MAT-4172-2

Data Collection in Fundamental Context

LEARNING AND EVALUATION SITUATION

THE CHALLENGE OF OUR TIME

Student Booklet

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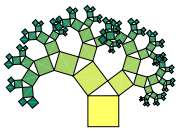

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0. PROBLEM SITUATION

At the recent American presidential campaign, candidates expressed their views on the issue of climate change. Some of the speeches were in opposition to what is currently being taught in high school. Indeed, we teach students that climate change is not due to issues such as ozone depletion or degrading air quality, but to Global Warming. According to teachers, this is the Challenge of Our Time because it directly affects the continuity of human civilizations on Earth.

The new American President is against measures limiting climate changes. He doesn't not consider it a national security issue. In fact, many people believe that climate change is a natural phenomenon independent from any human intervention. Nonetheless, it is a controversial position for a politician.

According to physics books, atmospheric CO_2 concentrations (carbon dioxide) determines global temperature fluctuations on Earth, as it's a greenhouse gas. The greenhouse effect is a well-known phenomenon. Maintaining balance is essential to life. For example, in the summer, a car parked in the sun will quickly heat up to the point of suffocation if you don't open a window. However, according to the scientific community, atmospheric CO_2 concentrations may have increased quickly and significantly on Earth due to massive use of fossil fuels (oil, natural gas and coal) in humankind's industrial practices.

This is the question you must answer: « **Is it possible to determine if the President is correct in his perspective of the issue?** ». Bear in mind that the scientific community supports the theory that an increase of 2° Celsius in the Earth's temperature would have alarming and irreversible consequences on the biosphere. Analyze the data provided in the following pages to have a clear understanding of the issue which, if it's real despite how American politics are portraying it through the media, may compromise your children and grand-children's future[1].

[1] Your work will help the teacher determine if you have mastered the concepts in the course. Reminders of key concepts can be found on page 21, as well as web-based resources. Throughout this assessment, you may use your class notes.

1. TASK 1: DATA COLLECTION AND ANALYSIS

The first thing to do is to find scientific data that will help you determine whether atmospheric CO_2 concentrations have increased considerably in a short period of time. Where do you think you could easily find this type of information, that is, scientific data?

