

Field Evaluation of Vaisala Air Quality Transmitter AQT410 v.1.15



Background

- From 3/06/2018 to 5/03/2018, three **Vaisala AQT410 v.1.15** sensors were deployed at the South Coast AQMD stationary ambient monitoring site in Rubidoux and were run side-by-side with reference instruments measuring the same pollutants
- Vaisala AQT410 v.1.15 (3 units tested):
 - Gas sensors (**electrochem gas sensor; non-FRM/FEM**)
 - Each unit measures NO₂ (ppm), SO₂ (ppm), CO (ppm), Ozone (ppm), ambient air temperature (degree F), relative humidity (%), and pressure (mbar)
 - **Unit cost: ~\$3,700**
 - Time resolution: 1-min
 - Units IDs:
 - 0006
 - 0001
 - 0002
- South Coast AQMD Reference instruments:
 - CO instrument; **FRM, cost: ~\$10,000**
 - Time resolution: 1-min
 - NO_x instrument; **FRM NO₂, cost: ~\$11,000**
 - Time resolution: 1-min
 - O₃ instrument; **FEM, cost: ~\$7,000**
 - Time resolution: 1-min
 - SO₂ instrument; **FEM, cost: ~\$11,000**
 - Time resolution: 1-min
 - Met Station (T, RH, P, WS, WD); **cost: ~\$5,000**
 - Time resolution: 1-min



Differences between Vaisala AQT410 v.1.11 and v.1.15

Vaisala AQT410 v.1.11 had previously been evaluated in the field from 7/14/2017 to 8/22/2017 ([Vaisala AQT410 Field Evaluation Report](#))

- Hardware remains the same for both Vaisala AQT410 v.1.11 and v.1.15

Key firmware updates from v.1.11 to v.1.15

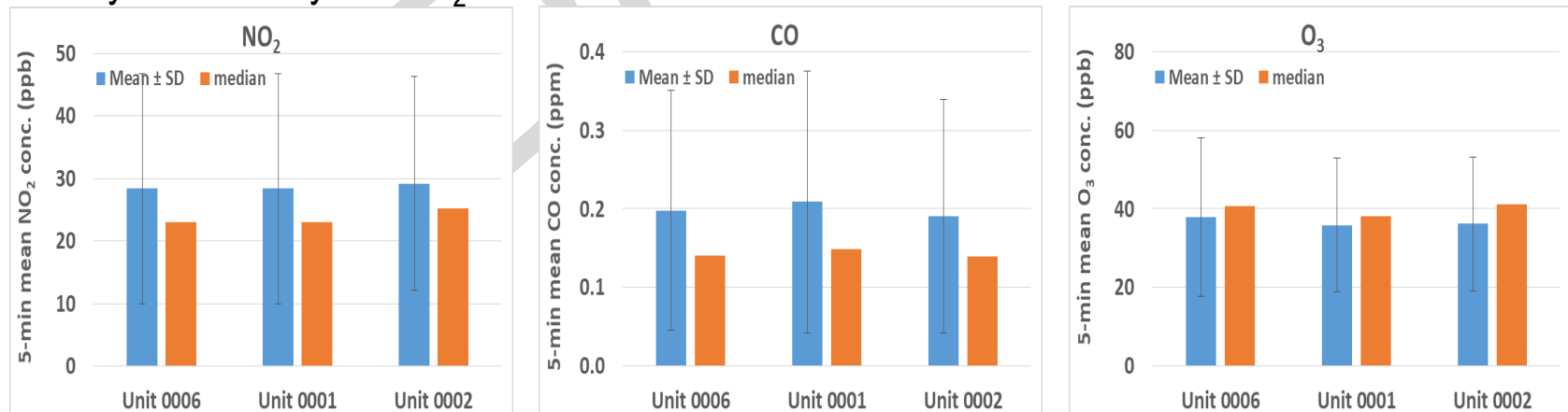
- Calibration parameters updated to new calibration system for baseline compensation of the gas measurements
- Instrument learning period increased based on tests at high concentrations
- Bug fix for temperature compensation of gas measurements at high ambient temperatures
- Reliability of use improved for the device and Modbus communications

Data validation & recovery

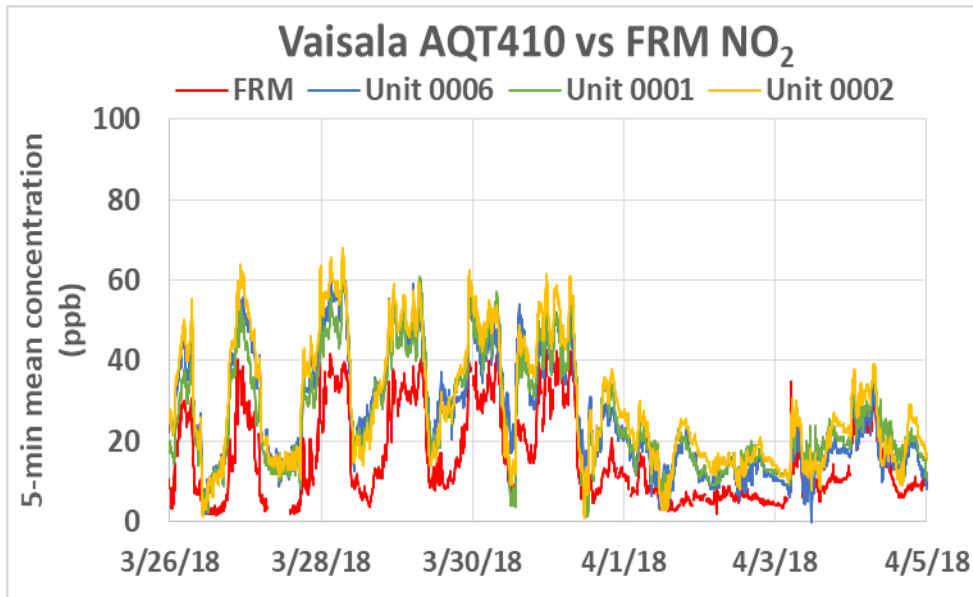
- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values, and invalid data-points were eliminated from the data-set)
- Data recovery was over 96% for all units/pollutants tested, except for ozone, which had a data recovery of >85%.

Vaisala AQT410; intra-model variability

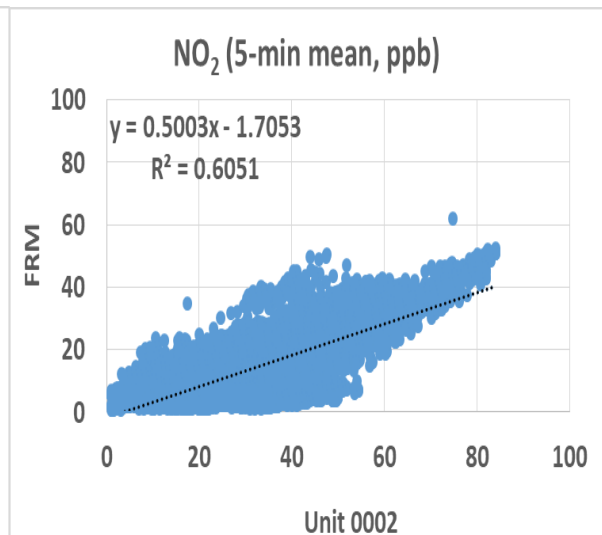
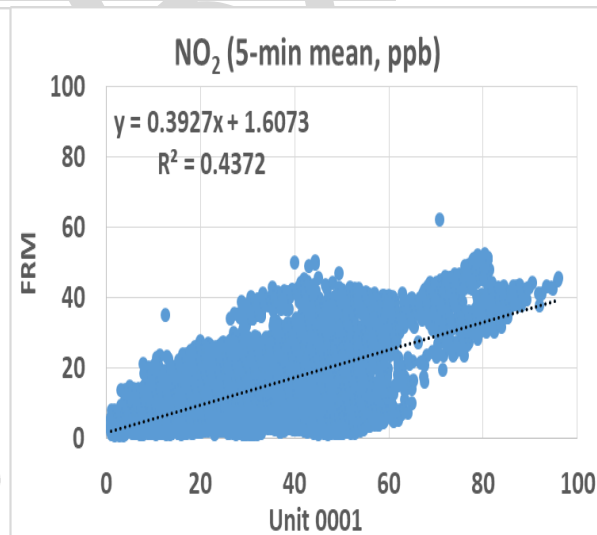
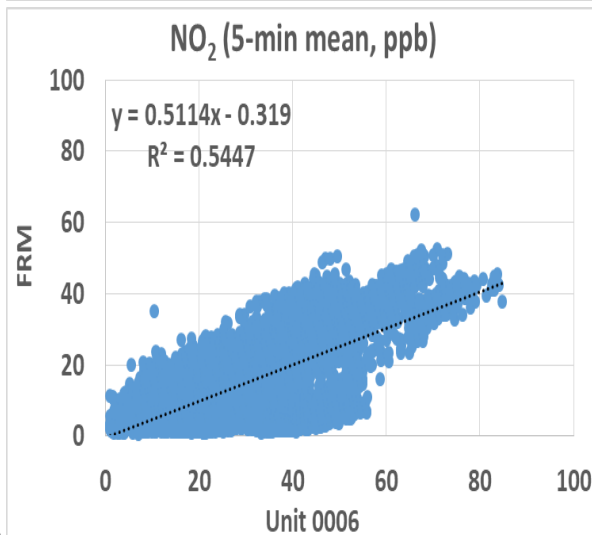
- Low intra-model variability was observed for CO and Ozone, from all Vaisala AQT410 sensors (5.4% and 9.5%, respectively)
- NO₂ levels showed a relatively higher variation among the tested AQT410 sensors (11.6%)
- SO₂ evaluation was not included in this report due to its concentrations being too low to be reliably detected by the SO₂ FEM instrument



