A Cause for Concern: Monitoring Atmospheric Carbon Dioxide on Governors Island, NYC

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Credit: Office of Weather and Air Quality, 2012

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Abstract:

The issue of Climate Change is one that has been studied since the early 19th century. Climate Change, also called Global Warming, refers to the long term change in the Earth's surface temperature. Among many other impacts, climate change is suspected for increased loss of ice sheet in Antarctica and Greenland ; large drop in sea ice ; rise in sea level as a result of ice melting ; acidification of oceans as a result of increased carbon dioxide in the atmosphere; and reduced agriculture productivity and quality (Manabe & Wetherland, 1980). Carbon dioxide is the major greenhouse gas that absorbs and re-emits the outgoing longwave radiation causing an increase of the Earth's heat content (Ruzmaikan and Byalko, 2015). Last year, Dr. Peter Tans at the NOAA/ESRL reported carbon levels reaching a record high concentration of 400 parts per million, numbers that have not seen in millions of years. This project studies and monitors the amount of Carbon Dioxide in the atmosphere in hopes to understand the constant flux that occurs in the course of a year. To avoid error or bias in data, CO2 concentrations were collected on two geographically distinct areas of Governors Island. Station 1, the Center of Governors Island, and Station 2 near the Upper NY bay. Later on, a series of t-tests were conducted to analyze significant variation between the two stations. By the end, it was calculated with a 95% certainty that both stations had no significant difference in mean CO2 concentration. It was found that the average amount of Carbon Dioxide had marginal fluxes all throughout the year, however there were no drastic increases or decreases. It is valuable information because it suggests that maybe there is still a chance to change Earth's fat. If there is more of a decline in the future, then maybe the earth can attain a climate safety reading of 350 ppm.

Introduction:

Carbon Dioxide is one of the most abundant greenhouse gasses in the world. Too much of this greenhouse gas can be dangerous because it traps outgoing ultraviolet radiation and can heat up the Earth's global temperature (EPA, 2015). This can lead to a chain of events such as the removal of polar ice caps and the rise in ocean levels. That is why it is imperative to maintain and monitor the amount of Carbon Dioxide in the atmosphere, to visually see the change occurring and take action to prevent the horrible effects Climate Change can bring. This project monitors the amount of CO2 in the atmosphere, analyzing the change in the greenhouse gas over the course of a year. The hope is that this project creates more awareness in society towards the threat of Climate Change, and to prompt action towards the prevention of it by reducing Carbon Dioxide emissions both domestically, and industrially.

Carbon Dioxide tends to have local variations due to factors affecting their release to the atmosphere (Colson, 2014). Based on previous research, the amount of Carbon Dioxide in one area can be affected by many factors. Plant abundance is an example. Plants respire about 50 percent of the carbon available from photosynthesis with the remainder available for growth, propagation, nutrient acquisition, and litter production (Ryan, 1991). It is for this reason that data collected over the course of this project was taken from two distinctive locations. Station 1, the center of Governors Island, an area that is well known to have a variety of trees and plants, and Station 2 near the Upper New York Bay, an area open to the wind. The problems this project addresses are 01) to figure out how CO2 tends to fluctuate over the Year under two distinct conditions, and 02) how does CO2 concentrations differ in two locations when factors like plant life affect it? It is hypothesized that the amount of Carbon Dioxide in the atmosphere would be much greater near the Upper NY Bay when it isn't being affected by the plant life in Governors

Island. It was also hypothesized that if atmospheric CO2 is monitored throughout the year, then the concentration would increase.

Background Information

Since the last Ice Age, the amount of Carbon Dioxide in the Atmosphere has increased at an astounding rate. Carbon dioxide is the major greenhouse gas that absorbs and re-emits the outgoing longwave radiation causing an increase of the Earth's heat content (Ruzmaikan & Byalko, 2015). The leading cause of this boost is the ceaseless use of fossil fuels that emit large amounts of the gas, dating back to the Industrial Revolution. If this were to continue, there will soon be noticeable and alarming effects on the planet. As Earth's temperature increases, Polar Regions experience this heat and ice sheets begin to melt, leading to rising ocean levels and eventual inundation. Wildlife would also experience the effects as they would lose their habitats, having to migrate inland. Polar bears rely on sea ice as a platform for hunting, migrating, and mating, but are forced to move to land in regions where sea ice does not seasonally persist (Hamilton et, al., 2014).

