Wind Induced Pressure Change Inside Structure

PHYS 398 FA18

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Project Focus

Main focus: observe and analyze relationship between wind speed outside of house and pressure change inside the house.

Other factors to consider: temperature, humidity.

Hardware

- BME680 for pressure, temperature, humidity.
- GPS for time information.
- RTC for time information.
- Anemometer for wind speed.

Data Acquisition Program

Snippets of pseudo-code:

```
// Specify the connected pin number on the Arduino board
const int sensor_pin = ##;

// Launch the sensor
sensor.begin(sensor_pin);

// Set operating parameters.
sensor set Setting 1;
sensor set Setting 2;
…

// Exception handling
IF sensor_not_working:
       restart after problem fixed
END IF

Asks the sensor to perform measurement

Save recorded data.
```

Data Acquisition Program

Snippets of pseudo-code:

```
Synchronize RTC and GPS
SET timestamp1
Do the measurement
WRITE RTC hour, minute, second (Synchronized to GPS at the start)
WRITE Arduino time (millisecond)

WHILE current_time - timestamp1 < 100ms
       do nothing and wait
END WHILE
```

Snippets of output file:

```
Data written below has such format:
hour(UTC), minute, second, millisecond
Temperature(°C), pressure(hPa), humidity(%)
Wind speed voltage (0.4V ~ 2V)

20,22,23,0
19.40,996.12,45.67
1.12
…
```

Data Acquisition Program

Initial Problem:

- SD file corruption

Data Taking

Took data at Professor Gollin’s house for approximately one and a half hour.

Total of nine devices.

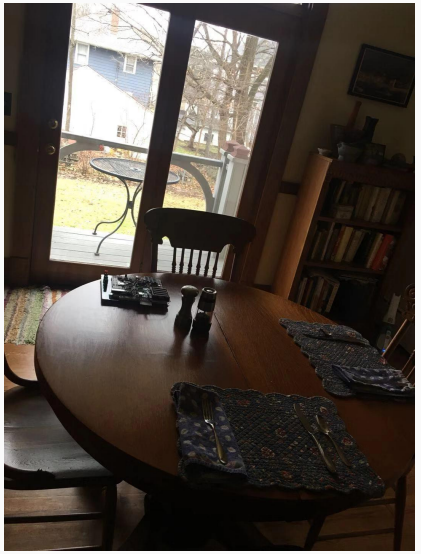
Two devices attached with anemometers placed outside of the house.

Seven devices placed at various locations inside the house.

