Atmospheric Concentrations of Greenhouse Gases

This indicator describes how the levels of major greenhouse gases in the atmosphere have changed over time.

Background

Since the Industrial Revolution began in the late 1700s, people have added a significant amount of greenhouse gases into the atmosphere by burning fossil fuels, cutting down forests, and conducting other activities (see the U.S. and Global Greenhouse Gas Emissions indicators on pp. 12–15). When greenhouse gases are emitted into the atmosphere, many remain there for long time periods ranging from a decade to many millennia. Over time, these gases are removed from the atmosphere by emissions sinks, such as oceans, vegetation, or chemical reactions. Emissions sinks are the opposite of emissions sources, and they absorb and store emissions or cause the gases to break down. However, if these gases enter the atmosphere more quickly than they can be removed, their concentrations increase.

Many greenhouse gases remain in the atmosphere for decades or longer. The greenhouse gases being reported here become well mixed throughout the entire global atmosphere because of their long lifetimes and because of transport by winds. Concentrations of other greenhouse gases such as tropospheric ozone, which has an atmospheric lifetime of hours to days, often vary regionally and are not included in this indicator.

Concentrations of greenhouse gases are measured in parts per million (ppm), parts per billion (ppb), or parts per trillion (ppt) by volume. In other words, a concentration of 1 ppb for a given gas means there is one part of that gas in 1 billion parts of a given amount of air. For some greenhouse gases, even changes as small as a few parts per trillion can make a difference in global climate.

About the Indicator

This indicator describes concentrations of greenhouse gases in the atmosphere. It focuses on the major greenhouse gases that result from human activities. These include carbon dioxide, methane,

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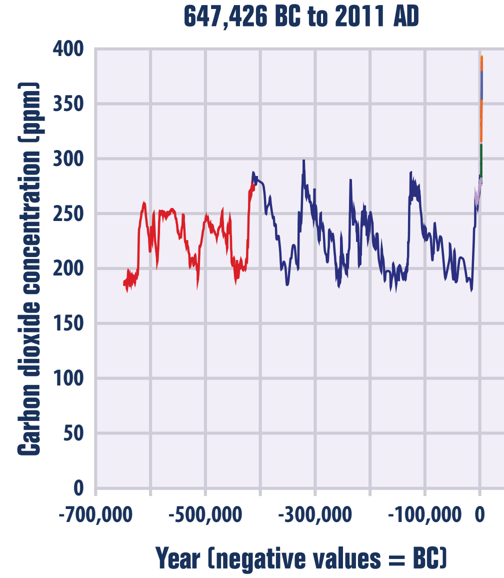
Figure 1. Global Atmospheric Concentrations of Carbon Dioxide Over Time

This figure shows concentrations of carbon dioxide in the atmosphere from hundreds of thousands of years ago through 2011. The data come from a variety of historical ice core studies and recent air monitoring sites around the world. Each line represents a different data source.



Data source: Various studies[12]

