Field Evaluation
PAMAir – Airmazing PAS-OA-320-3G

South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Background

- From 08/30/2023 to 10/25/2023, three **PAMAir Airmazing PAS-OA-320-3G (hereinafter PAMAir Airmazing)** sensors 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

PAMAir Airmazing (*3 units tested*):

- PM Sensors – Optical (Sensirion SPS30, non-FEM)
- Each unit measures: $PM_{2.5}$ (µg/m^3), T (°C), RH (%)
- Unit cost: $500
- Time resolution: 1-min
- Units IDs: K21S, 8BSU, D1TC

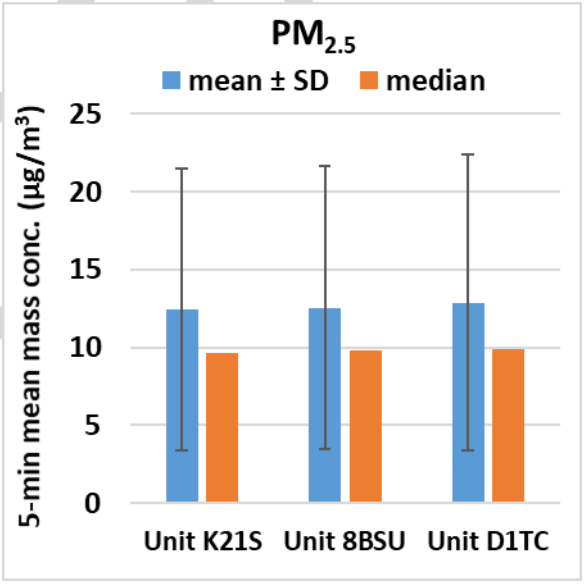
- South Coast AQMD Reference Instruments
- Teledyne API T640 (*hereinafter FEM T640 for $PM_{2.5}$, T640 otherwise*):
  - Optical particle counter (FEM $PM_{2.5}$)
  - Measures $PM_{1.0}$, $PM_{2.5}$ and PM_{10} (µg/m^3)
  - Cost: ~$21,000
  - Time resolution: 1-min
- MetOne BAM:
  - Beta-attenuation (FEM $PM_{2.5}$ & PM_{10})
  - Measures $PM_{2.5}$, and PM_{10} (µg/m^3)
  - 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 from Unit K21S, Unit 8BSU and Unit D1TC was ~ 85.2%, ~84.9% and ~83.5%, respectively, for $PM_{2.5}$ measurements

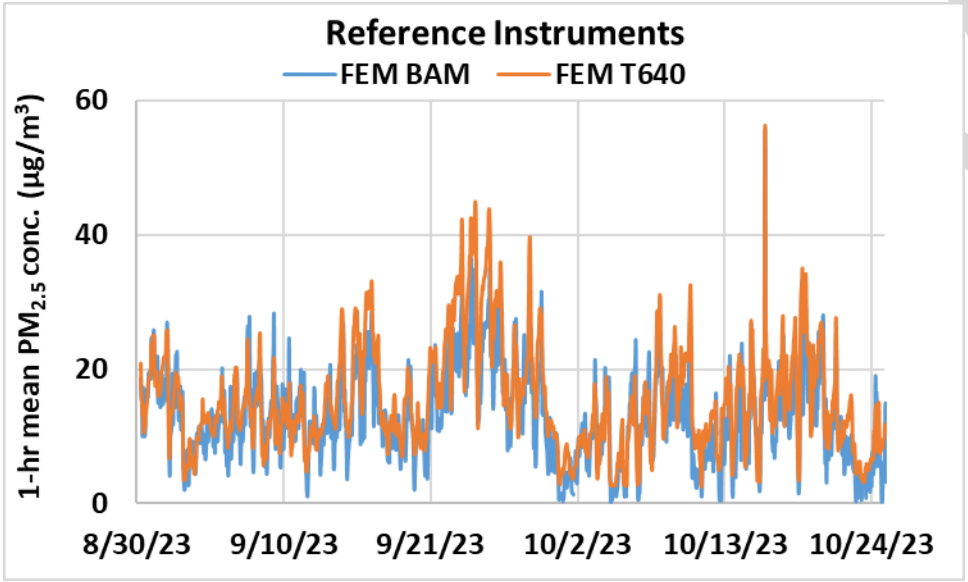
PAMAir Airmazing; intra-model variability

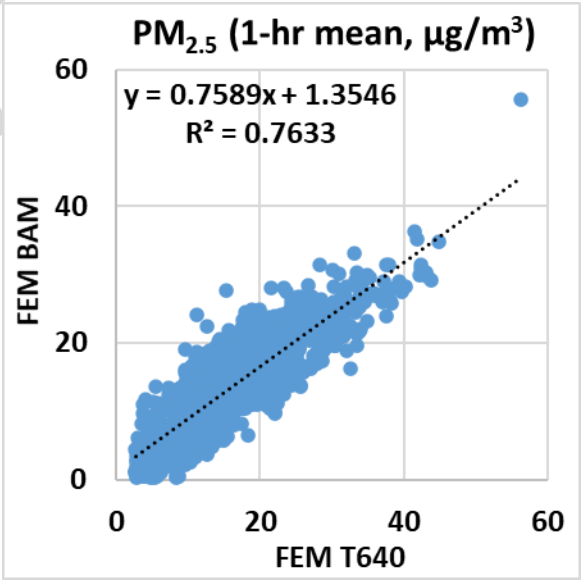
- Absolute intra-model variability was ~0.23 µg/m^3 for $PM_{2.5}$ (calculated as the standard deviation of the three sensor means)
- Relative intra-model variability was ~1.8% for $PM_{2.5}$ (calculated as the absolute intra-model variability relative to the mean of the three sensor means)



