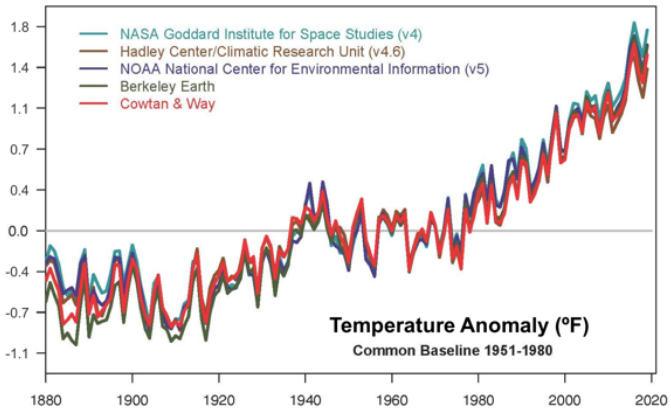
Back to Basics: The Science Behind Climate Change

Supplemental Materials

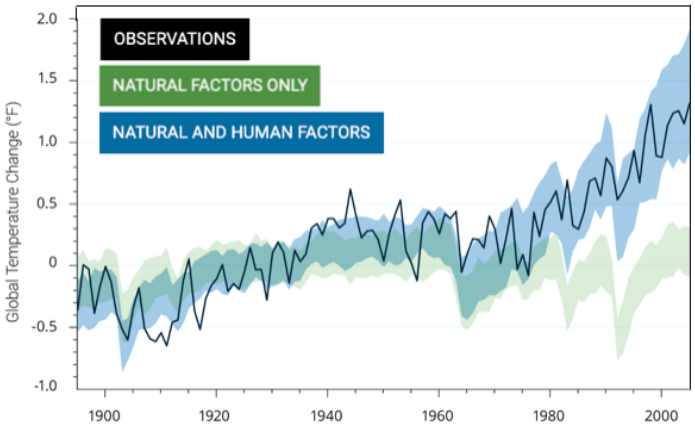
How do we know climate change is happening?



Every day, scientists record temperatures at thousands of weather stations around the world. Different agencies in the U.S. (NASA and NOAA), the U.K. (the Met Office Hadley Center), and independent research groups (UC Berkeley and University of York) analyze the data and provide a big picture overview of average global temperatures compared to a reference value (temperature anomaly). They have found global temperatures are rising, with the last decade the warmest on record. Scientists also take careful measurements of melting land-based ice in Greenland, Antarctica, and the Arctic; retreating glaciers in the Alps, Himalayas, Andes, Rockies, Africa, and Alaska; declining sea ice in the Arctic Ocean; and rising sea levels—all indicators of climate change.

The U.S. Global Change Research Program has developed an interactive dashboard to track important indicators of global change. It is available at https://www.globalchange.gov/indicators.

What's causing our climate to change?



