

H₂ Oh No: The Study of Water Vapor

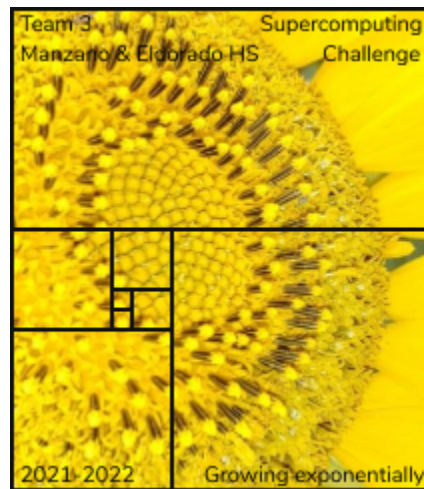
Final Report

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Team 18

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New Mexico Supercomputing Challenge



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Executive Summary

Water vapor contributes to climate change because it is a greenhouse gas, as it absorbs longwave radiation and returns it back to the Earth. Rising atmospheric temperatures evaporate more water from the surface of the Earth, which adds more water vapor to the atmosphere, in turn increasing atmospheric temperatures. In this project, we examined the relationship between the amount of water vapor, temperature, and altitude in the atmosphere.

This project began with an investigation into the major factors that contribute to the increase in water vapor. To do this the relative humidity equation, $\phi = \frac{P_{H_2O}}{P^*_{H_2O}}$, was used to figure out how much water vapor there was in every area in percentage wise. If we found out where the locations provided the most water vapor it could be used to grasp a better understanding of what are the major factors that are affecting water vapor. A Python simulation would then provide the user the ability to change certain variables and get the perfect environment where water vapor is at exactly 30%, that is the ideal amount (Lisbdnet). This could provide certain people with the help that they need to see how much water vapor is affecting the world and what they could do to change that outcome and reduce the feedback loop. In addition, we programmed a BME 680 sensor for an Adafruit microcontroller to detect humidity and temperature that would be needed in the relative humidity equation. This sensor was attached to a drone that can fly into the atmosphere and collect data, but this failed to garner results. The project moved on into phase 2, the Python simulation where a user can change variables to examine the relationship among altitude, humidity, and temperature. Since the sensor did not gather results, data was then scraped from WunderMap, which showed that water vapor concentrates in lower altitudes and in areas of higher population. It also leads us to believe that population factors, such as the presence of factories, affect the water vapor in an area.

