

Global Warming

Contents

0.1	Introduction and Methods	1
0.2	Result	1
0.2.1	Emission of Carbon Dioxide	1
0.2.2	Rise of Sea level	2
0.2.3	Increase in number of Natural Disaster	2
0.2.4	Prediction of Temperature in 2100	3
0.3	Discussion and Conclusion	3
0.4	Appendix A: Figures and Graphs	4
0.4.1	Sea Level Rise	4
0.4.2	Number of Natural disaster	5
0.4.3	Global Annual Average Temperature	6
0.5	Appendix B: Sample Calculation (for Temperature Prediction)	6
	Bibliography	8

Abstract

This project focuses on understanding the effect of the prime cause of global warming i.e. CO_2 gas present in the atmosphere and accounting for the post effects of the warming on the sea level and the occurrence of natural disasters. In this report, we studied the average increase in the temperature of earth surface (global warming) annually with an increase in CO_2 gas. Furthermore, we reported the most commonly noted effects of global warming like rise in sea level and increased in number of global catastrophe. A linear regression analysis was performed to understand how the changing carbon dioxide level in the atmosphere affected the global temperature. In addition, linear regression studies were made between rising global temperature and changing sea-level and frequency of appearance of natural disasters per annum. We found a strong positive correlation between the CO_2 level and global temperature suggesting CO_2 gas is a likely cause of global warming. Similarly, a positive correlation was observed in sea-level and number of recorded natural disasters with global warming which indicates that global warming does have an effect on increase in sea water and causing more number of natural disasters. This statistical survey could be used to understand how global warming is affecting our ecosystem, how the future global temperature change, and what measures we could possibly take to potentially prevent or reverse global warming and ultimately save the biosphere.

Research Question:

How has global warming increased in past years? Does global warming relate to sea level rise and increase in natural disasters(floods, drought, etc.)?

0.1 Introduction and Methods

Global warming is an ongoing process of rise in average temperature of earth's atmosphere, land, and ocean. Global warming has been demonstrated by direct measurement of Global average temperature of the planet over years. According to reports, the planet's average surface temperature has risen by two degree Fahrenheit since 1900. This change is unmatched in recorded history. Also, 2016 was the warmest year in history, with eight months setting record temperature highs around the globe. Human activities such as uncontrolled emission of Greenhouse gases, particularly carbon dioxide, Sulphur dioxide, and Nitrous oxide have been playing a major role in Global warming. The effects of Global warming are disastrous. Sea level has risen by about 8 inches since the ice-age. Number of catastrophic events like floods, drought, storm and tornado has increased severely.

In this project, we analysed the causes of global warming and the resulting effect on sea level and natural disasters. The scientific observation of CO_2 level in the atmosphere shows a rise in its level which makes it a likely candidate for causing global warming. In this report, we focused on the emission level of carbon dioxide (CO_2) while parallelly observing global warming. On the other hand, we heeded on sea level rise and frequency of natural disasters for showing any connection to changing global temperature. We will be using Linear Regression to test if there exist any linear relationships between - emission of CO_2 and global warming, global warming and sea level rise, and global warming and natural disasters. Using our developed linear model, we will predict the global average annual temperature at the end of 21st century.

0.2 Result

0.2.1 Emission of Carbon Dioxide

Carbon Dioxide (CO_2) is considered to be the main reason for global warming. In this section, we have studied the average rise in CO_2 concentration every year and compared it to the average annual increase in temperature as shown in Figure 1. Furthermore, to test a linear relationship between the emission of CO_2 and global warming, we have used atmospheric concentration of CO_2 as the independent variable (x) and global average annual temperature as the dependent variable (y). Then, we obtained data for average annual atmospheric CO_2 concentration (in ppm) from [Ritchie and Roser, 2020] and global average annual temperature (in degrees celsius) from [NOAA National Centers for Environmental information, 2020]. We used both of these data to develop a linear model between CO_2 emission and temperature increase; it's shown in the Figure 1.

According to our developed linear model,

$$Y = P_1 * X + P_2$$

Coefficients (with 95 % confidence bounds):

$P_1 = 0.009974(0.009273, 0.01067)$ and $P_2 = 10.71(10.48, 10.94)$

Correlation coefficient: $r = 0.9347$

Coefficient of determination: $r^2 = 0.8734$

We found the correlation coefficient (r) to be 0.9347 and the coefficient of determination (r^2) to be 0.8734. According to our developed linear model, 87.34 % of the increase in average global temperature is caused by the increase in global carbon dioxide emission.