The Greenhouse effect is the incoming of radiation from the sun. Essentially, the sun sends ultraviolet rays to Earth, a small sum are reflected by the atmosphere. The rest of radiation is absorbed by the Earth and then released into space (EPA, 2015). Greenhouse gasses such as carbon dioxide take part in the greenhouse effect through the absorption of the incoming and outgoing radiation. This natural equilibrium has kept our planet at stable temperatures for a long time. However, due to human meddling over the course of the past couple centuries, the amount of those greenhouse gasses have skyrocketed. This increase in greenhouse gasses being emitted increases the amount of radiation absorbed and increases the temperatures of Earth.

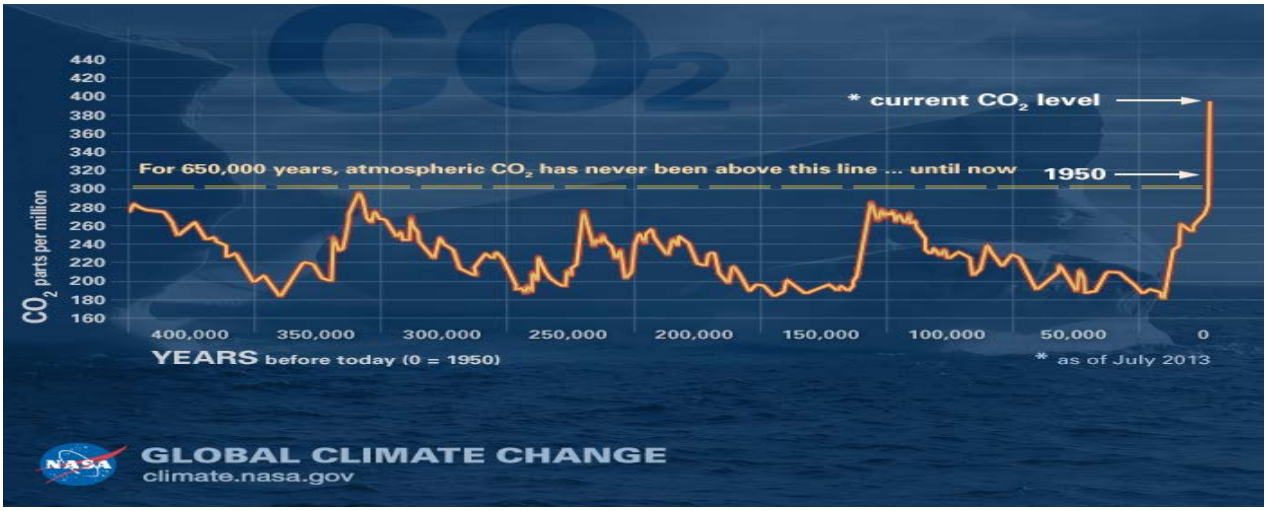

Figure 01. Based on previous research, the carbon dioxide concentration levels have been well documented. As you can see, the levels have had a constant flux throughout time. However, it is shown that by the 1950's, CO2 levels had already surpassed levels never before documented. At the moment, the current level has reached the 400 ppm mark. The Earth's average global temperature has increased by about 1.4 Degrees Fahrenheit since the 1880's (NASA/GISS, 2014).

Project Design Chart:

Problem:

How Does atmospheric CO2 fluctuate over the course of a year?

How Does CO2 change according to locations that are geographically different?

Hypothesis:

The hypothesis of the project is that if the monthly average CO2 concentration is taken in Governors Island, then there will be a gradual increase seen because of how much air pollution is constantly being emitted.

The Second hypothesis was that If CO2 concentration is taken from an area that has an abundance of plant life like at the center of Governors Island, then the amount of CO2 concentration will be higher near the Upper NY bay because it is an area that is geographically open to interference.

Null Hypothesis:

The null hypothesis in this project is that the data collected in both Station 1, the center of Governors Island, and Station 2 near the Upper NY bay have no significant difference.