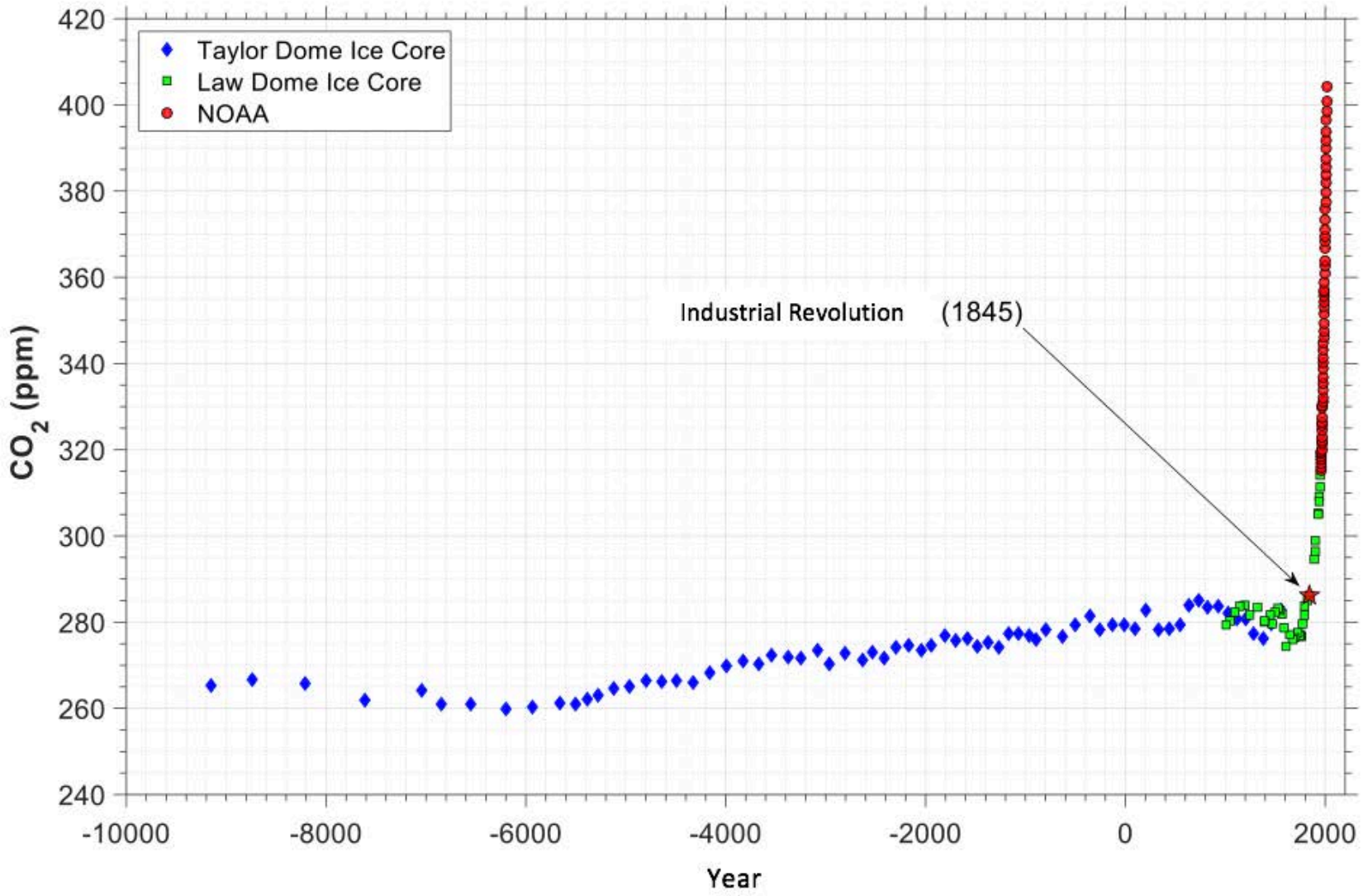
How can you ensure the data bases you find will be reliable?

1.1 FIRST DATA ANALYSIS

The following graph (Figure 1) depicts three databases showing atmospheric CO_2 concentrations (in parts per million or ppm) over time. The current state of scientific knowledge lets us see the atmospheric CO_2 concentrations for the last 12,000 years! Notice a significant increase in 1845. This date marks the start of industrialization age. Can you approximate a correlation between the preindustrial age date and atmospheric CO_2 concentrations?

Approximate a correlation between the preindustrial age date and atmospheric CO_2 concentrations on the following page.

Figure 1 – Atmospheric CO_2 Concentrations of the past 12,000 years



1.2 SECOND DATA ANALYSIS

This is the first database shown in the previous graph (Table 1). It shows the CO_2 concentration in air bubbles which were dated using ice cores drilled in Antarctica.

Table 1 – CO_2 Concentrations by year (*Taylor Dome Ice Core*)

YEAR	CO_2 (PPM)	YEAR	CO_2 (PPM)
1560	282.9	-2040	273.4
1464	279.7	-2171	274.6
1377	276.1	-2293	274.1
1280	277.4	-2418	271.6
1208	280.7	-2534	273.1
1120	280.8	-2633	271.2
1026	282.2	-2807	272.9
930	283.6	-2959	270.2
825	283.5	-3081	273.5
730	285	-3243	271.6
631	284	-3377	271.9
544	279.4	-3538	272.4
437	278.4	-3670	270.4
330	278.3	-3824	270.9
205	282.9	-3994	269.9
97	278.5	-4158	268.3
-15	279.4	-4323	266
-134	279.4	-4490	266.5
-253	278.2	-4636	266.2
-352	281.4	-4798	266.4
-503	279.4	-4964	265.1
-631	276.7	-5120	264.6
-792	278.2	-5280	263
-891	275.9	-5390	262.1
-962	276.9	-5500	261
-1071	277.3	-5657	261.3
-1168	277.3	-5933	260.3
-1271	274.1	-6197	259.9
-1370	275.4	-6555	261
-1485	274.4	-6844	261.1
-1583	276.1	-7042	264.1
-1703	275.8	-7614	262
-1808	276.9	-8206	265.8
-1940	274.7	-8740	266.6
		-9153	265.4

How can you use the *Taylor Dome Ice Core* database (Table 1) to determine the projected atmospheric CO_2 concentrations in 2016? Does your approximation (page 5) justify it?

