

# Field Evaluation uHoo PM<sub>2.5</sub>, ozone, and CO sensor



# Background

- From 08/07/2017 to 10/06/2017, three **uHoo Sensors** were deployed in Rubidoux and ran side-by-side with Federal Equivalent Method (FEM) and Federal Reference Method (FRM) instruments measuring the same pollutant.
- uHoo Sensor (3 units tested):
  - Each unit measures PM<sub>2.5</sub> mass conc. ( $\mu\text{g}/\text{m}^3$ ), CO (ppm), ozone (ppb), T ( $^{\circ}\text{C}$ ) and RH (%)
  - Unit cost: **~\$300**
  - Time resolution: 1-min
  - Units IDs: E2F8, 4976, and 807E  
(Note: 4976 was a replacement unit, and it was only deployed for one month)
- SCAQMD FEM and FRM instruments:
  - Beta-attenuation monitor (FEM)**
    - Measures PM<sub>2.5</sub> mass ( $\mu\text{g}/\text{m}^3$ )
    - Unit cost: **~\$20,000**
    - Time resolution: 1-min
  - CO instrument (FRM)**
    - Unit cost: **~\$10,000**
    - Time resolution: 1-min
  - Ozone instrument (FEM)**
    - Unit cost: **~\$7,000**
    - Time resolution: 1-min

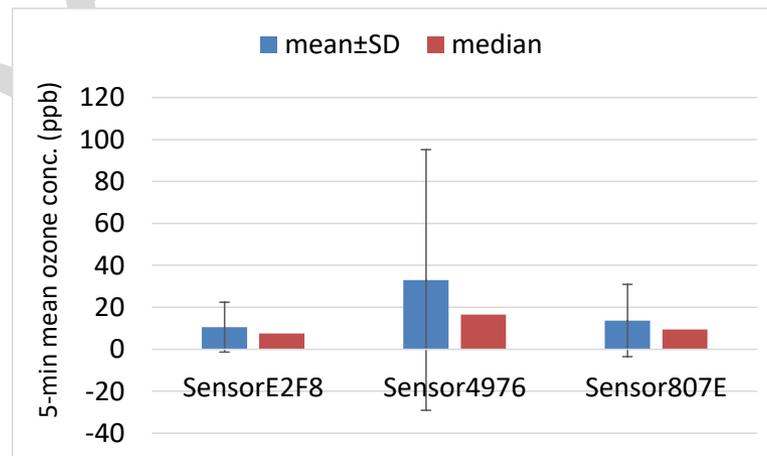
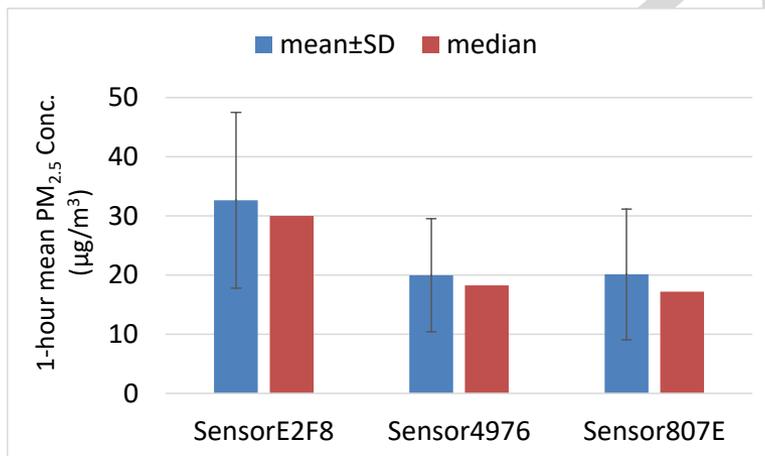


# Data validation & recovery

- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values and invalid data-points were eliminated from the data-set)
- Data recovery for the three uHoo sensors was 95%, 96%, and 88% for E2F2, 4976, and 807E, respectively.