Alternate Hypothesis:

The Alternate hypothesis of this project is that the data collected in both Station 1 and Station 2 has a significant difference

Objectives:

There were a number of objectives this project sought to achieve. The first was to monitor the amount of Carbon Dioxide on Governors Island. The second objective was to analyze the data gathered and determine the average concentration of CO2 on Governors Island. Lastly, this project also tries to create awareness as to the current issue of climate change.

Limitations & Risks:

This project experienced a number of limitations. The first would have to be time management. The purpose of this project was to monitor CO2 over the course of a year. However, since the school year consists of a 2 month break during summer, there was not enough data to analyze for

the whole year. A second limitation that was evident for this project was the equipment that was used. The Vernier software that was used to gather data had about a 10% error reading. The measurements that were taken might have an error of >100ppm .

Locality:

Figure 02. Governors Island, New York City. The coordinates for Station 1, the center of G.I, where there's an abundant amount of vegetation are 40°41'21.7"N, 74°01'04.4"W. The Coordinates of Station 2, an area that is near the Upper NY bay and prone to less interference from vegetation are 40°41'27.3"N 74°01'16.7"W

Materials:

Table 01 lists all the materials that were used all throughout the project. The quantity of the materials used, and the use for all the materials

Materials	Quantity	Purpose
Vernier CO2 Gas Sensor, Error: +/- 100ppm , 10%	2	Measure CO2
Vernier Interface Model: Vernier LabQuest 2 rev.2	2	Record Data
Flash Drive	1	Saves Data
200 ml Bottle	1	Serves as sample when Calibrating
Microsoft Excel	1	Graph Data, measure standard deviation, Perform T-test.

Procedures:

In order to use the CO2 sensor, it needs to first be calibrated, to do that follow these steps:

- Go outside with the Carbon dioxide Sensor and the Vernier Interface.
- Press the Calibration button on the side of the CO2 sensor.
- It will take 90 seconds for the sensor to warm up and give calibrated readings.
- If you wish to get readings indoors, you must be careful, if you go in too quickly you risk becoming uncalibrated again due to the Temperature changing too quickly.

Gathering Data:

In order to measure carbon dioxide levels in the atmosphere you need to:

- Connect the CO2 Gas Sensor to the interface
- Start the data collection software

- The software will identify the CO2 gas sensor and load a default data-collection setup
- Allow the CO2 Gas Sensor to warm up for about 90 seconds before collecting data
- If not calibrated, follow the previous steps to Calibrate the device
- You are ready to start collecting data

Analyzing the Results:

To analyze the data that is collected, this project will:

- Set up an excel spreadsheet
- Graph The Data Collected into a Bar Graph
- Add Error bars using the data set's standard deviation
- Perform a T-test to examine significant variation in the data collected by the two CO2 sensors, the U6 sensor and the U8. This will give a clear and insightful looks as to whether or not the discrepancies between the two sensors was actually statistically significant.
- Perform a second T-test in which the data collected at both Station 1 and Station 2 is examined for a significant difference. This will address a key objective in the project which is to see whether or not the CO2 levels have had a change between the two stations.
- Analyze/Discuss about the Data that was collected, and the results of the t-test.
- Try to find reason in to how it does or does not support the original Hypothesis. In this case, the project will also go in depth on how the CO2 concentrations varied over time, how there were differences between the two sites tested, and why there may be variations in the data gathered by the two sensors.

Results:

Table 02. Shows a data chart of the amount of CO2 concentration in the two stations, 2 different CO2 sensors were used to get a more accurate measure.

STATION:	G.I Station 1, Center Of G.I (ppm)	G.I Station 2, Near Upper NY bay (ppm)	G.I Station 1, Center of G.I (ppm)	G.I Station 2, Near Upper NY bay (ppm)
CO2 Sensor:	Sensor “U6”	Sensor “U6”	Sensor “U8”	Sensor “ U8”
Date:				
2/26/15		364	315	370
3/3/15	464		458	489
3/17/15	353	306		
3/31/15			284	
4/14/15	389	408	395	415
4/21/15	410	429	416	425
4/28/15	406	390	400	378
10/5/15	363	415	421	382
10/14/15	365	398	409	370