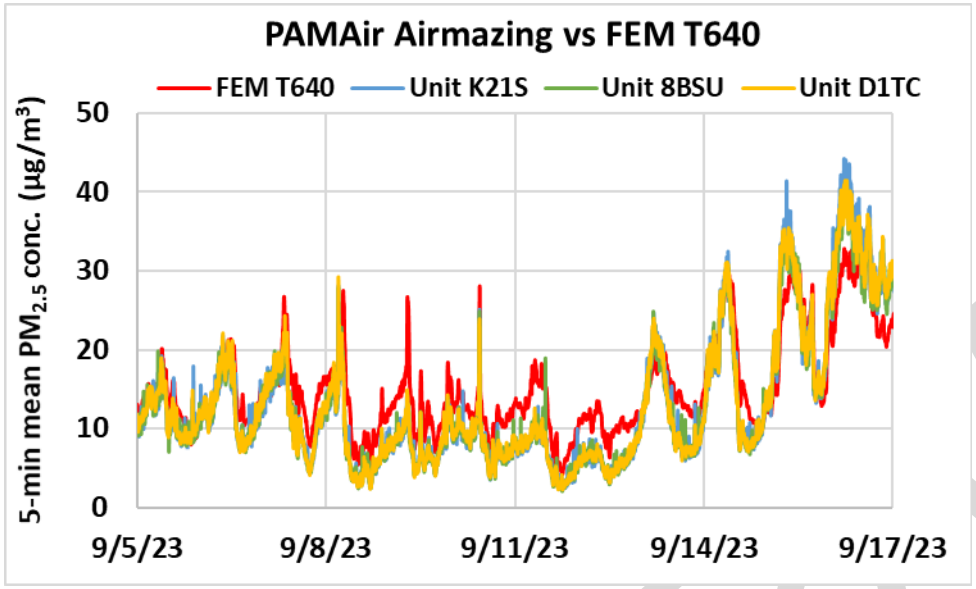
Reference Instruments: $PM_{2.5}$ FEM BAM and FEM T640

- Data recovery for $PM_{2.5}$ from FEM BAM and FEM T640 was 98.6% and 99.9%, respectively.
- Strong correlations between the reference instruments for $PM_{2.5}$ measurements (R^2 ~ 0.76) were observed.

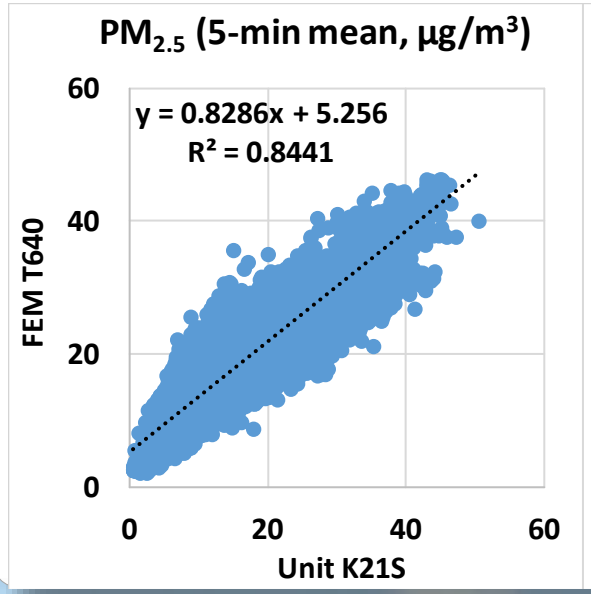


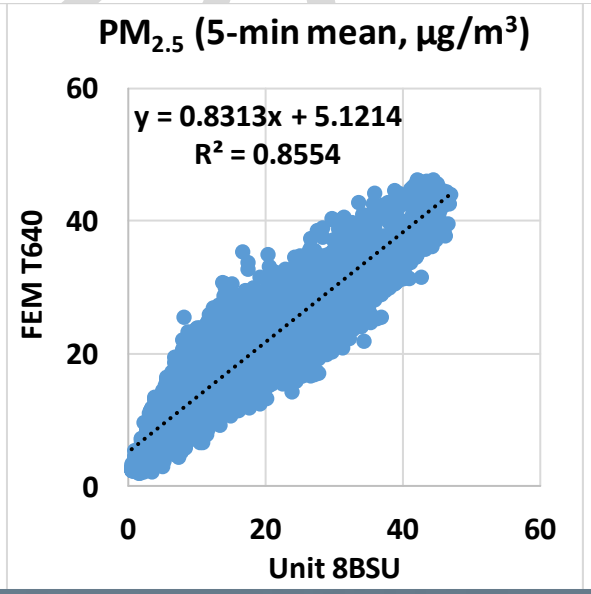


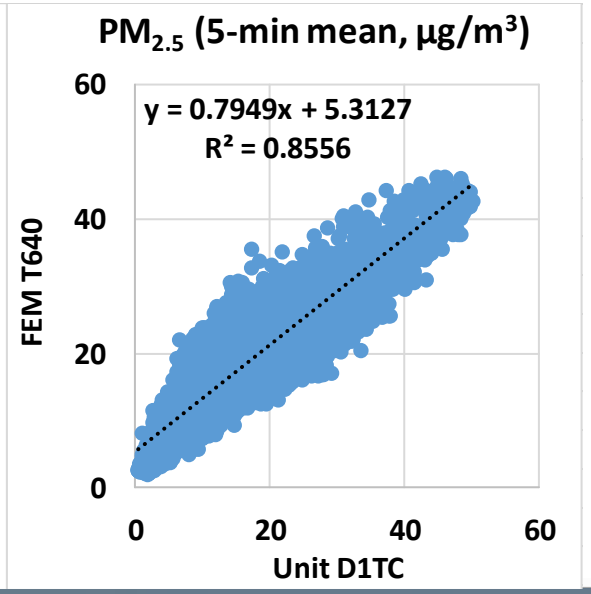
PAMAir Airmazing vs FEM T640 ($PM_{2.5}$; 5-min mean)