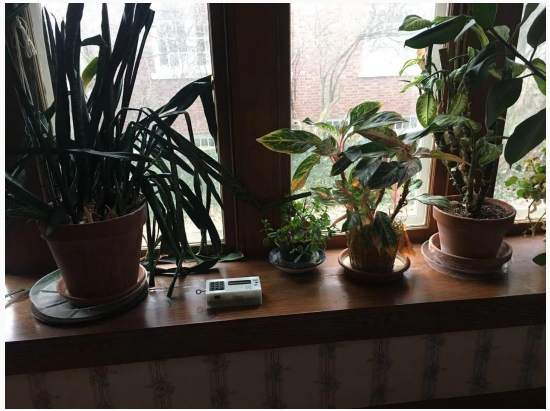
Data Taking

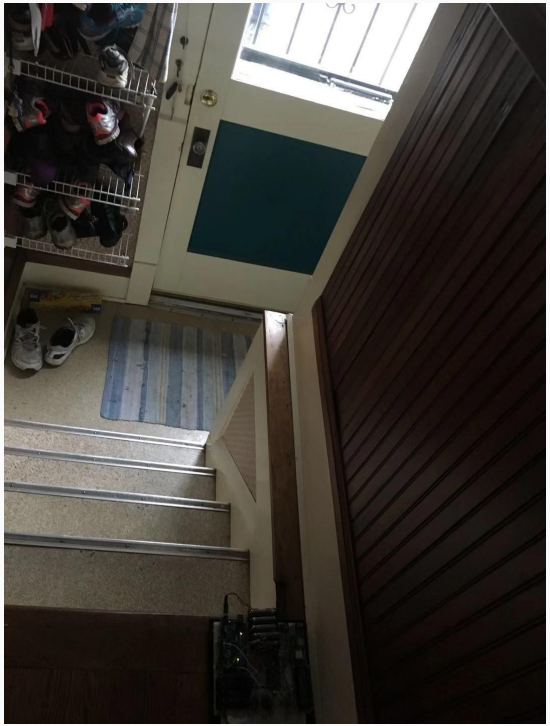
Data Taking

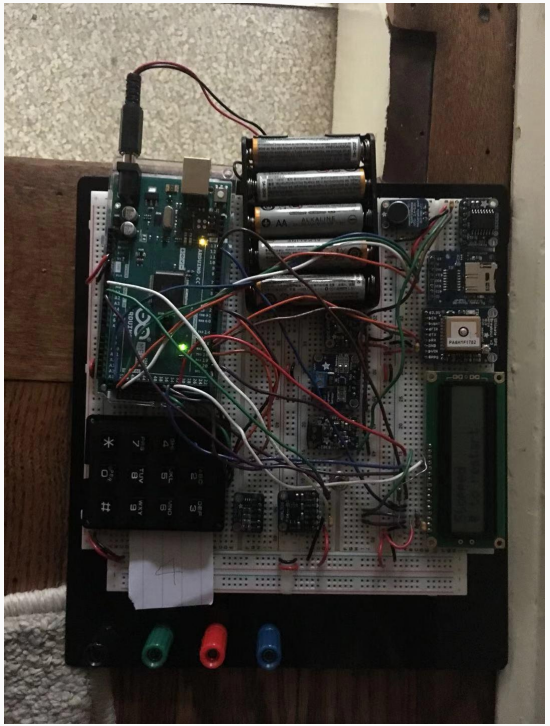
Data Taking



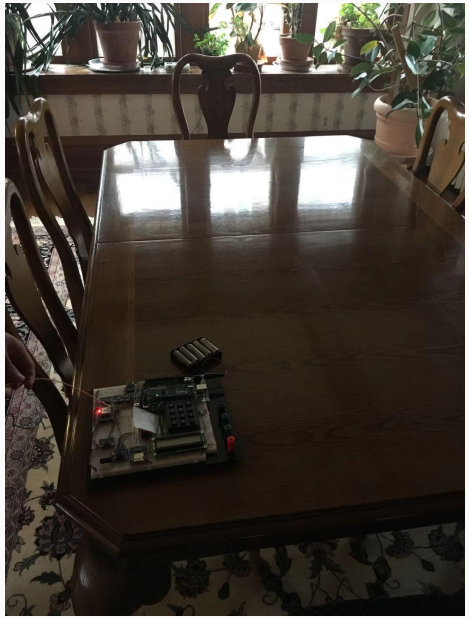
Data Taking

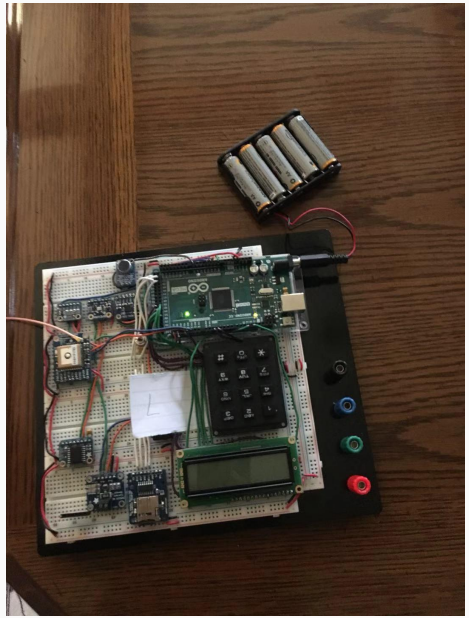




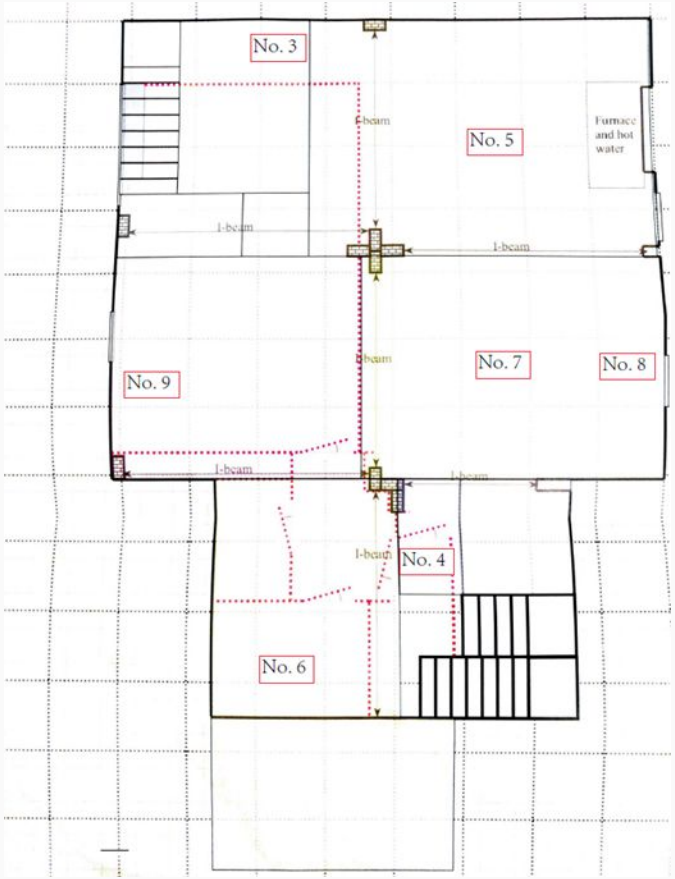


Data Taking





Data Taking



Data Taking

Time	Temperature	Dew Point	Humidity	Wind	Wind Speed	Wind Gust	Pressure
12:53 AM	48 ° F	45 ° F	89 %	SSE	9 mph	0 mph	28.6 in
1:53 AM	48 ° F	44 ° F	86 %	SSE	10 mph	0 mph	28.6 in
2:53 AM	48 ° F	43 ° F	83 %	SSE	17 mph	0 mph	28.6 in
3:53 AM	49 ° F	43 ° F	80 %	S	21 mph	0 mph	28.5 in
4:53 AM	48 ° F	43 ° F	83 %	S	15 mph	0 mph	28.5 in
5:53 AM	48 ° F	43 ° F	83 %	SW	13 mph	0 mph	28.6 in
6:53 AM	44 ° F	37 ° F	76 %	WSW	17 mph	0 mph	28.6 in
7:53 AM	43 ° F	38 ° F	82 %	WSW	12 mph	0 mph	28.6 in
8:53 AM	44 ° F	39 ° F	82 %	SW	15 mph	0 mph	28.6 in
9:07 AM	44 ° F	39 ° F	82 %	WSW	16 mph	0 mph	28.6 in
9:53 AM	43 ° F	38 ° F	82 %	SW	20 mph	0 mph	28.6 in
10:53 AM	43 ° F	36 ° F	76 %	SW	22 mph	0 mph	28.7 in
11:25 AM	41 ° F	38 ° F	89 %	SW	23 mph	30 mph	28.7 in
11:53 AM	42 ° F	38 ° F	85 %	WSW	17 mph	26 mph	28.7 in
12:53 PM	41 ° F	37 ° F	86 %	SW	17 mph	30 mph	28.7 in

Data Analysis

p3988dp_read_audio.py | Data analysis_beta.py | Plot data.py

```
7
8  import numpy as np
9  import pandas as pd
10 import scipy.stats
11 import matplotlib.pyplot as plt
12
13 file_name = 'Calibration_1.txt'
14 file_name_2 = '12_2_No3.txt'
15 file_name_3 = 'Pink Integrated.txt'
16
17 data = pd.read_csv("C:\\Users\\14625\\OneDrive\\Documents\\GitHub\\DataAcquire\\" + file_name, delimiter
18 data_2 = pd.read_csv("C:\\Users\\14625\\OneDrive\\Documents\\GitHub\\DataAcquire\\" + file_name_2, delimi
19 data_3 = pd.read_csv("C:\\Users\\14625\\OneDrive\\Documents\\GitHub\\DataAcquire\\" + file_name_3, delimi
20 data = data.values
21 data_2 = data_2.values
22 data_3 = data_3.values
23 #data_3=np.genfromtxt("C:\\Users\\14625\\OneDrive\\Documents\\GitHub\\DataAcquire\\byTheFronDoor.txt", de
24
25 count = int(len(data)/3)
26 ##-----------------------------------##
27 count_2 = int(len(data_2)/3)
28
29 count_3 = int(len(data_3)/3)
30
31
32 time_hour = np.zeros(count)
33 time_min = np.zeros(count)
34 time_sec = np.zeros(count)
35 time_ms = np.zeros(count)
36 temperature = np.zeros(count)
37 pressure = np.zeros(count)
38 humidity = np.zeros(count)
39 altitude = np.zeros(count)
40 seconds = np.zeros(count)
41 anemometer = np.zeros(count)
42 d_temperature = np.zeros(count)
43 number = np.linspace(1,count,count)
44 ##-----------------------------------------##
45 time_hour_2 = np.zeros(count_2)
46 time_min_2 = np.zeros(count_2)
47 time_sec_2 = np.zeros(count_2)
48 time_ms_2 = np.zeros(count_2)
```

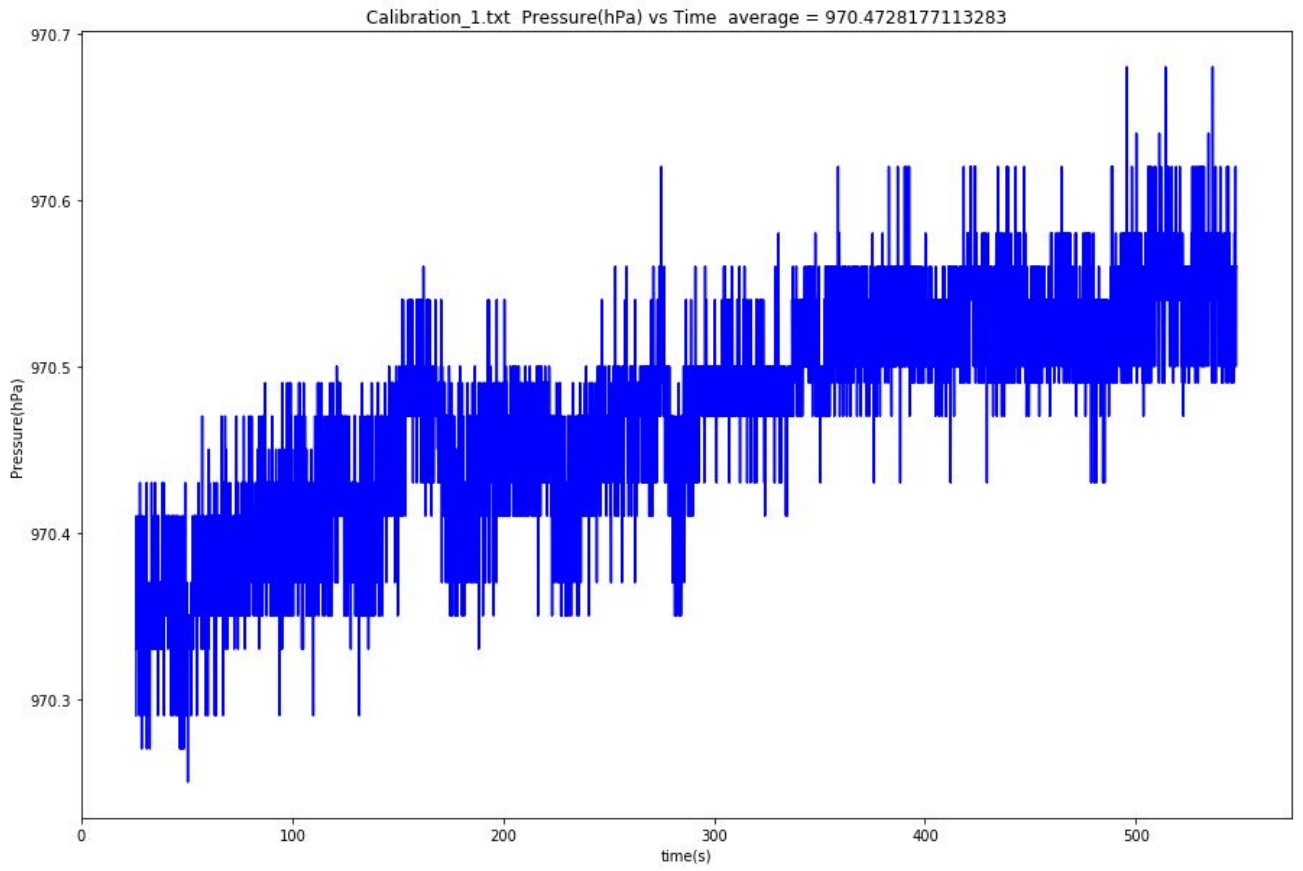
Data Analysis

```
x = pressure_3

y = temperature_3



slope, intercept, r_value, p_value, std_err = scipy.stats.linregress(x, y)
```