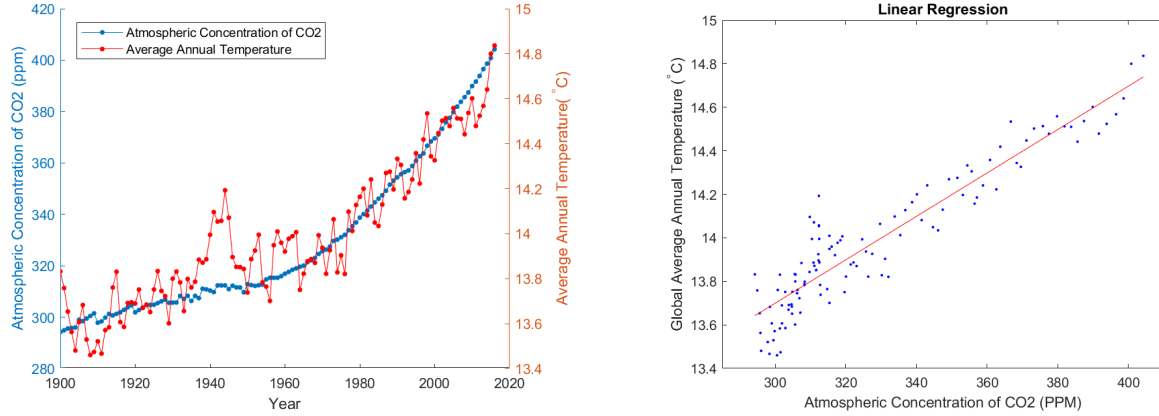


Figure 1: Carbon Dioxide concentration and Global temperature since 1900 (left). Linear Regression of Carbon Dioxide and Global temperature(Right)

0.2.2 Rise of Sea level

Various reports have stated that one of the direct effects of Global warming is melting of polar ice, which in result brings rise in sea level. In this analysis, we study the average rise in sea level of the planet since the 1900 [Center for Satellite Applications and Research, 2020] and compare it with changes in global temperature. Also, we have developed a linear model between sea level and global temperature of earth. For calculation, we took average annual temperature as independent variable(X) and sea level as dependent variable (Y). The developed linear model is described below. According to our developed linear model,

$$Y = P_1 * X + P_2$$

Coefficients (with 95 % confidence bounds):

$P_1 = 0.008523(0.007772, 0.009274)$ and $P_2 = -2.699(-4.169, -1.228)$

Correlation coefficient: $r = 0.9124$

Coefficient of determination: $r^2 = 0.8325$

The coefficient of correlation of the developed linear model is 0.9124, while the coefficient of determination is 0.8325. This means that about 83.25% of rise in sea level is caused by increasing global temperature.

0.2.3 Increase in number of Natural Disaster

Global warming can be linked with natural disasters too. Rise in temperature can take moisture out of plants that increases the risk of wildfires. Global warming heats up the planet, that means massive amounts of moisture escapes the surface and gets contained in the atmosphere, thus increasing the chances of a hurricane. Rise in temperature melts the polar ice caps which increases the sea level, thus increasing the chances of flooding. And it goes on and on. In this section, we will be observing the occurrences of natural disasters every year [Centre for Research on the Epidemiology of Disasters, 2020]. Then, using global annual average temperature as the independent variable (x) and annual number of natural disasters as the dependent variable (y), we have tested the linear relationship between these two.

According to our developed linear model,

$$Y = P_1 * X + P_2$$

Coefficients (with 95 % confidence bounds):

$P_1 = 707(631.9, 782.1)$ and $P_2 = -9695(-10750, -8645)$

Correlation coefficient: $r = 0.8669$

Coefficient of determination: $r^2 = 0.7516$

From our testing, we obtained the coefficient of correlation (r) to be 0.8669 and coefficient of determination (r^2) to be 0.7516. This means that according to our linear model, 75.16% of all global natural disasters occur due to the rise in global temperature.