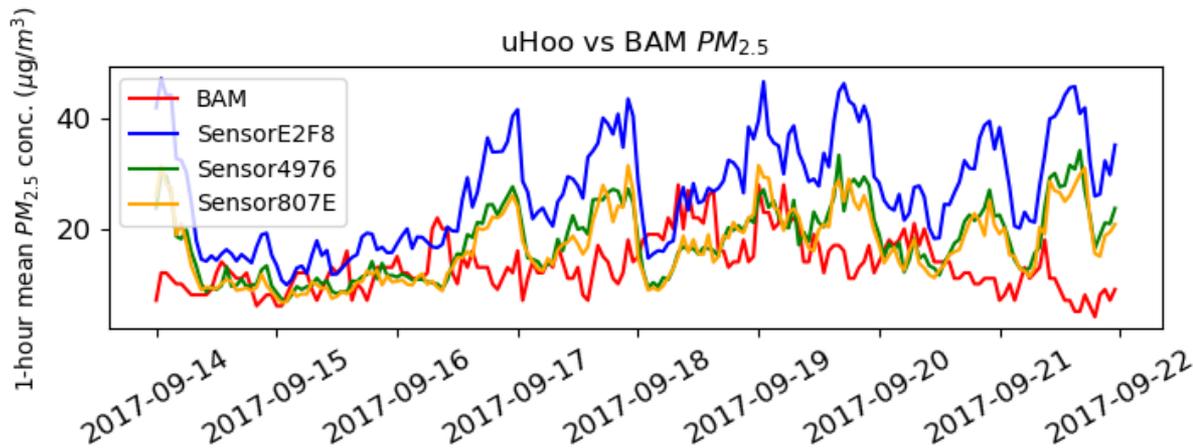
## uHoo sensors: Intra-model variability

- High measurement variations were observed between the three uHoo devices tested

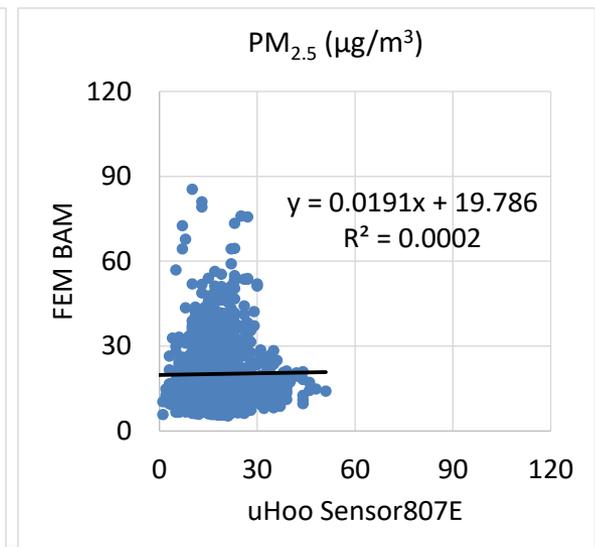
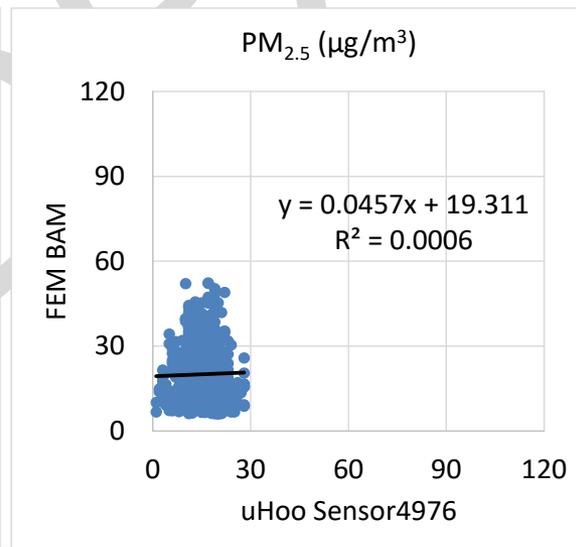
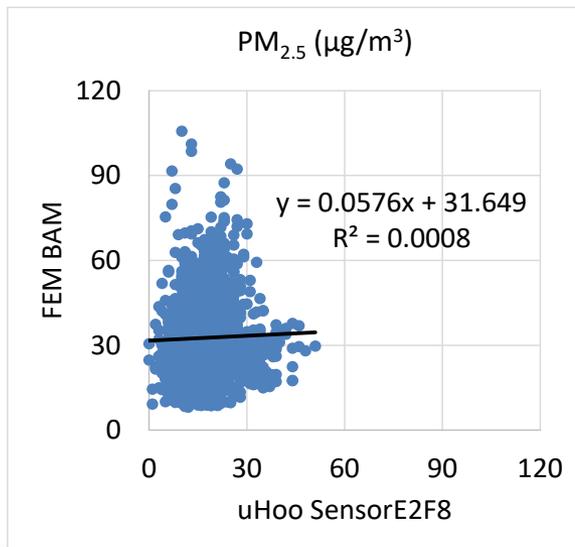