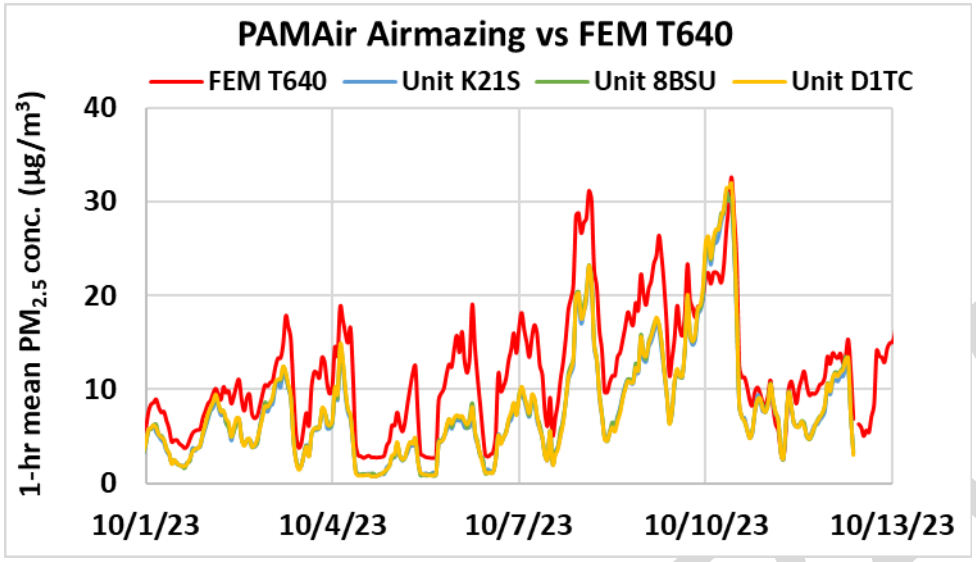
- The PAMAir Airmazing sensors showed strong correlations with the corresponding FEM T640 data ($0.84 < R^2 < 0.86$)
- Overall, the PAMAir Airmazing sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM T640
- The PAMAir Airmazing sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM T640



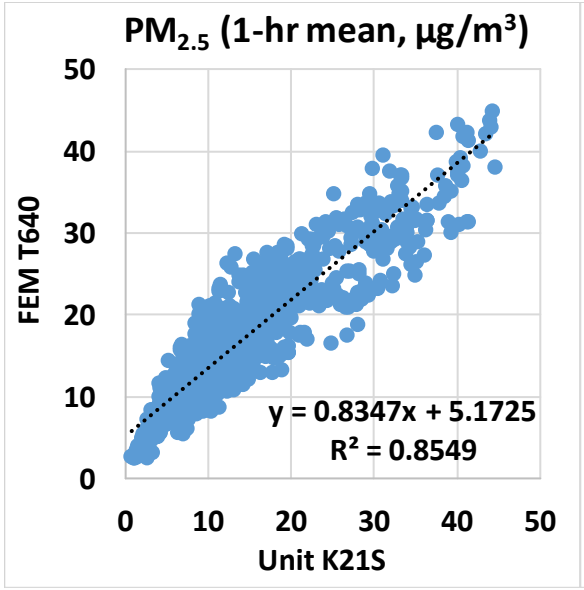


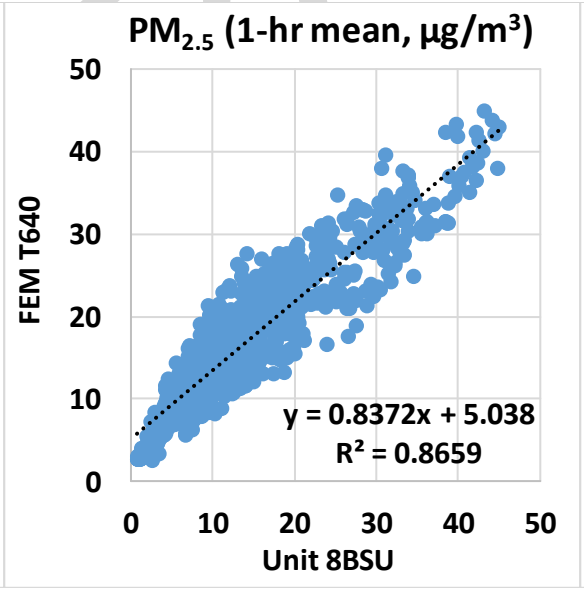


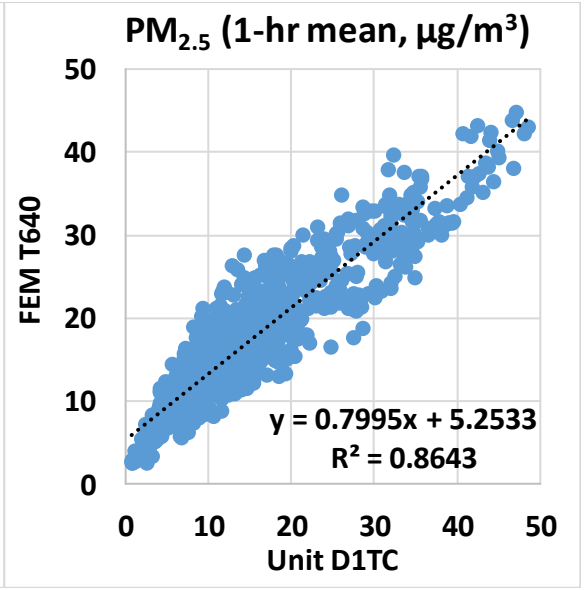
PAMAir Airmazing vs FEM T640 ($PM_{2.5}$; 1-hr mean)