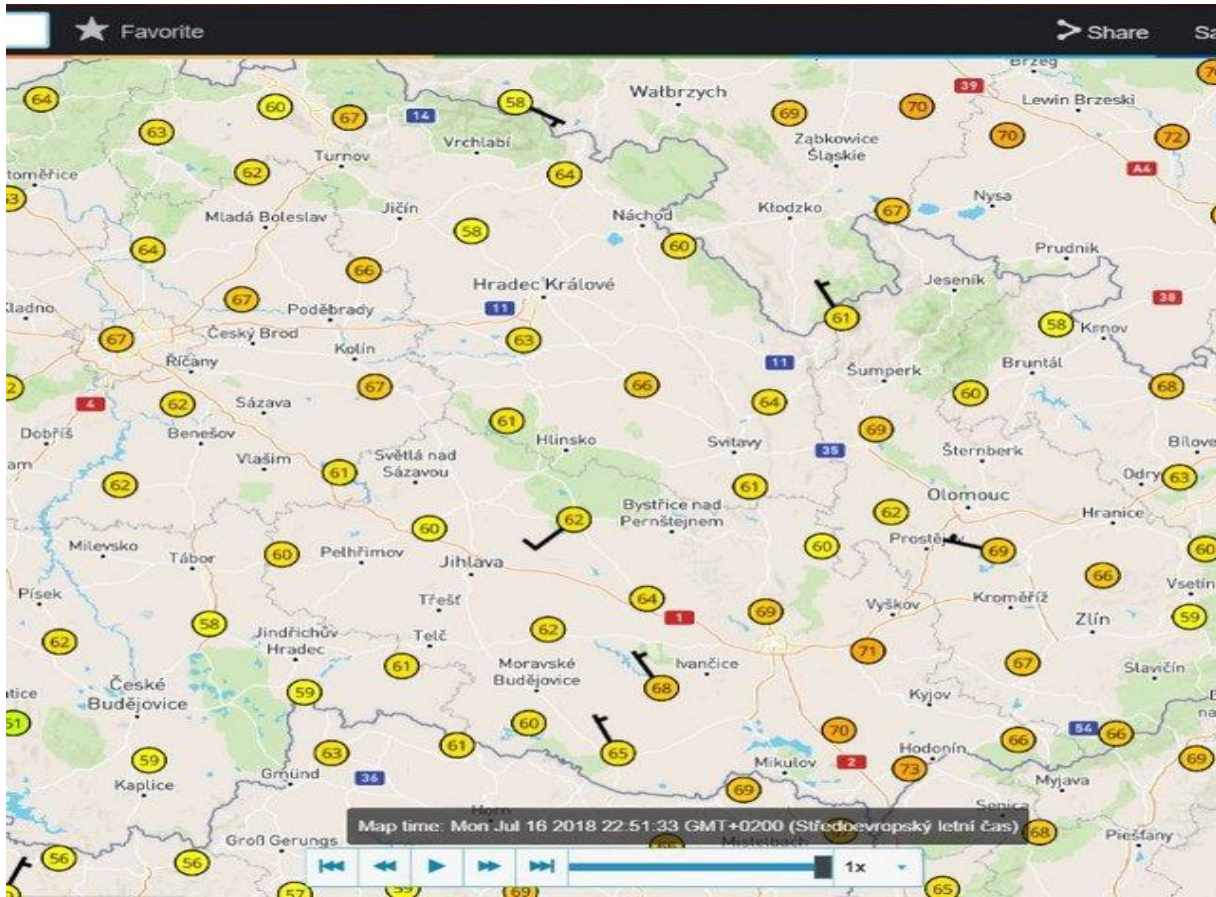
Introduction

In this investigation, we created a Python simulation to model how different environments affect the quantity of water vapor in the atmosphere and how that contributes to the greenhouse effect and global warming. We specifically focused on collecting temperature, humidity, and altitude data to incorporate these as sliders into our Python simulation. We then graphed these results to look for patterns in relationships among the three.

Background

Water vapor exists in all forms on the Earth; water evaporates from the surface of the Earth and exists as a gas (vapor) in the atmosphere. Once water vapor is in the atmosphere it starts to trap in infrared waves that, in turn, heat the surface of the Earth that helps to heat the surface of the planet. In our model, we used the relative humidity equation to find humidity in the atmosphere (Habay). The relative humidity equation is $\Phi = \frac{PH_2O}{P^*H_2O}$, where the relative humidity is (ϕ) equals the partial pressure of water vapor (PH_2O) over equilibrium vapor pressure of water (P^*H_2O). We applied this equation to figure out the humidity in the atmosphere. The environment also affects how much water vapor is in the atmosphere. If the altitude is low, then there is more water vapor in the atmosphere, and when the altitude is higher there is less water vapor since they are closer to the stratosphere. To be able to gather data on water vapor, an interactive weather map, Wundermap, was used. Wundermap is a website where people add a weather station to their houses that collect data from that environment that then is added to the wundermap website for everyone to be able to see and use. You can see an example of the website on Figure 1.

Figure 1: WunderMap. Available at <https://www.wunderground.com/wundermap>



The data collected from the website was then added into the relative humidity equation to calculate the water vapor in our spreadsheet, $\Phi = \frac{PH_2O}{P^*H_2O}$. At the beginning of the project, the plan was to use a sensor to collect data and compare it to WunderMap, and if the data was supported, we would collect data from different environments. We used a BME 680 sensor for an Adafruit Circuit Playground Express that is able to collect humidity, temperature, and pressure that is shown in Figure 2.

Figure 2: BME 680 temperature, humidity, and pressure sensor. Available at

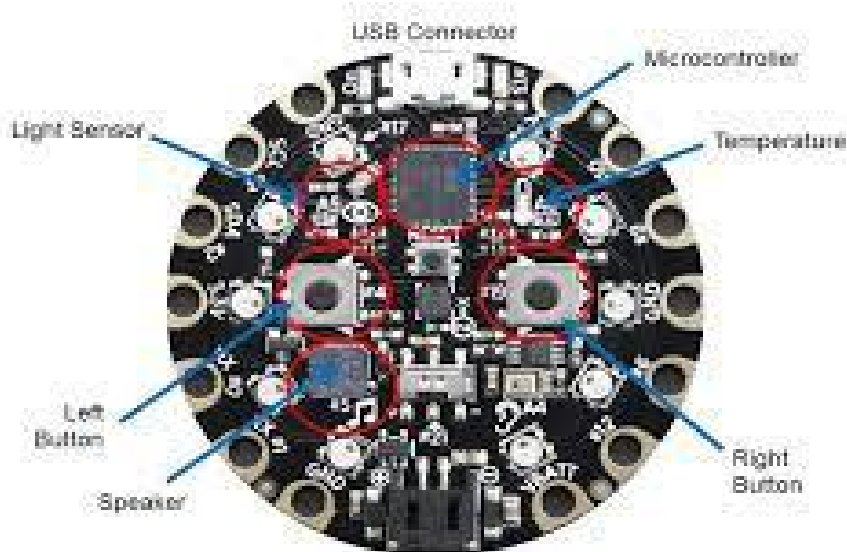
<https://www.adafruit.com/product/3660>



We used an Adafruit Circuit Playground Express as the microcontroller to run the sensor as you can see in Figure 3.

