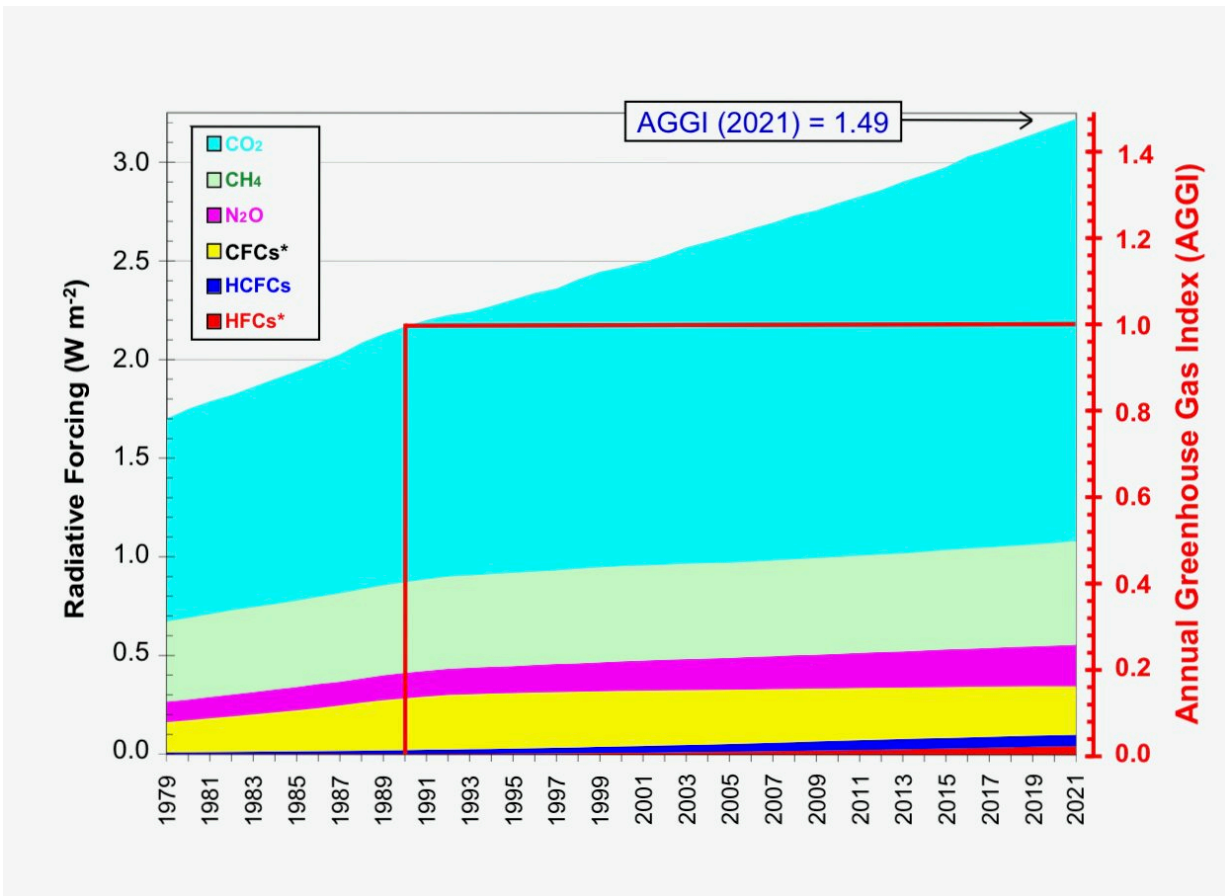


# Greenhouse gas pollution trapped 49% more heat in 2021 than in 1990

May 24 2022



This graph depicts the relative contributions of the major greenhouse gas pollutants to global warming, in watts per square meter along the left axis. The NOAA Annual Greenhouse Gas Index (AGGI) is shown on the right axis. Credit: NOAA Global Monitoring Laboratory

Greenhouse gas pollution caused by human activities trapped 49% more heat in the atmosphere in 2021 than they did in 1990, according to NOAA scientists.

NOAA's Annual Greenhouse Gas Index, known as the AGGI, tracks increases in the warming influence of human emissions of heat-trapping gases, including [carbon dioxide](#), methane, [nitrous oxide](#), chlorofluorocarbons, and 16 other chemicals. The AGGI converts the complex scientific computations of how much extra heat these gases capture into a single number that can easily be compared to previous years and tracks the rate of change.