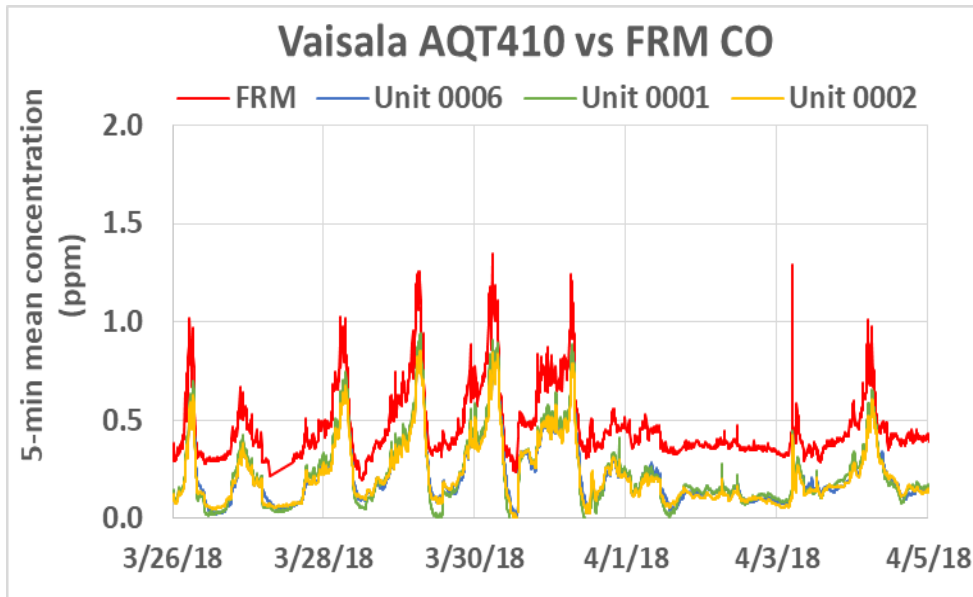
Vaisala AQT410 vs FRM (NO₂; 5-min mean)



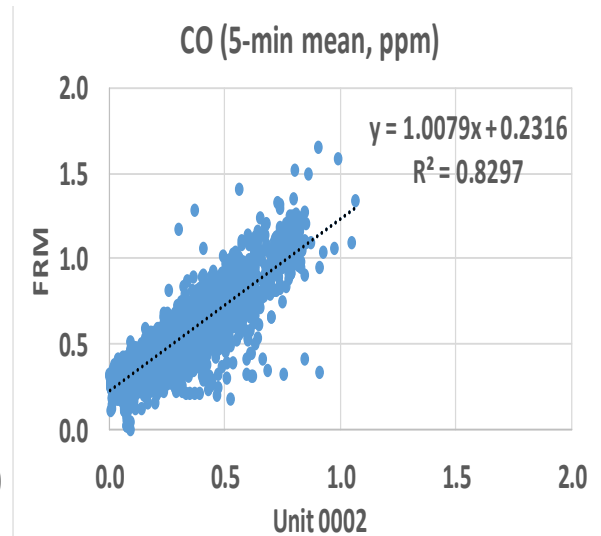
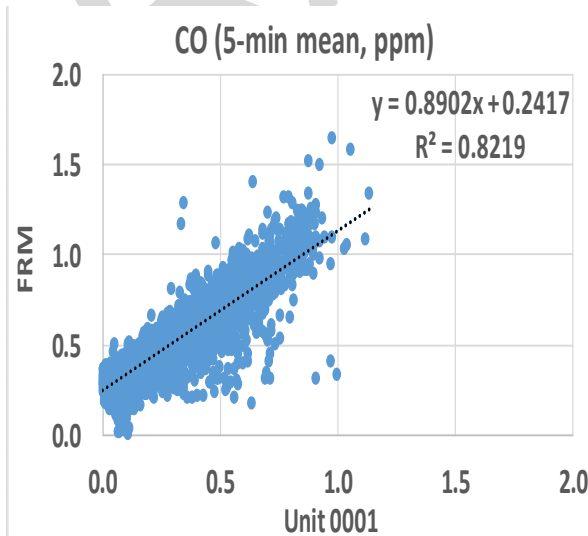
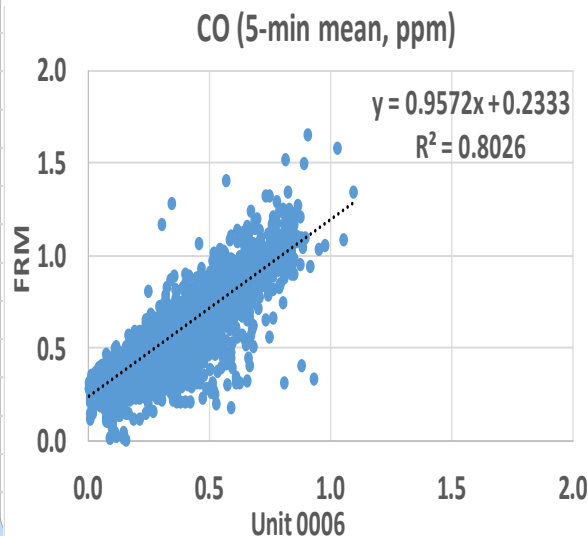
- AQT410 sensors showed weak-to-moderate correlations with the corresponding FRM NO₂ data ($0.43 < R^2 < 0.61$)
- Overall, the AQT410 sensors overestimated NO₂ concentration as measured by the FRM instrument
- AQT410 sensors seemed to track the NO₂ diurnal variations as recorded by the FRM instrument



