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Application of Mounting Personal PID VOC Sensors to Small Unmanned Aircraft Systems to Aid First Responders

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Small Unmanned Aerial Systems in Emergency Response

- Current sUAS Uses
  - Search and rescue
  - Thermal imaging
  - Evaluating structural stability
  - Spread of wildfires
  - Storm damage

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Small Unmanned Aerial Systems in Emergency Response

- Crash Sites/Chemical Spills
  - Unknown exposures require full protection for responders until airborne concentrations can be characterized
  - Why not send in drones instead?

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Research Questions

- Is it possible to remotely evaluate potential emergency responder exposures using sUAS, or does the rotor wash from the sUAS cause too much interference?
- What is the optimal configuration of mounting the VOC sensor on the sUAS to obtain accurate exposure data?

sUAS Platforms Used

DJI Mavic Pro with Ion Cub PID attached directly below the sUAS

DJI Inspire 1 with Ion Cub PID attached with a short tether

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Mock Spill Scenario

- Jet-A and Gasoline
- Steel Pan
- Personal PID
- Kestrel 5500 Weather Meter
  - wind direction and velocity
  - temperature
  - wet bulb
  - dew point
  - pressure
  - relative humidity

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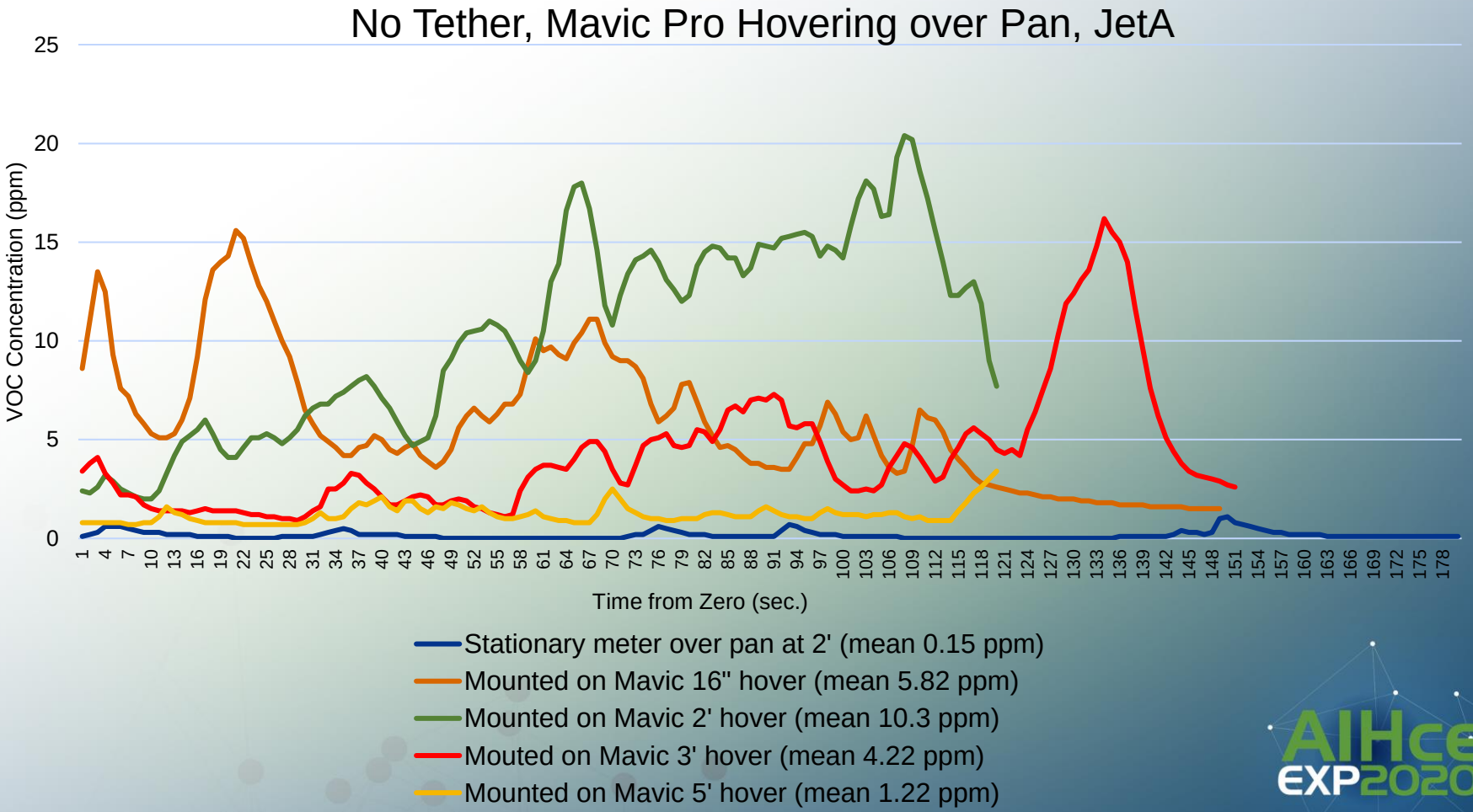
No Tether

