"CLOUD AND PM2.5 SPATIOTEMPORAL MONITORING USING THE PM2.5 IOT AND AIRLINK SENSORS IN KRABI, THAILAND"

Students: Kristin Malayaphon, Tianrawit Komalittipong, Pongwarin Twesre, Dechatorn Khongcharoenchai, Charanchai akkeesuwan, Peranat Pornjaturin, Puntut Tanapaisarnwattana, Wanpee Julpamorn, Papangkorn Methavararak, Phattarapol Lakhan, Warot Phanphoowong, Napatsanan Ngeonbumroong, Chisakan Boonmee

School: Samsenwittayalai
Teacher: Mrs. Kornkamon Kumnerdkarn
Scientist: John Rex, Mr. Tewakorn Yaowa, Assoc. Prof. Dr. Krisnadej Jaroensutasinee, Assoc. Prof. Dr. Mullica Jaroensutasinee
Email: rat.kornkamon@gmail.com

INTRODUCTION

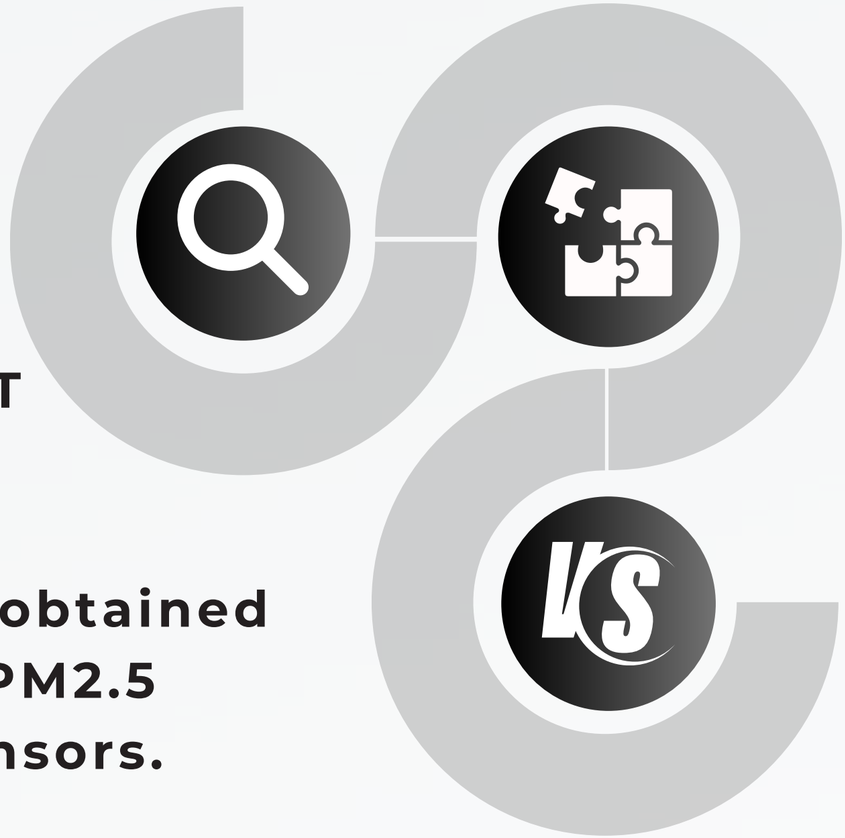
- Air pollution is the contamination of the environment by any biological, physical, or chemical means that modify the characteristics of the atmosphere.
- Chronic exposure to particulates has been associated with increased rates of bronchitis and other respiratory ailments, loss of lung function, and increased risk of lung cancer.
- Therefore, air quality measuring equipment must be installed to reduce air pollution at traffic intersections and industrial areas.
- This study compares the accuracy of low-cost sensors in measuring PM2.5 levels at two locations.
- The study also explores the relationship between PM2.5 and air temperature, humidity, cloud types, and cloud cover percentage using the GLOBE Observer: Cloud App.

GOALS AND OBJECTIVES

01 Calculating the PM2.5 dust concentration in the province of Krabi.

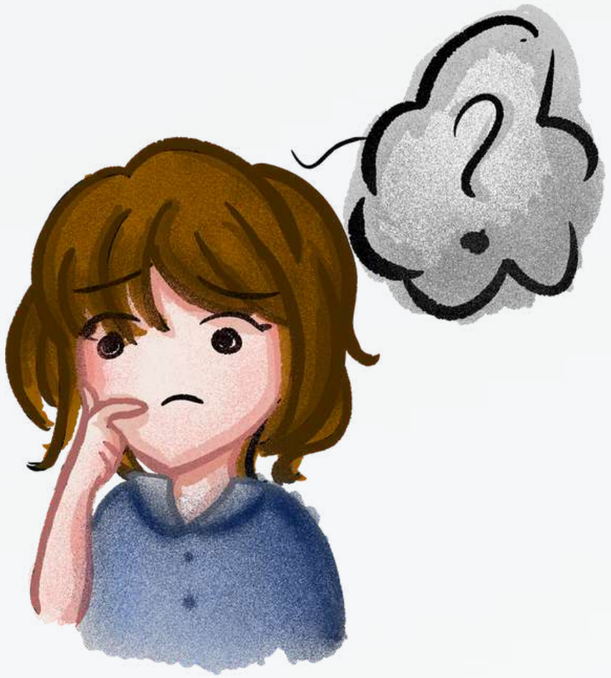
02 To evaluate the self-produced IoT sensors' quality.

03 To compare the PM2.5 dust data obtained by Censor Davis Erling with the PM2.5 dust values from our own IOT sensors.



RESEARCH QUESTIONS:

01 How does air temperature and relative humidity affect PM 2.5?



02 How does cloud types, and amounts of clouds relate to the increase or decrease of the amounts of PM2.5 in the air?

03 Is the Low-cost IoT dust sensor PM30003 able to detect PM 2.5 data accurately as compared to Davis Airlink PM 2.5 sensor?

where do PM 2.5 come from

WHAT IS PM 2.5

- particles that are 2.5 microns or less in diameter (PM2.5).

1.Open Burning

2.Industry

3.Transportation

4.Power plants

5.Accommodation

STUDY SITES

Areas with little traffic

- **Boonsiam Hotel**

Areas with heavy traffic

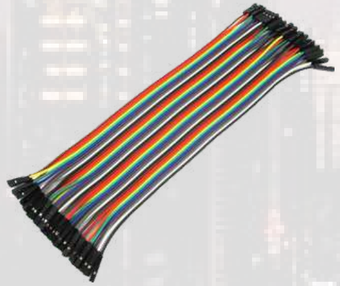
- **Chaofa Pier**

MATERIALS AND METHODS

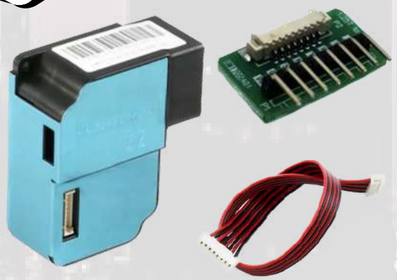
MATERIALS

1.Arduino IDE

2.Jump wires
(Male-Female)



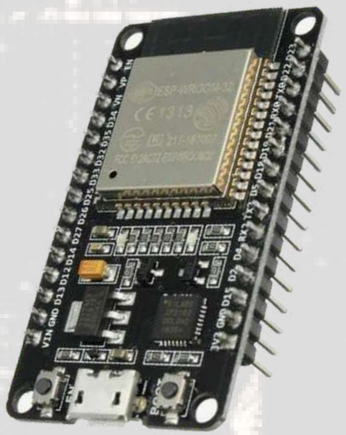
3.Jump wire
(Female-Female)



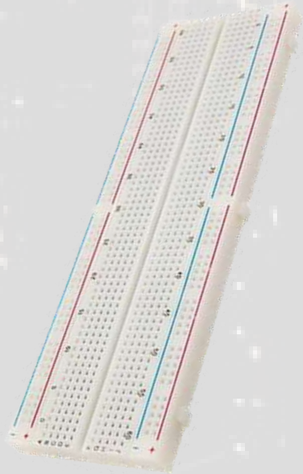
4.PM 2.5 sensor
(PMS3003)

MATERIALS AND METHODS

MATERIALS



5.Node MCU



6.Breadboard

7.Micro-USB

8.Notebook or Computer

9.Arduino IDE

MATERIALS AND METHODS

PM 2.5 Iot Sensor Construction and Operation

1.

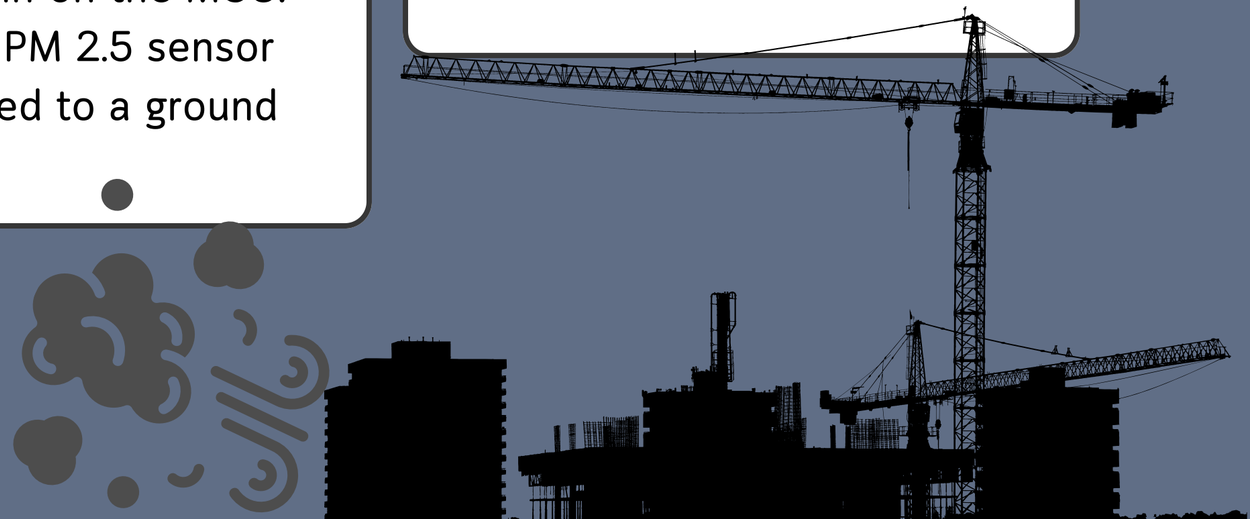
Place the NodeMCU on the breadboard.

2.

Connect the jumper wire to the PM 2.5 sensor. The second pin of the DHT 22 should connect to D2, D3 on the MCU, 3v3, or Vin on the MCU. The last pin of the PM 2.5 sensor should be connected to a ground (GND).

3.

Connect the Micro-USB to the MCU and PM 2.5 sensor and connect it to the computer.



4.

Open ARDUINO IDE software and set up the SoftwareSerial library.

5.

Open the Arduino IDE and use the following codes. (Figure 2):

6.

Connect the Micro-USB to the MCU and PM 2.5 sensor and connect it to the notebook.

Figure 2. Arduino Code for Laser Dust Sensor

```
const char* ssid     = "TVOWalailak2021"; //ชื่อwifiโรงแรม ริมน้ำ
const char* password = "TVOwifi@007"; //password


const int analogInPin = A0;
int sensorValue = 0;

#define DHTPIN D4
#define DHTTYPE DHT22

DHT dht(DHTPIN, DHTTYPE);

SoftwareSerial mySerial(D2,D3); // RX, TX
unsigned int pm1 = 0;
unsigned int pm2_5 = 0;
unsigned int pm10 = 0;

void setup() {
  Serial.begin(9600);
  while (!Serial) ;
  Serial.println(F("IoT AI Module v 1.0"));
  Serial.println(F("CoE for Ecoinformatics, Walailak University
  Serial.println(F("(c) 2023 Krisanadej Computing"));
  Serial.println(F("DHTxx test!"));
```

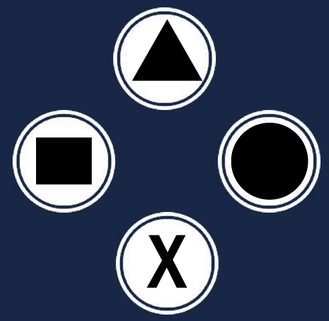
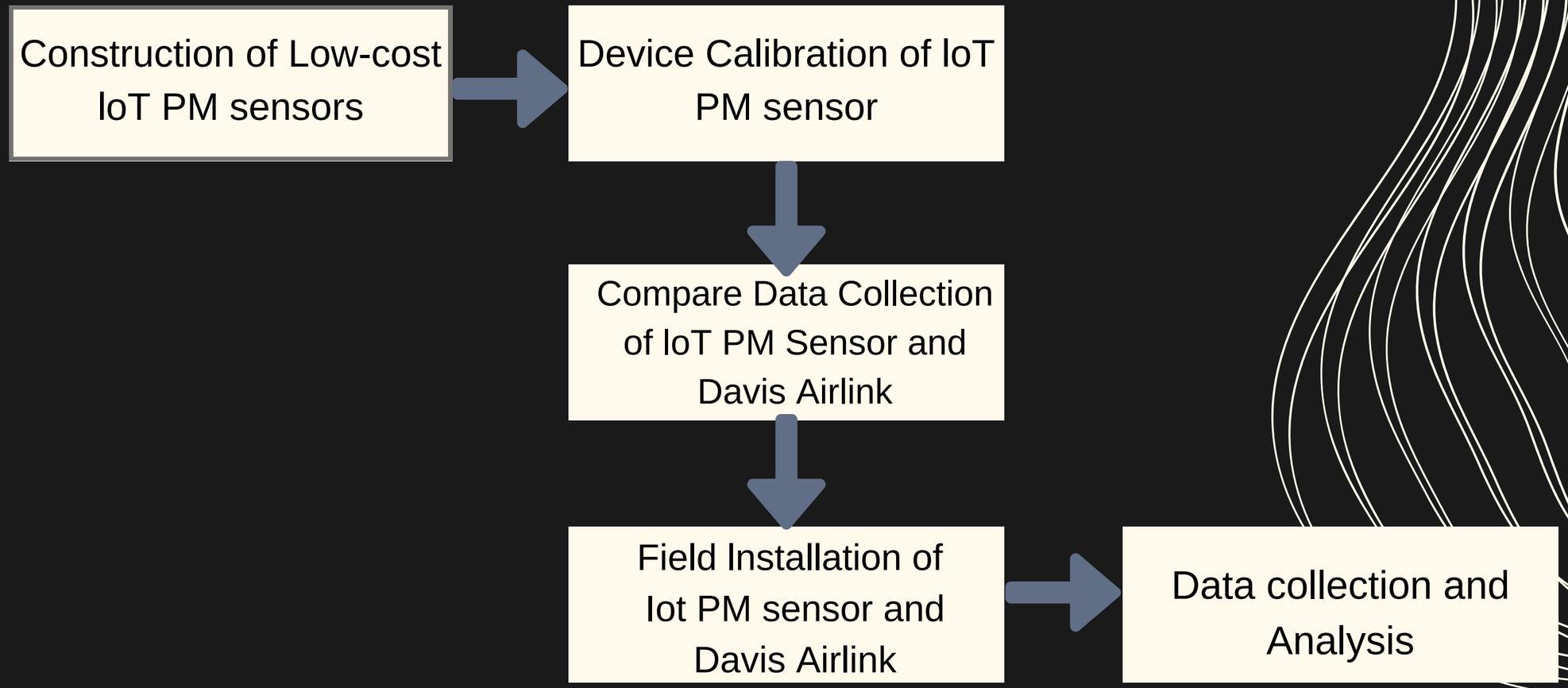