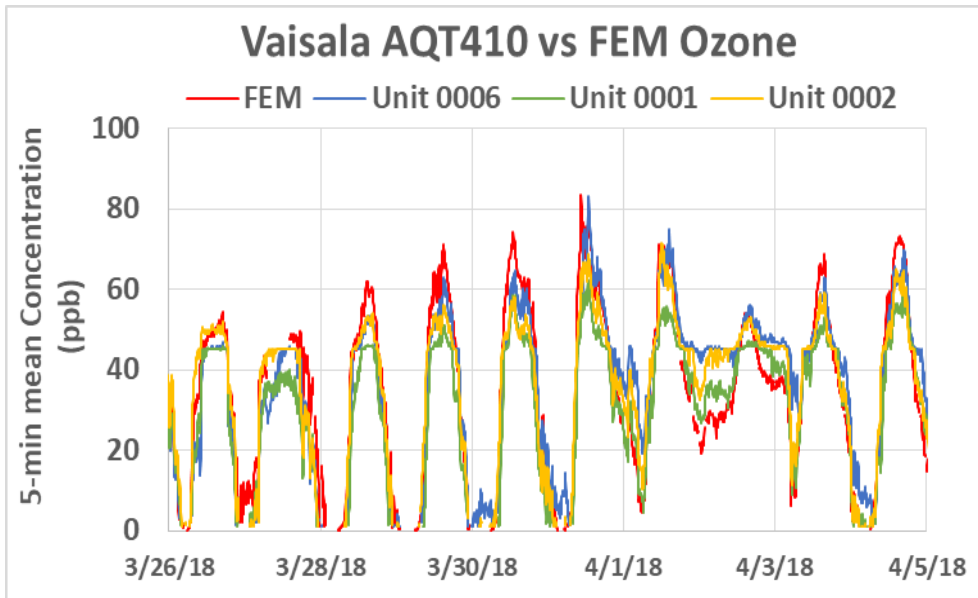
Vaisala AQT410 vs FRM (CO; 5-min mean)



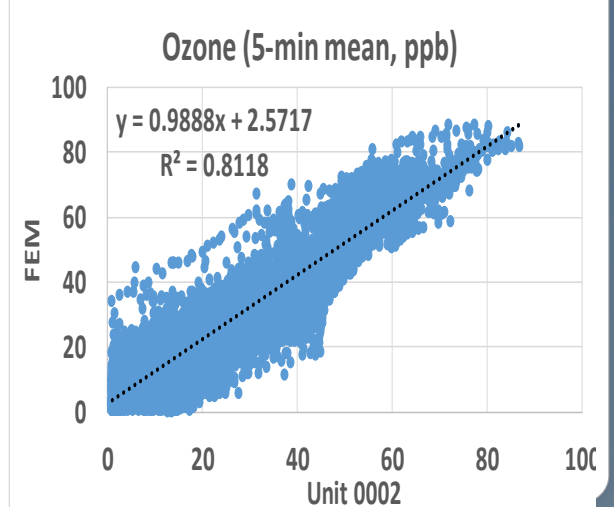
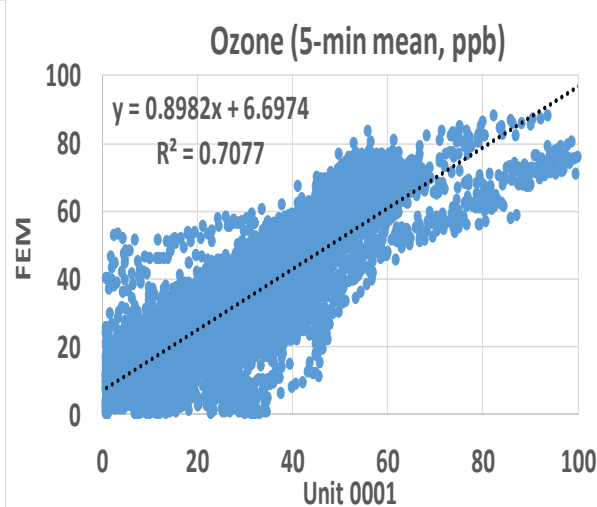
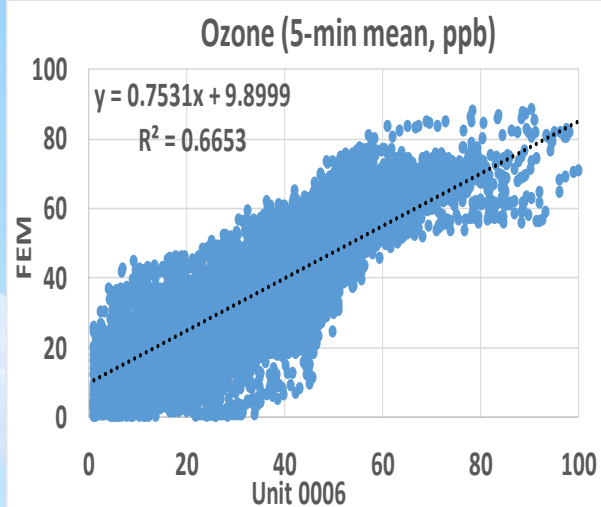
- AQT410 sensors showed strong correlations with the corresponding FRM CO data ($0.80 < R^2 < 0.83$)
- AQT410 sensors seemed to track well the diurnal CO variation recorded by the FRM instrument



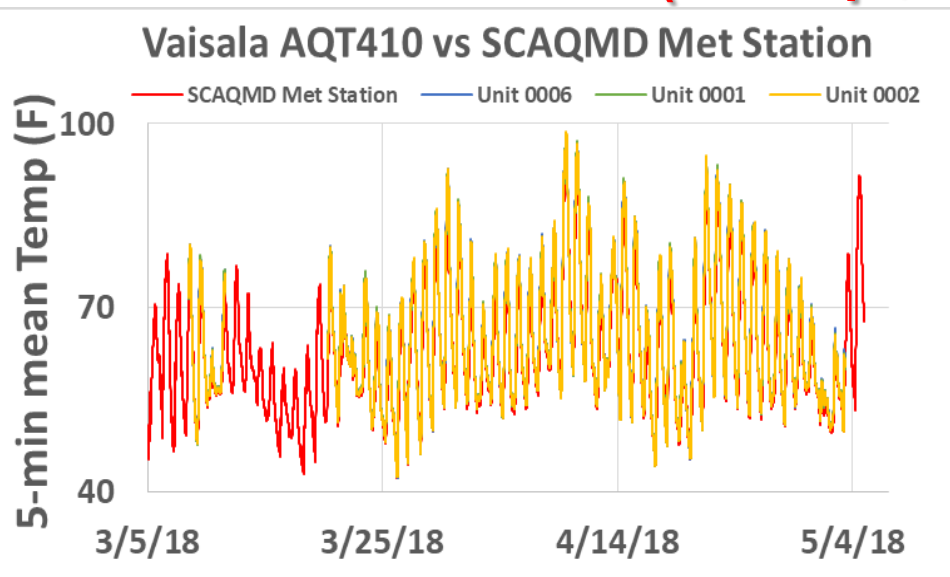
Vaisala AQT410 vs FEM (ozone; 5-min mean)



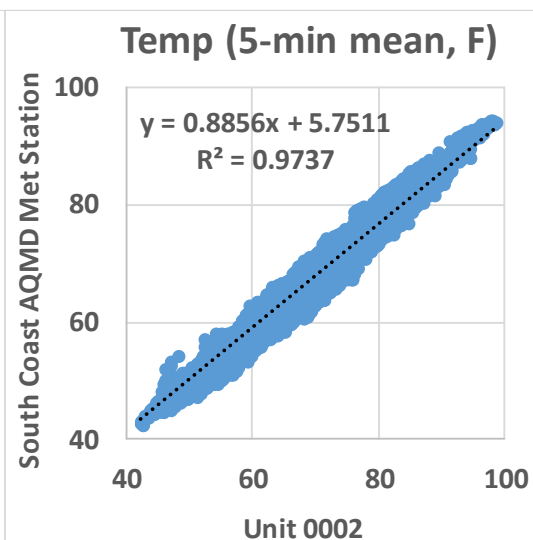
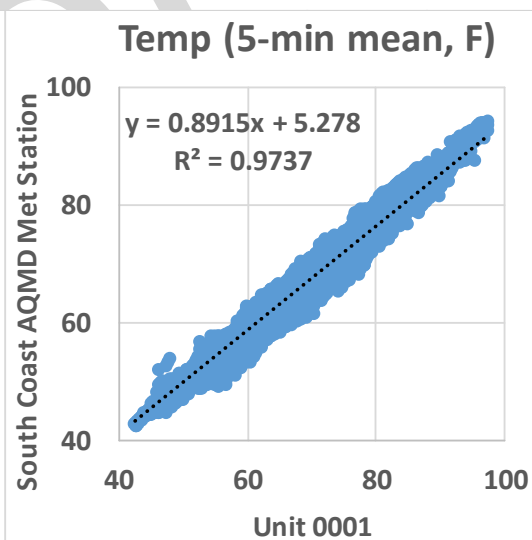
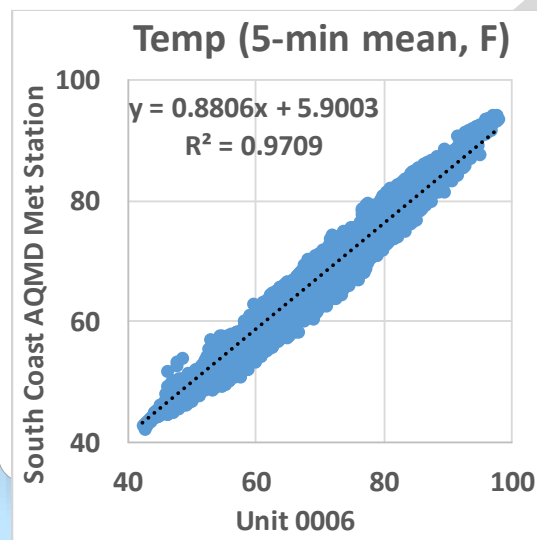
- AQT410 sensors showed moderate-to-strong correlations with the corresponding FEM ozone data ($0.66 < R^2 < 0.82$)
- Overall, the AQT410 sensors overestimated ozone concentration as measured by the FEM instrument
- AQT410 sensors seemed to track well the diurnal ozone variations recorded by the FEM instrument



