

TEACHER BACKGROUND INFORMATION

CLIMATE CHANGE AND HUMAN ACTIVITY

Scientists studying the Earth's climate system believe that human activities are responsible for changes in the composition of the atmosphere by increasing the concentration of **greenhouse gases (GHGs)**. Some greenhouse gases occur naturally in the atmosphere, while others are man-made or the result of human activity. The increase in the concentrations of GHGs are creating what atmospheric scientists call the **enhanced greenhouse effect** or **global warming**. It is important to remember that the **natural greenhouse effect** is what keeps the earth warm enough to support life. The current concern is that an enhanced greenhouse effect is increasing the heat-absorbing gases into the atmosphere and thereby increasing the **average global temperature**. The enhanced greenhouse effect has been linked to increased GHG emissions from human activities.

Carbon dioxide (CO₂) a colorless, odorless gas, is an important molecule in the basic physiological processes carried out by all living things, **Respiration** in animals involves the consumption of oxygen and the release of carbon into the atmosphere, while **photosynthesis** in plants consumes carbon dioxide and releases oxygen back into the air and soil. The important factor here is that carbon atoms in the form of CO₂ are constantly being "cycled" from one form to another between the **abiotic** part of the Earth system, the atmosphere and the **biotic** part, the biosphere.

Carbon dioxide is considered the most important greenhouse gas and for that reason increases in its concentration are cause for concern. Over the past 200 years, human activities have drastically altered the cycle of carbon storage and release known as the **carbon cycle**. The use of organic (fossil) fuels like coal, oil and natural gas and the process of deforestation free the carbon atoms stored in the fuels and forests and release them back into the atmosphere as carbon dioxide in the combustion process. By doing so, the normal storage time for carbon is being disrupted and the concentration in the atmosphere is increasing as the processes that normally remove CO₂ from the air (dissolution in the oceans and uptake by plants) cannot keep pace with the supply.

There is irrefutable evidence that global levels of carbon dioxide are higher than they have been since before the start of the Industrial Revolution (1750-

1800). The trend was first observed in the CO_2 record from the Mauna Loa Observatory in Hawaii in 1958. Since then, monitoring of atmospheric CO_2 levels has been rigorously maintained. In addition to showing an overall annual increase in CO_2 levels, the Mauna Loa records also show annual oscillations due to seasonal variations in the amount of CO_2 caused by increased vegetative activity in the spring and summer months and decreased activity in the fall and winter. Satellite images give a clear picture of the "greenness" of vegetation, which outside of the tropics can be seen to wax and wane during a twelve month period, with the cycles in the Northern and Southern Hemispheres opposing each other in perfect symmetry.

This increase arises primarily from the burning of fossil fuels (motorized vehicles, electric power plants, and homes heated with gas or oil) and the burning and clearing of forested land for agricultural purposes.

The concentrations of these GHG are increasing, however emissions are not uniformly distributed globally. The majority of the emissions come from developed countries where power generation, power consumption, and living standards are highest.

GOALS:

- Students will examine graphs of GHG emissions and their increases associated with human activity focusing on CO_2 .
- Students will calculate some personal contributions to CO_2 emissions.

ALIGNMENT TO NATIONAL SCIENCE STANDARDS:

- ✓ Unifying Concepts and Processes (K-12)
 - Consistency, change, and measure
- ✓ Science as Inquiry, Content Standard A (9-12):
 - Abilities necessary to do scientific inquiry
 - Understandings about scientific inquiry
- ✓ Life Science, Content Standard C (9-12):
 - Interdependence of organisms
 - Matter, energy, and organization in living systems
 - Behavior of organisms
- ✓ Earth and Space Science, Content Standard D (9-12):
 - Energy in the earth system

- ✓ Science in Personal and Social Perspective, Content Standard F (9-12):
 - Personal and community health
 - Environmental quality
 - Science and technology in local, national, and global changes

GRADE LEVEL/TIME

- **Grade level:** 6 to 9
- **Time:**
 - Teacher introduction to human activities and GHG: 20 minutes
 - Student activity: 40 minutes
 - Student discussion: 15 minutes

MATERIALS

- Graphs and charts of greenhouse gases and human activity
- City map
- Calculator

PROCEDURE:

1. Brainstorm, list and discuss possible human sources of GHGs. Where do these gases come from? Are the sources common all over the world or are some areas larger sources than others?
2. Read and discuss the charts and graphs. How does the information support or contradict the ideas formed during the brainstorming session?
3. Encourage the students to compare the GHG graphs with other graphs (for example, global temperature and human population increases) during the same time span. Encourage them to come up with their own comparisons. What kinds of trends do they predict? Can seemingly upward trends be reversed?
4. Ask students to discuss global emissions of GHGs. For example, the United States has only a small percentage of the world's population but emits a disproportionate share of the global CO₂. China has a population of over a billion people. What would happen if China "developed" to the point where most families owned an automobile that emitted CO₂?