Using an algebraic model, make the necessary calculations below to extrapolate the atmospheric CO_2 concentrations (ppm) expected in 2016, according to the *Taylor Dome Ice Core* database (Table 1).

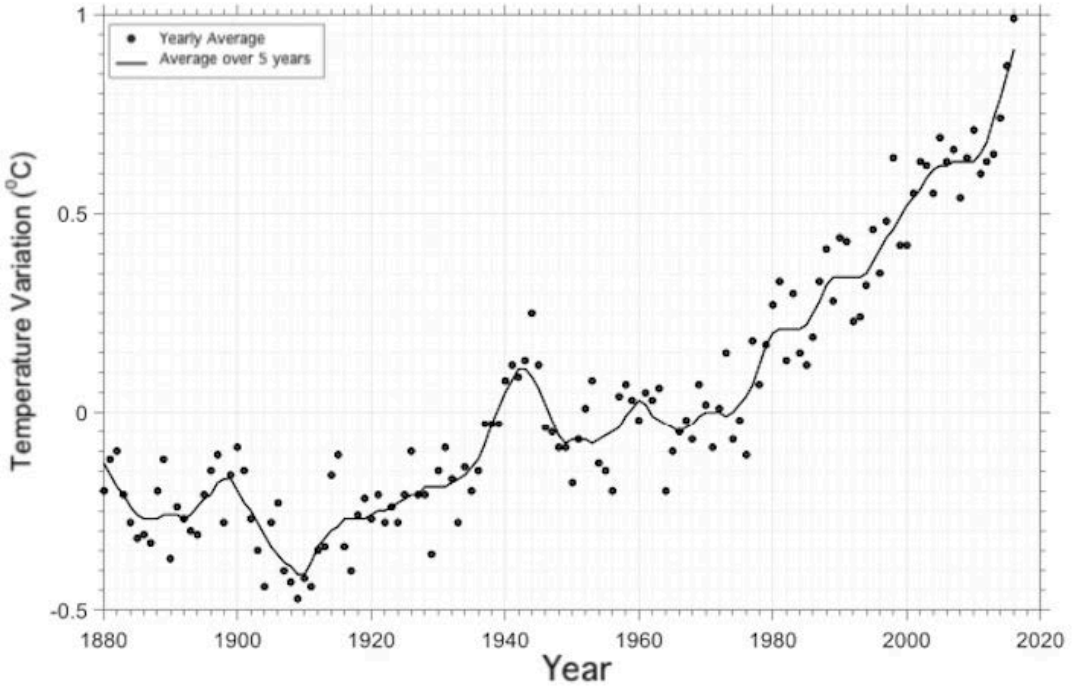
Why would you use this database to model the atmospheric CO_2 concentrations (ppm) in 2016?

What is the difference, in percentage, between the modelled data and the real data (Figure 1) for 2016? What do you think about it?

2. TASK 2: TEMPERATURE TREND

On the NASA website, there is a graph showing temperature variations in relation to the preindustrial age (Figure 2).

Figure 2 – Temperature Variations since 1880 (*NASA*)



What are your observations from Figure 2?

What are the major differences between Figure 1 and Figure 2?

Figure 2 does not show data as far back as Figure 1. What do you think is a plausible explanation for the difference in the state of our knowledge?

The increase in CO_2 concentrations didn't have an instant impact on global warming; there is a time lag. Can this be observed on both Figures 1 and 2?

Using Figure 2, and despite the irregularity of the dots, approximate a correlation between the years and temperature variations.

