A Recommendation for Battling Climate Change in Hawaii

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Overview

The purpose of this paper is to understand the causes of temperature increases to recommend a course of action to Hawaiin government as they seek to make decisions to limit the impact of climate change. I will explain the current state of knowledge on CO2 emissions, share overarching trends regarding greenhouse gas emissions and temperature changes, and attempt to find close reltionships between the concentrations of CO2 at Mauna Loa and the concentrations of CO2 globally.

The threat of climate change has the potential to impact billions of lives due to rising sea levels, changes in temperature, fluctuations in the gases that compose our air, among many others. These threats will impact our financial decision-making and the resource allocation of governments, as business adjusts to new climates and individuals make decisions in reaction to resource limits. In the following data sets, we will look to further understand the interaction between emissions levels and temperature levels, both of which are standards for measuring climate change.

Introduction

In Section 1, I will share the process I took to read in and clean the appropriate data chosen for this paper. This includes selection of data and my process for subsetting and cleaning the data.

In Section 2, I will share the research questions I will perform exploratory data analysis to better understand the data. In this section, I will specifically look to show the countries that historically emit the most, share the global rise in CO2 concentrations, and compare that with the readings at Mauna Loa volcano in Hawai'i.

In Section 3, I will perform statistical analysis to demonstrate causal factors. In this section, I will seek to show which emissions type is most correlated with global temperature changes, explore how the rise in global temperature relates to Country-specific emissions, and understand which countries have emissions amounts that correlate most positively with Mauna Loa CO2 readings.

In Section 4, I will share conclusions and explain future work to further understand the problem.

Section 1: Data Selections and Cleaning

The chunk below shows my process for loading and cleaning my data.

Risetemp

'risetemp' is a .csv file found at https://www.kaggle.com/vageeshabudanur/riseintemp-dataset. This data is a record of mean Temperature and Emissions Concentrations (in parts per million or parts per billion). My process for loading and cleaning this data was to read in the raw .csv file, coerce the year variable to factor format (for likewise comparisons among years), remove unnecessary columns MEI and TSI, and rename the variables into easily readble format.

Emissions Data

'emissionsdata' is a data set also found at https://www.kaggle.com/srikantsahu/co2-and-ghg-emission-data. The dataset shows total emissions in metric tons for each year from 1750 - 2019. My process for cleaning this data set was to read in the raw dat in .csv format, conver the wide data format to long data format using the gather() function, rename the variables, subset the data for only years after 2000, coerce the Year variable into factor format for likewise comparisons, and then rename the factor levels of Year to drop the leading "X" character. This was the most challenging data set to read in and clean, due to the given wide data format, and the leading X in front of each given "Year".

Mauna Loa

The third data set I chose to read in and clean is 'manualoa'. This data set exists at https://www.kaggle.com/dan3dewey/co2-mauna-loa-weekly and shows weekly CO2 reading at the Manua Loa volcano on the island of Hawai'i in the Pacific Ocean. It shows the Year of the reading, the CO2 level in parts per million, and the changes of that reading in 1 year, 10 years, and since 1800. My process for cleaning this data was to read in the raw .txt file using a delimiter of 'space', skip the first 49 lines due to introductory text in the raw data, set column names to a given readable list, and then coerce each individual variable into an appropriate format.

Section 2: Research Questions & Exploratory Data Analysis

Who Emits the most Greenhouse Gases?

To understand and begin to quantify the causes of climate change, we identify the top 4 countries by total greenhouse gas emittants. These countries and the Emissions from these countries (reprresented below in Metric Tons), China, Germany, the United Kingdom, and Japan. This is seen in Table 1 below.

Table 1: Table 1

Country	Total_Emissions
China	196805807048
Germany	168873660020
United Kingdom	145118094867
Japan	98305082527

Have Total Emissions Increased or Decreased since 2000?

Next, we understand how total emissions have fluctuated since 2000. In Figure 2 below, we see that since the year 2000, total emissions appears relatively stable, with two specific spikes in data in the years 2005, and 2014. I will address these data opportunities in Conclusions and Future Work section at the end of this paper.