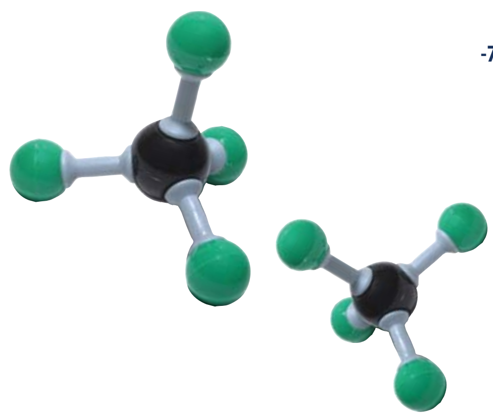
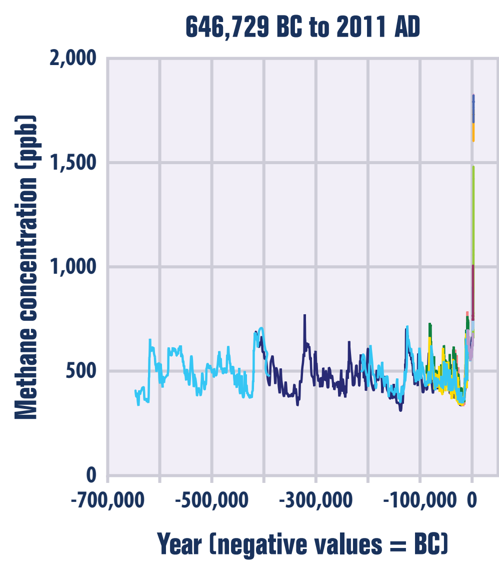
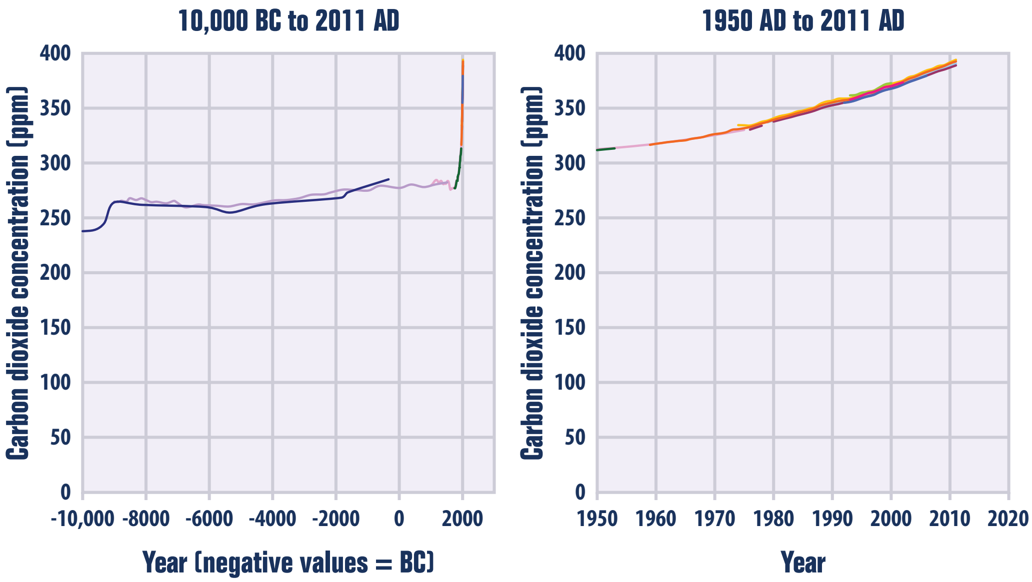


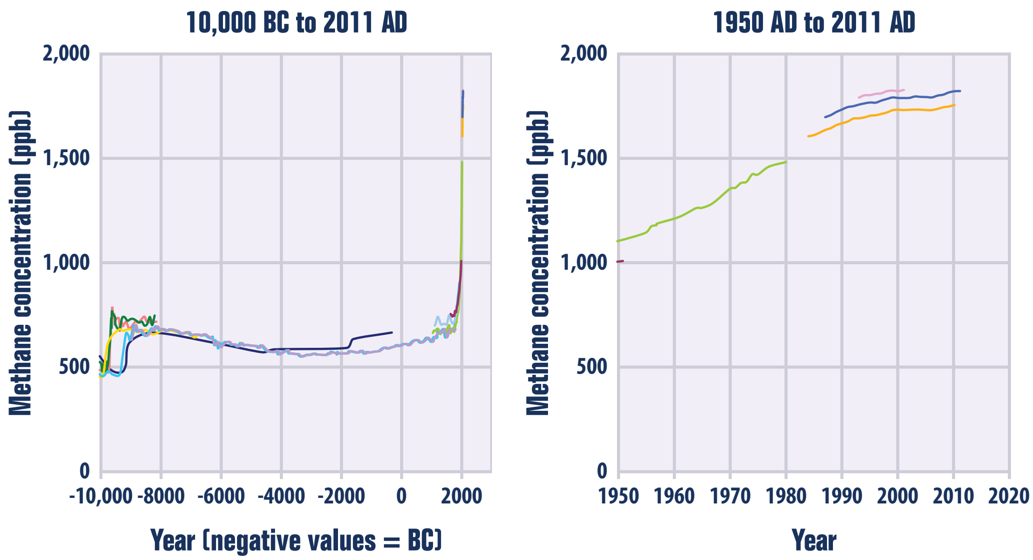
Figure 2. Global Atmospheric Concentrations of Methane Over Time

This figure shows concentrations of methane in the atmosphere from hundreds of thousands of years ago through 2011. The data come from a variety of historical ice core studies and recent air monitoring sites around the world. Each line represents a different data source.



Data source: Various studies[13]