Figure 3: Adafruit Circuit Playground Express. Available at

<https://www.adafruit.com/product/3333>



Methods

We began by trying to collect our own data through the Adafruit Circuit Playground that would power the BME 680 and save the data into itself. This sensor and microcontroller were attached to a DJI Mini drone that could fly up to 6 miles into the atmosphere. . We got our drone running; however, there were technical difficulties through this route as the microcontroller did not save any of the data; rather, it kept deleting it. We made multiple attempts in using the website and followed their instructions to the letter, but the microcontroller would not work no matter what we tried. We then moved onto the simulation, phase two, of our project and simply scraped some atmospheric data from WunderMap, but the code that was used as an example needed the BME 680 sensor to be working to make the simulation run. Since the sensor was not working we had to start from scratch and remake a program that was unfinished due to lack of time. However, we were able to analyze our WunderMap data by making some graphs.

Data

In order to have data to feed into our model, we collected weather station data from WunderMap Interactive. The following Table shows a sample of data that we collected and put into our climate simulation.

Table 1: Atmospheric conditions across various cities

Place	Altitude Ft.	Temperature F°	Humidity %	Barometric Pressure (in)
Montgomery, AL	240	65	92%	29.68
Juneau, AK	56	39	82%	29.82
Phoenix, AZ	1086	80	26%	29.77
Little Rock, AR	335	71	64%	29.87
Sacramento, CA	30	61	36%	30.06
Denver, CO	5279	47	49%	29.56
Hartford, CT	59	59	33%	29.91
Dover, DE	30	54	70%	29.97
Tallahassee, FL	203	78	83%	29.93
Atlanta, GA	738	56	23%	29.99
Honolulu, HI	19	74	60%	30.09
Boise, ID	2730	43	43%	29.78
Springfield, IL	584	47	74%	29.89
Indianapolis, IN	719	55	79%	29.79
Des Moines, IA	955	51	65%	29.78
Topeka, KS	945	65	36%	29.79
Frankfort, KY	509	55	89%	30.13
Baton Rouge, LA	56	69	48%	29.78
Augusta, ME	68	57	22%	29.8
Anapolis, MD	39	52	69%	29.99
Boston, MA	141	56	35%	29.77
Lansing, MI	860	51	81%	30.04
Saint Paul, MN	795	38	61%	29.83
Jackson, MS	279	70	69%	29.94
Jefferson City, MO	630	68	35%	30.04
Helena, MT	3875	37	43%	29.85
Lincoln, NE	1176	54	28%	29.75
Carson City, NV	4802	56	19%	30.05
Concord, NH	288	58	23%	29.83
Trenton, NJ	49	57	47%	30.03
Santa Fe, NM	7199	61	17%	30.04