The AGGI is indexed to 1990, the baseline year for the [Kyoto Protocol](#) and the year the first IPCC Scientific Assessment of Climate Change was published.

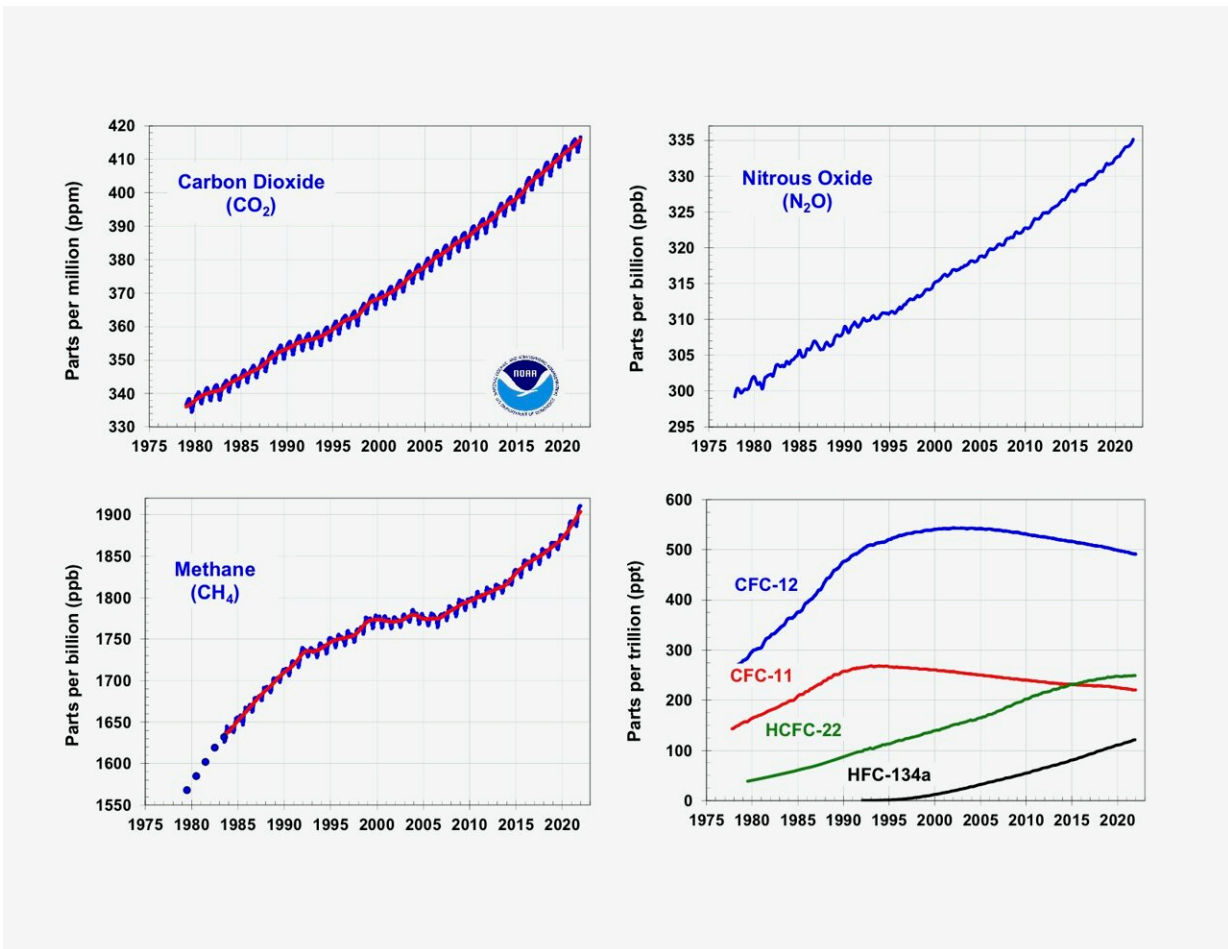
"The AGGI tells us the rate at which we are driving global warming," said Ariel Stein, the acting director of NOAA's Global Monitoring Laboratory (GML). "Our measurements show the primary gases responsible for climate change continue rising rapidly, even as the damage caused by climate change becomes more and more clear. The scientific conclusion that humans are responsible for their increase is irrefutable."

In 2021, the AGGI reached a value of 1.49, which means that human-emitted [greenhouse gases](#) trapped 49% more heat in the atmosphere than in 1990. Because it is based primarily on highly accurate measurements of greenhouse gases in air samples collected around the globe, the result contains little uncertainty.

