College of Engineering | Department of Biological and Ecological Engineering and Department of Electrical Engineering and Computer Science

EVAPOROMETER: RAIN AND EVAPORATION DATA ANALYSIS

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Abstract

The Evaporometer is a device that uses a scale to measure rainfall and evaporation. Every 5 minutes, it takes dozens of weight measurements and summarizes them in a CSV file. This poster will summarize the process of taking the raw data from the device and analyzing it to gain information about the device and if it was working correctly. The process involved:

- Calculating rainfall, evaporation, siphoning, and the cumulative values for them.
- Graphing the calculations to learn more about how the device interacts with precipitation.
- Solving issues and fluctuations with the data by using different data analysis techniques and data treatment methods.
- Comparing the measurements and data with wind speeds and a rolling standard deviation.
- Summarizing the findings and figuring out how to move forward.

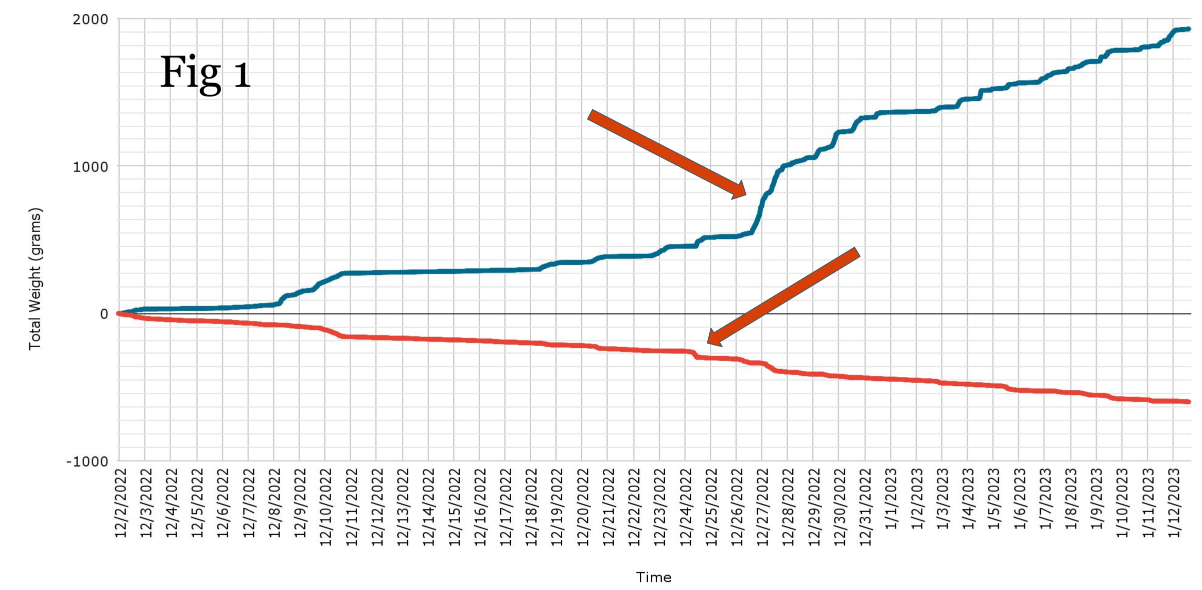
Background

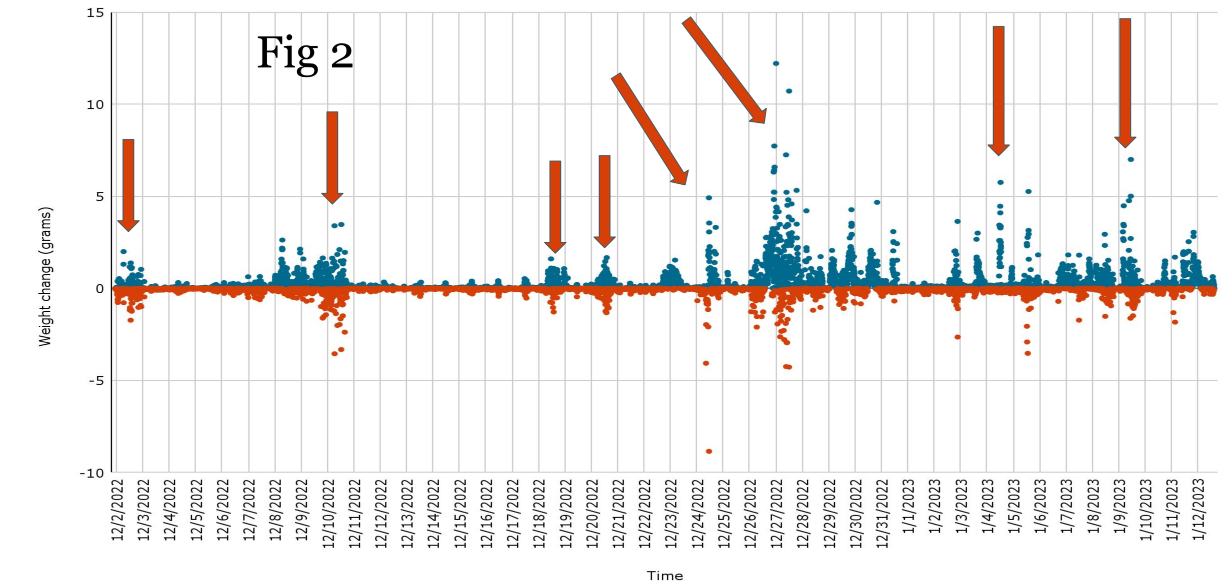
The Evaporometer is crucial to the study of climate and will revolutionize how we measure rainfall and especially evaporation. Currently, our measurements for evaporation at weather stations are a crude method where a pan is filled with water and then left out to see how much will evaporate after a few hours. Instead, the Evaporometer is able to take hundreds of measurements every few minutes, without human intervention, allowing for real-time accurate measurements on whether the water inside of its bucket lessened or greatened. It is also a much cheaper device than others of its type, allowing for a wider spread of usage. By creating this new method to measure evaporation, the Evaporometer will change what we understand of our climate.