- Ripples on the surface


No Tether, Mavic Pro Hovering over Pan, JetA
VOC Concentration (ppm)
25
20
15
10
5
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82 85 88 91 94 97 100 103 106 109 112 115 118 121 124 127 130 133 136 139 142 145 148 151 154 157 160 163 166 169 172 175 178
Time from Zero (sec.)
Stationary meter over pan at 2' (mean 0.15 ppm)
Mounted on Mavic 16" hover (mean 5.82 ppm)
Mounted on Mavic 2' hover (mean 10.3 ppm)
Mouted on Mavic 3' hover (mean 4.22 ppm)
Mounted on Mavic 5' hover (mean 1.22 ppm)

No Tether, Mavic Pro Hovering over Pan, Gasoline

VOC Concentration (ppm)

Time from Zero (sec.)

- Stationary meter over pan (mean 3.7 ppm)
- Mavic hover 3 feet (mean 67.4 ppm)
- Mavic hover 5 feet (mean 14.2 ppm)
- Mavic hover 10 feet (mean 4.1 ppm)

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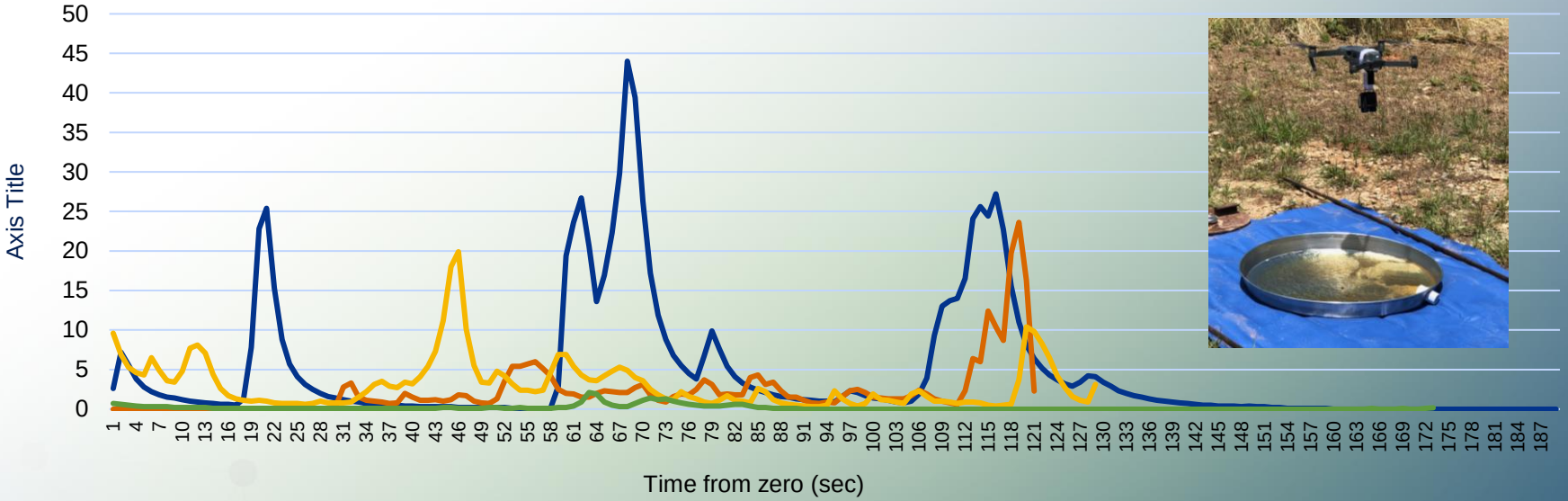
No Tether, Inspire 1 Hovering over Pan, Gasoline



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No Tether
Circular Pattern Around the Pan

