Field Evaluation
Aeroqual AQY (v1.0) – PM_{10}

South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Background

- From 10/29/2020 to 12/24/2020, three **Aeroqual AQY v1.0** multi-sensor units were deployed at the South Coast AQMD stationary ambient monitoring site in Rubidoux and were run side-by-side with Federal Equivalent Method (FEM) instruments measuring the same pollutants.

- Aeroqual AQY v1.0 (*3 units tested*):
  - Sensors: Ozone – Gas Sensitive Semiconductor (GSS);
  - NO_2 – Gas Sensitive Electrochemical (GSE) (non-FEM/non-FRM);
  - PM – Laser Particle Counter (LPC) (non-FEM), (model SDS011 by Nova Fitness)
  - Each unit measures: O_3 (ppb), NO_2 (ppb), $PM_{2.5}$ (µg/m^3), **PM_{10} (µg/m^3), T (°C), RH (%)**
  - Unit cost: ~$3,000 w/ modem ($4000 including 2-yr care package with cloud software and remote tech support)
  - Time resolution: 1-min
  - Units IDs: 1062, 1068, 1098
  - Differences from AQY v0.5
    - Separate USB drive memory
    - New PCB board with sensor connector
    - Real time clock added
    - Mounting bracket for Ozone, NO_2 and $PM_{2.5}$ sensors

Note: This evaluation shows the results for PM_{10}. For evaluations of other parameters, please visit http://www.aqmd.gov/docs/default-source/aq-spec/field-evaluations/aeroqual-aqy-v1-0---field-evaluation.pdf?sfvrsn=21

- South Coast AQMD Reference instruments:
  - Teledyne API T640 (FEM $PM_{2.5}$); cost: $21,000
    - Time resolution: 1-min
  - MetOne BAM (FEM PM_{10}); cost: ~$20,000
    - Time resolution: 1-hr
  - Met station (T, RH, P, WS, WD); cost: ~$5,000
    - 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 PM_{10} from Unit 1062, Unit 1068 and Unit 1098 was 100%, 100% and 86%, respectively.

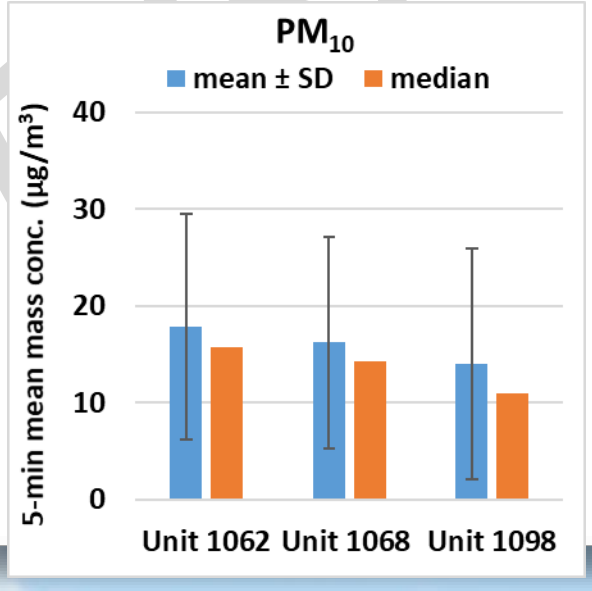
Aeroqual AQY v1.0; Intra-model variability

- Absolute intra-model variability was ~ 1.58 µg/m^3 for the PM_{10} measurements

(calculated as the standard deviation of the three sensor means)

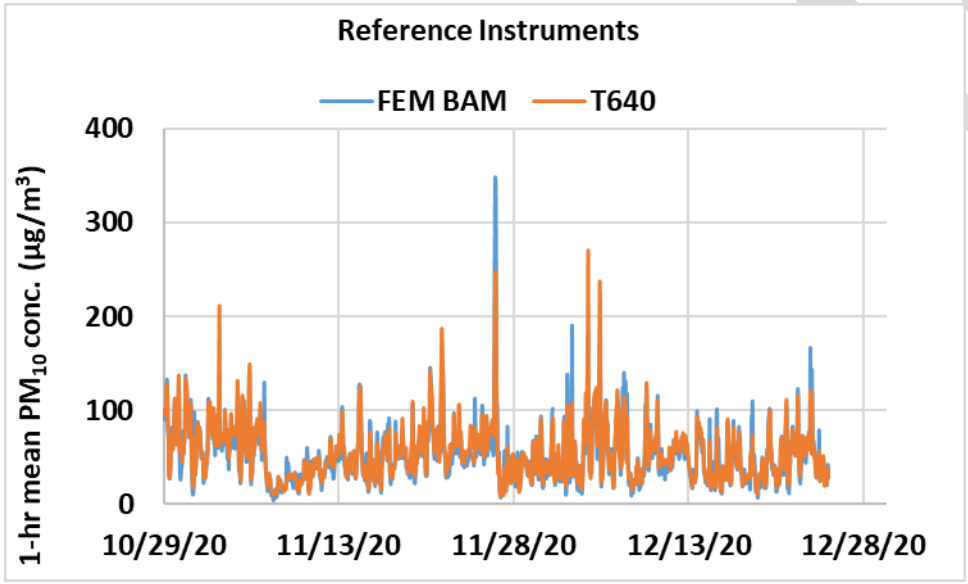
- Relative intra-model variability was ~ 9.89% for the PM_{10} measurements

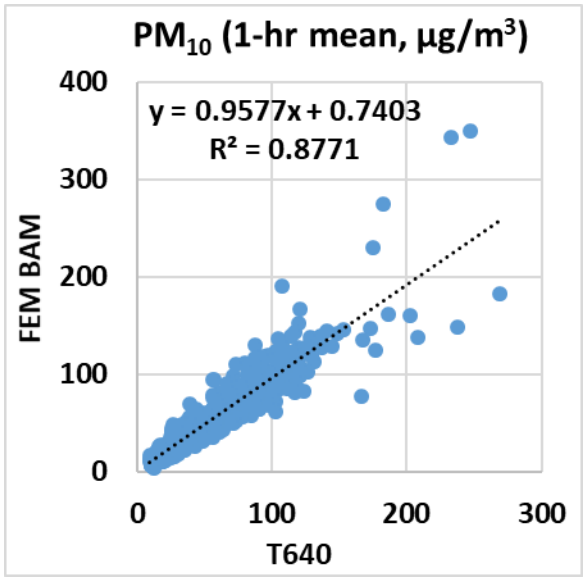
(calculated as the absolute intra-model variability relative to the mean of the three sensor means)



