

GLOBAL CHANGE TEACHER INSTITUTE INVESTIGATION

Atmospheric Carbon Dioxide Concentration, Human Activity and Greenhouse Effect.

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Scientists have determined the concentration of CO₂ in the atmosphere from past times by the analysis of ice cores extracted from Antarctica and Greenland. Now, scientists determine the concentration of CO₂ directly from the air. The data from Mauna Loa station in Hawaii has the longest and most continuous recent direct-records of CO₂ in the atmosphere available in the world.

CO₂ is a greenhouse gas that absorbs infrared radiation (heat). Some human activities (i.e. motorized vehicles, electric power plants, heating and air conditioning) are increasing the burning of fossil fuels which contribute to the increase of carbon dioxide concentration in the atmosphere and the enhancement of the greenhouse effect.

PROJECT DESIGN

Question:

Why and how is the CO₂ concentration changing in the atmosphere? Is this change enhancing the greenhouse effect?

Hypothesis:

The concentration of CO₂ in the atmosphere has been increasing in recent times because human activities that burn fossil fuels in the world are also increasing. These emissions are increasing the concentration of CO₂ in the air and enhancing the greenhouse effect.

Study design to test hypothesis:

- Basic knowledge will be given to students regarding the following topics: Atmospheric composition, Greenhouse gases and their effects, Carbon Cycle, Human sources of carbon dioxide.
- Students will gather data from the Internet on the concentration of CO₂ in the atmosphere measured both indirectly from ice cores and directly from the air to represent the CO₂ concentration in the past and recent times.
- Students will create graphs of atmospheric CO₂ concentration both from past and recent times.
- Students will gather data on the world population and the Earth's average temperature.
- Students will analyze and relate the CO₂, world population, and temperature graphs.
- Students will draw relevant conclusions on human activity, atmospheric CO₂ concentration, and the greenhouse effect.

Lesson Objectives

After this lesson students will be able to:

1. Describe composition of air and the greenhouse gases, and their effects.
2. Distinguish between data measured indirectly and directly.
3. Create graphs from tables to make interpretation easier.

4. Compare changes in the concentration of CO₂ in the atmosphere with the increasing world population and changes in the air temperature and the greenhouse effect.

SOURCES

Carbon Cycle

http://www.windows.ucar.edu/tour/link=/earth/Water/co2_cycle.html&edu=high

Greenhouse Effect and greenhouse gases

http://www.windows.ucar.edu/tour/link=/earth/interior/greenhouse_effect.html&edu=high

CO₂ Concentration in the atmosphere at Mauna Loa, Hawaii

<http://cdiac.esd.ornl.gov/ftp/trends/co2/maunaloa.co2>

CO₂ Concentration in the ice cores at Siple, Antarctica

<http://cdiac.esd.ornl.gov/ftp/trends/co2/siple2.013>

Average air temperature in the world

http://www.grida.no/climate/ipcc_tar/slides/05.16.htm

World Population

http://en.wikipedia.org/wiki/World_population

Sneider, Cary, Richard Golden, and Florence Gaylin (2002). Climate Change. Global Systems Science. Lawrence Hall of Science. University of California, Berkeley.

Henderson, Sandra, Steven Holman, and Lynn Mortensen (1993). Global Climates-Past, Present, and Future. Activities for Integrated Science Education. EPA, United States Environmental Protection Agency.

DATA COLLECTION

1. Table 1, Atmospheric CO₂ concentration from Siple, Antarctica (1744 to 1953).
2. Table 2, Atmospheric CO₂ concentration from Mauna Loa, Hawaii (1959 to 2004).
3. Graph 1, Atmospheric CO₂ concentration graph from Siple (1744 to 1953).
4. Graph 2, Atmospheric CO₂ concentration graph from Mauna Loa (1959 to 2004).
5. Graph 3, World Population.
6. Graph 4, Variation of the Earth's surface temperature.

DATA ANALYSIS AND CONCLUSIONS

7. Students will create Graph 1, Atmospheric CO₂ concentration graph from Siple (1744 to 1953).
8. Students will create Graph 2, Atmospheric CO₂ concentration graph from Mauna Loa (1959 to 2004).
9. Students will compare the atmospheric CO₂ concentrations with the world population.
10. Students will analyze and compare the atmospheric CO₂ concentrations with the average air temperature.
11. Students will draw relevant conclusions regarding the changes on CO₂ concentrations caused by the increasing human-caused emissions of fossil fuels into the air, and their relation with the greenhouse effect.