- Goal was to collect data to generate 3D concentration map

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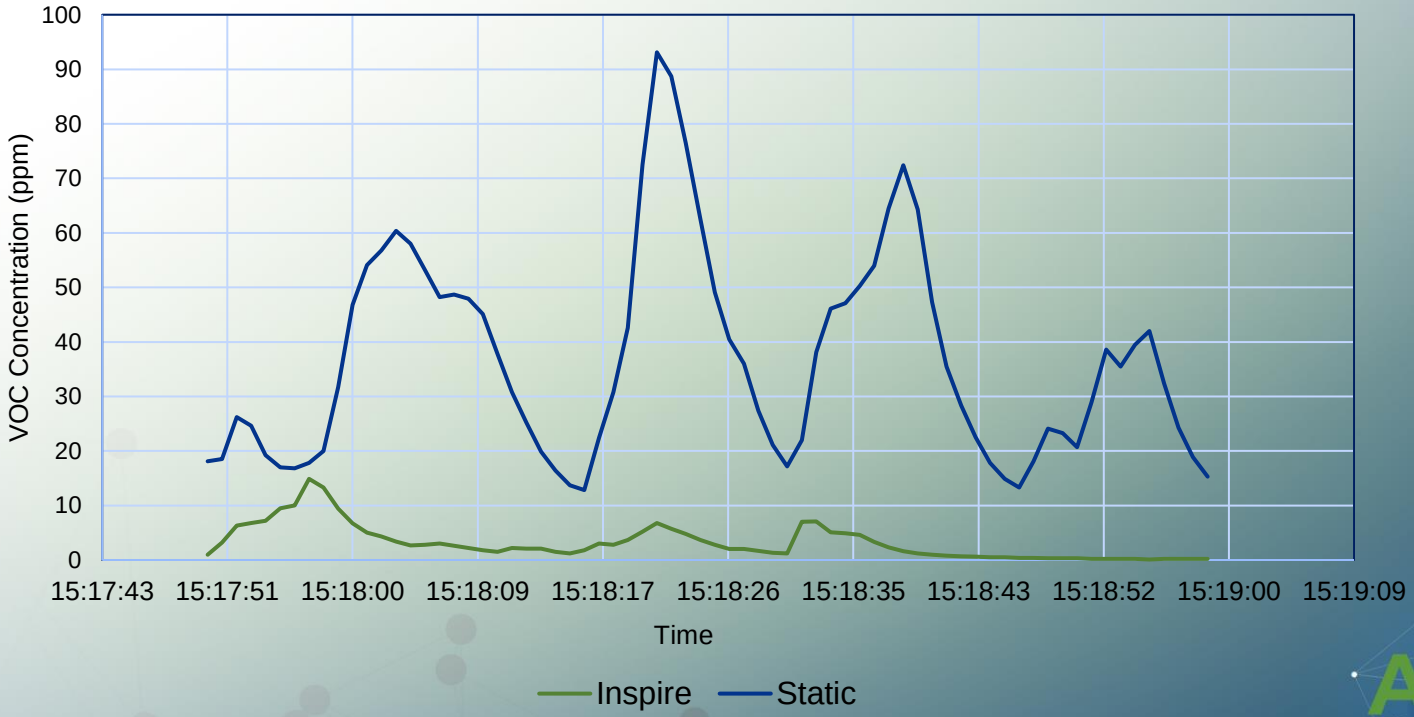
Velcro Harness-Mounted on Inspire 1
3' High, 5' Radius



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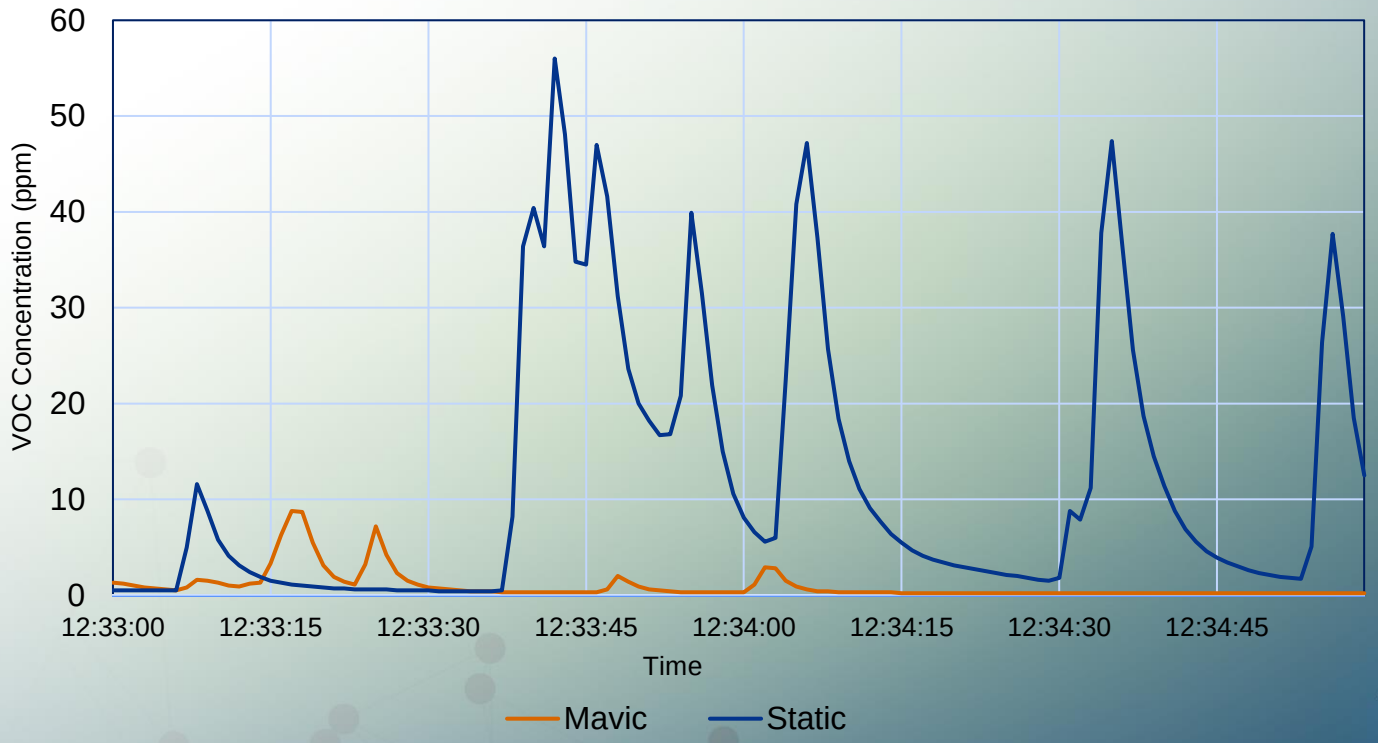
Velcro Harness-Mounted on Mavic Pro
5' High, 5' Radius