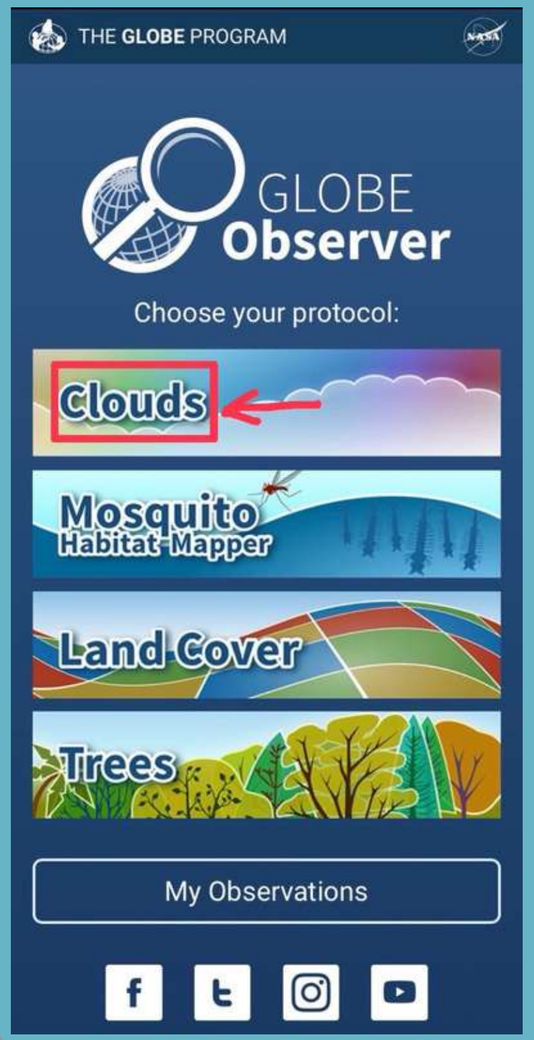
Figure 3. PM Sensor Data Generated from the Server

{"T":{2023,11,27,00,06,46}","Temp":"26.20","Humid":"76.00","CO":"218","TimeStamp":"6420522","PM1":"1","PM25":"4","PM10":"5"},
{"T":{2023,11,27,00,16,56}","Temp":"26.30","Humid":"75.30","CO":"214","TimeStamp":"7030695","PM1":"1","PM25":"7","PM10":"7"},
{"T":{2023,11,27,00,27,07}","Temp":"26.10","Humid":"76.40","CO":"211","TimeStamp":"7640865","PM1":"1","PM25":"5","PM10":"7"},
{"T":{2023,11,27,00,32,12}","Temp":"26.10","Humid":"76.90","CO":"192","TimeStamp":"7946025","PM1":"0","PM25":"7","PM10":"7"},
{"T":{2023,11,27,00,37,17}","Temp":"26.10","Humid":"76.80","CO":"188","TimeStamp":"8251193","PM1":"1","PM25":"10","PM10":"10"},
{"T":{2023,11,27,00,42,22}","Temp":"26.20","Humid":"76.10","CO":"208","TimeStamp":"8556360","PM1":"1","PM25":"7","PM10":"8"},
{"T":{2023,11,27,00,47,27}","Temp":"26.10","Humid":"75.80","CO":"204","TimeStamp":"8861519","PM1":"1","PM25":"8","PM10":"8"},
{"T":{2023,11,27,00,52,32}","Temp":"26.20","Humid":"75.70","CO":"199","TimeStamp":"9166687","PM1":"1","PM25":"7","PM10":"7"},
{"T":{2023,11,27,00,57,38}","Temp":"26.20","Humid":"76.50","CO":"207","TimeStamp":"9471848","PM1":"4","PM25":"11","PM10":"11"},
{"T":{2023,11,27,01,02,43}","Temp":"26.20","Humid":"76.90","CO":"205","TimeStamp":"9777105","PM1":"0","PM25":"4","PM10":"5"},
{"T":{2023,11,27,01,07,48}","Temp":"26.20","Humid":"77.10","CO":"204","TimeStamp":"10082270","PM1":"4","PM25":"7","PM10":"8"},
{"T":{2023,11,27,01,12,53}","Temp":"26.20","Humid":"76.60","CO":"196","TimeStamp":"10387511","PM1":"0","PM25":"5","PM10":"5"},
{"T":{2023,11,27,01,17,58}","Temp":"26.10","Humid":"76.10","CO":"201","TimeStamp":"10692673","PM1":"5","PM25":"11","PM10":"13"},
{"T":{2023,11,27,01,23,04}","Temp":"26.20","Humid":"75.90","CO":"199","TimeStamp":"10997841","PM1":"1","PM25":"7","PM10":"8"},
{"T":{2023,11,27,01,28,09}","Temp":"26.10","Humid":"76.60","CO":"199","TimeStamp":"11303008","PM1":"0","PM25":"2","PM10":"2"},
{"T":{2023,11,27,01,33,14}","Temp":"26.30","Humid":"77.20","CO":"200","TimeStamp":"11608167","PM1":"0","PM25":"4","PM10":"4"},
{"T":{2023,11,27,01,38,19}","Temp":"26.20","Humid":"77.40","CO":"197","TimeStamp":"11913333","PM1":"1","PM25":"5","PM10":"7"},
{"T":{2023,11,27,01,43,24}","Temp":"26.10","Humid":"76.80","CO":"195","TimeStamp":"12218494","PM1":"1","PM25":"4","PM10":"5"},
{"T":{2023,11,27,01,48,29}","Temp":"26.20","Humid":"76.20","CO":"189","TimeStamp":"12523648","PM1":"1","PM25":"7","PM10":"7"},
{"T":{2023,11,27,01,58,40}","Temp":"26.10","Humid":"76.30","CO":"195","TimeStamp":"13133895","PM1":"0","PM25":"4","PM10":"5"},
{"T":{2023,11,27,02,03,45}","Temp":"26.10","Humid":"77.40","CO":"189","TimeStamp":"13439063","PM1":"0","PM25":"5","PM10":"7"},
{"T":{2023,11,27,02,08,50}","Temp":"26.10","Humid":"77.60","CO":"188","TimeStamp":"13744225","PM1":"0","PM25":"4","PM10":"5"},
{"T":{2023,11,27,02,24,05}","Temp":"26.20","Humid":"76.40","CO":"192","TimeStamp":"14659558","PM1":"0","PM25":"5","PM10":"5"},
{"T":{2023,11,27,02,29,11}","Temp":"26.20","Humid":"77.60","CO":"186","TimeStamp":"14964733","PM1":"0","PM25":"8","PM10":"8"},
{"T":{2023,11,27,02,34,16}","Temp":"26.10","Humid":"77.90","CO":"189","TimeStamp":"15270160","PM1":"2","PM25":"7","PM10":"7"},
{"T":{2023,11,27,02,39,21}","Temp":"26.10","Humid":"77.30","CO":"188","TimeStamp":"15575323","PM1":"0","PM25":"4","PM10":"5"},
{"T":{2023,11,27,02,44,26}","Temp":"26.10","Humid":"76.70","CO":"185","TimeStamp":"15880485","PM1":"0","PM25":"5","PM10":"5"},
{"T":{2023,11,27,02,49,31}","Temp":"26.10","Humid":"76.40","CO":"185","TimeStamp":"16185657","PM1":"1","PM25":"11","PM10":"13"},
{"T":{2023,11,27,02,59,42}","Temp":"26.20","Humid":"77.90","CO":"183","TimeStamp":"16795903","PM1":"0","PM25":"4","PM10":"4"},
{"T":{2023,11,27,03,04,47}","Temp":"26.10","Humid":"78.10","CO":"185","TimeStamp":"17101070","PM1":"2","PM25":"8","PM10":"8"},
{"T":{2023,11,27,03,09,52}","Temp":"26.10","Humid":"77.50","CO":"181","TimeStamp":"17406272","PM1":"5","PM25":"11","PM10":"11"},

