THINGY IoT™

NW-AIRQUEST - Oct 14, 2021

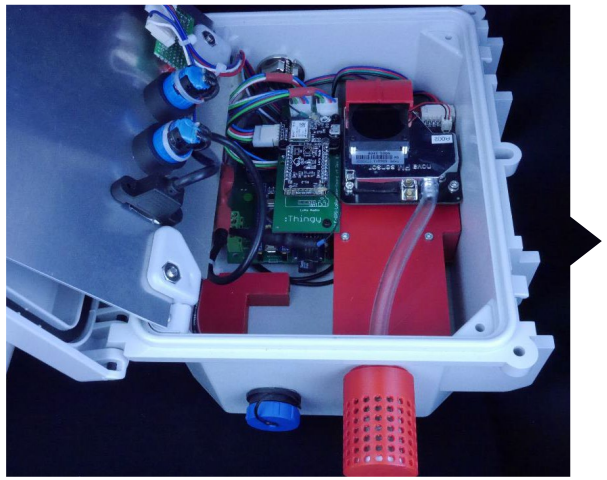
Tracking Wildfire Smoke across the PNW in Rural Communities with Thingy AQ

Scott Waller – CEO and Co-Founder

October 2021

Since NW-AIRQUEST 2018….

- We've come a long way since the "Challenge"
- Key focus areas:
  - Correlation with Reference/Regulatory sensors
  - Collaborating with researchers on different projects
  - Commercializing Thingy AQ
  - Building remote networks to connect sensors



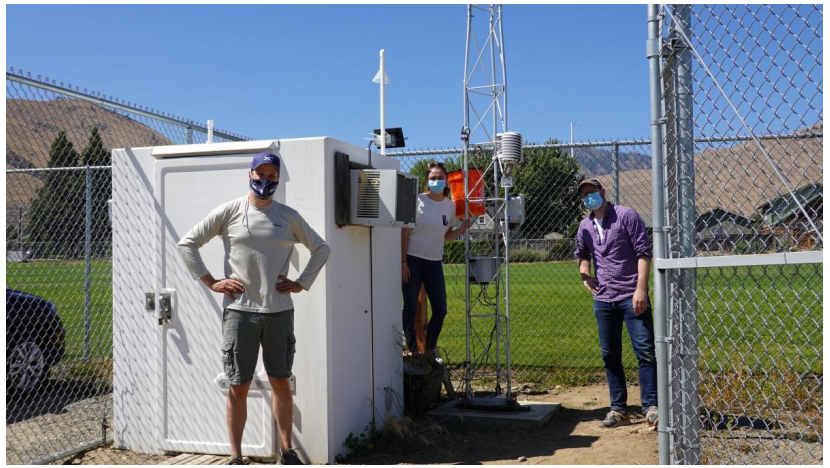
Funded Research Projects in 2020/2021

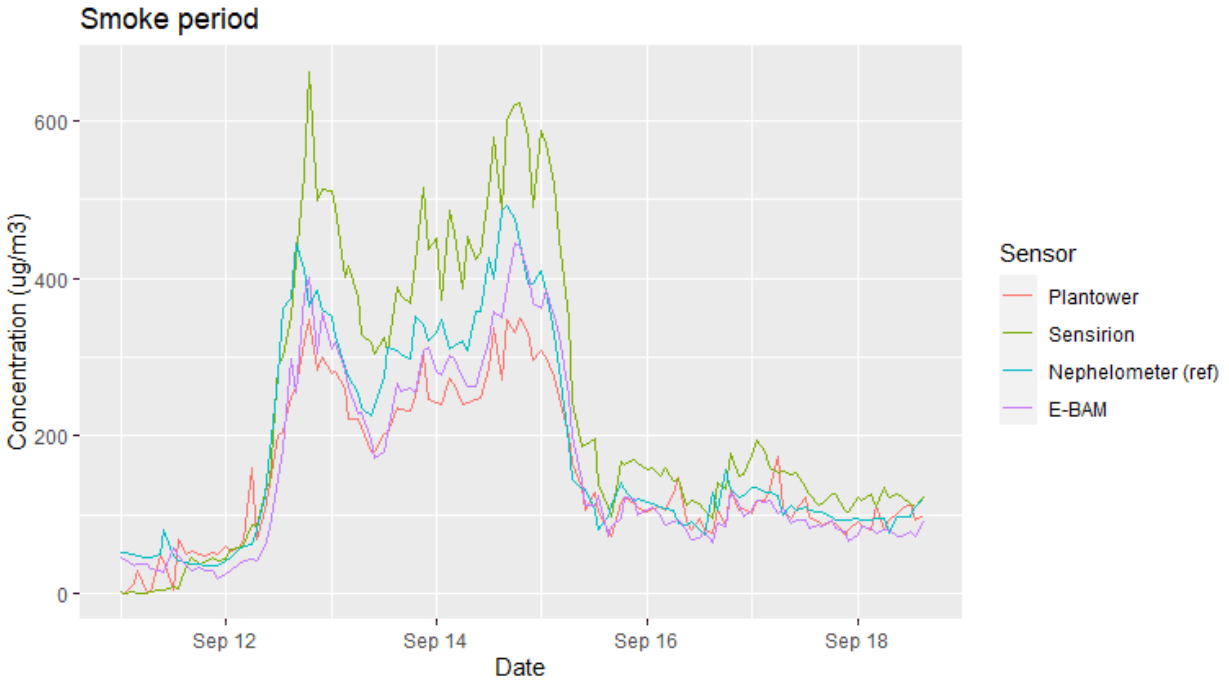
- **CDC/NIOSH** #5U54OH007544
  - Smoke Monitoring for Ag Safety and Health (SMASH) *UW/WSU AWN*
- **EPA** Phase II SBIR #68HERC20C0053
  - Ultralow Power Sensor Package for Ground Level Air Pollution Levels from Wildland Fires – *KWJ/Spec*
- **USDA NIFA** #2020-33530-32997
  - Ultralow Power Sensors for Firefighter Safety and Monitoring or Surrounding Air Quality– *KWJ/Spec*
- **EPA** STAR Program 2021
  - Indoor Air Quality in Schools – *UW*
- **EPA** #68HE0B21P0530
  - Wildfire Smoke Air Monitoring Response Technology (WSMART) Pilot
- **WSU, OSU, UC Davis, WA Wine Commission**
  - Smoke Taint in Wine Grapes
- **USDA NIFA SCRI**
  - TBD Wine Smoke Taint across West Coast

United States Department of Agriculture
National Institute of Food and Agriculture

UW PNASH – NIOSH SMASH Project 2020

- Co-located Thingy AQ, WA ECY Neph, USFS E-BAM, and UW NIOSH Method 600 filter samplers in Wenatchee WA.
- Evaluating against Wildfire smoke occupational exposure control requirements
- Compared low-cost Plantower and Sensirion PM sensors in Thingy AQ system during wildfire events





EPA/USFS/Thingy Smoke Characterization Study 2021

EPA/USFS/Thingy Smoke Characterization Study 2021

USFS Fire Sciences Lab Combustion Chamber - Missoula, MT

- Multiple Thingy AQ monitors
- EPA FRM/FEM reference monitors for particulate and a suite of gaseous pollutants
- 40 one-hour burn events over a 2-week period.
- Variety of fuels, loadings, and moisture contents.