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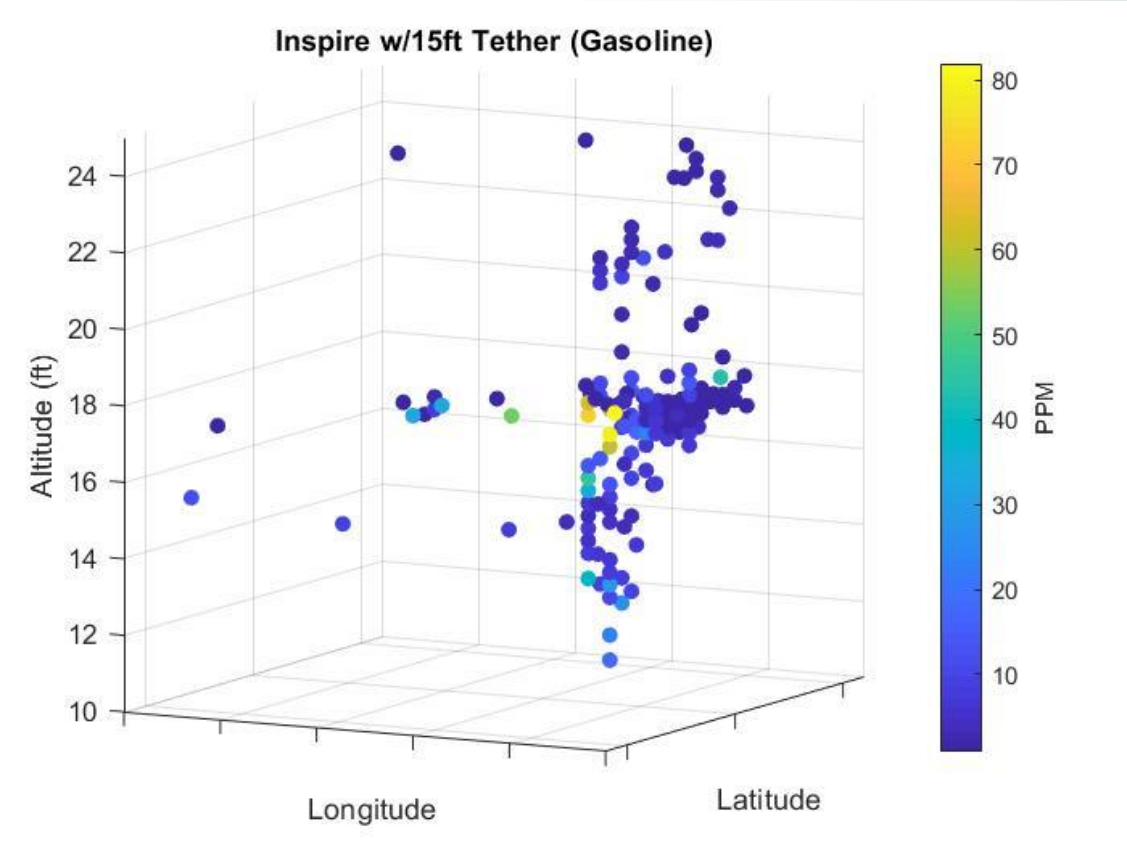
3D Concentration Plot



By combining:

- time points of PID concentrations
- time points of sUAS GPS location (adjusted for tether length)