Name: _____

**Activity: Atmospheric Carbon Dioxide Concentration,
Human Activity and Greenhouse Effect.**

Student Response sheet

Time: 2 hours

Question:

Why and to what extent is the carbon dioxide content changing in the atmosphere? Is this change enhancing the greenhouse effect?

Hypothesis:

Materials:

1. Table 1, Atmospheric CO₂ concentration from Siple, Antarctica (1744 to 1953).
2. Table 2, Atmospheric CO₂ concentration from Mauna Loa (1959 to 2004).
3. Graph 1, Atmospheric CO₂ concentration from Siple, Antarctica (1744 to 1953).
4. Graph 2, Atmospheric CO₂ concentration from Mauna Loa (1959 to 2002).
5. Graph 3, World Population.
6. Graph 4, Variation of the Earth's surface temperature.

Procedure:

1. Looking at Table 1 makes you realize that it is difficult to interpret the data. Having the data in a graph rather than a table would enable you to see changes over time, certain patterns, and unusual variations. Create a line-graph (Graph 1) with the data on Table 1. Analyze this graph and answer the following questions:
 - a) What pattern is shown in the graph? _____

 - b) What was the total CO₂ increase in ppm from the period of 1744 to 1953? _____
By what percentage has the CO₂ increased in that period of time? _____
What is the annual percentage? _____

2. Analyze Table 2, CO₂ from Mauna Loa that contains the monthly data records from 1959 to 2004. Answer the following questions:
 - a) During which months does the concentration of carbon dioxide seem to increase?

 - b) During which months does the concentration of carbon dioxide seem to decrease?

 - c) During which months would you expect plants to grow? _____ Would they absorb or release carbon dioxide? _____

d) During which months would you expect leaves to fall and annual plants to die?
 _____ Would they absorb or release carbon dioxide? _____

3. Create a line-graph (Graph 2) including only the months of February and August from Mauna Loa for 1959 to 2004. Analyze this graph and answer the following questions:

a) What pattern is shown in the graph? _____

b) What was the total CO₂ increase in ppm from the period of 1959 to 2004?
 _____ By what percentage has the CO₂ increased in that period of time?
 _____ What is the annual percentage? _____

c) Seasonally, how does the CO₂ content change in Mauna Loa (February to August)?

