CARBON DIOXIDE TRENDS

Adapted from Facing the Future, www.facingthefuture.org

Overview: Students graph data to examine seasonal and long-term atmospheric carbon dioxide trends over the past 45 years and then predict future carbon dioxide emissions.

Objectives: Students will…

- Identify processes that contribute to CO_2 emissions
- Graph CO_2 emissions
- Assess the relationship between atmospheric carbon dioxide and global surface temperatures
- Brainstorm ways to reduce CO_2 emissions

Subject: Science, Math

Suggested Grade Level: 9 – 12

Materials:

- Graph paper or a graphing program such as Microsoft Excel
- Handout: CO_2 Dataset, 1 per student pair
- Overhead: long-term carbon dioxide and temperature trends

INTRODUCTION

- Ask students to recall which gases are involved in the greenhouse effect (water vapor, carbon dioxide, methane, and nitrous oxide, along with manmade gases). Tell students that today they'll be exploring historical trends in carbon dioxide emissions. Explain that CO_2 is an important greenhouse gas that has been linked to many human activities.
- Ask students if they can name some activities (human or otherwise) that might add CO_2 to our atmosphere – burning fossil fuels, cutting tress, burning wood, volcanoes, all release CO_2).

PROCEDURE

- Divide the class into pairs
- Give each pair 1 sheet of graph paper and 1 CO_2 data set (source: http://cdiac.ornl.gov/trends/co2/sio-mlo.htm)
- Have students graph the data (year should be on the X axis and CO_2 emissions on the y-axis. The scale should be appropriate for the data.) Students can use a computer graphing program as an alternative to graphing by hand.
- Ask students to predict an average CO_2 concentration for the year 2020 and put a star on their graph to represent that number on the graph.
- Reconvene the class to view and discuss the graphs from the Woods Hole Research Center on historical temperature and CO_2 trends. Ask students to explain what they see in these graphs. Where is the yearly CO_2 data shown in these graphs? When does the most recent warming trend begin?
- Bring the class together for a discussion using the following reflection questions.

REFLECTION

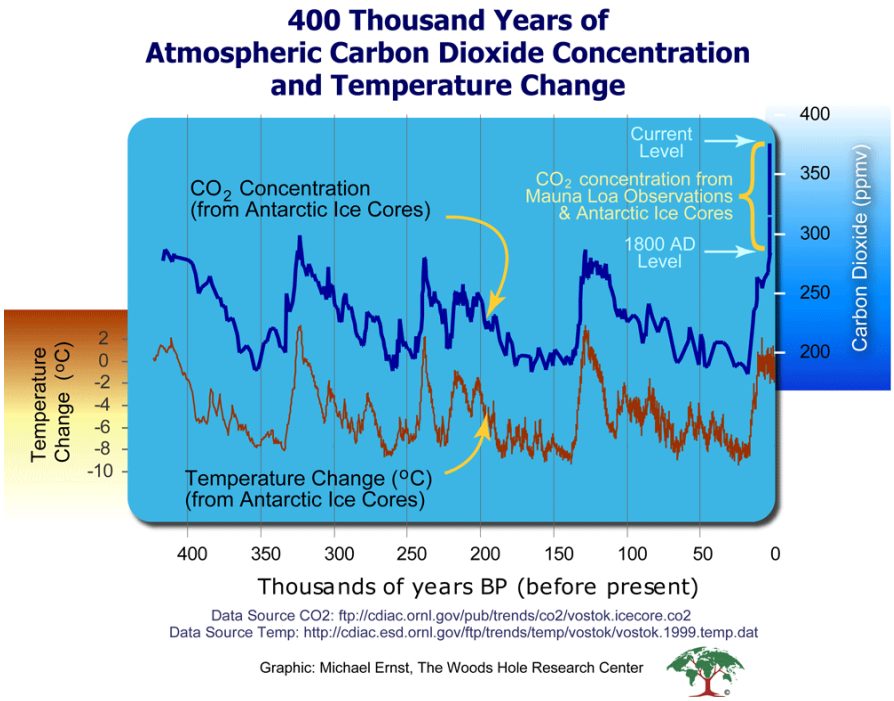
- What might account for differences in the CO_2 concentrations measured in May and October of each year?
    - A: Lower values represent increased CO_2 uptake during the summer when plants are photosynthesizing more; high values represent decreased photosynthesis during the winter.)
- How could we take advantage of those natural periods of increased CO_2 uptake to reduce overall CO_2 in our atmosphere?
- Based on the data shown on your graph, what do you think the CO_2 concentration will be in the year 2020?
- Why do you think carbon dioxide levels have continued to rise during the past 45 years?
- What types of activities might raise carbon dioxide levels even faster?
- How do you think this will affect Earth's climate? Predict how your life will be different if this climate change occurs.
- What types of actions can we take to lower our CO_2 emissions?