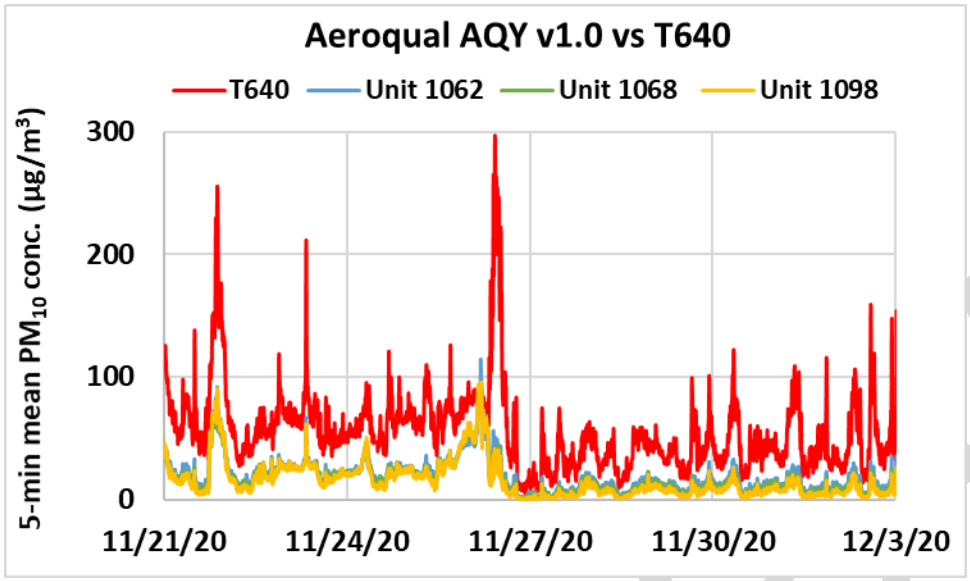
Reference Instruments: PM_{10} BAM & T640

- 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 PM_{10} from FEM BAM and T640 is ~100%
- Strong correlations between FEM BAM and T640 for PM_{10} measurements (R^2 ~ 0.88)

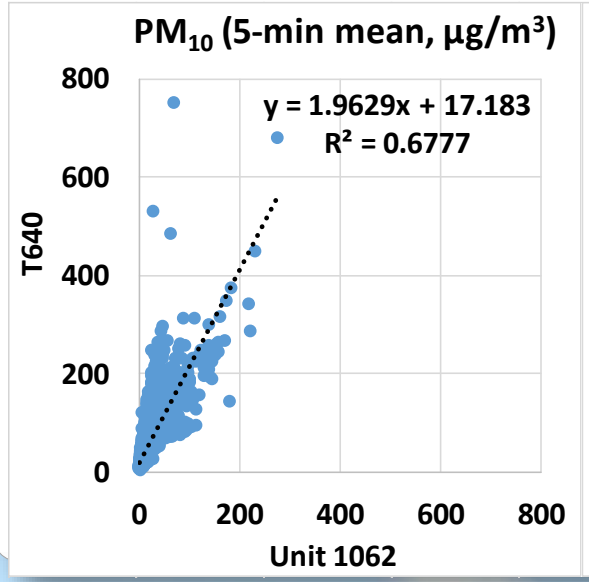


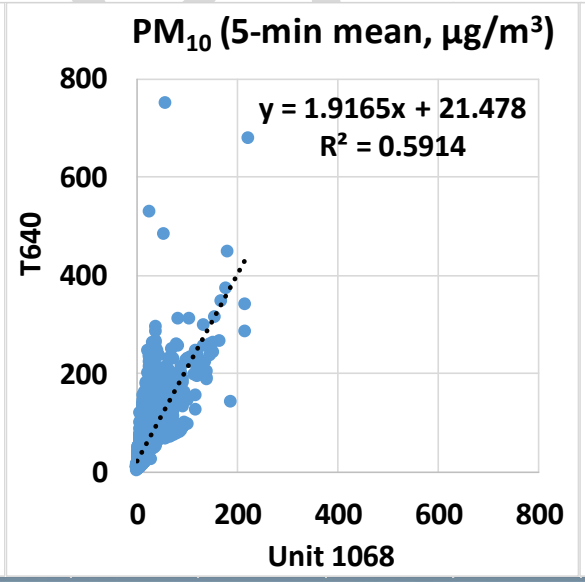


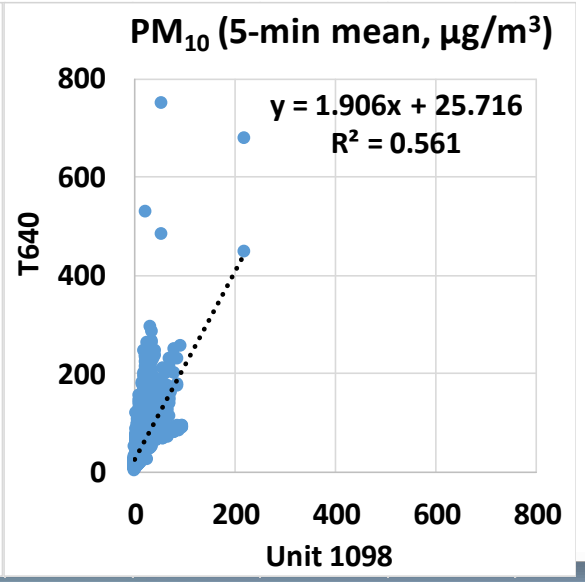
Aeroqual AQY v1.0 vs T640 (PM_{10}; 5-min mean)