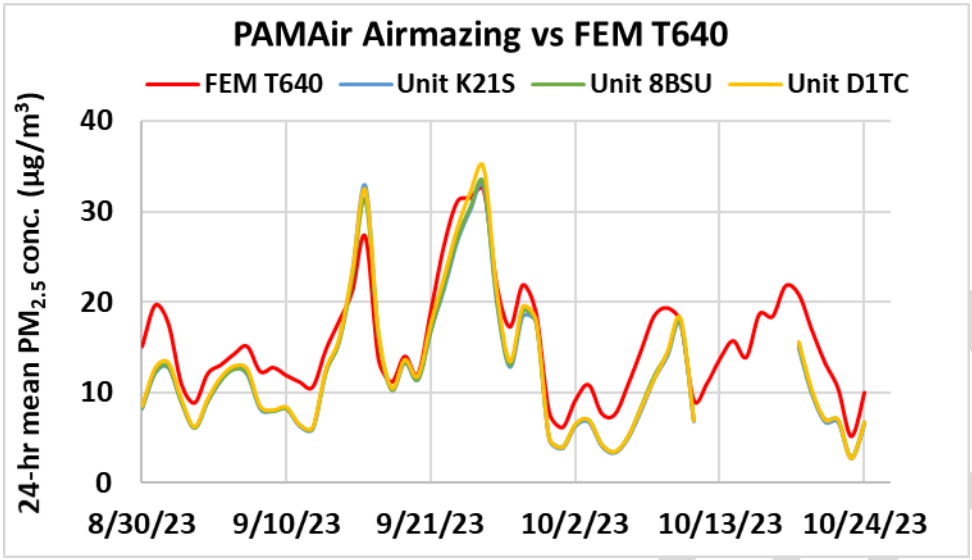
- The PAMAir Airmazing sensors showed strong correlations with the corresponding FEM T640 data ($0.85 < R^2 < 0.87$)
- Overall, the PAMAir Airmazing sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM T640
- The PAMAir Airmazing sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM T640



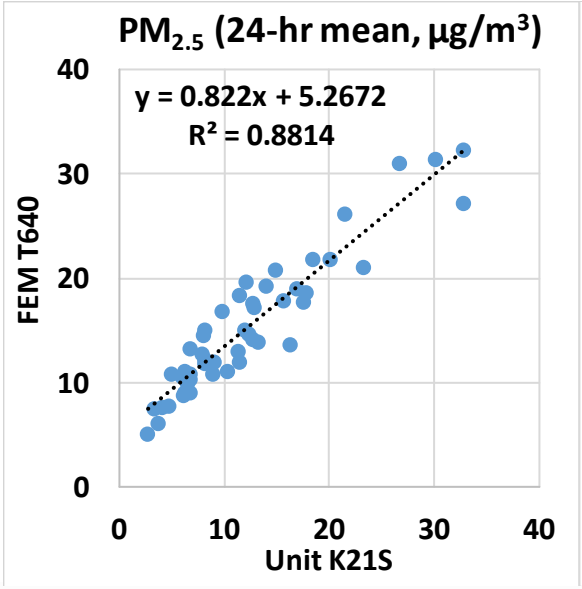


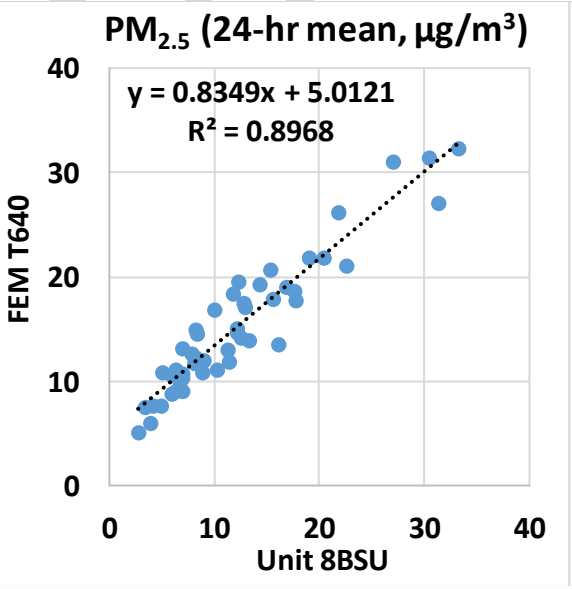


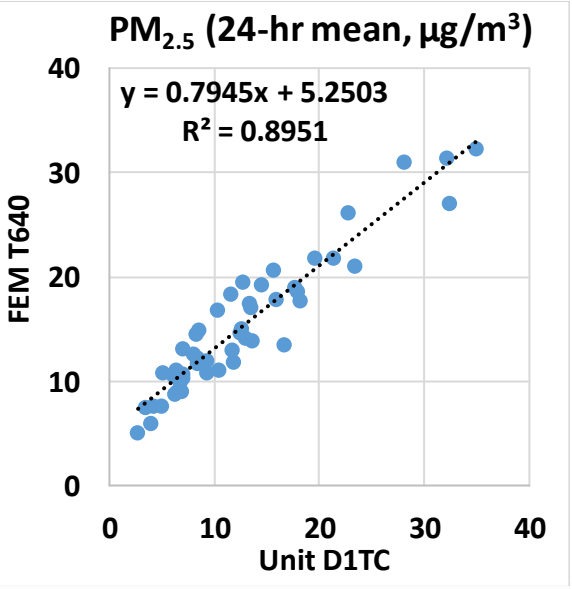
PAMAir Airmazing vs FEM T640 ($PM_{2.5}$; 24-hr mean)