\*uHoo reported mostly 0 ppm of CO during the evaluation period

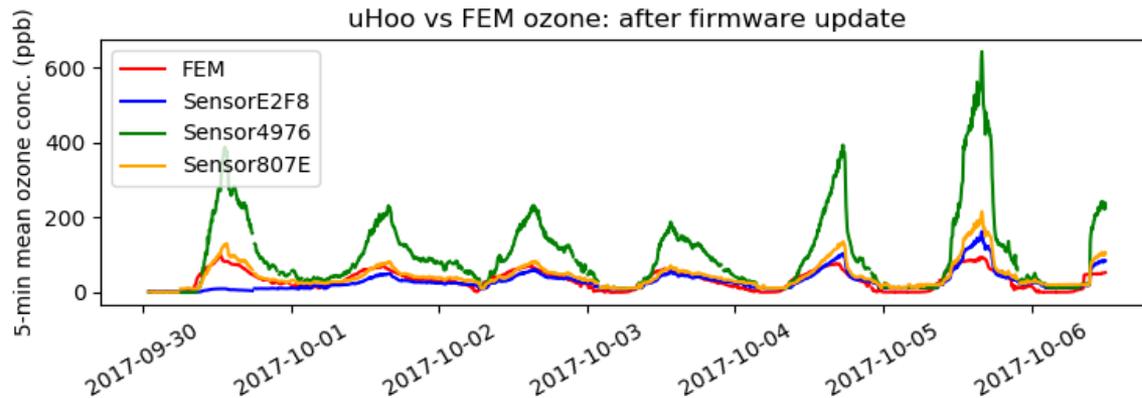
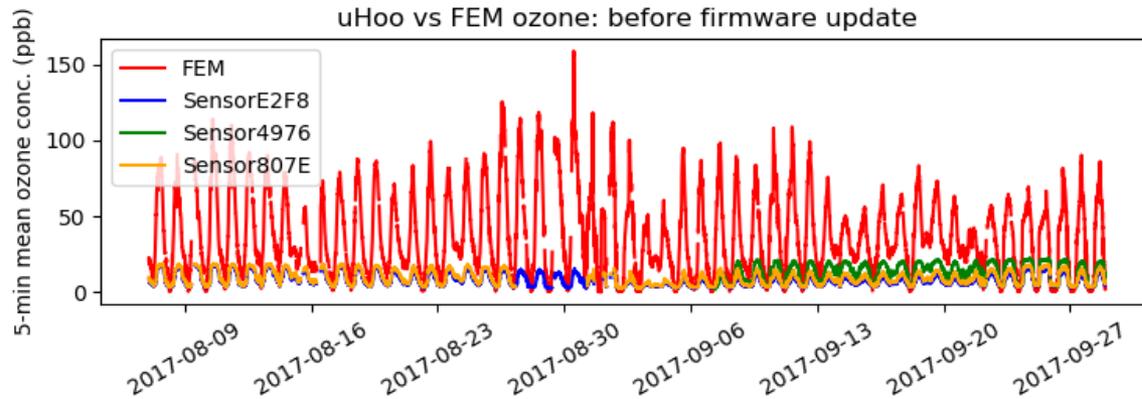
# uHoo Sensor vs FEM BAM (PM<sub>2.5</sub> mass conc.; 1-hr mean)



- uHoo PM<sub>2.5</sub> mass concentration measurements do not correlate with the corresponding FEM BAM data ( $R^2 < 0.01$ ).



