Experiment Details

Mobile Air Quality Monitoring of Farm Fire with Drone and Car

Abstract

In this work we try to evaluate the PM-2.5 data by doing mobile monitoring using drone and car as the platform with low-cost Purple air (Plantower PMS5003) and Alphasense OPC-R1 sensors. Our sensor validation results were quite close to CPCB reference sensors.
During our study of evaluating PM values of farm fire with drone, we observed significant change in PM-2.5 values before, during and after the fire, with a clear spike in PM-2.5 values during the fire. We also tried to compare our results from the sensor integrated on drone to the data taken by the Satellite at 1:30 pm and found … ?
We also found a significant spike in PM-2.5 values due to farm fire by keeping the sensor on ground near the fire site.
Similarly we also observed the impact of Farm fire on PM-2.5 values in rural areas by doing mobile sensing with car and clearly found spike in PM-2.5 values near fire sites. We also did mobile sensing in rural area with negligible farm fires, and interestingly found that rural areas where farm fires are very frequent, had significantly higher PM-2.5 concentrations, thus showing impact of farm fires in rural areas.

1.) 21/10/2020

Sensor Data Validation of OPC-R1 and Purple Air (PA) sensor before experiment with CPCB references sensor in Jaipur, Rajasthan.

Average PM2.5 of CPCB Reference sensor Between 2:30 to 3 PM on 21/10 = 51 ug/m3 (Location - Shastri Nagar , Jaipur)

Average PM2.5 of PA Between 2:30 to 2:48 PM on 21/10 = 47.43 ug/m3

Average PM2.5 of OPC-R1 Between 2:33 to 2:49 PM on 21/10 = 61 ug/m3

Data matches quite closely between these sensors.

Fig. 1 : Sensor (PA and OPC-R1) taking data near to Reference sensor)

2.) 22/10

Mobile Monitoring in Karnal near farm fire sites using Alphasense OPC-R1 sensor.

A.) Farm Fire : (Time - 3:15pm)

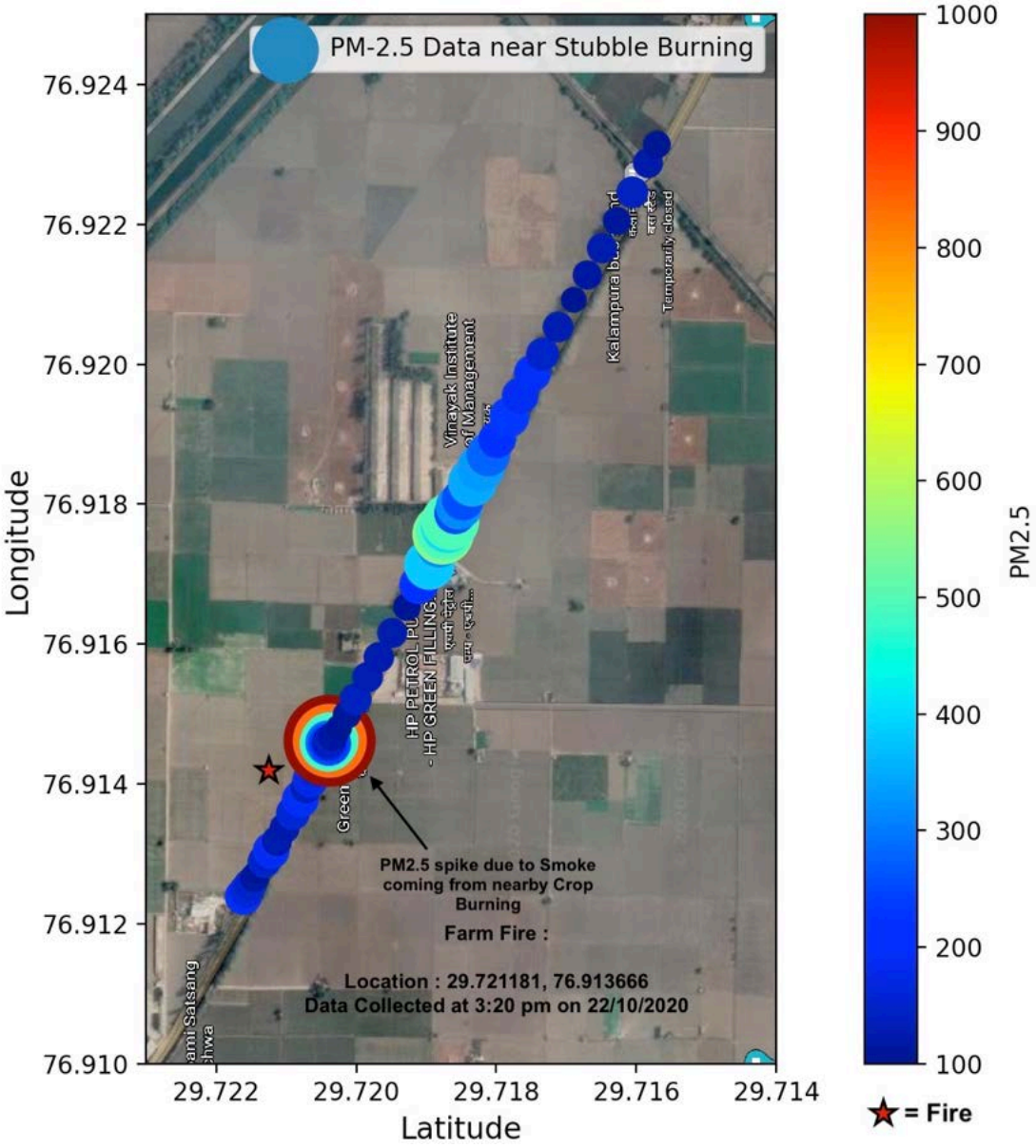


Fig. 2 : PM-2.5 values of Farm Fire 1 near Karnal observed by mobile sensing with car

Fig. 3 : Image of Farm Fire 1 and sensor taking data

B.) Farm Fire 2 : (Time - 6 pm)