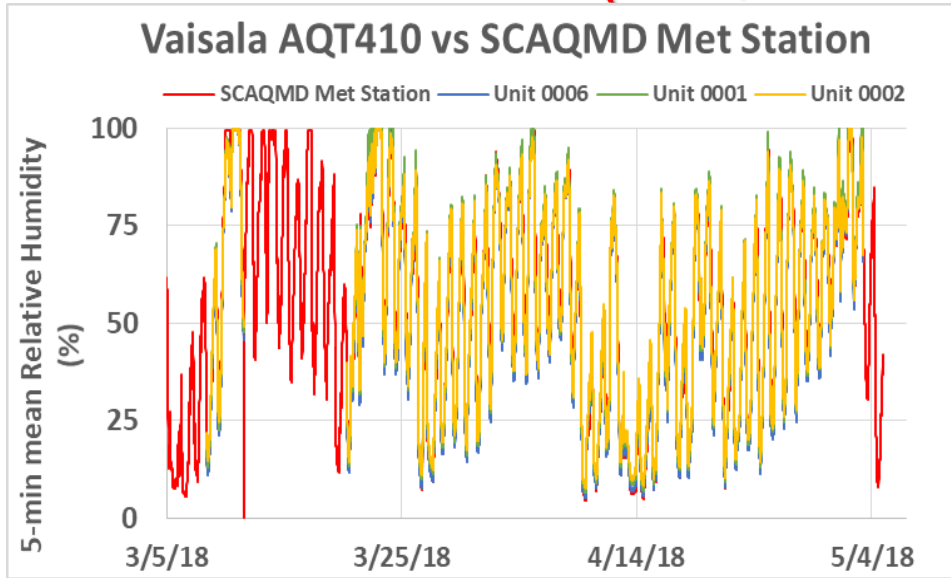
Vaisala AQT410 vs South Coast AQMD Met Station (Temp; 5-min mean)



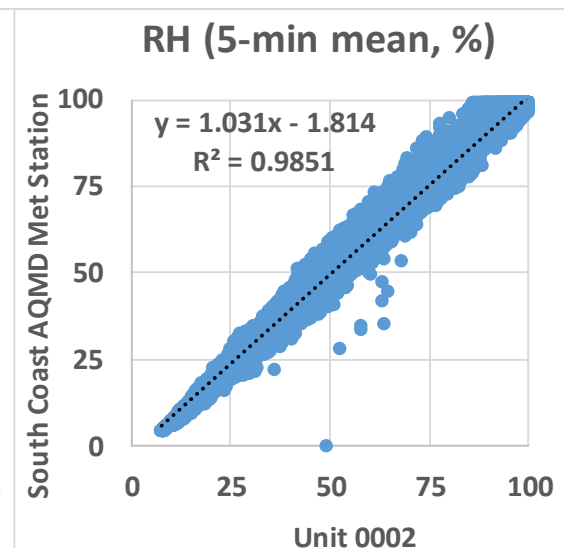
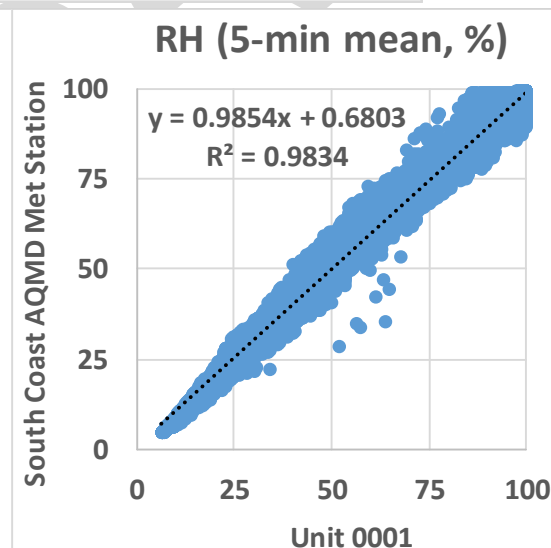
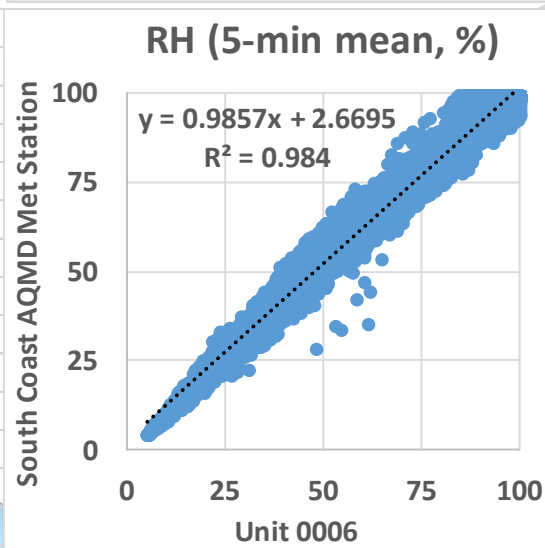
- The AQT410 temperature measurements showed very strong correlations with the corresponding South Coast AQMD Met Station data ($R^2 > 0.97$)
- Overall, the AQT410 temperature measurements overestimated the corresponding South Coast AQMD Met Stations data
- AQT410 sensors seemed to track well the diurnal Temp variations recorded by the South Coast AQMD Met station



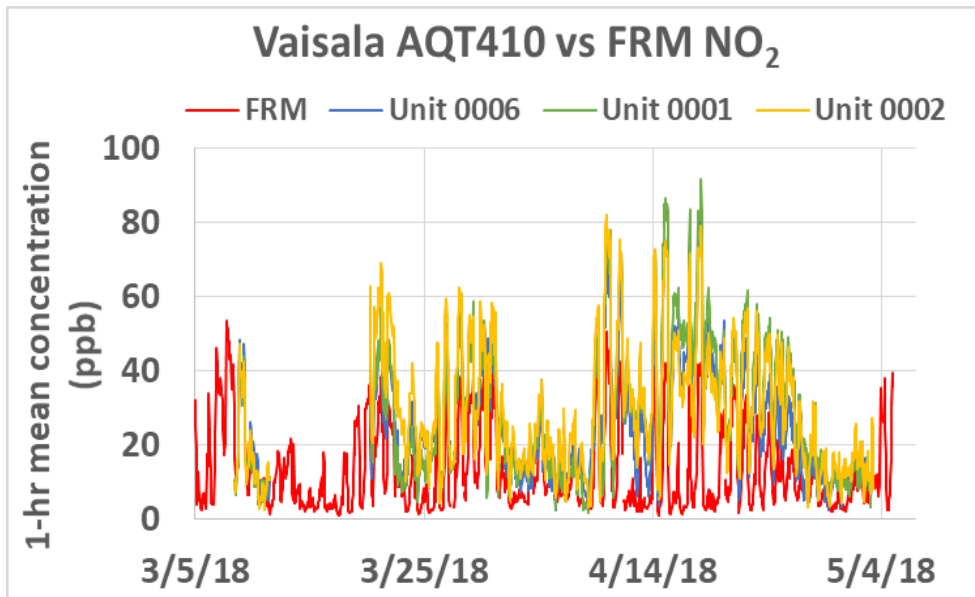
Vaisala AQT410 vs South Coast AQMD Met Station (RH; 5-min mean)