## **The biggest culprit**

Carbon dioxide, or CO<sub>2</sub>, is by far the most abundant human-emitted

greenhouse gas. Roughly 36 billion metric tons of CO<sub>2</sub> are emitted each year by transportation, electrical generation, cement manufacturing, deforestation, agriculture, and many other practices. A substantial fraction of CO<sub>2</sub> emitted today will persist in the atmosphere for more than 1,000 years. Not surprisingly, it is also the largest contributor to the AGGI in terms of both amount and rate of increase.



Global average abundances of the major, well-mixed, long-lived greenhouse gases - carbon dioxide, methane, nitrous oxide, CFC-12 and CFC-11 - from the NOAA global air sampling network since the beginning of 1979 are depicted here. These five gases account for about 96% of the direct radiative forcing by long-lived greenhouse gases since 1750. The remaining 4% is contributed by 15

other halogenated gases including HCFC-22 and HFC-134a, for which NOAA observations are also shown here. Credit: NOAA Global Monitoring Laboratory

NOAA measurements showed the global average concentration of CO<sub>2</sub> in 2021 was 414.7 parts per million (ppm). The annual increase was 2.6 ppm during this year, about the average [annual increase](#) for the previous decade, and much higher than the increase measured during 2000–2009. CO<sub>2</sub> levels have risen by 61 ppm since 1990, accounting for 80% of the increased heat tracked by the AGGI since that year.

"CO<sub>2</sub> is the main player because it stays in the atmosphere and oceans for thousands of years and it is by far the largest contributor to [global warming](#)," said GML Senior Scientist Pieter Tans. "Eliminating CO<sub>2</sub> pollution has to be front and center in any efforts to deal with [climate change](#)."

## **Methane: Is warming feeding warming?**

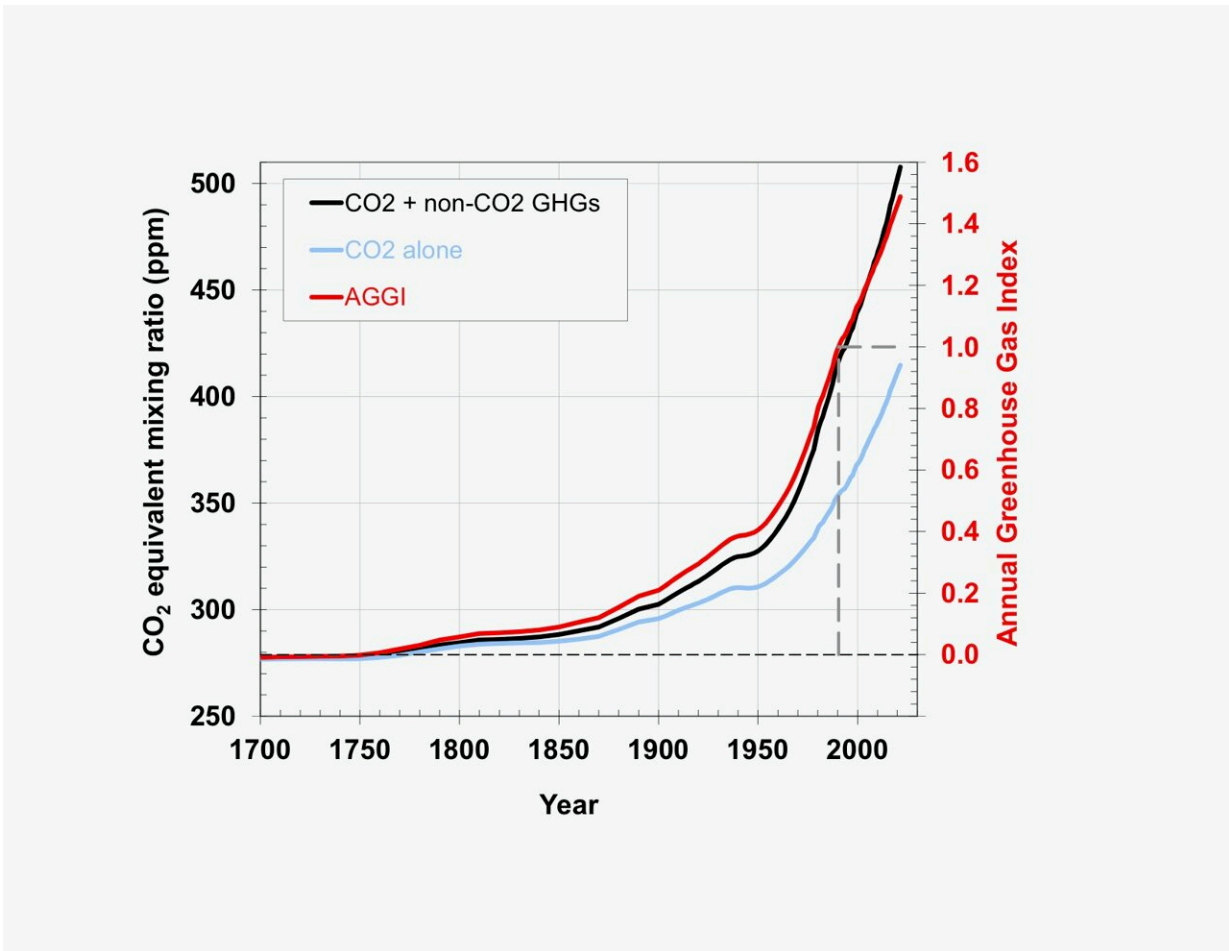
One of the most important scientific questions for [climate scientists](#) is what's been driving the sharp, sustained increase of the second-most important greenhouse gas—methane—since 2006.