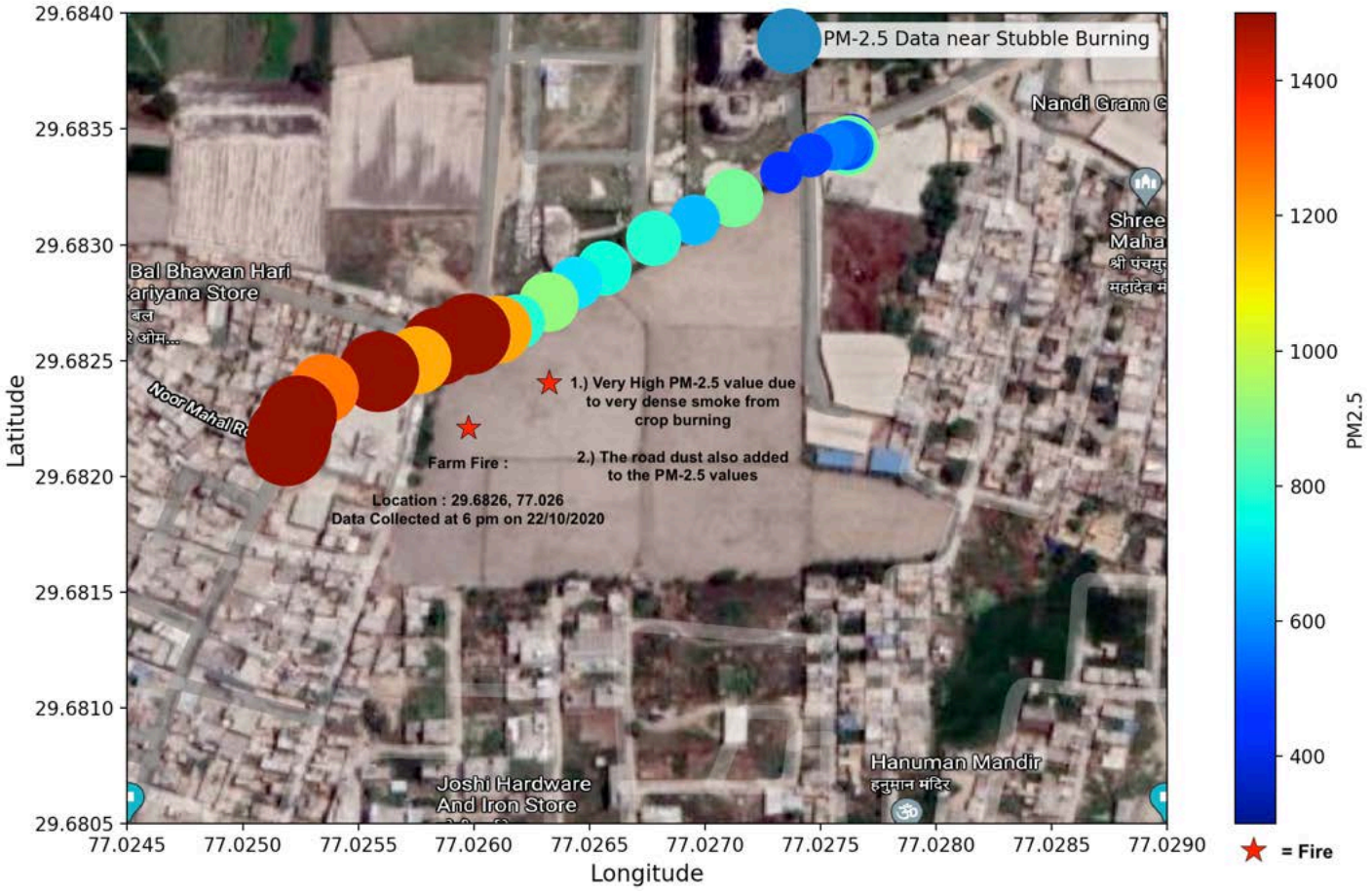


Fig. 4 : PM-2.5 values of Farm Fire 2 near Karnal observed by mobile sensing with

Fig. 5 : Image of Farm Fire 2

3.) 23/10

a.) Drone AQ Data

We took the data from Purple Air Sensor by connecting it to a drone using a rope and collected data from the sensor before, during and after the farm fire.

Equipments used for the experiment :

- Drone - We used a DJI Phantom 4 Advanced drone to get smoke data from crop fire. The drone had an onboard gimbal camera that took video of the flight above crop fire.

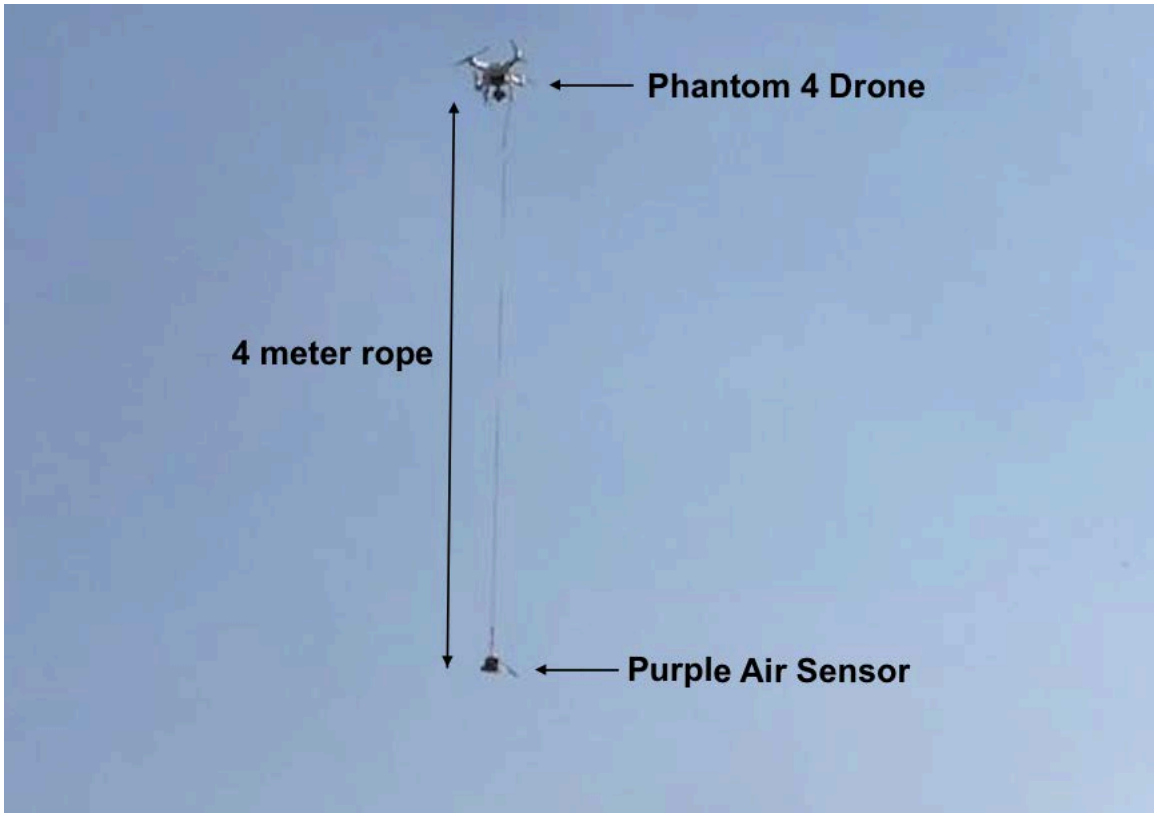


Fig. 6 : Phantom 4 drone with Purple Air Sensor suspended using a 4 meter rope to overcome effect of propeller wash.

(https://www.dji.com/phantom-4-adv)

- Sensor - Purple Air

Purple Air sensor weighs about 350 grams. In order to make it capable to fly on phantom 4 drone, we had to reduce its weight. So, we removed the outer fairing of the sensor, which reduced its weight significantly. The final weight Sof the Purple Air sensor, 4 meter rope and a 2 Ah power bank was 255 grams. The sensor stored the data on an onboard SD card.

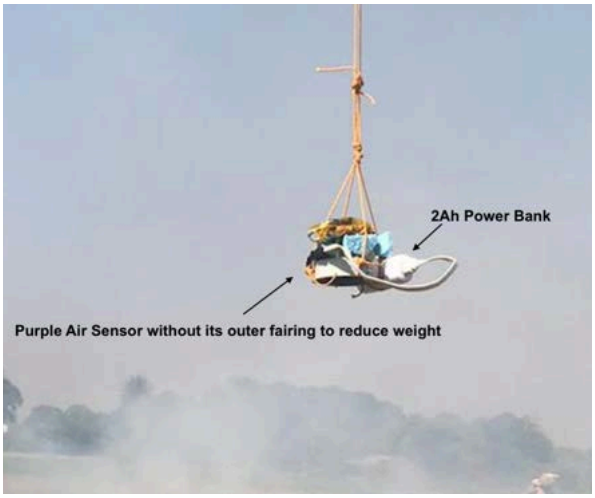


Fig. 7 : Purple Air sensor with 2Ah power bank

In order to reduce the impact of the propeller wash on the sensor readings, we decided to suspend the Purple Air sensor with the Drone using a 4 meter rope. The purple air sensor has a sampling rate of 80 seconds and generates PM data along with Temperature and Pressure values using 2 Plantower PMS5003 units. The advantage of using 2 PMS5003 is to overcome any data redundancy issues caused by the conditions.