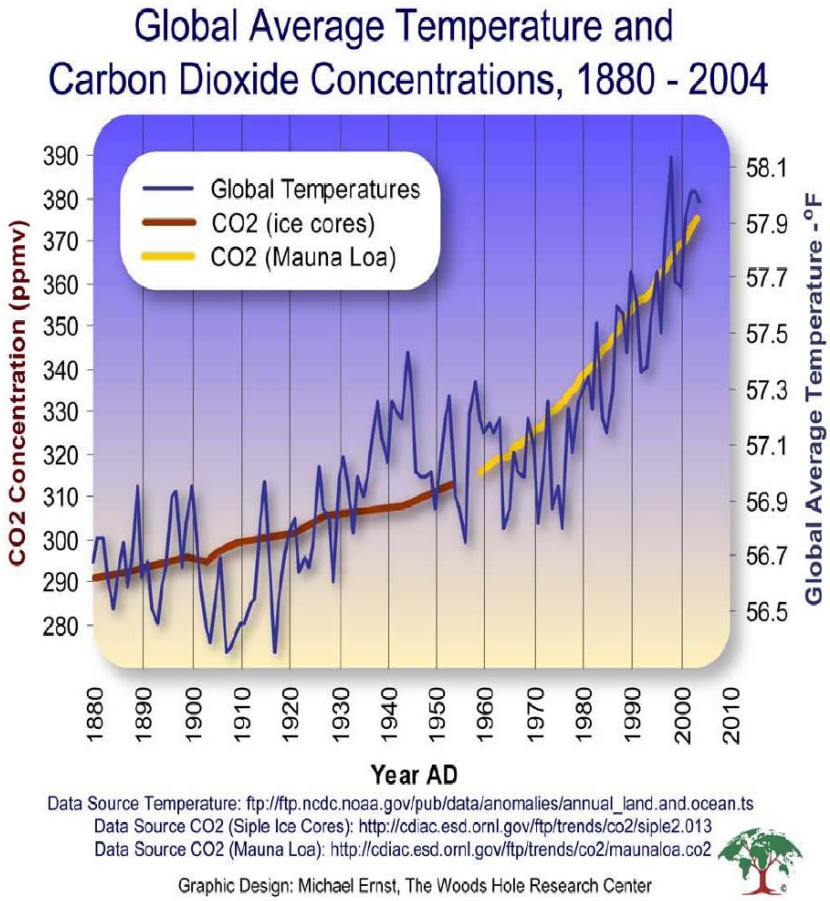
CARBON DIOXIDE DATASET

Mauna Loa, Hawaii: These measurements constitute the longest, continuous record of atmospheric CO_2 concentrations available in the world.