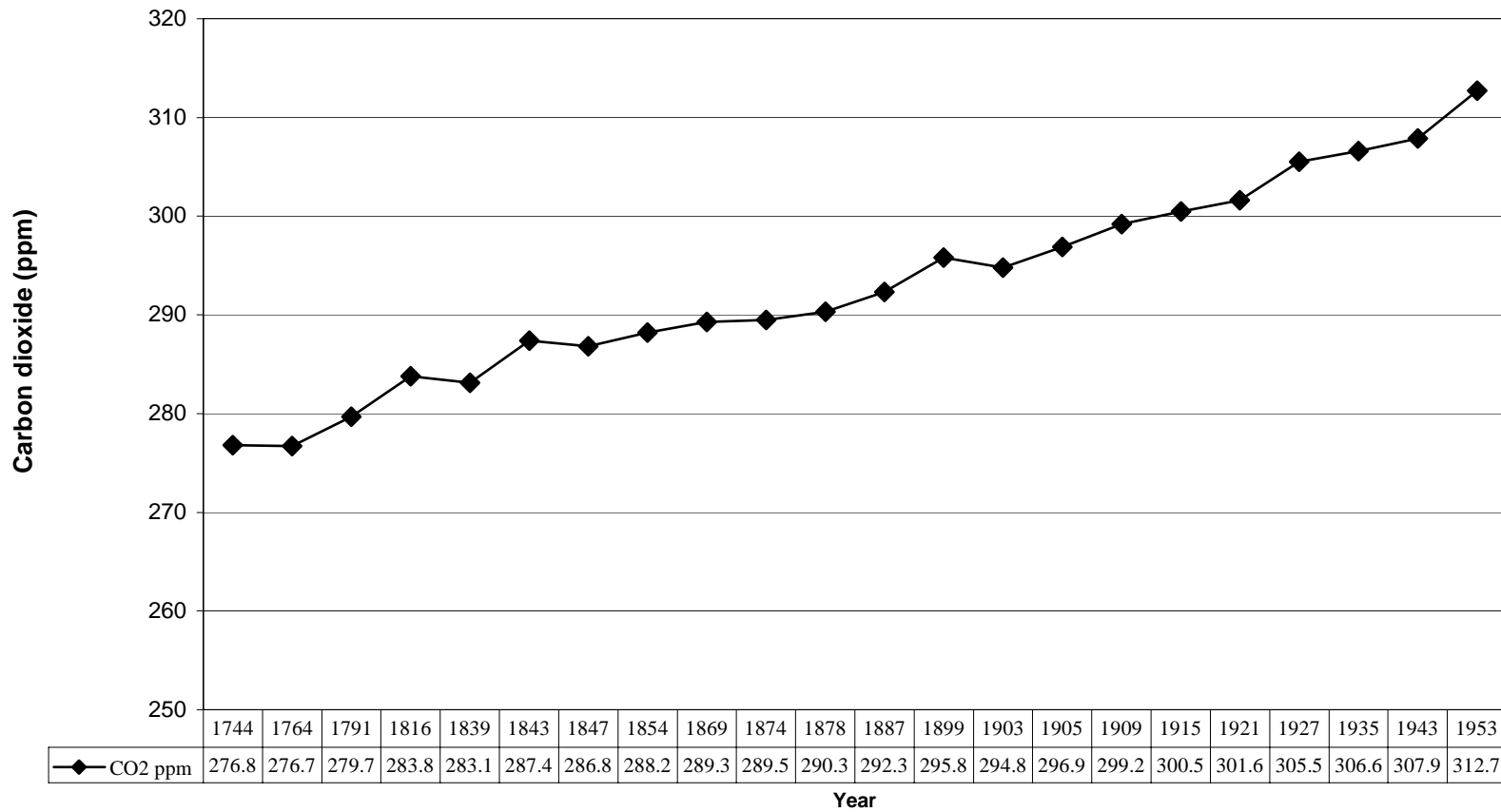
d) Does the data support a relation between plant growth cycles and atmospheric concentration of carbon dioxide? _____ Explain yourself _____

Table 1. Historical CO₂ Record from the Siple Station Ice Core

Year	CO ₂ gas concentration (ppmv)
1744	276.8
1764	276.7
1791	276.7
1816	279.7
1839	283.8
1843	287.4
1847	286.8
1854	288.3
1869	289.3
1874	289.5
1878	290.3
1887	292.3
1899	295.8
1903	294.8
1905	296.9
1909	299.2
1915	300.5
1921	301.6
1927	305.5
1935	306.6
1943	307.9
1953	312.7