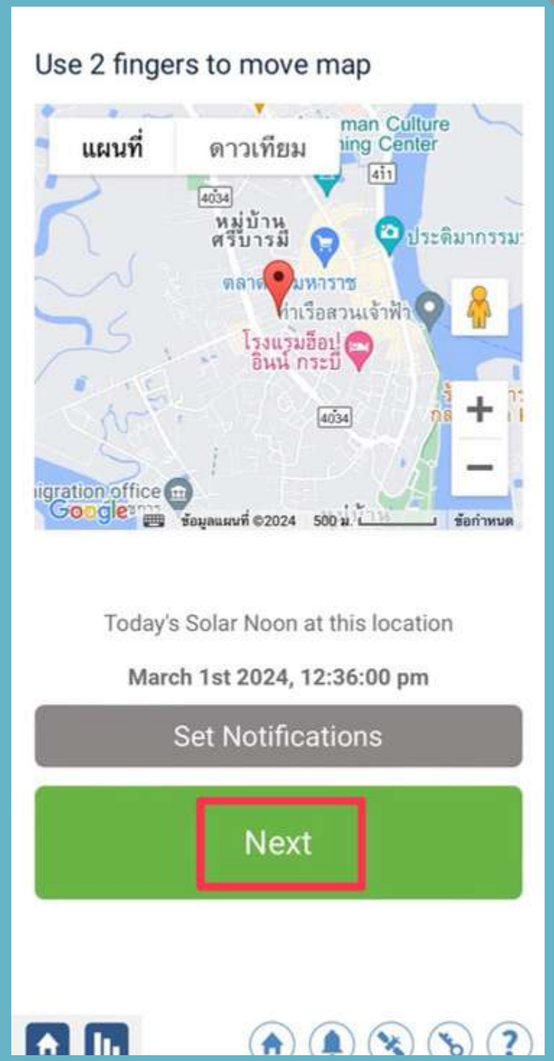
RESEARCH METHOD

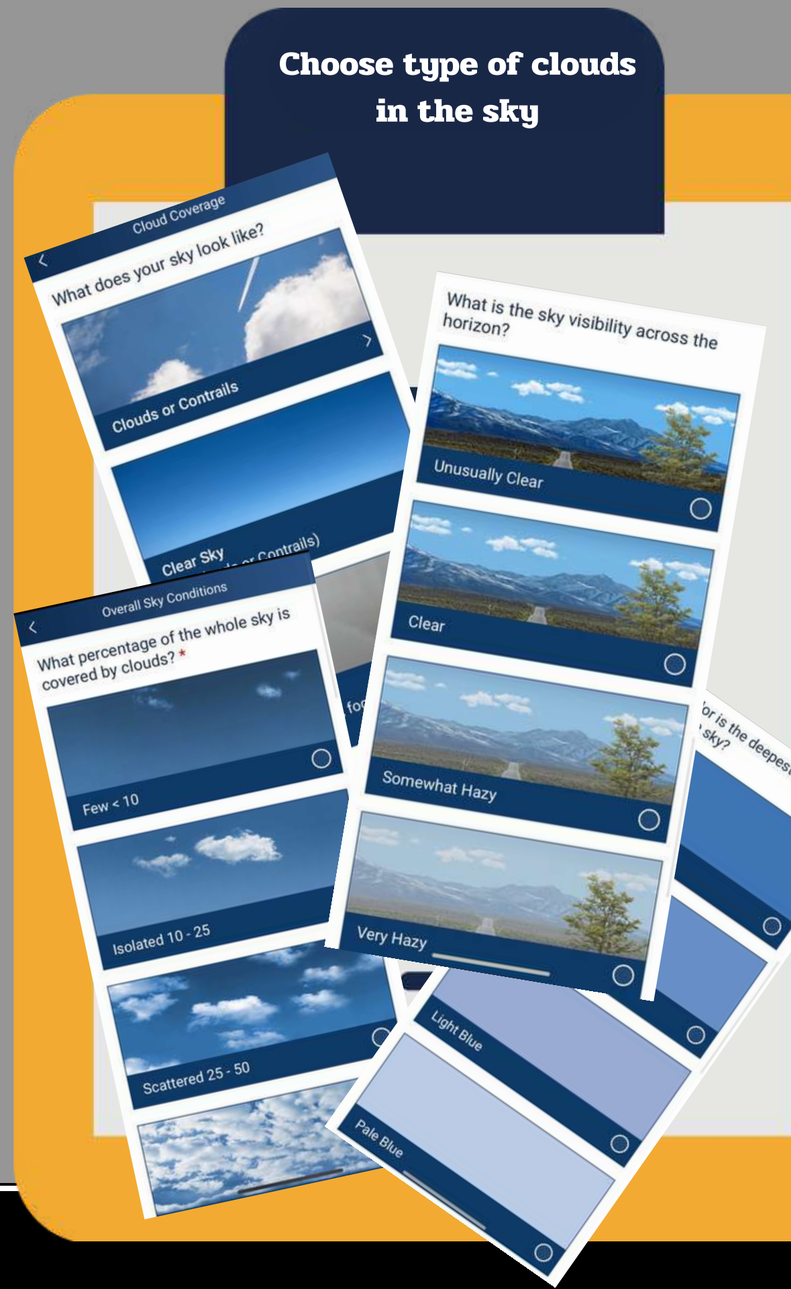


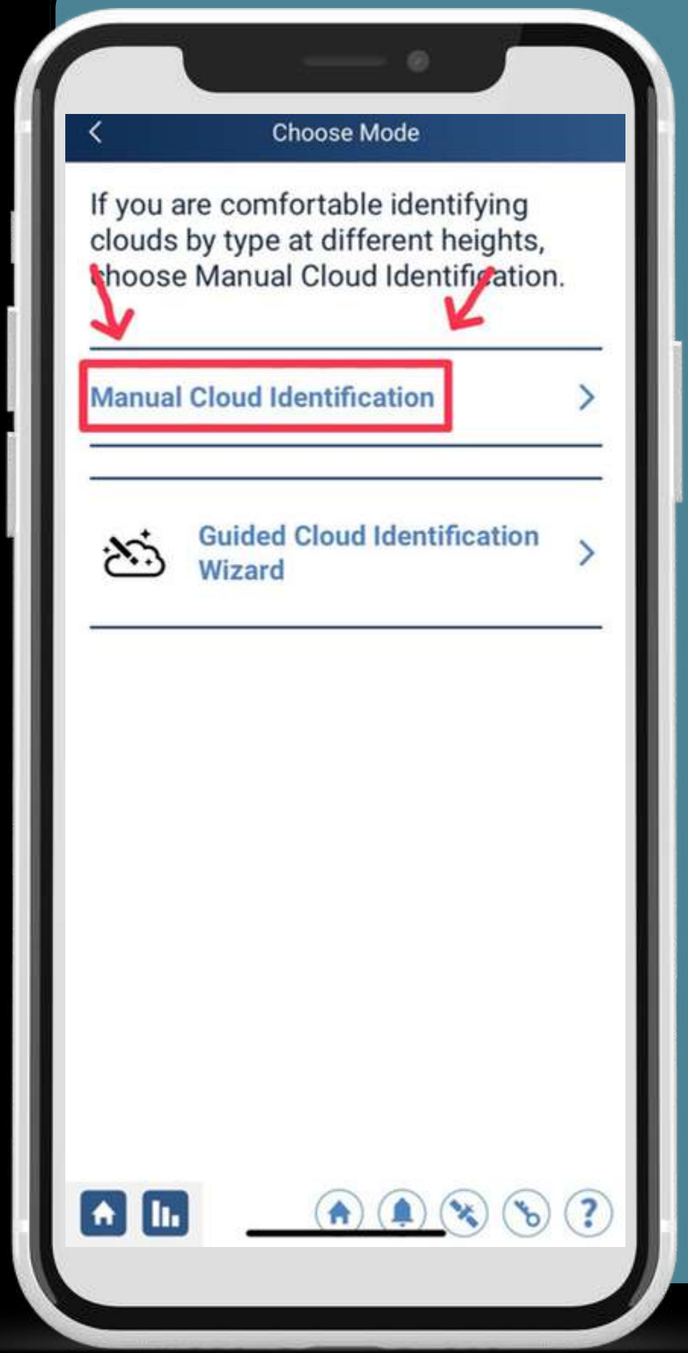
DATA COLLECTION


THE GLOBE PROGRAM
GLOBE Observer
Choose your protocol:
Clouds
Mosquito Habitat Mapper
Land Cover
Trees
My Observations

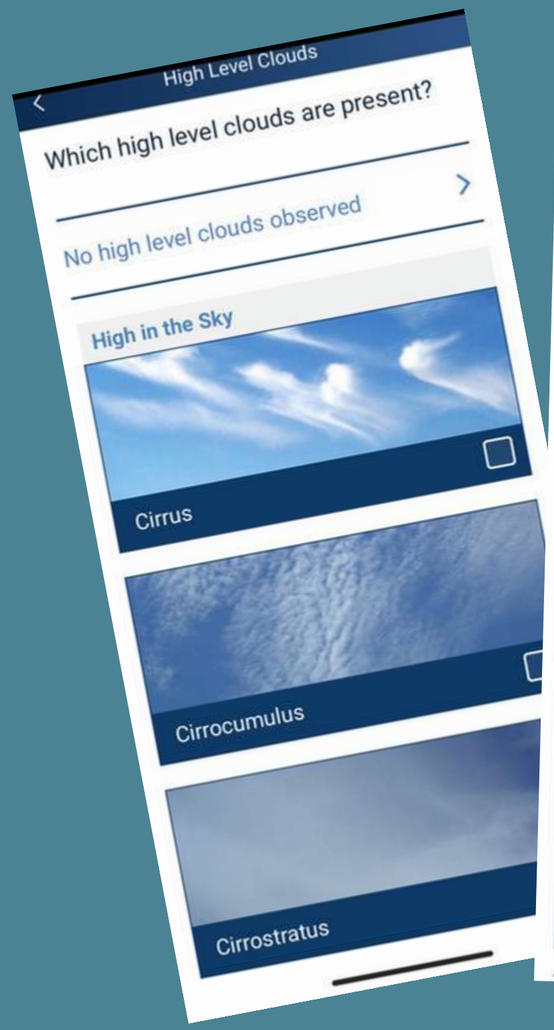

metharyu@gmail.com
GLOBE clouds
Observations: 1
New Cloud Observation
Review/Send Observations
Check Satellite Flyovers
My Observations
Map Today's Cloud Measurements

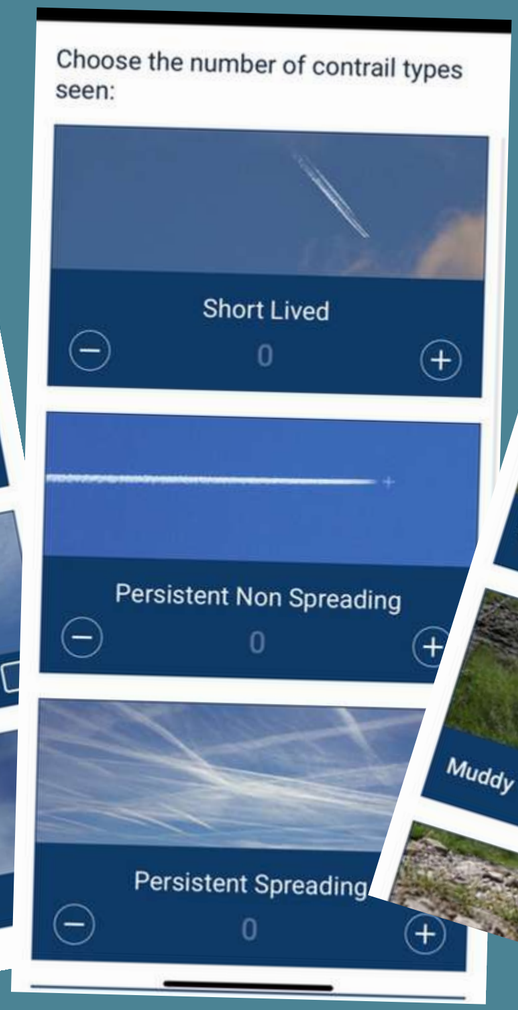

Use 2 fingers to move map
แผนที่
ดาวเทียม
Today's Solar Noon at this location
March 1st 2024, 12:36:00 pm
Set Notifications
Next

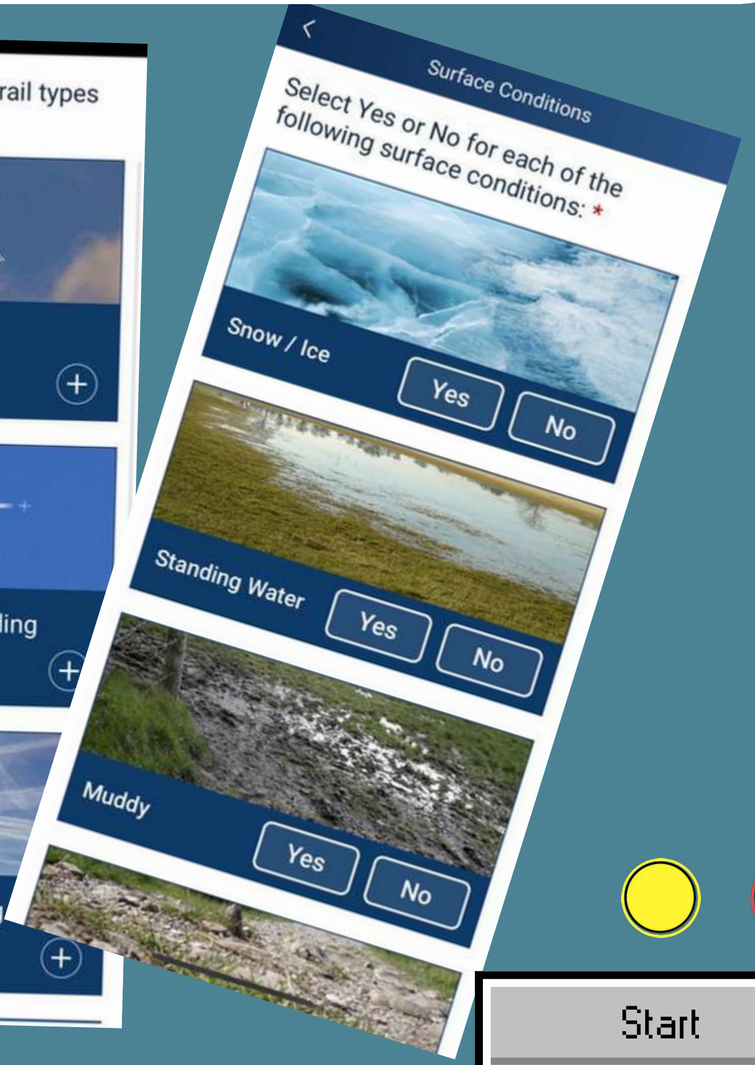

Choose type of clouds in the sky
Cloud Coverage
What does your sky look like?
Clouds or Contrails
Clear Sky
What is the sky visibility across the horizon?
Unusually Clear
Clear
Somewhat Hazy
Very Hazy
Overall Sky Conditions
What percentage of the whole sky is covered by clouds? *
Few < 10
Isolated 10 - 25
Scattered 25 - 50
Light Blue
Pale Blue



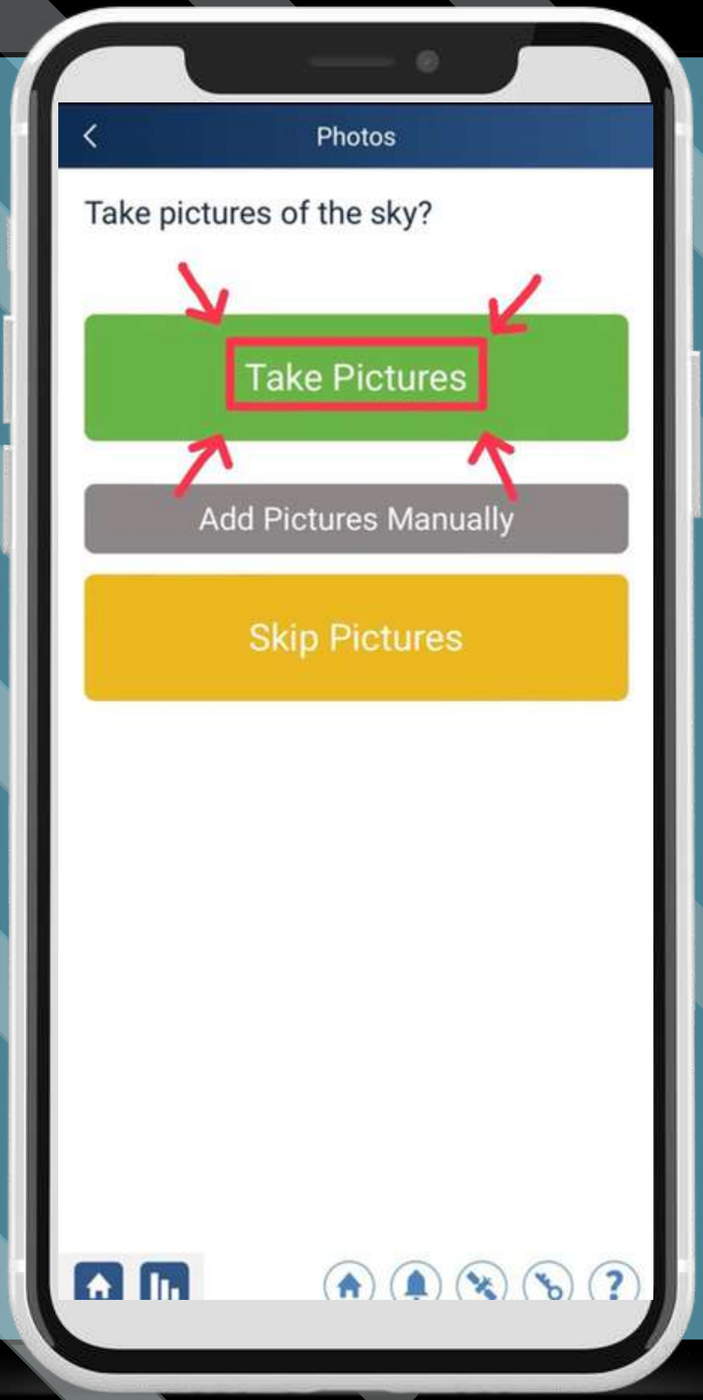
Choose type of clouds in the sky and geography in that area