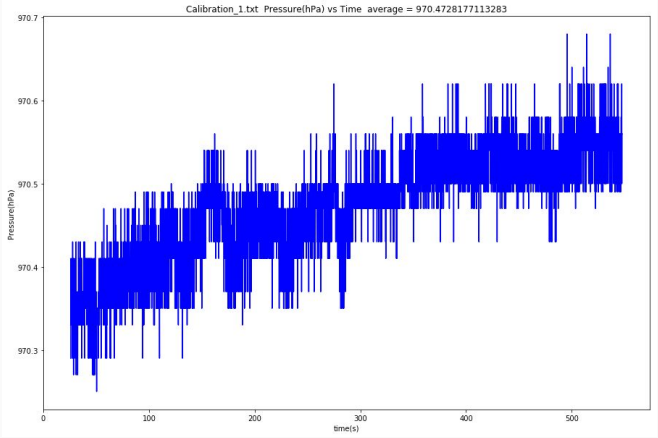
Calibration Graph range

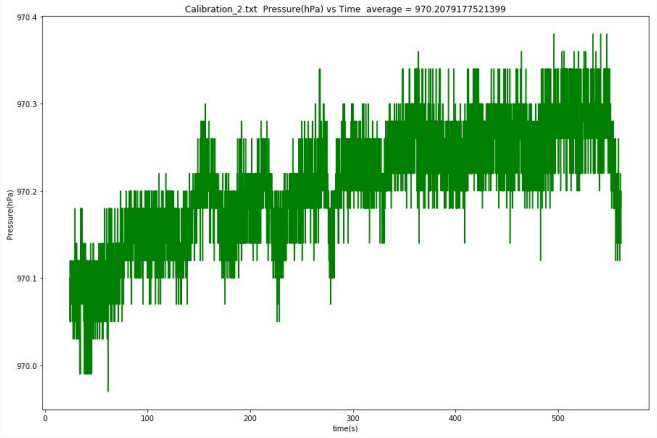
Device	Type	Location	Calibration Temp(Celcius)	Deviation from Avg	Calibration Pressure(hPa)	Deviation from Avg	Calibration Humidity(%)	Deviation from Avg
No.1	Pink Box	Outside West	22.77~22.82	0.4271	970.3~970.6	0.1357	48.6~49.2	0.0071
No.2	Yellow Box	Outside East	23.22~23.40	0.9421	970.0~970.4	-0.1143	48.7~49.6	0.2571
No.3	White Box	Front Door	22.20~22.35	-0.0929	969.8~970.1	-0.3643	51.4~52.8	3.2071
No.4	Bred	Triple Doors	22.22~22.40	-0.0579	969.8~970.2	-0.3143	47.0~48.8	-0.9929
No.5	Bred	Living Room	21.50~21.85	-0.6929	970.3~970.8	0.2357	42.7~44.7	-5.1929
No.6	Bred	Kitchen	22.25~22.45	-0.0179	970.0~970.4	-0.1143	48.0~50.2	0.2071
No.7	Bred	Dining Room	21.77~21.95	-0.5079	970.7~971.0	0.5357	50.6~52.2	2.5071
No.8	Red Box	Piano	N/A		N/A		N/A	
No.9	Transluscent Box	Plants	N/A		N/A		N/A	
Avg			22.3679		970.3143		48.8929	