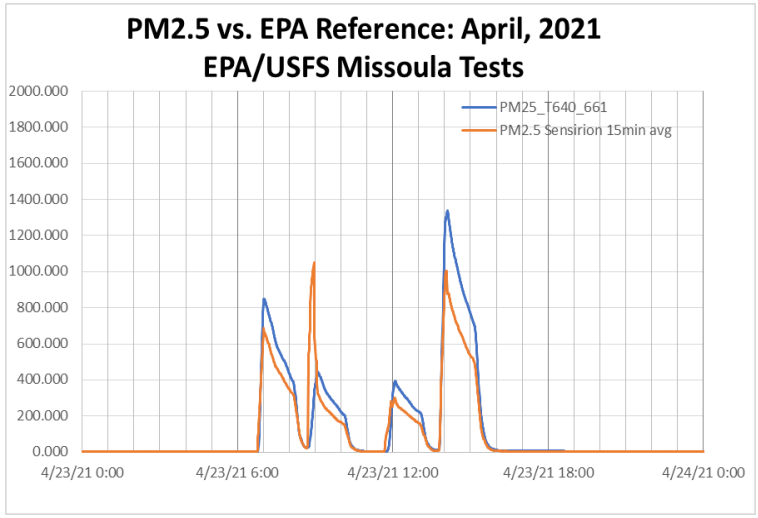
EPA Mobile Ambient Smoke Investigation Capability (MASIC)

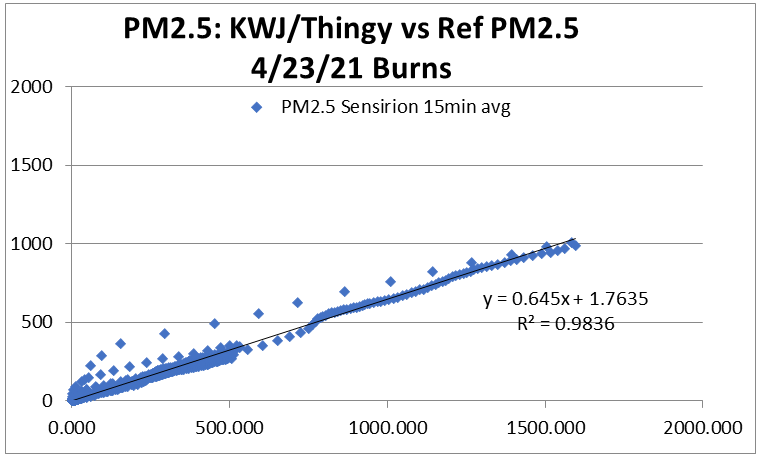
- 4 Thingy AQ monitors and other sensors
- Ambient conditions at EPA MASIC sites (FRM)
- EPA's new PM and O3 Performance Testing Protocols (Feb 2021)
- 3 sensors at 3 sites at least 30 days each in duration
- Missoula, Reno, Boise (in process)

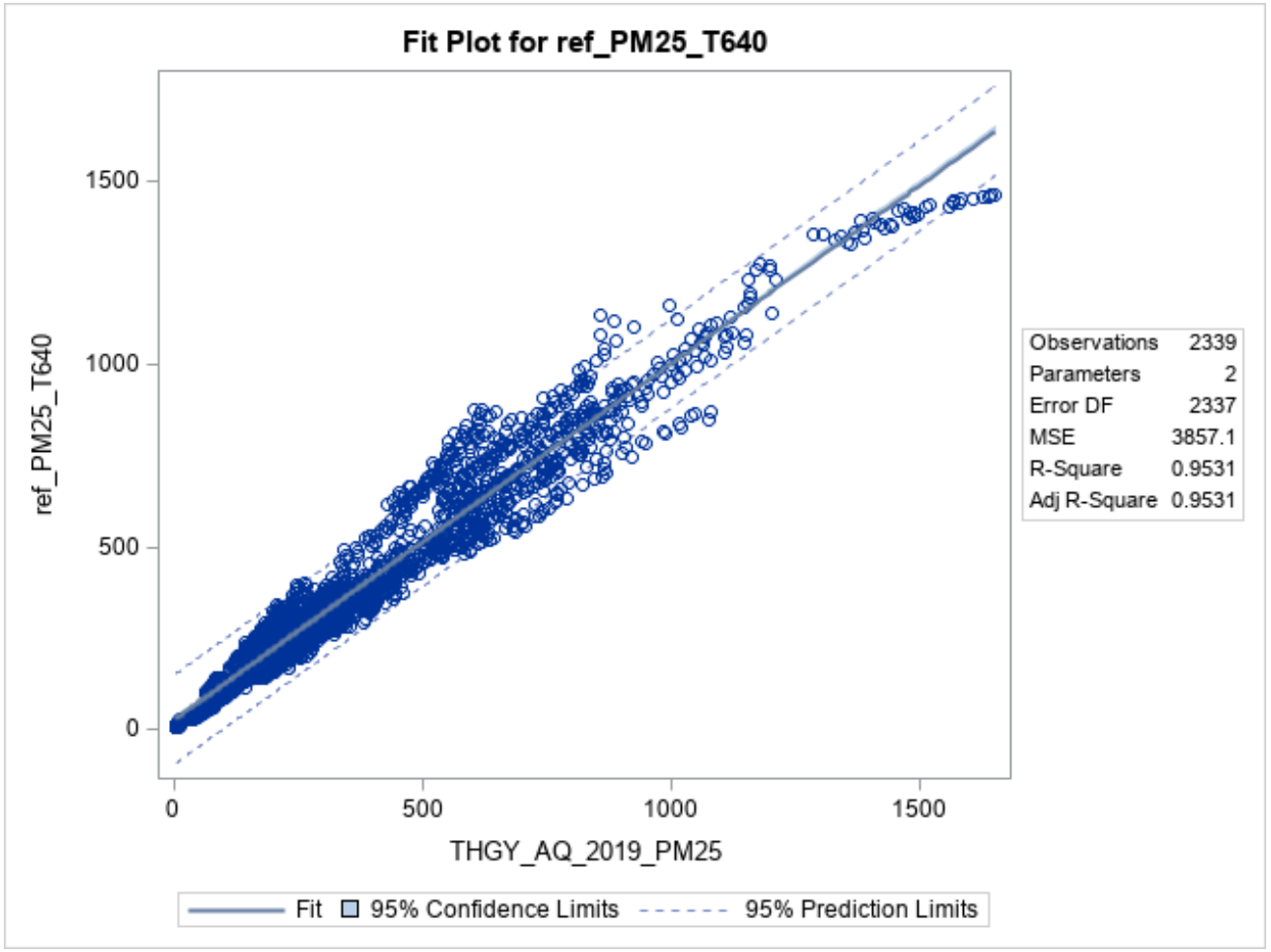
*We wish to acknowledge the support of Dr. Matthew Landis of EPA ORD and the EPA and USFS technical staff for their logistical support in combustion testing at the USFS Combustion Lab in Missoula, MT.