We also placed an Alphasense OPC-R1 sensor on the ground, just below the drone. We connected it to a RaspberryPi using a SPI to USB connector (https://github.com/piyushy6/Mobile-Air-Quality-Sensor). The RaspberryPi also had an onboard GPS to get Latitude-Longitude data. This air quality module had a 3s 1Ah Lipo battery to power it.

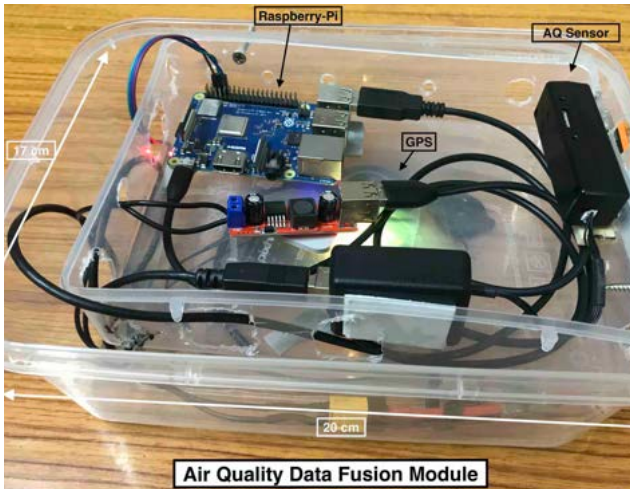


Fig. 8 : Alphasense OPC-R1 sensor with GPS and RaspberryPi

We used this same system to do mobile monitoring with car in rural areas of Karnal to get spatiotemporal data.

Experiment Sensor Data -

Sensor Data of experiment available in Excel Sheet - Farm Fire Data from Drone.xlsx

Experiment Video -

https://drive.google.com/drive/u/4/folders/1yQTbllgLPr3c9V7HNQWFJo04lzmBBcMy

- Farm Fire Details

We performed this experiment on 2 nearby farm locations in Karnal, Haryana

1.) Farm 1 : (29.684285, 77.047881)

Data collected between - 12:51 pm to 1:22 pm

Farm Details - 1 Acre Rice Farm

It was very windy, so the farm caught fire very quickly. We got the data during the period. After the fire in this farm was over, we started burning stubble in a nearby farm, 20 meter away from this farm.

2.) Farm 2 : (29.685080, 77.046886)

Data collected between - 1:22 pm to 2:28 pm

This fire started around 1:25 pm, it lead to a lot of dense smoke, but intensity of fire was less this time. The smoke kept on changing its direction due to wind.

Fig. 9 : Farm where crop fire took place

1.) Farm 1

Farm Before Fire (Average PM2.5 = 55.5 ug/m3)

Fig. 10 : Farm 1 before fire

Farm During Fire (Average PM2.5 = 171.65 ug/m3)

Farm After Fire (Average PM2.5 = 39.8 ug/m3)

Fig. 11 : Farm 1 after fire

PA Sensor Integrated to drone by rope , OPC-R1 on ground next to crop fire

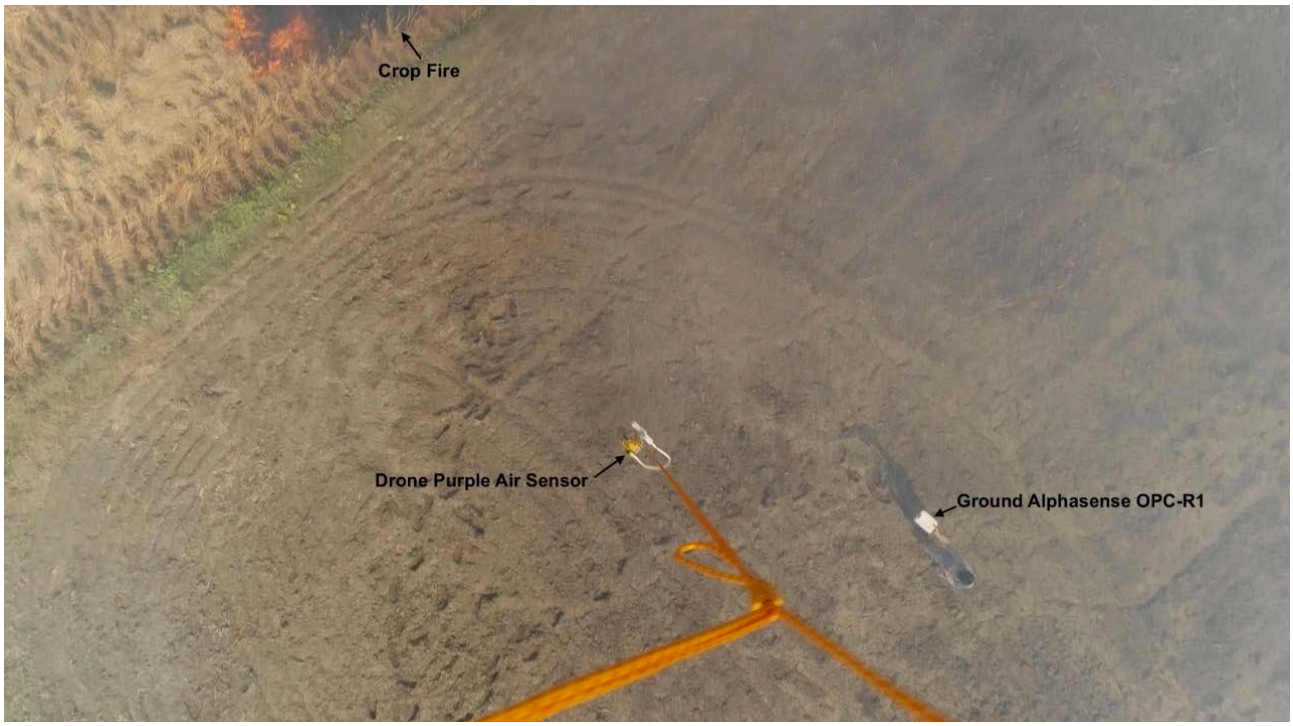


Fig. 12 : Sensors taking the data during the experiment

Fig. 13 : Drone Above Fire in Farm 1

2.) Farm 2

Farm Before Fire (Average PM2.5 = 65.78 ug/m3)

Fig. 14 : Farm 2 before Fire

Farm during Fire (Average PM2.5 = 212.73 ug/m3)

