Field Evaluation
Elitech Temtop P20

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South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Background

- From 08/26/2020 to 10/21/2020, three **Elitech Temtop P20 (hereinafter Temtop P20)** 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

- Temtop P20 (*3 units tested*):
  - Particle sensor: optical; non-FEM (PMJG200, Temtop)
  - Each unit reports: $PM_{2.5}$ ($\mu g/m^3$), Temperature and Relative Humidity
  - Unit cost: ~$70
  - Time resolution: 5-min
  - Units IDs: Unit 1, Unit 2 and Unit 3

- MetOne BAM (*reference instrument*):
  - Beta-attenuation monitor (FEM $PM_{2.5}$ & PM_{10})
  - Measures $PM_{2.5}$ & PM_{10} ($\mu g/m^3$)
  - Unit cost: ~$20,000
  - Time resolution: 1-hr

- Teledyne API T640 (*reference instrument*):
  - Optical particle counter (FEM $PM_{2.5}$)
  - Measures $PM_{2.5}$ & PM_{10} ($\mu g/m^3$)
  - Unit cost: ~$21,000
  - Time resolution: 1-min

- Met station (T, RH, P, WS, WD)
  - Unit cost: ~$5,000
  - Time resolution: 1-min

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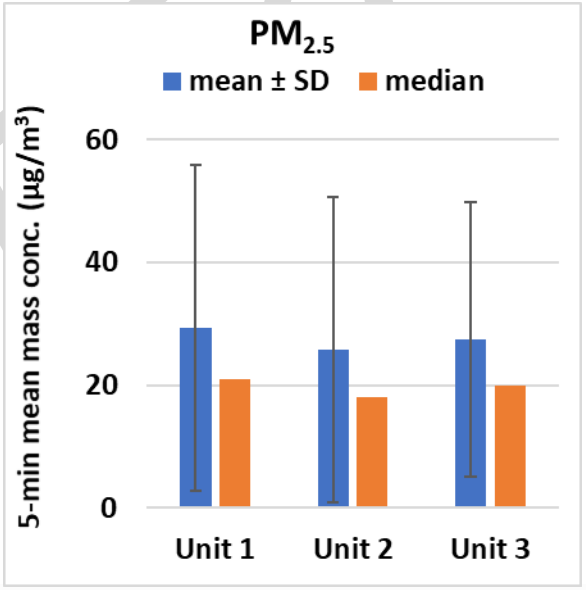
Data validation & recovery

- 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 1, Unit 2 and Unit 3 was ~ 90%, ~ 100% and ~ 100%, respectively, for $PM_{2.5}$ measurements

Temtop P20; intra-model variability

- Absolute intra-model variability was ~ 1.43 µg/m^3 for $PM_{2.5}$ measurements (calculated as the standard deviation of the three sensor means)
- Relative intra-model variability was ~ 5.2% for $PM_{2.5}$ measurements (calculated as the absolute intra-model variability relative to the mean of the three sensor means)