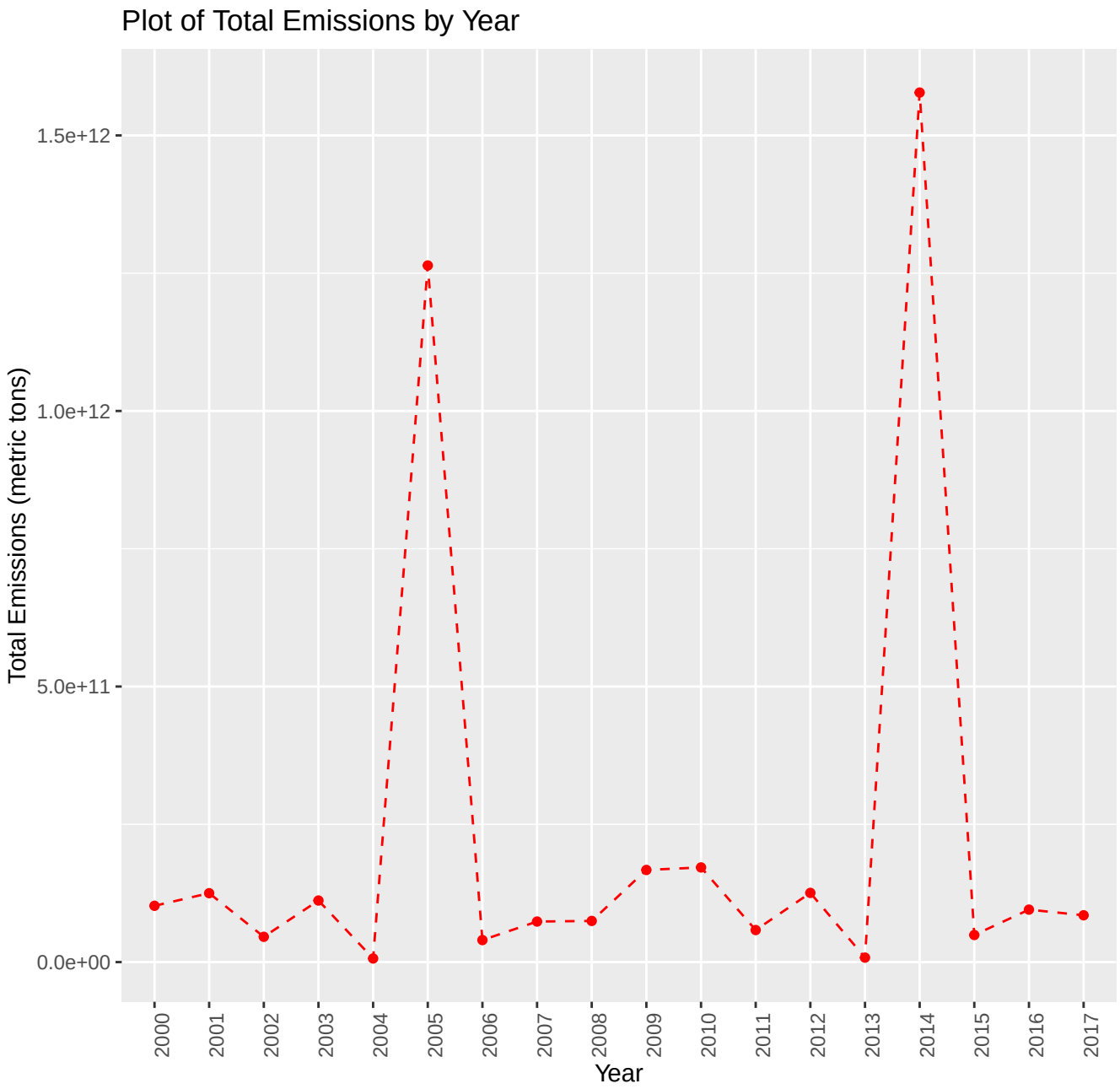


Figure 2

Does CO2 concentration change over time?

Next, we understand how CO2 concentration in parts per million changes over time. To do this, we analyze our data and summarize our overall CO2 concentration data using the sum equation below.

Equation for Mean

$$mean = \frac{\sum_{i=1}^{n} values}{n}$$

We see from Figure 3 that the mean global CO2 concentration steadily increases from 1983 to 2008.