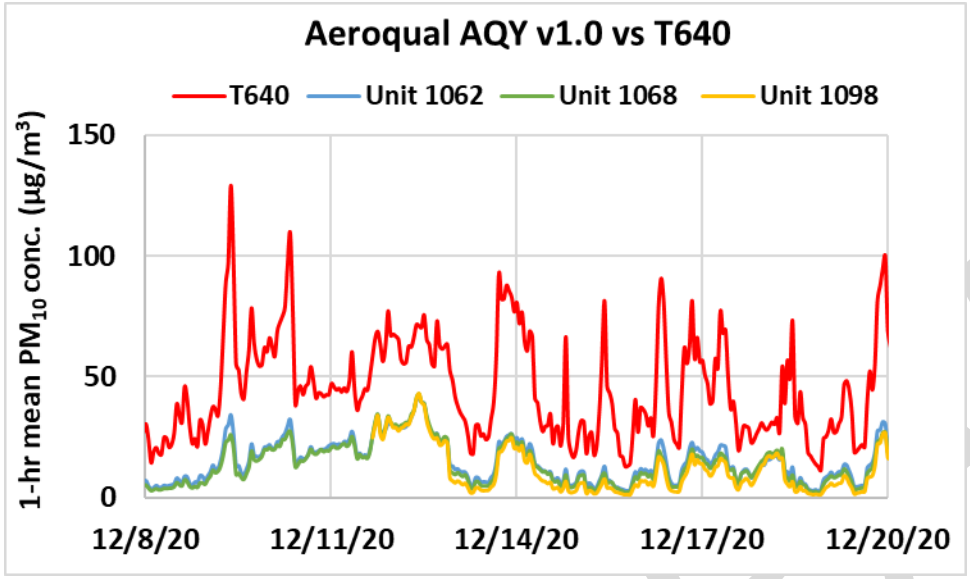
- The Aeroqual AQY v1.0 sensors showed moderate correlations with the corresponding T640 data ($0.56 < R^2 < 0.68$)
- Overall, the Aeroqual AQY v1.0 sensors underestimated the PM_{10} mass concentration as measured by the T640
- The Aeroqual AQY v1.0 sensors seemed to track the diurnal PM_{10} variations as recorded by the T640



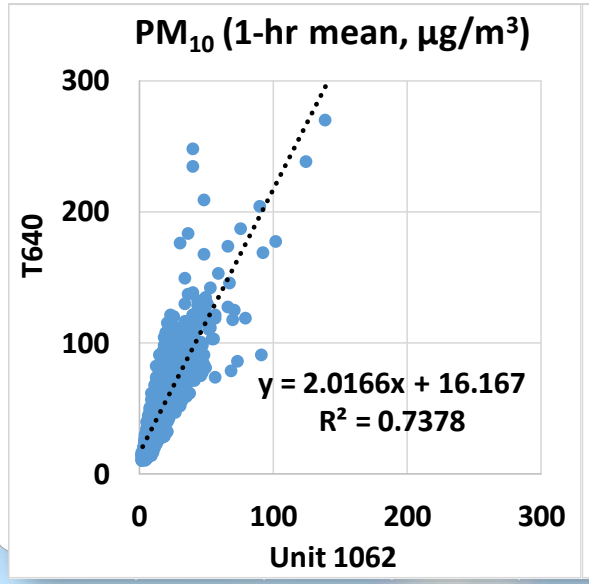


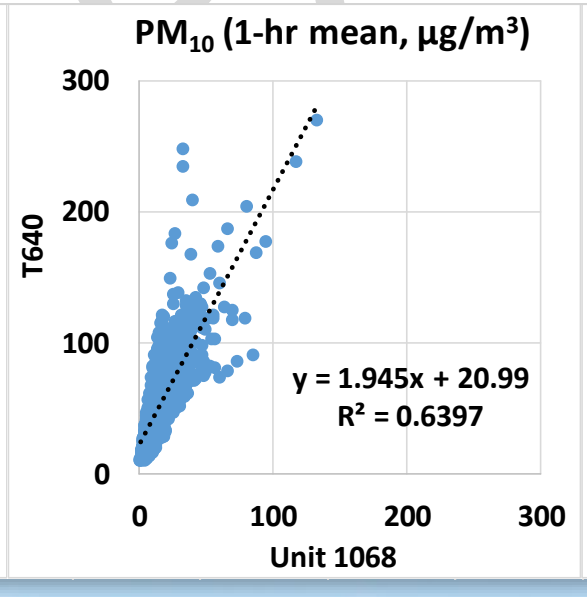


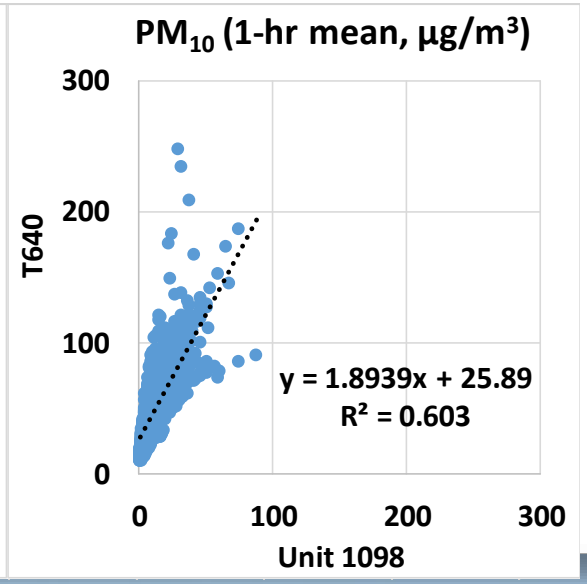
Aeroqual AQY v1.0 vs T640 (PM_{10}; 1-hr mean)