Correlation and Accuracy Summary - Thingy AQ vs Ref

PM2.5

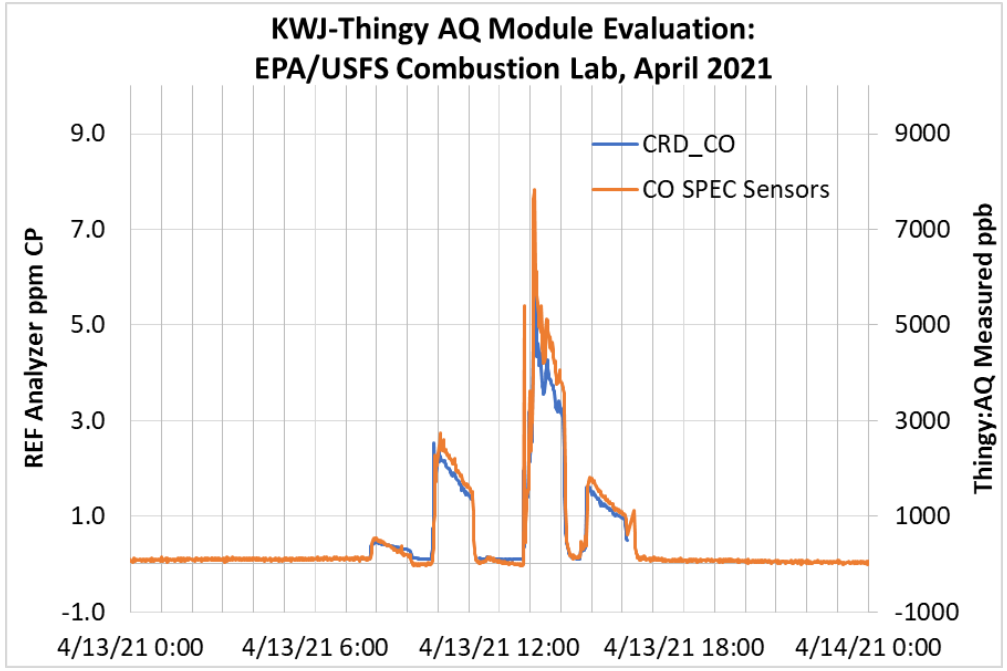


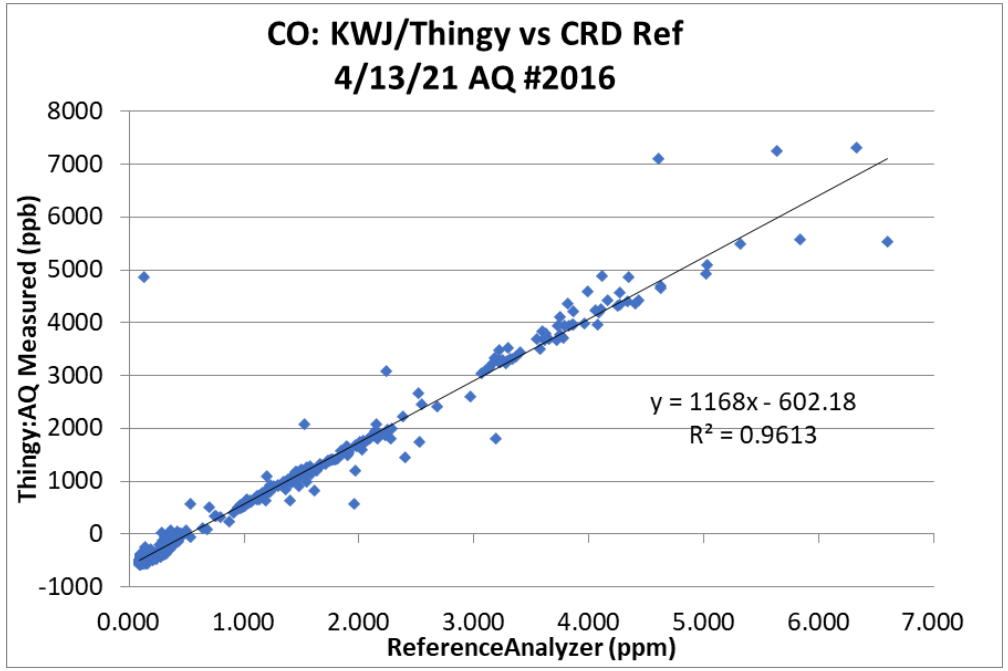




Correlation and Accuracy Summary - Thingy AQ vs Ref

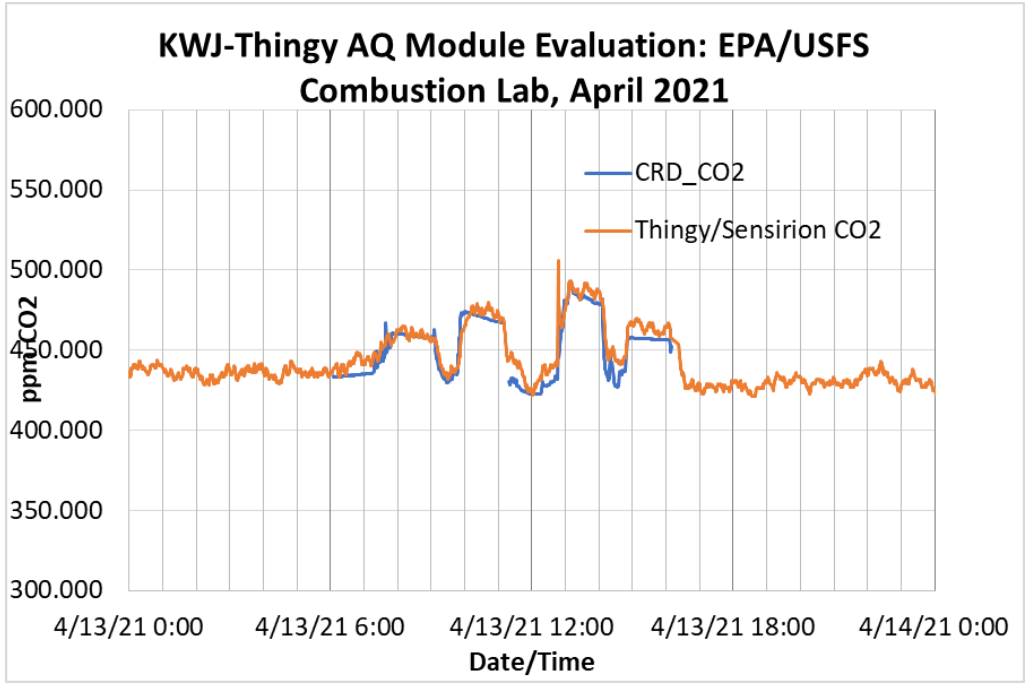
Carbon Monoxide

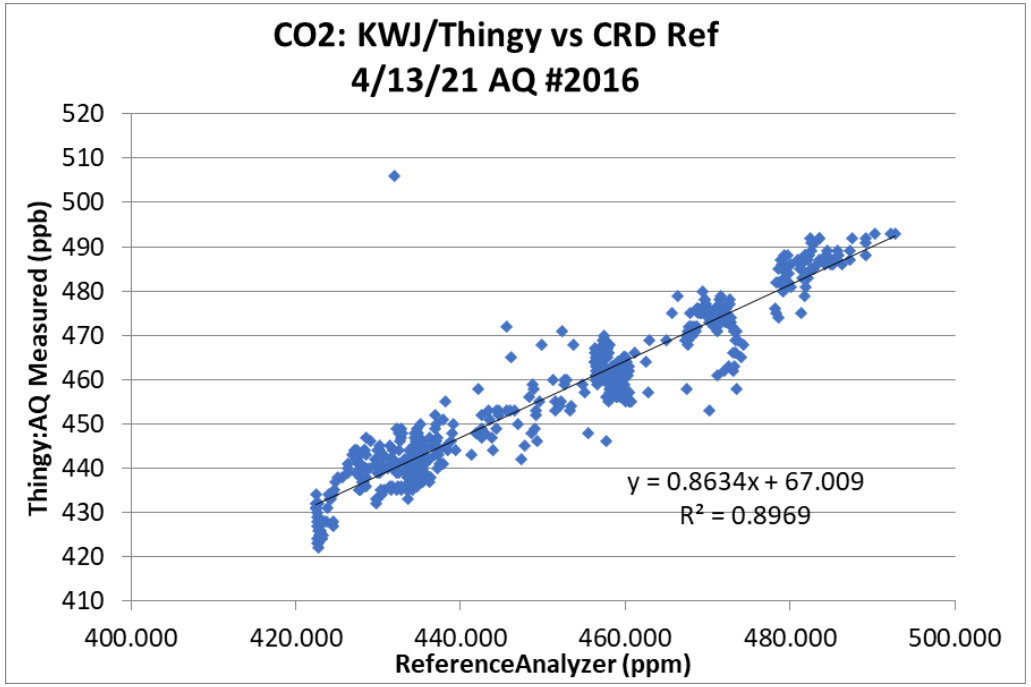




