



Climate Forcing

This indicator measures the “radiative forcing” or heating effect caused by greenhouse gases in the atmosphere.

Background

When energy from the sun reaches the Earth, the planet absorbs some of this energy and radiates the rest back to space as heat. The Earth’s surface temperature depends on this balance between incoming and outgoing energy. If this energy balance is altered, the Earth’s average temperature will become warmer or cooler, leading to a variety of other changes in global climate.

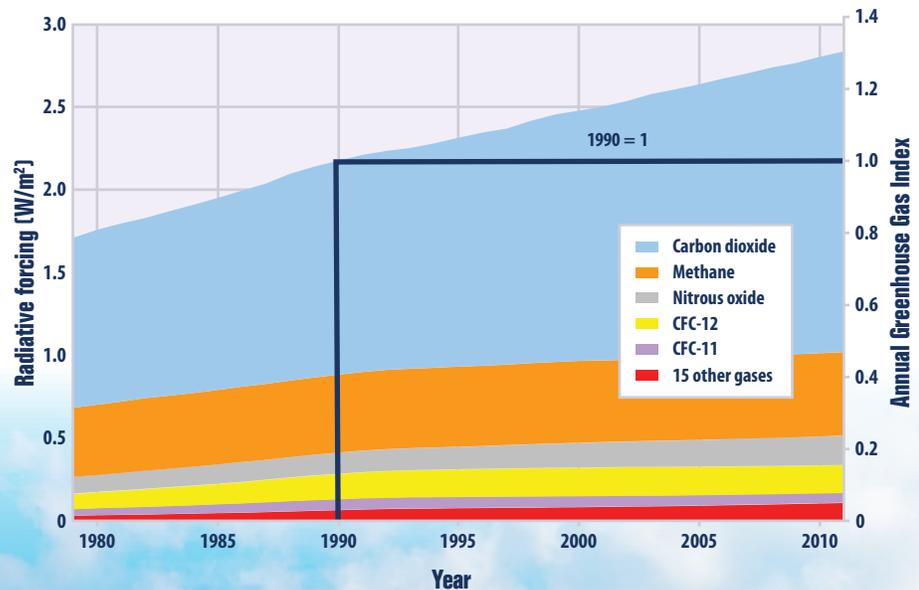
A number of natural and human-influenced mechanisms can affect the global energy balance and force changes in the Earth’s climate. Changes in greenhouse gas concentrations are one such mechanism. Greenhouse gases in the atmosphere absorb and re-emit most of the energy that radiates upward from the Earth’s surface, adding the heat back to the lower atmosphere and warming the Earth’s surface. Because elevated concentrations of many of the greenhouse gases emitted by human activities can remain in the atmosphere for decades, centuries, or longer, their associated warming effects persist over a long time. Factors that influence the Earth’s energy balance can be quantified in terms of “radiative climate forcing.” Positive radiative forcing indicates a warming influence (for example, by decreasing the amount of energy that escapes to space), while negative forcing is associated with a cooling influence. The balance between positive and negative forcing is what drives the actual change in surface temperature.

About the Indicator

This indicator measures the average total radiative forcing of 20 greenhouse gases, including carbon dioxide, methane, and nitrous oxide. The results were calculated by the National Oceanic and Atmospheric Administration based on measured concentrations of the gases in the atmosphere, compared with the concentrations that were present around 1750, before the Industrial Revolution began. Because each gas has a different capacity to absorb and emit heat energy, this indicator converts the changes in greenhouse gas

Figure 1. Radiative Forcing Caused by Major Greenhouse Gases, 1979–2011

This figure shows the amount of radiative forcing caused by various greenhouse gases, based on the concentrations present in the Earth’s atmosphere. On the right side of the graph, radiative forcing has been converted to the Annual Greenhouse Gas Index, which is set to a value of 1.0 for 1990.



Data source: NOAA, 2012²⁷



Key Points

- In 2011, the Annual Greenhouse Gas Index was 1.30, an increase in radiative forcing of 30 percent since 1990 (see Figure 1).
- Of the greenhouse gases shown in Figure 1, carbon dioxide accounts for by far the largest amount of radiative forcing, and its contribution continues to grow at a steady rate. By 2011, radiative forcing due to carbon dioxide was 40 percent higher than in 1990. Carbon dioxide accounts for approximately 80 percent of the overall increase in radiative forcing since 1990.
- Although the overall Annual Greenhouse Gas Index continues to rise, the rate of increase has slowed somewhat over time. This change has occurred in large part because methane concentrations have remained relatively steady since 1990 (although they have recently begun to rise again), and chlorofluorocarbon (CFC) concentrations have been declining because the production of these gases has been banned globally due to the harm they cause to the ozone layer (see Figure 1).

concentrations into a measure of the total radiative forcing (energy absorption) caused by each gas. Radiative forcing is calculated in watts per square meter, which represents the rate of energy transfer over a particular area.

The National Oceanic and Atmospheric Administration also translates the total radiative forcing of these measured gases into an index value called the Annual Greenhouse Gas Index. This number represents the ratio of the radiative forcing for a particular year compared with the radiative forcing in 1990, which is a common baseline year for global efforts to measure greenhouse gas concentrations. This indicator does not consider all substances that contribute to climate change (see Indicator Notes).

Indicator Notes

This indicator does not consider certain other substances that contribute to climate forcing. For example, the indicator does not measure reflective aerosol particles in the atmosphere, which can reduce radiative forcing, nor ground-level ozone or black carbon (soot), which can increase it. One gas shown in this indicator (methane) can also have an indirect influence on radiative forcing through its effects on water vapor and ozone formation; these indirect effects are not shown.

Data Sources

Data for this indicator were provided by the National Oceanic and Atmospheric Administration. This figure and other information are available at: www.esrl.noaa.gov/gmd/aggi.