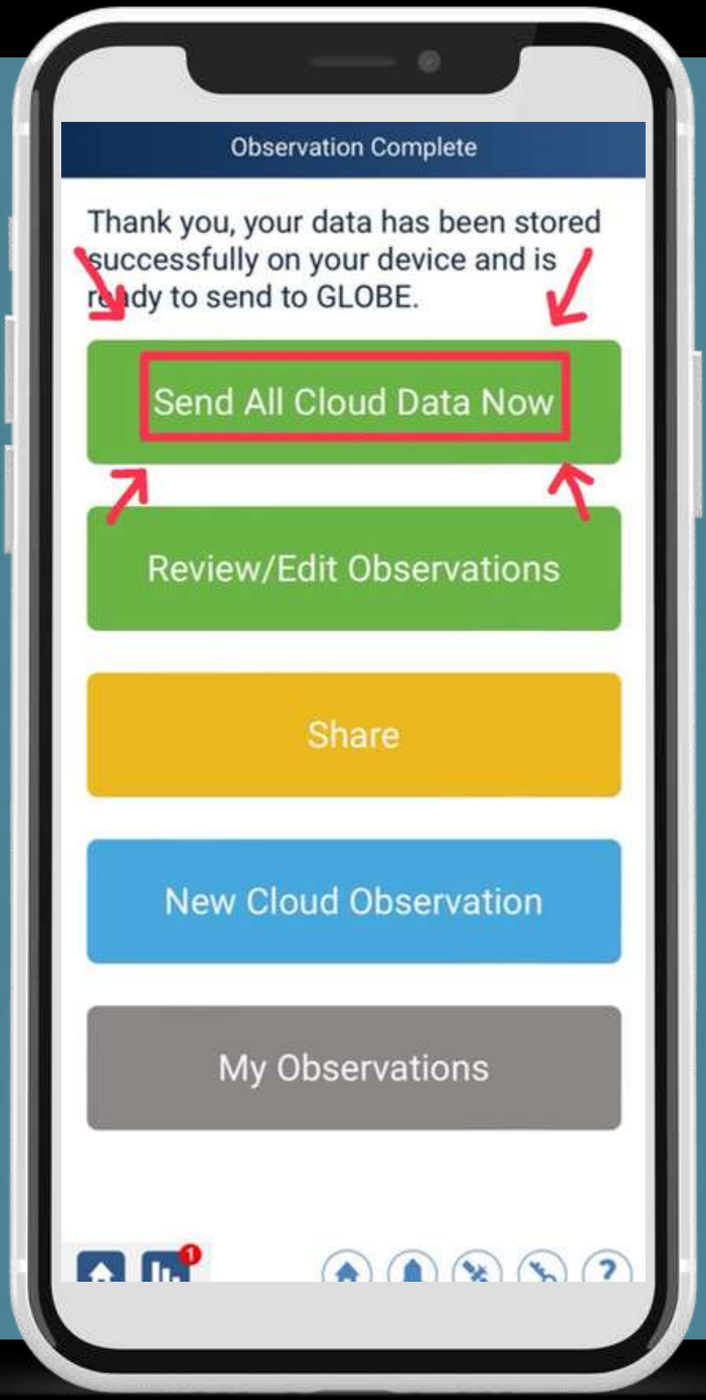






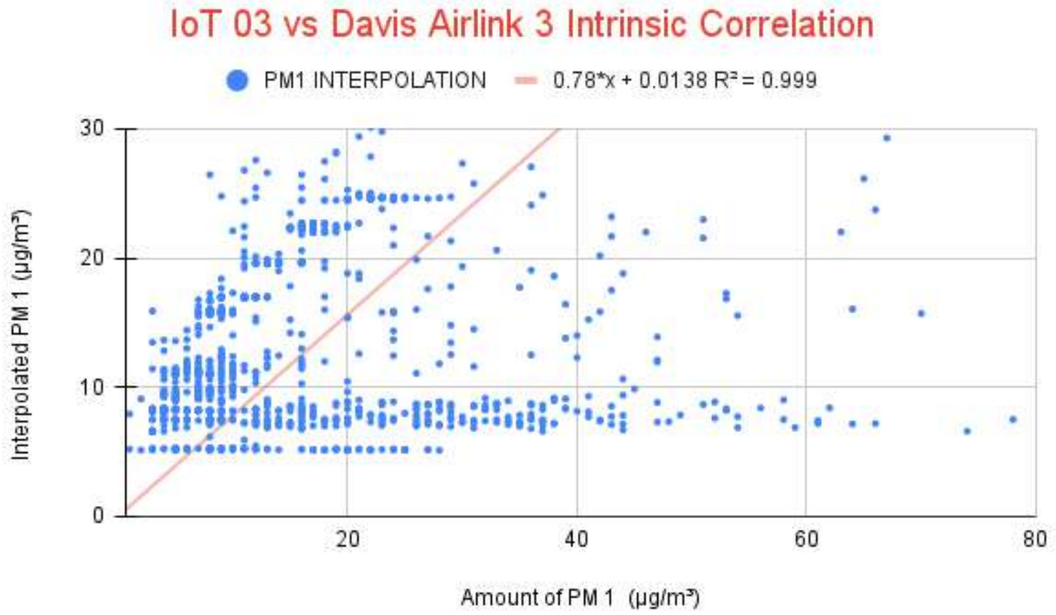
Start

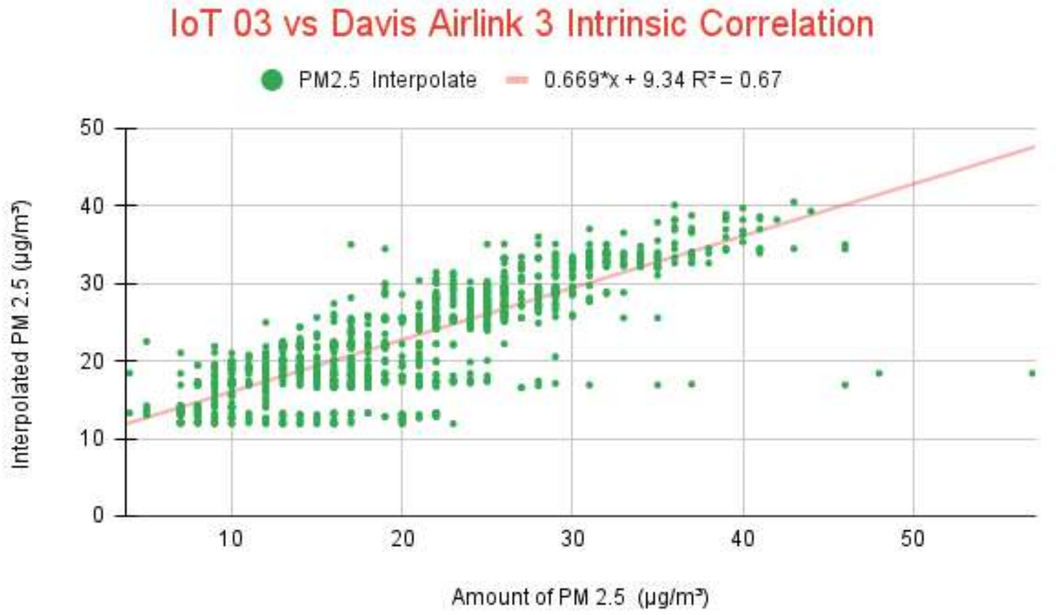

Photos
Take pictures of the sky?
Take Pictures
Add Pictures Manually
Skip Pictures

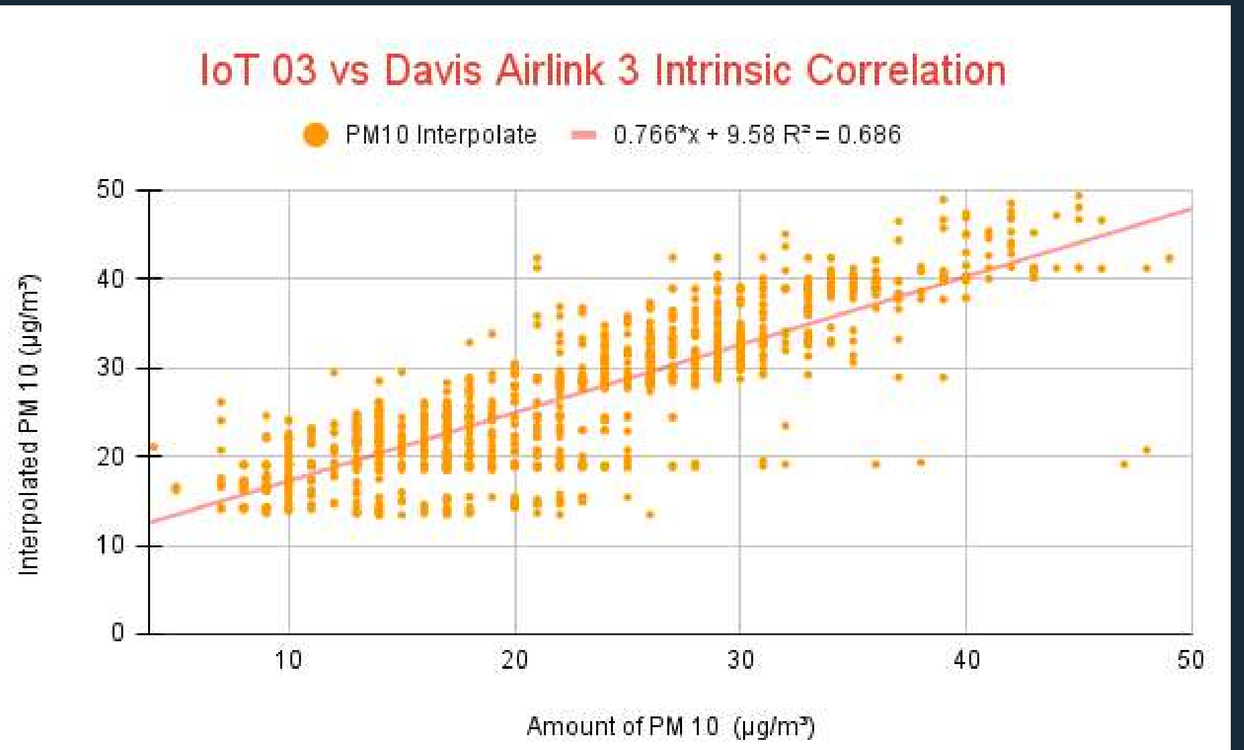

Observation Complete
Thank you, your data has been stored successfully on your device and is ready to send to GLOBE.
Send All Cloud Data Now
Review/Edit Observations
Share
New Cloud Observation
My Observations