Correlation and Accuracy Summary - Thingy AQ vs Ref

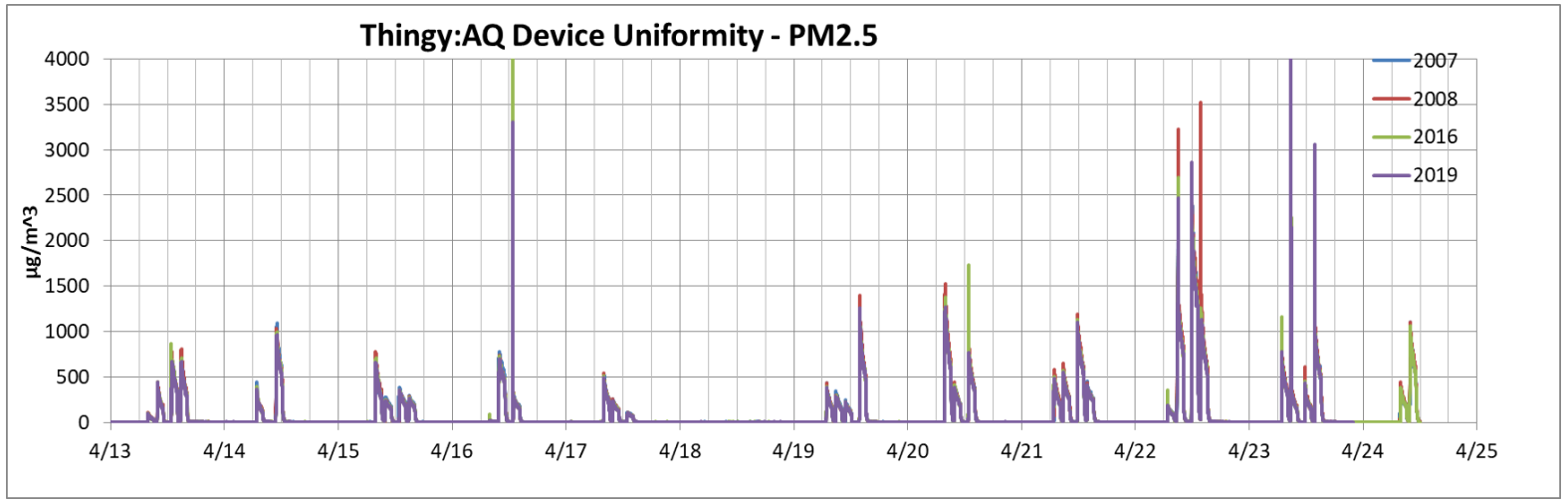
Carbon Dioxide



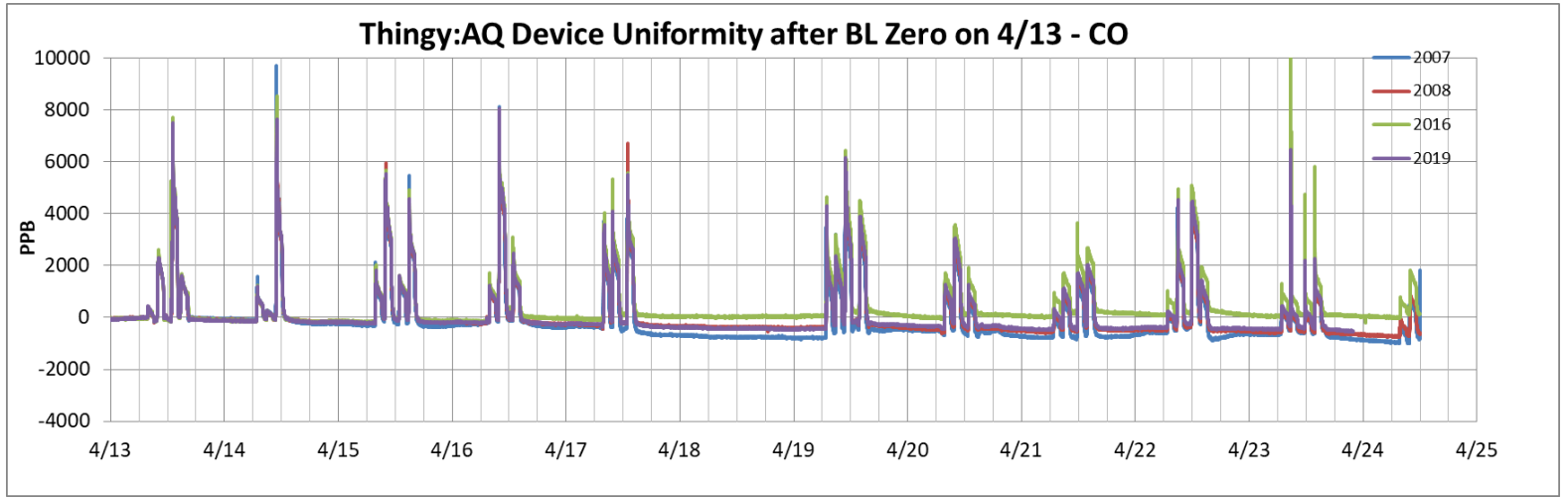


Device-to-Device uniformity

PM2.5

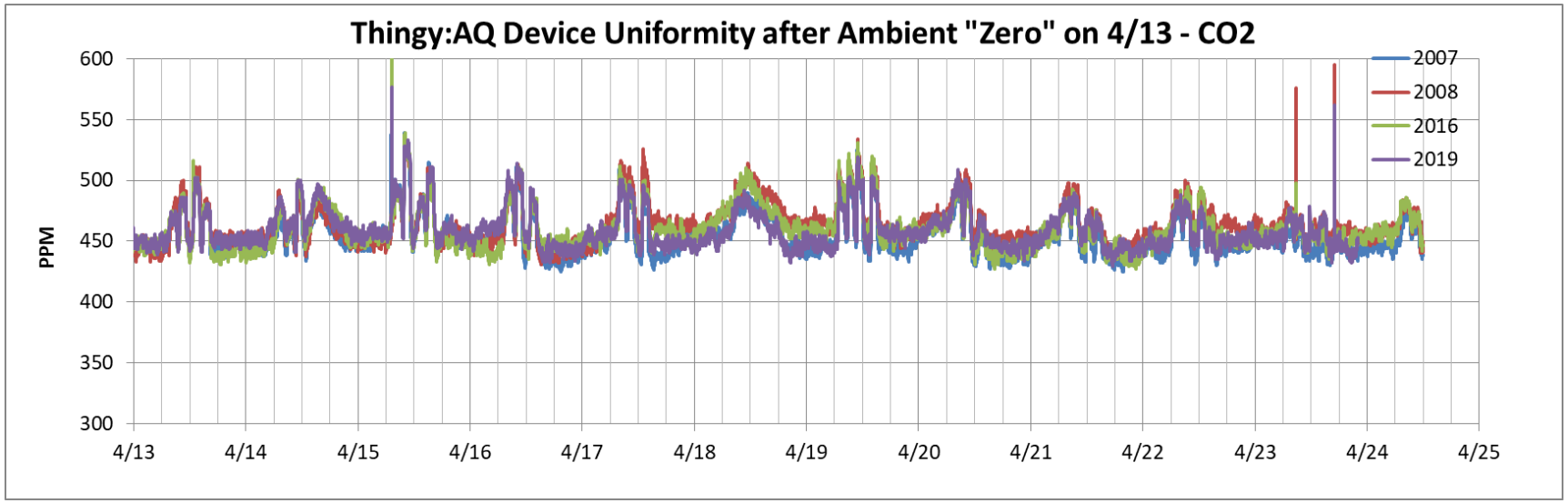


CO



Device-to-Device uniformity

CO2:



West Coast Ag Deployment

- 25 sites in WA
  - Yakima to Walla Walla, Richland to Chelan
- 5 sites in OR
  - Corvallis/Willamette/Medford
- 15 sites in CA
  - Napa/Sonoma

- Collaboration with WSU, OSU, UC Davis and USDA

- Measuring “local” versus “aged” wildfire smoke in close proximity to vineyards with PM1.0 focus

