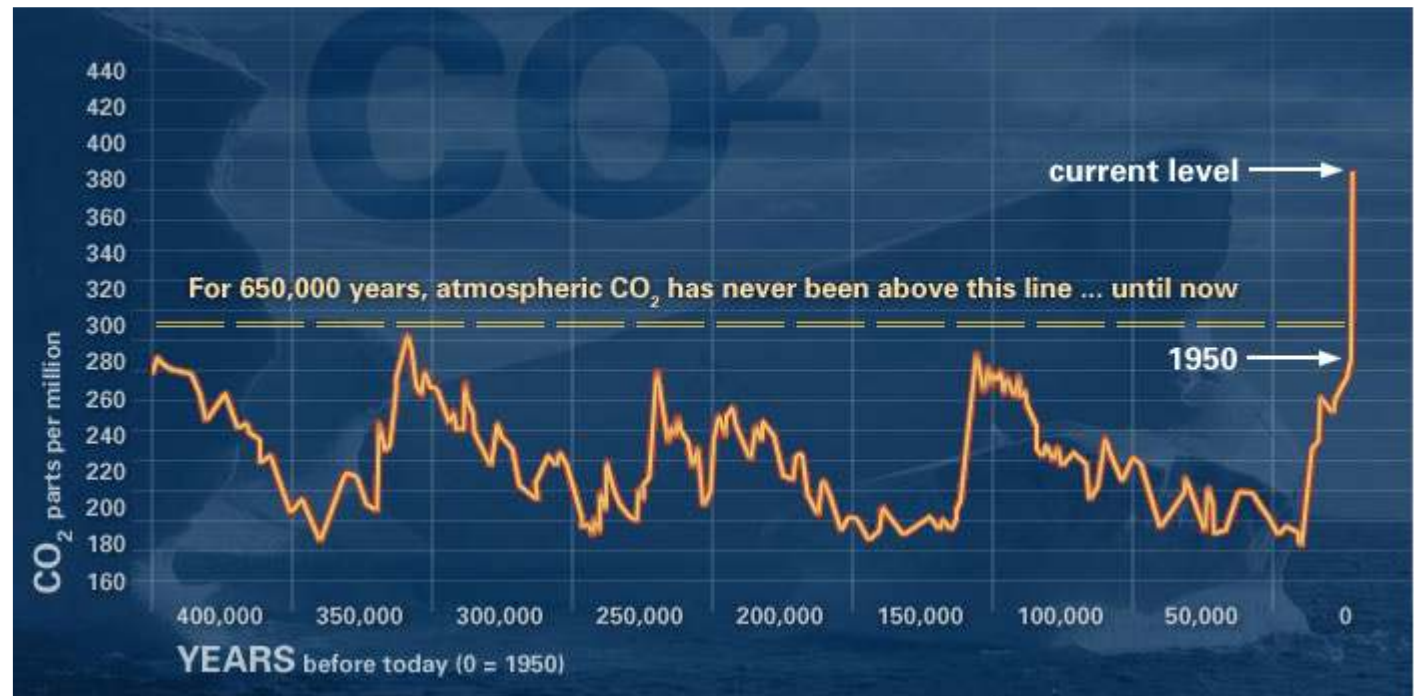
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## EVIDENCE

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### Climate change: How do we know?



This graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO<sub>2</sub> has increased since the Industrial Revolution. (Source: NOAA)

The Earth's climate has changed throughout history. Just in the last 650,000 years there have been seven cycles of glacial advance and retreat, with the abrupt end of the last ice age about seven thousand years ago, marking the beginning of the modern climate era—and of human civilization. Most of these changes are attributed to the very small changes in the Earth's orbit changing the amount of solar energy the Earth receives.

"Scientific evidence for warming of the climate system is unequivocal."

- Intergovernmental Panel  
on Climate Change

The current warming trend is of particular significance because most of it is very likely human-induced and proceeding at a rate that is unprecedented in the past 1,300 years.<sup>1</sup>

Earth-orbiting satellites and other technological advances have enabled scientists to see the big picture, collecting many different types of information about our

planet and its climate on a global scale. Studying these climate data collected over many years reveal the signals of a changing climate.