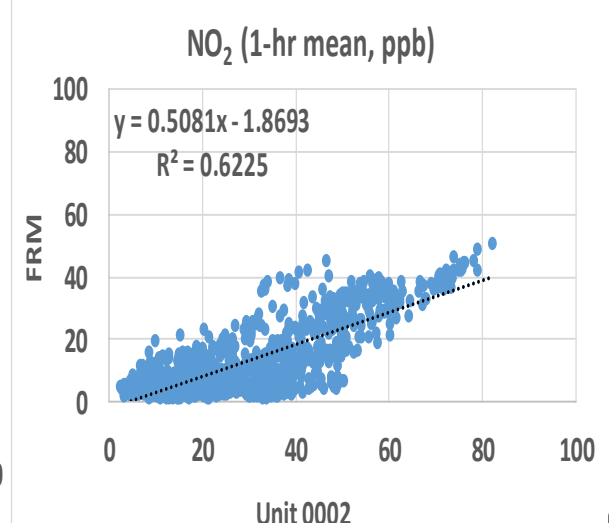
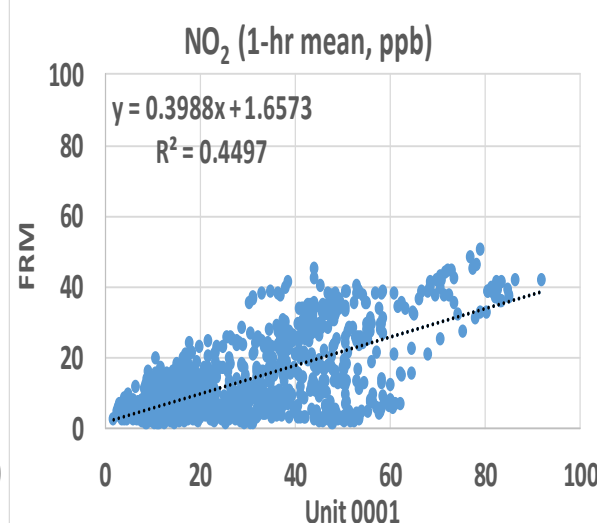
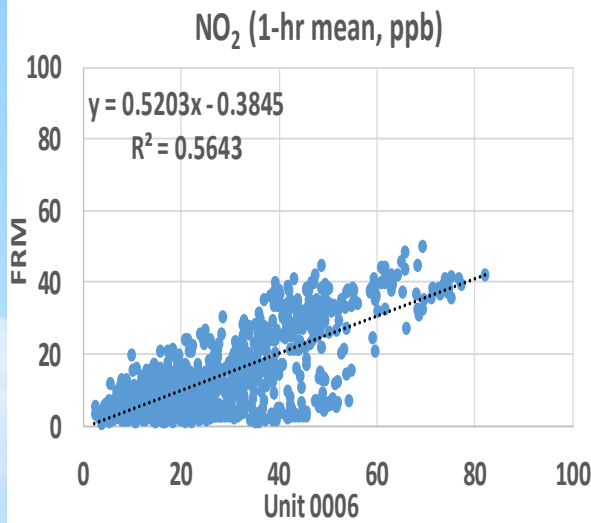
- The AQT410 RH measurements showed very strong correlations with the corresponding South Coast AQMD Met Station data ($R^2 > 0.98$)
- AQT410 sensors seemed to track well the diurnal RH variations recorded by the South Coast AQMD Met station sensor



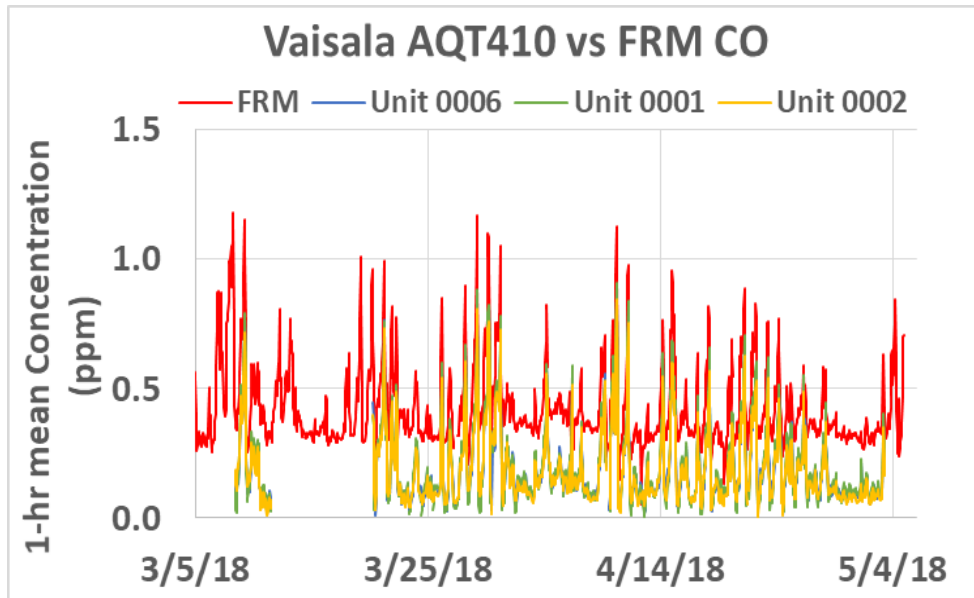
Vaisala AQT410 vs FRM (NO₂; 1-hr mean)



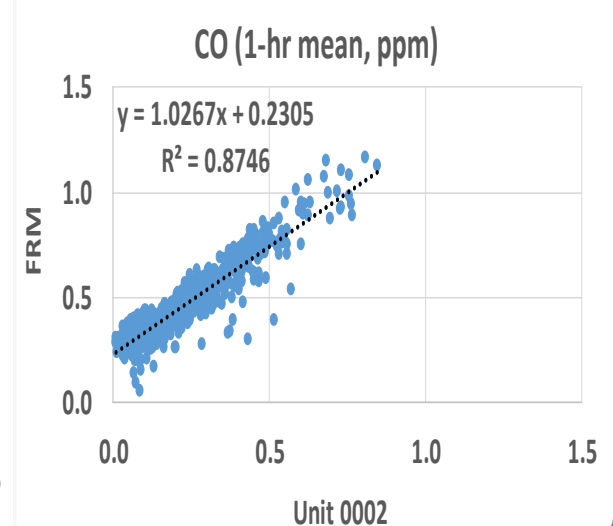
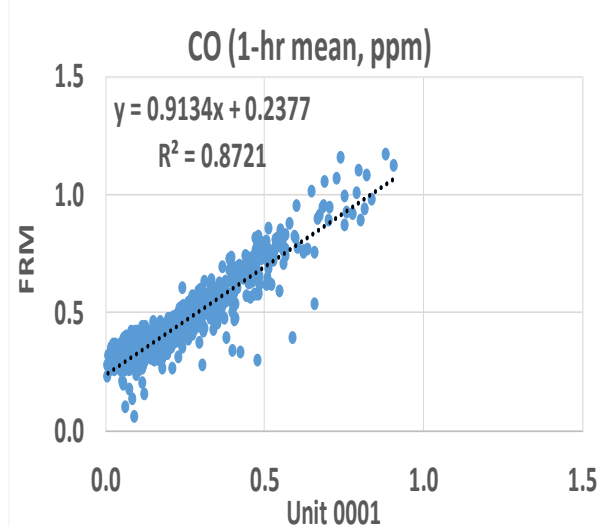
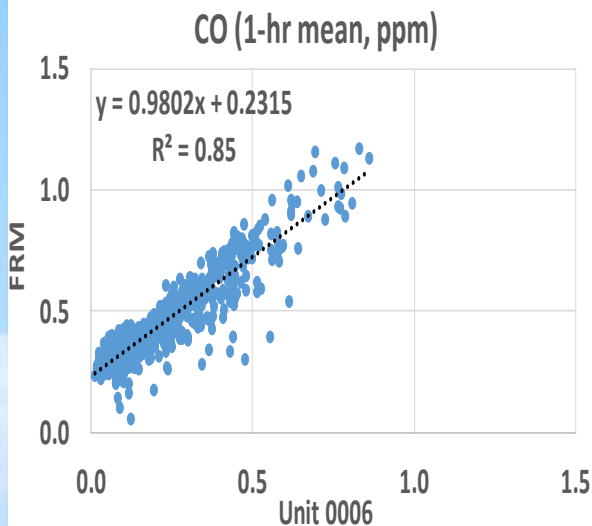
- AQT410 sensors showed weak-to-moderate correlations with the corresponding FRM data ($0.44 < R^2 < 0.63$)
- Overall, the AQT410 sensors overestimated NO₂ concentration as measured by the FRM instrument
- The AQT410 sensors seemed to track the NO₂ diurnal variations as recorded by the FRM instruments