Results

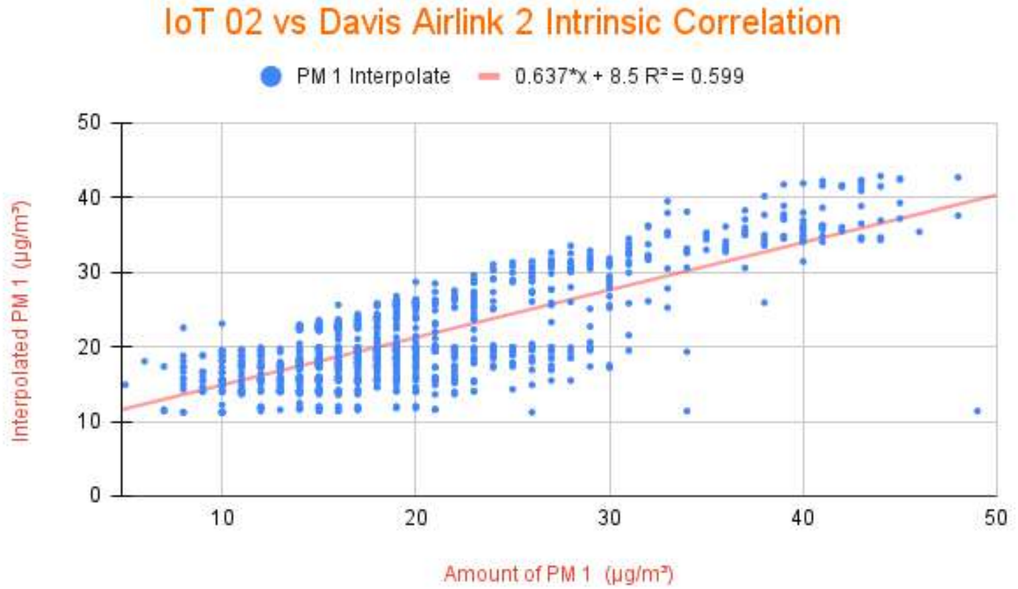
Sensor 03 At Hotel

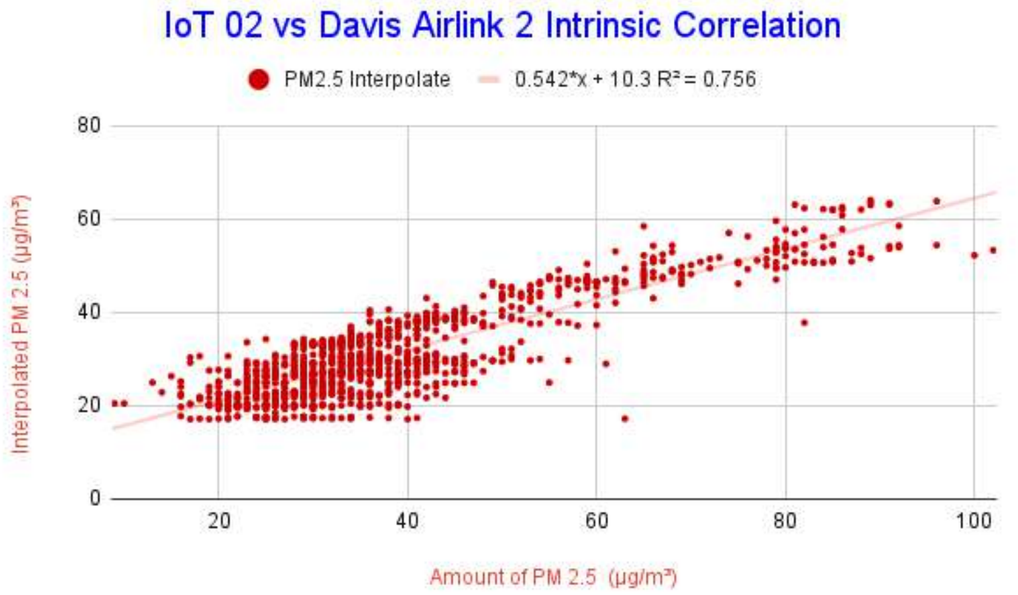


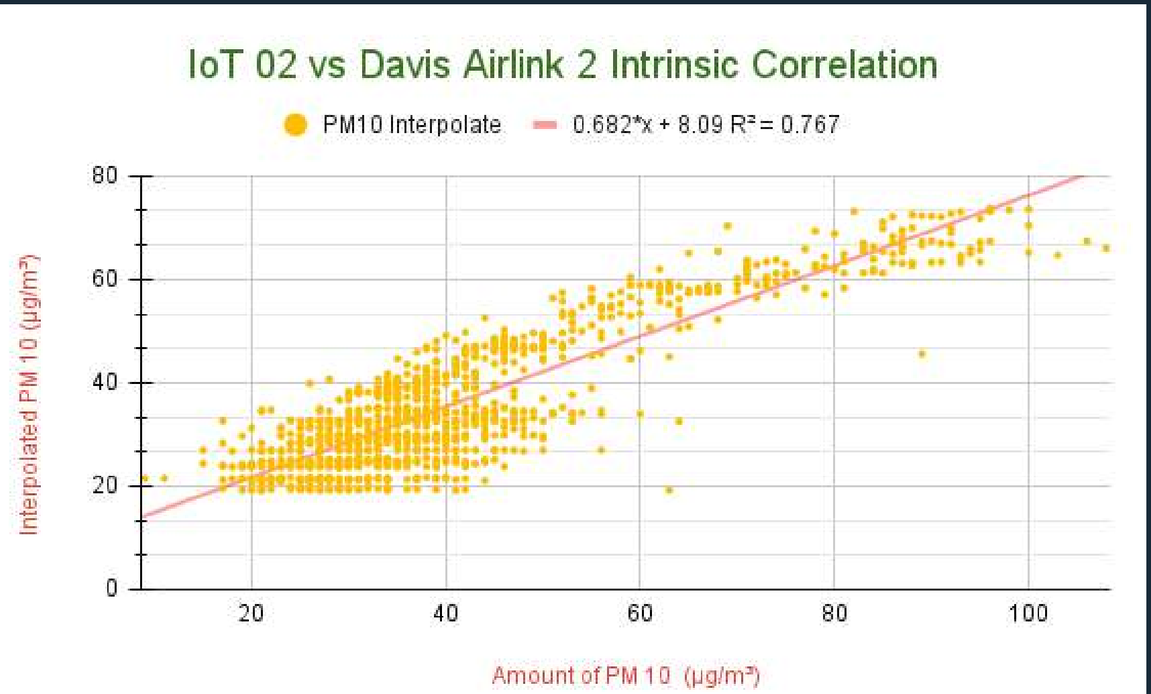




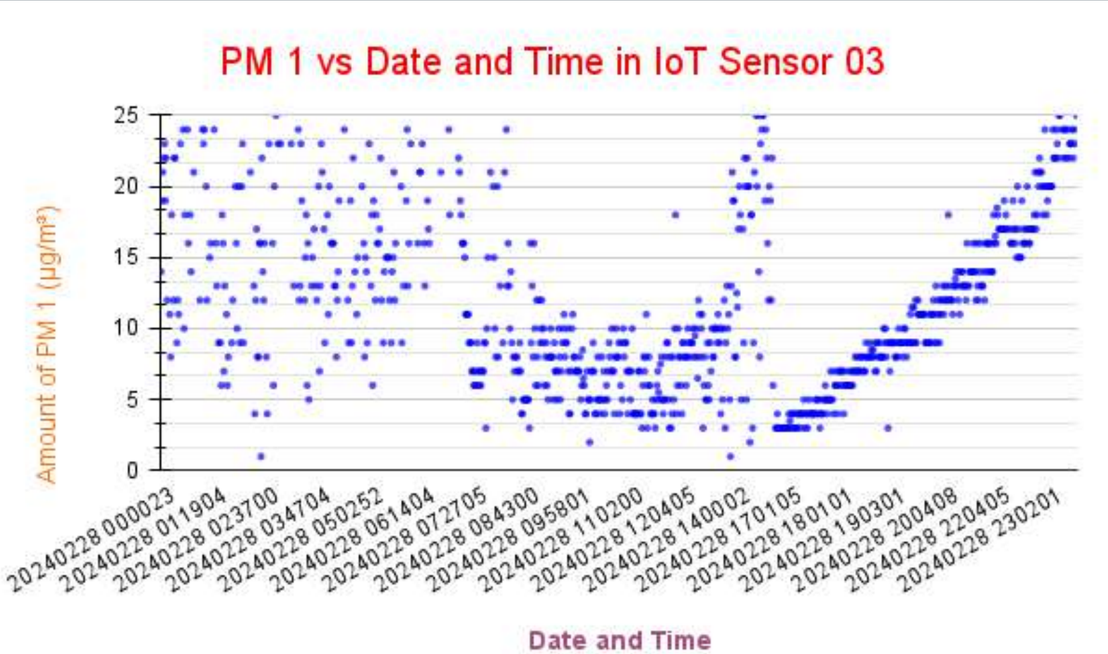
Sensor 02
At Chaofa Pier

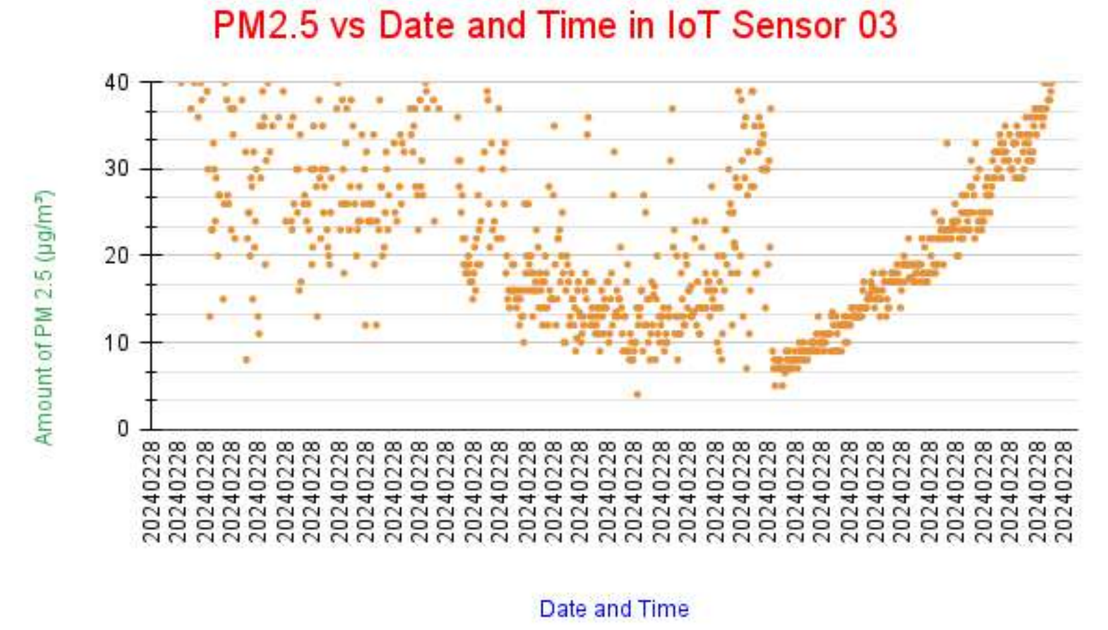


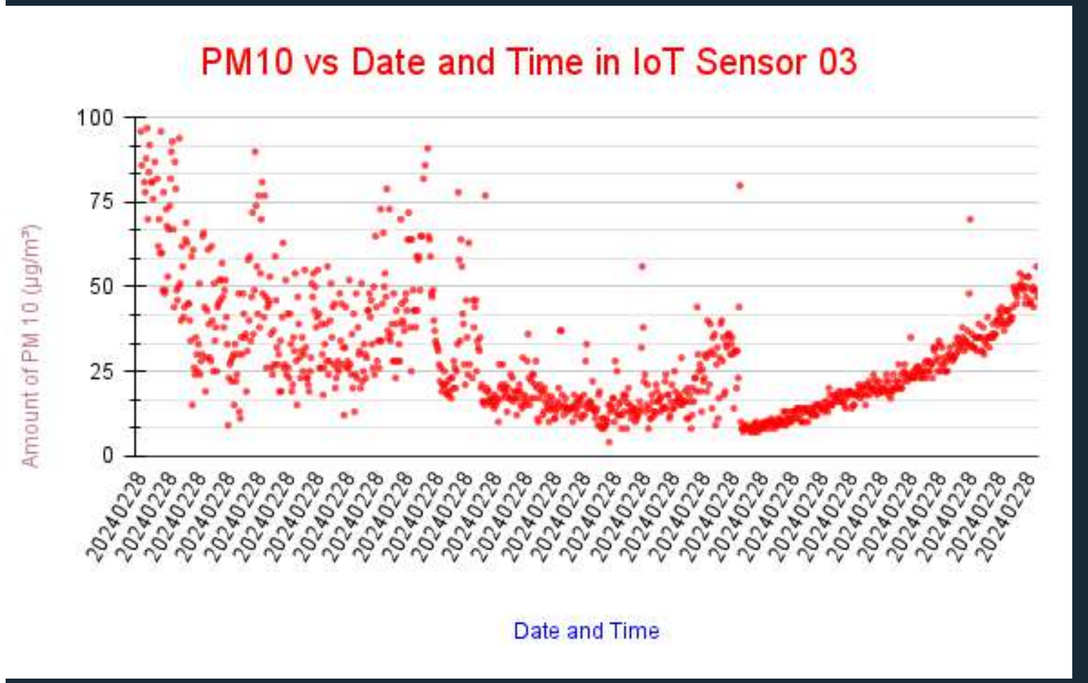




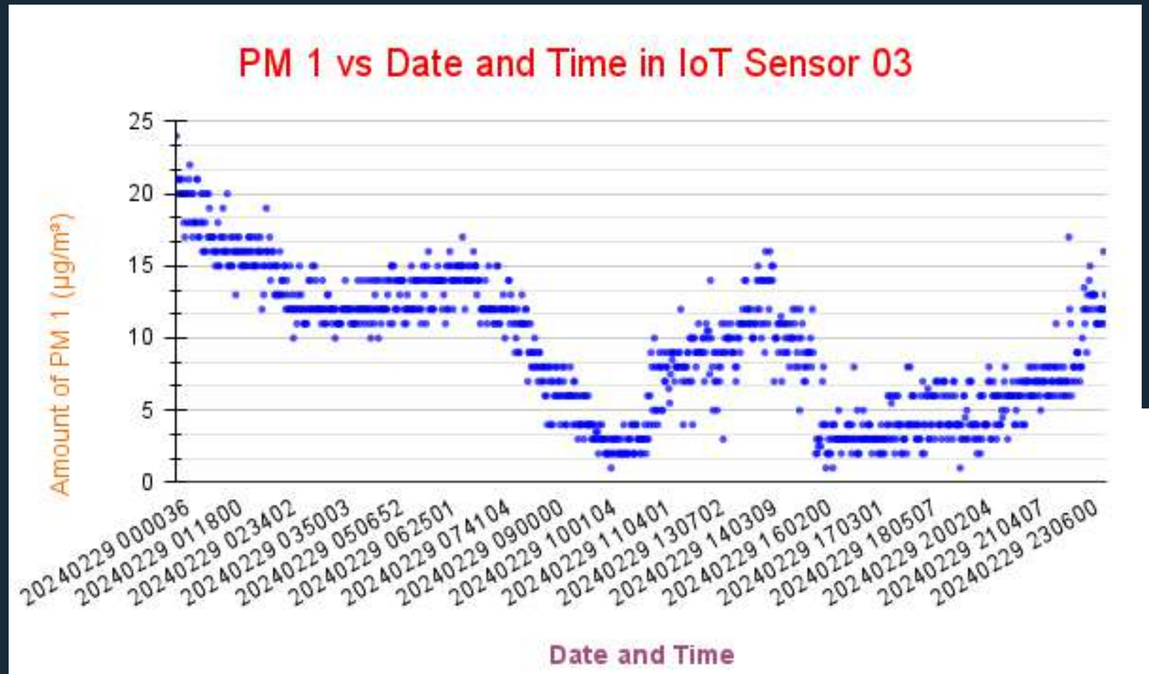
Sensor 03 day 28/01/2024

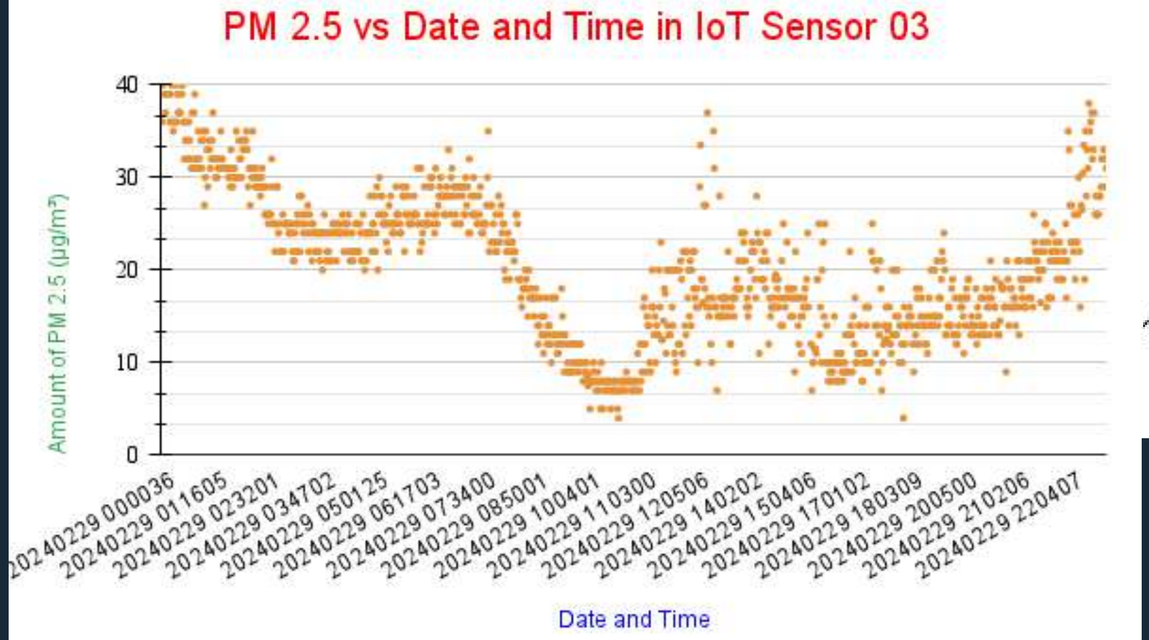


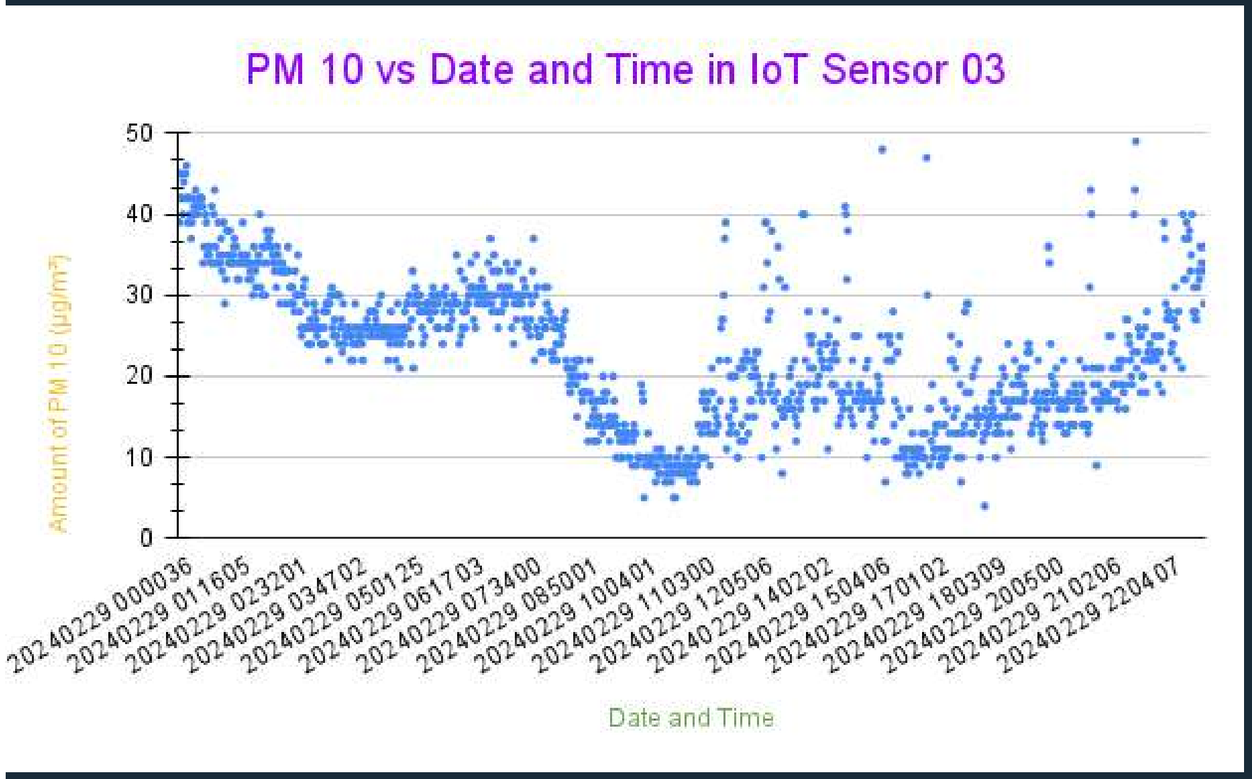




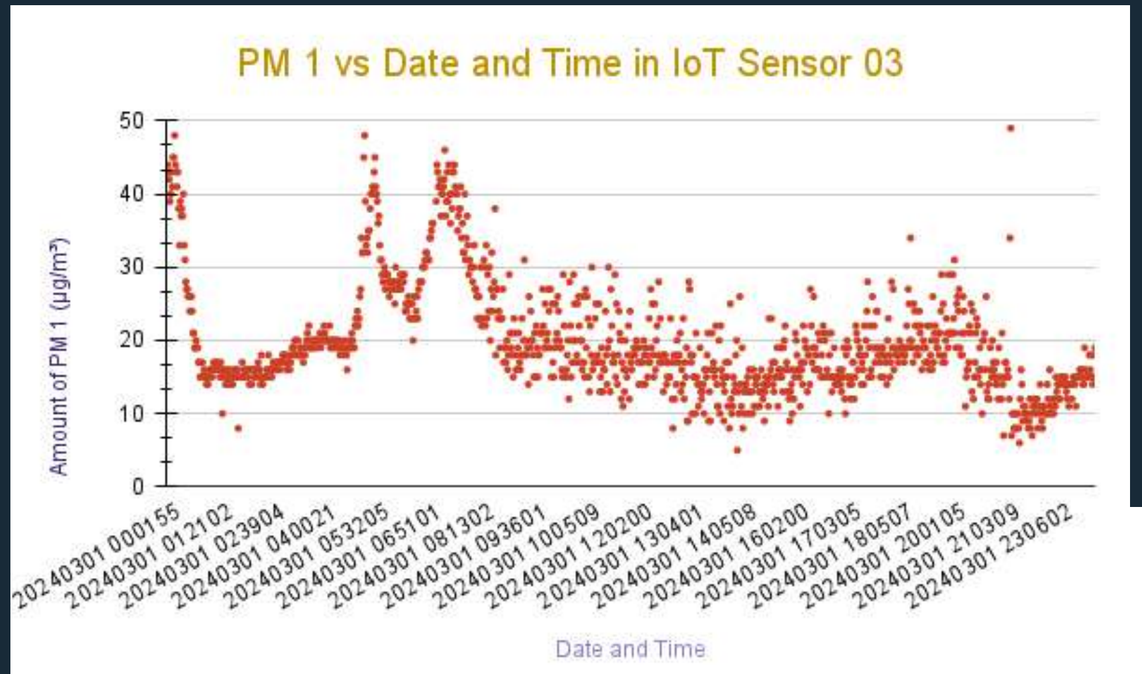
Sensor 03 day 29/02/2024

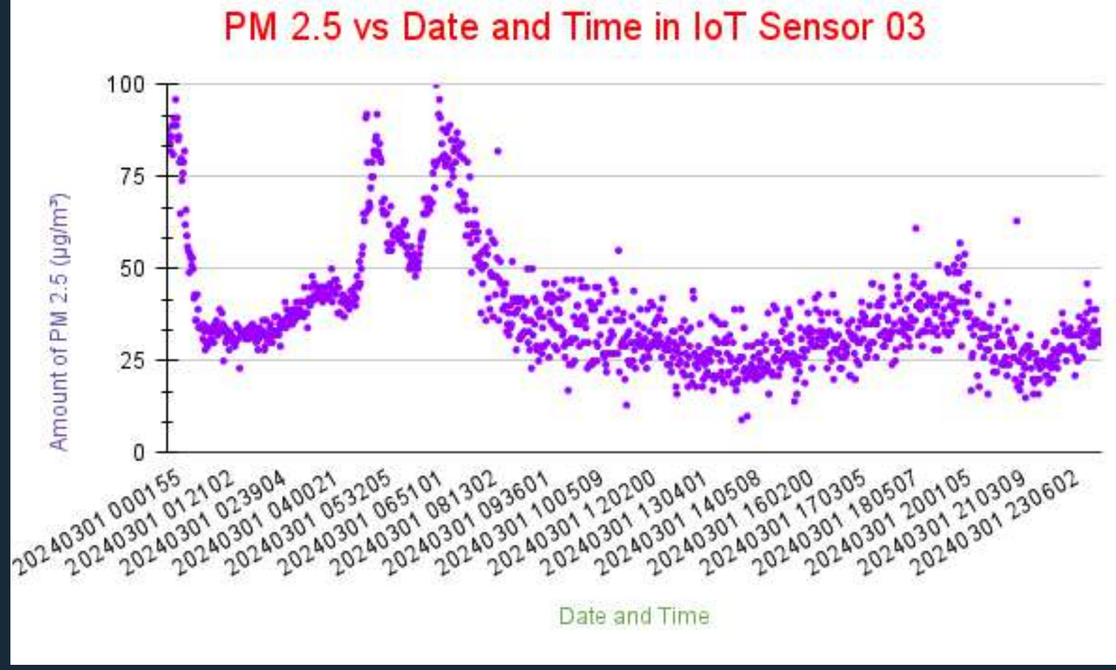


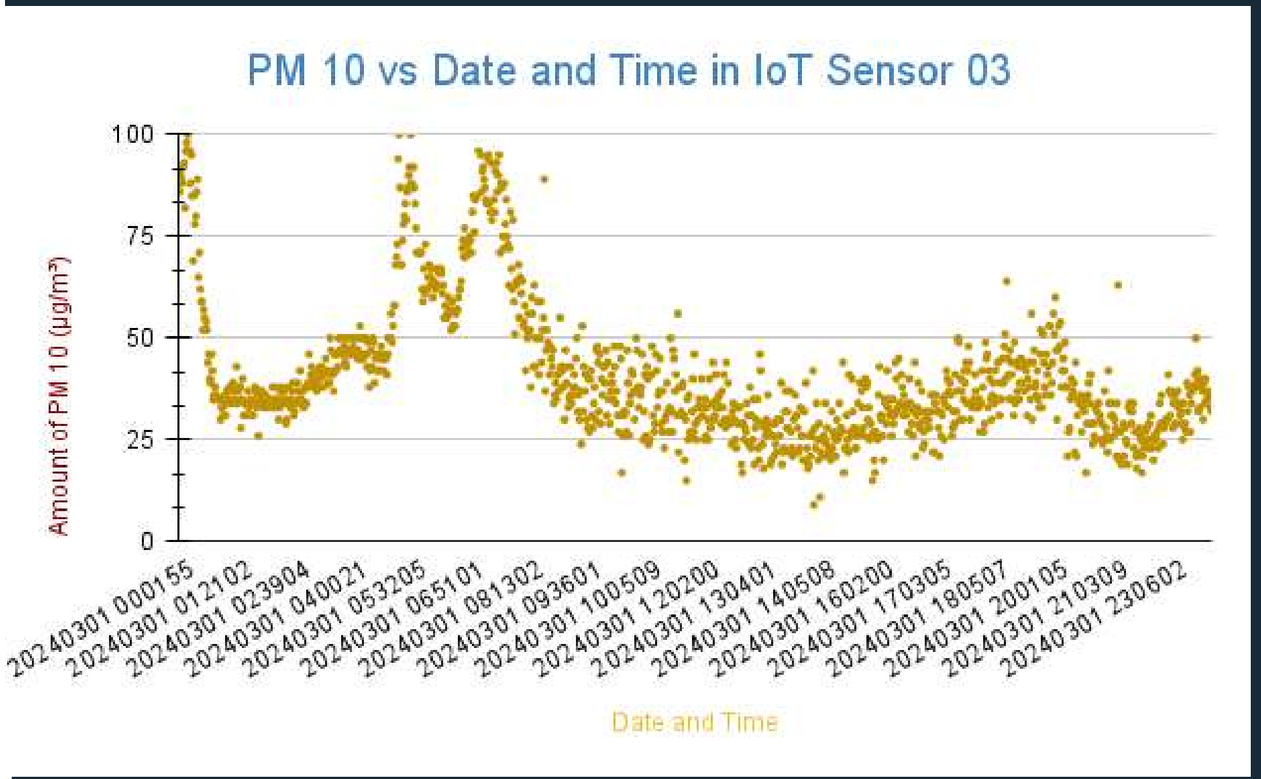




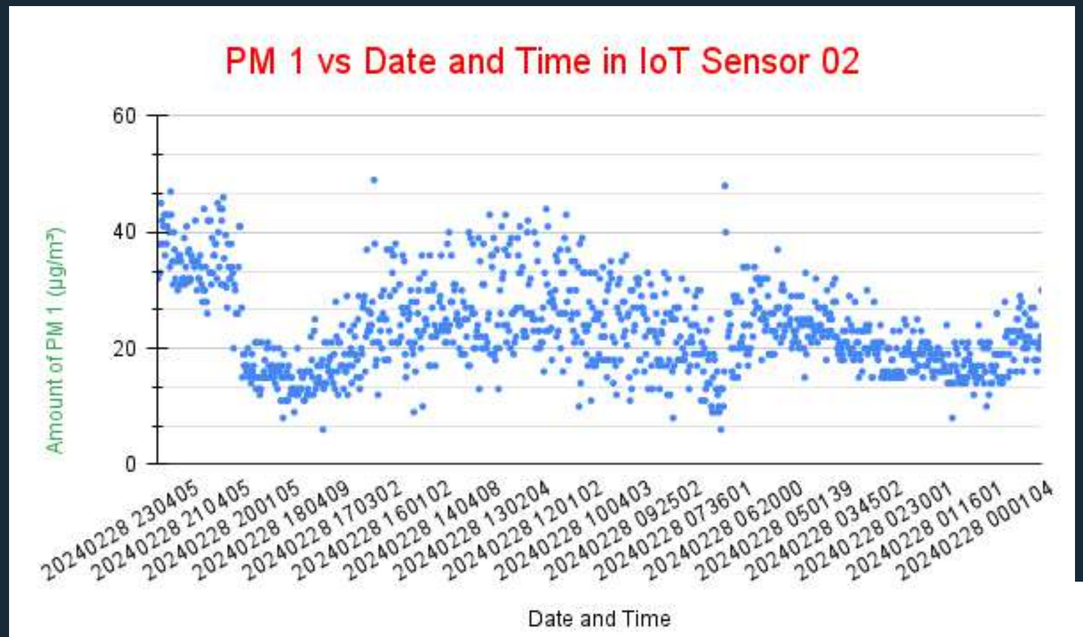
Sensor 03 day 01/03/2024

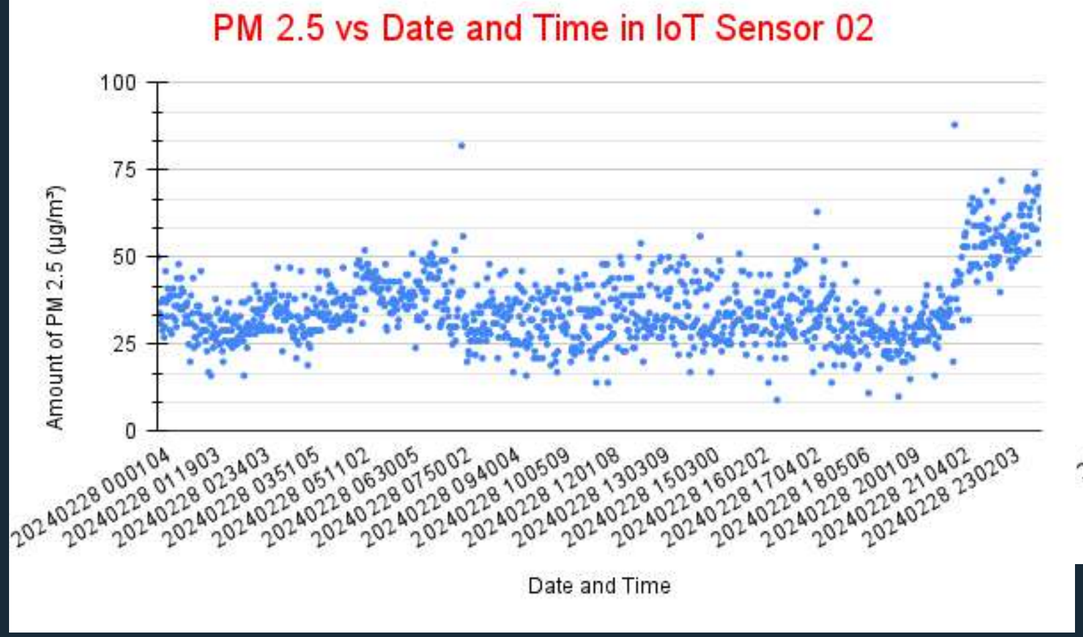


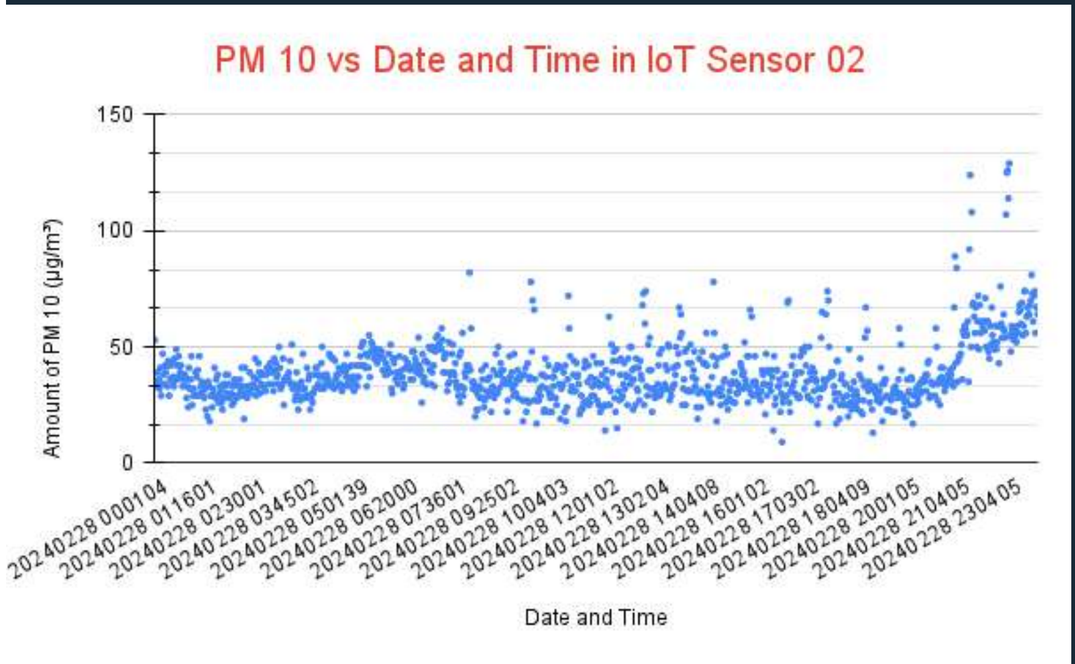




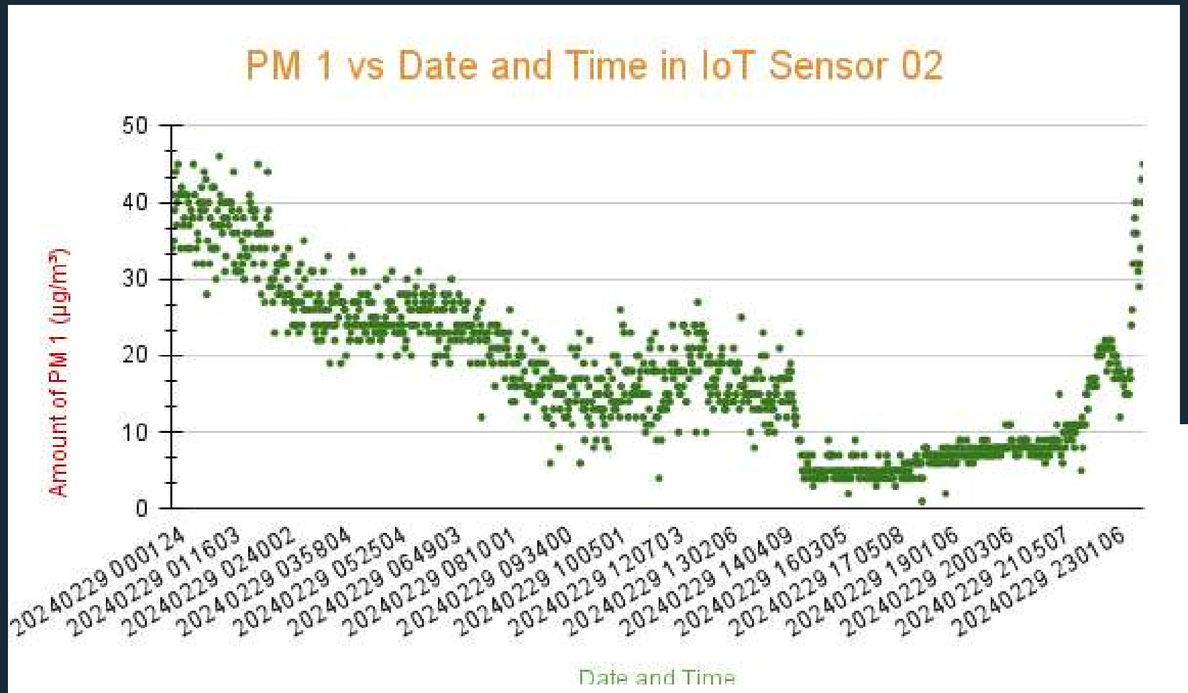
Sensor 02 day 28/01/2024

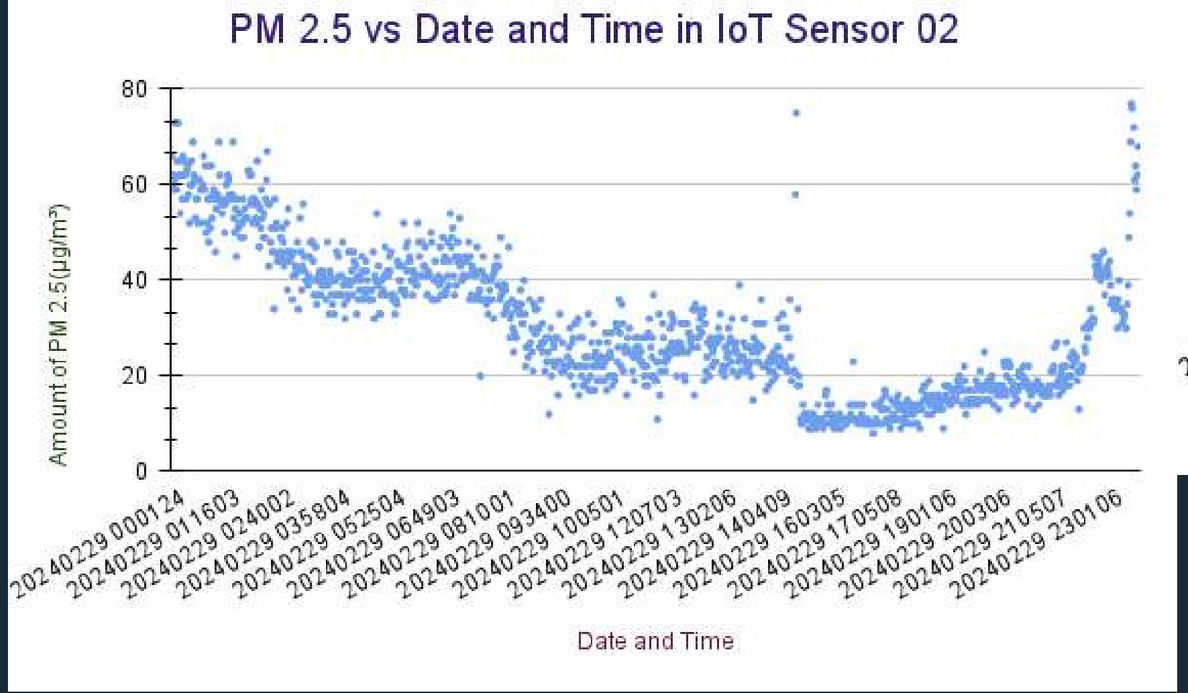


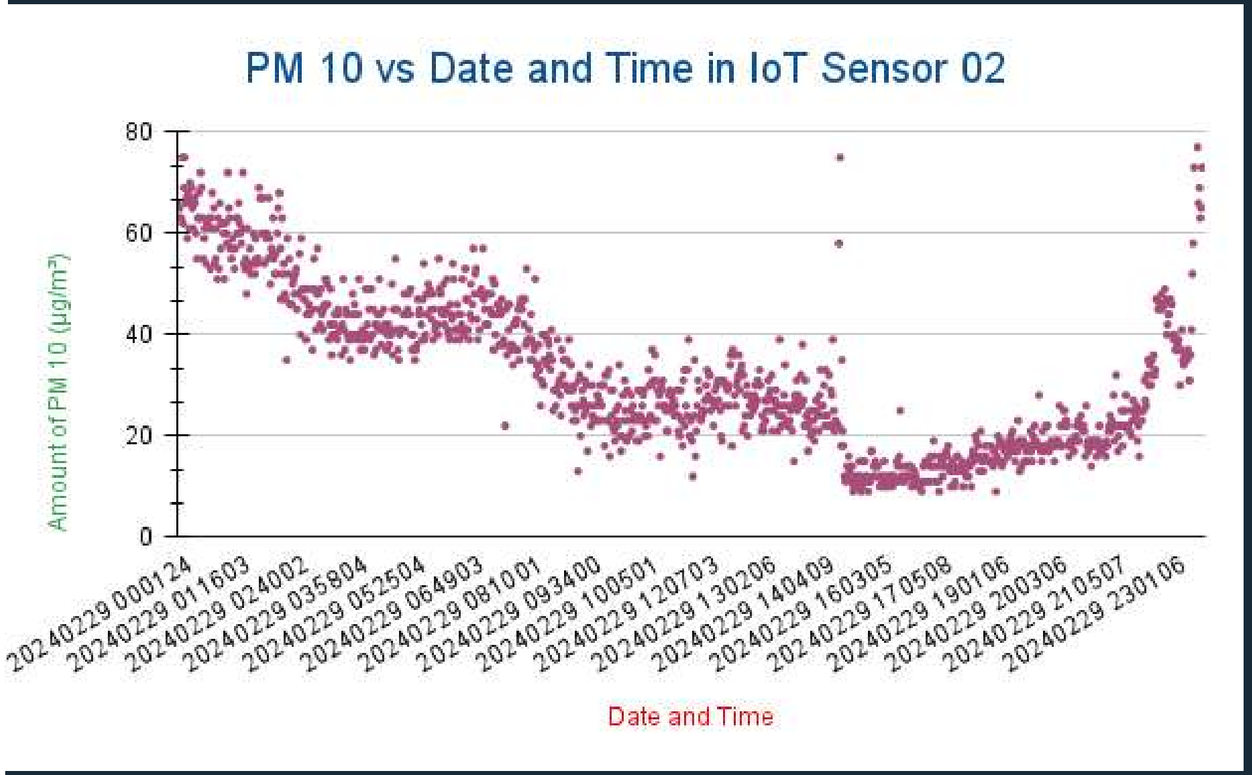




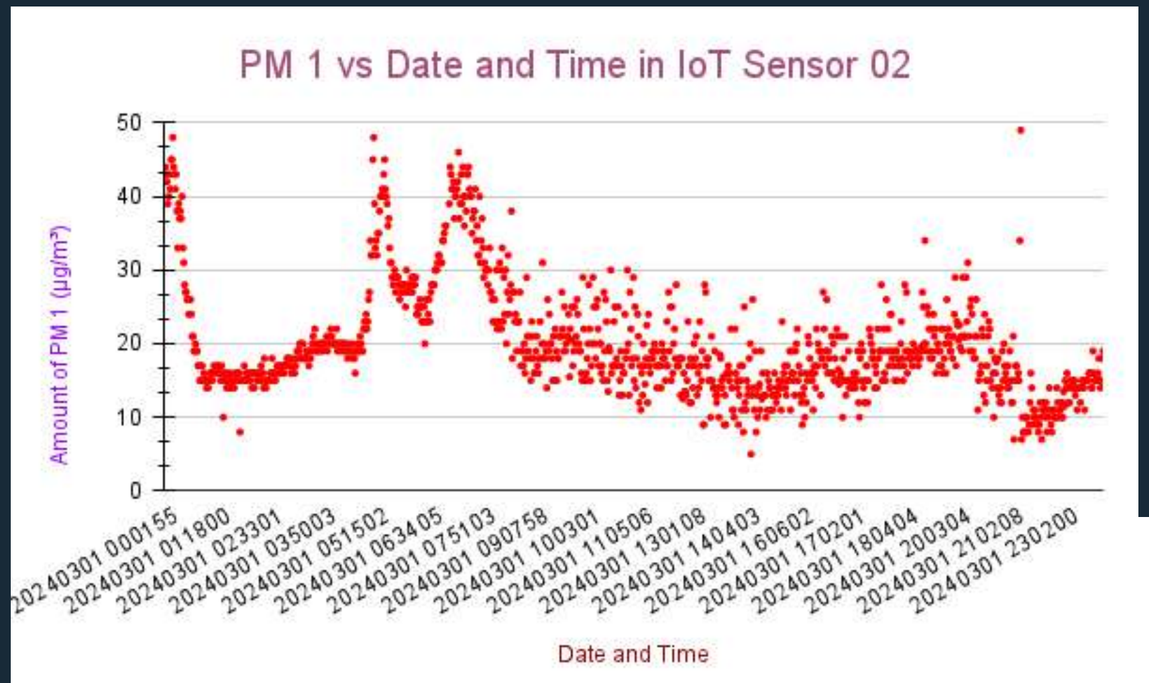
Sensor 02 day 29/02/2024

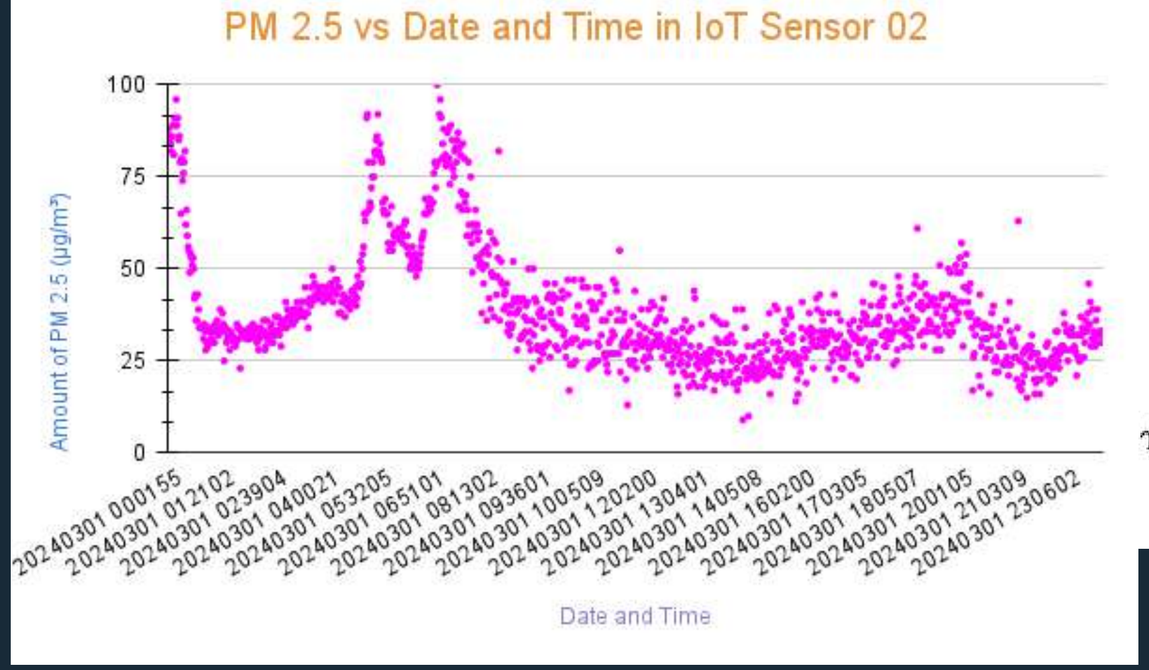


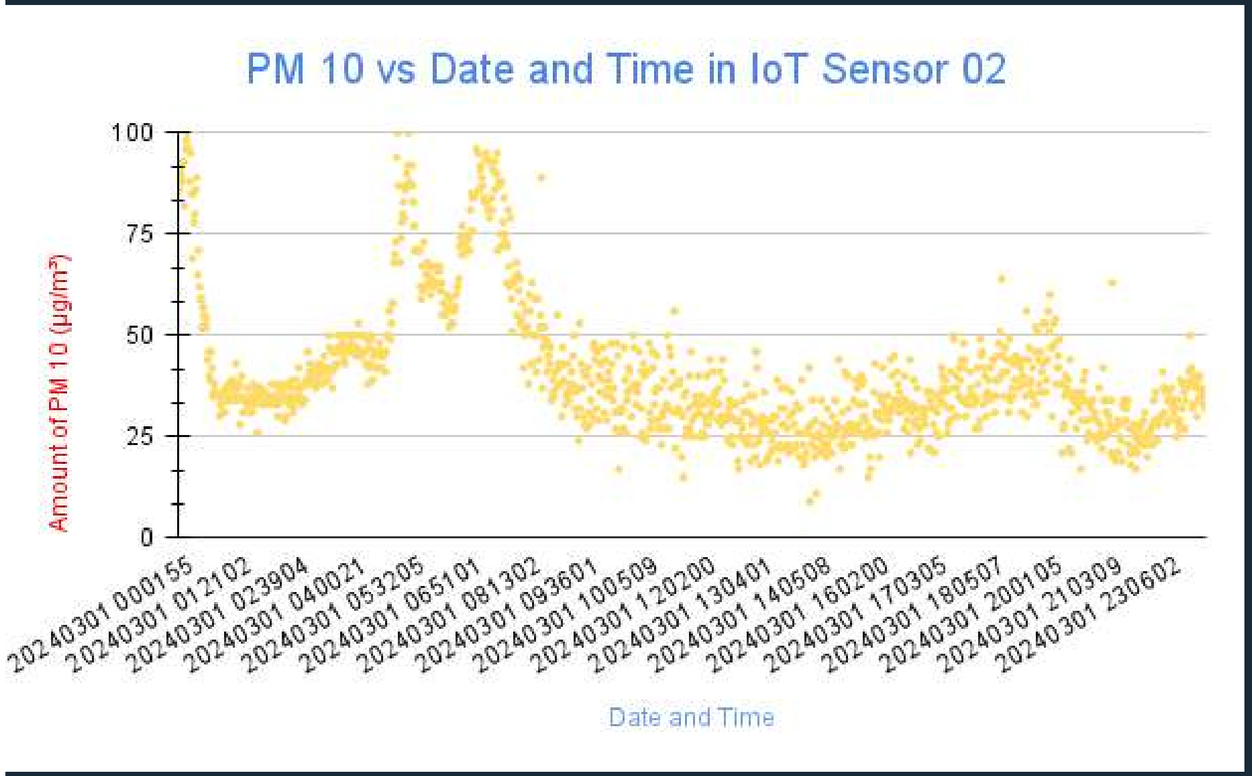




Sensor 02 day 01/03/2024





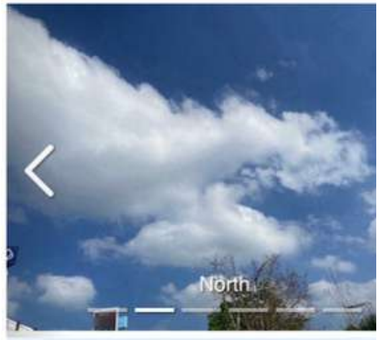


Cloud Results

Clouds

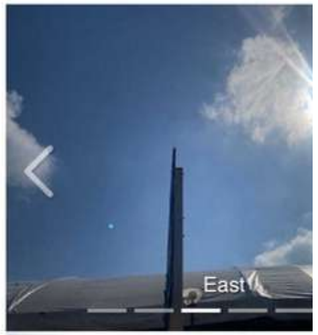
Measured Date:	2024-03-02
Organization Name:	Thailand Citizen Science
Site ID:	340535
Site Name:	47PMJ909913
Latitude:	8.06333
Longitude:	98.917409
Elevation:	10.9m