5. Students will calculate the personal/family/class contribution of **CO₂** due to vehicle use.

- Estimate the distance from their home to school in miles or refer to a map of the city or local area.
- Identify their type of family vehicle based on the types listed in the table below.
- Calculate the amount of gas used weekly if they ride to and from school everyday in a private car. To do this:
 - Add up the total number of miles for 10 round trips to school (there are *2 round trips a day* since the driver generally returns home after dropping students off at school).
 - Divide the total by the miles per gallon to determine the gallons of gas burned.
 - Multiply the **CO₂** released per gallon.

Example: If you live 4 miles from school, your car travels 16 miles per day to drop you off and pick you up, or 80 miles per week. At that mileage, a full-size car will burn 5 gallons of gas per week. Five gallons of gas will produce 100 pounds of **CO₂** every week.

- Calculate the class total as if everyone rode to school in a private vehicle.
- Have students who ride the bus do the same calculations again, using the figures for the bus and dividing the total **CO₂** released by the approximate number of students that ride on the bus.
- Determine how many students walk or bike to school. They do not contribute additional **CO₂** to get to and from school.
- Now re-calculate the class total based on the type of transportation actually used by students. Compare the results. How much difference is there?

Vehicle	MPG	Pounds CO ₂ per gallon
Compact car	24	20
Full-size car	16	20
Truck/Van	13	21
Bus	8	22*

*Buses add more CO₂ per gallon, but they carry more passengers, so be sure to consider contribution by passenger, not just vehicle.

ASSESSMENT OPTIONS:

The disparity between population size and GHG emissions is large, but very difficult to address without altering the lifestyle of the highest GHG emitters, at least in the short term.

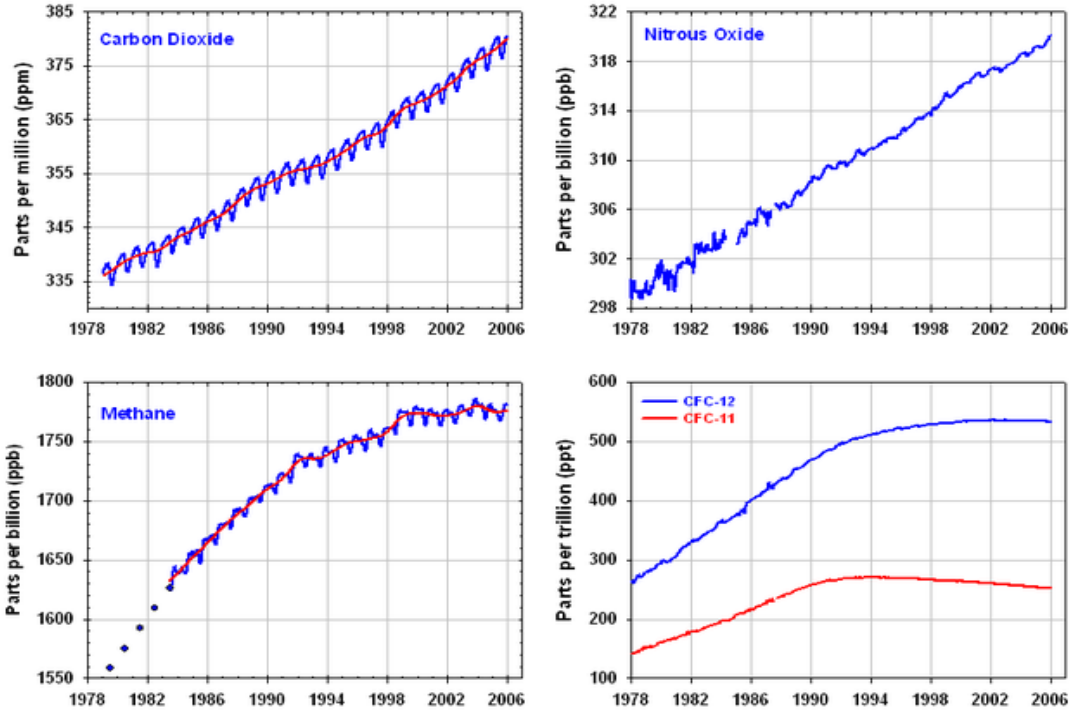
As a written/oral assignment students are to pick one source of CO₂ emissions common in the U.S. and argue in support of a 50% reduction in CO₂ emissions from that source. To do so, they must explain:

- The sources
- How they propose to achieve the reduction
- The impact of the reduction on American lifestyles and/or economy
- How the reduction might slow the build-up of GHGs