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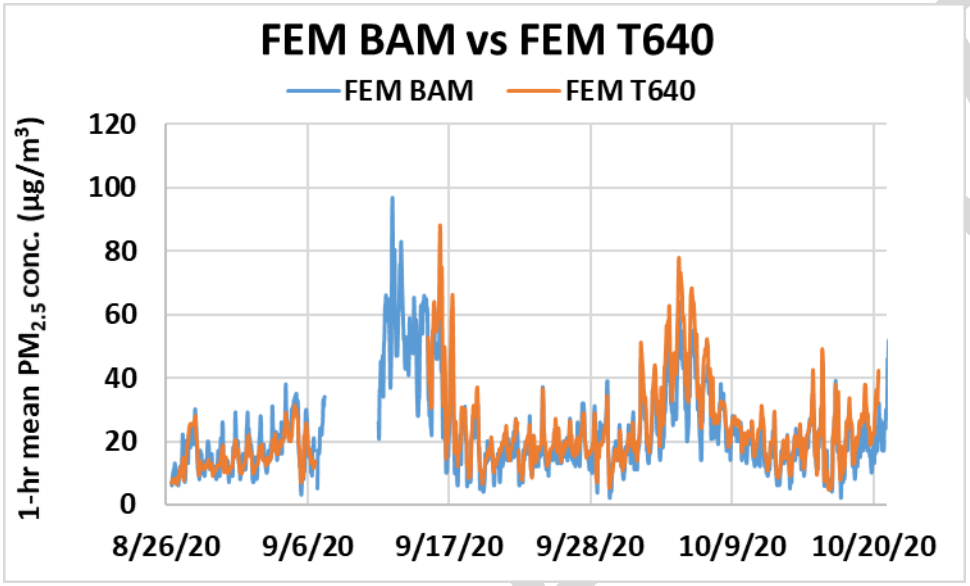
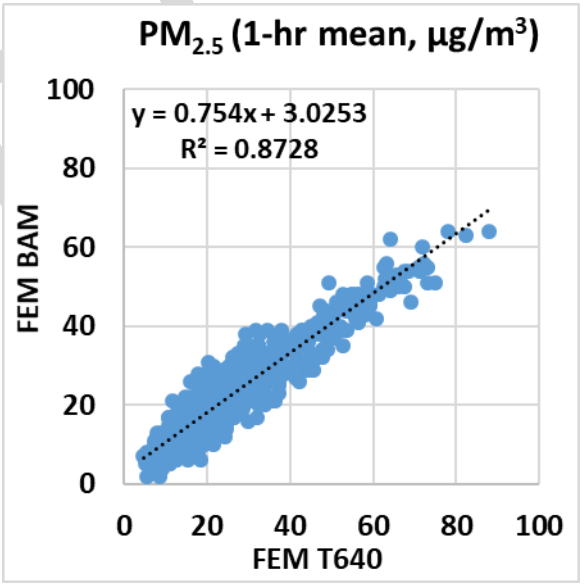
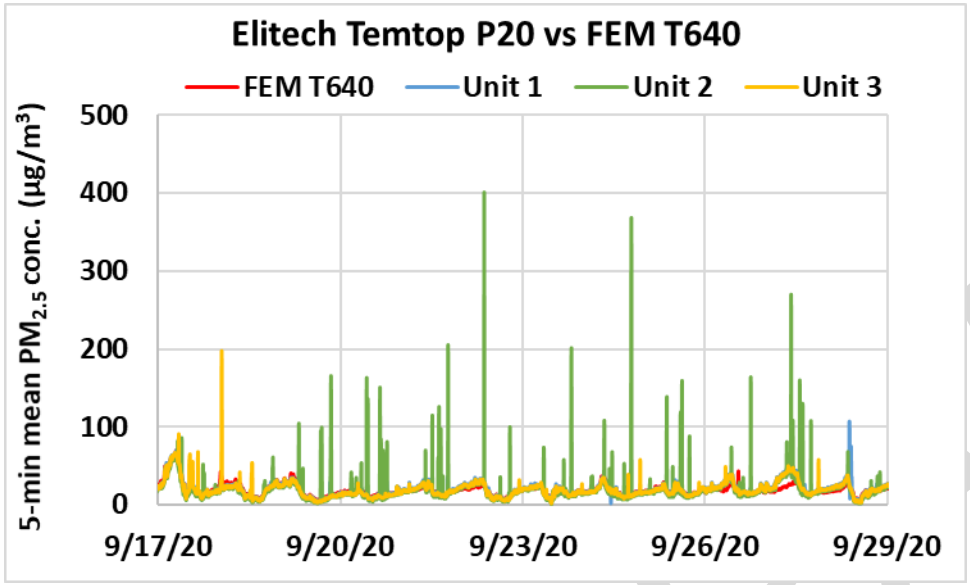
Reference Instruments: $PM_{2.5}$ FEM BAM & FEM T640

- Data recovery for $PM_{2.5}$ from FEM BAM and FEM T640 was ~ 92% and 94%, respectively.
- Strong correlations between the FEM BAM and FEM T640 for $PM_{2.5}$ measurements (R^2 ~ 0.87) were observed.