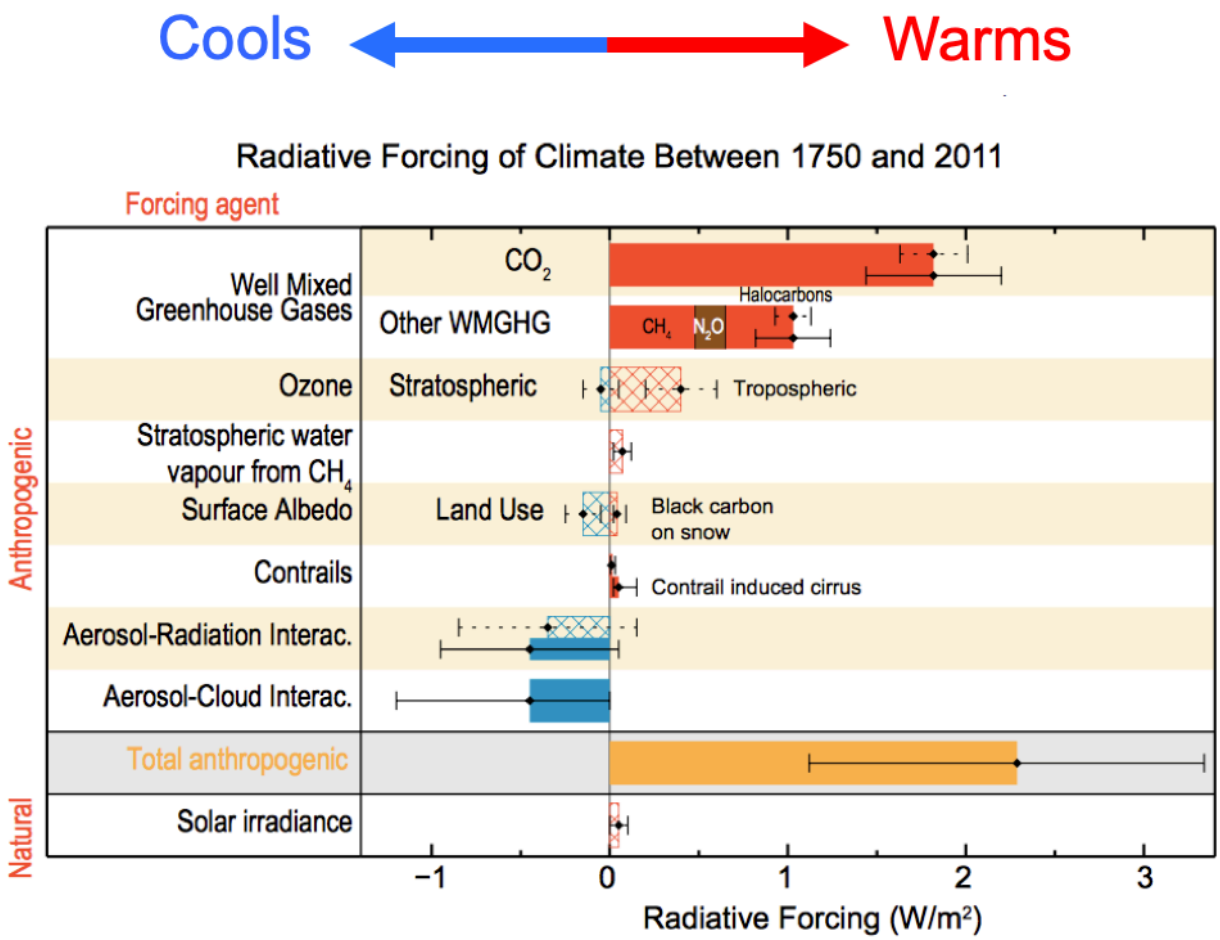
The Earth's climate has always fluctuated because of natural reasons, but today we are giving rise to a period of climate instability that would not be occurring naturally. We are doing this by increasing the amount of **greenhouse gases** in our atmosphere, primarily by burning fossil fuels. Greenhouse gases like carbon dioxide, methane, and nitrous oxide are a small, but critically important, natural part of our atmosphere.

Their heat-trapping property is what insulates Earth from the freezing cold of outer space, making our planet warm enough to live on. But as we continue to add more greenhouse gases to the atmosphere, we trap more heat and increase the Earth's average temperature—which is disrupting our climate system.

Curious about how the greenhouse effect works? This 3-minute video from Minute Earth simply explains this critical process: https://www.youtube.com/watch?v=sTvqIijqvTg.

You can read more about how scientists determine the human and natural contributions to climate change in this interactive resource: What's Really Warming the World https://cleanet.org/resources/51236.html.

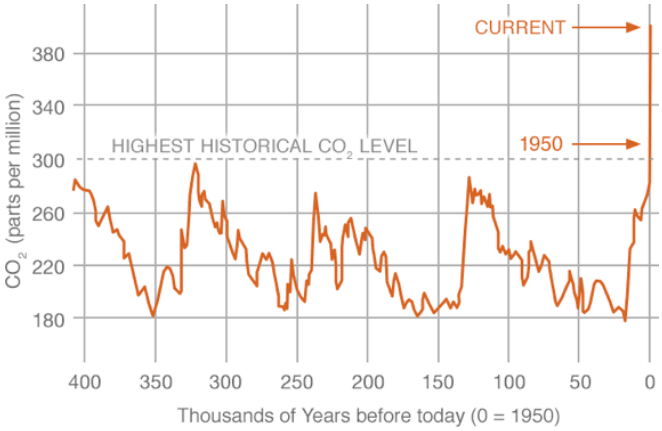
The relative contributions of different heat-trapping gases and natural factors to warming (or cooling) since the Industrial Revolution are shown here:



The relative importance of different factors affecting Earth's energy balance and climate. Positive radiative forcings warm the Earth, while negative forcings have a cooling effect. (from IPCC, 2013, Ch. 8, available here: http://www.climatechange2013.org/report/full-report/)

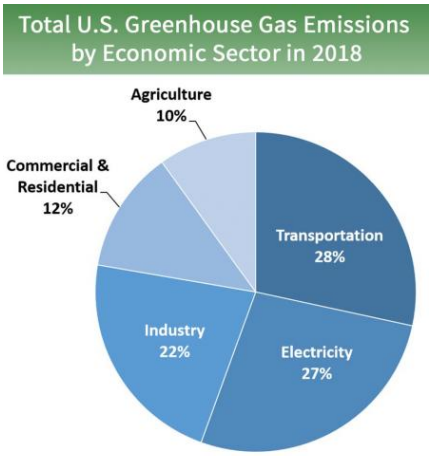
Do scientists agree?

Yes, the vast majority of climate scientists—97 percent—agree that the world is unequivocally warming and that human activity is the primary cause of the warming over the past century. Thousands of studies conducted by researchers around the world have documented climate warming trends, and while spirited debates on some details of climate science continue, these fundamental conclusions are not in dispute. The pace of change is accelerating and the broad-reaching effects of climate change are becoming more apparent. The amount of carbon dioxide (CO_2) in the atmosphere now exceeds 410 parts per million. This is the highest it has been in hundreds of thousands of years.



What types of human activities produce greenhouse gases?

Nearly every aspect of our modern lifestyle results in greenhouse gases being added to our atmosphere. From the way we make and move the foods we eat and the goods we use, to the way we power our buildings, homes, and transportation systems, we are burning fossil fuels. According to the U.S. Energy Information Administration, 79% of total U.S. energy consumption is fueled by natural gas, petroleum, and coal.



Additional Concepts and Resources

The Carbon Cycle

Our world is built on carbon, and how quickly or slowly it flows throughout Earth's atmosphere, oceans, land surfaces, and vegetation has important consequences for our global climate. NASA Earth Observatory is an excellent resource to learn about how the carbon cycle works: https://earthobservatory.nasa.gov/features/CarbonCycle.

Earth's Energy Budget

Earth's temperature is ultimately determined by how much energy is coming to and going from the Earth. Accounting for all of the energy—how and where it's reflected and absorbed, for instance—is part of what's called the Earth's energy budget. NASA Earth Observatory takes a deep dive into the various components of the energy budget and describes how imbalances dues to human activities affects Earth's climate: https://earthobservatory.nasa.gov/features/EnergyBalance.

Glossary of Frequently Used Terms

Weather – A snapshot of atmospheric conditions in a specific place and time.

Climate – Average weather conditions over a long time period, usually 30 or more years.

Global warming – The long-term heating of the Earth's climate caused by human activities, mostly burning fossil fuels, that increase greenhouse gases in the atmosphere.

Climate change – The long-term changes in weather patterns that result from global warming.

Shortwave radiation – The high-energy light waves coming from the sun to Earth, including visible light and ultraviolet (UV) radiation. The vast majority of the energy that Earth receives from the sun arrives as shortwave radiation.

Longwave radiation – Also called infrared radiation, are lower energy waves that are emitted from objects depending on their temperature. The Earth radiates heat outward toward space as longwave radiation. If you put your hands up close to a radiator you can feel the longwave radiation warming them.

Radiative forcing – A radiative forcing is essentially the amount of change in Earth's energy budget caused by a change in some relevant property, such as the energy output of the sun or the concentration of a greenhouse gas. Positive radiative forcings act to warm the planet, while negative forcings cool the planet.

Albedo – The proportion of incoming shortwave radiation that is reflected off of a surface.

Carbon sink – A part of Earth's system that absorbs more carbon than it releases, resulting in less CO_2 in the atmosphere.

Carbon source – A part of Earth's system that releases more carbon than it absorbs, resulting in more CO_2 in the atmosphere.