0.2.4 Prediction of Temperature in 2100

Global warming is an alarming situation and it is highly probable that we can see its effects till next century unless any preventive measure is taken. We have developed a linear regression for increase in temperature since 1900 and use this linear model to predict the Global average temperature of 2100. The result from the calculation are discussed below. The linear model of increase in Global average annual temperature is:

$$Y = P_1 * X + P_2$$

Coefficients (with 95 % confidence bounds):

$P_1 = 0.008523(0.007772, 0.009274)$ and $P_2 = -2.699(-4.169, -1.228)$

Correlation coefficient: $r = 0.9025$

Coefficient of determination: $r^2 = 0.8145$

Temperature Prediction (with 95% confidence bounds):

$$15.2 \pm 0.1085^\circ C$$

This shows that increase in Global average annual temperature is strongly and positively correlated with time. With this data, the predicted temperature in 2100 is $15.2 \pm 0.1085^\circ C$ with 95 % confidence level.

0.3 Discussion and Conclusion

Global warming is a hot issue of contention. It is an utmost necessity to study its underlying causes and impacts it can bring. The average global temperature is rising annually and the emission of Carbon Dioxide gas into the atmosphere accounts for a significant increase of it. As consequences of Global warming, there is a remarkable rise in sea level, which places coastal areas around the globe in imminent danger. Similarly, the number of natural disasters is soaring rapidly. Our statistical investigation also supported the argument about CO_2 causing global warming followed by sea-level rise and recurrent natural disasters around the world. Our study also predicted the surface temperature of earth to will rise to $15.2 \pm 0.1085^\circ C$ at the end of 21st century. Such a surge in temperature makes it difficult to sustain life in this biosphere. This study calls for action on a global scale to control human activities that produce greenhouse gases like CO_2 . It further alerts world leaders to cooperate and form policies to reduce the emission of Carbon Dioxide for saving our planets from the imminent danger.

0.4 Appendix A: Figures and Graphs

0.4.1 Sea Level Rise

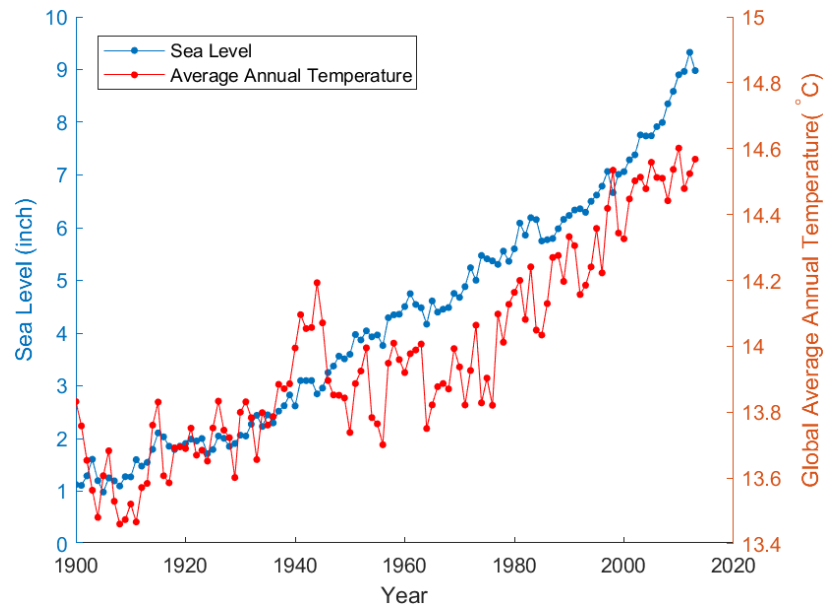


Figure 2: Comparison of rise in sea level (inch) and increase in Global average annual temperature (Celsius) since 1900