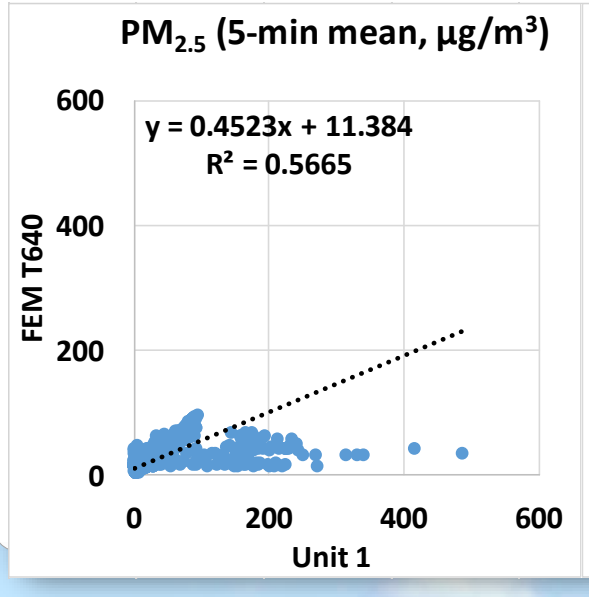


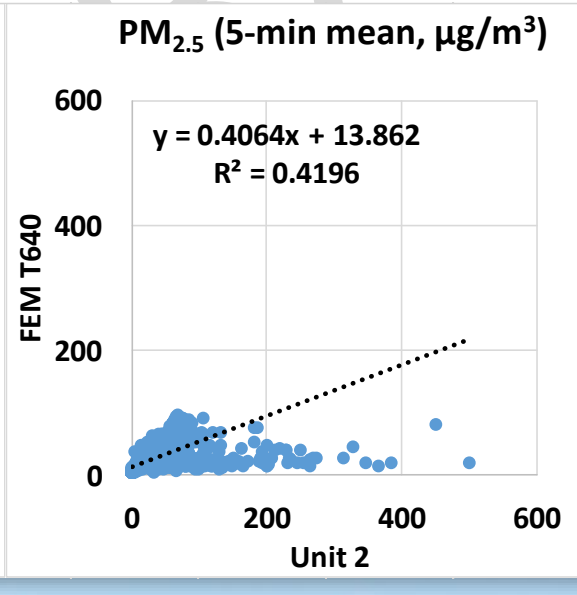


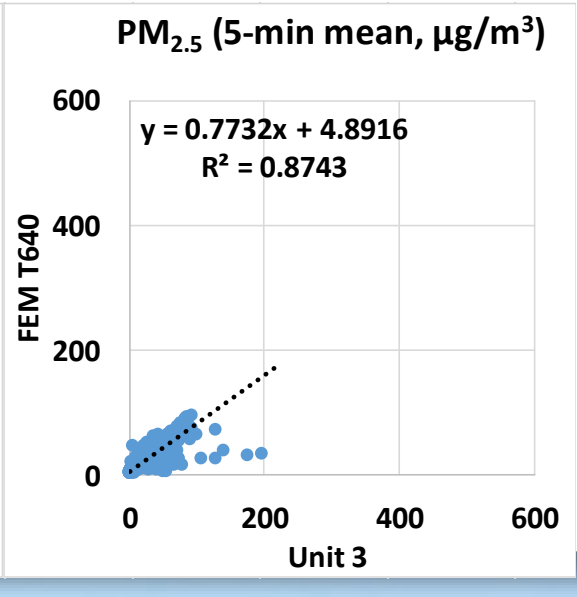
Temtop P20 vs FEM T640 ($PM_{2.5}$; 5-min mean)