- Leading to larger USDA NIFA research with WSU, OSU, UC Davis in 2022-2025

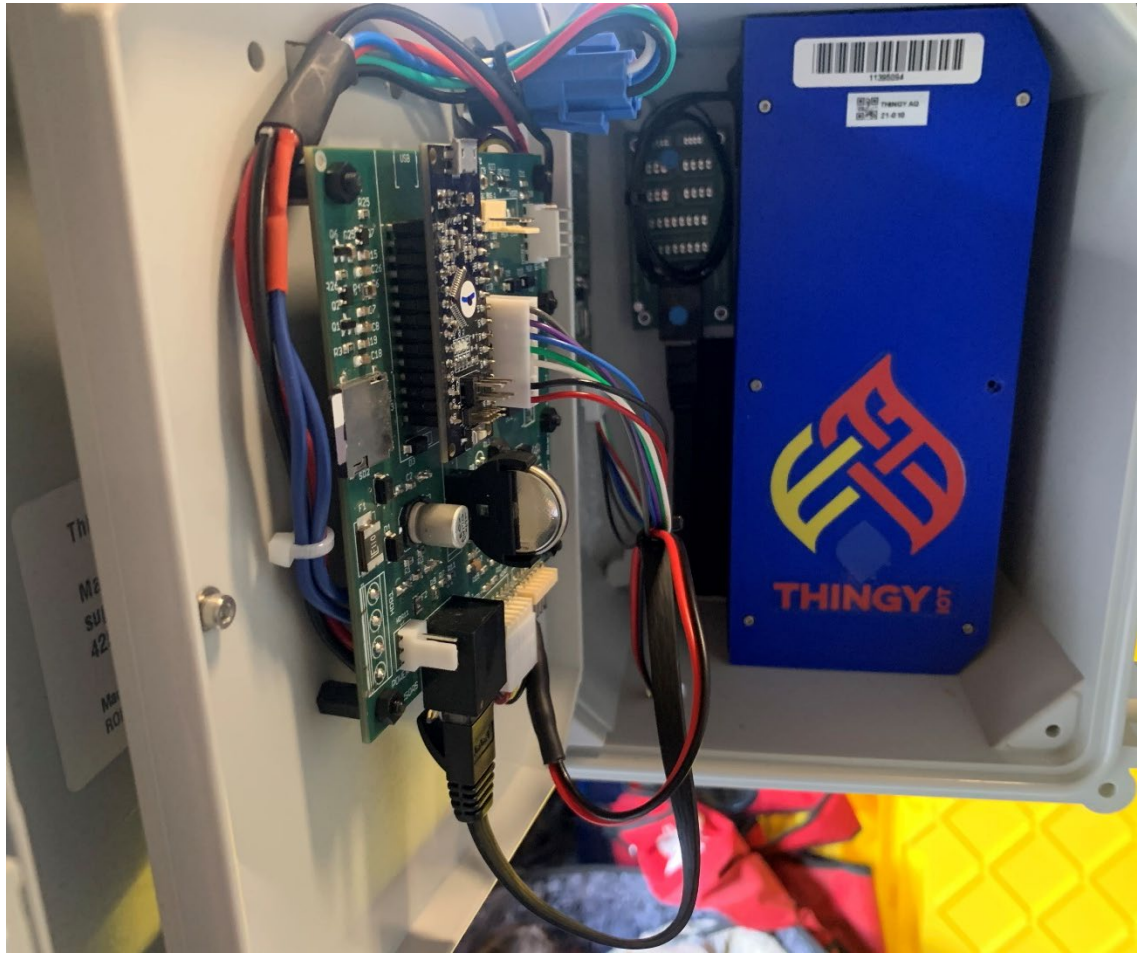
- Prescribed fires at WSU Roza Farm “Hoop Houses”

EPA Wildfire Smoke Air Monitoring Response Technology (WSMART) Pilot

- 20 Systems at EPA ORD
- Thingy AQ Sensor with:
  - PM (1.0/2.5/4/10)
  - CO, CO2, T-VOC
  - Temp/RH
- Solar Panel + Battery Pack
- LoRaWAN Telemetry Gateway with LTE
- Tripod and Transport Case
- Dashboard for real-time access to data streams (1 minute uplinks)

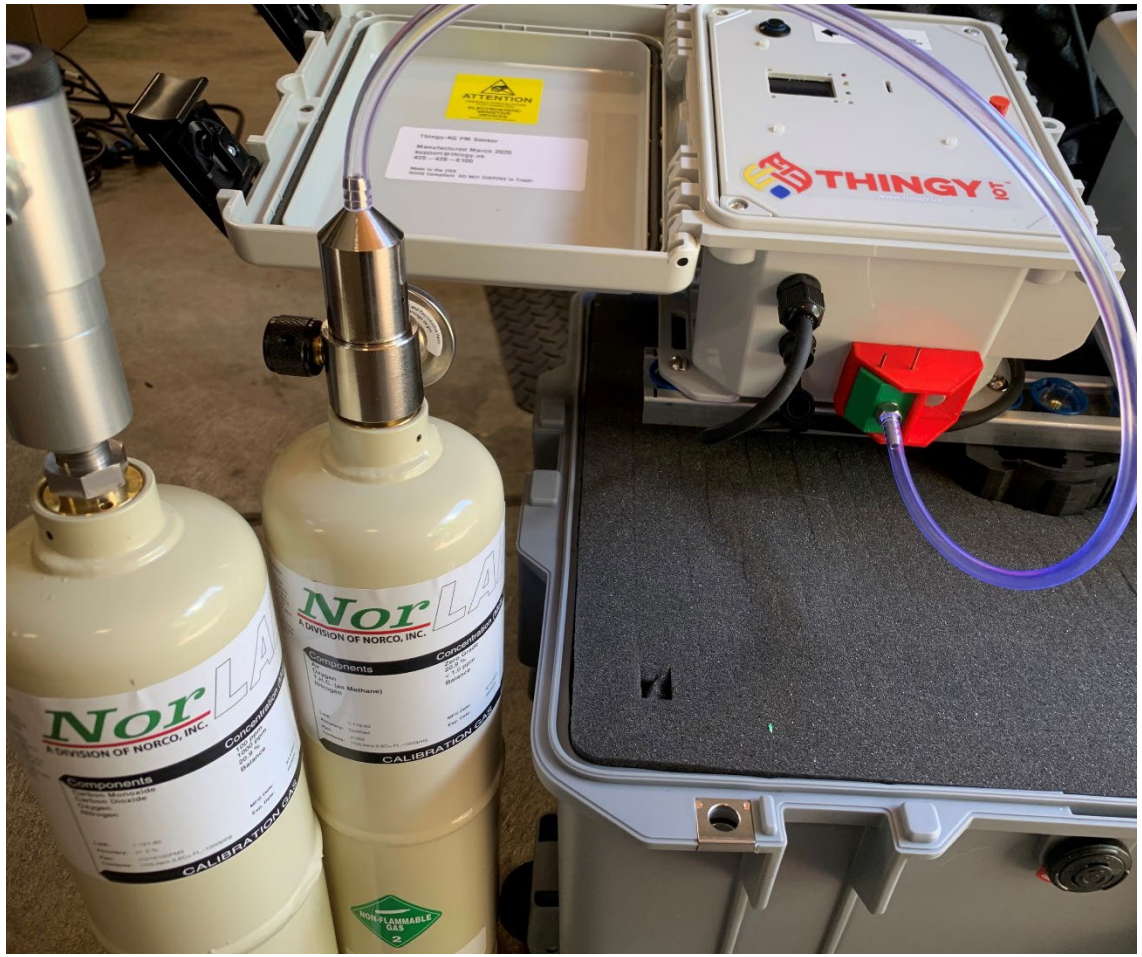
Thingy AQ MK2 Specifications

- Main System Features:
  - Data logger with 32GB SD card
  - LoRaWAN Radio for long-range telemetry
  - Serial cable/console with raw sensor streaming output
  - Sampling intervals as fast as 1 minute
  - Sleep mode for battery optimization
  - Scheduler for sampling at certain times of day
  - Software upgradable via SD Card
  - NEMA 4x outdoor enclosure is weatherproof and portable
  - OLED screen for current readings and diagnostics