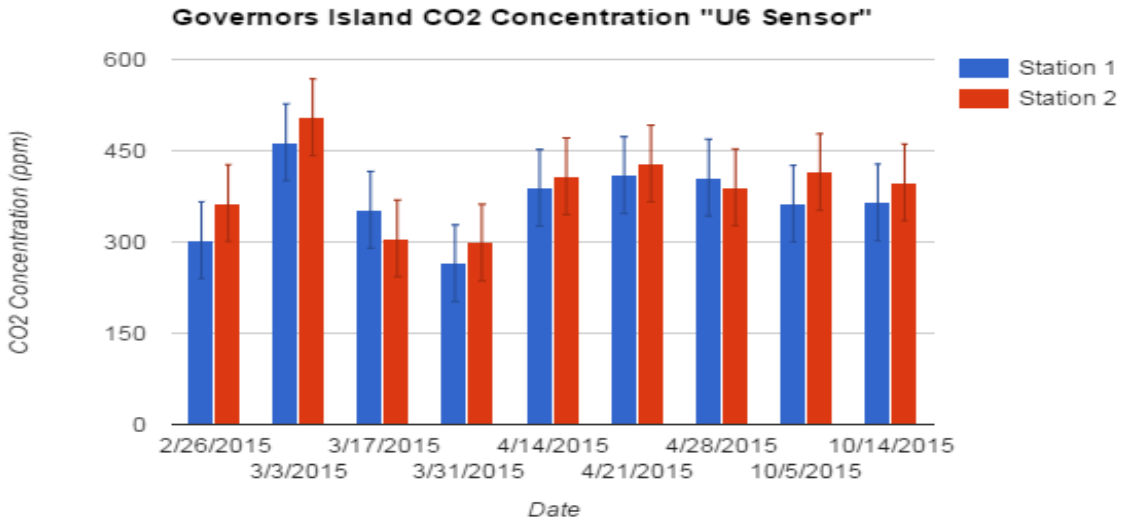

Figure 03. is a visual representation of the data set , but only for the “U6” sensor. The data starts off relatively normal however as it goes on there are constant spikes that occur. There are slight differences in the data gathered between the two test sites in all of the sample dates.

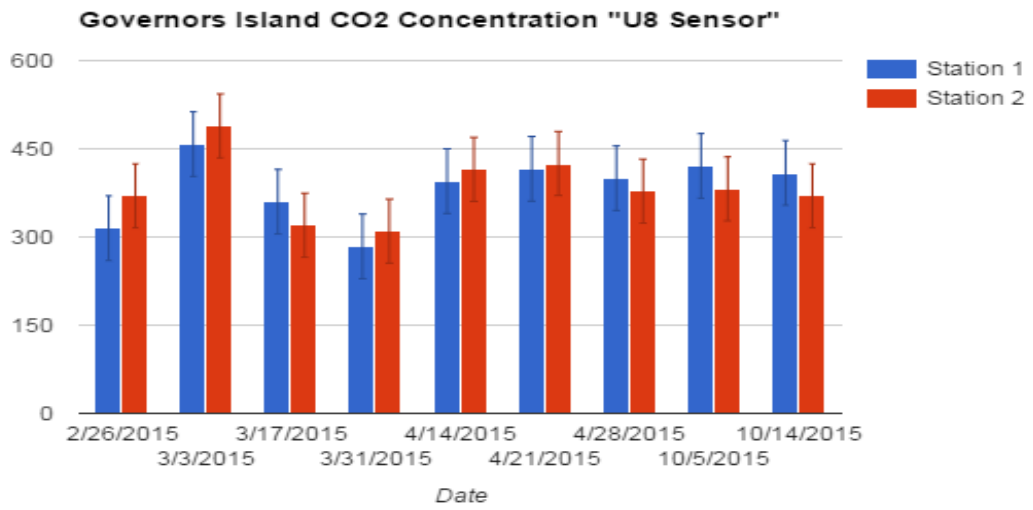

Figure 04. This graph is a visual representation of the data gathered by the "U8" Sensor. The data is relatively similar to that of the "U6" Sensor in that it starts off normal, but is followed by a number of sudden upsurges. The most notable rise occurred on March 3rd, that sample day recorded the highest CO2 concentration level throughout the whole project. Like the "U6 Sensor", there are minor differences in the data gathered in the two test sites.