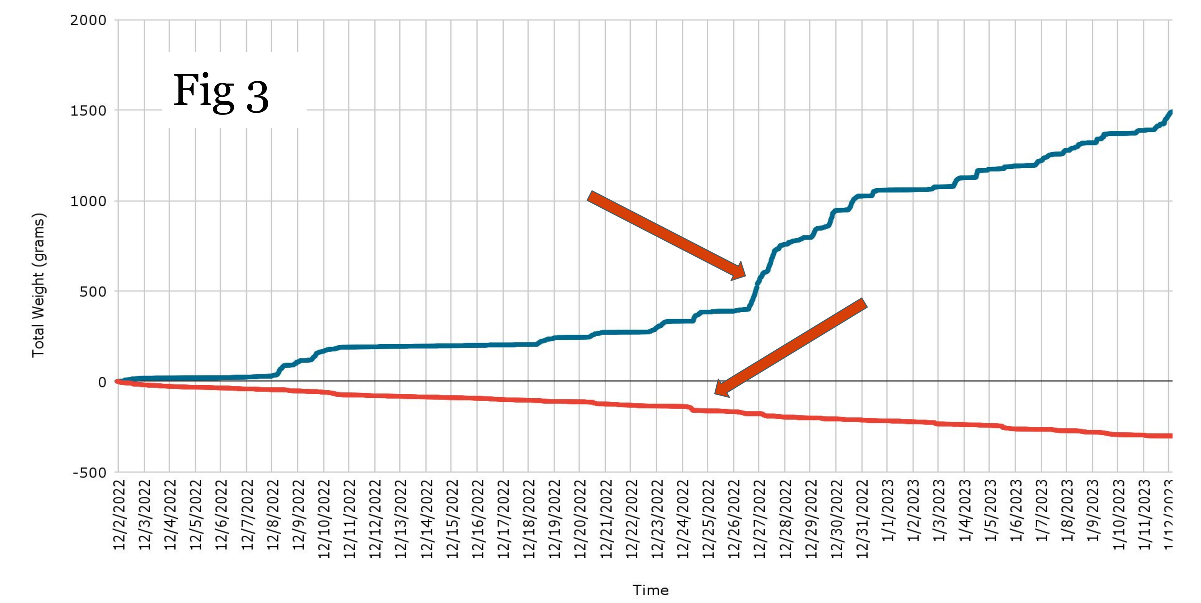
Methodology and Results

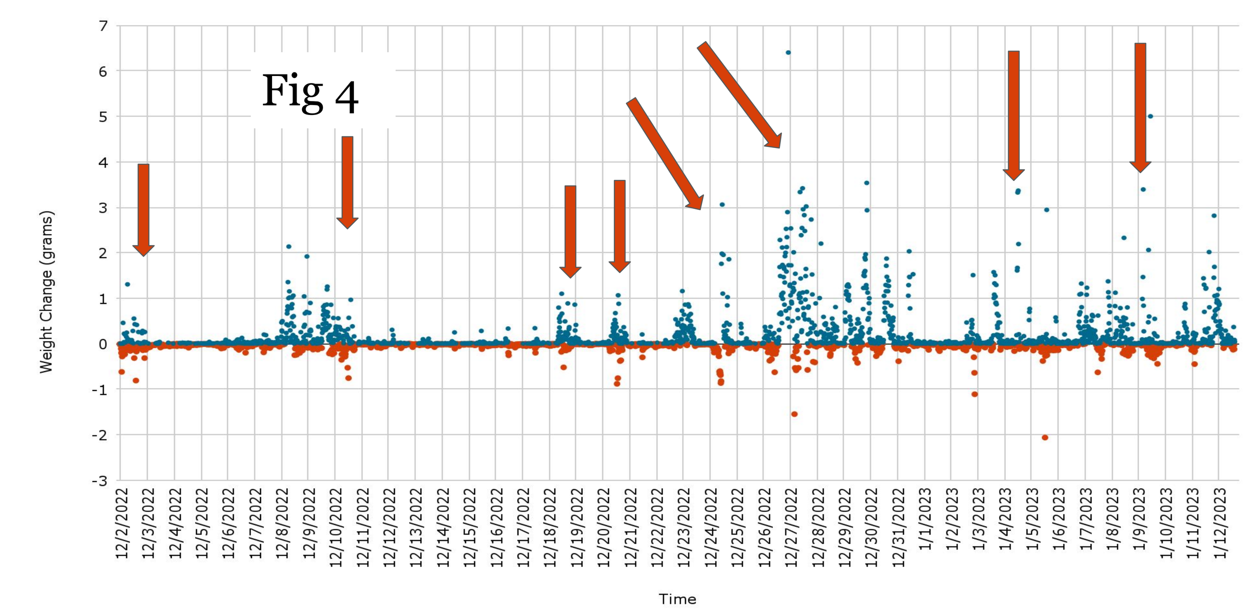
Initially, I had to create an algorithm to calculate rainfall and evaporation. This algorithm would read a CSV file of data from the Evaporometer, which would be weight measurements in grams every 5 minutes, and calculate the difference between minute x and minute x+5. Once this difference was calculated, it would divide by 5, giving the grams per minute and outputting this information in a CSV format, for easy spreadsheet transferring. The algorithm also handles siphoning, where the device rapidly loses weight, trying to empty itself a bit, and it recognizes siphoning versus evaporation by setting a limit of -10 grams for evaporation, with anything larger than that being categorized as siphoning and ignored from any calculations.