Source: <http://cdiac.esd.ornl.gov/ftp/trends/co2/siple2.013>

**Graph 1. Atmospheric Carbon Dioxide Concentration.
Siple Station , Antarctica
(Ice cores), 1744-1953.**



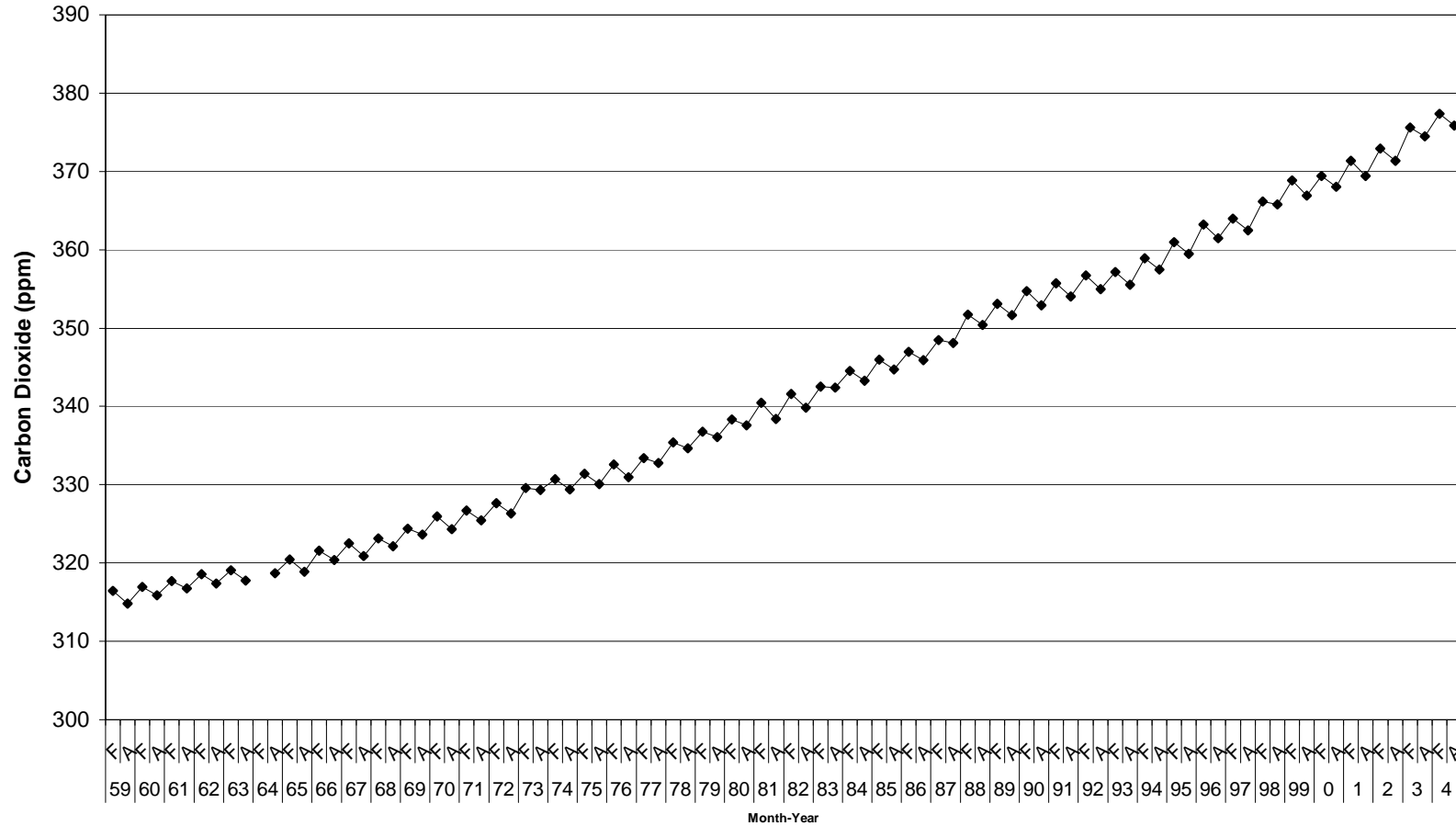
**Table 2. Atmospheric Carbon Dioxide Concentration
Mauna Loa Station (1959-2004).**