What are the characteristics of your correlation?

How do you explain the results of your approximation?

For which period could you observe a better correlation on Figure 2? Why?

The NOAA database (Figure 1) covers from 1958 to 2016. The data is based on direct observations using instruments as opposed to using air bubble samples trapped in ice. Here is the NASA data (Figure 2) covering 1958 to 2016 (Table 2).

Table 2 – Temperature Variations since 1958 (*NASA*)

YEAR	TEMPERATURE VARIATION (°C)	YEAR	TEMPERATURE VARIATION (°<T2/>C<T3/>)
1958	0.03	1987	0.33
1959	0.07	1988	0.41
1960	-0.02	1989	0.28
1961	0.05	1990	0.44
1962	0.03	1991	0.43
1963	0.06	1992	0.23
1964	-0.20	1993	0.24
1965	-0.10	1994	0.32
1966	-0.05	1995	0.46
1967	-0.02	1996	0.35
1968	-0.07	1997	0.48
1969	0.07	1998	0.64
1970	0.02	1999	0.42
1971	-0.09	2000	0.42
1972	0.01	2001	0.55
1973	0.15	2002	0.63
1974	-0.07	2003	0.62
1975	-0.02	2004	0.55
1976	-0.11	2005	0.69
1977	0.18	2006	0.63
1978	0.07	2007	0.66
1979	0.17	2008	0.54
1980	0.27	2009	0.64
1981	0.33	2010	0.71
1982	0.13	2011	0.60
1983	0.30	2012	0.63
1984	0.15	2013	0.65
1985	0.12	2014	0.74
1986	0.19	2015	0.87
		2016	0.99

How can you use the NASA database (Table 2) to determine the projected temperature variation in 2016?

Using an algebraic model, make the necessary calculations below to extrapolate the global temperature variation in 2100.

Why would you use this database to model the global temperature variation in 2100?

Should we worry about the projected temperature variation in your model? Why?

3. TASK 3: CO_2 CONCENTRATION TREND

This is the NOAA database (Table 3). It shows the annual average atmospheric CO_2 concentrations since 1958.

Table 3 – Annual Average Atmospheric CO_2 Concentrations since 1958 (*NOAA*)

YEAR	CO_2 (PPM)	YEAR	CO_2 (PPM)
1958	315.3	1987	349.2
1959	316.0	1988	351.6
1960	316.9	1989	353.1
1961	317.6	1990	354.4
1962	318.5	1991	355.6
1963	319.0	1992	356.4
1964	319.6	1993	357.1
1965	320.0	1994	358.8
1966	321.4	1995	360.8
1967	322.2	1996	362.6
1968	323.0	1997	363.7
1969	324.6	1998	366.7
1970	325.7	1999	368.4
1971	326.3	2000	369.5
1972	327.5	2001	371.1
1973	329.7	2002	373.3
1974	330.2	2003	375.8
1975	331.1	2004	377.5
1976	332.0	2005	379.8
1977	333.8	2006	381.9
1978	335.4	2007	383.8
1979	336.8	2008	385.6
1980	338.8	2009	387.4
1981	340.1	2010	389.9
1982	341.4	2011	391.7
1983	343.1	2012	393.9
1984	344.6	2013	396.5
1985	346.1	2014	398.6
1986	347.4	2015	400.8
		2016	404.2

How can you use the NOAA database (Table 3) to determine the projected atmospheric CO_2 concentrations in 2100?