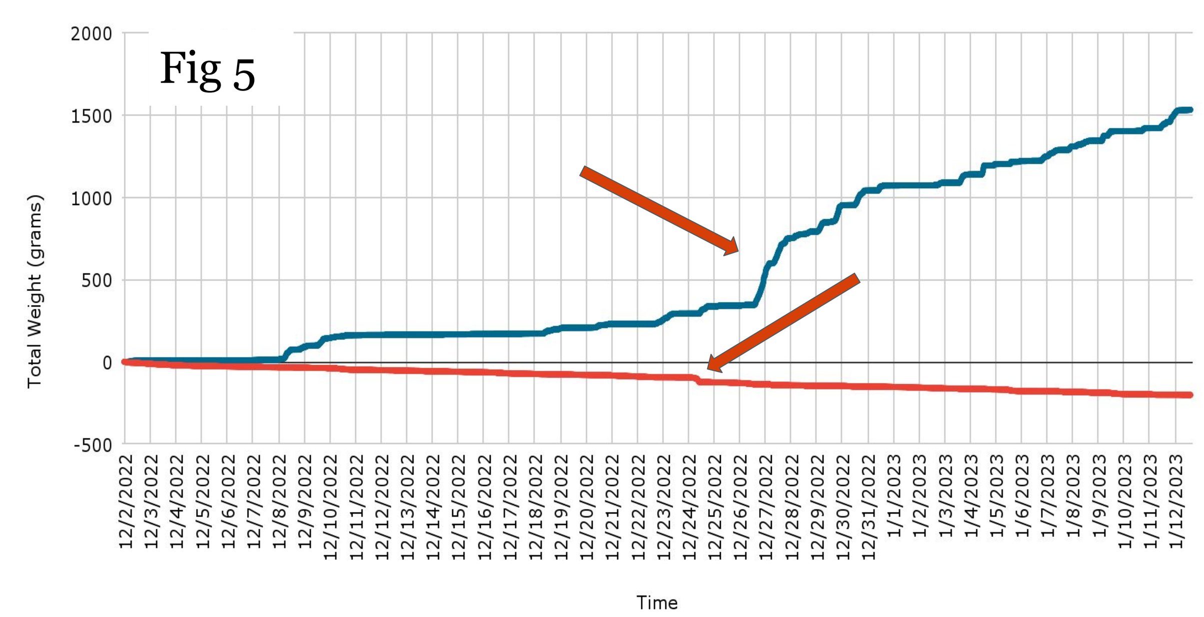
This output was used to create graphs (Figures 1 and 2) that the research group then analyzed. There are a lot of fluctuations in the graphs, as well as rainfall and evaporation rates that should not be possible, such as an evaporation rate of -9 grams in just 5 minutes (Figure 2). To try and smooth the data out and get rid of outliers, I implemented median filtering (Figures 3 and 4). I editing the algorithm to assign the median of every 3 data points as the value for 15 minute intervals. I did this by creating a double for loop that correctly indexes and find the median of every three data points from the Evaporometer. By doing this, we got a massive improvement in spread, with the highest evaporation rate now just being slightly higher that -2 grams per 5 minutes (Figure 4), but we still had massive outliers, such as a rainfall of 6 grams in just 5 minutes (Figure 4). Due to this, we decided to change our data treatment method to the box-car method, which is a rolling mean. I changed the algorithm again so that for 7 data points, it takes the average and assigns this average to the 4th, time interval, then it moves one data point to the right and does the same thing with this new group of 7 data points. To do this, I using a single for loop, improving the time complexity of the algorithm. I would have a variable count up to 7 and track the position of a 2D array storing the data, while doing the box-car method every 7 data points. This rolling mean applied over 35 minute intervals, created a much smoother graph (Figure 5) and much better results, with the highest evaporation being a bit higher than -1.5 grams in 5 minutes and the highest rainfall being a bit higher than 4 grams in 5 minutes (Figure 6). We decided to stick with the box-car methods for future algorithms and instead change the algorithm to figure out what was wrong with the device or its environment.