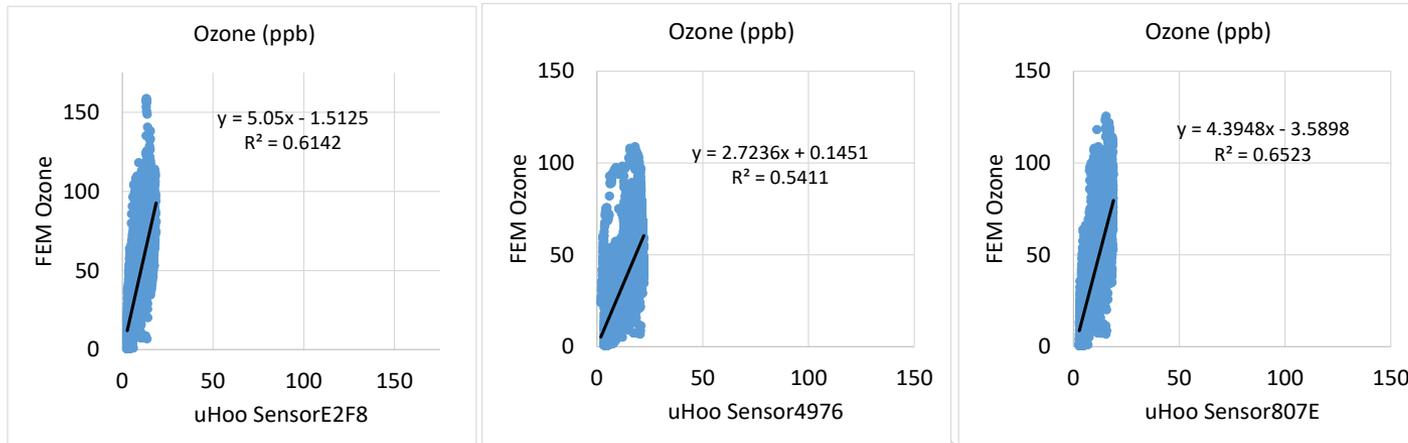
# uHoo Sensor vs FEM Ozone (ppb; 5-min mean)



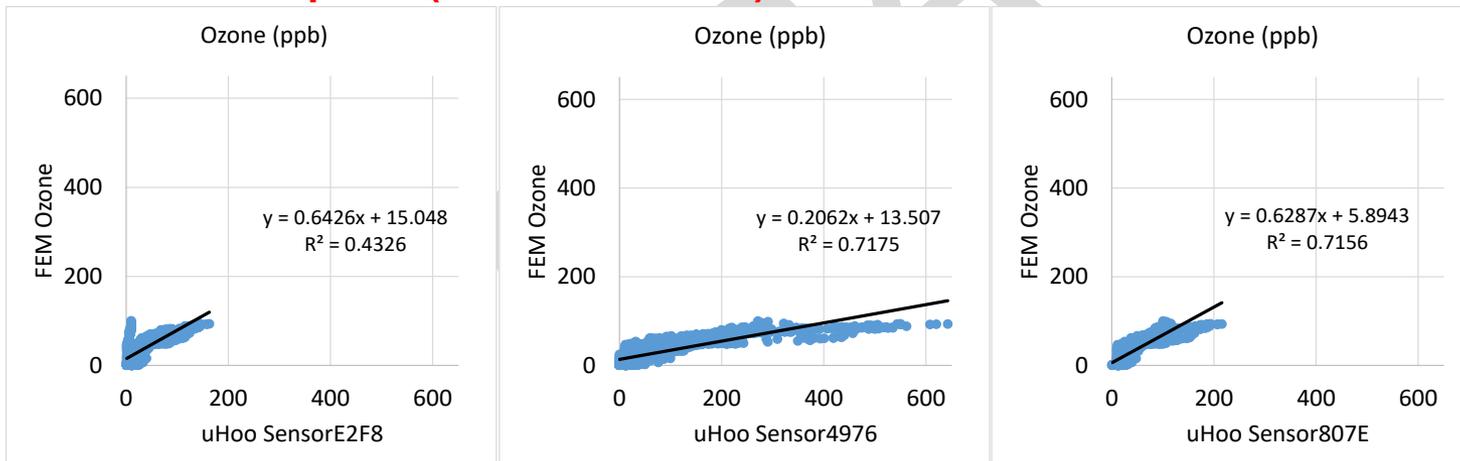
- uHoo ozone sensors somewhat tracked the ozone concentration change measured by FEM ozone during the first 7 weeks of deployment (before firmware update). However, the sensors significantly underestimated the ozone conc.
- After the firmware update on 2017-09-29, the ozone sensor algorithm was affected.