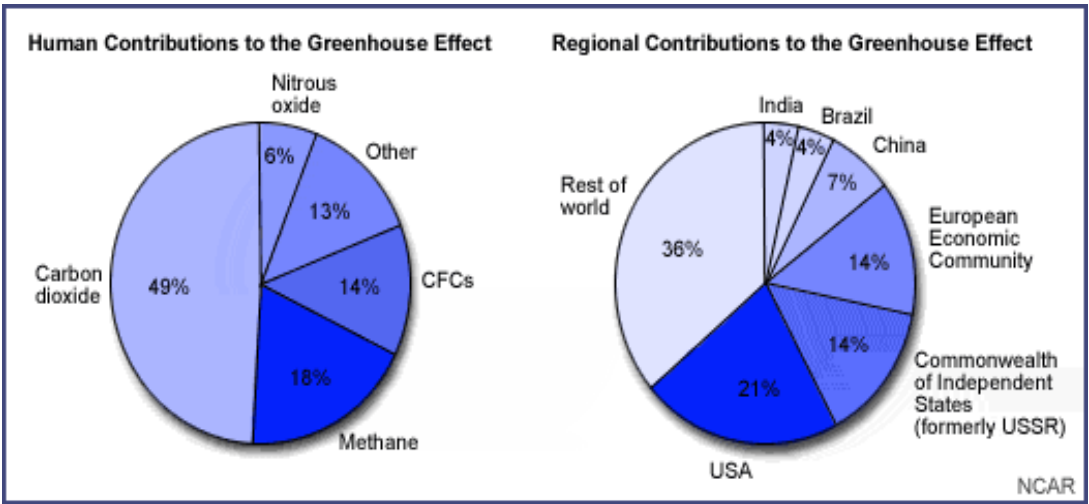
OPTIONAL: Have students imagine that they live in a developing country. Have them argue that they should be allowed to continue to increase GHG emissions as they pursue a better material standard of living for their citizens.

**** Modified with permission from *Global Climates - Past, Present, and Future*, S. Henderson, S. Holman, and L. Mortensen (Eds.), EPA Report No. EPA/600/R-93/126. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC., pp. 91 - 94.**

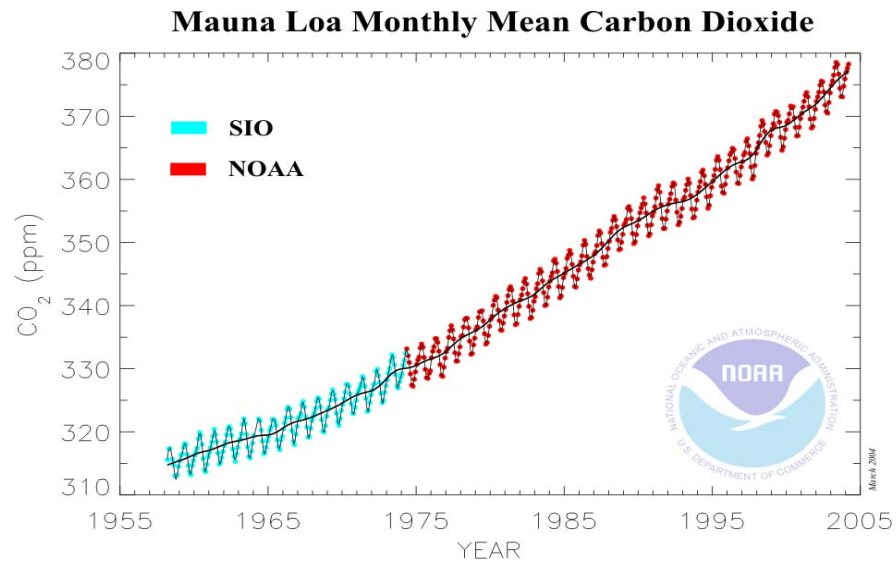
GRAPHS OF GHG EMISSIONS



GRAPH OF HUMAN/REGIONAL CONTRIBUTIONS OF GHGs



GRAPH OF CO₂ EMISSIONS/ MAUNA LOA OBSERVATORY 1958-2005



Atmospheric carbon dioxide monthly mean mixing ratios. Data prior to May 1974 are from the Scripps Institution of Oceanography (SIO, blue), data since May 1974 are from the National Oceanic and Atmospheric Administration (NOAA, red). A long-term trend curve is fitted to the monthly mean values. Principal investigators: Dr. Pieter Tans, NOAA CMDL Carbon Cycle Greenhouse Gases, Boulder, Colorado, (303) 497-6678, pieter.tans@noaa.gov, and Dr. Charles D. Keeling, SIO, La Jolla, California, (616) 534-6001, cdkeeling@ucsd.edu.