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Tether, 15, 30, 45 Feet

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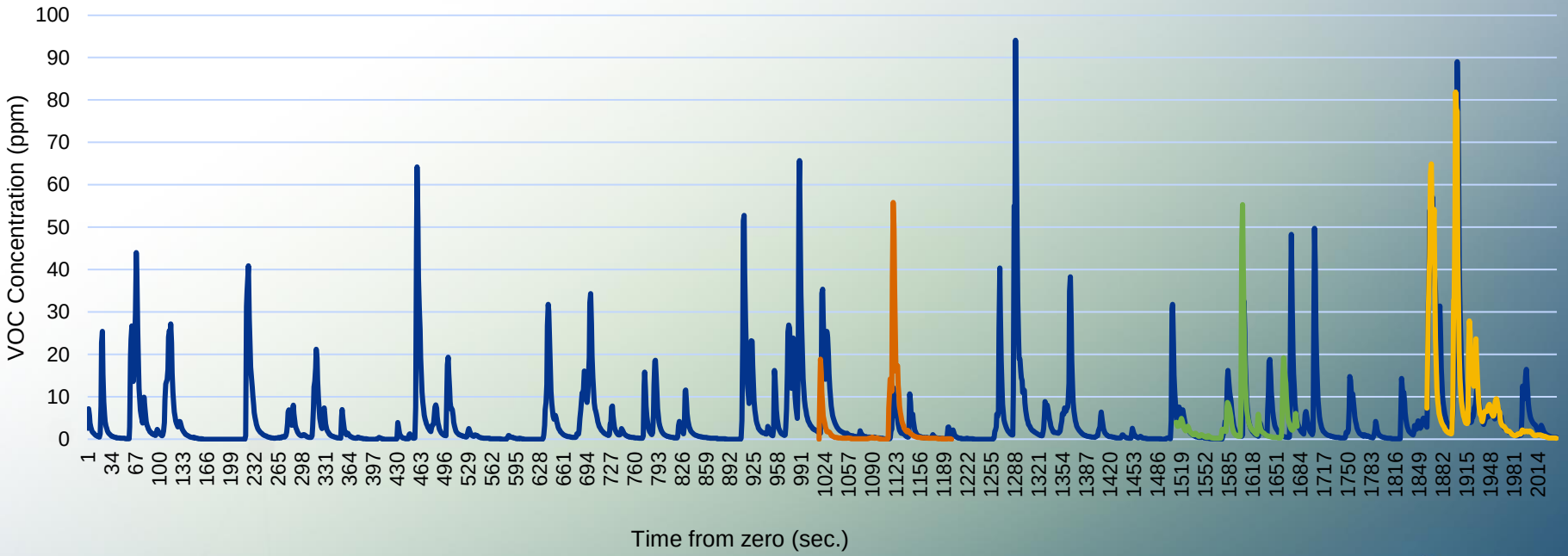
Inspire 1 over Gasoline, with Tether, Run 1



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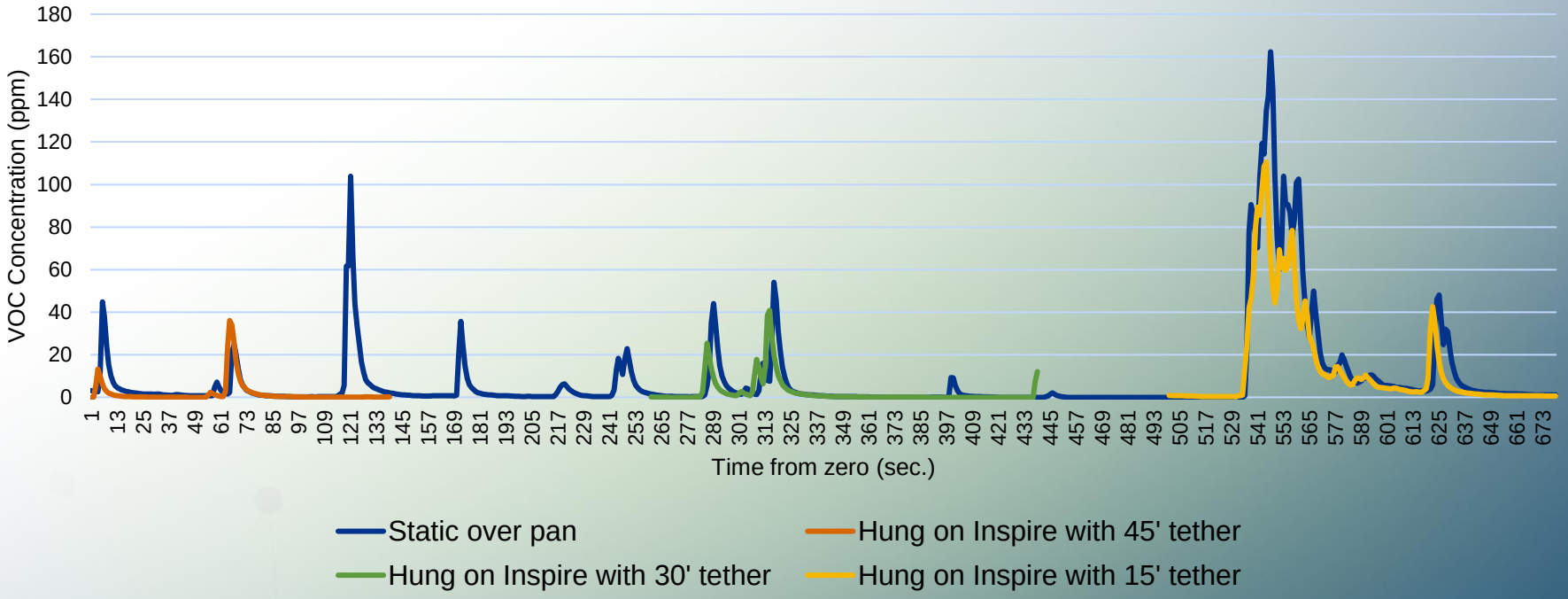
Inspire 1 over Gasoline, with Tether, Run 2