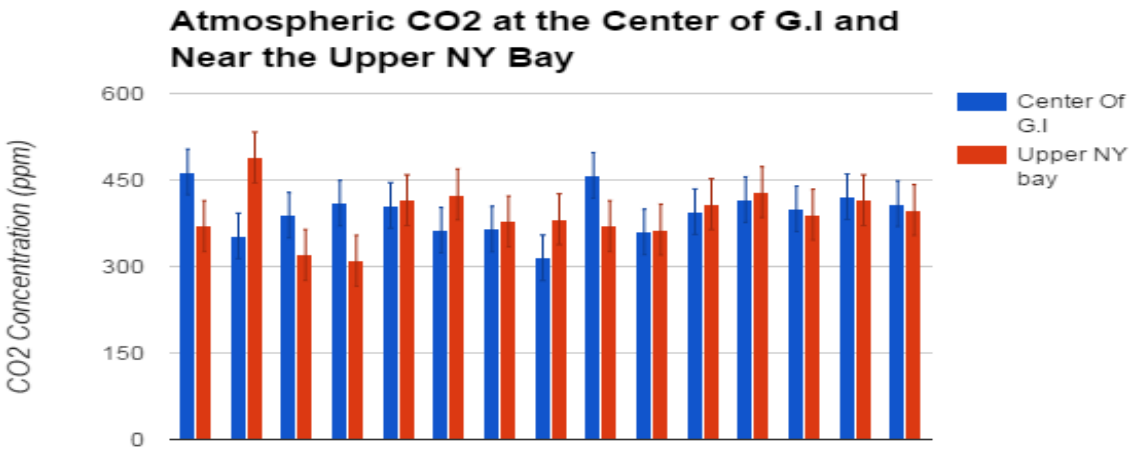

Figure 05. shows a visual illustration of both stations on Governors Island. There were a couple of outliers that were omitted from the graph, but there is still enough data to actually note the differences in data,

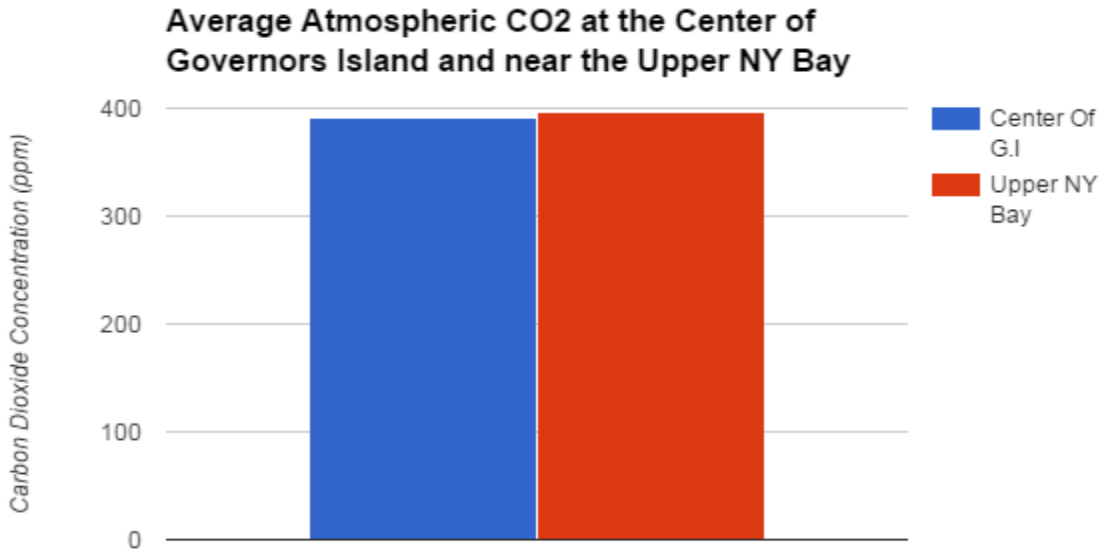

Figure 06. The graph above shows the average concentration from both stations on Governors Island. Easily, it is seen that both stations have similar means. Station 1, the center of Governors Island had an average mean of about 395 ppm, and Station 2, Upper NY bay had a close 391 ppm.