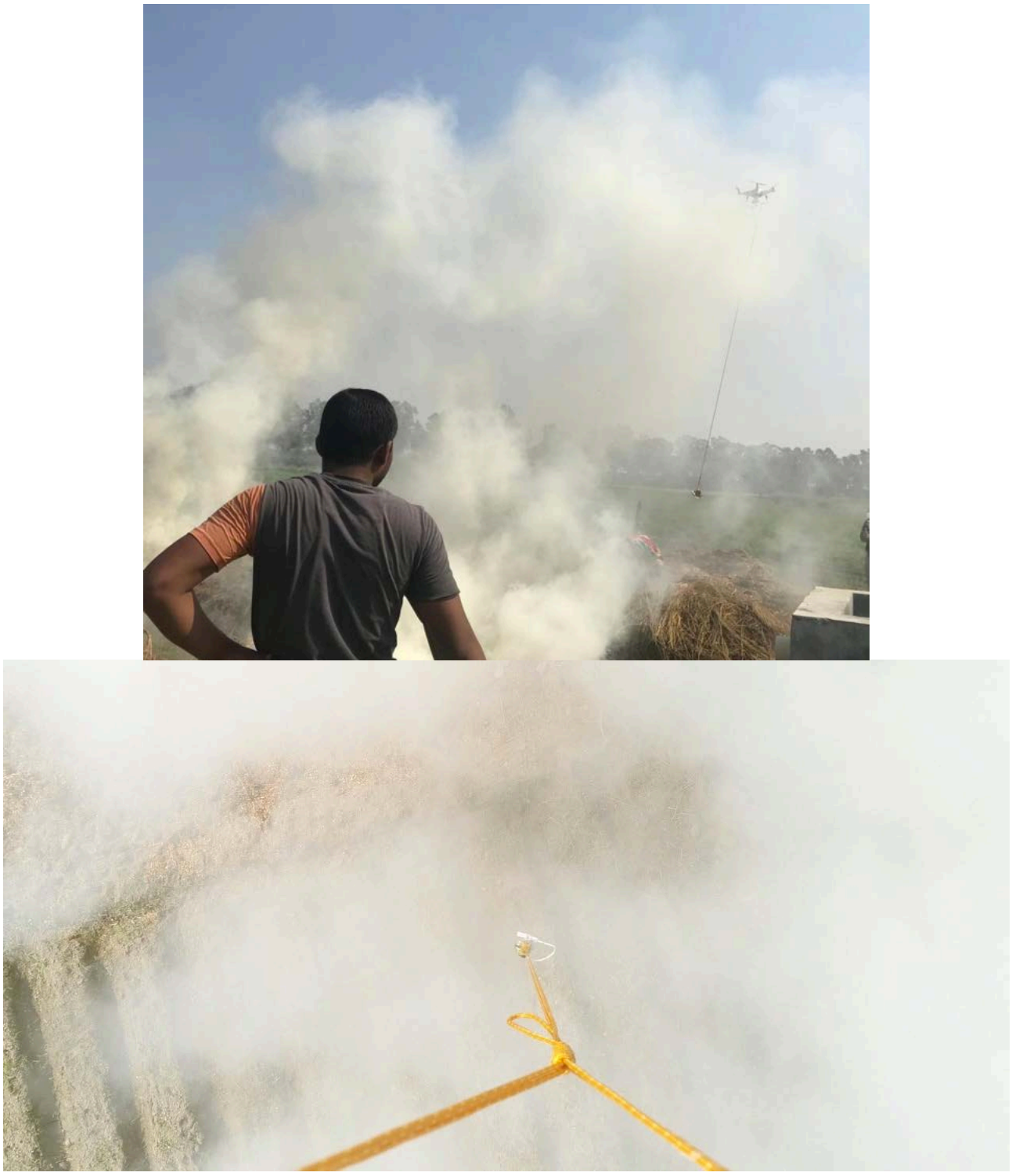


Fig. 15 : Farm 2 during Fire. Sensor in dense smoke

Farm after Fire (Average PM2.5 = 49.11 ug/m3)

Experiment Results Analysis of PM2.5 from Purple Air Sensor -

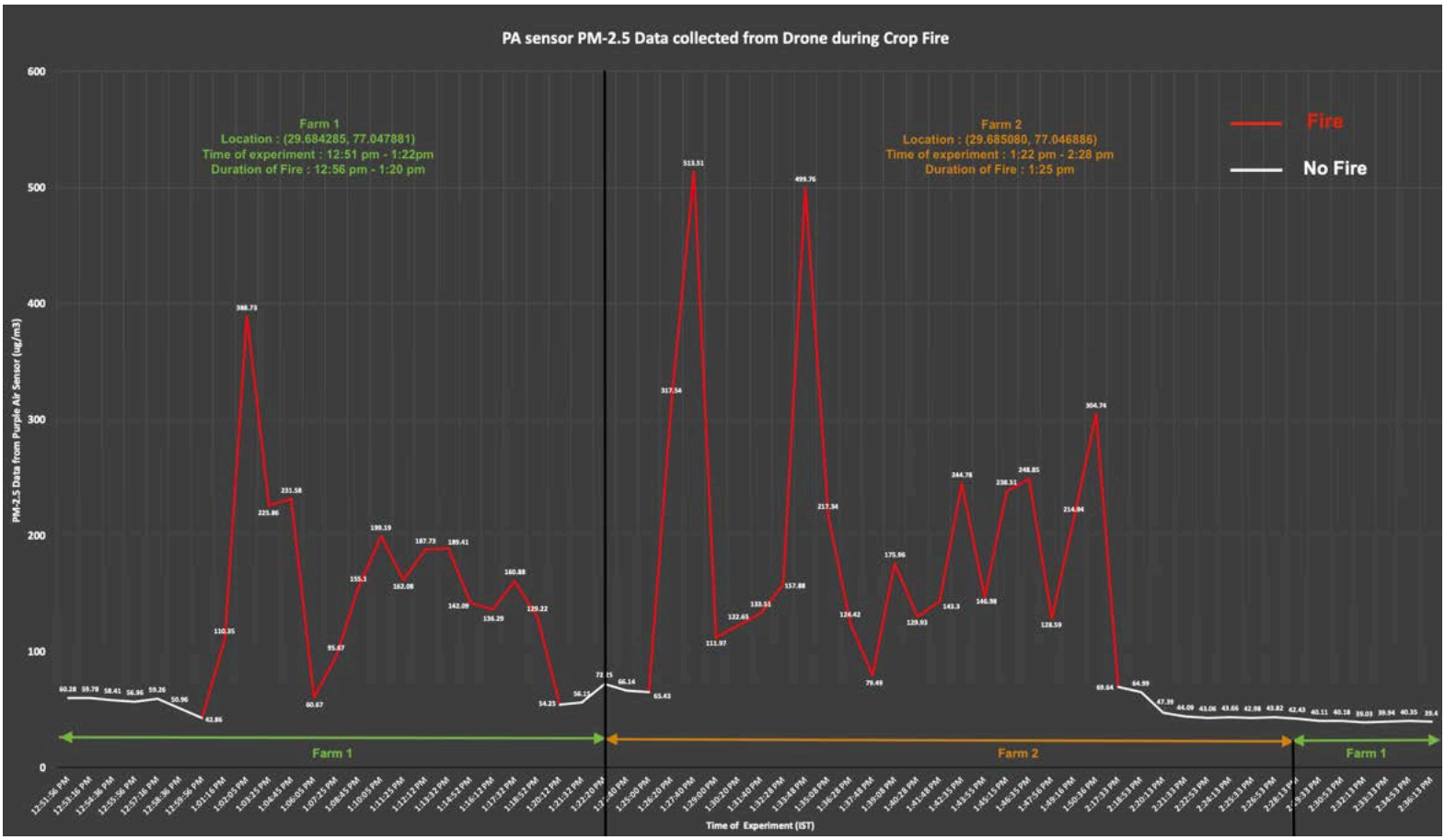


Fig. 16 : Analysis of the impact of Farm Fire on PM-2.5 collected by drone using Purple Air

1.) Farm 1 : (29.684285, 77.047881)

Data collected between - 12:51 pm to 1:22 pm

Average PM2.5 before Farm Fire = 55.5 ug/m3

Average PM2.5 during Farm Fire = 171.65 ug/m3

Average PM2.5 after Farm Fire :
Between 1:19 pm to 1:22 pm = 60.88 ug/m3
Between 2:28 pm to 2:36 pm = 39.8 ug/m3

This graph clearly shows the impact of fire on the PM values. As can be seen from the graph, the average PM2.5 values of Farm 1 before fire was 55.5 ug/m3.

During fire the Farm 1 PM2.5 values spikes to an average of 171.658 ug/m3.