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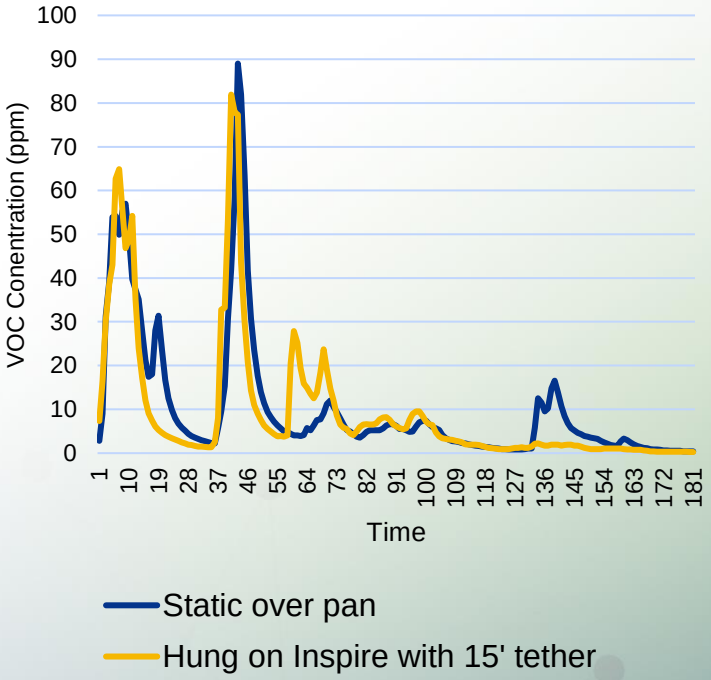
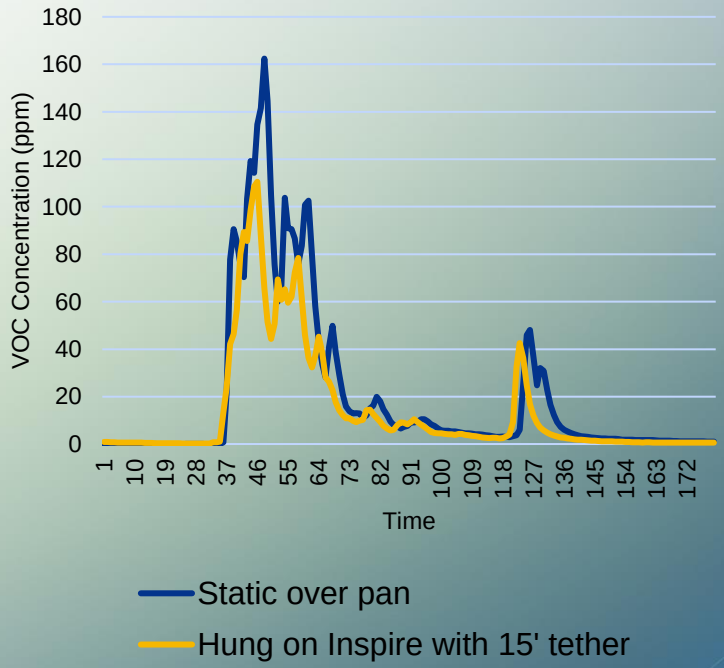
Inspire 1 over Gasoline,15' Tether, First Run