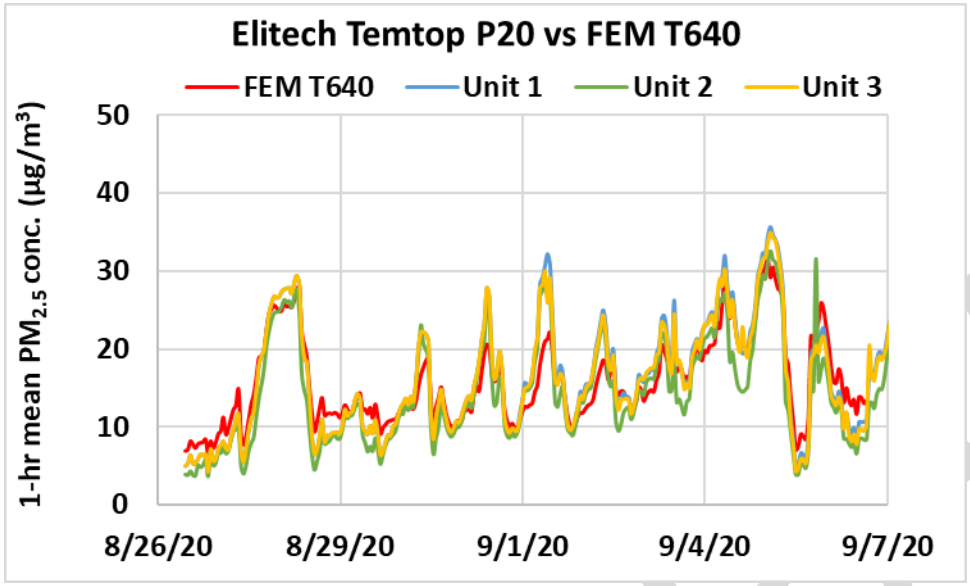
- The Temtop P20 sensors showed weak to strong correlations with the corresponding FEM T640 data ($0.41 < R^2 < 0.88$)
- Overall, the Temtop P20 sensors overestimated the $PM_{2.5}$ mass concentrations as measured by FEM T640
- The Temtop P20 sensors (Units 1 and 3) seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM T640; Unit 2 did not seem to track the $PM_{2.5}$ diurnal variations as recorded by FEM T640