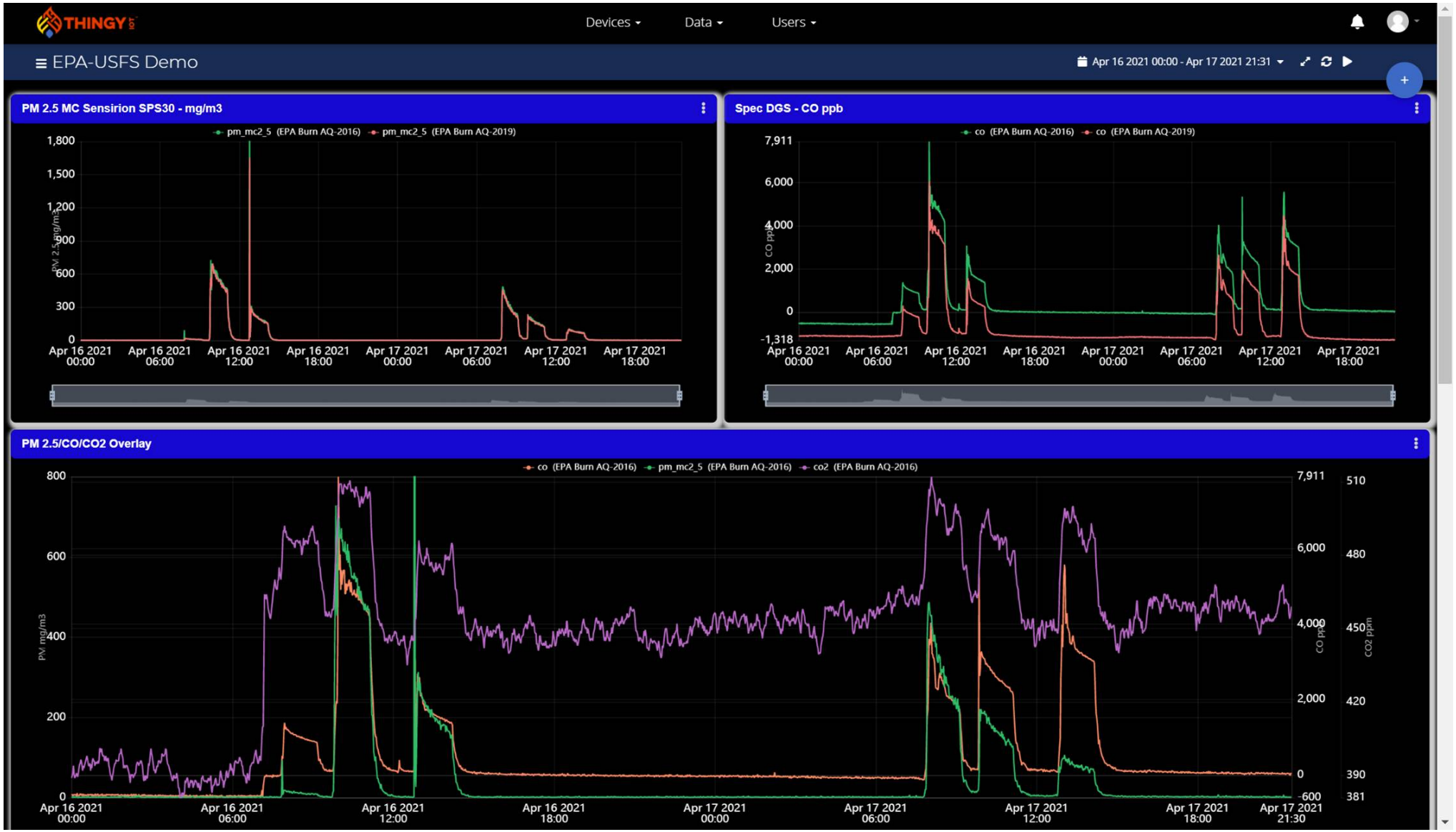
Thingy AQ MK2 Specifications

- Sensor System Features:
  - Self Contained PM+Gas flow chamber
  - Screen filters at inlet and exhaust
  - Factory calibrated sensor elements
  - Can be field calibrated:
    - Zero gas for CO/O3/NO2/SO2, Span for CO2
- Sensors used:
  - PM – Sensirion SPS30
  - CO2 – Sensirion SCD30 or SCD41
  - CO, O3, NO2, SO2 – Spec Sensor DGS
  - VOC – Sensirion SGP40
  - Temp/RH – Sensirion SHT3x plus on-board sensors (DGS)
  - See slide 20 for datasheet links



Thingy Data Dashboard

Customized to agency or event needs



THINGY IOT

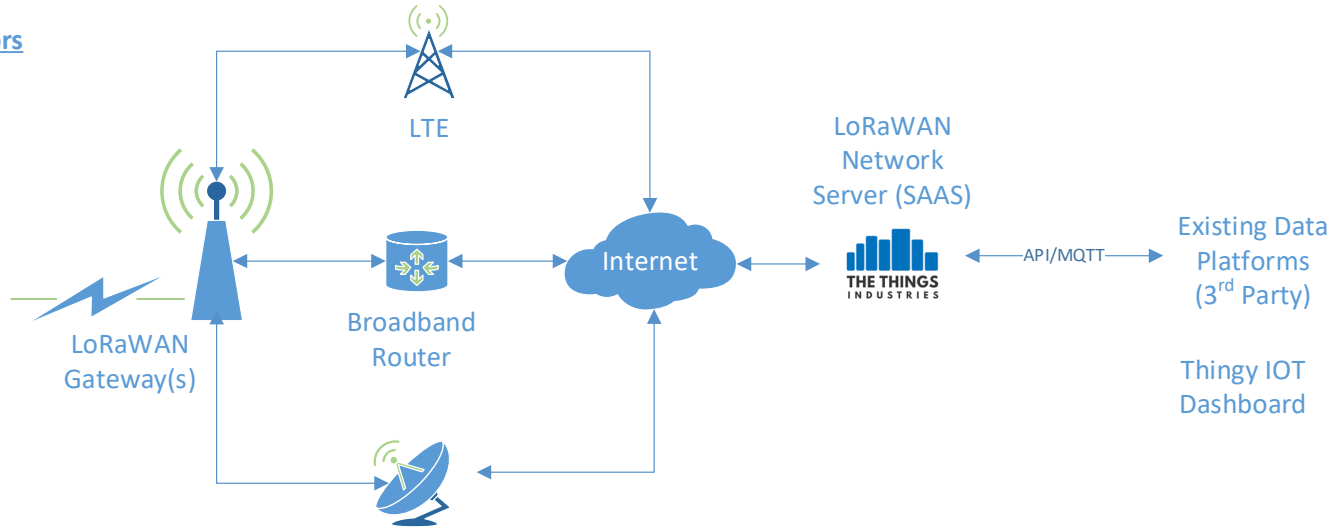
Secure, Lightweight, Two-Way LoRaWAN Communication From Sensors to Cloud Data Applications