After fire in Farm 1 was finished, we started moving towards Farm 2, just 20 meters away from Farm 1. We recored PM2.5 values around Farm 1 to be 60.88 ug/m3. The sudden drop in PM2.5 value is due to no smoke as fire was finished and wind which blew the smoke away from sensor. So, the sensor was in clean air during this period.

We also started recording the PM-2.5 data of Farm 1 around 2:28 pm, and found it to be around 39.8 ug/m3 average.

2.) Farm 2 : (29.685080, 77.046886)

Data collected between - 1:22 pm to 2:28 pm

Average PM2.5 before Farm Fire = 65.78 ug/m3

Average PM2.5 during Farm Fire = 212.73 ug/m3

Average PM2.5 after Farm Fire = 49.11 ug/m3

As can be seen from the above graph, the average PM2.5 values of Farm 2 before fire was 65.78 ug/m3.

During fire the Farm 2 PM2.5 values spikes to an average of 212.73 ug/m3.

The average PM-2.5 data recorded from Farm 2 after the fire was found to be around 49.11 ug/m3.

b.) Mobile Monitoring in Karnal

We used Alphasense OPC-R1 sensor for doing mobile sensing

Fig. 17 : Sensor integrated on car for doing mobile sensing

In rural area :

Interestingly, most of the farmers are already informed about Satellite taking stubble burning data between 12pm to 2pm. So we decided to visit farm field in rural areas nearby Karnal city after 4 pm. This is the time during which most farm fires start (as informed by local people). Interestingly we found couple of fires in every few kilometres distance.

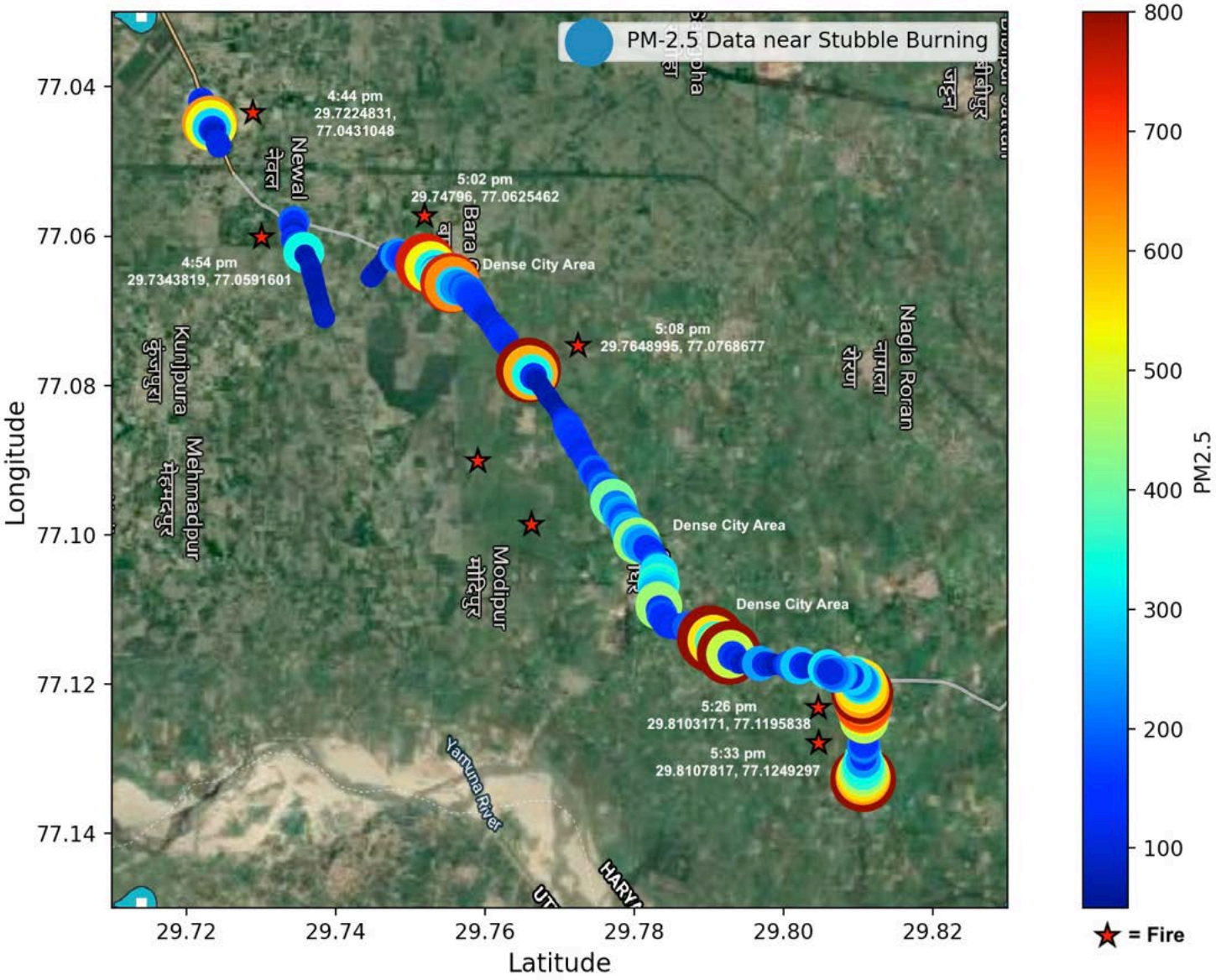


Fig. 18 : Mobile sensing near Crop Burning sites marked by red star in Rural area near Karnal

Fires in this map have been marked by red star. It could be easily seen how frequent these fires were. Interestingly, these fires also showed change on OPC-R1 sensor readings due to smoke created by the fires.

Fig. 19 : Stubble Burning images taking while taking the data

In city area :