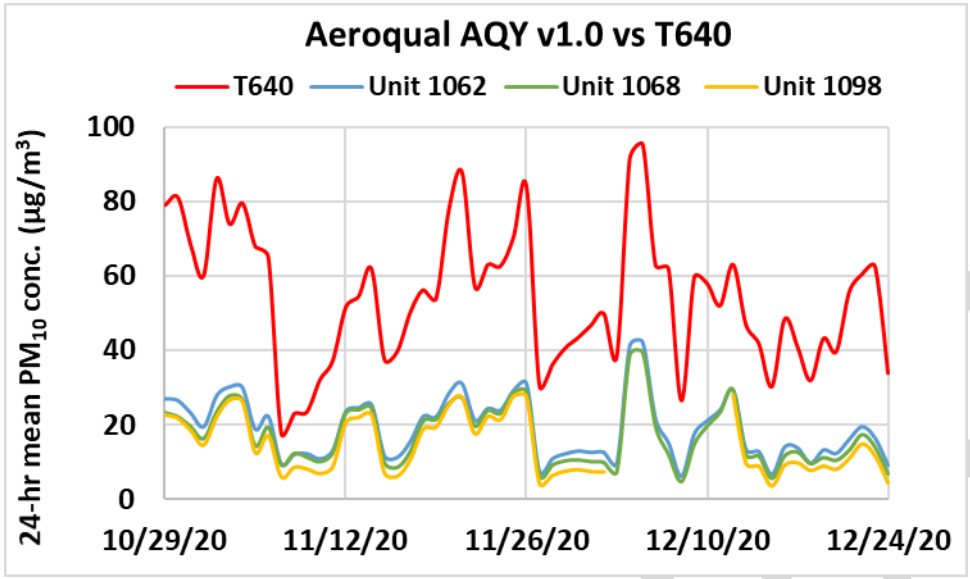
- The Aeroqual AQY v1.0 sensors showed moderate to strong correlations with the corresponding T640 data ($0.60 < R^2 < 0.74$)
- Overall, the Aeroqual AQY v1.0 sensors underestimated the PM_{10} mass concentration as measured by the T640
- The Aeroqual AQY v1.0 sensors seemed to track the diurnal PM_{10} variations as recorded by the T640



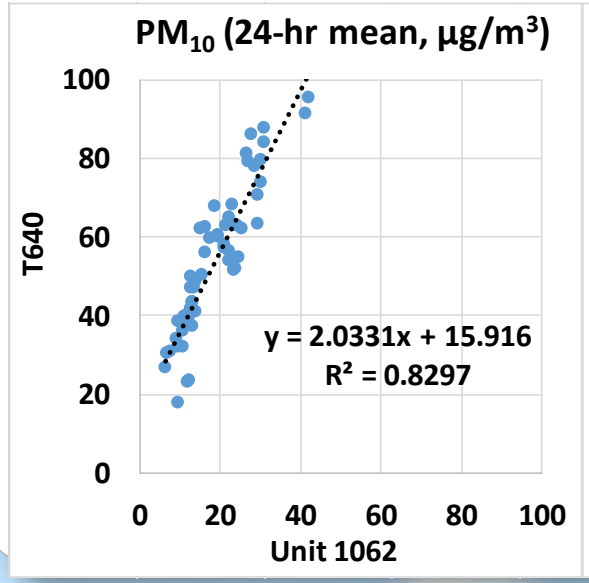


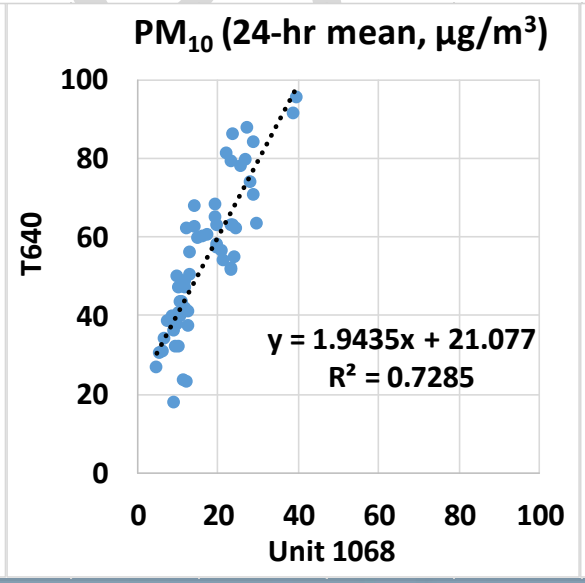


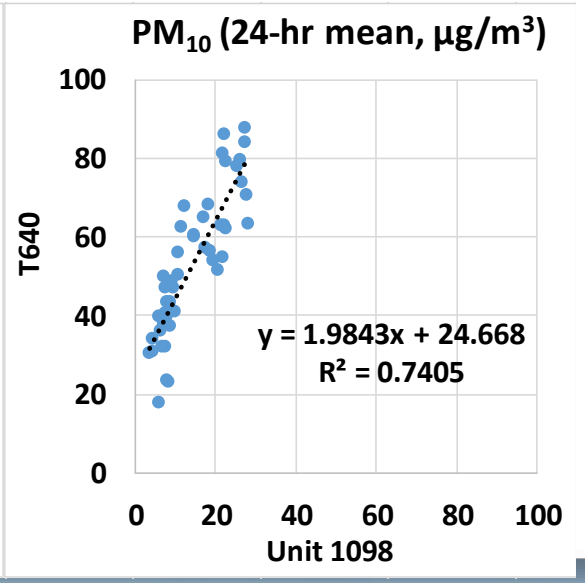
Aeroqual AQY v1.0 vs T640 (PM_{10}; 24-hr mean)



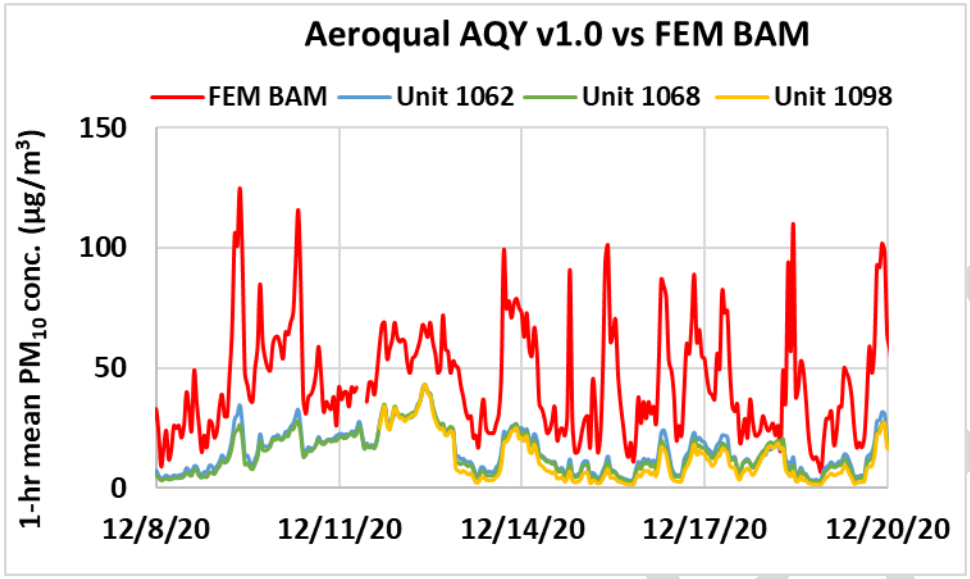
- The Aeroqual AQY v1.0 sensors showed strong correlations with the corresponding T640 data ($0.72 < R^2 < 0.83$)
- Overall, the Aeroqual AQY v1.0 sensors underestimated the PM_{10} mass concentration as measured by the T640
- The Aeroqual AQY v1.0 sensors seemed to track the diurnal PM_{10} variations as recorded by the T640