Inspire 1 over Gasoline,15' Tether, Second Run



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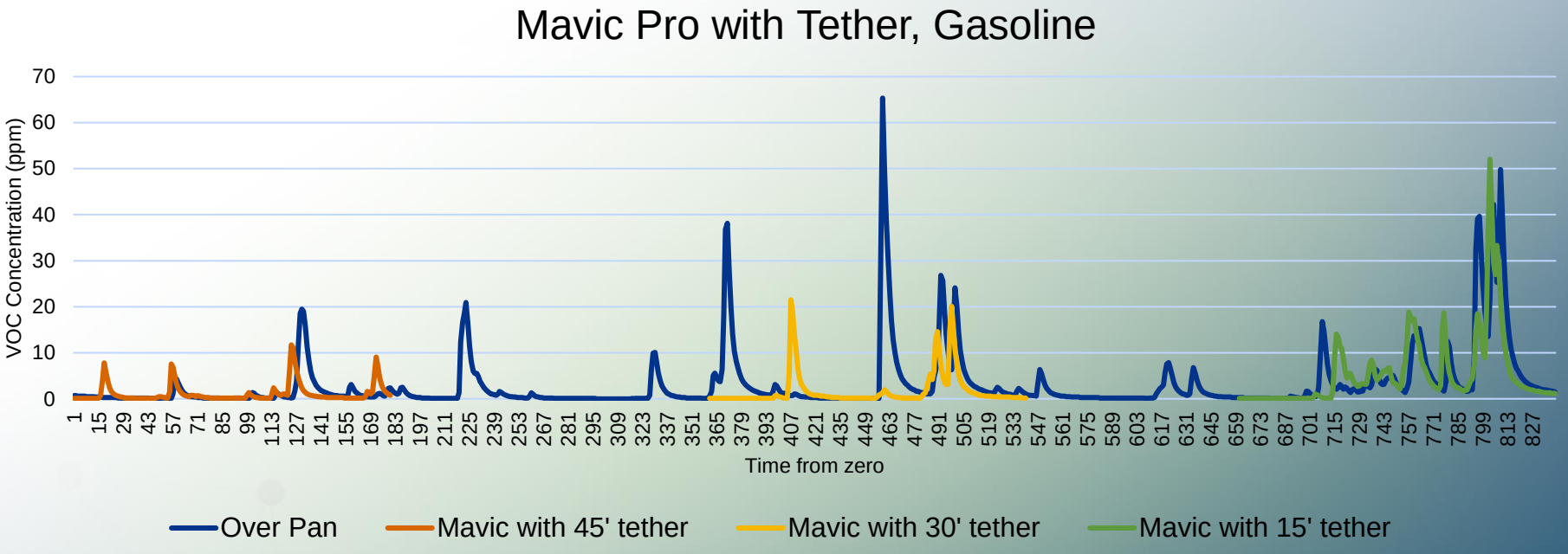
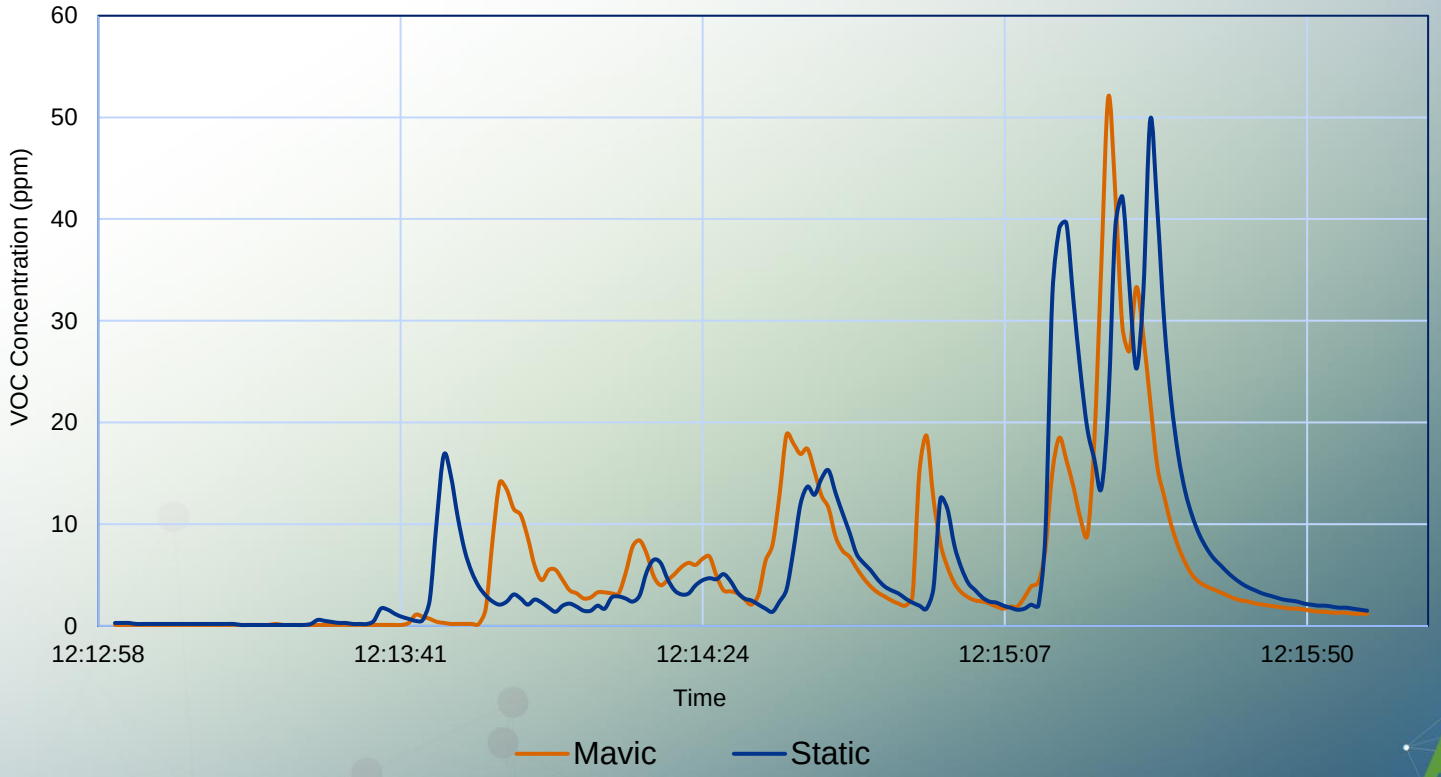

Mavic Pro with Tether, Gasoline
VOC Concentration (ppm)
70
60
50
40
30
20
10
0
1
15
29
43
57
71
85
99
113
127
141
155
169
183
197
211
225
239
253
267
281
295
309
323
337
351
365
379
393
407
421
435
449
463
477
491
505
519
533
547
561
575
589
603
617
631
645
659
673
687
701
715
729
743
757
771
785
799
813
827
Time from zero
Over Pan
Mavic with 45' tether
Mavic with 30' tether
Mavic with 15' tether