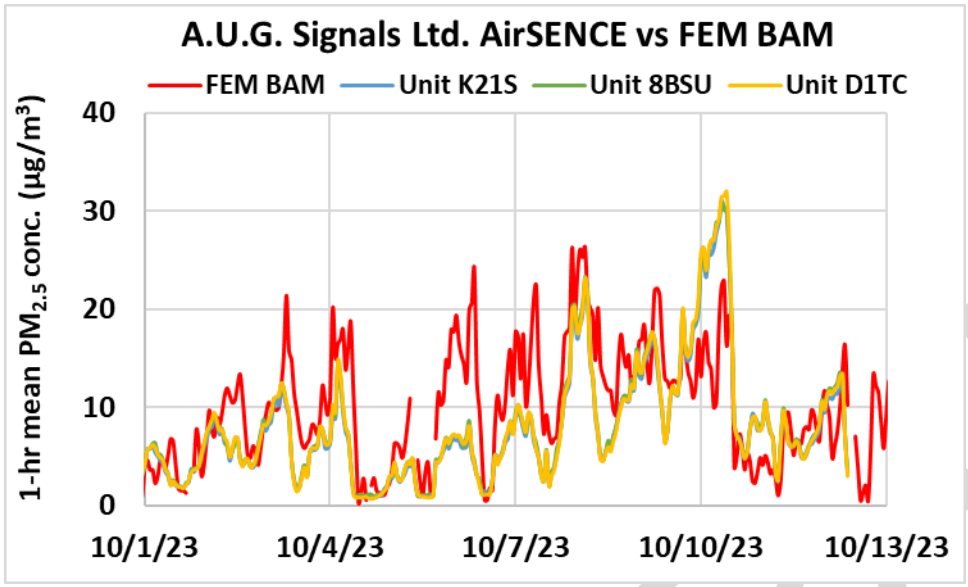
- The PAMAir Airmazing sensors showed strong correlations with the corresponding FEM T640 data ($0.88 < R^2 < 0.90$)
- Overall, the PAMAir Airmazing sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM T640
- The PAMAir Airmazing sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM T640



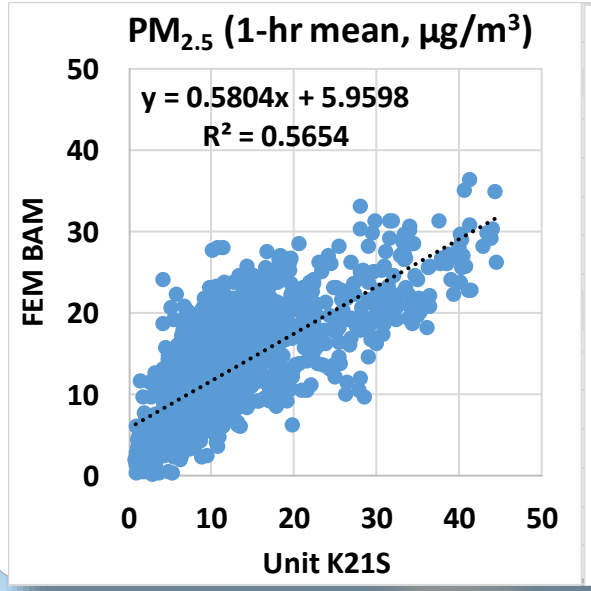


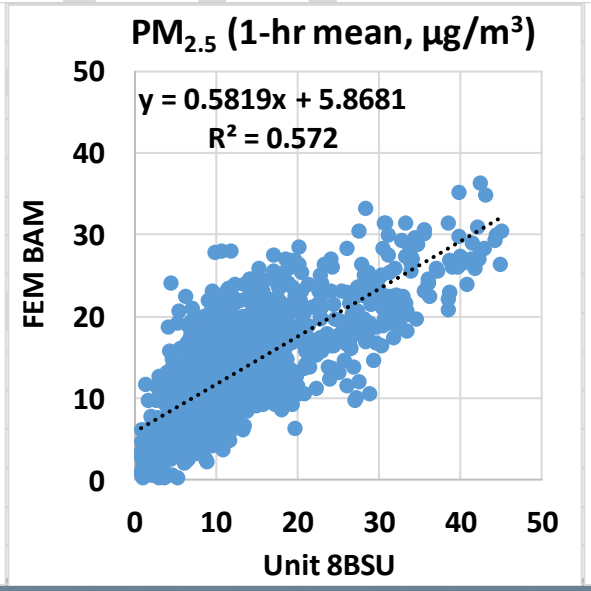


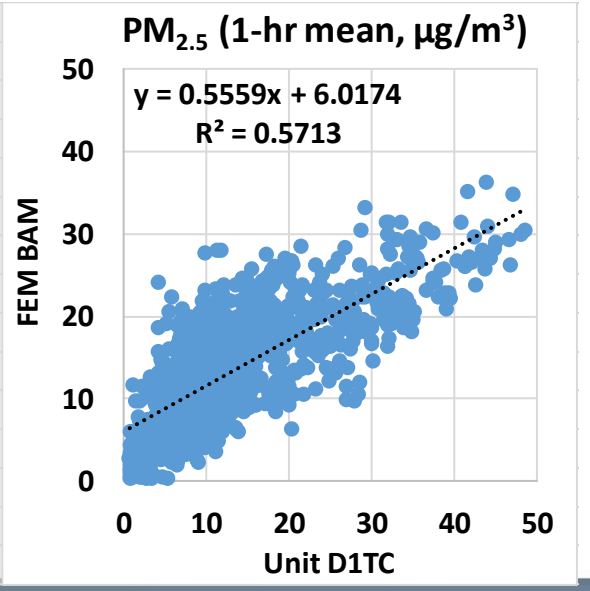
PAMAir Airmazing vs FEM BAM ($PM_{2.5}$; 1-hr mean)



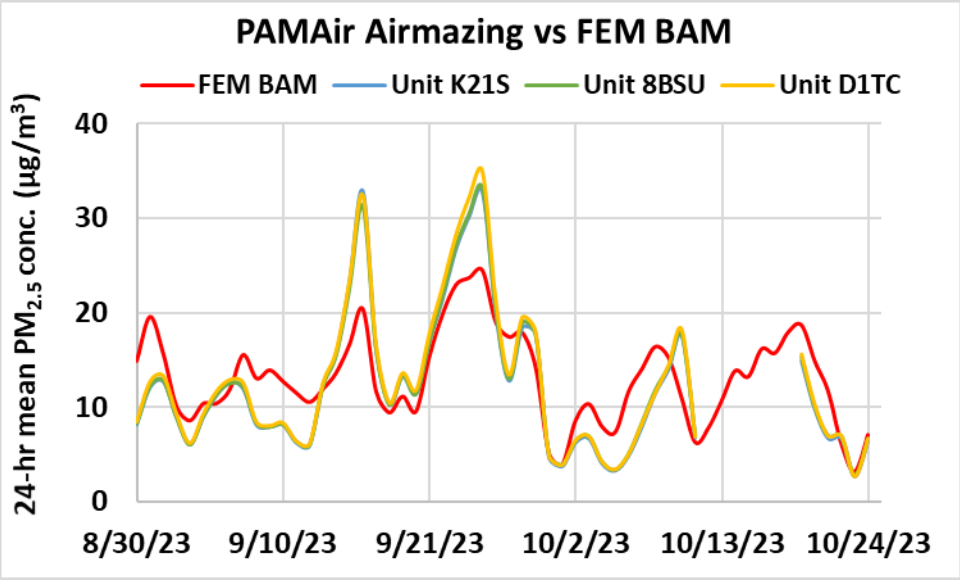
- The PAMAir Airmazing sensors showed moderate correlations with the corresponding FEM BAM data ($0.56 < R^2 < 0.58$)
- Overall, the PAMAir Airmazing sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM BAM
- The PAMAir Airmazing sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM BAM