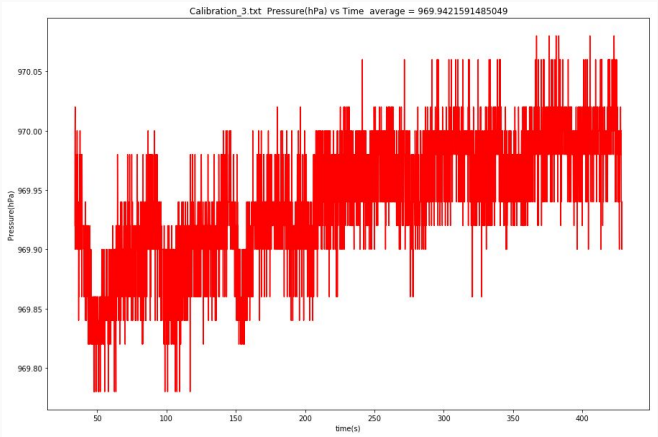
Plotting Example

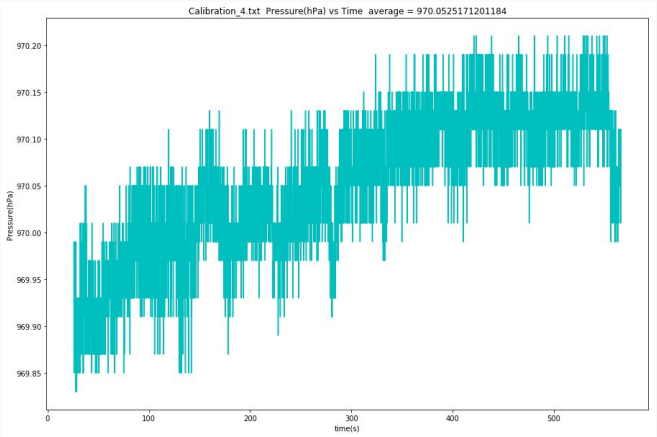


Pressure Calibration

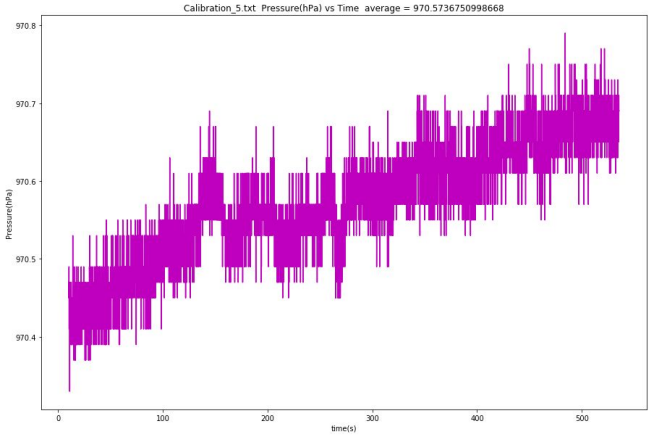


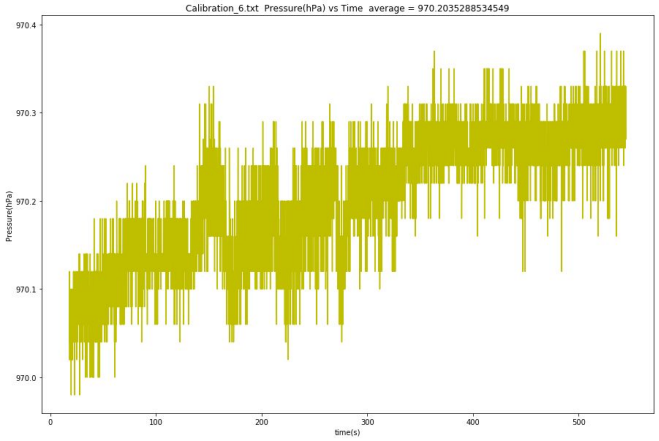


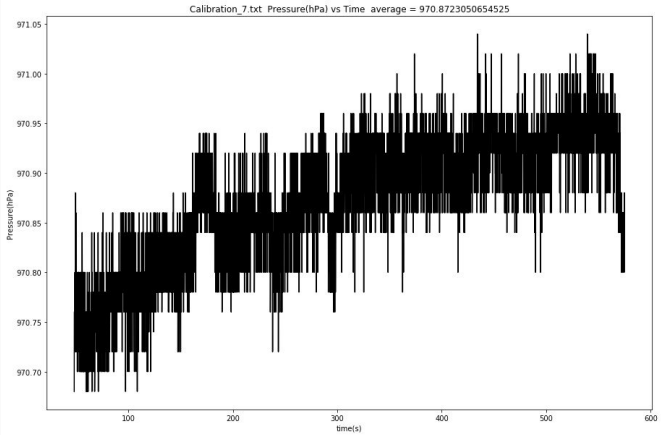




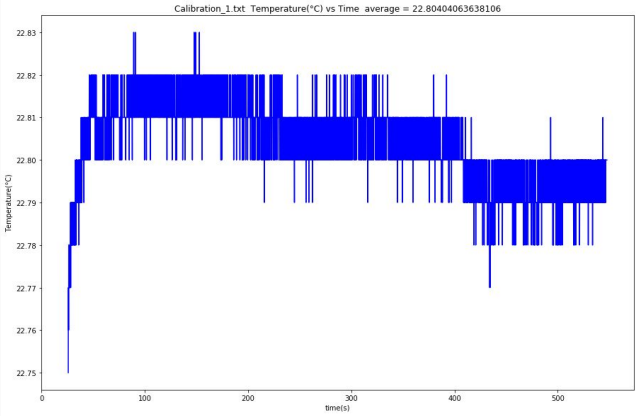
Pressure Calibration

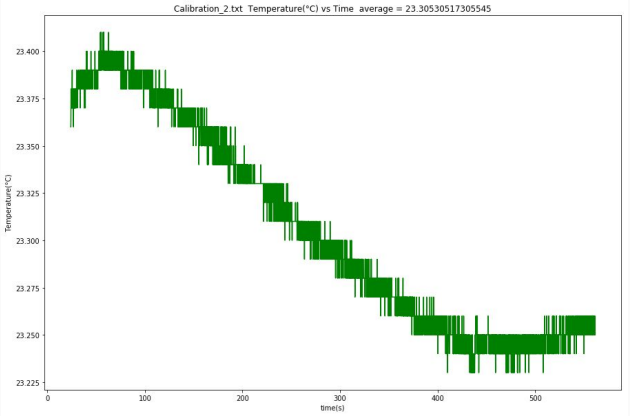


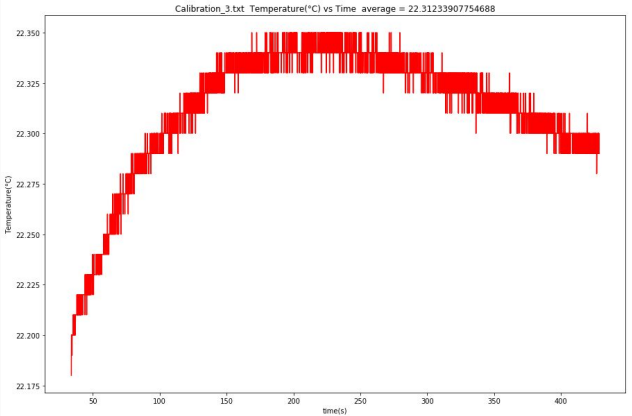


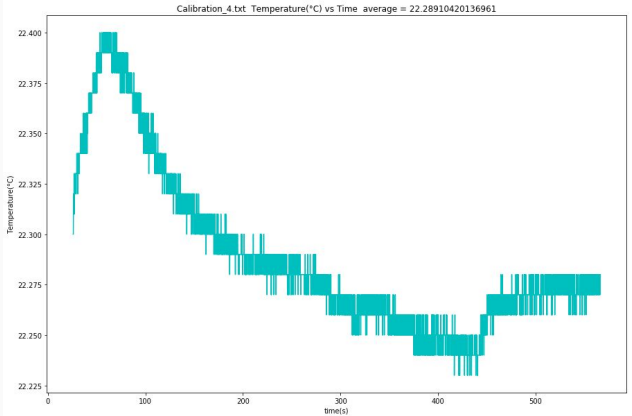


Temperature Calibration

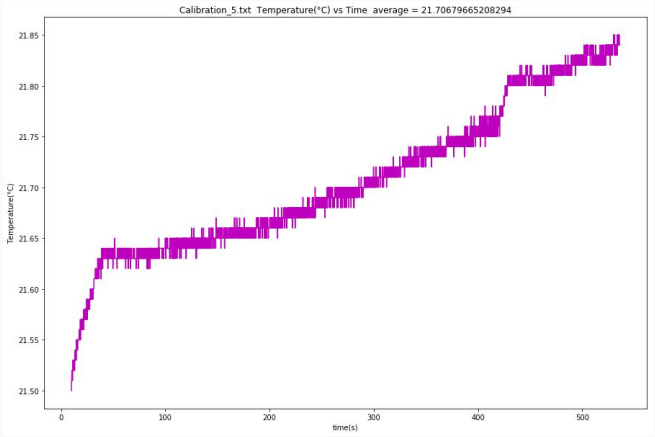


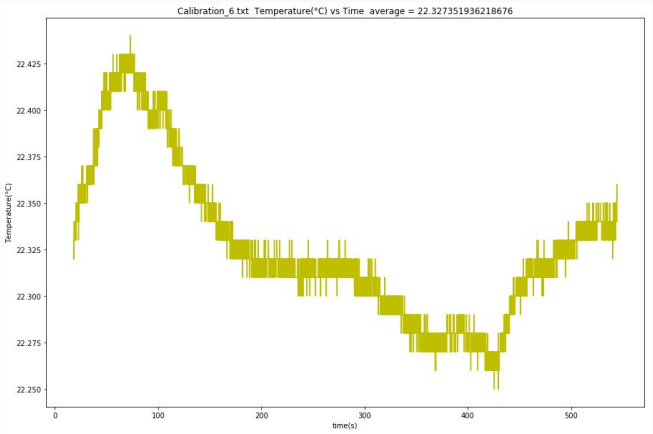


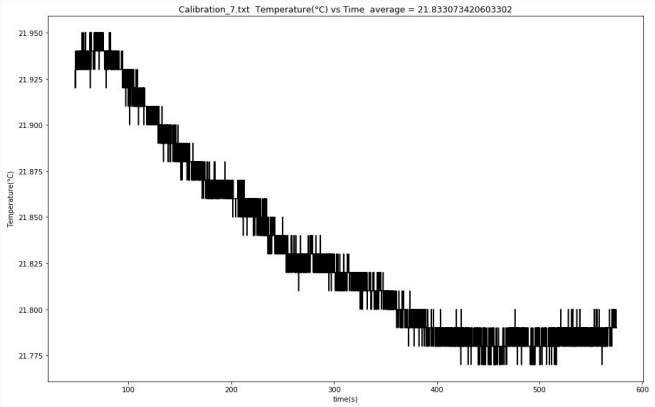




Temperature Calibration



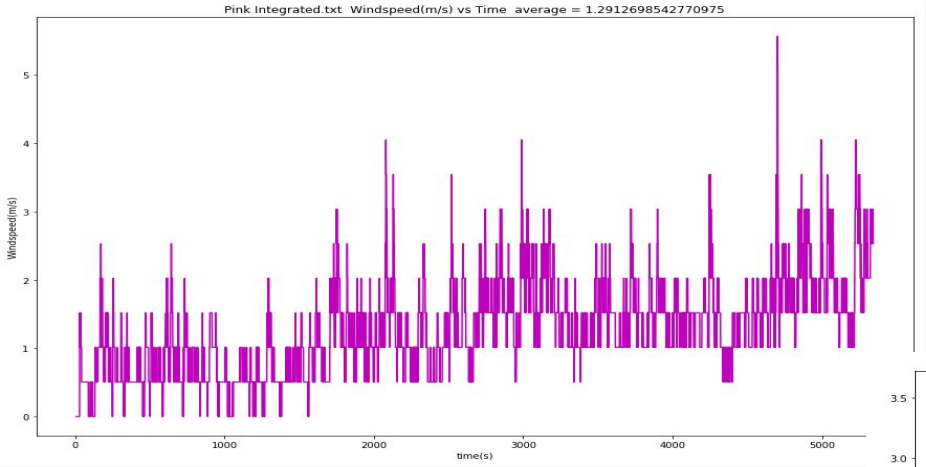


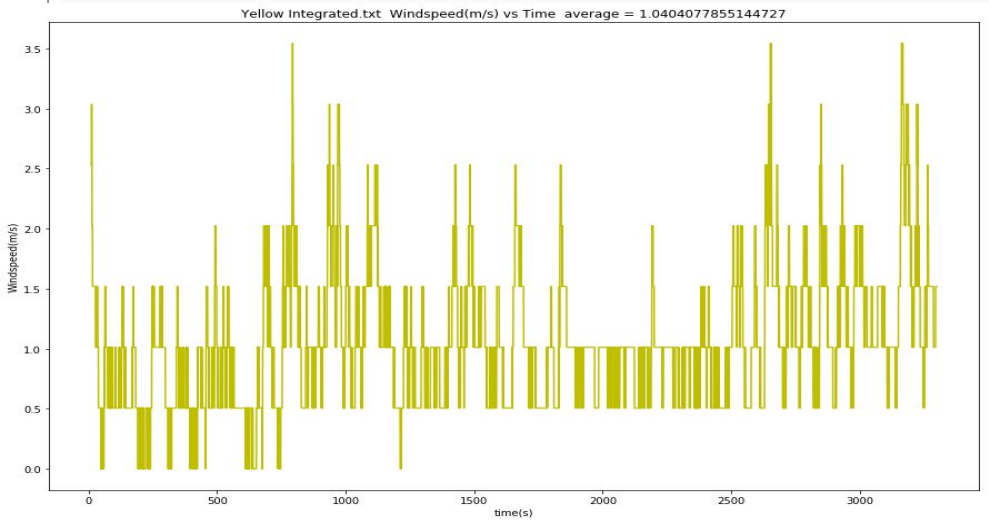


Calibration Result

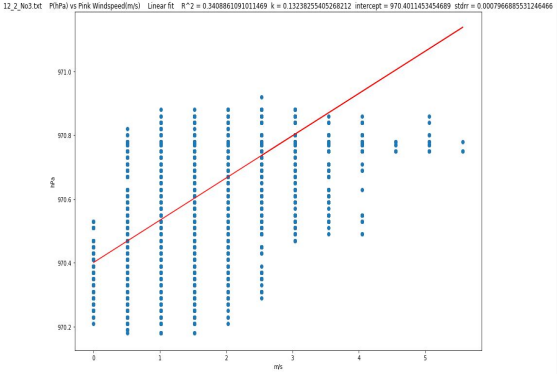
Device	Type	Location	Calibration Temp(Celcius)	Deviation from Avg	Calibration Pressure(hPa)	Deviation from Avg	Calibration Humidity(%)	Deviation from Avg	Calibration Windspeed(m/s)	Deviation from Avg
No.1	Pink Box	Outside West	22.80404064	0.435753337	970.4728177	0.140686175	49.05788576	0.520290253	3.146320093	0.171405187
No.2	Yellow Box	Outside East	23.30530517	0.937017873	970.2079178	-0.124213784	49.00951991	0.471924406	2.803509719	-0.171405187
No.3	White Box	Front Door	22.31233908	-0.055948222	969.9421591	-0.389972387	51.4	2.862404495		
No.4	Bred	Triple Doors	22.2891042	-0.079183098	970.0525171	-0.279614416	47.54754026	-0.99005525		
No.5	Bred	Living Room	21.70679665	-0.661490648	970.5736751	0.241543564	43.14534335	-5.39225215		
No.6	Bred	Kitchen	22.32735194	-0.040935363	970.2035289	-0.128602682	48.67219058	0.13459508		
No.7	Bred	Dining Room	21.83307342	-0.535213879	970.8723051	0.54017353	50.93068867	2.393093169		
No.8	Red Box	Piano	N/A		N/A		N/A			
No.9	Transluscent Box	Plants	N/A		N/A		N/A			
Avg			22.3682873		970.3321315		48.5375955		2.974914906	

