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# GREENHOUSE GAS BASICS

Julie E. Doll[1] and Marci Baranski [1,2] [1]W.K. Kellogg Biological Station, Michigan State University, [2]Michigan State University Extension

## What are greenhouse gases?

Many chemical compounds in the atmosphere act as *greenhouse gases*. These gases allow sunlight (shortwave radiation) to freely pass through the Earth's atmosphere and heat the land and oceans. The warmed Earth releases this heat in the form of infrared light (longwave radiation), invisible to human eyes[1]. Some of the infrared light released by the Earth passes through the atmosphere back into space. However, greenhouse gases will not let all the infrared light pass through the atmosphere[1]. They absorb some and radiate it back down to the Earth. This phenomenon, called the *greenhouse effect*, is naturally occurring and keeps the Earth's surface warm. It is vital to our survival on Earth. Without the greenhouse effect, the Earth's average surface temperature would be about 60° Fahrenheit colder, and our current way of life would be impossible[1].

**Greenhouse gases occur naturally and allow us to survive on Earth by warming air near Earth's surface. Human activities are now increasing the amount of greenhouse gases in the atmosphere, which leads to changes in climate. These changes are affecting many human activities, including agriculture.**

We know that several gases in the atmosphere can absorb heat. These greenhouse gases are produced both by natural processes and by human activities. The primary ones are:

- Carbon dioxide ($CO_2$)
- Methane ($CH_4$)
- Nitrous oxide ($N_2O$)
- Industrial Gases, including hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride

Water vapor is the most abundant greenhouse gas and plays an important role in regulating the climate. Changes in water vapor from human activities such as irrigation and deforestation can directly affect temperatures at the Earth's surface[2]. However, because human emissions of water vapor do not significantly change water vapor levels in the atmosphere, water vapor is not counted in the United States or international greenhouse gas inventories[3].

## Why do greenhouse gas levels matter?

Atmospheric concentrations of several important greenhouse gases have increased significantly since large-scale industrialization began around 200 years ago[4]. Fossil fuel combustion converts carbon that had been stored deep in the Earth to carbon dioxide that enters the atmosphere. Clearing land for agriculture converts carbon stored in soils and plants to carbon dioxide. Even though the most important greenhouse gases occur naturally and are important for life on Earth, burning fossil fuels and other human activities have caused a large increase in their concentrations (Figure 1).

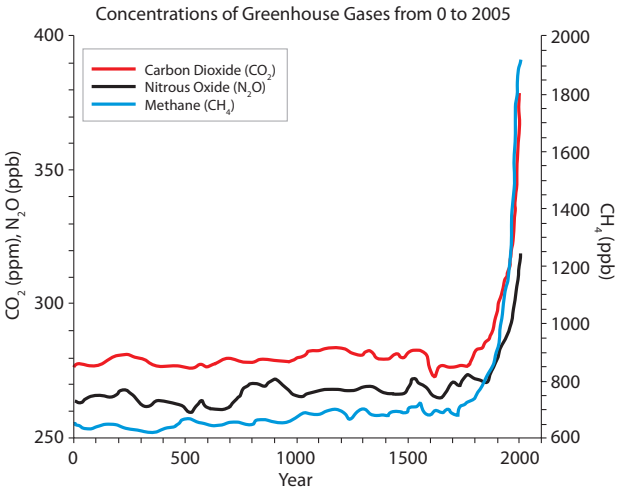


Figure 1: Atmospheric concentrations of the naturally occurring greenhouse gases carbon dioxide, methane, and nitrous oxide over the past 2000 years. Data are from ice core records and contemporary measurements[4].

**This all matters because there is general scientific consensus among climatologists, atmospheric chemists, and other scientists who study Earth's systems that the increase of greenhouse gas concentrations causes a rise in the average global temperature**[5,6]. Assessments by the independent Intergovernmental Panel on Climate Change (IPCC) note that Earth's average global surface temperature has risen between 1.1° and 1.6° Fahrenheit over the past century and that this is very likely caused by human activity[4]. Although this rise in temperature does not seem like much, even small changes in the global temperature can lead to changes we notice at the local level, and

warming in some places – in the Arctic, for example – is much greater than in others. Local changes include shifts in the patterns and severity of rainfall and snowfall, droughts, cloudiness, humidity, and growing season length[7]. These changes have the capacity to greatly affect agriculture (see MSU Extension E3149).

**Do all greenhouse gases have the same effect?**
Greenhouse gases have different capacities to absorb heat. Scientists use two terms to differentiate the impacts of different greenhouse gases:

> ***Global Warming Potential*** (GWP)[4] is an index that represents the global warming impact of a greenhouse gas relative to carbon dioxide. GWP represents the combined effect of how long the gas remains in the atmosphere and its relative effectiveness in absorbing outgoing infrared heat. Table 1 lists the GWP of the three main greenhouse gases (based on a 100-year time horizon). As the table shows, a given molecule of nitrous oxide has over 300 times the impact on global warming as does a molecule of carbon dioxide.

Table 1: Global Warming Potential of greenhouse gases[4]

| | Atmospheric lifetime (years) | Global Warming Potential (GWP) |
|---|---|---|
| Carbon dioxide ($CO_2$) | Variable | 1 |
| Methane ($CH_4$) | 12 | 21 |
| Nitrous oxide ($N_2O$) | 114 | 310 |

> **Carbon dioxide-equivalents** ($CO_2$-eq)[4] are units that represent the relative impact of a given gas on atmospheric warming, based on the gas' GWP. For example, a ton of methane can be expressed as 21 tons of $CO_2$-eq, and a ton of nitrous oxide can be expressed as 310 tons of $CO_2$-eq. Using a common unit helps when making inventories of greenhouse gases or when comparing strategies to reduce greenhouse gas emissions.

Despite the already changing global climate, we can use a combination of strategies to mitigate climate change both by emitting fewer greenhouse gases and by removing carbon dioxide from the atmosphere. Decreasing our reliance on fossil fuels and investing in alternative energy sources and more efficient technologies can help to reduce emissions of greenhouse gases. Removing carbon dioxide from the atmosphere and storing it permanently, referred to as carbon sequestration, is another mitigation strategy. This can be accomplished through planting crops or trees that absorb carbon dioxide from the atmosphere via photosynthesis and store it in their ecosystem as roots, wood, or soil organic matter.

See MSU Extension E3149 for a more detailed description of field crop agriculture and climate change.

**References:**


[1] Climate Central and Sally Ride Science (2010). What you need to know: 20 questions and answers about climate change. Sally Ride Science, San Diego, CA.

[2] IPCC (2007). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[3] IPCC (2008). IPCC Guidelines for National Greenhouse Gas Inventories: Frequently Asked Questions, Prepared by the National Greenhouse Gas Inventories Programme. http://www.ipcc-nggip.iges.or.jp/faq/faq.html

[4] IPCC (2007). Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland.

[5] Oreskes, Naomi (2004). Beyond the Ivory Tower: The Scientific Consensus on Climate Change. Science 306:1686.

[6] U.S. Environmental Protection Agency (Accessed Feb 2011). Climate Change Science: State of Knowledge. http://www.epa.gov/climatechange/science/stateofknowledge.html

[7] U.S. Global Change Research Program (2009). Climate Literacy: The Essential Principles of Climate Sciences. http://www.globalchange.gov/resources/educators/climate-literacy


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