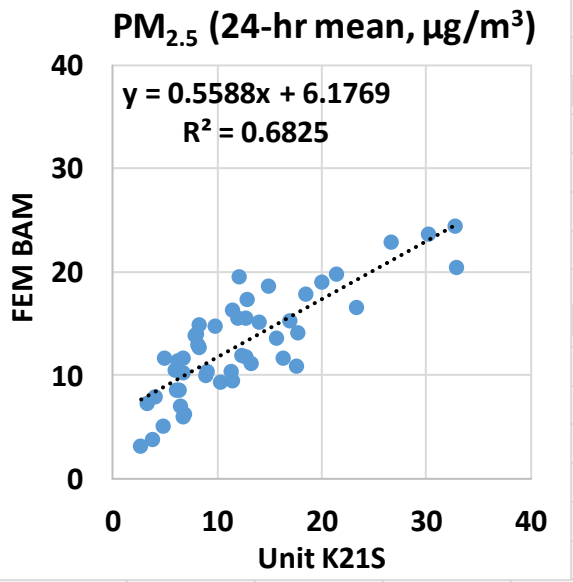


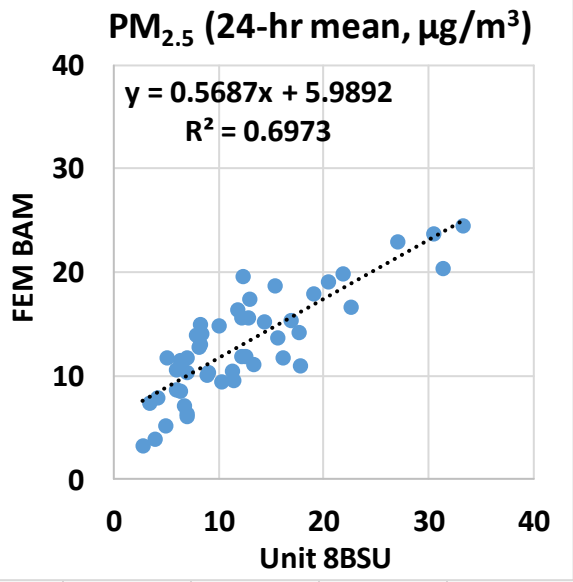


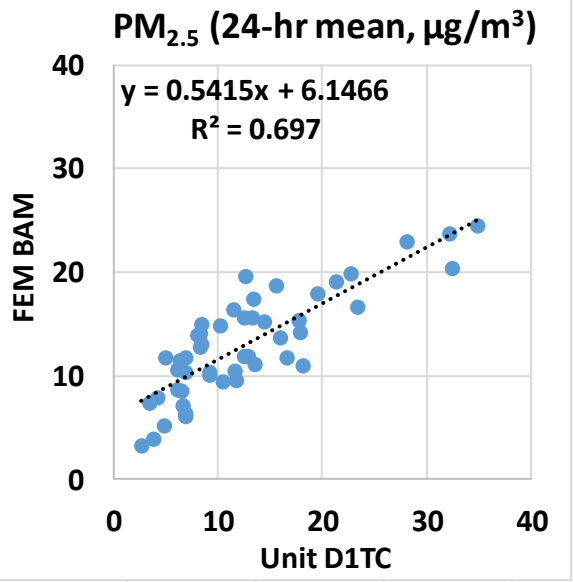
PAMAir Airmazing vs FEM BAM ($PM_{2.5}$; 24-hr mean)



- The PAMAir Airmazing sensors showed moderate correlations with the corresponding FEM BAM data ($0.68 < R^2 < 0.70$)
- Overall, the PAMAir Airmazing sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM BAM
- The PAMAir Airmazing sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM BAM