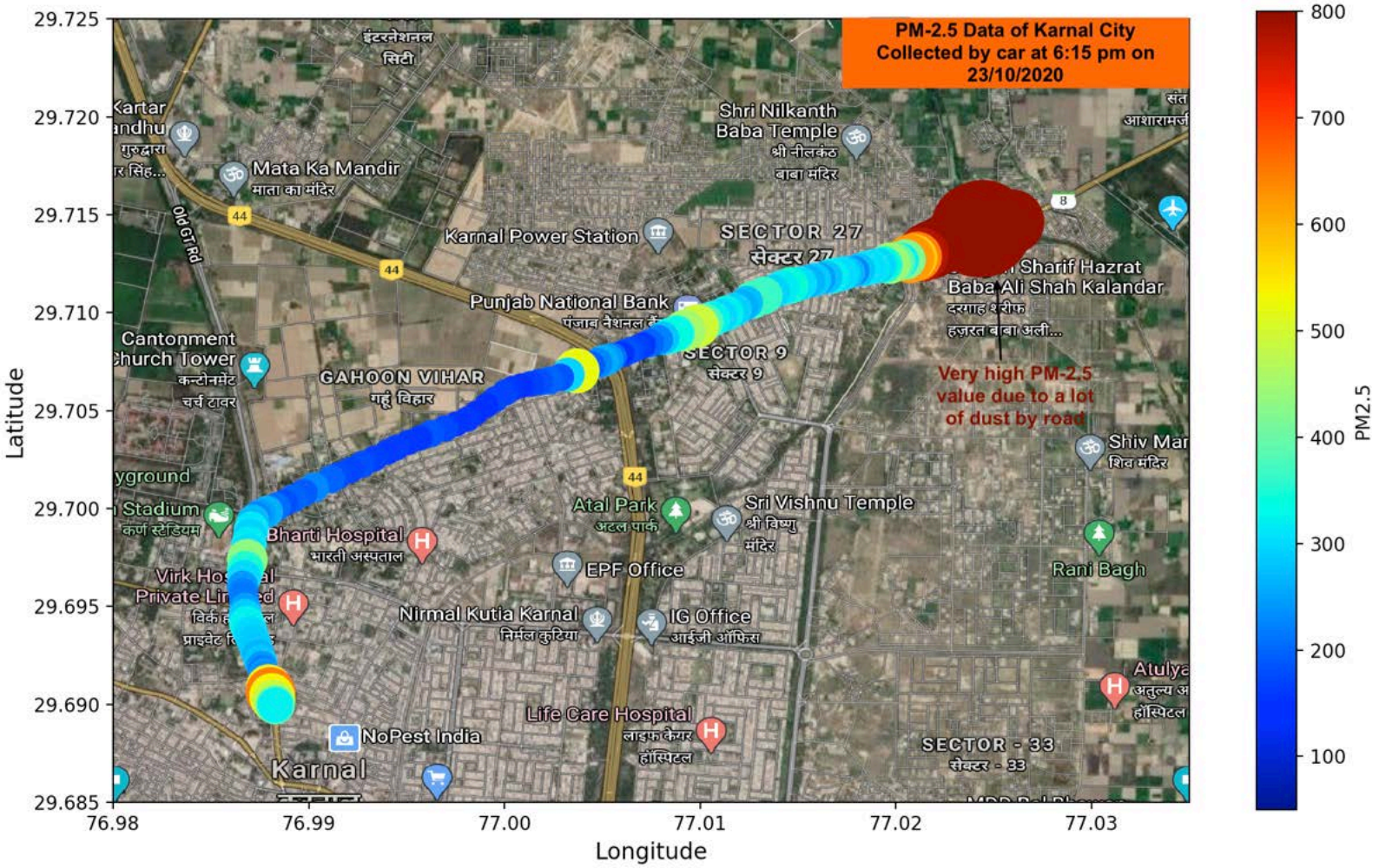


Fig. 20 : Mobile sensing in Karnal city to observe the impact of nearby crop burning on city air quality

The impact of stubble burning in nearby rural areas of Karnal could be easily observed on the AQ levels of Karnal city at around 6pm. The PM-2.5 were in the range of 400-500 ug/m3 in the city area.

4.) 24/10

a.) Sensor Data Validation after experiment with CPCB Sensor in Karnal

Fig. 21 : Sensor Data Validation near a CPCB Reference sensor in Karnal

Average PM2.5 of PA Between 12:30 to 12:47 PM on 24/10 = 137.9 ug/m3

Average PM2.5 of CPCB Reference sensor Between 12:30 to 1 PM on 24/10 = 169 ug/m3 ; Location - Sector-12, Karnal (There might be some difference between reference monitor values and PA values as they were placed nearby but not exactly at the same spot, and traffic might have an impact on the data. Still the data looks very close.)

b.) Ground Based Stubble Burning data for 1 hour (1:30 pm to 2:20 pm)

Farm Fire Location - 29.637249, 77.026601

Fig. 22 : Purple Air sensor taking data near a Farm Fire in Karnal Rural area

While doing mobile monitoring, we found a stubble burning site in Karnal rural area. The fire was just about to begin when we reached. We collected data just before the fire. When the fire began, it lead to a lot of smoke. We got a lot of data during the fire. The fire was very big and lead to a lot of smoke.

Fig. 23 : Farm Fire Image while taking the data

Impact of Fire on nearby road leading to zero visibility.

Fig. 24 : Impact of smoke from fire on the road's visibility

Experiment Results of PM2.5 from Purple Air Sensor fixed on Ground -

Farm Before Fire (Average PM2.5 = 70.96 ug/m3 at 1:31 pm)

Farm During Fire (Average PM2.5 = 180.1 ug/m3 between 1:32 pm to 2:11 pm)

Farm After Fire (Average PM2.5 = 85.6 ug/m3 between 2:12 pm to 2:20 pm)

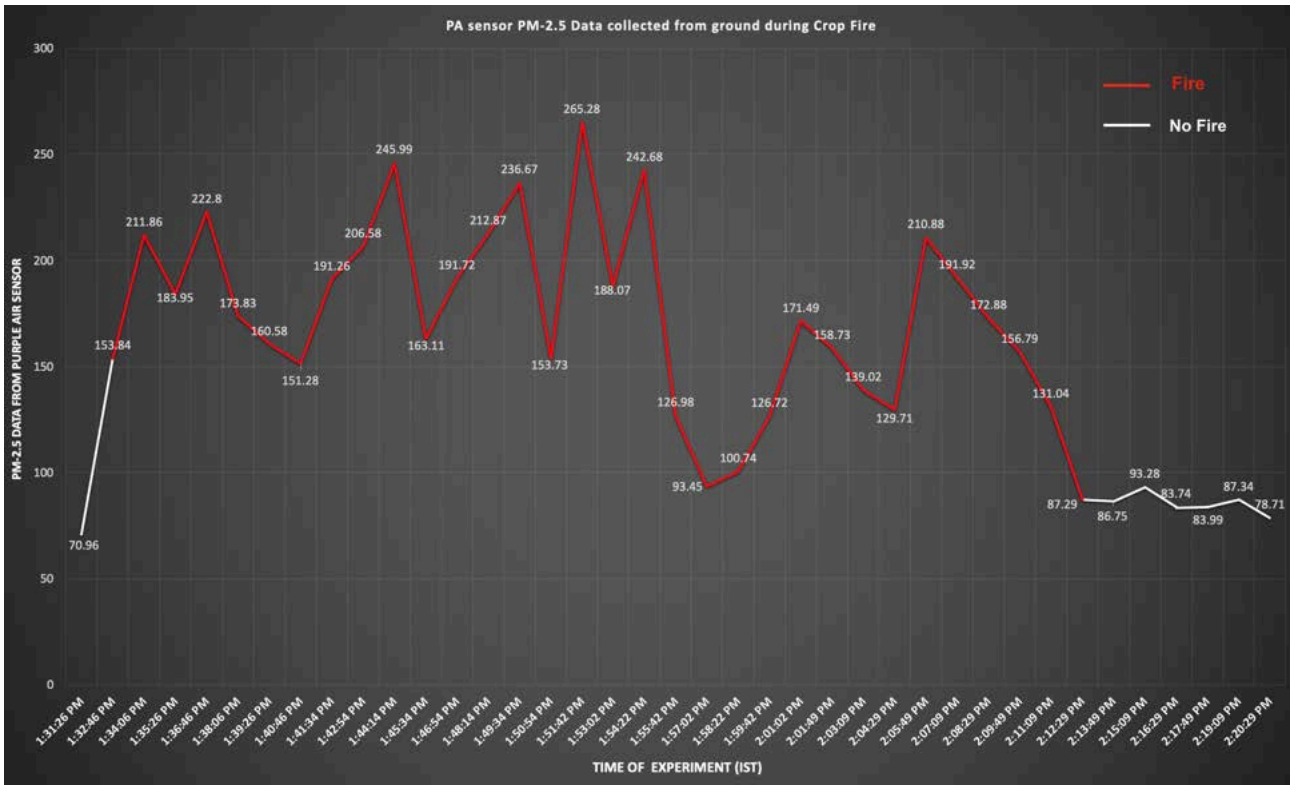


Fig. 25 : Analysis of the impact of Farm Fire on PM-2.5 collected by keeping the Purple Air sensor on Ground next to