Source: <http://cdiac.esd.ornl.gov/ftp/trends/co2/maunaloa.co2>

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1958	-99.99	-99.99	315.71	317.45	317.5	-99.99	315.86	314.93	313.19	-99.99	313.34	314.67	-99.99
1959	315.58	316.47	316.65	317.71	318.29	318.16	316.55	314.8	313.84	313.34	314.81	315.59	315.98
1960	316.43	316.97	317.58	319.03	320.03	319.59	318.18	315.91	314.16	313.83	315	316.19	316.91
1961	316.89	317.7	318.54	319.48	320.58	319.78	318.58	316.79	314.99	315.31	316.1	317.01	317.65
1962	317.94	318.56	319.69	320.58	321.01	320.61	319.61	317.4	316.26	315.42	316.69	317.69	318.45
1963	318.74	319.08	319.86	321.39	322.24	321.47	319.74	317.77	316.21	315.99	317.07	318.36	318.99
1964	319.57	-99.99	-99.99	-99.99	322.23	321.89	320.44	318.7	316.7	316.87	317.68	318.71	-99.99
1965	319.44	320.44	320.89	322.13	322.16	321.87	321.21	318.87	317.81	317.3	318.87	319.42	320.03
1966	320.62	321.59	322.39	323.7	324.07	323.75	322.4	320.37	318.64	318.1	319.79	321.03	321.37
1967	322.33	322.5	323.04	324.42	325	324.09	322.55	320.92	319.26	319.39	320.72	321.96	322.18
1968	322.57	323.15	323.89	325.02	325.57	325.36	324.14	322.11	320.33	320.25	321.32	322.9	323.05
1969	324	324.42	325.64	326.66	327.38	326.7	325.89	323.67	322.38	321.78	322.85	324.12	324.62
1970	325.06	325.98	326.93	328.13	328.07	327.66	326.35	324.69	323.1	323.07	324.01	325.13	325.68
1971	326.17	326.68	327.18	327.78	328.92	328.57	327.37	325.43	323.36	323.56	324.8	326.01	326.32
1972	326.77	327.63	327.75	329.72	330.07	329.09	328.05	326.32	324.84	325.2	326.5	327.55	327.46
1973	328.54	329.56	330.3	331.5	332.48	332.07	330.87	329.31	327.51	327.18	328.16	328.64	329.68
1974	329.35	330.71	331.48	332.65	333.09	332.25	331.18	329.4	327.44	327.37	328.46	329.58	330.25
1975	330.4	331.41	332.04	333.31	333.96	333.59	331.91	330.06	328.56	328.34	329.49	330.76	331.15
1976	331.74	332.56	333.5	334.58	334.87	334.34	333.05	330.94	329.3	328.94	330.31	331.68	332.15
1977	332.92	333.42	334.7	336.07	336.74	336.27	334.93	332.75	331.58	331.16	332.4	333.85	333.9
1978	334.97	335.39	336.64	337.76	338.01	337.89	336.54	334.68	332.76	332.54	333.92	334.95	335.5
1979	336.23	336.76	337.96	338.89	339.47	339.29	337.73	336.09	333.91	333.86	335.29	336.73	336.85
1980	338.01	338.36	340.08	340.77	341.46	341.17	339.56	337.6	335.88	336.01	337.1	338.21	338.69
1981	339.23	340.47	341.38	342.51	342.91	342.25	340.49	338.43	336.69	336.85	338.36	339.61	339.93
1982	340.75	341.61	342.7	343.56	344.13	343.35	342.06	339.82	337.97	337.86	339.26	340.49	341.13
1983	341.37	342.52	343.1	344.94	345.75	345.32	343.99	342.39	339.86	339.99	341.16	342.99	342.78
1984	343.7	344.51	345.28	347.08	347.43	346.79	345.4	343.28	341.07	341.35	342.98	344.22	344.42
1985	344.97	346	347.43	348.35	348.93	348.25	346.56	344.69	343.09	342.8	344.24	345.56	345.9
1986	346.29	346.96	347.86	349.55	350.21	349.54	347.94	345.91	344.86	344.17	345.66	346.9	347.15

1987	348.02	348.47	349.42	350.99	351.84	351.25	349.52	348.1	346.44	346.36	347.81	348.96	348.93
1988	350.43	351.72	352.22	353.59	354.22	353.79	352.39	350.44	348.72	348.88	350.07	351.34	351.48
1989	352.76	353.07	353.68	355.42	355.67	355.13	353.9	351.67	349.8	349.99	351.3	352.53	352.91
1990	353.66	354.7	355.39	356.2	357.16	356.22	354.82	352.91	350.96	351.18	352.83	354.21	354.19
1991	354.72	355.75	357.16	358.6	359.34	358.24	356.17	354.03	352.16	352.21	353.75	354.99	355.59
1992	355.98	356.72	357.81	359.15	359.66	359.25	357.03	355	353.01	353.31	354.16	355.4	356.37
1993	356.7	357.16	358.38	359.46	360.28	359.6	357.57	355.52	353.7	353.98	355.33	356.8	357.04
1994	358.36	358.91	359.97	361.26	361.68	360.95	359.55	357.49	355.84	355.99	357.58	359.04	358.88
1995	359.96	361	361.64	363.45	363.79	363.26	361.9	359.46	358.06	357.75	359.56	360.7	360.88
1996	362.05	363.25	364.03	364.72	365.41	364.97	363.65	361.49	359.46	359.6	360.76	362.33	362.64
1997	363.18	364	364.57	366.35	366.79	365.62	364.47	362.51	360.19	360.77	362.43	364.28	363.76
1998	365.32	366.15	367.31	368.61	369.29	368.87	367.64	365.77	363.9	364.23	365.46	366.97	366.63
1999	368.15	368.87	369.59	371.14	371	370.35	369.27	366.94	364.63	365.12	366.67	368.01	368.31
2000	369.14	369.46	370.52	371.66	371.82	371.7	370.12	368.12	366.62	366.73	368.29	369.53	369.48
2001	370.28	371.5	372.12	372.87	374.02	373.3	371.62	369.55	367.96	368.09	369.68	371.24	371.02
2002	372.43	373.09	373.52	374.86	375.55	375.41	374.02	371.49	370.71	370.24	372.08	373.78	373.1
2003	374.68	375.63	376.11	377.65	378.35	378.13	376.62	372.99	373.00	374.35	375.70	375.64	375.61
2004	376.79	377.37	378.41	380.52	380.63	379.57	377.79	375.86	374.24	375.86	377.48	377.38	377.43