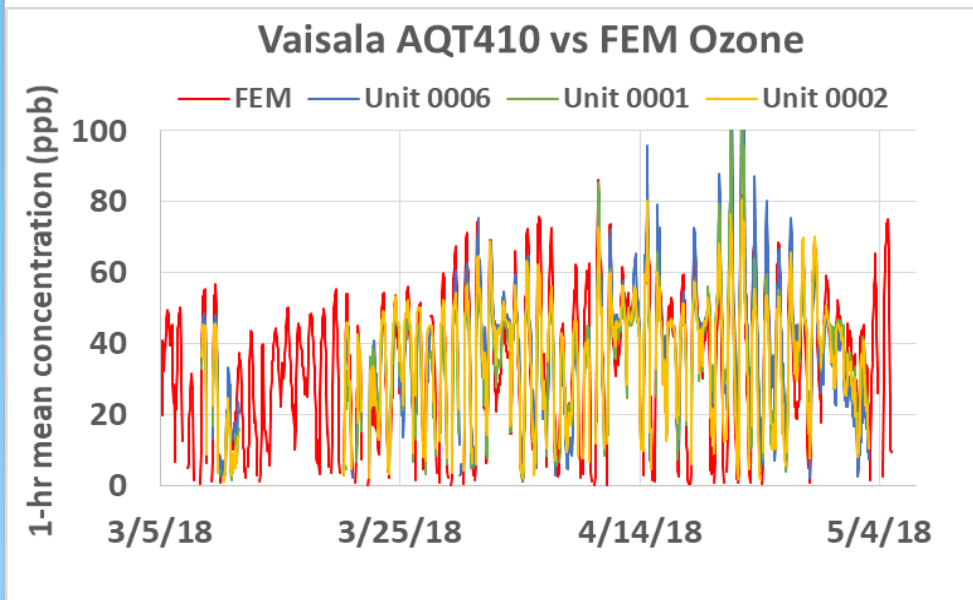
Vaisala AQT410 vs FRM (CO; 1-hr mean)



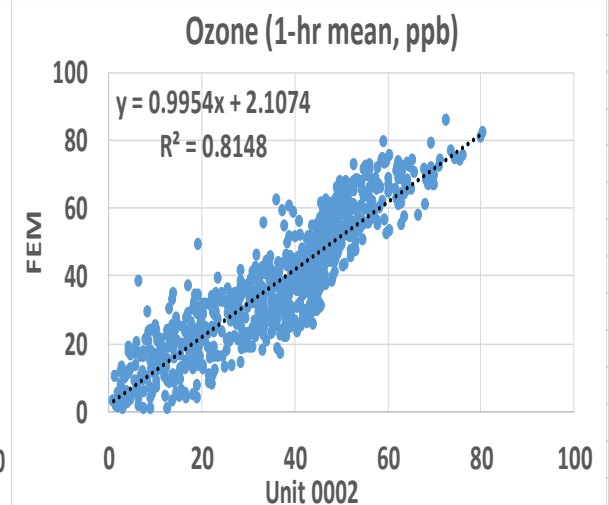
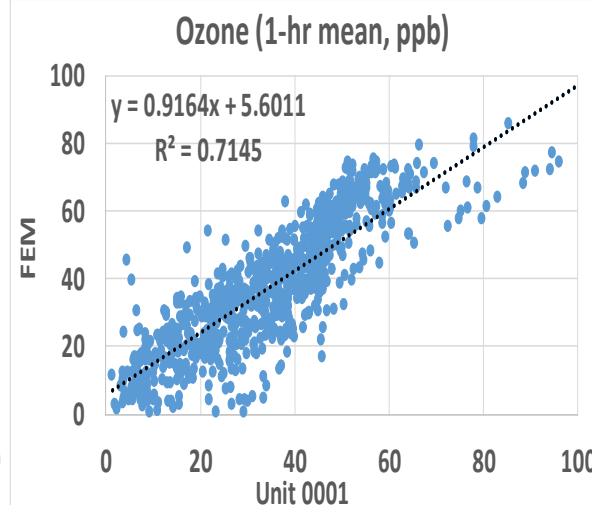
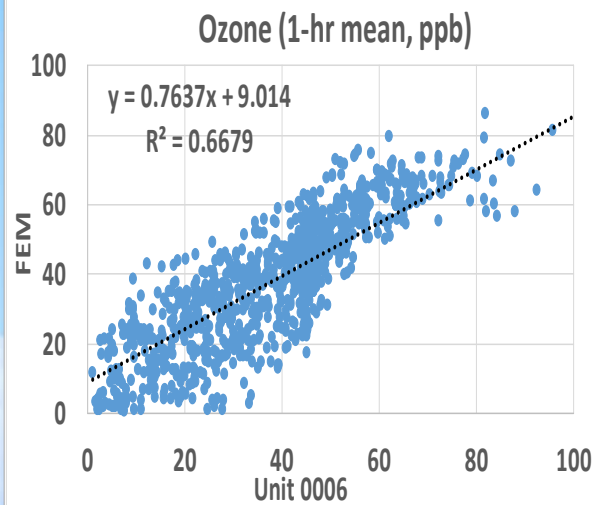
- AQT410 sensors showed strong correlations with the corresponding FRM CO data ($0.85 < R^2 < 0.88$)
- AQT410 sensors seemed to track the CO diurnal variations as recorded by the FRM instrument



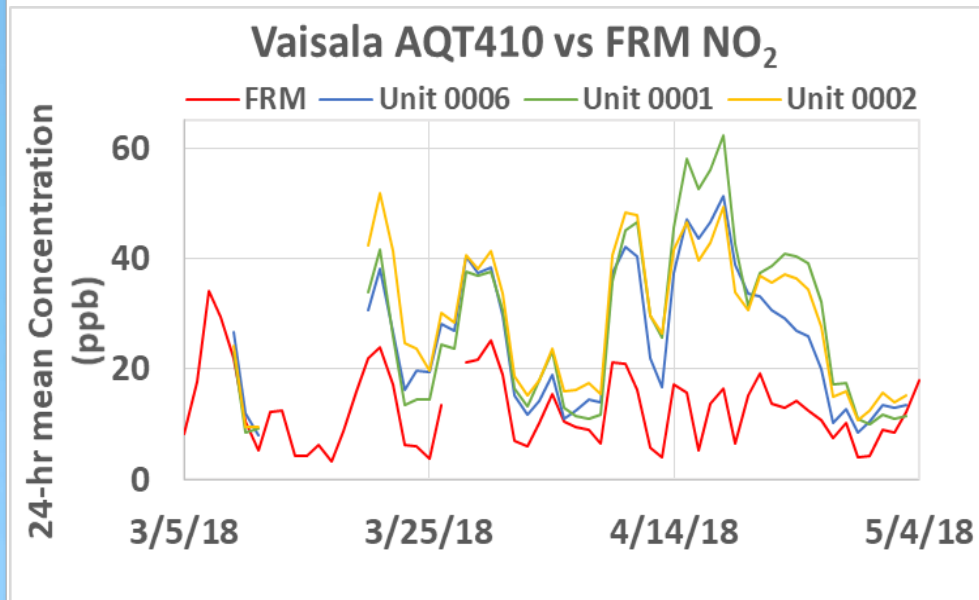
Vaisala AQT410 vs FEM (Ozone; 1-hr mean)