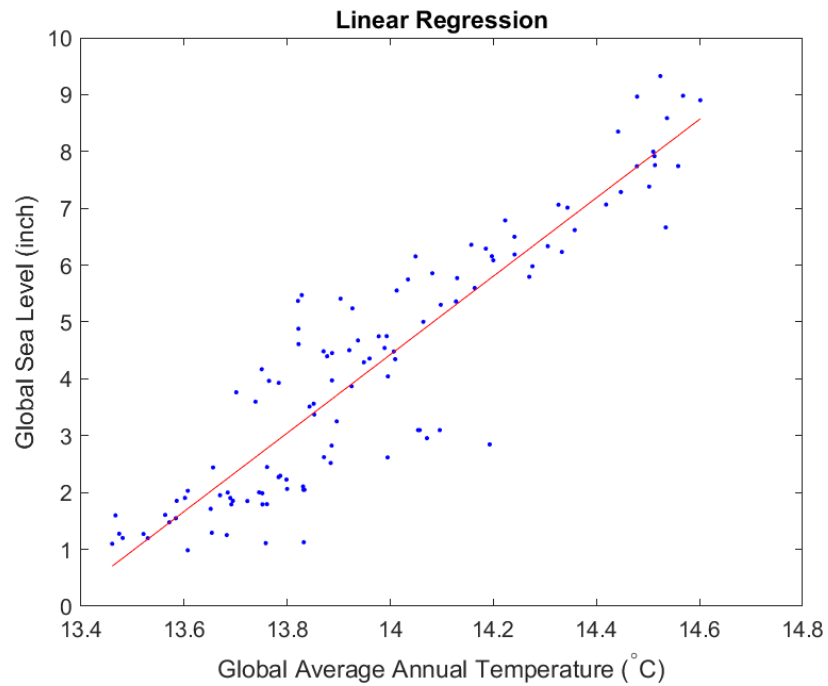


Figure 3: Linear Regression of rise in sea level (inch) and increase in Global average annual temperature (Celsius)