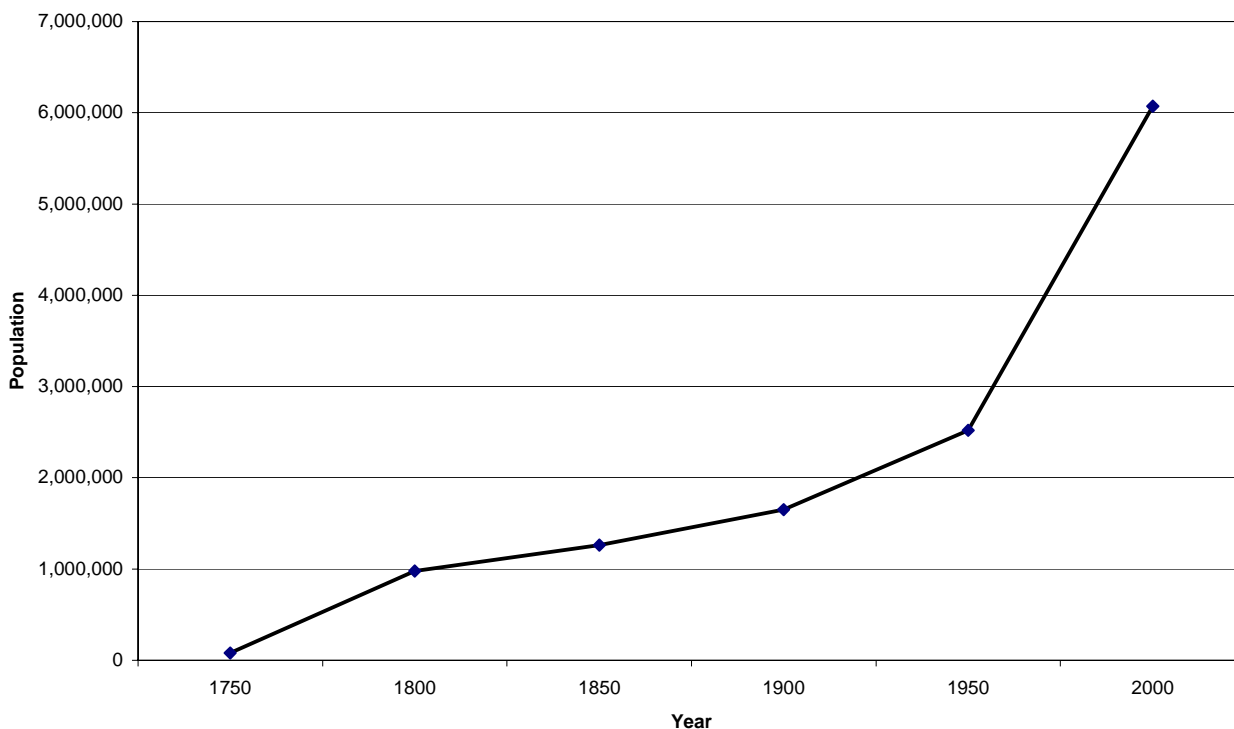
Graph 2. Atmospheric Carbon Dioxide Concentration Mauna Loa Station (1959-2004).



Graph 3.