# uHoo Sensor vs FEM Ozone (ppb; 5-min mean)

Prior to firmware update (8/7/17 – 9/28/17)

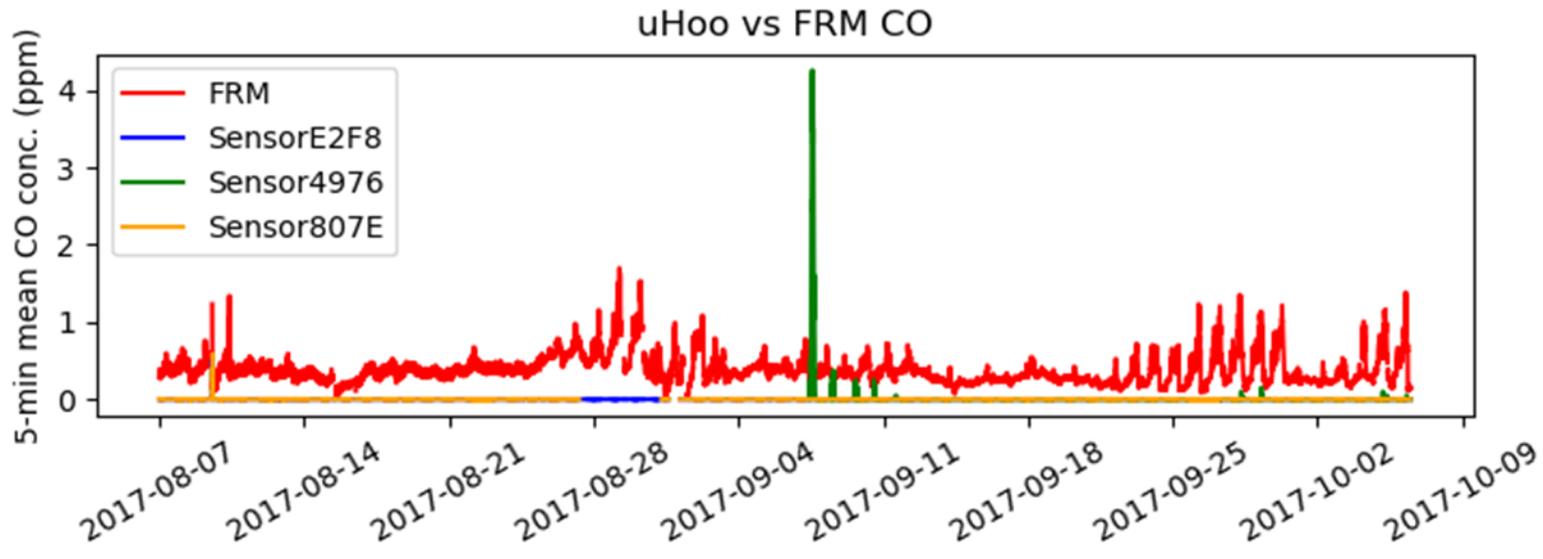


After firmware update (9/29/17 – 10/6/17)



- uHoo ozone sensors showed fair-to-good correlation with the corresponding FEM ozone data ( $0.43 < R^2 < 0.72$ ).
- uHoo reported a firmware update on 2017-09-29 which affected the ozone algorithm. After treating the post-firmware-update data separately, uHoo sensors 4976 and 807E's  $R^2$  improved, while sensor E2F8's  $R^2$  worsened.

## uHoo Sensor vs FRM CO (ppm; 5-min mean)



- uHoo reported mostly 0 ppm of CO during the evaluation period.
- uHoo tech specs indicate the CO measurement range is between 0 to 1000 ppm. During this evaluation, ambient CO concentration was below 2 ppm. uHoo seemed not to respond to ambient low CO concentration.

# Discussion

- Overall, the three uHoo sensors tested, each one measuring PM<sub>2.5</sub>, ozone, and CO, had good data recovery (88-96%)
- High measurement variations were observed between the three uHoo devices tested.
- uHoo PM<sub>2.5</sub> and CO sensors correlated poorly with FEM and FRM instruments. (PM<sub>2.5</sub> R<sup>2</sup> < 0.01; CO R<sup>2</sup>: not applicable)
- uHoo ozone sensors showed fair-to-good correlation with FEM ozone instrument (0.43 < R<sup>2</sup> < 0.72). uHoo reported a firmware update on 2017-09-29 which affected the ozone algorithm. After treating the post-firmware-update data separately, uHoo sensors 4976 and 807E's R<sup>2</sup> improved, while sensor E2F8's R<sup>2</sup> worsened.
- Laboratory chamber testing is necessary to fully evaluate the performance of these sensors over different / more extreme environmental conditions
- All results are still preliminary