Measured At:	2024-03-02T02:41:00
Measured	2024-03-

Clouds



Measured Date:	2024-03-02
Organization Name:	Thailand Citizen Science
Site ID:	340535
Site Name:	47PMJ909913
Latitude:	8.06333
Longitude:	98.917409
Elevation:	10.9m
Measured At:	2024-03-02T02:41:00

Clouds



Measured Date:	2024-03-
Organization Name:	Thailand Science
Site ID:	340535
Site Name:	47PMJ9
Latitude:	8.06333
Longitude:	98.9174
Elevation:	10.9m
Measured At:	2024-03-02T02:41:00

Clouds

Measured Date:	2024-03-02
Organization Name:	Thailand Citizen Science
Site ID:	340535
Site Name:	47PMJ909913
Latitude:	8.06333
Longitude:	98.917409
Elevation:	10.9m
Measured At:	2024-03-02T02:41:00
Solar Measured	2024-03-

Clouds

Measured Date:	2024-03-02
Organization Name:	Thailand Citizen Science
Site ID:	340535
Site Name:	47PMJ909913
Latitude:	8.06333
Longitude:	98.917409
Elevation:	10.9m
Measured At:	2024-03-02T02:41:00
Solar Measured	2024-

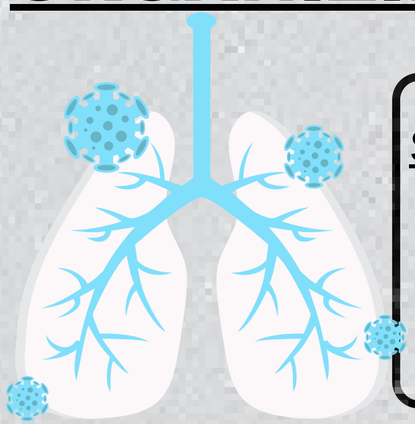
Conclusion

Based on the results, it could be concluded that Figure 7 (a-f) tells that the Low-cost IoT PM sensor is accurate and reliable in measuring and gathering the PM concentration as compared to the referenced instrument Davis Airlink in which the intrinsic correlation showed almost near to 1 or at least more than 0.5. However, some calibration methods could be suggested to reduce the error of the IoT device. Moreover, The