Levels of atmospheric methane, or CH<sub>4</sub>, averaged 1,895.7 parts per billion during 2021. The 16.9 ppb increase recorded for 2021 was the fastest observed since the early 1980s, when a more rigorous measurement regime was initiated. Methane levels are currently around 162% greater than pre-industrial levels. From NOAA's observations, scientists estimate the amount of methane emitted in 2021 was 15% greater than the 1984–2006 period.

Methane is the second-most important greenhouse gas in warming the

globe. The warming influence of CH<sub>4</sub> since pre-industrial times is about a quarter of that from CO<sub>2</sub>. Causes for the dramatic post-2007 increase are not fully understood, but NOAA scientists have concluded that changes in isotopic composition of atmospheric methane over time point to microbial sources, likely from wetlands, agriculture and landfills, as the dominant driver. Fossil fuel emissions, they suggest, have made a smaller contribution.

"We should absolutely target man-made methane emissions—especially those from fossil fuel— because it is technologically feasible to control them," said Xin Lan, a CIRES scientist working in the Global Monitoring Lab. "If wetlands are giving off more methane because of warming and changes in global precipitation caused by rising CO<sub>2</sub> levels , that's something we can't control directly. And that would be very concerning."



This graphic shows the increasing warming influence over time of CO<sub>2</sub> and non-CO<sub>2</sub> greenhouse gases, in CO<sub>2</sub> equivalents, on the left axis. The corresponding increase in the AGGI is shown on the right axis. Credit: NOAA Global Monitoring Laboratory

## No laughing matter

The third-most important greenhouse gas is one you may have encountered as an anesthesia in the dentist's chair. Nitrous oxide, or N<sub>2</sub>O, is another long-lived climate forcing pollutant primarily emitted by people. It is rising every year. But it's different in that it's being driven

by expanding populations, not energy demands. N<sub>2</sub>O pollution is primarily a result of fertilizer use to support agriculture and food production, especially for an expanding global population .

"We can find alternative energy sources to replace fossil fuels," said Stephen Montzka, the GML scientist who leads the AGGI report each year, "but cutting emissions associated with producing food is a very difficult task."

These three greenhouse gases, plus two banned ozone-depleting chemicals, account for about 96% of the excess heat trapped in the atmosphere due to human activity since 1750. The remaining 4% is from 16 other greenhouse gases also tracked by the AGGI. In aggregate, they trapped an amount of heat equivalent to 508 ppm of CO<sub>2</sub> in 2021.

## **One number to track human impact on climate**

NOAA scientists released the first AGGI in 2006 as a way to help policymakers, educators, and the public understand the cumulative impact of greenhouse gases on climate over time.

Scientists benchmarked the AGGI to the year 1750, the onset of the Industrial Revolution, assigning it a value of zero. An AGGI value of 1.0 was assigned to 1990.

The AGGI is based on thousands of air samples collected from sites around the world each year from NOAA's [Global Greenhouse Gas Reference Network](#). Concentrations of these greenhouse gases and other chemicals are determined through the analysis of those samples at NOAA's Global Monitoring Laboratory in Boulder, Colorado. Scientists then calculate the amount of extra heat being trapped in the Earth system by these gases and how much that has changed over time to understand the contribution from human activity.

Provided by NOAA Headquarters

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