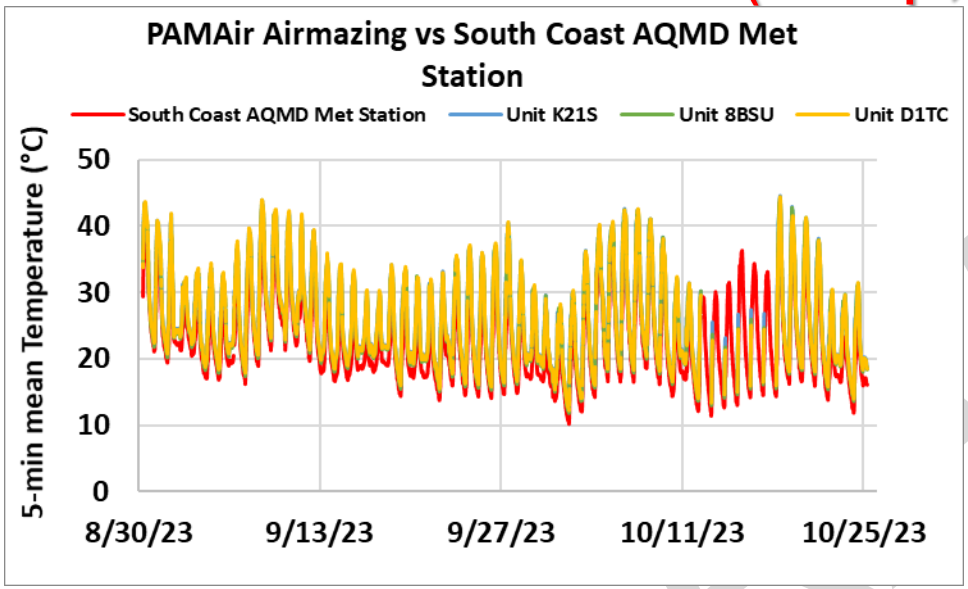


Summary

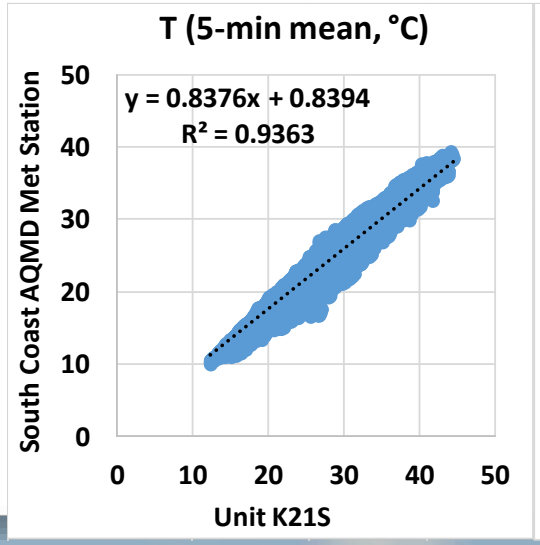
	Average of 3 Sensors, $PM_{2.5}$		PAMAir Airmazing vs FEM BAM & FEM T640, $PM_{2.5}$						FEM BAM & FEM T640 ($PM_{2.5}$, $\mu g/m^3$)		
	Average ($\mu g/m^3$)	SD ($\mu g/m^3$)	R^2	Slope	Intercept	MBE[1] ($\mu g/m^3$)	MAE[2] ($\mu g/m^3$)	RMSE[3] ($\mu g/m^3$)	Ref. Average	Ref. SD	Range during the field evaluation
5-min	12.5	9.2	0.84 to 0.86	0.79 to 0.83	5.1 to 5.3	-3.1 to -2.7	3.8 to 4.0	4.5 to 4.8	15.4	8.1	2.1 to 146.2
1-hr	12.5	9.0	0.57 to 0.87	0.56 to 0.84	5.0 to 6.0	-3.1 to -0.3	3.8 to 4.7	4.4 to 6.1	13.1 to 15.4	6.9 to 7.9	0.2 to 56.2
24-hr	12.4	7.5	0.68 to 0.90	0.54 to 0.83	5.0 to 6.2	-3.1 to -0.3	3.2 to 3.6	3.7 to 4.5	13.1 to 15.4	4.8 to 6.2	3.2 to 32.4

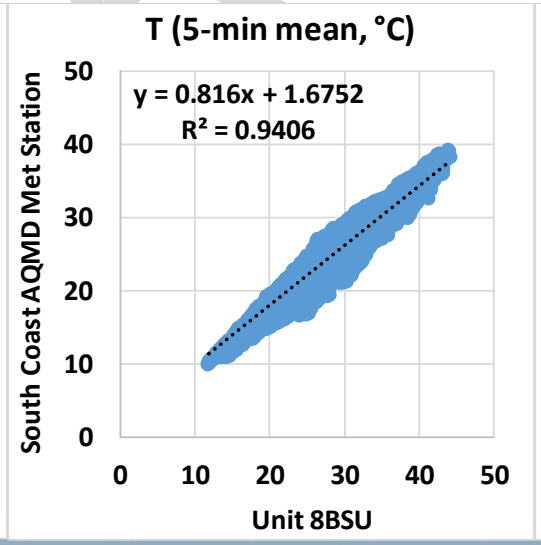
[1] Mean Bias Error (MBE): the difference between the sensors and the reference instruments. MBE indicates the tendency of the sensors to underestimate (negative MBE values) or overestimate (positive MBE values).
[2] Mean Absolute Error (MAE): the absolute difference between the sensors and the reference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

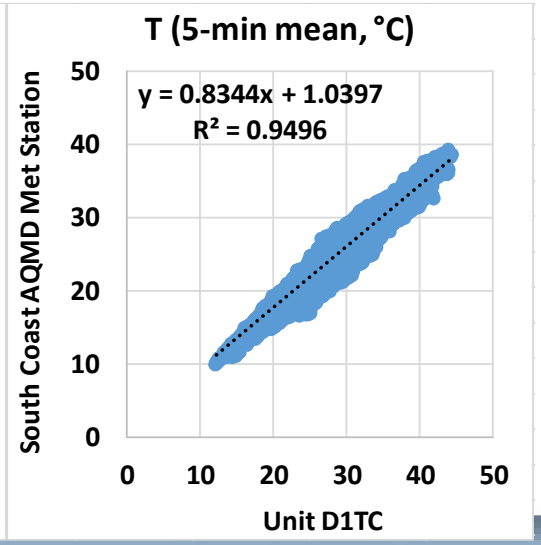
PAMAir Airmazing vs South Coast AQMD Met Station (Temp; 5-min mean)



