

Our Changing Atmosphere

Explore a famous environmental data set to learn about climate change.

Graph carbon dioxide data from the National Oceanic and Atmospheric Administration (NOAA) to learn about natural cycles and unnatural changes in our atmosphere. *Note: This activity works best with multiple groups, with each group graphing a different year's data.*

Tools and Materials

- Gridded chart paper with 1-inch squares, one sheet per group—smaller graph paper can be used, but the result is less dramatic
- Meter stick (not shown)
- Marker
- 1/2-inch sticky dots (use smaller dots if you are using smaller graph paper), 12 dots per year of data; all dots should be the same color
- Tape
- [Mauna Loa monthly CO₂ data, 2008–2015](#)
- Earth globe
- **Optional:** [South Pole monthly CO₂ data, 2008–2013](#); a different color of sticky dots should be used for South Pole data, 12 dots per year of data



Assembly

Note: Preparing the graphs before doing this Snack with a group will save you time. If students are preparing graphs themselves, it is very important that they all use the same scales on their graph axes.

1. Use the meter stick and marker to draw a large x-axis and y-axis on the graph paper. You will need at least 24 squares of space along each axis.
2. Label the y-axis “Average monthly CO₂ data from Mauna Loa (in ppm)” and choose a scale that will accommodate values from 380 ppm to 404 ppm (if you are graphing data from earlier than 2008, you will need to adjust the scale accordingly), letting each 1-inch line equal 1 ppm along the y-axis.
3. Label the x-axis “Month” and place the numbers 1 through 12 along the x-axis, letting two 1-inch lines equal one month.
4. In the upper right corner, write the word “Year.” One sheet of paper will be used for each year of data you graph.
5. Print out two years’ worth of data per sheet of paper and cut into half sheets so that each group receives one year’s worth of data.

To Do and Notice

The data you are going to graph are mean monthly atmospheric CO₂ data from Mauna Loa, collected by the National Oceanic and Atmospheric Administration (NOAA). Use the globe to locate Mauna Loa. Is it in the Northern or Southern Hemisphere?

Write the Mauna Loa CO₂ values from your data sheet on the sticky dots—one monthly value per dot. Place the dots appropriately on the graph, and also label the graph with the year in which your data were collected.

What do you notice? When are the values the highest? The lowest?

Discuss this seasonal variation (see **What's Going On?** below). This is usually a very interesting discussion, and is well worth the time before continuing.

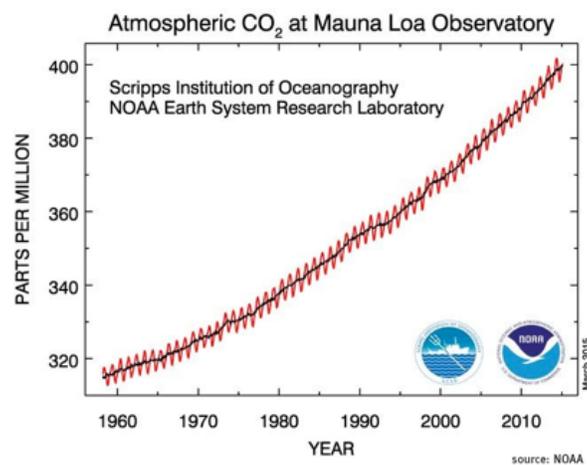
If you are also graphing South Pole data, they should be added to the same graph paper (be sure the data are from the same year) using sticky dots that are a different color. What do you notice about the seasonal fluctuation pattern of the Northern Hemisphere and in the Southern Hemisphere? Why do you think these different patterns occur in the data?

Tape all of the graphs together in chronological order, overlapping the “month 0” and “month 12” to create a continuous graph of multiple years’ data. What do you notice?

What's Going On?

Direct measurements of atmospheric carbon dioxide (CO_2) concentrations have been recorded at Mauna Loa since 1958. Its mid-Pacific location makes it an ideal place to collect atmospheric data. The units of atmospheric carbon dioxide measurements are ppm—parts per million. For every million molecules of air in our atmosphere, some number of them are carbon dioxide molecules.

Since 1958, the concentration of atmospheric CO_2 has risen from 315 ppm to over 403 ppm (as of March, 2016). This is depicted in the graph shown below, known as the Keeling Curve (click to enlarge). The Keeling Curve is named for Charles David Keeling of the Scripps Institution of Oceanography, who was the first person to make frequent regular measurements of atmospheric CO_2 concentrations at Mauna Loa.



The periodic annual fluctuations in the graph reflect seasonal changes. The Northern Hemisphere has far more land area than the Southern Hemisphere, and most of the land area in the Southern Hemisphere is desert. As plants in the Northern Hemisphere grow leaves each spring and summer, they remove some CO_2 from the air via photosynthesis, causing CO_2 levels to drop. There is a lag time for this effect to show in the data, so the lowest annual CO_2 concentrations occur in the fall. During Northern Hemisphere fall and winter, plants

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lose their leaves, and the decrease in photosynthesis causes the CO₂ level to rise. There is a lag time for this change to show in the data as well. Thus, highest CO₂ concentrations occur in May each year. This seasonal fluctuation is the natural cycling of carbon from an atmospheric gas to solid plant material and back.

When you view multiple years of data together, the obvious upward trend is not part of the natural cycling of carbon between the atmosphere and the biosphere. Human activities are altering the carbon cycle—both by adding more CO₂ to the atmosphere and, through land use changes such as deforestation, influencing the ability of natural sinks, like forests, to remove CO₂ from the atmosphere.

While CO₂ emissions come from a variety of natural sources, human-related emissions are responsible for the increase that has occurred in the atmosphere since the Industrial Revolution (1760–1840). Until that time, atmospheric CO₂ had not been higher than 280 ppm. Direct measurements of gas bubbles in ice cores from Antarctica show that atmospheric CO₂ levels did not exceed 280 ppm during the previous 800,000 years.

The main human activity that emits CO₂ is the combustion of fossil fuels (coal, natural gas, and oil) for energy and transportation, although certain industrial processes and land-use changes also emit CO₂.

Teaching Tips

Preparing the graphs before doing this Snack with a group will save you time.

Resources

We've included data from 2008–2015 in **Tools and Materials**, but if you want to get data for other years, they are available at the websites below. Export the text file for the years in which you are interested, put them into a spreadsheet, and eliminate the columns of data you don't need.

- Mauna Loa CO₂ Data: ftp.cmdl.noaa.gov/products/trends/co2/co2_mm_mlo.txt
- South Pole CO₂ Data: ftp.cmdl.noaa.gov/data/trace_gases/co2/in-situ/surface/spo/co2_spo_surface-insitu_1_ccgg_MonthlyData.txt
- Suro Tower Data, San Francisco: <http://www.esrl.noaa.gov/gmd/dv/iadv/graph.php?code=STR&program=ccgg&type=ts>
- Keeling Curve: <http://www.esrl.noaa.gov/gmd/ccgg/trends/>
- CO₂ Emissions: <http://www.epa.gov/climatechange/ghgemissions/gases/co2.html>