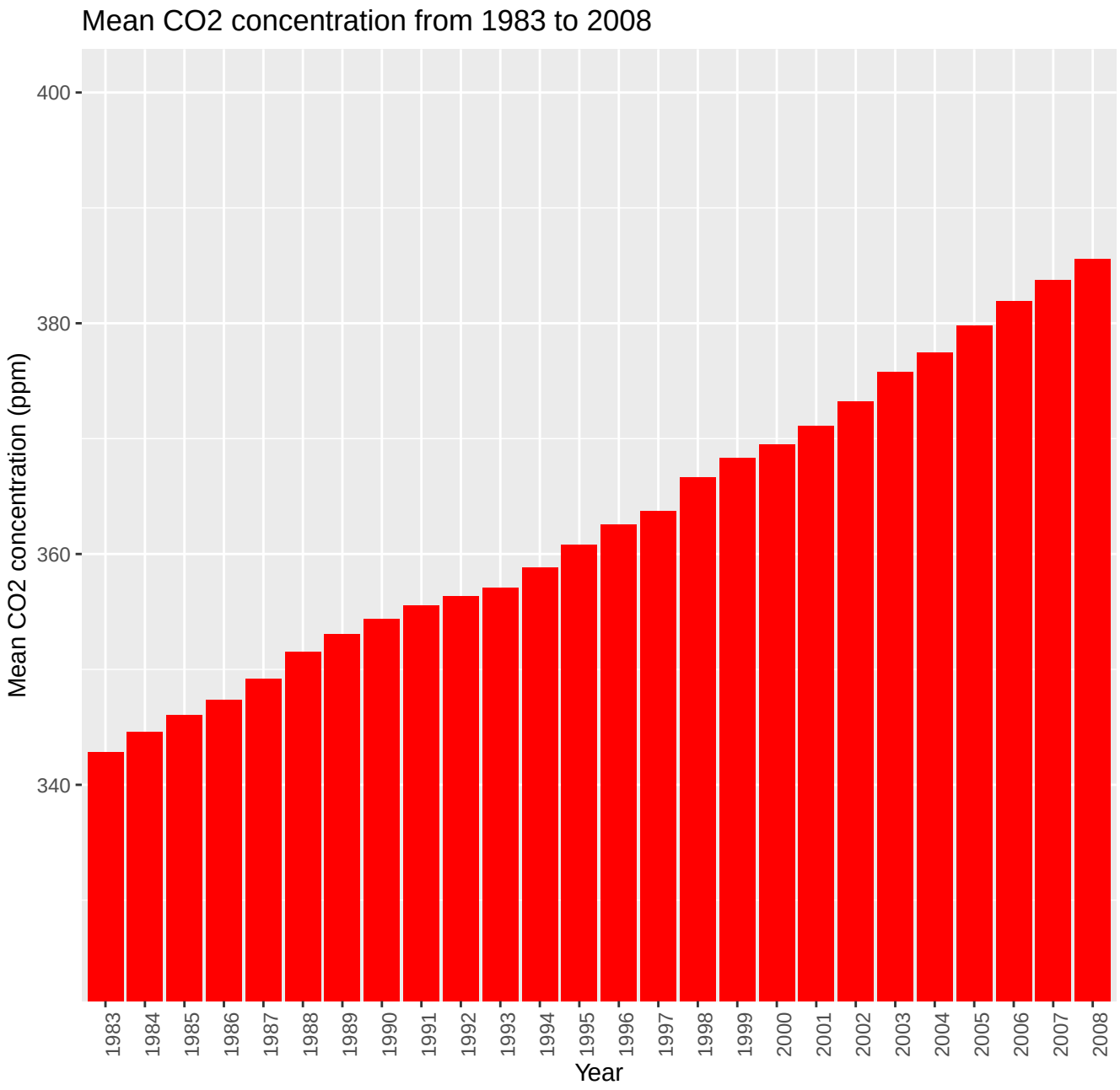


Figure 3

Does temperature fluctuate over time?

In the above tables and figures, we have shown the top 4 countries by emissions levels, the increase of emissions over time, and the mean concentration of CO2 over time.

Next we show the fluctuations of temperature over time, to see how the global average temperature has changed. Recall that Temperature Difference in the figure below is represented by the difference of the global average temperature to the reference temperature as set by the data owners. Positive temperature differences represents a rise in global temperatures compared to what was expected, a negative temperature difference represents a decline in temperatures compared to what was expected.

As we see in Figure 4, the boxplot of temperature changes shows increasingly higher highs and increasingly higher lows. From 1983 to 2008, the median Temperature Difference generally rises, with varying amounts of spread within the years. There is a large spread in 1997, and a very tight spread in 2005.