IoT device was able to record the daily concentrations of PM in both areas without much interruptions. It was found out that PM concentrations in both areas are at the highest during the morning due to active human activities like traveling, selling and cooking street foods and daily household activities surrounding the area compared during night time. Furthermore, cumulus types of clouds are mostly seen in the area during the cloud survey. During day time, where PM is the highest, cumulus clouds are covering the sky.

REFERENCE

1. Liu, H.-Y., Schneider, P., Haugen, R. & Vogt, M. Performance assessment of a low-cost PM2.5 sensor for a nearly four-month period in Oslo, Norway. Atmosphere 10, 41 (2019).
2. Bi, J., Wilden, A., Chang, H. H. & Liu, Y. Incorporating low-cost sensor measurements into high-resolution PM2.5 modeling at a large spatial scale. Environ. Sci. Technol. 54, 2152–2162 (2020).
3. Munir, S., Mayfield, M., Coca, D., Jubb, S. A. & Osammor, O. Analyzing the performance of low-cost air quality sensors, their drivers, relative benefits and calibration in cities—a case study in Sheffield. Environ. Monit. Assess. 191, 94 (2019).
4. Lin, Y.-C., Chi, W.-J. & Lin, Y.-Q. The improvement of spatial-temporal resolution of PM2.5 estimation based on micro-air quality sensors by using the data fusion technique. Environ. Int. 134, 105305 (2020).