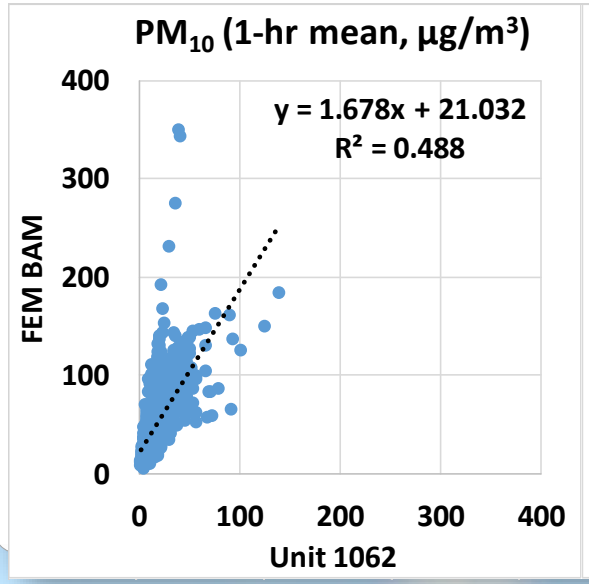


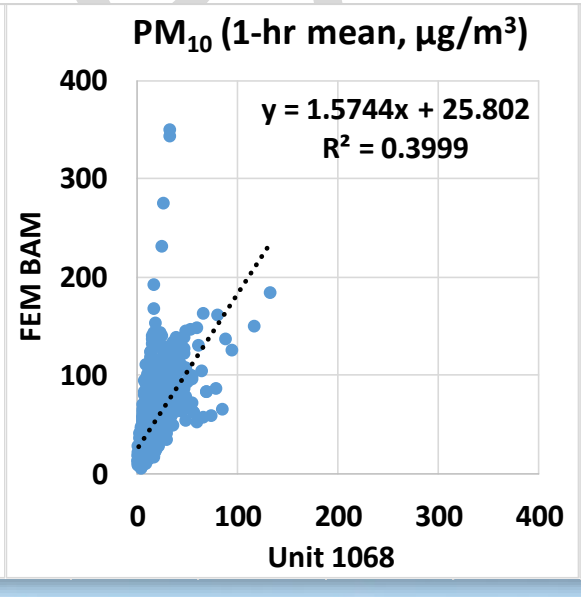


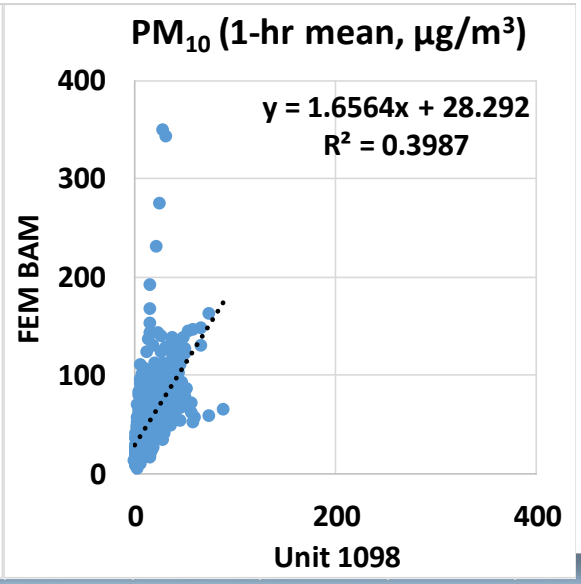
Aeroqual AQY v1.0 vs FEM BAM (PM_{10}; 1-hr mean)



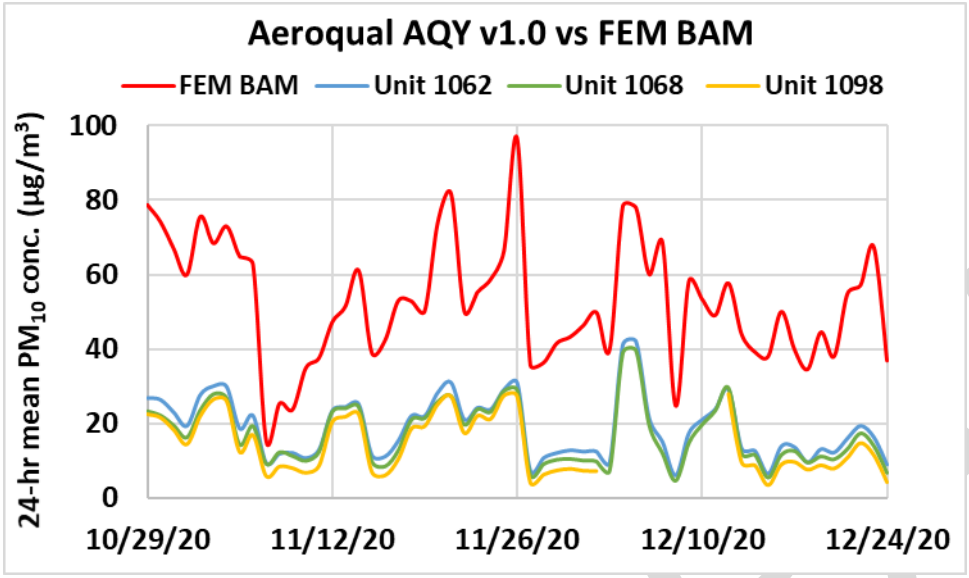
- The Aeroqual AQY v1.0 sensors showed weak correlations with the corresponding FEM BAM data ($0.39 < R^2 < 0.49$)
- Overall, the Aeroqual AQY v1.0 sensors underestimated the PM_{10} mass concentration as measured by the FEM BAM
- The Aeroqual AQY v1.0 sensors seemed to track the diurnal PM_{10} variations as recorded by the FEM BAM