World Population

Source: http://en.wikipedia.org/wiki/World_population



4. Analyze Graph 3 and answer the following questions:

- What was the total population increase from the period of 1750 to 1950?
_____ By what percentage did the population increased in that period of time? _____
- What was the total population increase from the period of 1950 to 2000?
_____ By what percentage did the population increased in that period of time? _____
- Is there any relation between the increase in the concentration of CO₂ in the air and the increase of the world population? _____
Explain yourself _____

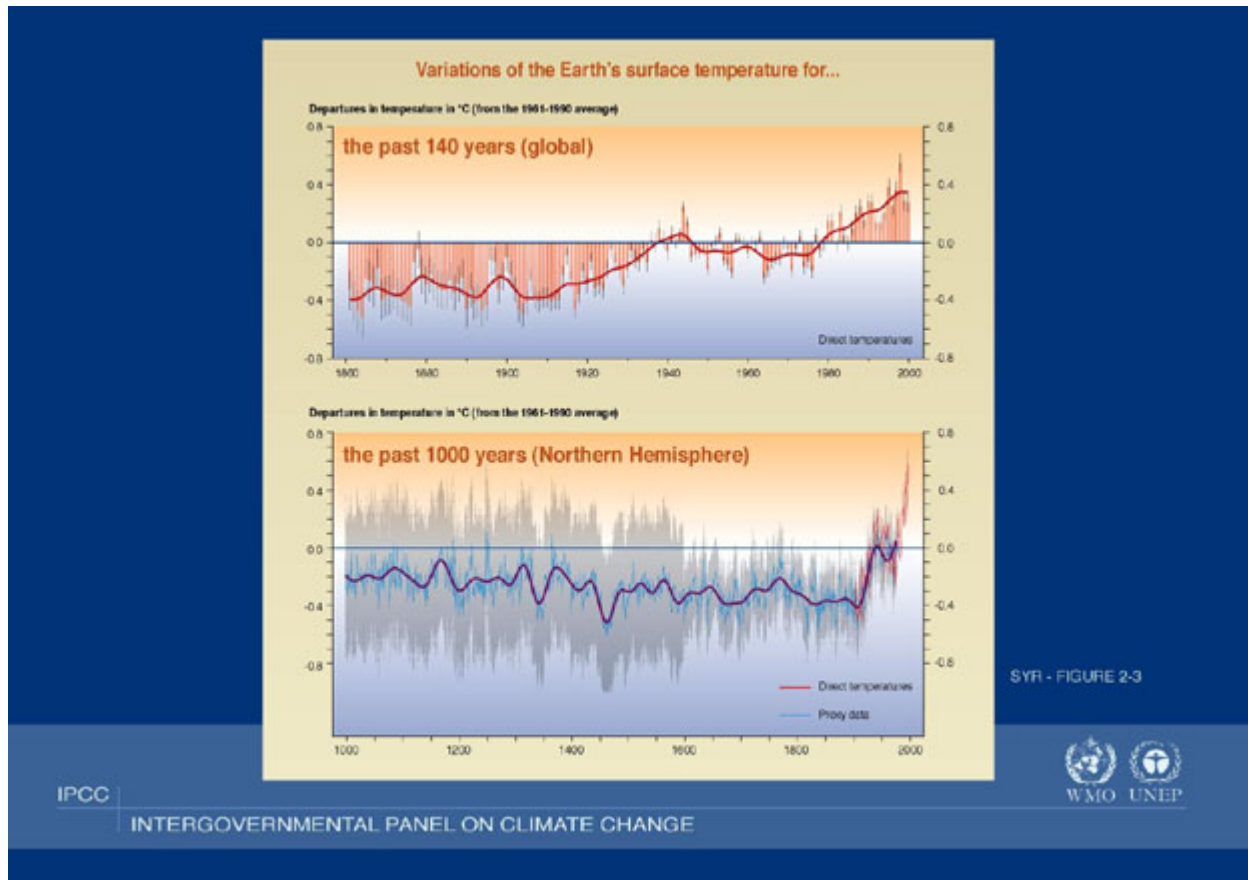
5. Analyze Graph 4 (upper graph) and answer the following questions:

- What is the general pattern shown in the upper graph? _____

- What was the total increase in temperature from the period of 1940 to 2004?

- c) Is there any relation between the increase in temperature and the increase in CO₂ concentration in the air? _____
6. Do you think that the enhancement of the greenhouse effect is a global problem? _____ Explain your answer _____
7. What measures could be taken to reduce the CO₂ concentration in the atmosphere? _____

Graph 4. Variations of the Earth’s surface temperature.



Source: http://www.grida.no/climate/ipcc_tar/slides/05.16.htm