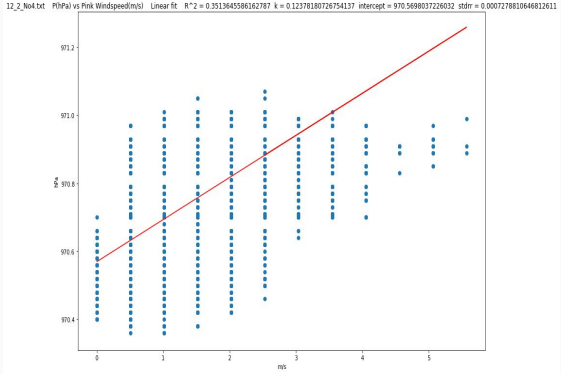
Wind speed vs time

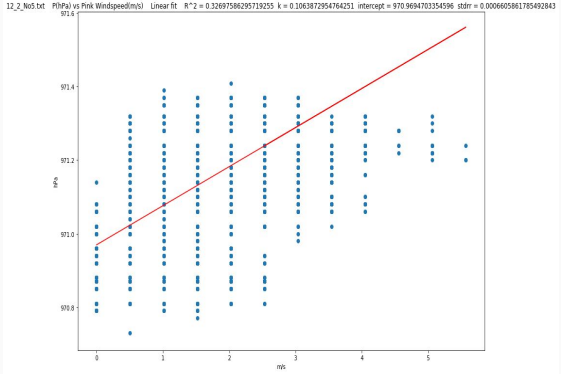


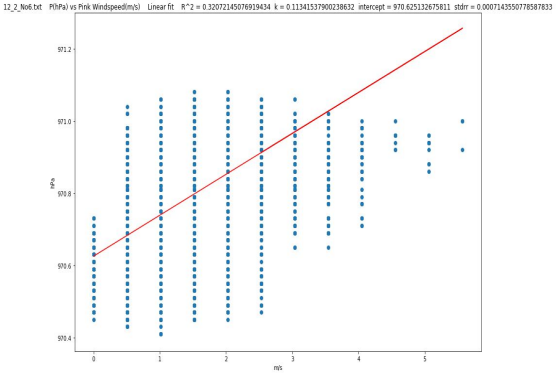


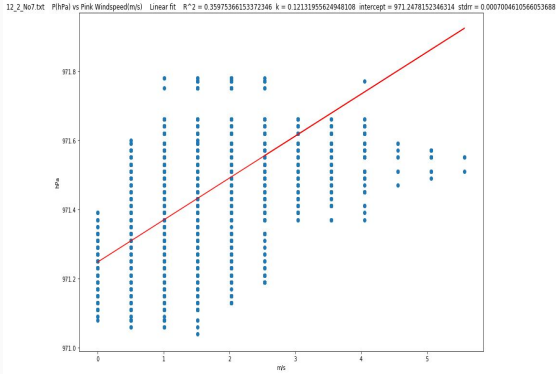
Pressure Inside - Wind speed No.1

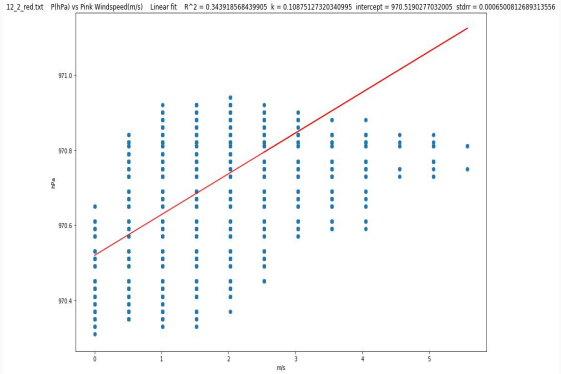




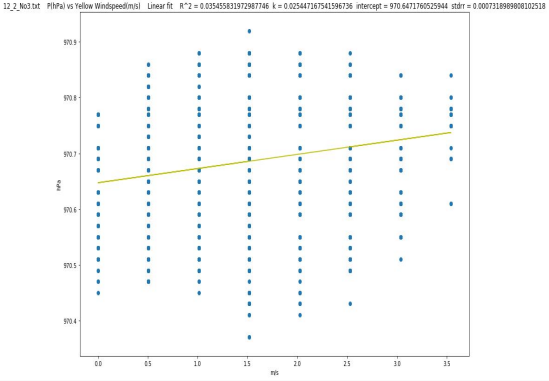


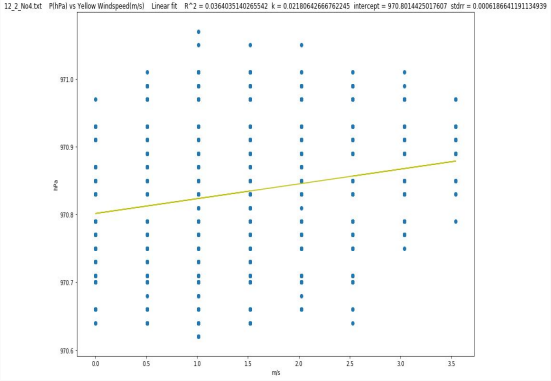


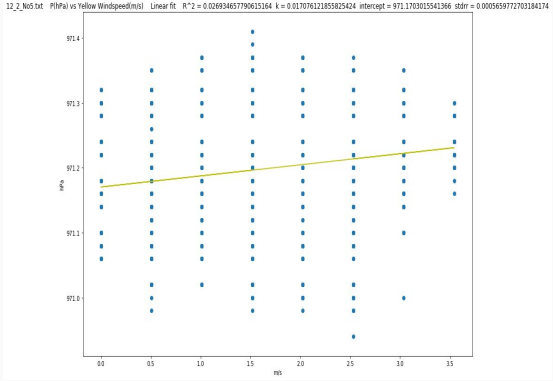


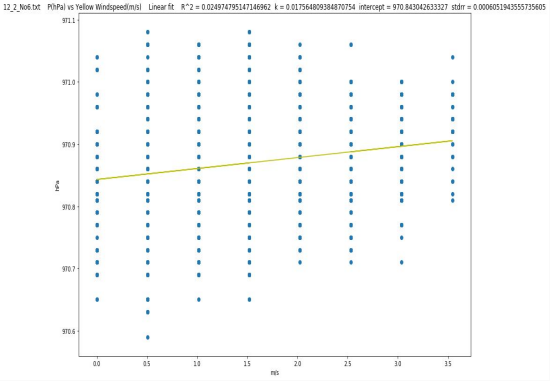


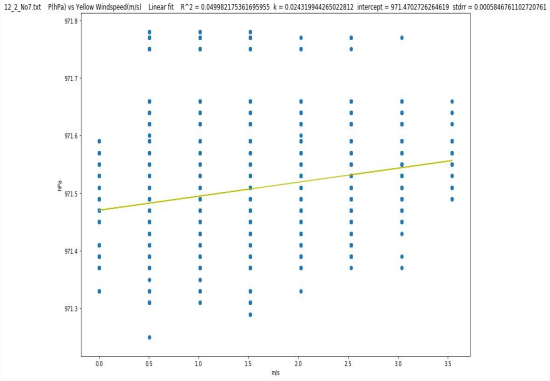
Pressure Inside - Wind speed No.2

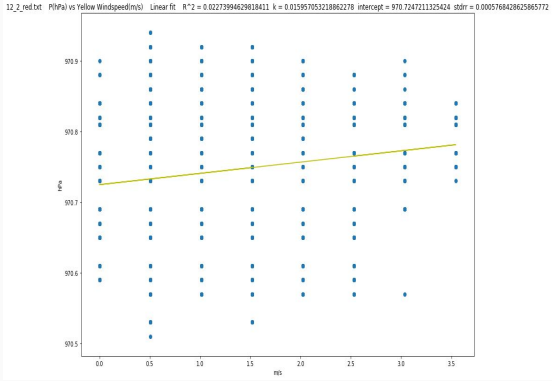