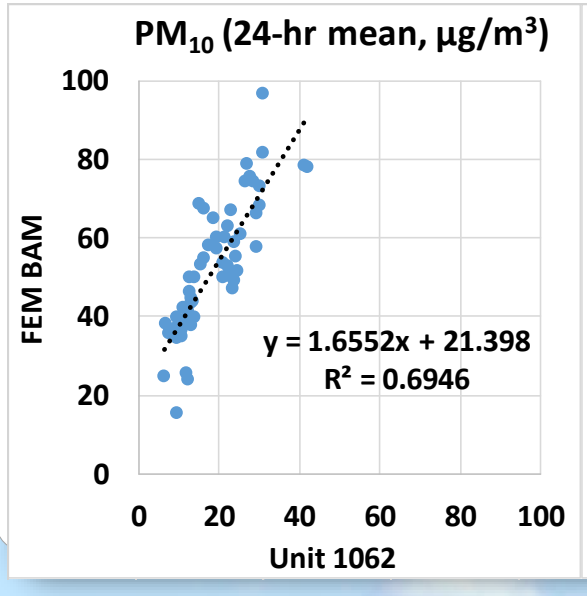


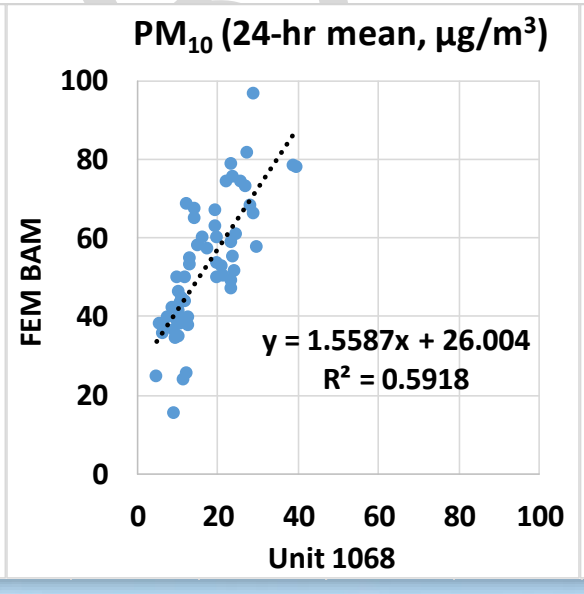


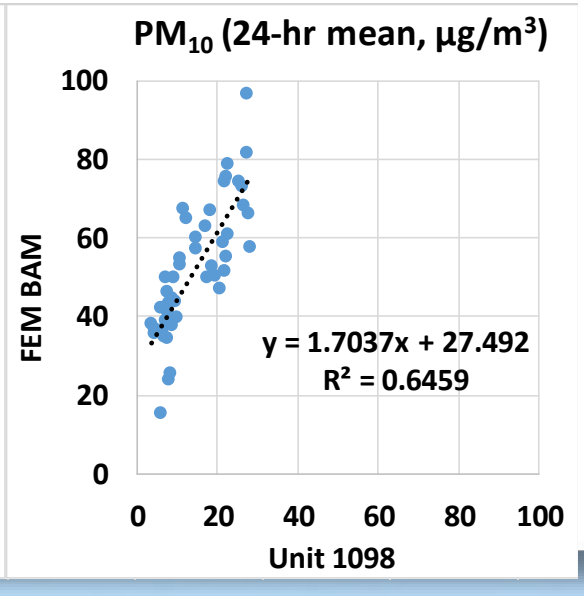
Aeroqual AQY v1.0 vs FEM BAM (PM_{10}; 24-hr mean)



- The Aeroqual AQY v1.0 sensors showed moderate correlations with the corresponding FEM BAM data ($0.59 < R^2 < 0.70$)
- Overall, the Aeroqual AQY v1.0 sensors underestimated the PM_{10} mass concentration as measured by the FEM BAM
- The Aeroqual AQY v1.0 sensors seemed to track the diurnal PM_{10} variations as recorded by the FEM BAM







Summary: PM_{10}

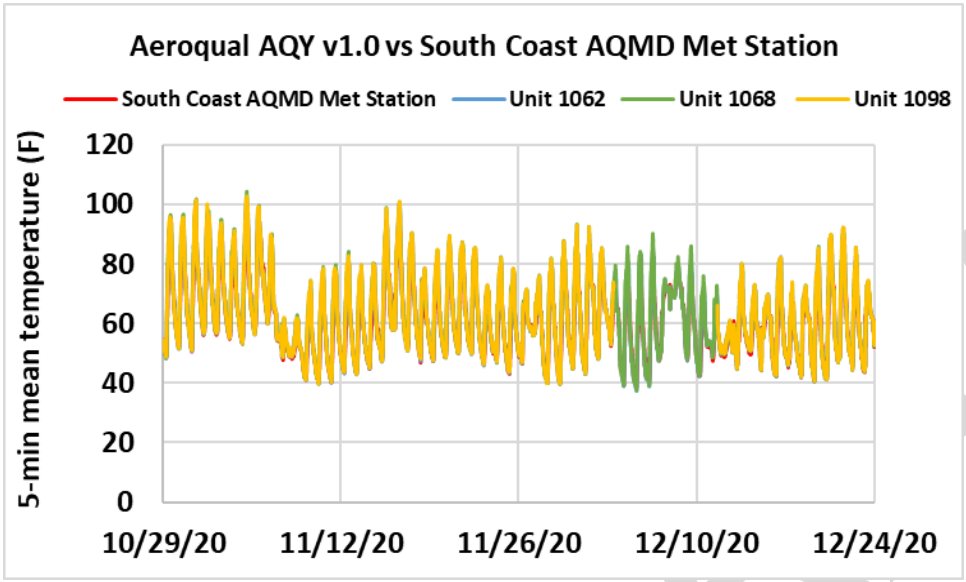
	Average of 3 Sensors, PM_{10}		Aeroqual AQY v1.0 vs Reference Instruments, PM_{10}						FEM BAM and T640 (PM_{10}, $\mu g/m^3$)		
Aeroqual AQY v1.0	Average ($\mu g/m^3$)	SD ($\mu g/m^3$)	R^2	Slope	Intercept	MBE[1] ($\mu g/m^3$)	MAE[2] ($\mu g/m^3$)	RMSE[3] ($\mu g/m^3$)	Ref. Average	Ref. SD	Range during the field evaluation
5-min	16.8	12.8	0.56 to 0.68	1.91 to 1.96	17.2 to 25.7	-35.4 to -38.8	35.4 to 38.8	41.7 to 44.1	54.3	32.3	4.1 to 748.6
1-hr	16.8	12.2	0.40 to 0.74	1.57 to 2.02	16.2 to 28.3	-33.9 to -38.8	33.9 to 38.8	40.7 to 43.2	52.7 to 54.3	30.0 to 30.7	4 to 349
24-hr	16.7	8.0	0.59 to 0.83	1.56 to 2.03	15.9 to 27.5	-33.8 to -38.8	33.5 to 38.4	35.4 to 37.4	52.2 to 53.9	16.2 to 18.3	15.3 to 96.5