5.) 25/10

Mobile Monitoring in Kosli (Haryana) with less crop burning

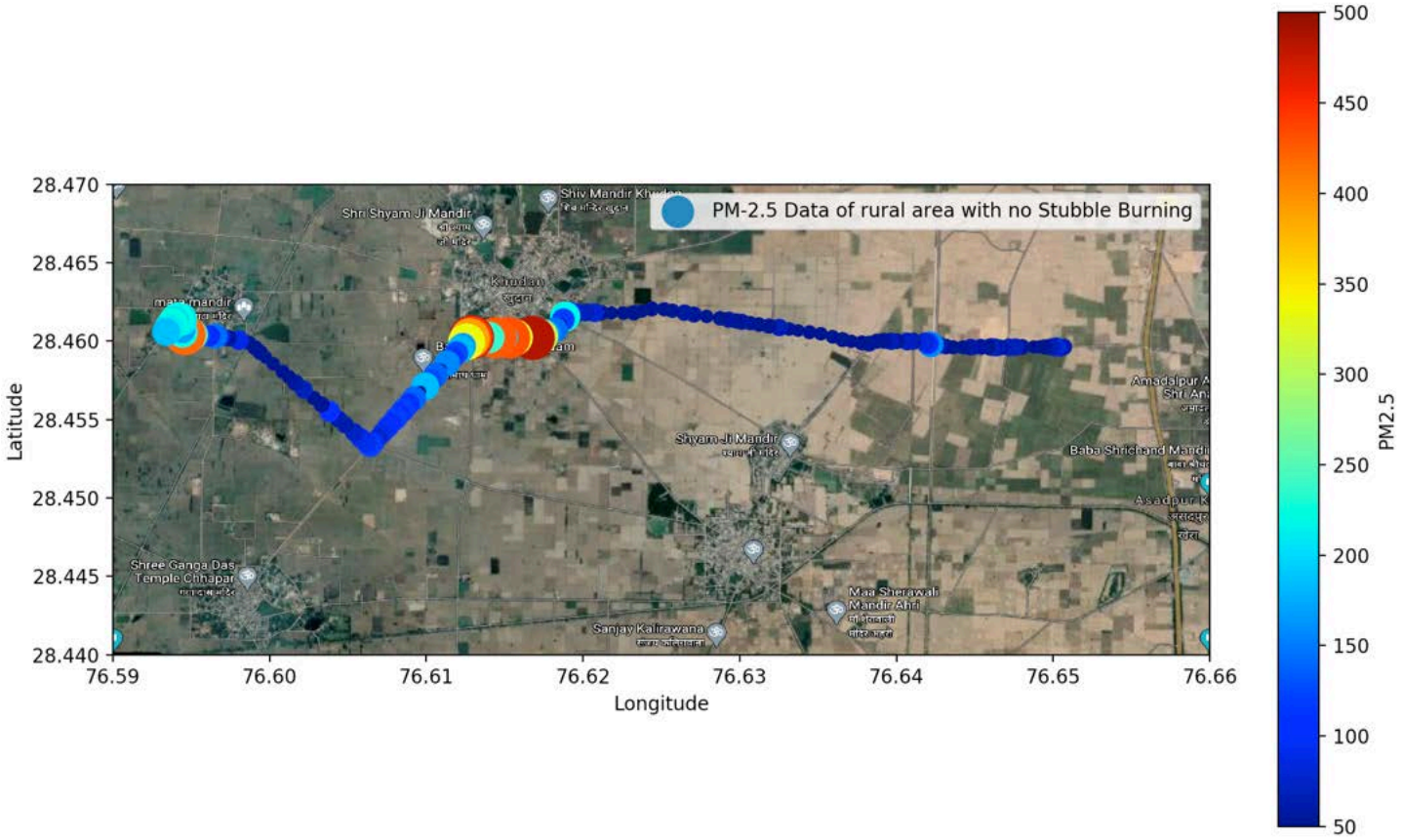


Fig. 26 : Mobile sensing in a rural area of Haryana, 170 kms from karnal with negligible stubble burning. Clearly the air is very clean.

We did some spatiotemporal PM2.5 sensing in a rural area (Kosli) of Haryana around 170 km away from Karnal. This region had negligible Stubble burning instances. We clearly found that PM2.5 values in this village was in the range of 50 ug/m3. This is significantly lower than the rural area in Karnal which had PM2.5 values in the range of 300 ug/m3 which we found while doing spatiotemporal sensing on 22nd and 23rd October with car. This clearly shows that Stubble Burning does impact Air Quality in Rural areas significantly.

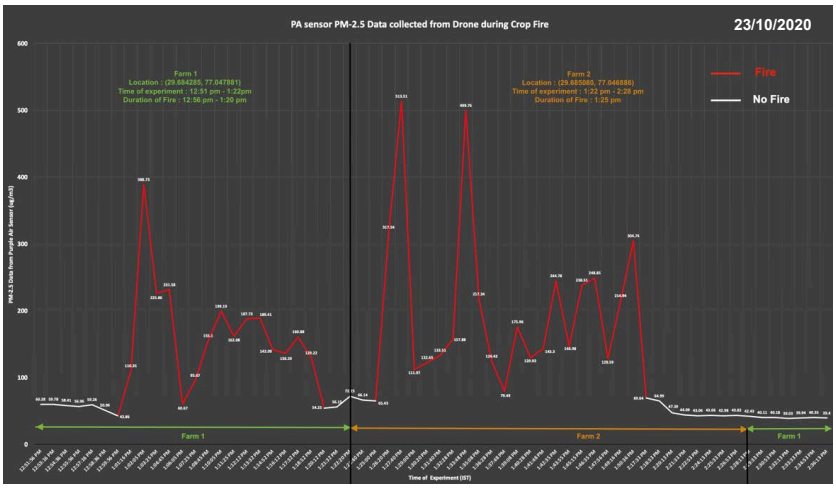
Note - The sudden spike in PM2.5 values in the above map is due to temporary roads in village areas made of mud. So, the air in that region had a lot of dust.

Conclusion / Results Summary :

Analysis of results of different experiments -

1.) Mobile sensing with Drone of Farm Fire :