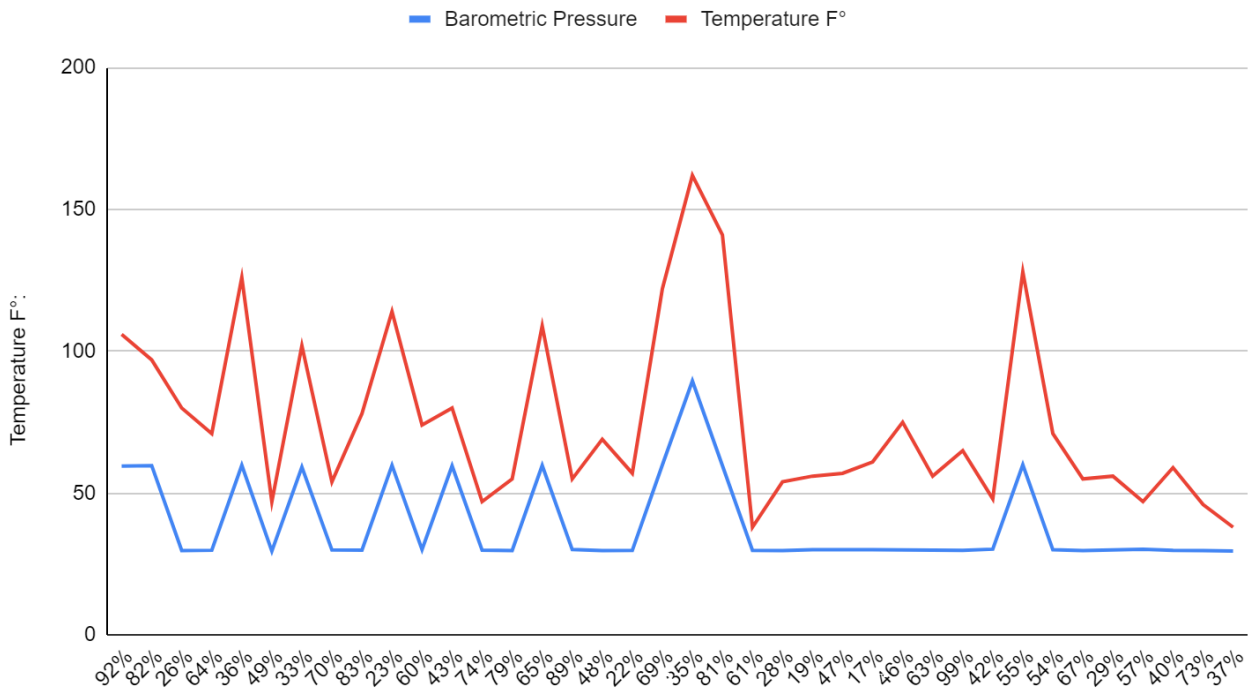
Albany, NY	141	58	82%	29.9
Raleigh, NC	315	75	46%	29.97
Bismark, ND	1686	41	92%	29.84
Columbus, OH	902	56	63%	29.89
Oklahoma City, OK	1198	65	99%	29.85
Salem, OR	154	48	42%	30.25
Harrisburg, PA	322	58	65%	30
Providence, RI	75	59	55%	30
Columbia, SC	292	71	54%	30.05
Peirre, SD	1453	43	33%	29.28
Nashville, TN	597	55	67%	29.77
Austin, TX	489	90	81%	29.65
Salt Lake City, UT	4226	38	35%	29.74
Montpelier, VT	525	56	29%	29.99
Richmond, VA	166	69	55%	30
Olympia, WA	95	47	57%	30.22
Charleston, WV	597	59	40%	29.87
Madison, WI	873	46	73%	29.77
Cheyenne, WY	6063	38	37%	29.57

Analysis

At first our data seemed to show that there was no correlation among altitude, humidity, temperature, and pressure. Although this data showed similarities, the humidity seemed unrelated until the equation was put into effect (in column four of Table 1 above). Then, the relative humidity matched up with our dewpoint and temperature data point, which then could be traced back to our air pressure measurements. After further examination we saw that the barometric pressure and the temperature had the same patterns. You can see this information in Figure 4.

Figure 4: Relationship between temperature and pressure at various relative humidities

Temperature F°:



When examining our dataset from WunderMap, it showed that there is consistently more water vapor in lower altitudes. We also noticed that other factors in the environment have greater impacts on water vapor than we initially thought. For example, our WunderMap data also showed that the highest concentrations of water vapor were often located in highly dense areas that also had factories. We infer that CO₂ or some form of pollution, maybe even water, is also a contributor to the addition of water vapor. This is an area that should be further explored in the future.

Our initial goal was to find out what are the major contributors to water vapor. With the data we gathered, we determined this to be areas of lower altitude areas and higher population. If

this project had more time we could have been able to finish the code for the simulation to manipulate these variables and how we could change them to make a dent in global warming and improve the world.

Most Significant Achievement

Even though we did not complete our initial goals, we gained many skills and learned lessons from this project. First, we need to get a head start in ordering parts and equipment, as we unfortunately got a very slow start. We also feel like we should have narrowed down our goals than could be achieved in the given amount of time. Working with the sensor and flying the drone were fun, but we could have achieved much more if we had skipped this and went straight to the WunderMap data to inform our Python climate model. The most significant achievements that we have gained throughout this project is that we gained the ability to code in Javascript, which was new to us, and we gained a deeper understanding of Python.

Acknowledgements

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Appendix A

Adafruit Data Collection Code

```
import time
from rainbowio import colorwheel
from adafruit_circuitplayground import cp

CurrentTemp = 0
MyString = ""

def on_forever():
    global CurrentTemp, MyString
    if input.temperature(TemperatureUnit.FAHRENHEIT) >= 100:
        light.set_all(0xff0000)
    else:
        light.graph(input.temperature(TemperatureUnit.FAHRENHEIT), 100)
    CurrentTemp = input.temperature(TemperatureUnit.FAHRENHEIT)
    MyString = convert_to_text(CurrentTemp)
    storage.append_line("TempLog.txt", MyString)
forever(on_forever)
```