Key Points

- Global atmospheric concentrations of carbon dioxide, methane, nitrous oxide, and certain manufactured greenhouse gases have all risen over the last few hundred years (see Figures 1, 2, 3, and 4).
- Before the industrial era began in the late 1700s, carbon dioxide concentrations measured approximately 280 ppm. Concentrations have risen steadily since then, reaching 391 ppm in 2011—a 40 percent increase. Almost all of this increase is due to human activities.[14]
- The concentration of methane in the atmosphere has more than doubled since preindustrial times, reaching about 1,818 ppb in 2011. It is very likely that this increase is predominantly due to agriculture and fossil fuel use.[15]
- Historical measurements show that the current global atmospheric concentrations of carbon dioxide and methane are unprecedented compared with the past 650,000 years (see Figures 1 and 2).
- Over the past 100,000 years, concentrations of nitrous oxide in the atmosphere have rarely exceeded 280 ppb. Levels have risen since the 1920s, however, reaching a new high of 324 ppb in 2011 (see Figure 3). This increase is primarily due to agriculture. [16]
- Concentrations of many of the halogenated gases shown in Figure 4 (gases that contain chlorine, fluorine, or bromine) were essentially zero a few decades ago but have increased rapidly as they have been incorporated into industrial products and processes. Some of these chemicals are now being phased out of use because they are ozone-depleting substances, meaning they also cause harm to the Earth's ozone layer. As a result, concentrations of some ozone-depleting gases have begun to stabilize or decline (see Figure 4, left panel). Concentrations of other halogenated gases have continued to rise, however, especially where the gases have emerged as substitutes for ozone-depleting chemicals (see Figure 4, right panel). Some of these halogenated gases are considered major greenhouse gases due to their very high global warming potentials and long atmospheric lifetimes (see table on p. 10).

nitrous oxide, and certain manufactured gases known as halogenated gases. This indicator shows concentrations of greenhouse gases over thousands of years. Recent measurements come from monitoring stations around the world, while older measurements come from air bubbles trapped in layers of ice from Antarctica and Greenland. By determining the age of the ice layers and the concentrations of gases trapped inside, scientists can learn what the atmosphere was like thousands of years ago.

Indicator Notes

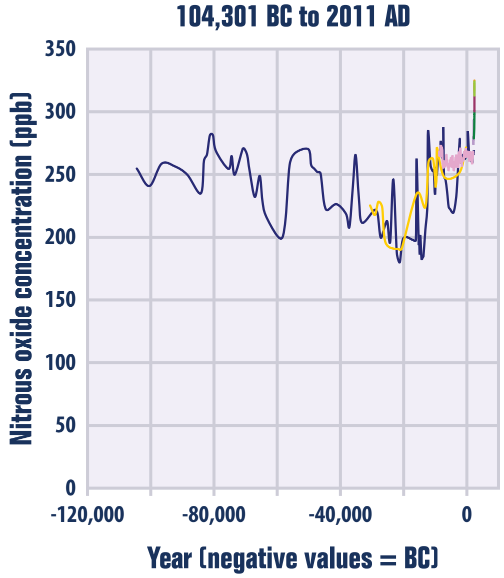
This indicator includes several of the most important halogenated gases, but some others are not shown. Many other halogenated gases are also greenhouse gases, but Figure 4 is limited to a set of common examples that represent most of the major types of these gases. The indicator also does not address certain other pollutants that can affect climate by either reflecting or absorbing energy. For example, sulfate particles can reflect sunlight away from the Earth, while black carbon aerosols (soot) absorb energy. Data for nitrogen trifluoride (Figure 4) reflect measurements made in the Northern Hemisphere only, where concentrations are expected to be slightly higher than the global average.

Data Sources

Global atmospheric concentration measurements for carbon dioxide (Figure 1), methane (Figure 2), and nitrous oxide (Figure 3) come from a variety of monitoring programs and studies published in peer-reviewed literature. References for the underlying data are included in the corresponding exhibits. Global atmospheric concentration data for selected halogenated gases (Figure 4) were compiled by the Advanced Global Atmospheric Gases Experiment,[17] the National Oceanic and Atmospheric Administration,[18] and two studies on nitrogen trifluoride.[19,20] An older figure with many of these gases appeared in the Intergovernmental Panel on Climate Change's Fourth Assessment Report.[21]

Figure 3. Global Atmospheric Concentrations of Nitrous Oxide Over Time

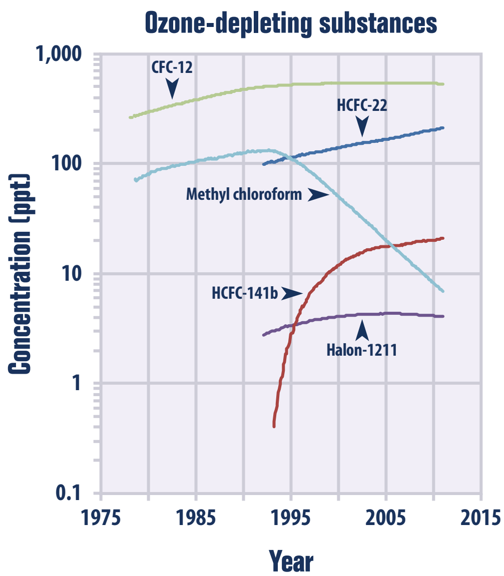
This figure shows concentrations of nitrous oxide in the atmosphere from 100,000 years ago through 2011. The data come from a variety of historical ice core studies and recent air monitoring sites around the world. Each line represents a different data source.