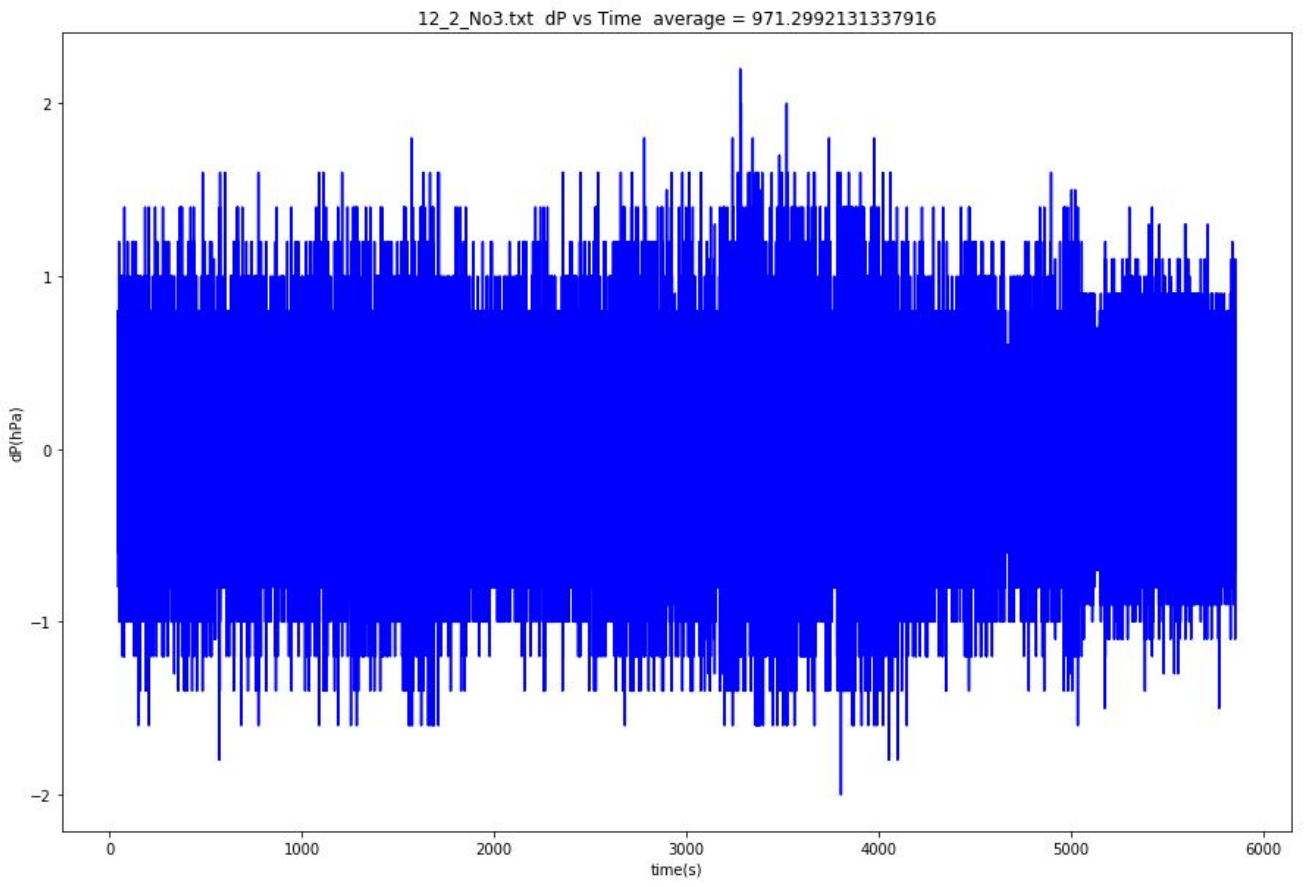




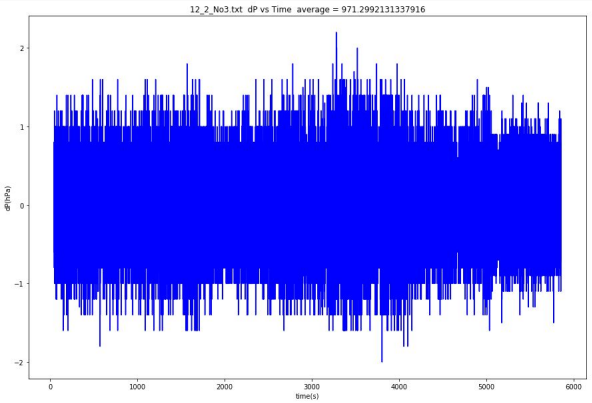


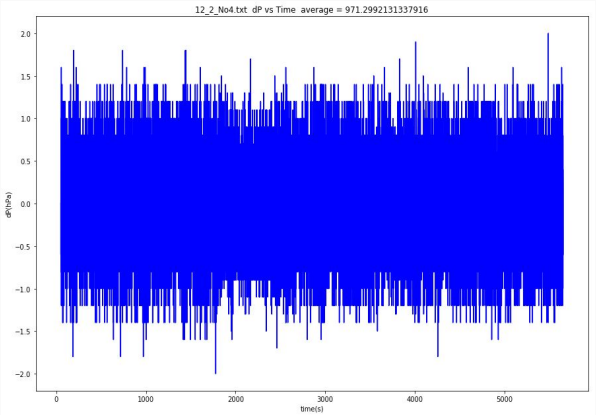


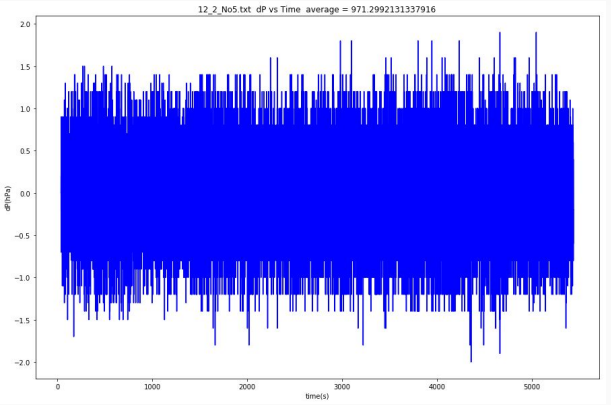
dP/dt Example

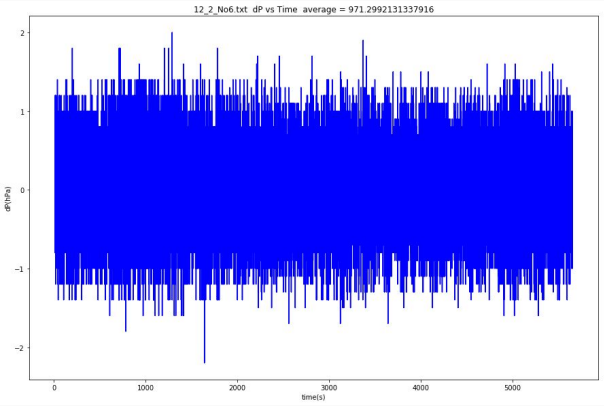


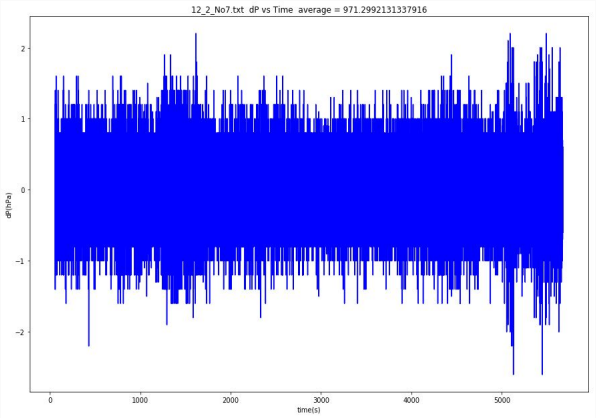
dP/dt all

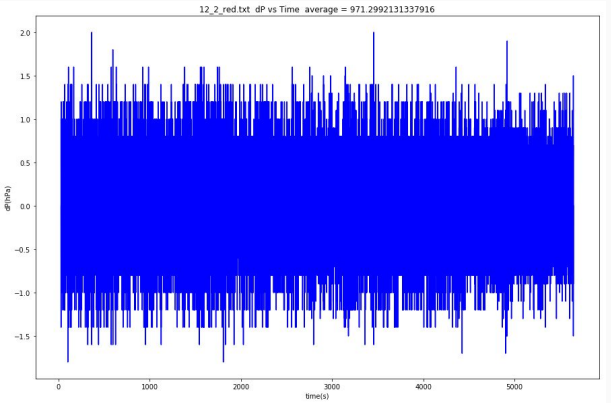

12_2_No3.txt dP vs Time average = 971.2992131337916
dP(hPa)
time(s)


12_2_No4.txt dP vs Time average = 971.2992131337916
dP(hPa)
time(s)

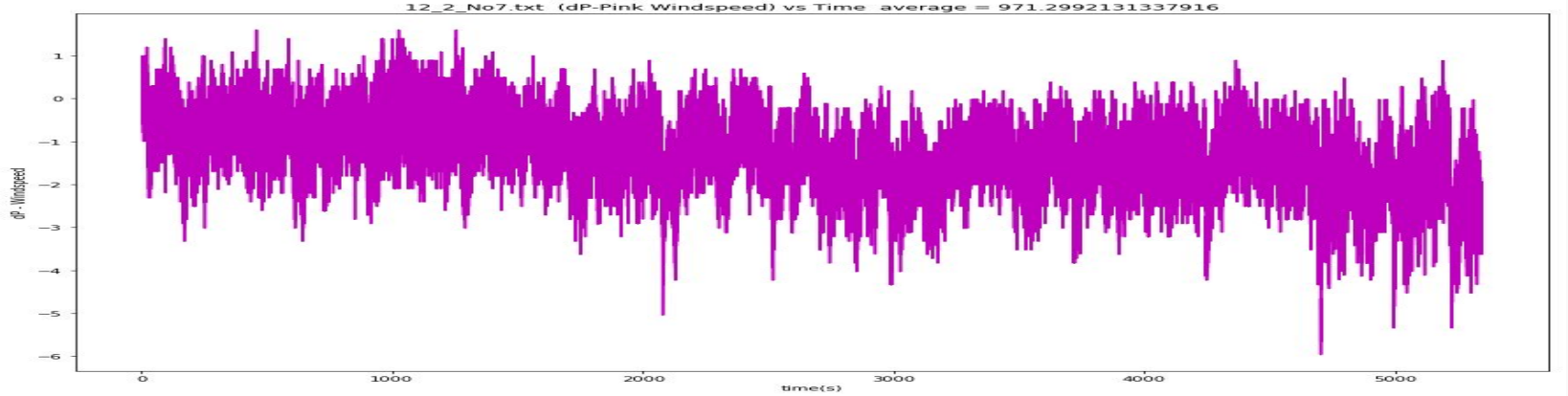

12_2_No5.txt dP vs Time average = 971.2992131337916
dP(hPa)
time(s)