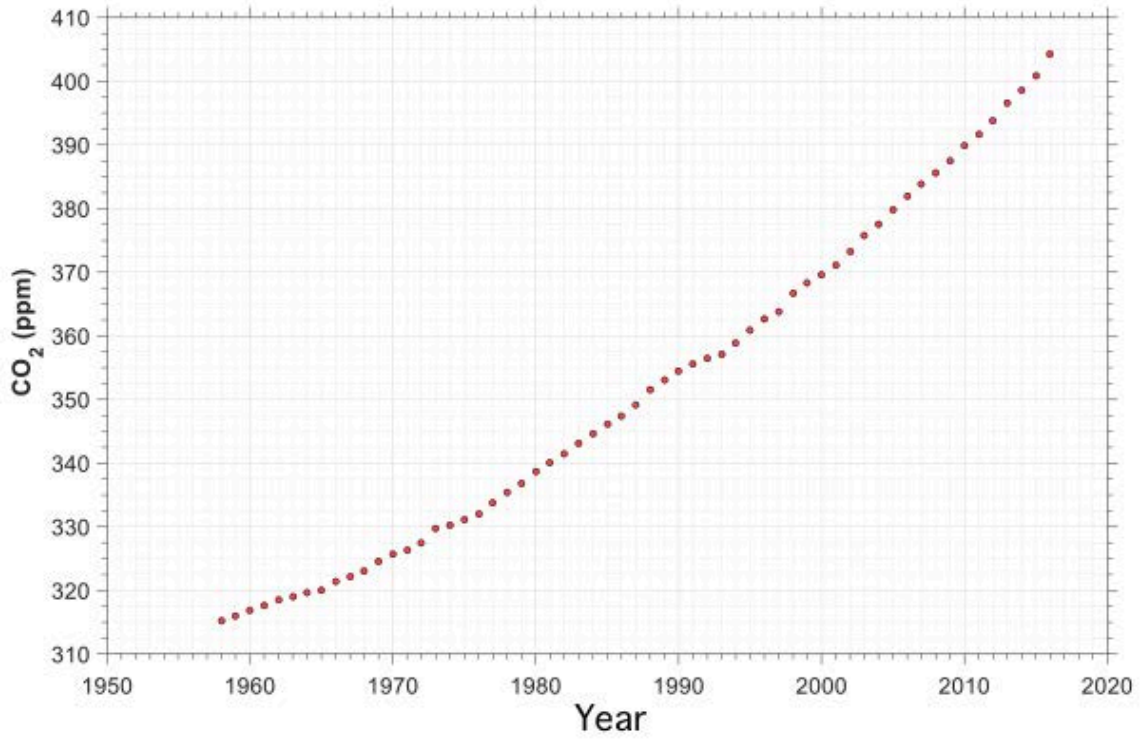
Using an algebraic model, make the necessary calculations below to extrapolate the atmospheric CO_2 concentrations in 2100.

Why would you use this database to model the projected atmospheric CO_2 concentrations in 2100?

Should we worry about the projected atmospheric CO_2 concentrations in your model? Why?

We used software to produce a graph from the NOAA data (Figure 3). Without calculating, is there a correlation between the period (1958 to 2016) and atmospheric CO_2 concentrations? Why?

Figure 3 – CO2 Concentrations since 1958 (*NASA*)



If you believe there is a correlation between the period (1958 to 2016) and atmospheric CO_2 concentrations (Figure 3), produce an approximation to determine its characteristics and their impact on your model from page 13.

4. TASK 4: CO_2 AND TEMPERATURE RELATIONSHIP

How could you establish a relationship between atmospheric CO_2 concentrations and global temperature variations?

What is the independent variable?

By combining the atmospheric CO_2 concentrations data with five-year average variation of global temperature, we produced a new Table (Table 4, page 16). Using an algebraic model, make the necessary calculations below to extrapolate temperature variations according to atmospheric CO_2 concentration in 2100 (use the value for CO_2 in your extrapolation on page 13).

What is the difference, in percentage, between your answer and your temperature model (page 11)? What do you think about it?