Analysis/ Discussion:

In the results, there were a substantial amount of noticeable changes in the amount of Carbon Dioxide throughout the year. In the beginning months of the project, levels were at very low levels, but soon there were instances where the amount of CO2 would reach high levels such as 480-500 ppm. They may simply have been outliers in the data sets. After that, the Carbon concentration seemed to remain stable and constant. The rest of the data remained consistent in the 380-400 range.

The readings between the two stations differed quite a bit too. There were many instances in the data where the Carbon measurements were higher in Station 2. However, there were also a

number of sampling dates that noted the center of G.I to have higher readings. The original hypothesis was that Station 2, the sampling site that is near the Upper NY bay was going to have a higher CO2 concentration. A t-test was conducted to test for a significant difference between the two sites, and to provide a quantitative and statistical response. By the end of the T-test, the derived T= 0.162 was lower the critical value of T= 1.701 at a p =.05 with df = 26. In other words, the null hypothesis was supported and it's concluded that the mean Carbon dioxide concentration of the center of G.I (397.428) was not significantly different than the average concentration at the coast near the Upper NY bay (395.642). T (26) = 0.162, p< .05. To address one of the key objectives of this project, it seems as though the Carbon Dioxide concentration recorded near the Upper NY Bay seemed higher than the concentration at the Center of Governors Island at times, however it was not significantly different

The main problem in this paper was the question of exactly how atmospheric CO2 changed over a specific period of time. As you can see from the graphs, the entirety of the year was not able to be recorded. This is one of the issues that is going to improve in for the future. However, some interesting information was able to come out of the data that was gathered. It is that many of the monthly average CO2 concentrations seem to have been relatively similar. This could be classified as instrument error which is why a second instrument was used to record data. A series of T-tests were then used to determine any significant difference between both instruments that were utilized. T-Tests were used to compare data collected by each instrument at individual stations.

In the first T-test at the center of Governors Island the derived T= 1.46 and ended up being lower than the Critical T= 1.761 at p= .05 with d(f)= 16, meaning that the null hypothesis that both instruments had no significant difference was supported and that the mean CO2

concentration for the U6 sensor at station 1 (368.66 ppm) had no significant difference to the U8 sensors mean CO2 concentration (384.22 ppm).

Similarly at the coast of Governors Island, the derived T= .563 and was lower than the critical T= 1.746 at p=.05 with df= 16, which again supported the null hypothesis that both instrument's had no significant difference and the mean of the U6 sensor at station 2 (384.3 ppm) is not significantly different from the U8 sensor's mean (390.4 ppm).

Conclusion:

The amount of carbon dioxide being released into the atmosphere has become a matter of great concern. The primary objective of this project was to get a clear understanding of the way carbon fluctuates over the span of a year. An entire year's worth of data was no able to be recorded, but it was still enough to see that the CO2 didn't change much from data from the past. Another objective for this project was to determine if there was a significant difference in CO2 concentrations in two geographically distinct places in Governors Island. Based on the results, it is a 95% certainty that both the station in the center of Governors Island and the station at the coast had no significant difference.

The results from the T-test taken did not support the original hypothesis of this paper which predicted that the Station at the center of Governors Island would hold a higher concentration. This means that both stations had statistically similar data, and actually reinforces it. Both stations having average CO2 concentrations between 395-400 ppm shows how high these levels are. One thing to note that was interesting was that there were a few times where Station 1 had a higher CO2 concentration even though it is an area that has a high quantity of vegetation. It could have simply been machine error, but the t-test provided enough evidence to suggest that these differences in data were not significant. The main problem this project tackled

was exactly how CO2 levels change throughout a specific time period. Although some readings may be of by a specific margin, the readings on this paper does indicate that levels have passed what are considered to be dangerous, bringing the Earth even closer to the irreversible effects of Global Warming. The results shows that CO2 has remained relatively stable. In some cases, the monthly average had marginally gone over the 400 ppm mark but declined soon enough. However, both levels still convey a high CO2 concentration, levels that are higher than before.