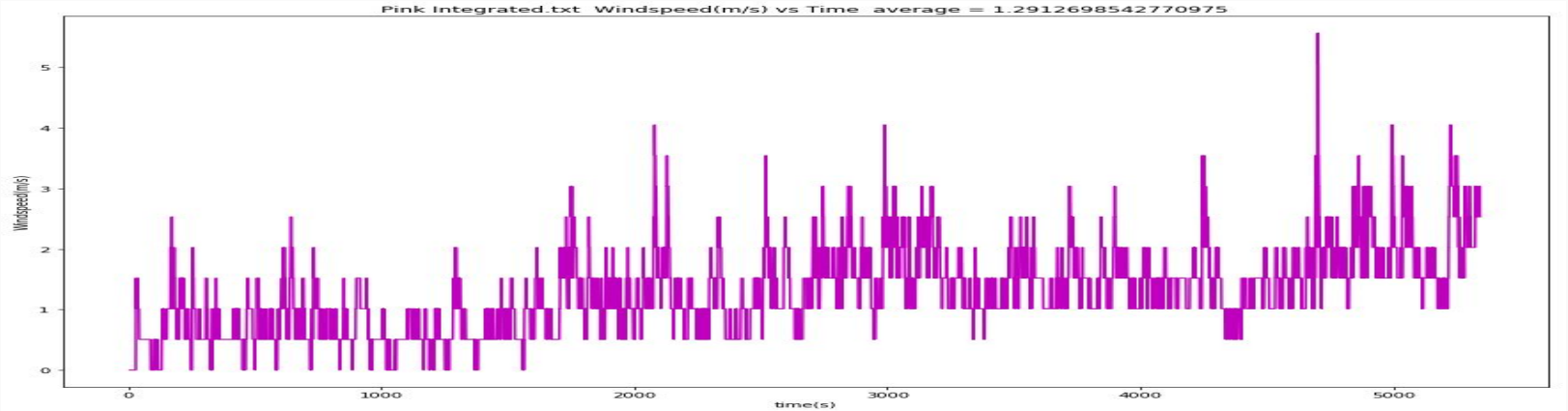

12_2_No6.txt dP vs Time average = 971.2992131337916
dP(hPa)
time(s)


12_2_No7.txt dP vs Time average = 971.2992131337916
dP(hPa)
time(s)

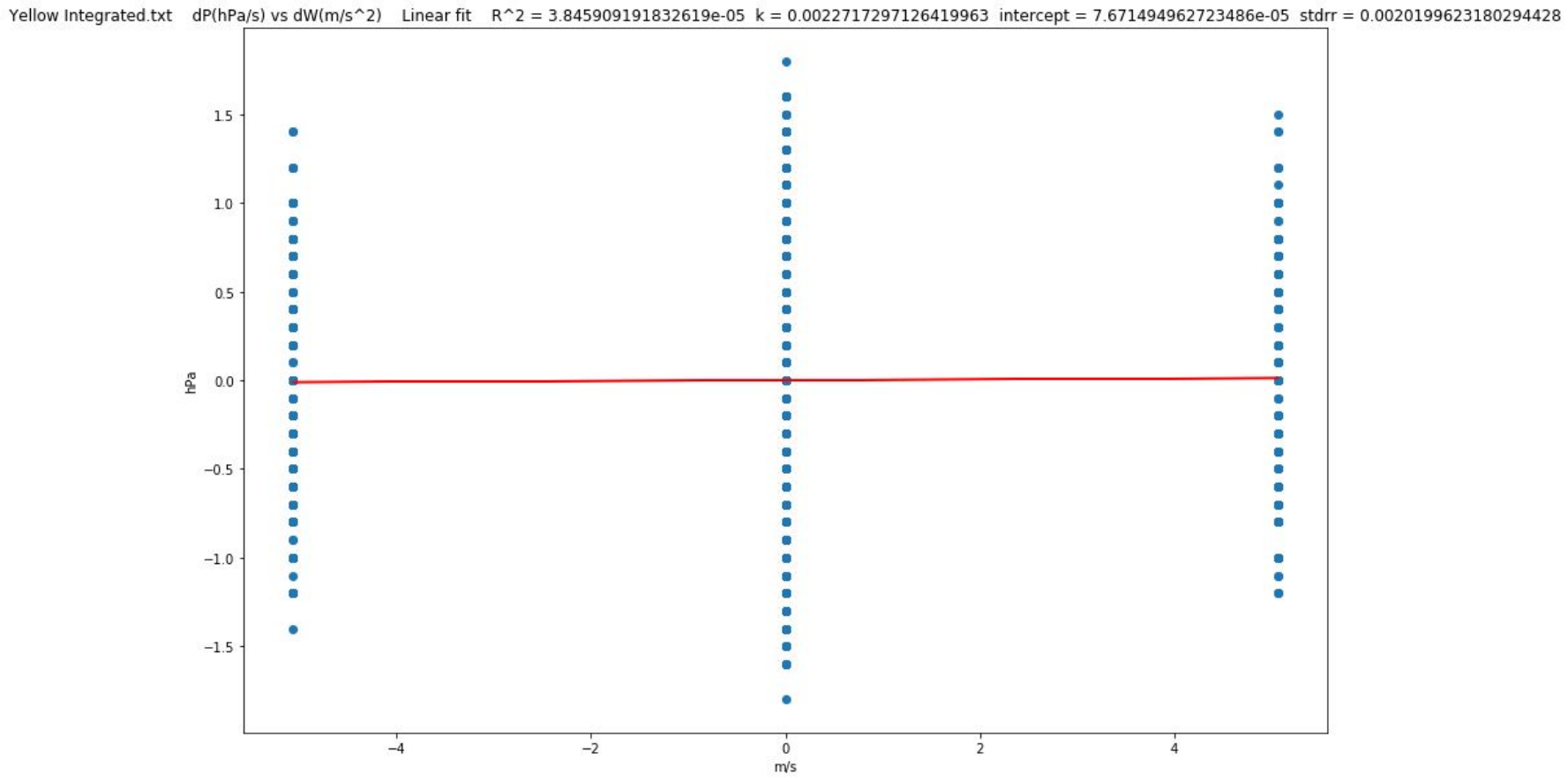

12_2_red.txt dP vs Time average = 971.2992131337916
dP(hPa)
time(s)

dP/dt No.7 - Wind speed No.1





dP/dw


Yellow Integrated.txt dP(hPa/s) vs dW(m/s^2) Linear fit R^2 = 3.845909191832619e-05 k = 0.0022717297126419963 intercept = 7.671494962723486e-05 stdrr = 0.0020199623180294428
hPa
m/s
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−4
−2
0
2
4

Conclusion

Our analysis probably lacks both accuracy and universality, provided that there's only 9 sets of data taken at mere 1 place in 1 day due to our limited hardware setup and sample size.

Therefore, our data is not sufficient or accurate enough to show any observable pressure gradient to support our pressure - wind speed correlation, so further study and experimenting is recommended to draw convincing conclusion to the matter.