Table 4 – $CO_2$and 5-year Average Temperature Variation since 1958 (*NOAA and NASA*)

YEAR	CO_2 (PPM)	TEMPERATURE VARIATION (°C)	YEAR	CO_2 (PPM)	TEMPERATURE VARIATION (°C)
1958	315.3	-0.01	1987	349.2	0.28
1959	316.0	0.01	1988	351.6	0.32
1960	316.9	0.03	1989	353.1	0.34
1961	317.6	0.02	1990	354.4	0.34
1962	318.5	-0.01	1991	355.6	0.34
1963	319.0	-0.02	1992	356.4	0.34
1964	319.6	-0.03	1993	357.1	0.34
1965	320.0	-0.04	1994	358.8	0.35
1966	321.4	-0.05	1995	360.8	0.38
1967	322.2	-0.04	1996	362.6	0.41
1968	323.0	-0.03	1997	363.7	0.44
1969	324.6	-0.01	1998	366.7	0.46
1970	325.7	0.00	1999	368.4	0.49
1971	326.3	0.00	2000	369.5	0.52
1972	327.5	0.00	2001	371.1	0.54
1973	329.7	-0.01	2002	373.3	0.56
1974	330.2	0.00	2003	375.8	0.59
1975	331.1	0.02	2004	377.5	0.61
1976	332.0	0.04	2005	379.8	0.62
1977	333.8	0.07	2006	381.9	0.62
1978	335.4	0.12	2007	383.8	0.63
1979	336.8	0.17	2008	385.6	0.63
1980	338.8	0.2	2009	387.4	0.63
1981	340.1	0.21	2010	389.9	0.63
1982	341.4	0.21	2011	391.7	0.65
1983	343.1	0.21	2012	393.9	068
1984	344.6	0.21	2013	396.5	0.74
1985	346.1	022	2014	398.6	0.79
1986	347.4	0.25	2015	400.8	0.85
			2016	404.2	0.91

Why would we want to graph Table 4?

On the next page (Page 17), graph the date from Table 4, estimate the correlation and sketch the regression line from your algebraic model