Mavic Pro with 15 Tether, Gasoline



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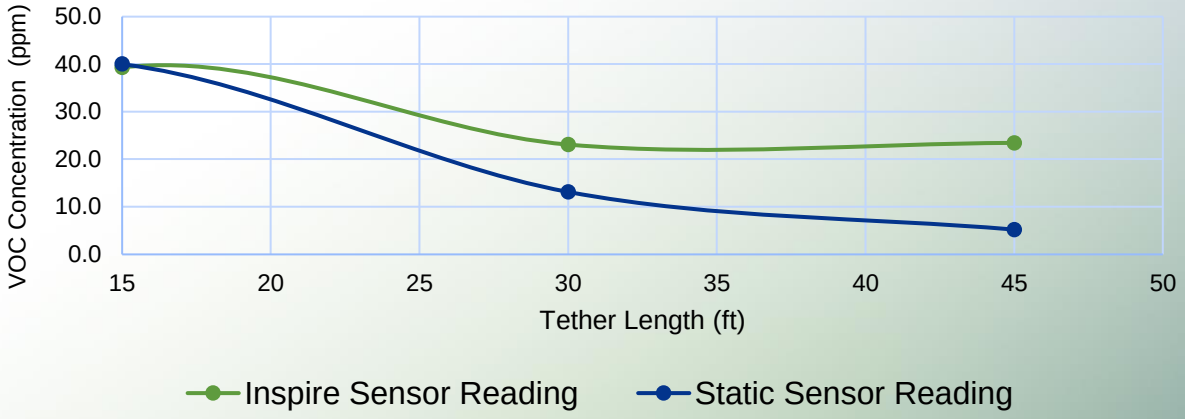
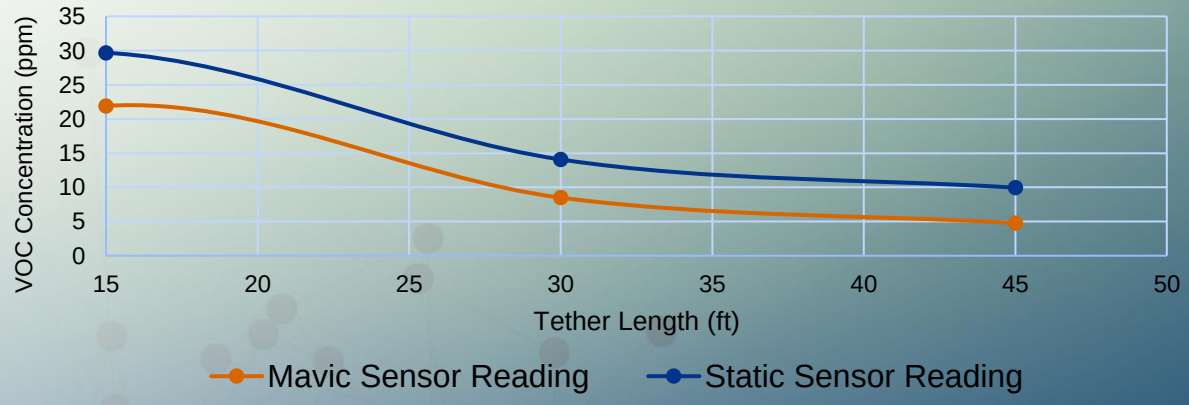
Influence of Tether, Inspire 1



Influence of Tether, Mavic Pro



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Results/Conclusions

- If the sensor is mounted directly on the drone, and the drone hovers directly over the spill, it depends on the drone configurations as to whether the vapor concentrations detected are higher or lower than ambient levels without the drone present

Results/Conclusions

- If the sensor is mounted directly on the drone, and the drone is **not** directly over the spill, the vapors from the spill did not always reach the sensor and were not always detected.

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Results/Conclusions

- The hanging sensor data at 15, 30, and 45 feet below the sUAS provided similar readings to the static sensor data.
- However, even with the use of a 30’ tether, a ripple from the rotor wash could be visibly seen on the surface, potentially elevating measured exposure levels, thus interfering with the ability to accurately measure potential emergency responder exposure levels.

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Results/Conclusions

- With the sUAS platforms used for this experiment, a 45 foot tether provided the optimal length of separation from the rotors to be able to estimate exposures above the spill.
- However, using a tether that long is potentially limiting because of the potential for interference by ground objects and the potential impact of wind on the hanging sensor.
- The UAS operators reported a lot of drift in the operation of the UAS, and it was hard to keep the aircraft level

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Results/Conclusions

- With a 15 foot tether, there was a strong similarity between the sensors, but the concentration was also at the highest point, so estimating potential responder exposure is impacted.
- The UAS operators reported that using a shorter tether was more stable than the longer tethers.
- Using a 15 foot tether could be useful if the intent is to detect the presence of a spill, but not to determine responder exposure.

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Further Studies Needed

- Full characterization of the impact of rotorwash for each type of UAS
- Optimization of the placement of the VOC sensor

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Questions?

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