YEAR	May CO_2 (parts per million)	October CO_2 (parts per million)
1958	317.5	--
1959	381.3	313.3
1960	320.0	313.8
1961	320.6	315.3
1962	321.0	315.4
1963	322.2	316.0
1964	322.2	316.9
1965	322.2	317.3
1966	324.1	318.1
1967	325	319.4
1968	325.6	320.3
1969	327.4	321.8
1970	328.1	323.1
1971	328.9	323.6
1972	330.1	325.2
1973	332.5	327.2
1974	333.1	327.4
1975	334.0	328.3
1976	334.9	328.9
1977	336.7	331.2
1978	338.0	332.5
1979	339.5	333.9
1980	341.5	336.0
1981	342.9	336.9
1982	344.1	337.9
1983	345.8	340.0
1984	347.4	341.4
1985	348.9	342.8
1986	350.2	344.2
1987	351.8	346.4
1988	354.2	348.9
1989	355.7	350.0
1990	357.2	351.2
1991	359.3	352.2
1992	359.7	353.3
1993	360.3	354.0
1994	361.7	356.0
1995	363.8	357.8
1996	365.4	359.6
1997	366.8	360.8
1998	369.3	364.2
1999	371.0	365.1
2000	371.8	366.7
2001	374.0	368.1
2002	375.6	370.2
2003	378.4	376.0
2004	380.6	374.2
YEAR	May CO_2	October CO_2

	(parts per million)	(parts per million)
1958	317.5	--
1959	381.3	313.3
1960	320.0	313.8
1961	320.6	315.3
1962	321.0	315.4
1963	322.2	316.0
1964	322.2	316.9
1965	322.2	317.3
1966	324.1	318.1
1967	325	319.4
1968	325.6	320.3
1969	327.4	321.8
1970	328.1	323.1
1971	328.9	323.6
1972	330.1	325.2
1973	332.5	327.2
1974	333.1	327.4
1975	334.0	328.3
1976	334.9	328.9
1977	336.7	331.2
1978	338.0	332.5
1979	339.5	333.9
1980	341.5	336.0
1981	342.9	336.9
1982	344.1	337.9
1983	345.8	340.0
1984	347.4	341.4
1985	348.9	342.8
1986	350.2	344.2
1987	351.8	346.4
1988	354.2	348.9
1989	355.7	350.0
1990	357.2	351.2
1991	359.3	352.2
1992	359.7	353.3
1993	360.3	354.0
1994	361.7	356.0
1995	363.8	357.8
1996	365.4	359.6
1997	366.8	360.8
1998	369.3	364.2
1999	371.0	365.1
2000	371.8	366.7
2001	374.0	368.1
2002	375.6	370.2
2003	378.4	376.0
2004	380.6	374.2


400 Thousand Years of
Atmospheric Carbon Dioxide Concentration
and Temperature Change
Current Level
CO2 concentration from Mauna Loa Observations & Antarctic Ice Cores
1800 AD Level
CO2 Concentration (from Antarctic Ice Cores)
Temperature Change (°C) (from Antarctic Ice Cores)
Temperature Change (°C)
Carbon Dioxide (ppmv)
400
350
300
250
200
2
0
-2
-4
-6
-8
-10
400 350 300 250 200 150 100 50 0
Thousands of years BP (before present)
Data Source CO2: ftp://cdiac.ornl.gov/pub/trends/co2/vostok.icecore.co2
Data Source Temp: http://cdiac.esd.ornl.gov/ftp/trends/temp/vostok/vostok.1999.temp.dat
Graphic: Michael Ernst, The Woods Hole Research Center


Global Average Temperature and
Carbon Dioxide Concentrations, 1880 - 2004
Global Temperatures
CO2 (ice cores)
CO2 (Mauna Loa)
CO2 Concentration (ppmv)
Global Average Temperature - °F
390
380
370
360
350
340
330
320
310
300
290
280
58.1
57.9
57.7
57.5
57.3
57.1
56.9
56.7
56.5
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010
Year AD
Data Source Temperature: ftp://ftp.ncdc.noaa.gov/pub/data/anomalies/annual_land.and.ocean.ts
Data Source CO2 (Siple Ice Cores): http://cdiac.esd.ornl.gov/ftp/trends/co2/siple2.013
Data Source CO2 (Mauna Loa): http://cdiac.esd.ornl.gov/ftp/trends/co2/maunaloa.co2
Graphic Design: Michael Ernst, The Woods Hole Research Center