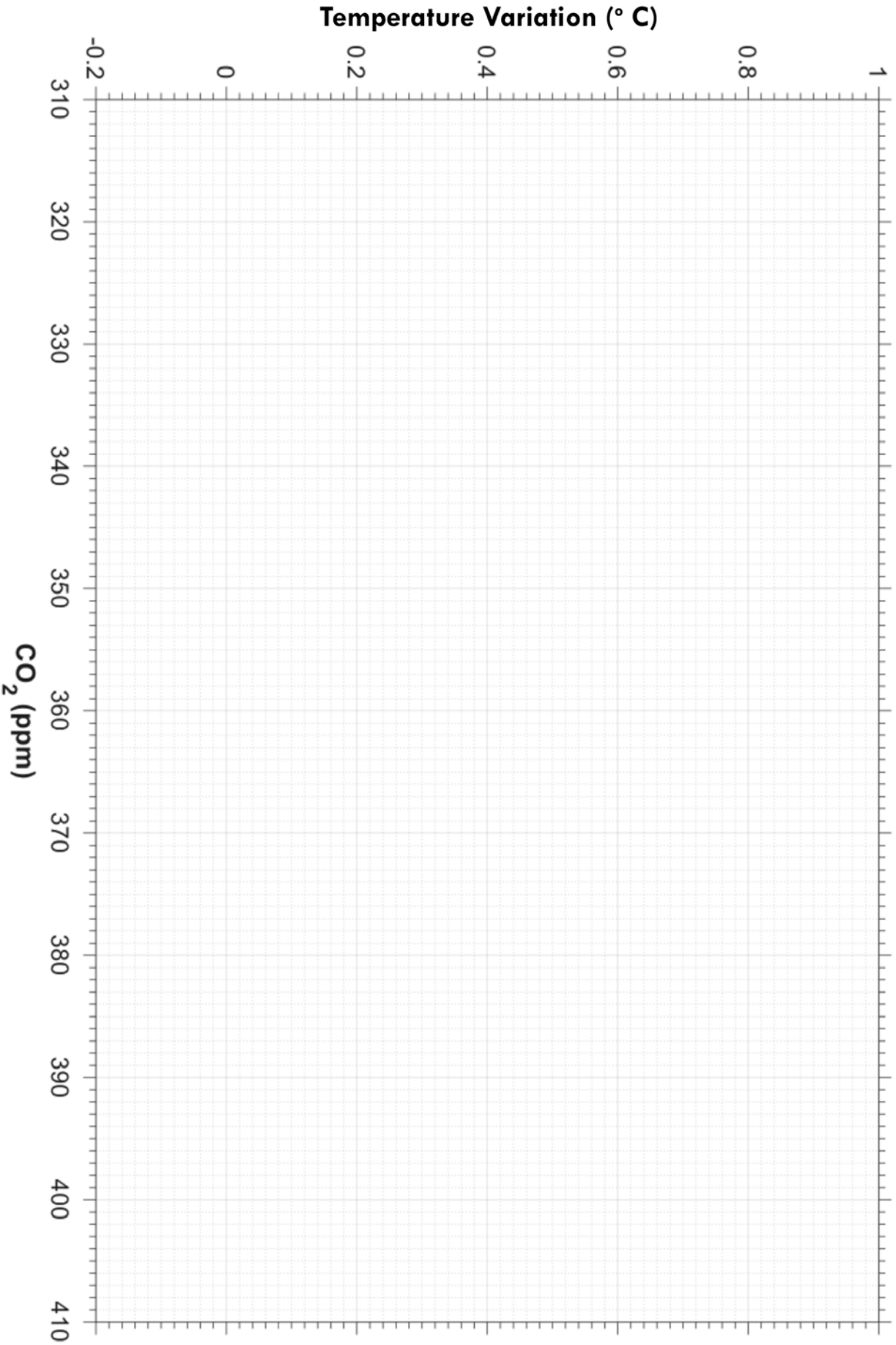


Figure 4 – 5-year Average Temperature Variation according to CO_2 Concentration

What are the characteristics of the correlation between atmospheric CO_2 concentrations and the five-year average variation of global temperature (Figure 4)?

To be more accurate, use Excel software to determine the correlation between atmospheric CO_2 concentrations and the five-year average variation of global temperatures. Type in the data Table 4 in a spreadsheet and apply the CORREL function. If you are unfamiliar with Excel software, ask your teacher for help.

What is the value of the correlation coefficient calculated in Excel?