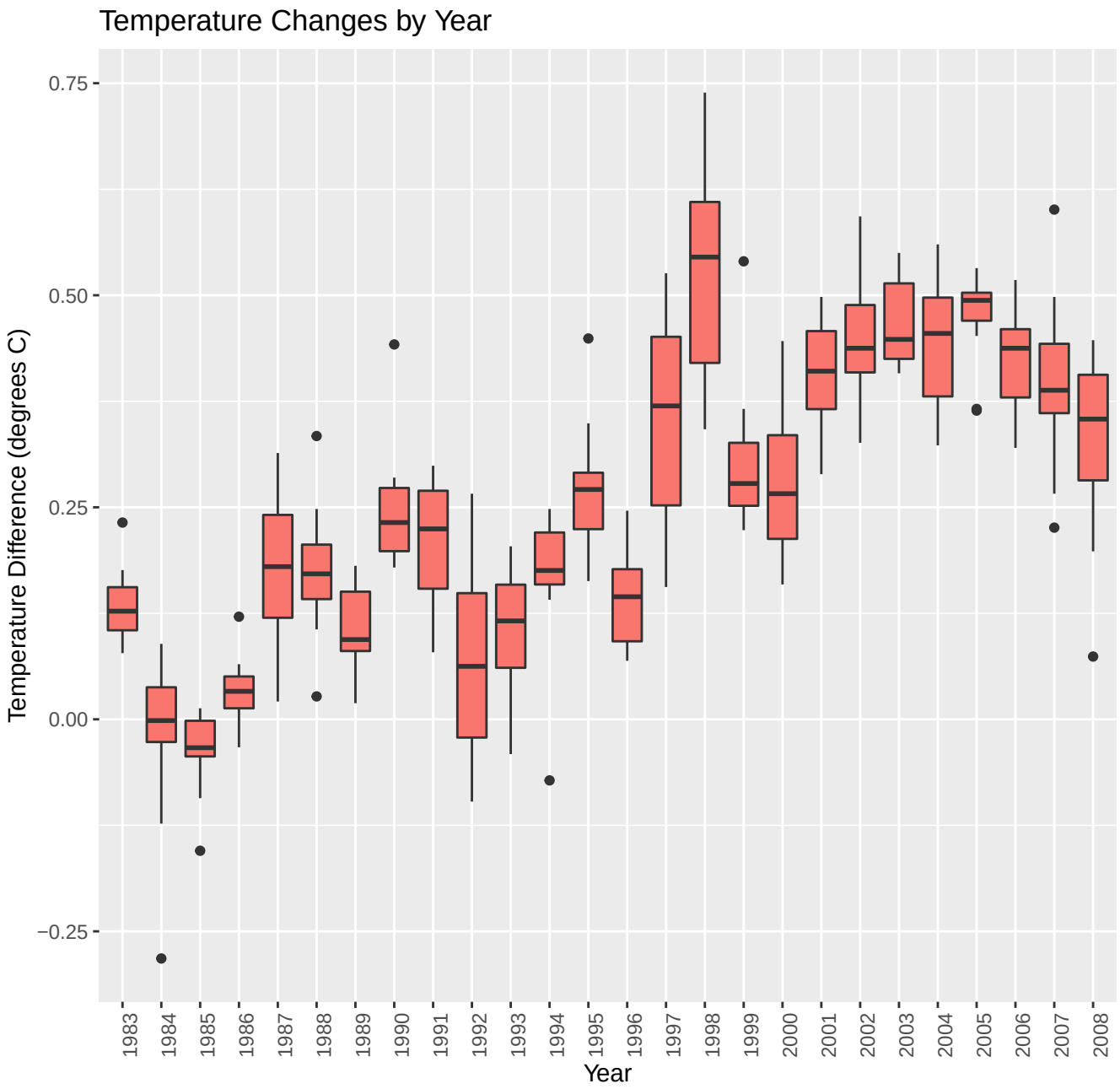


Figure 4

How do CO2 levels fluctuate in Mauna Loa?

In Figure 4, we showed the global shifts of temperature differences and CO2 emissions levels. Below in Figure 5, we show a similar trend line for Mauna Loa CO2 concentrations. This shows that rising CO2 levels is truly a global phenomenon. Rising global concentrations is felt on a remote volcano in Hawaii, an island in the middle of the Pacific.

There are some outlieing data points in the years 1975, and between 1980 and 1984, but perhaps there are external factors causing these low readings at the time.