[1] Mean Bias Error (MBE): the difference between the sensors and the reference instruments. MBE indicates the tendency of the sensors to underestimate (negative MBE values) or overestimate (positive MBE values).

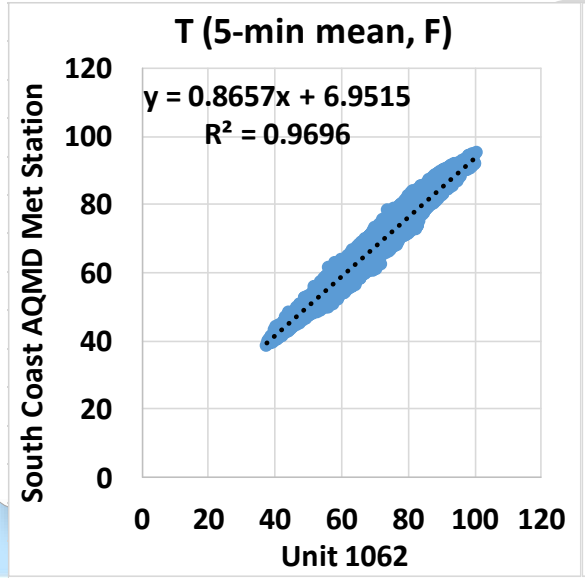
[2] Mean Absolute Error (MAE): the absolute difference between the sensors and the reference instruments. The larger MAE values, the higher measurement errors as compared to the reference instruments.

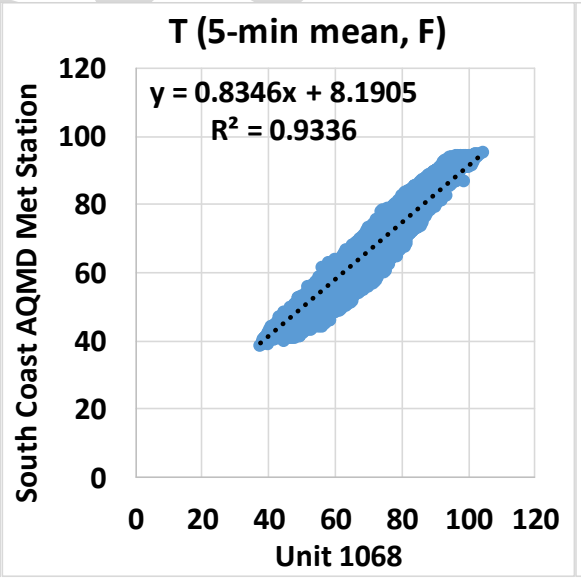
[3] Root Mean Square Error (RMSE): another metric to calculate measurement errors.

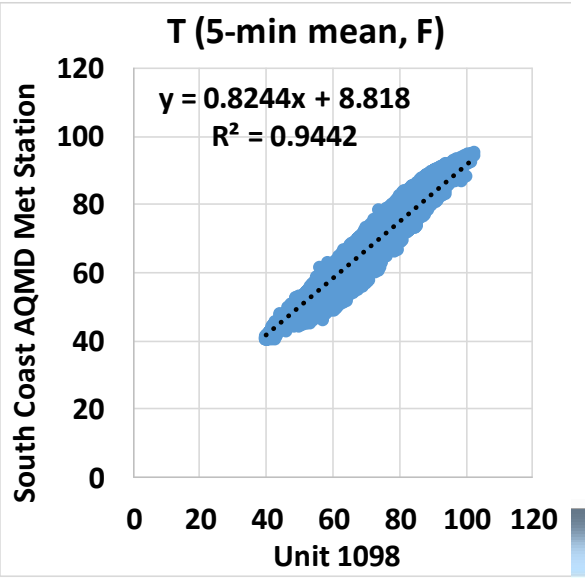
Aeroqual AQY v1.0 vs South Coast AQMD Met Station (Temp; 5-min mean)



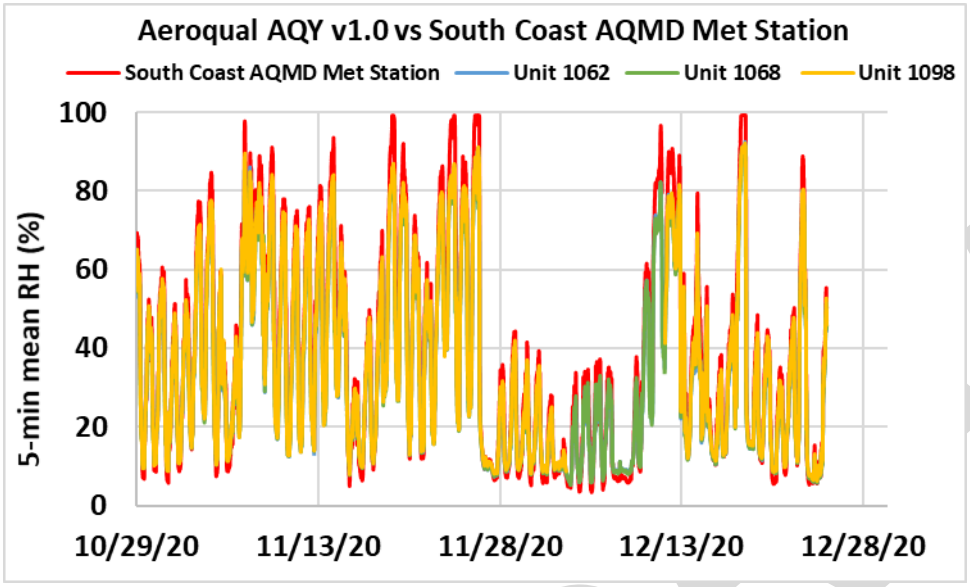
- The Aeroqual AQY v1.0 sensors showed very strong correlations with the corresponding South Coast AQMD Met Station data ($0.93 < R^2 < 0.97$)
- Overall, the Aeroqual AQY v1.0 sensors overestimated the temperature measurement as recorded by South Coast AQMD Met Station
- The Aeroqual AQY v1.0 sensors seemed to track the diurnal temperature variations as recorded by South Coast AQMD Met Station