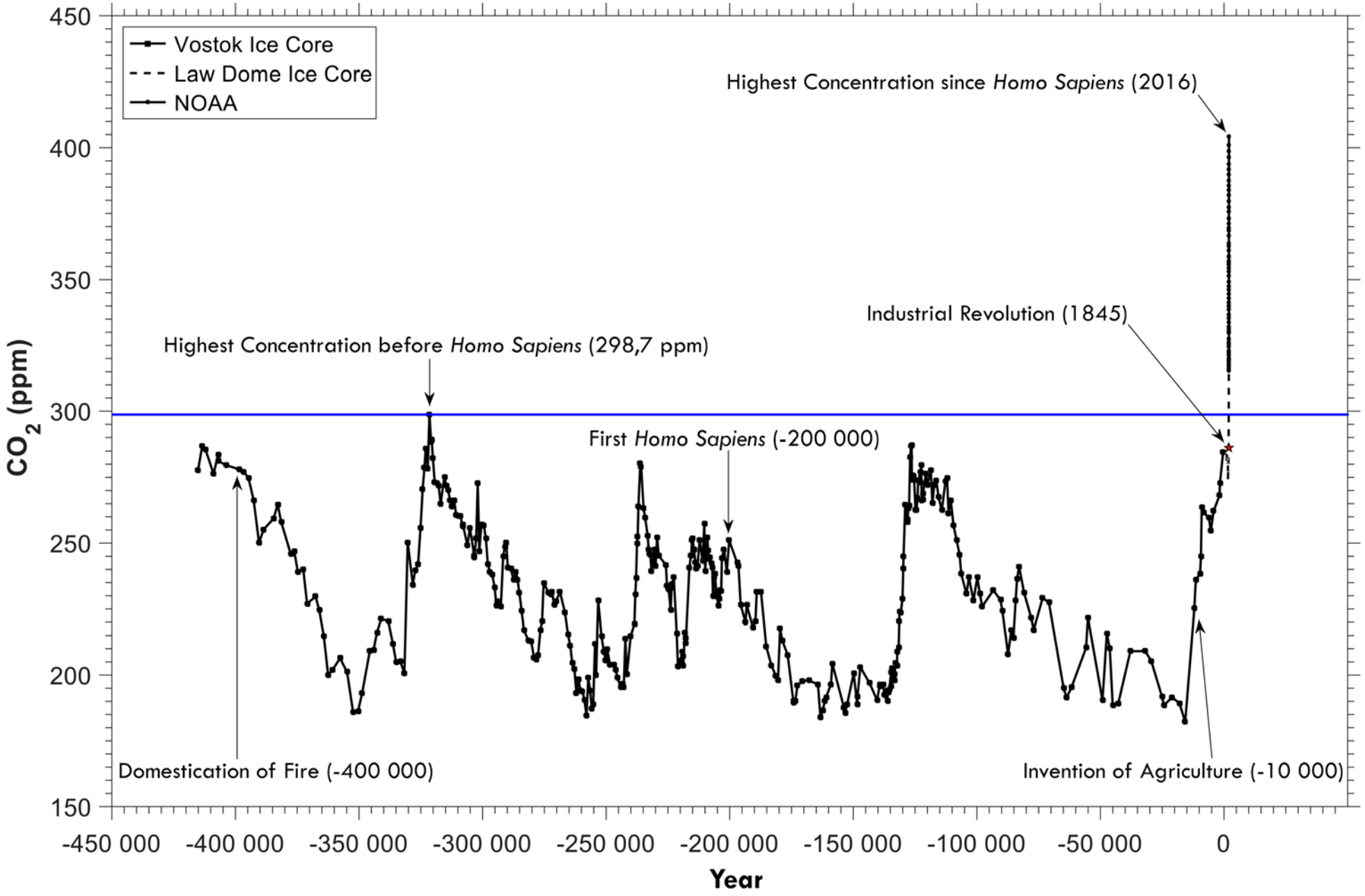
What is the difference, in percentage, between your estimation of the correlation coefficient and the value calculated in Excel? What do you think about it?

5. LET'S REFLECT

Does the state of scientific knowledge confirm that human activities contribute to global warming (Figure 5, p. 19)?

How likely is a 2° Celsius increase in average global temperature, between the preindustrial age and 2100?

Figure 1 – Atmospheric CO_2 Concentrations of the past 400,000 years



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Barnola, J.-M., D. Raynaud, C. Lorius, and N.I. Barkov. 2003. IFR*Historical CO_2 Record From The Vostok Ice Core. In Trends: A Compendium of Data on Global Change*. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A.. Link to Database: : http://cdiac.ornl.gov/trends/co2/vostok.html

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Kleder, M. (2004). SATGLOBE - Rendering Satellite Views of Earth. Link to Database Script: https://www.mathworks.com/matlabcentral/fileexchange/5490-satglobe-rendering-satellite-views-of-earth?focused=5058950&tab=function

REMINDERS[2]…

Two-Variable Distribution: A two-variable distribution is the set of pairs of data collected in a statistical study of two characters from the same situation.

Joint Distribution Table: a double entry table is used to represent the number corresponding to each combination of values, categories or classes related to the two variables studied.

Scatter Plot: A scatter plot is a graph that represents each pair of a distribution with two types of strictly quantitative variables. If there is a dependency between the variables studied, we place the independent on the x-axis and the dependent on the y-axis.

The correlation of a distribution: A correlation is a link between two quantitative characteristics of a distribution that describes the type, meaning, and strength of that link.

Linear Correlation Coefficient: The linear correlation coefficient, generally written as r, quantifies the strength of the linear link between the two characters of a distribution.

Regression Line: The regression line is the line that can be drawn in the scatter plot that best represents the two-variable distribution studied. There are several ways to find the equation of this regression line. In addition to the use of graphing calculators and some software, the equation of the regression line can be calculated manually.

[2] http://www.alloprof.qc.ca (in French)

GOING FURTHER

Can you use a regression line to interpret reality?

Are regression models a reliable way to make decisions?