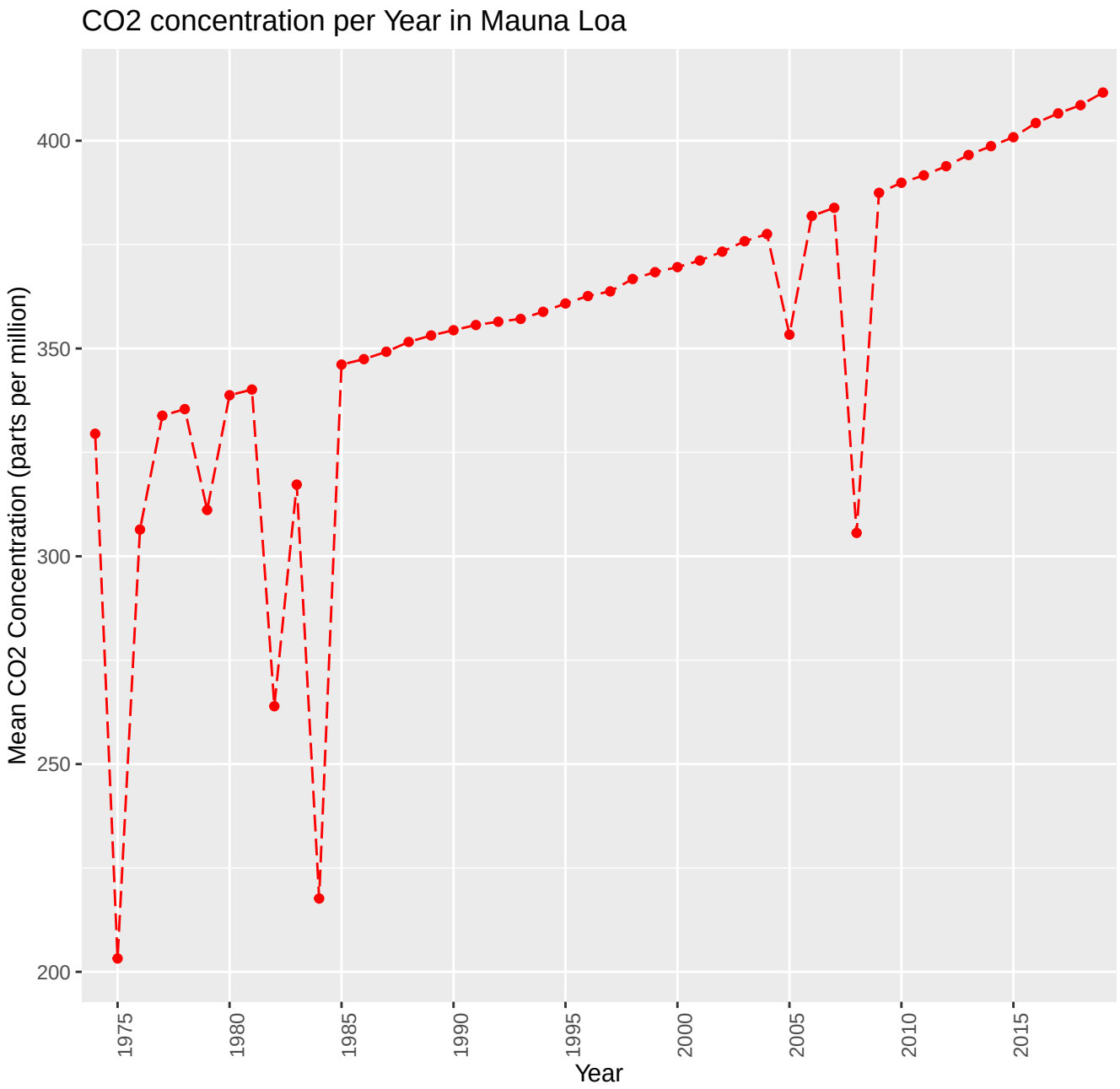


Figure 5

Section 3: Statistical Analysis

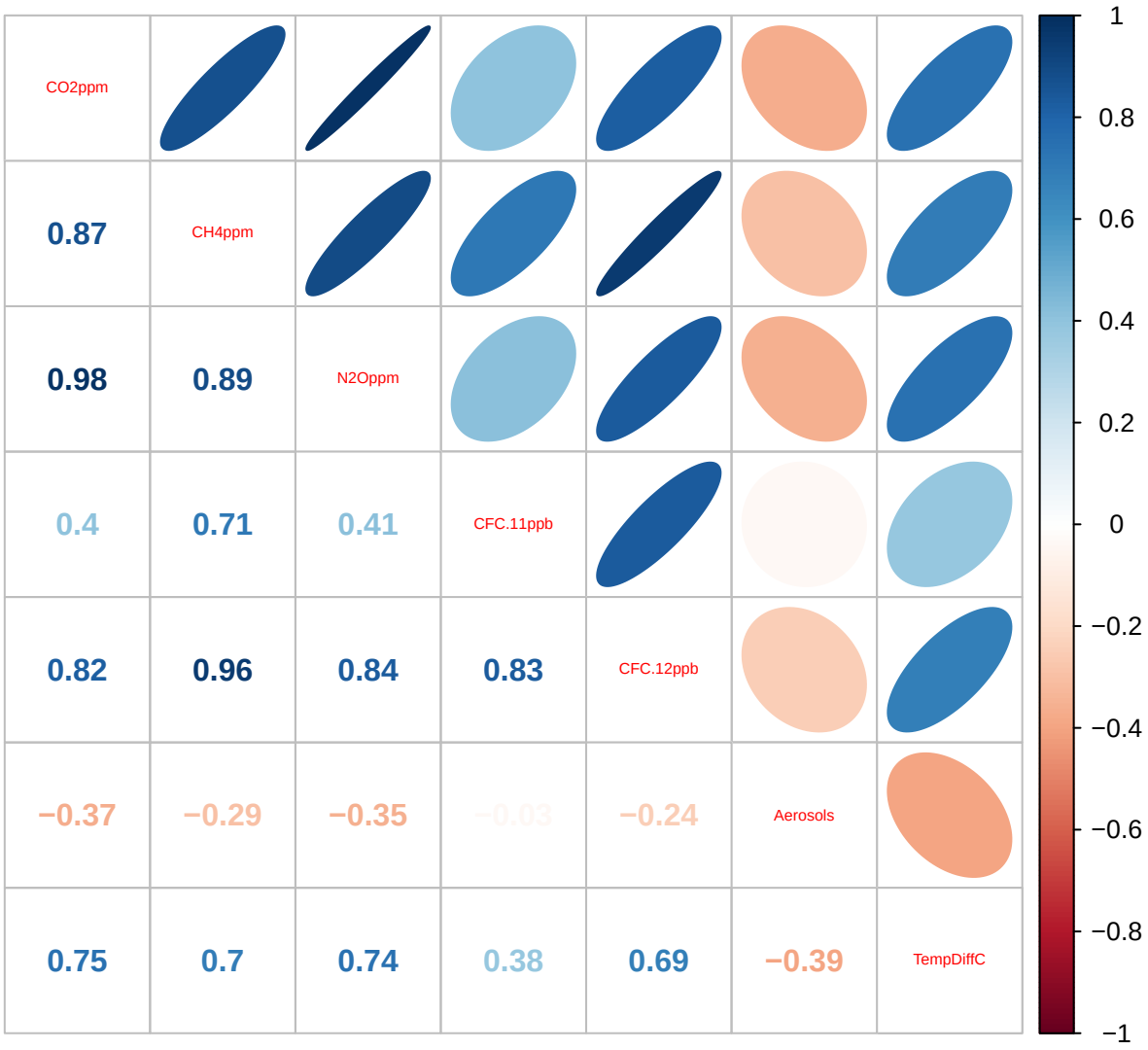
Which Greenhouse Gas has the strongest link to Temperature Rises?

In the EDA section of this paper, we have explored global CO2 emissions concentration, local CO2 emissions concentration changes, and global temperature changes.

In the section below we will look to uncover the correlated factors with temperature changes, by running a correlation of greenhouse gas types with temperature differences. In the correlation in Figure 6 below, we show that the 3 emittants with the largest correlation to temperature increase are CO2 (r=.75), N20 (r=.74), and CH4 (r=.7).

Note: R represents the correlation of two variables. The closer r is to 1, the more positive the relationship. The close r is to -1, the more negative the relationship. The description of R is shown below Figure 6.

Figure 6: Correlation of Emission to Temperature



$$correlationcoefficient = r$$

How closely is Global CO2 concentrations linked to Mauna Loa CO2 emissions?

Last, we seek to understand the relationship between Mauna Loa CO2 emissions and global CO2 emissions, by plotting the median CO2 emissions amount per year. Median is represented below, showing the ith value in a set of ordered values, where i = n+1/2.

Equation for Median

$$median = \frac{\alpha_{n+1}}{2}$$

In Figure 7 below, we plot the Mauna Loa Median CO2 concentration against the Global CO2 concentration. What we observe is an overlying line, showing that Mauna Loa Median CO2 amounts directly align with global CO2 amounts.