LoRaWAN Sensors

Thingy AQ
PM + Gas

Weather
Temp/RH
Wet bulb
Dew point
Wind Speed
Wind Direction
Wind Gusts

Other
Asset Tracking
Panic Button
Water flow
Leak Detection



LoRaWAN N+1 Communications to Terrestrial or Satellite Gateways

>10km Line-Of-Sight over LoRaWAN 915MHz	Internet/Cloud

LoRaWAN Network Encryption

Application Encryption & Segmentation

RF Domain	IP Domain	API/MQTT - App Domain

Client	Page 1 of 1	Prepared by	Date
Thingy Wildfire Network		Scott Waller	4/29/2021
Process		Approved by	Date
Network Topo – High Level		SW	7/4/2021

Contact Us

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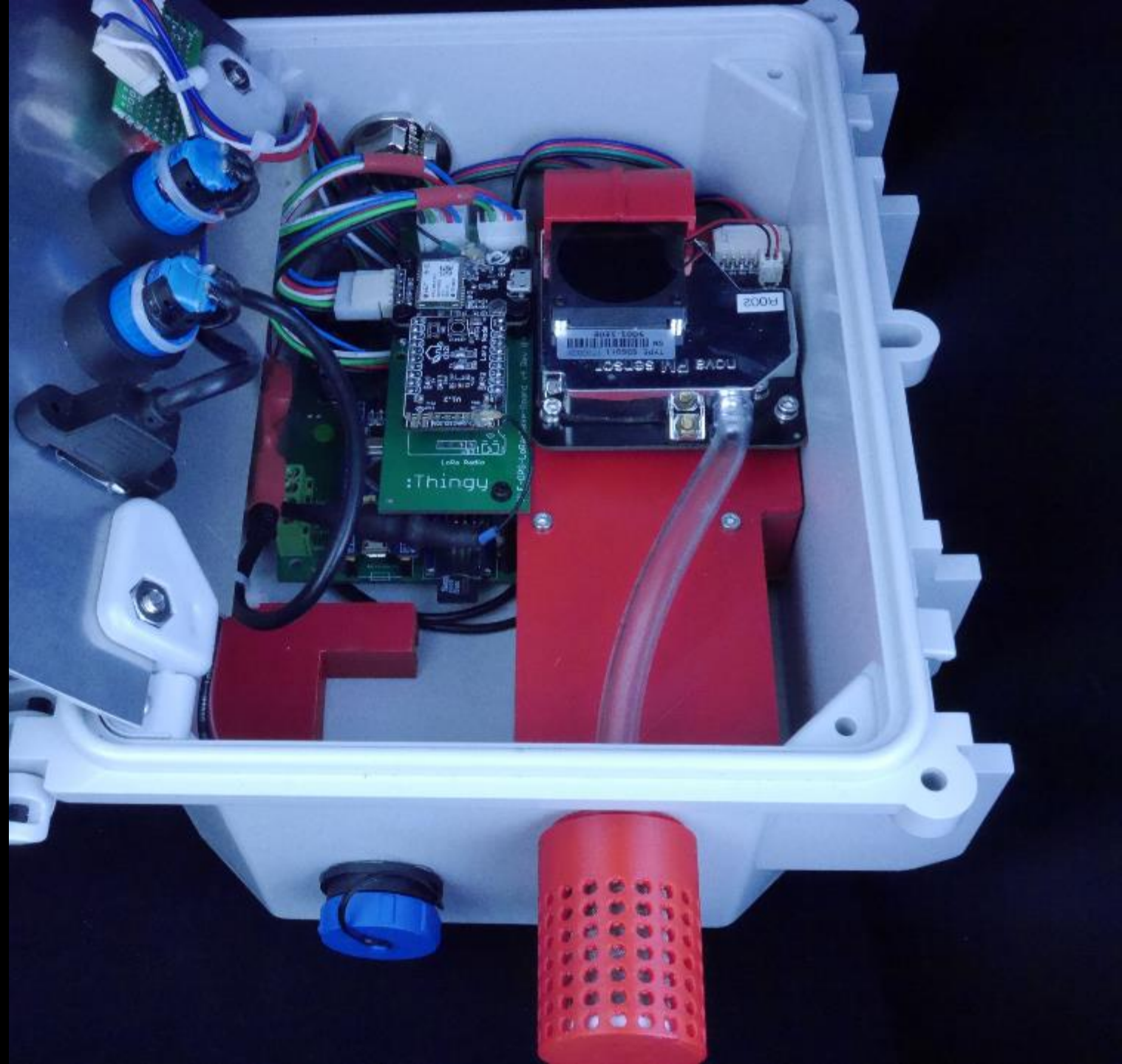

Articles, Publications, Links

- https://www.sciencedirect.com/science/article/pii/S1352231020308955
- https://www.epa.gov/sciencematters/epa-expands-air-monitoring-capabilities-support-wildfire-impacted-states-tribes-and
- https://www.epa.gov/newsreleases/epa-awards-over-7-million-research-help-communities-reduce-their-exposure-wildland
- https://www.sbir.gov/node/1895079
- https://portal.nifa.usda.gov/web/crisprojectpages/1024296-ultralow-power-sensors-for-firefighter-safety-and-monitoring-of-surrounding-air-quality.html
- https://deohs.washington.edu/hsm-blog/heat-fire-smoke-and-health-washingtons-ag-industry
- https://www.epa.gov/sciencematters/wildland-fire-sensors-challenge-winners-provide-real-time-systems-measuring-pollutant
- https://www.youtube.com/watch?v=J2pZ8aI3BfE

Sensor Manufacturer Data Sheets

- Sensorion SPS30 PM
  - https://www.sensirion.com/en/environmental-sensors/particulate-matter-sensors-pm25/
- Spec Sensor CO
  - https://www.spec-sensors.com/wp-content/uploads/2017/01/DGS-CO-968-034.pdf
- Sensirion CO2
  - https://www.sensirion.com/en/environmental-sensors/carbon-dioxide-sensors/carbon-dioxide-sensor-scd4x/
- Spec Sensor O3
  - https://www.spec-sensors.com/wp-content/uploads/2017/01/DGS-O3-968-042_9-6-17.pdf
- Spec Sensor NO2
  - https://www.spec-sensors.com/wp-content/uploads/2017/01/DGS-NO2-968-043_9-6-17.pdf
- Spec Sensor SO2
  - https://www.spec-sensors.com/wp-content/uploads/2017/01/DGS-SO2-968-038.pdf
- Sensirion VOC
  - https://www.sensirion.com/en/environmental-sensors/gas-sensors/sgp40/