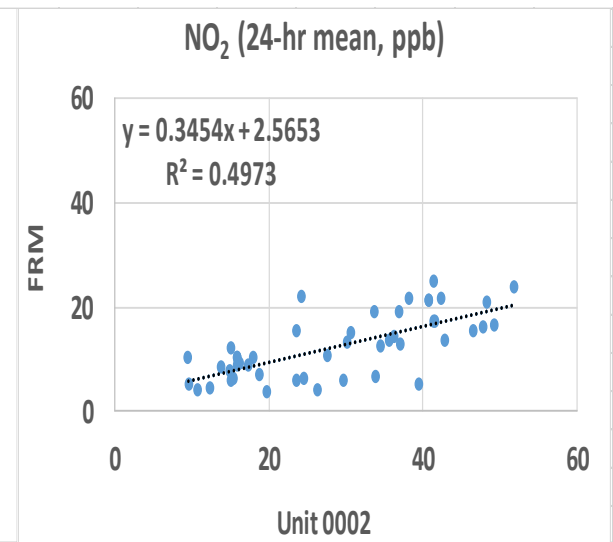
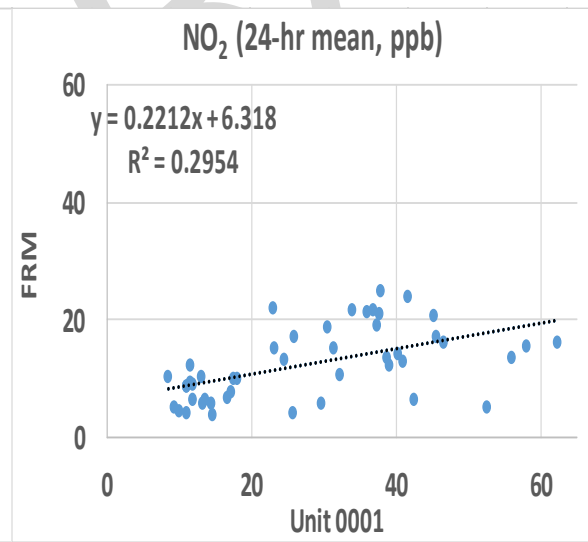
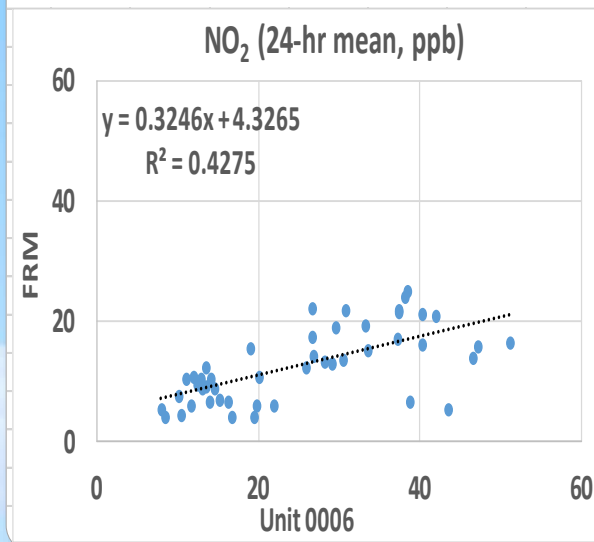
- AQT410 sensors showed moderate-to-strong correlations with the corresponding FEM data ($0.66 < R^2 < 0.82$)
- Overall, the AQT410 sensors overestimated ozone concentration as measured by the FEM instrument
- AQT410 track well the diurnal O_3 variations recorded by the FEM instrument



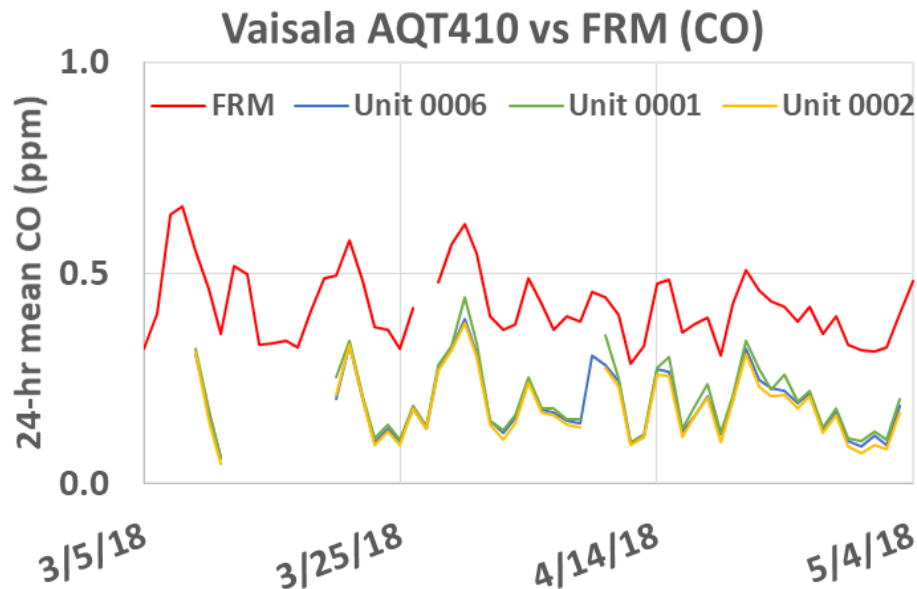
Vaisala AQT410 vs FRM (NO₂; 24-hr mean)



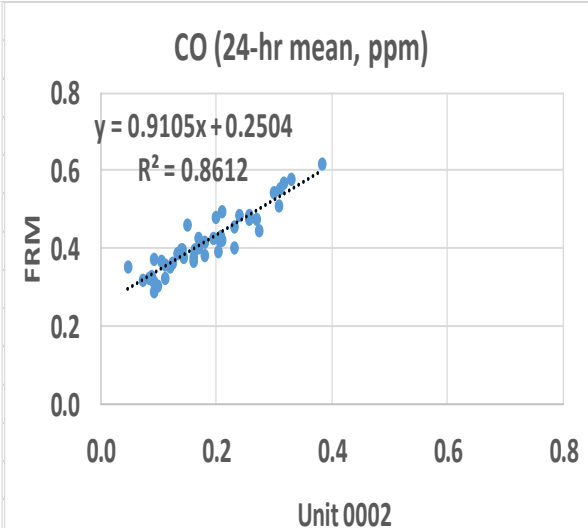
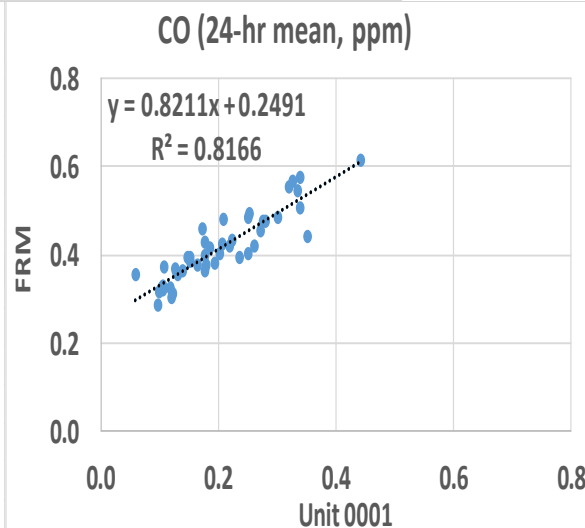
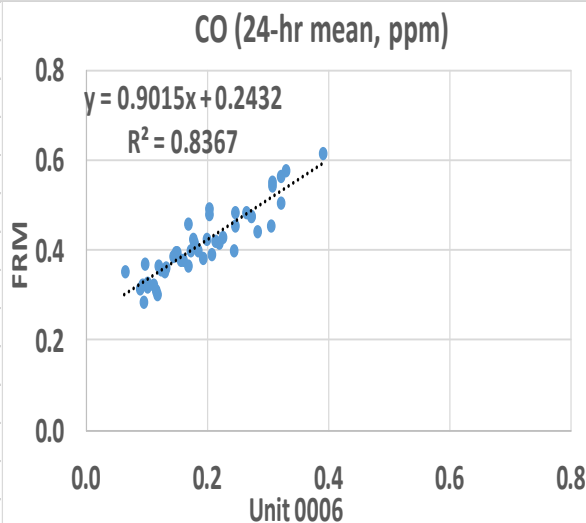
- AQT410 sensors showed very weak-to-weak correlations with the corresponding FRM NO₂ data ($0.29 < R^2 < 0.50$)
- Overall, the AQT410 sensors overestimated NO₂ concentration as measured by the FRM instrument
- The AQT410 sensors seemed to track the NO₂ diurnal variations as recorded by the FRM instrument