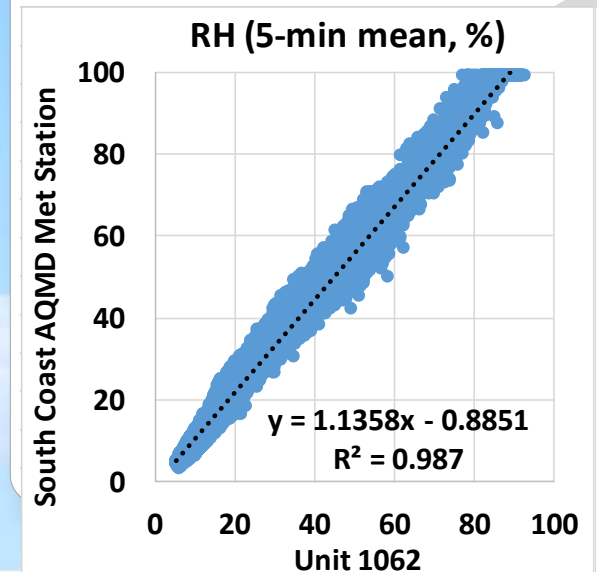


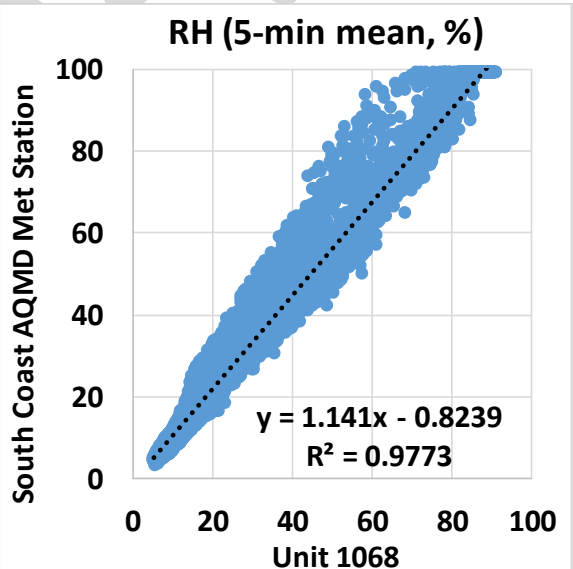


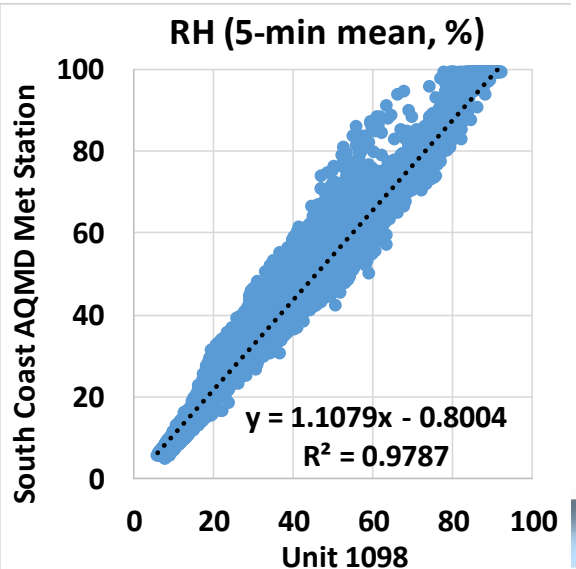
Aeroqual AQY v1.0 vs South Coast AQMD Met Station (RH; 5-min mean)



- Aeroqual AQY v1.0 sensors showed very strong correlations with the corresponding South Coast AQMD Met Station data (R^2 ~ 0.98)
- Overall, the Aeroqual AQY v1.0 sensors underestimated the RH measurement as recorded by South Coast AQMD Met Station
- The Aeroqual AQY v1.0 sensors seemed to track the diurnal RH variations as recorded by South Coast AQMD Met Station







Discussion

- The three **Aeroqual AQY v1.0** sensors' data recovery for PM_{10} from Unit 1062, Unit 1068 and Unit 1098 was 100%, 100% and 86%, respectively.
- The absolute intra-model variability was 1.58 µg/m^3 for PM_{10} measurements.
- The FEM BAM and T640 showed strong correlations for PM_{10} mass concentration measurements (R^2 ~ 0.88, 1-hr mean)
- PM_{10} mass concentrations measured by the Aeroqual AQY v1.0 sensors showed weak to strong correlations with the FEM BAM and T640 ($0.39 < R^2 < 0.49$ and $0.60 < R^2 < 0.74$ for FEM BAM and T640, respectively, 1-hr mean) and underestimated the corresponding FEM BAM and T640 data
- Temperature and relative humidity sensors showed very strong correlations with the South Coast AQMD Met Station data (T: R^2 ~ 0.95 and RH: R^2 ~ 0.98) and overestimated the T data and underestimated the RH data as recorded by the South Coast AQMD Met Station
- No sensor calibration was performed by AQ-SPEC prior to the beginning of this field testing
- Laboratory chamber testing is necessary to fully evaluate the performance of these sensors under controlled T and RH conditions and known target and interferent pollutants concentrations.
- These results are still preliminary