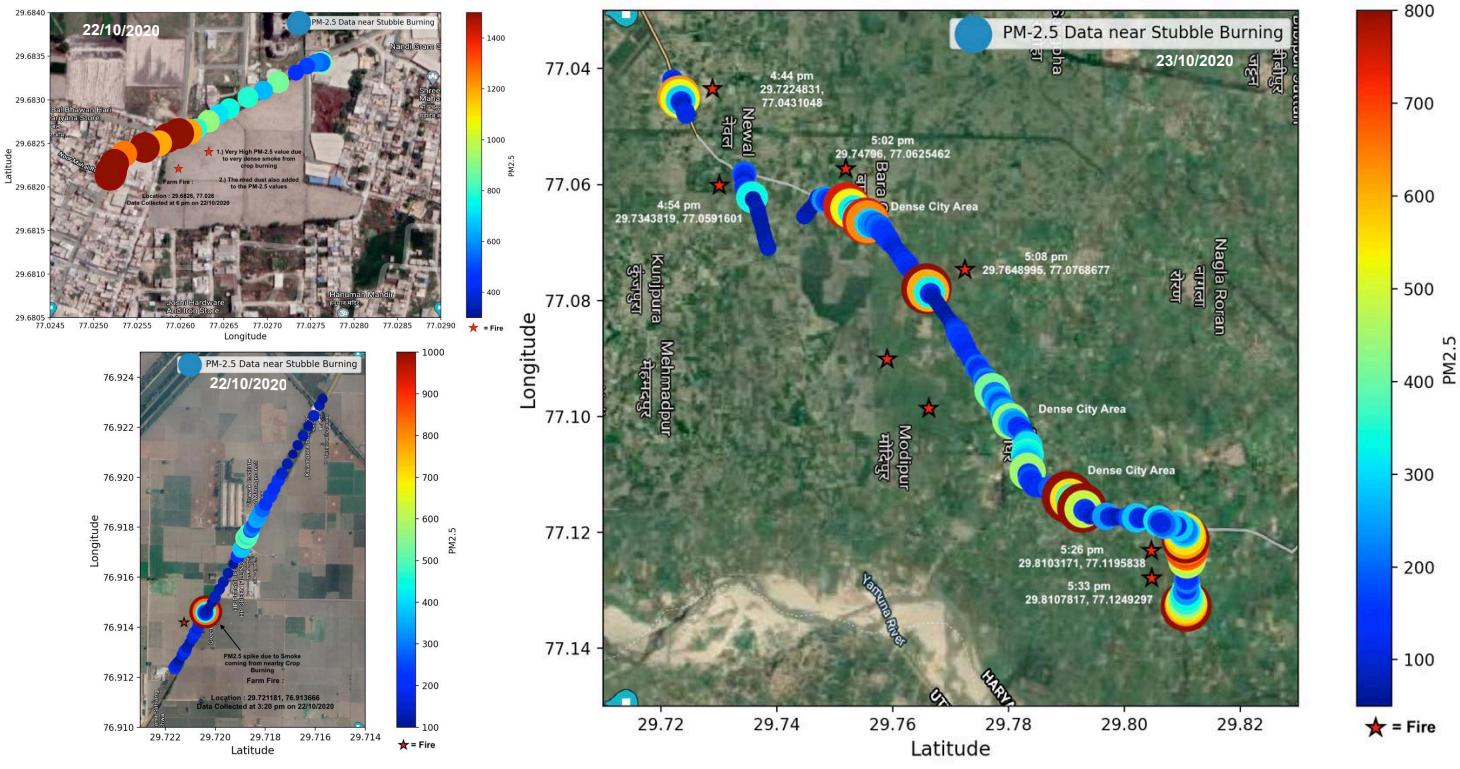
As can be seen in Fig- 16 , there was significant variation in PM values observed by the sensor from the drone before the farm fire began and during the fire. When the fire stopped, due to strong winds, the air again began clear and the PM values dropped again after fire.



2.) Mobile sensing with Car:

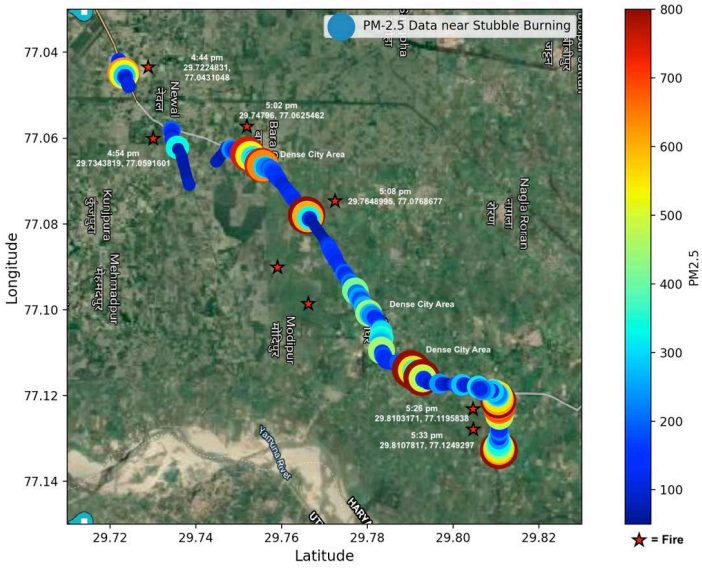
a.) Near stubble burning sites in Karnal

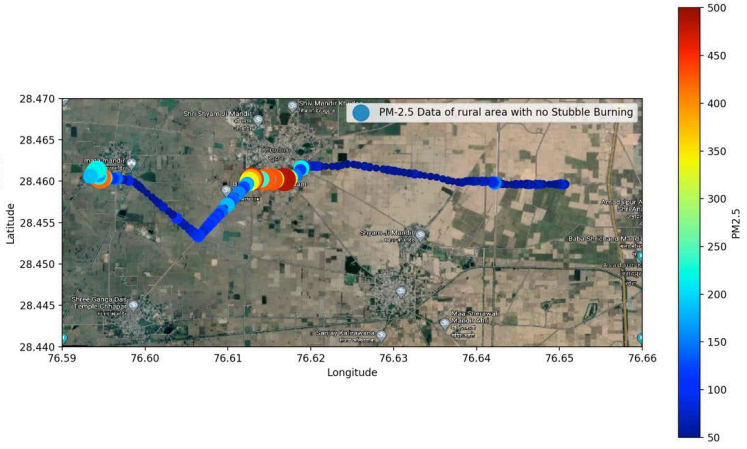
As can be seen in Fig- (2, 4, 18), whenever we were near any stubble burning sites, there was a spike observed in PM values of the sensor readings. Thus showing the significant impact of stubble burning in nearby air quality.



b.) Karnal vs Kosli

As can be differentiated between graph Fig. 18 (Karnal) and graph Fig. 26 (Kosli), there is a significant difference in PM-2.5 values in rural areas with less stubble burning.





Stubble Burning Rural Area

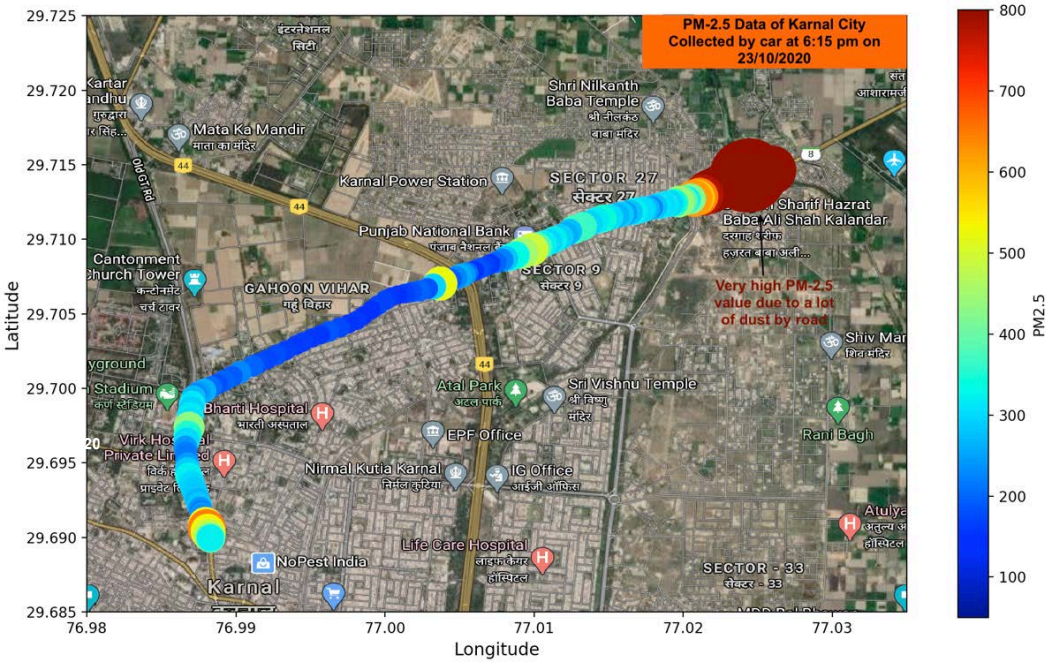
23/10/2020

No Stubble Burning Rural Area

25/10/2020

c.) Karnal City

Fig 20- shows the impact of stubble burning on the air quality of Karnal city.



3.) Ground sensing PA data

As can be seen in Fig- 25 , a spike was observed in PM-2.5 values during the farm fire from the data collected by Purple air sensor.