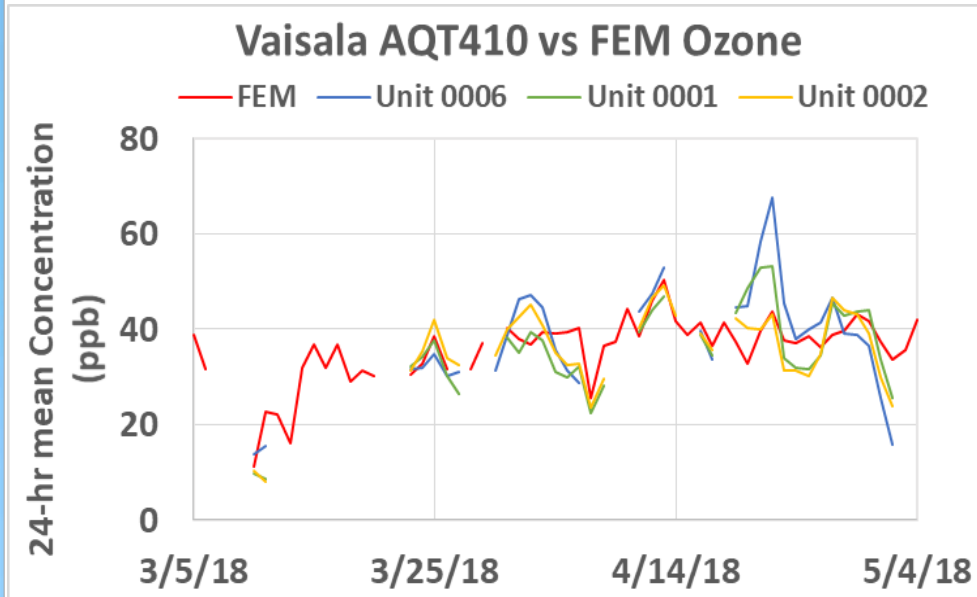
Vaisala AQT410 vs FRM (CO; 24-hr mean)



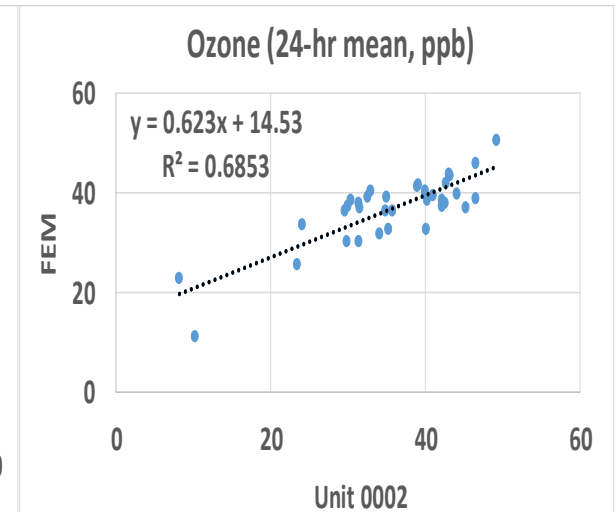
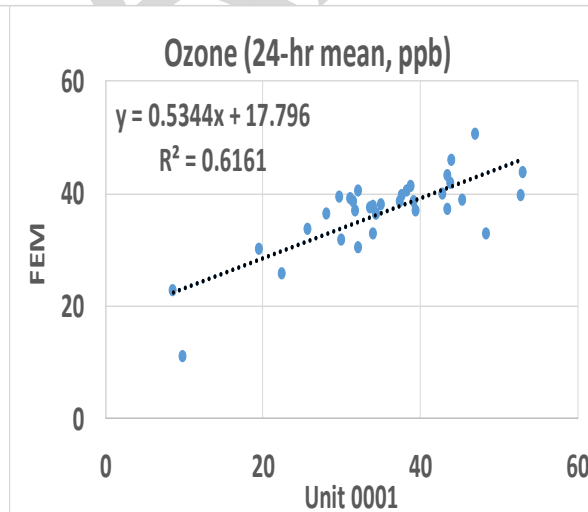
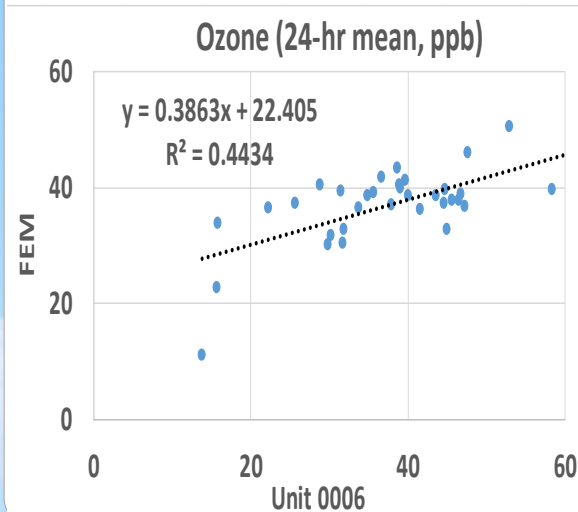
- AQT410 sensors showed strong correlations with the corresponding FRM CO data ($0.81 < R^2 < 0.87$)
- Overall, the AQT410 sensors overestimated CO concentration as measured by the FRM instrument
- AQT410 sensors seemed to track the CO variation as recorded by the FRM instrument



Vaisala AQT410 vs FEM (Ozone; 24-hr mean)



- AQT410 sensors showed weak-to-moderate correlations with corresponding FEM ozone data ($0.44 < R^2 < 0.69$)
- Overall, the AQT410 sensors overestimated ozone concentration as measured by the FEM instrument
- The AQT410 sensors seemed to track the ozone diurnal variations as recorded by the FRM instrument



Discussion

- Data recovery for **Vaisala AQT410 v.1.15** CO and NO₂ sensors was higher than 96%. The Ozone sensors had 85% data recovery.
- The three sensors showed low intra-model variability for CO and O₃ and moderate intra-model variability for NO₂.
- During the field deployment testing period:
 - Ozone sensors showed moderate-to-strong correlations ($0.66 < R^2 < 0.82$, 5-min mean) with the reference instrument and overestimated the corresponding FEM Ozone measurements
 - NO₂ sensors showed weak-to-moderate correlations ($0.43 < R^2 < 0.61$, 5-min mean) with the reference instrument and overestimated the corresponding FRM NO₂ data
 - CO sensors showed strong correlations ($0.80 < R^2 < 0.83$, 5-min mean) with the FRM instrument
- No sensor calibration was performed by South Coast AQMD Staff prior to the beginning of this test
- Laboratory chamber testing is necessary to fully evaluate the performance of these sensors under known aerosol concentrations and controlled temperature and relative humidity conditions
- All results are still preliminary