0.4.2 Number of Natural disaster

Increase in Natural Disasters

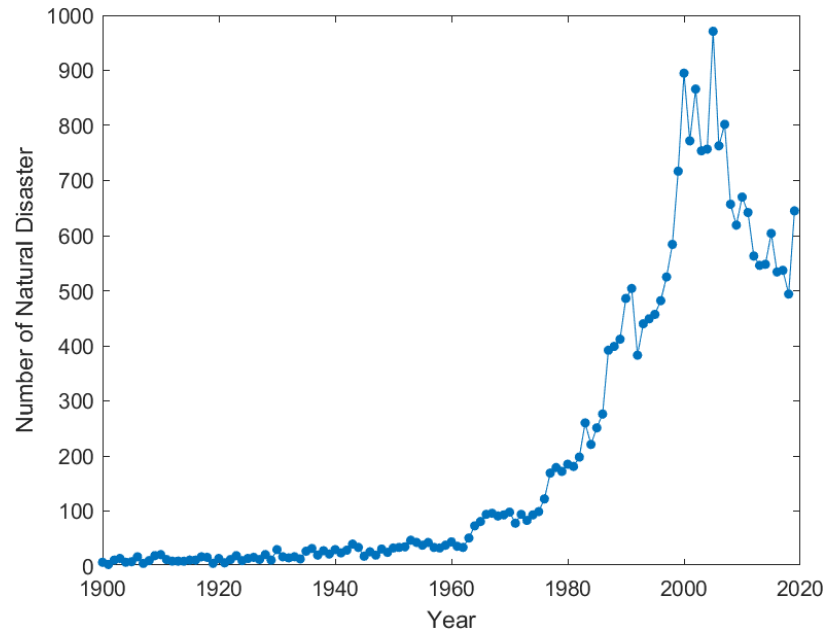


Figure 4: Number of natural disaster since 1900

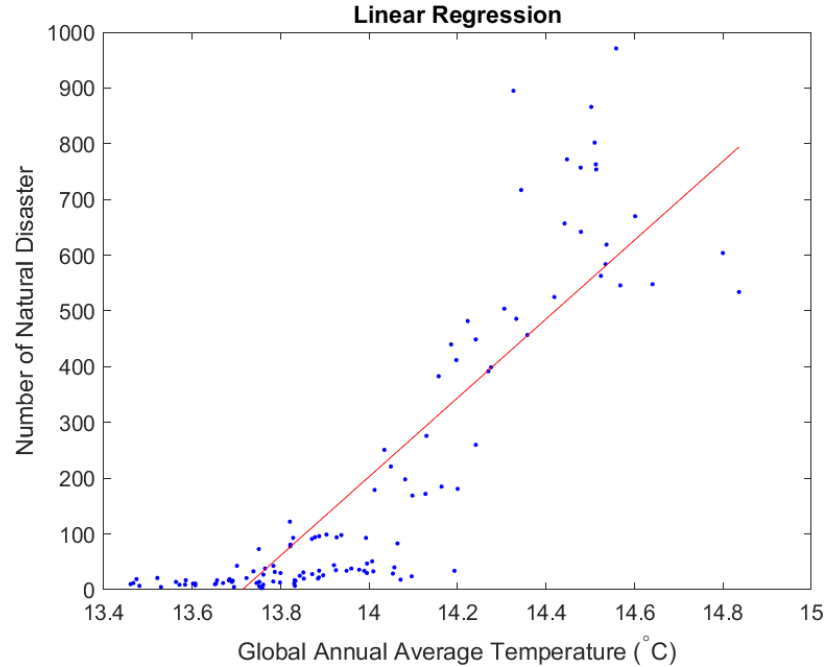


Figure 5: Linear Regression of Number of Natural disaster and Global average annual temperature (Celsius)

0.4.3 Global Annual Average Temperature

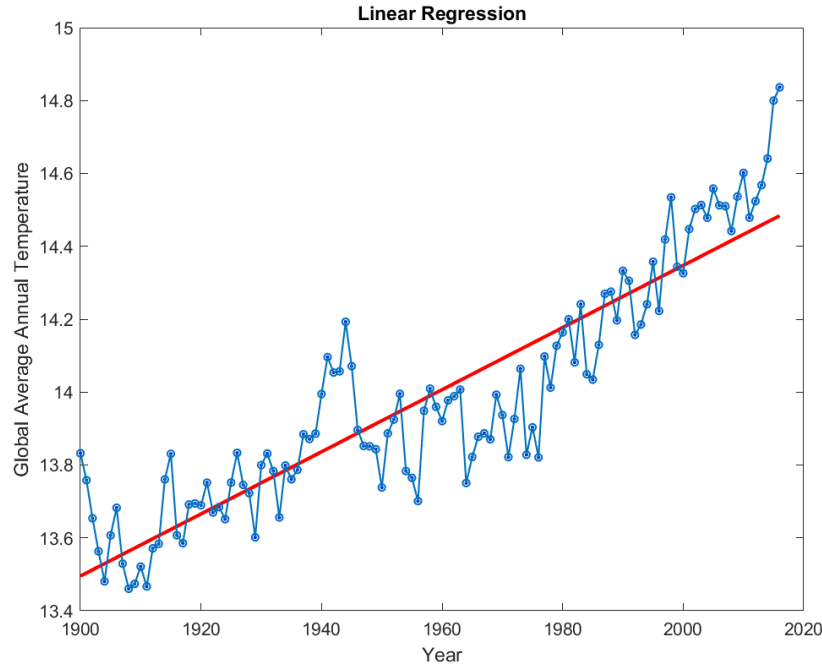


Figure 6: Linear Regression for Global Average Annual Temperature (Celsius)

0.5 Appendix B: Sample Calculation (for Temperature Prediction)

DATA

$$\sum X = 229086$$

$$\sum Y = 1636.78$$

$$\sum X^2 = 448683846$$

$$\sum Y^2 = 22910$$

$$\sum XY = 3.2060 * 10^6$$

$$n = 117$$

CALCULATIONS

$$S_{XX} = \sum X^2 - (\sum X)^2/n = 133458$$

$$S_{YY} = \sum Y^2 - (\sum Y)^2/n = 11.9010$$

$$S_{XY} = \sum XY - (\sum X)(\sum Y)/n = 1137.5$$

Linear Model:

$$Y = P_1 * X + P_2$$

where,

$$P_1 = \frac{S_{XY}}{S_{XX}} = 0.008523$$

$$P_2 = \bar{Y} - P_1 * \bar{X} = -2.699$$

For Standard deviation of error (s):

$$SSE = \sum Y^2 - P_2 \sum Y - P_1 \sum XY = 2.206$$

$$s = \sqrt{\frac{SSE}{n - 2}} = 0.1385$$

Correlation Coefficient(r) and Coefficient of determination(r^2):

$$r = \frac{S_{XY}}{\sqrt{S_{XX} * S_{YY}}} = 0.9025$$

$$r^2 = 0.8145$$

For prediction at $X^* = 2100$ with confidence interval of 95 %:

$$\hat{Y} = P_1 * 2100 + P_2 = 15.2$$

For confidence interval:

$$\hat{Y} \pm t * s \sqrt{\frac{1}{n} + \frac{(X^* - \bar{X})^2}{S_{XX}}} = 15.2 \pm 0.1085$$

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