5. Chen, L.-J. et al. An open framework for participatory PM2.5 monitoring in smart cities. IEEE Access 5, 14441–14454 (2017).
6. Karagulian, F. et al. Review of the performance of low-cost sensors for air quality monitoring. Atmosphere 10, 506 (2019).
7. Lee, C.-H., Wang, Y.-B. & Yu, H.-L. An efficient spatiotemporal data calibration approach for the low-cost PM25 sensing network: a case study in Taiwan. Environ. Int. 130, 104838 (2019).
8. Holsters, D. M., Pillarisetti, A., Smith, K. & Seto, E. Field calibrations of a low-cost aerosol sensor at a regulatory monitoring site in California. Atmos. Meas. Tech. 7, 1121–1131 (2014).1. Liu, H.-Y., Schneider, P., Haugen, R. & Vogt, M. Performance assessment of a low-cost PM2.5 sensor for a nearly four-month period in Oslo, Norway. Atmosphere 10, 41 (2019).

ORGANIZING TEAM



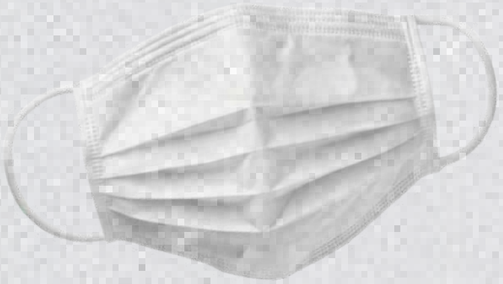
Students: Kristin Malayaphon, Tianrawit Komalittipong, Pongwarin Twesre, Dechatorn Khongcharoenchai, Charanchai akkeesuwan, Peranat Pornjaturin, Puntut Tanapaisarnwattana, Wanpee Julpamorn, Papangkorn Methavararak, Phattarapol Lakhan, Warot Phanphoowong, Napatsanan Ngeonbumroong, Chisakan Boonmee

School: Samsenwittayalai

Teacher: Mrs. Kornkamon Kumnerdkarn

Scientist: John Rex, Mr. Tewakorn Yaowa, Assoc. Prof. Dr. Krisnadej Jaroensutasinee, Assoc. Prof. Dr. Mullica Jaroensutasinee

Email: rat.kornkamon@gmail.com



THANK YOU