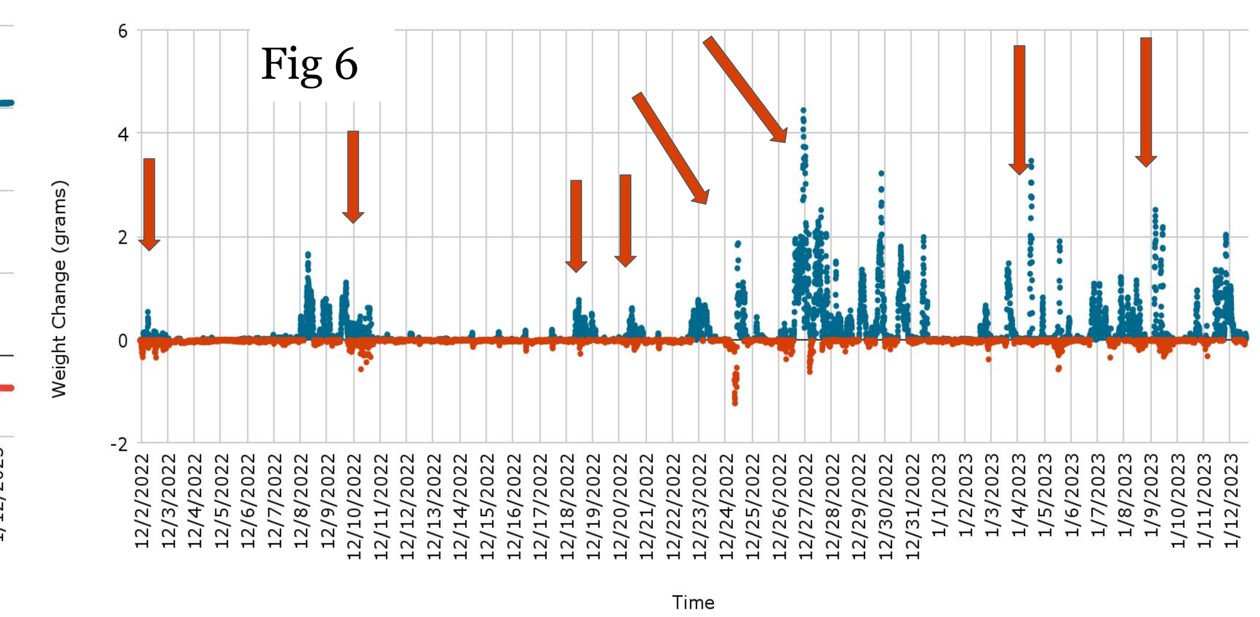


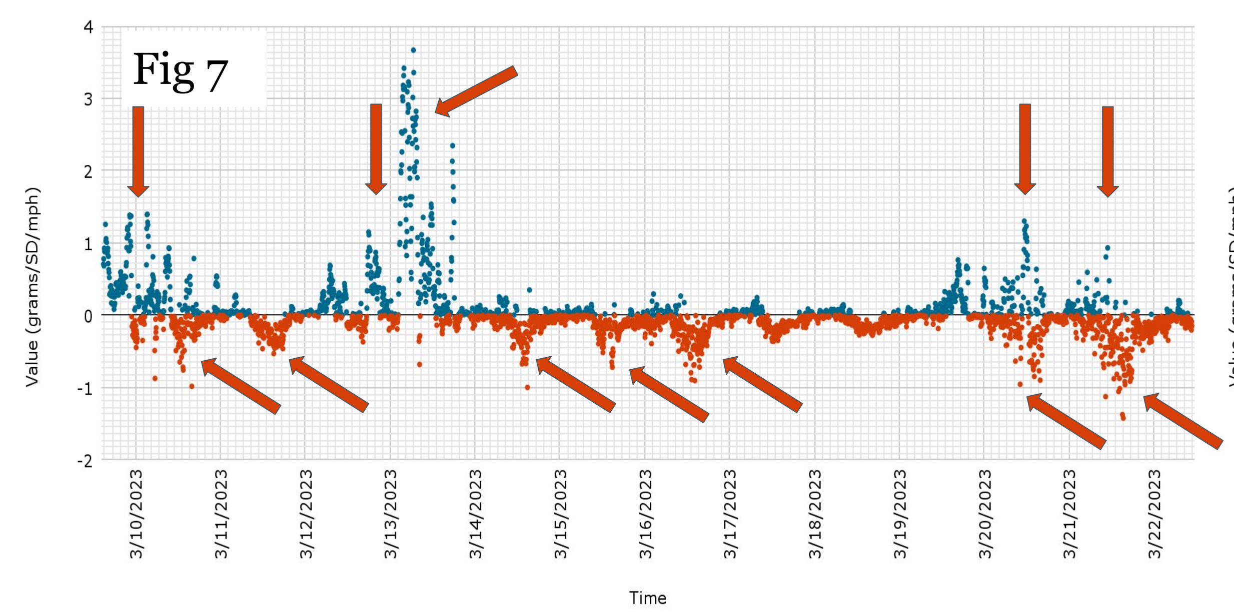


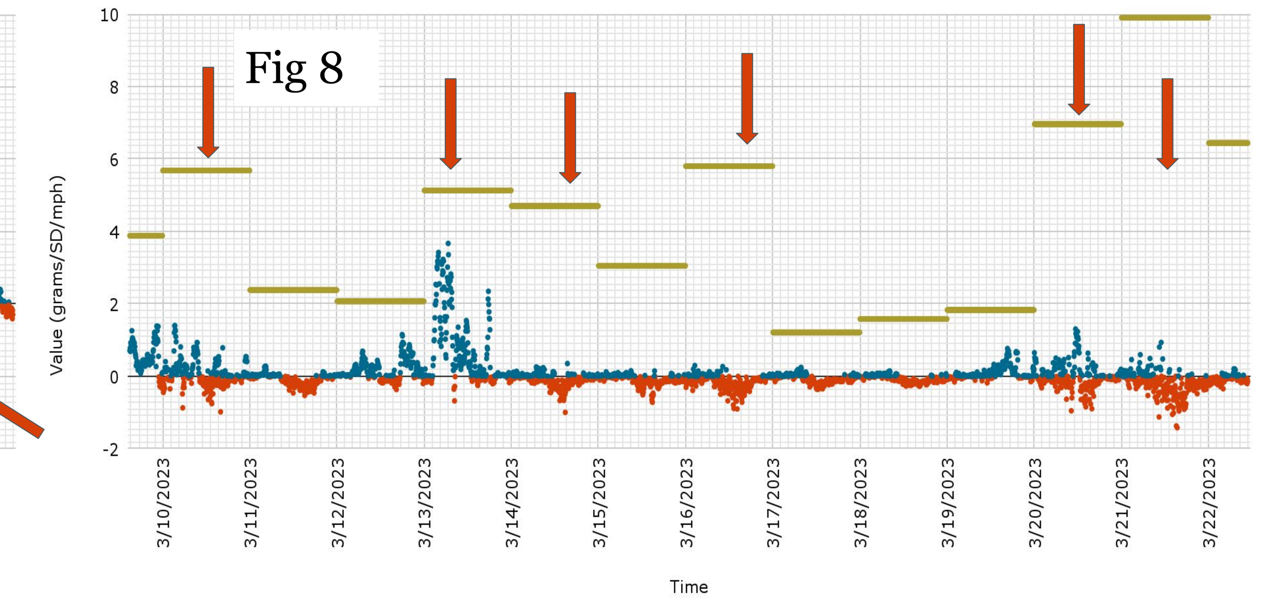


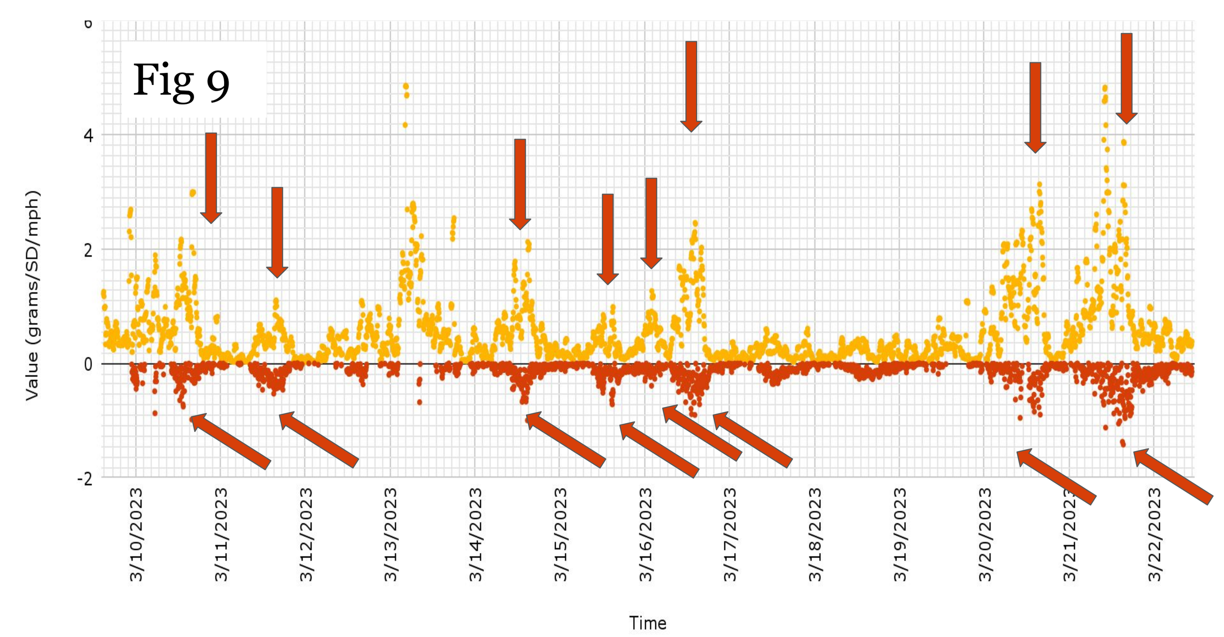


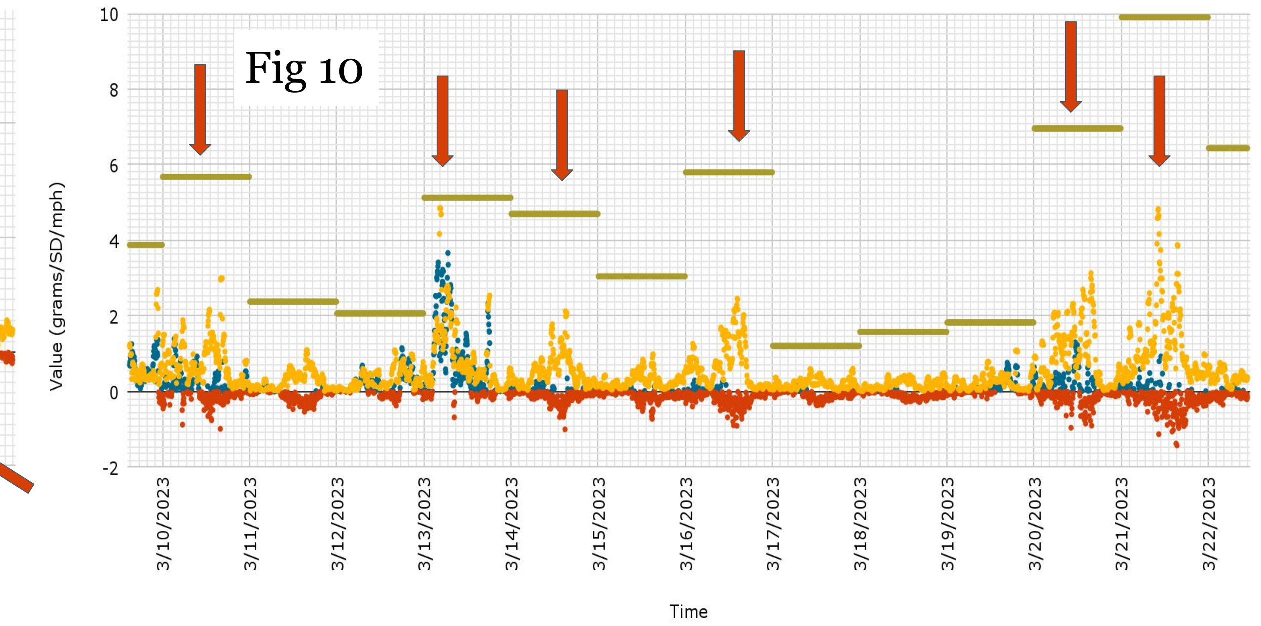












- Rainfall
- Evaporation
- Standard Deviation
- Wind Speed

Discussion

We believed the fluctuations to be caused by wind speed, so I added a part int he algorithm that would calculate rolling standard deviation and daily wind speeds to new data we receive for the month of March. To calculate the rolling standard deviation, I would use the mean from the box-car method to calculate the standard deviation and then assign this value to a cell of an array. For daily wind speed, I used another data file from USBR Pacific Northwest Region Hydromet/AgriMet Data Access and had the algorithm read this file and assign these values into the array.

I changed the algorithm to account for this data and then graphed it (Figures 7, 8, 9, and 10). We found the days with the highest rainfall and evaporation (Figure 7), also had a higher standard deviation (Figure 9) and was associated with higher wind speeds (Figure 8). We also found that when we graphed everything together, we saw a correlation between standard deviation, wind-speed, and higher peaks in our rainfall and evaporation, pointing to wind speed being the culprit (Figure 10).

In the future, we will attempt to both solve the issue with the device and continue to tweak the code to adapt to the wind issue. We hope to create a sustainable and inexpensive device that will be able to be placed in weather stations across the globe and give humanity a better understanding of our climate and precipitation.

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