Certain facts about Earth's climate are not in dispute:

- The heat-trapping nature of carbon dioxide and other gases was demonstrated in the mid-19th century.<sup>2</sup> Their ability to affect the transfer of infrared energy through the atmosphere is the scientific basis of many JPL-designed instruments, such as AIRS. Increased levels of greenhouse gases must cause the Earth to warm in response.
- Ice cores drawn from Greenland, Antarctica, and tropical mountain glaciers show that the Earth's climate responds to changes in solar output, in the Earth's orbit, and in greenhouse gas levels. They also show that in the past, large changes in climate have happened very quickly, geologically-speaking: in tens of years, not in millions or even thousands.

### The evidence for abrupt climate change is compelling:



Aitutaki atoll: Vulnerable to rising sea levels

Global sea level rose about 17 centimeters (6.7 inches) in the last century. In the last decade, however, the rate of rise nearly doubled.<sup>3</sup>

Multimedia



### CLIMATE TIME MACHINE

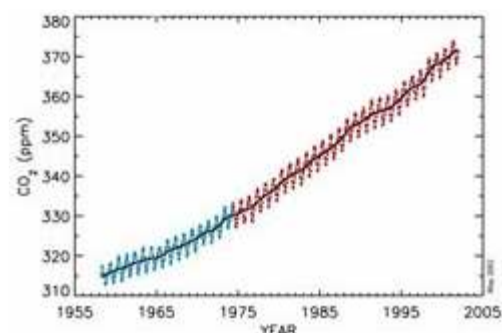
View global changes over time.

› flash interactive

### Resources

The following are the key sources of data and information contained on this page:

- [IPCC Fourth Assessment Report, Summary for Policymakers](#)
- [IPCC Fourth Assessment Report, Technical Summary](#)
- [NOAA Paleoclimatology](#)



The Keeling Curve shows a pattern of steadily increasing carbon dioxide in the atmosphere since 1958.

Levels of Carbon Dioxide are higher today than at anytime in past 650,000 years.

Scientists reconstruct past climate conditions through evidence preserved in tree rings, coral reefs and ice cores. For example, ice cores removed from 2 miles deep in the Antarctic contain atmospheric samples trapped in tiny air bubbles that date as far back as 650,000 years. These samples have allowed scientists to construct a historical record of greenhouse gas concentration stretching back hundreds of thousands of years.



The effects of climate change will likely include more frequent droughts in some areas and heavier precipitation in others.

Global surface air temperatures rose three-quarters of a degree Celsius (almost one and a half degrees Fahrenheit) in the last century, but at twice that amount in the past 50 years. Eleven of the last 12 years (1995-2006) are the warmest since accurate recordkeeping began in 1850.<sup>4</sup>



The oceans have absorbed much of this increased heat, with the top 700 meters (about 2,300 feet) of ocean showing warming of 0.18 degrees Fahrenheit since 1955.



Flowing meltwater from the Greenland ice sheet

The Greenland and Antarctic ice sheets have shrunk in both area and mass. Data from JPL's Gravity Recovery and Climate Experiment show Greenland lost 150 to 250 cubic kilometers (36 to 60 cubic miles) of ice per year between 2002 and 2006, while Antarctica lost about 152 cubic kilometers (36 cubic miles) of ice between 2002 and 2005.



The disappearing snowcap of Mount Kilimanjaro, from space.

Mountain glaciers and snow cover have declined on average in both hemispheres, and may disappear altogether in certain regions of our planet, such as the Himalayas, by 2030.<sup>5</sup>



Many species of plants and animals are already responding to global warming, moving to higher elevations or closer to the poles.



Precipitation and evaporation patterns over the oceans have changed, as evidenced by increased ocean salinity near the equator and decreased salinity at higher latitudes.<sup>6</sup>



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#### References

<sup>1</sup> *IPCC Fourth Assessment Report, Technical Summary*

<sup>2</sup> *In the 1860s, physicist John Tyndall recognized the Earth's natural greenhouse effect and suggested that slight changes in the atmospheric composition could bring about climatic variations. In 1896, a seminal paper by Swedish scientist Svante Arrhenius first speculated that changes in the levels of carbon dioxide in the atmosphere could substantially alter the surface temperature through the greenhouse effect.*

<sup>3</sup> *IPCC Fourth Assessment Report, Summary for Policymakers, pp. 5, 7*

<sup>4</sup> *ibid.*, p 5

<sup>5</sup> *ibid*

<sup>6</sup> *IPCC Fourth Assessment Report, Technical Summary, p. 48*



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