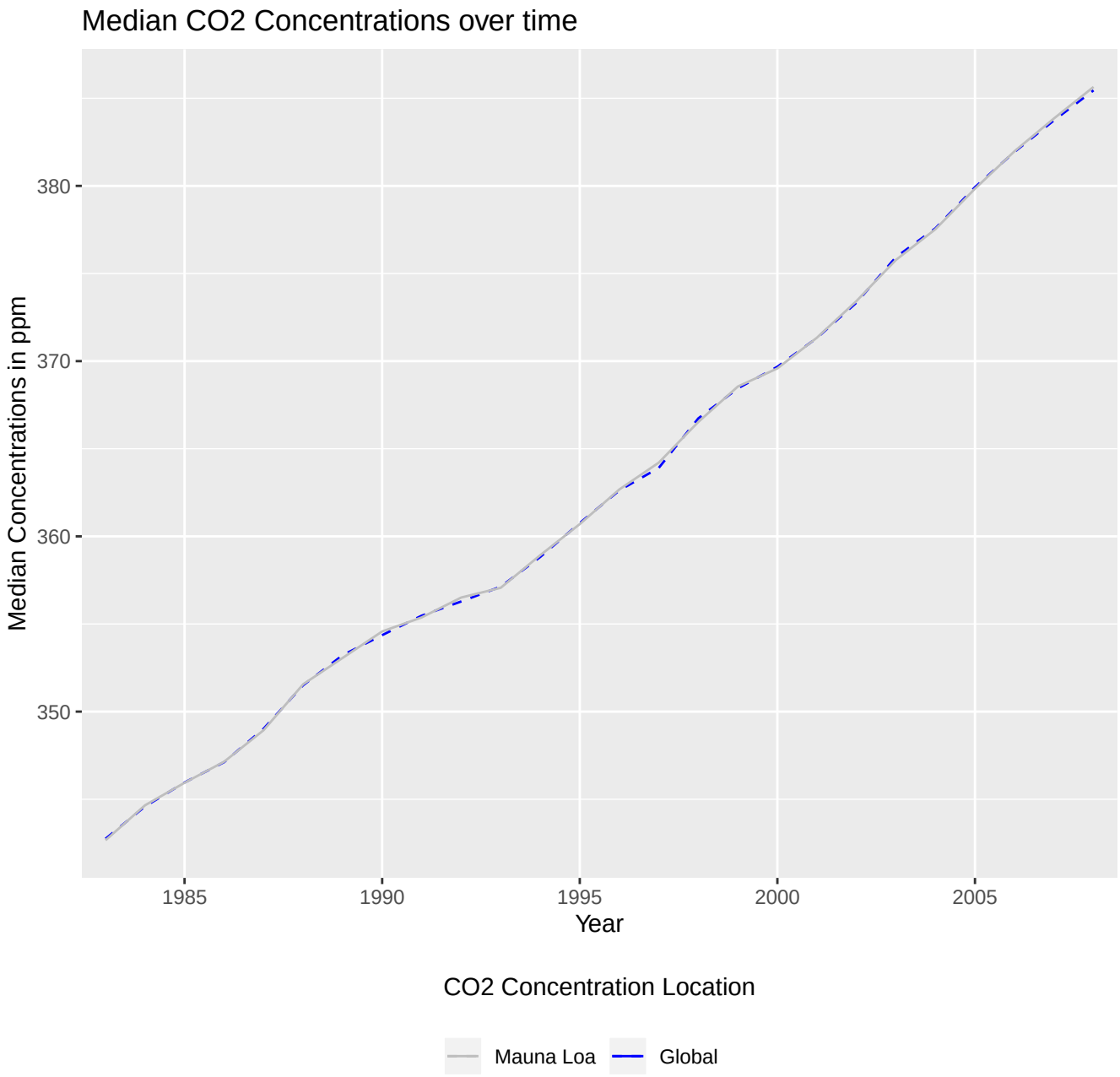
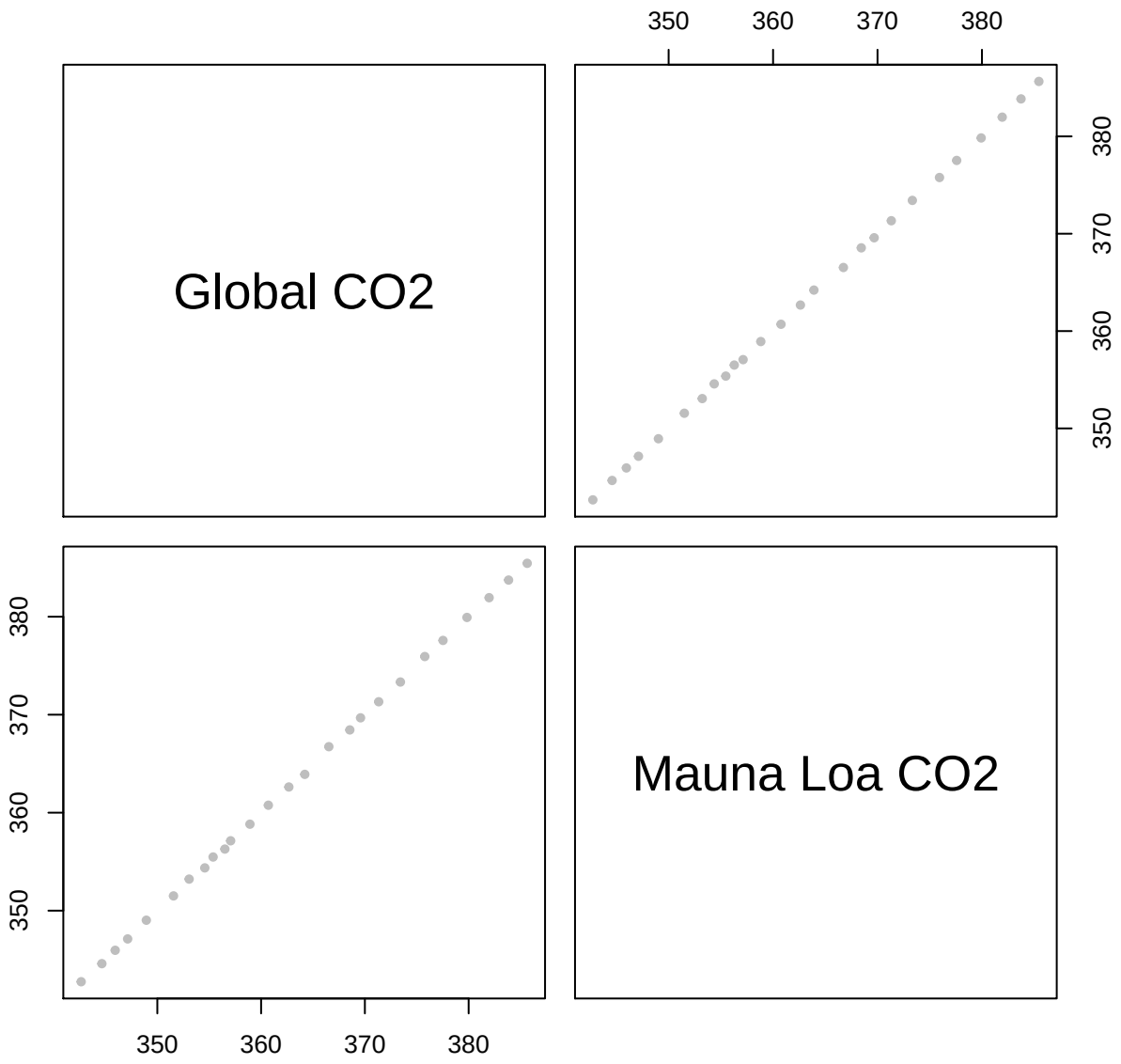


Figure 7

The below pair plot supports the conclusion that the two are directly aligned, showing a near perfect correlation.



Section 4: Conclusions and Future Work

Conclusions that are drawn from the research in this paper are:

1. Global CO2 emissions are rising from 1983-2008 as shown in Figure 3
2. Global Temperature Differences are increasing from 1983-2008 as shown in Figure 4
3. CO2 concentrations at Mauna Loa are increasing from 1975-present as shown in Figure 5
4. The three emittants most correlated with positive temperature differences are CO2, N2O, and CH4.

In summary, for the island of Hawai'i, specifically within the Mauna Loa volcanic region, the area is not immune from global climate change because of its remote location in the Pacific Ocean. Furthermore, if local government were to make a choice on which greenhouse gases to limit in order of importance in the battle to fight overall global temperature increases, the decision should be to limit CO2, followed by N20, followed by CH4.

Further work to explore the topic further would include understanding how CO2 concentration fluctuate within different tographies in Hawai'i, how volcanic activity affects CO2 concentrations within Hawai'i, and the overall temperature fluctuations within the Hawaiin microclimate.