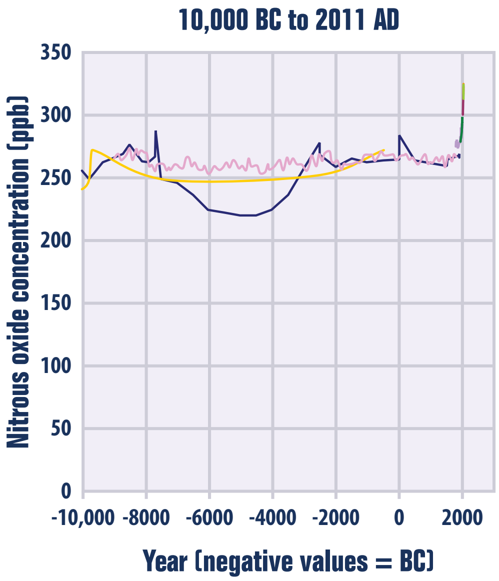
Data source: Various studies[22]

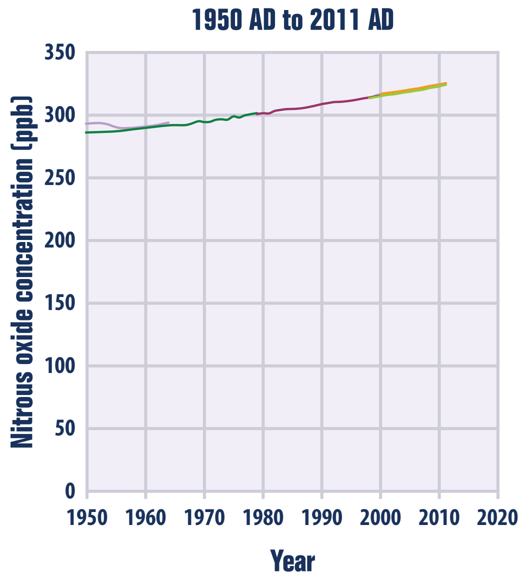
Figure 4. Global Atmospheric Concentrations of Selected Halogenated Gases, 1978–2011

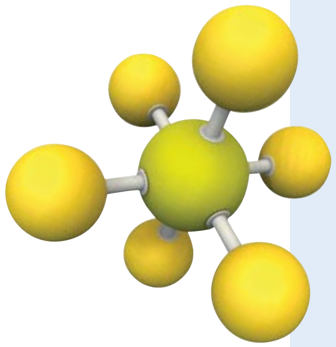
This figure shows concentrations of several halogenated gases (which contain fluorine, chlorine, or bromine) in the atmosphere. The data come from monitoring sites around the world. Note that the scale is logarithmic, which means it increases by powers of 10. This is because the concentrations of different halogenated gases can vary by a few orders of magnitude. The numbers following the name of each gas (e.g., HCFC-22) are used to denote specific types of those particular gases.

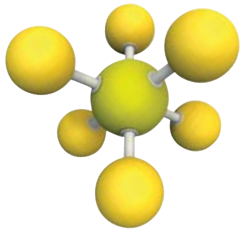


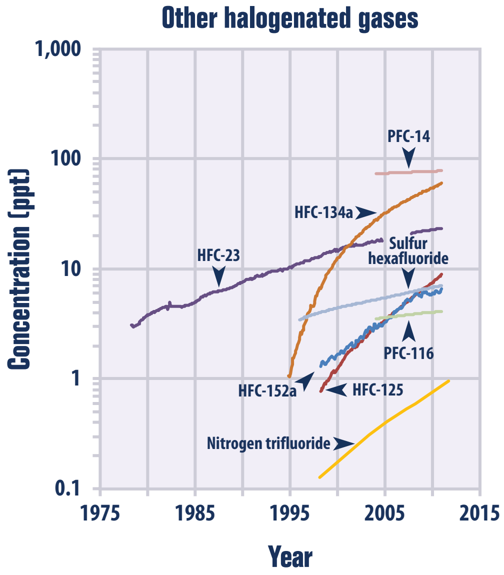
Data sources: AGAGE, 2011;[23] Arnold et al., 2012;[24] NOAA, 2011;[25] Weiss et al., 2008[26]











Water Vapor as a Greenhouse Gas

Water vapor is the most abundant greenhouse gas in the atmosphere. Human activities have only a small direct influence on atmospheric concentrations of water vapor, primarily through irrigation and deforestation, so it is not included in this indicator. However, the surface warming caused by human production of other greenhouse gases leads to an increase in atmospheric water vapor, because a warmer climate increases evaporation. This creates a positive "feedback loop" where warming leads to more warming.