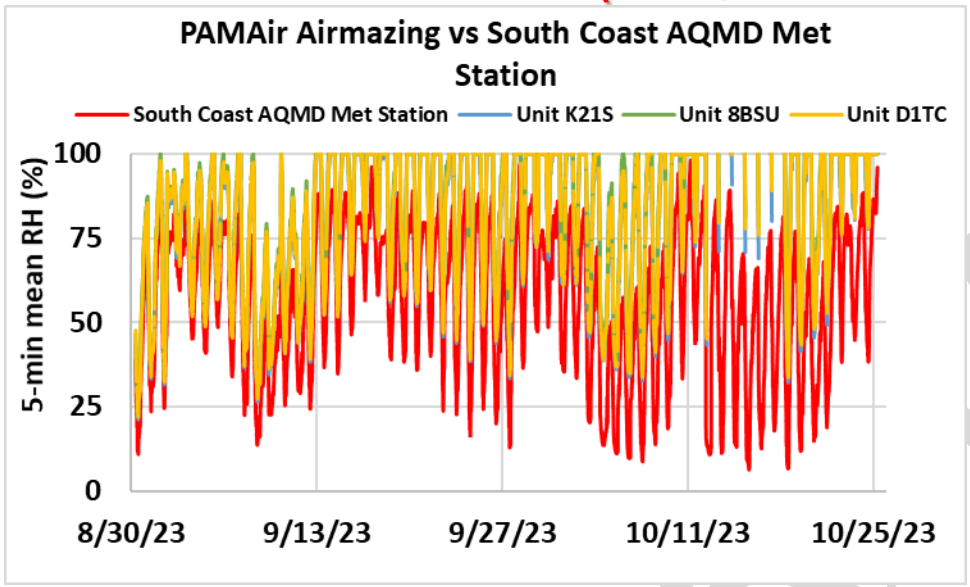
- The PAMAir Airmazing sensors showed very strong correlations with the corresponding South Coast AQMD Met Station data ($0.93 < R^2 < 0.95$)
- Overall, the PAMAir Airmazing temperature measurements overestimated the corresponding South Coast AQMD Met Station data
- The PAMAir Airmazing sensors seemed to track the temperature diurnal variations as recorded by South Coast AQMD Met Station



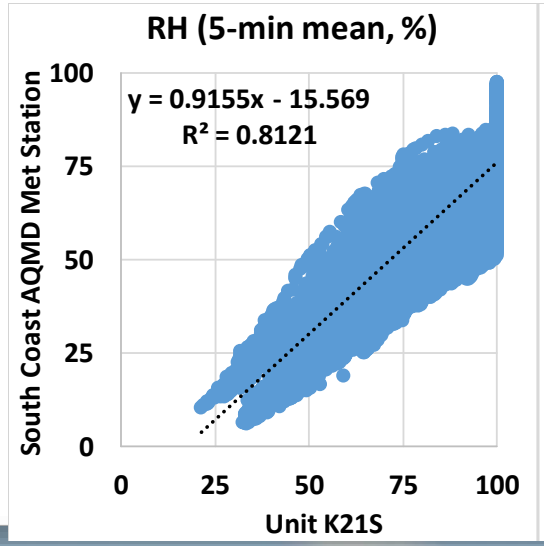


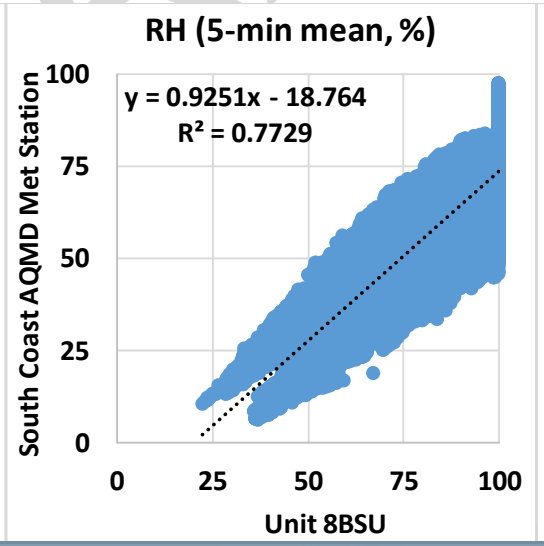


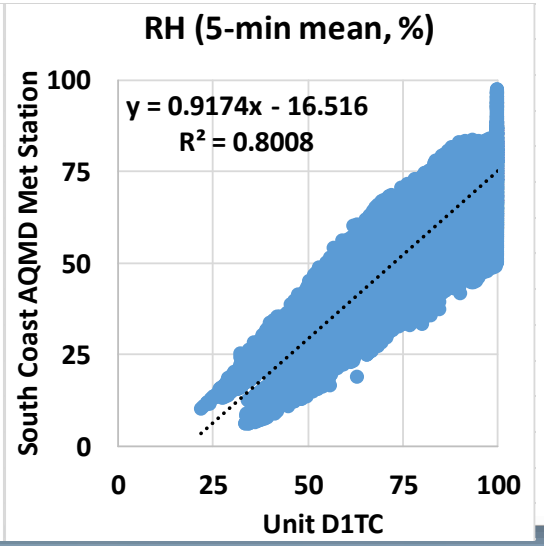
PAMAir Airmazing vs South Coast AQMD Met Station (RH; 5-min mean)



- The PAMAir Airmazing sensors showed strong correlations with the corresponding South Coast AQMD Met Station data ($0.77 < R^2 < 0.82$)
- Overall, the PAMAir Airmazing RH measurements overestimated the corresponding South Coast AQMD Met Station data
- The PAMAir Airmazing sensors seemed to track the RH diurnal variations as recorded by South Coast AQMD Met Station







Discussion

- The three **PAMAir Airmazing** sensors' data recovery Unit K21S, Unit 8BSU and Unit D1TC was ~ 85.2%, ~84.9% and ~83.5%, respectively, for $PM_{2.5}$ measurements
- The absolute intra-model variability was ~ 0.23 µg/m^3 for $PM_{2.5}$ measurements
- The reference instruments (BAM and T640) showed strong correlations with each other for $PM_{2.5}$ mass concentration measurements (R^2 ~ 0.76, 1-hr mean)
- $PM_{2.5}$ mass concentrations measured by the PAMAir Airmazing sensors showed strong correlations with the corresponding FEM T640 data ($0.85 < R^2 < 0.87$, 1-hr mean) and moderate correlations with the corresponding FEM BAM data ($0.56 < R^2 < 0.58$, 1-hr mean). The sensors underestimated $PM_{2.5}$ mass concentrations as measured by FEM T640 and FEM BAM
- No sensor calibration was performed by South Coast AQMD Staff for this evaluation
- 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