A call for action is necessary at this point, in which people strive to reduce the amount of greenhouse gasses being released by humans, and to help prevent Climate change by stopping the acts of deforestation, usage of fossil fuels, etc. The world is treading in a dangerous territory as it has measured CO2 levels that have not been reached for thousands of years.

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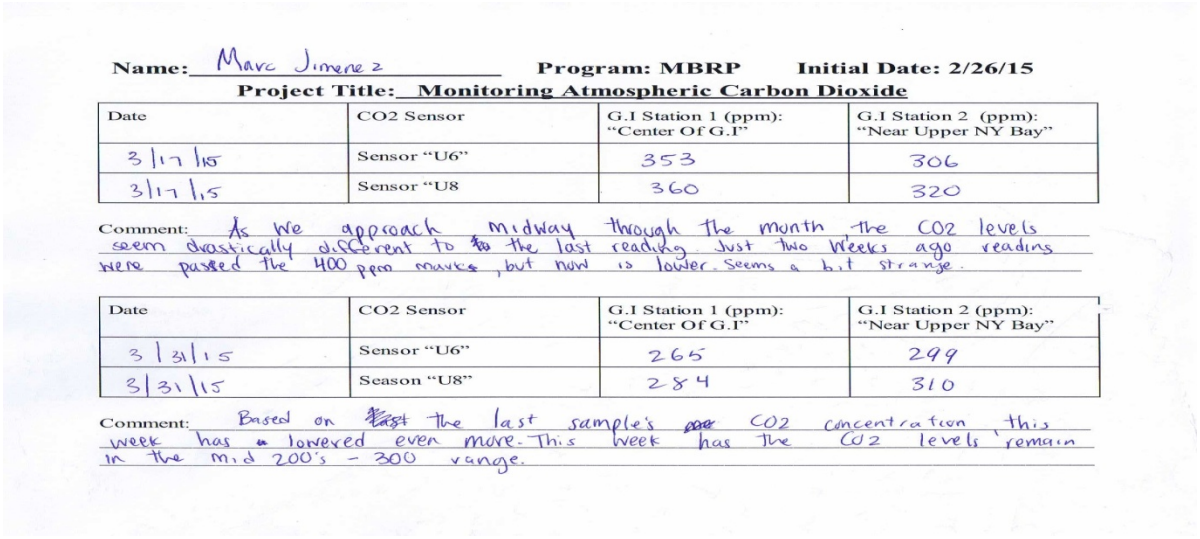
Suggestions For Improvement:

For improvement on similar research in the future, there are a few things to advise. For one, take samples on a weekly basis. This will not only provide you with more than enough data points, but will help you better detect a significant difference if you were to use a t-test analysis.

In addition, if you are testing for Carbon Dioxide data, be sure to use a more precise instrument. Note, that each instrument may have its own set of percent error. If you are using instruments with a percent error, then be sure to set a baseline to determine if the readings are similar or not. One more thing to note is that the Vernier software has a calibration process that also presented a big limitation in this project. To calibrate the software, you will need to be located outdoors, and do the process listed in the procedures. Of course as to not damage the equipment, you cannot go calibrate or sample in days of bad weather.

Annexes: Data Sheets



Name: Marc Jimenez **Program: MBRP** **Initial Date: 2/26/15**

Project Title: Monitoring Atmospheric Carbon Dioxide

Date	CO2 Sensor	G.I Station 1 (ppm): "Center Of G.I"	G.I Station 2 (ppm): "Near Upper NY Bay"
3/17/15	Sensor "U6"	353	306
3/17/15	Sensor "U8	360	320

Comment: As we approach midway through the month the CO2 levels seem drastically different to the last reading. Just two weeks ago readins were passed the 400 ppm marks, but now is lower. Seems a bit strange.

Date	CO2 Sensor	G.I Station 1 (ppm): "Center Of G.I"	G.I Station 2 (ppm): "Near Upper NY Bay"
3/31/15	Sensor "U6"	265	299
3/31/15	Season "U8"	284	310

Comment: Based on ~~first~~ the last sample's ~~one~~ CO2 concentration, this week has lowered even more. This week has the CO2 levels remain in the mid 200's - 300 range.