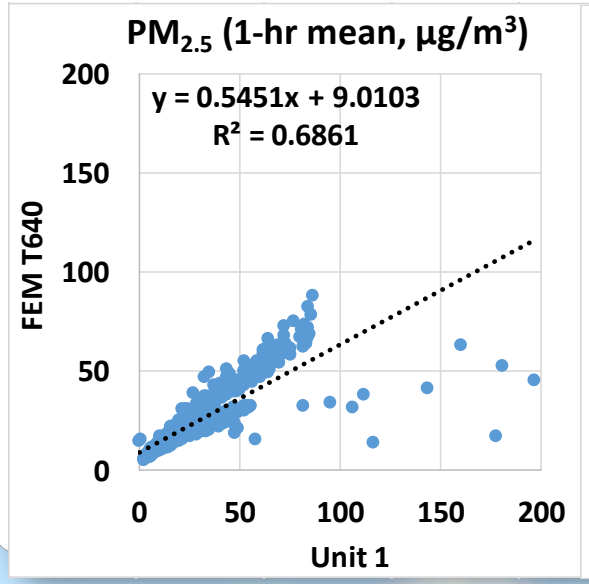


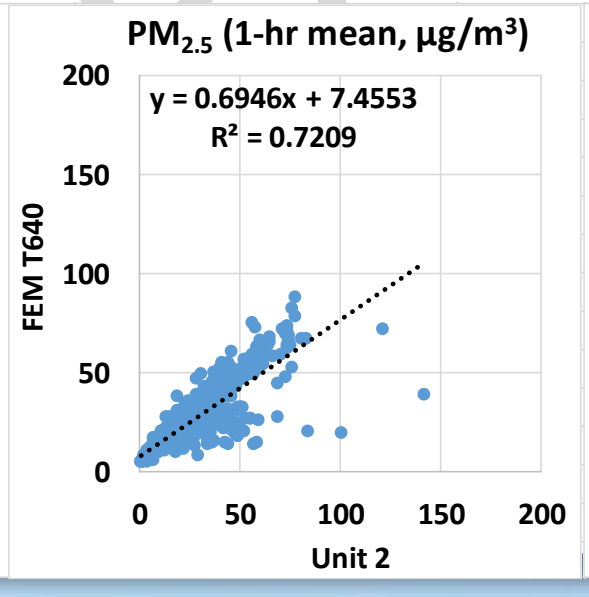


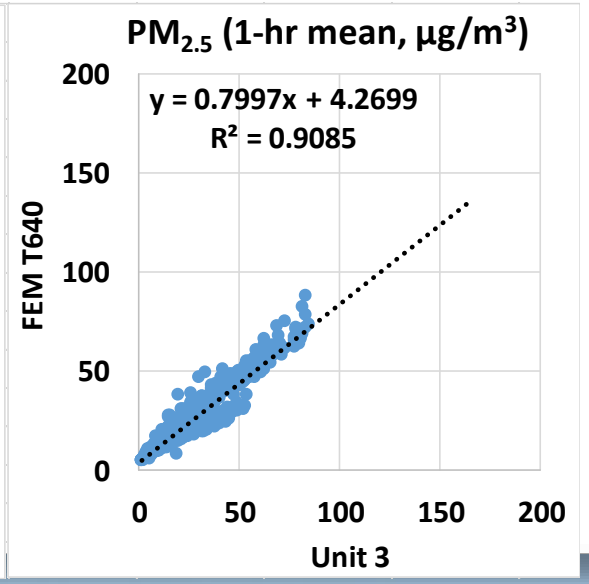
Temtop P20 vs FEM T640 ($PM_{2.5}$; 1-hr mean)



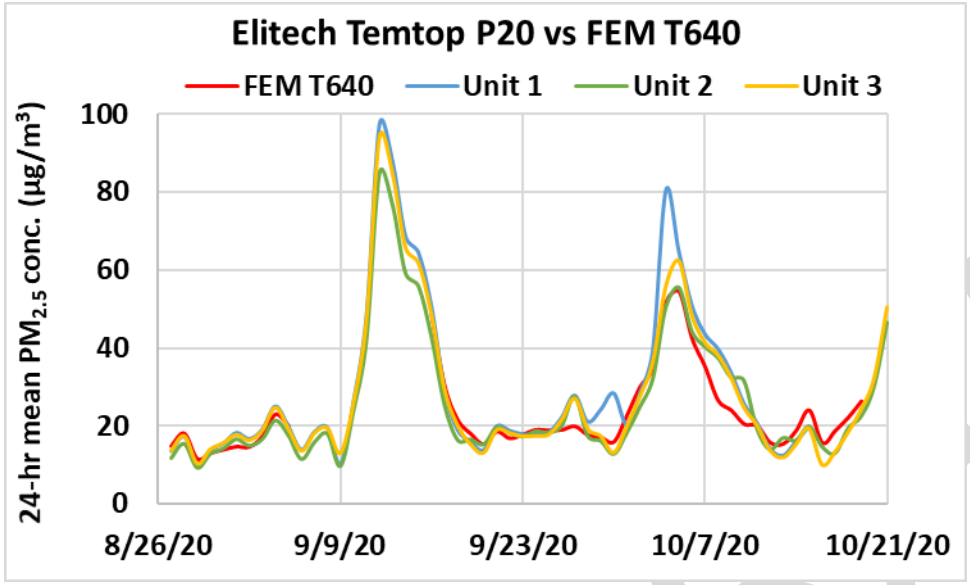
- The Temtop P20 sensors showed moderate to very strong correlations with the corresponding FEM T640 data ($0.68 < R^2 < 0.91$)
- Overall, the Temtop P20 sensors overestimated the $PM_{2.5}$ mass concentrations as measured by FEM T640
- The Temtop P20 sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM T640



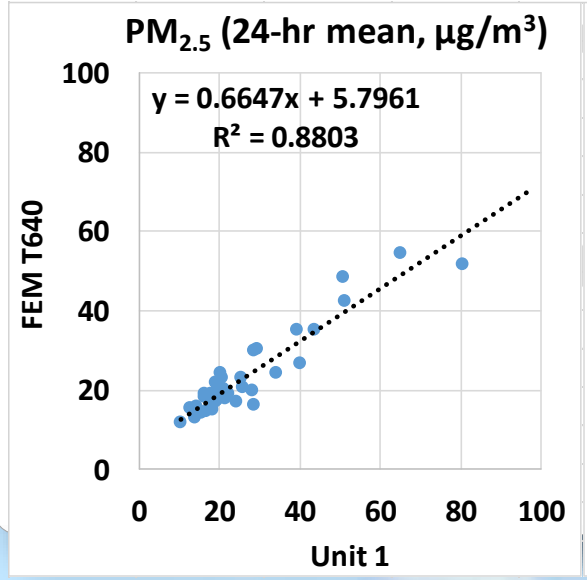


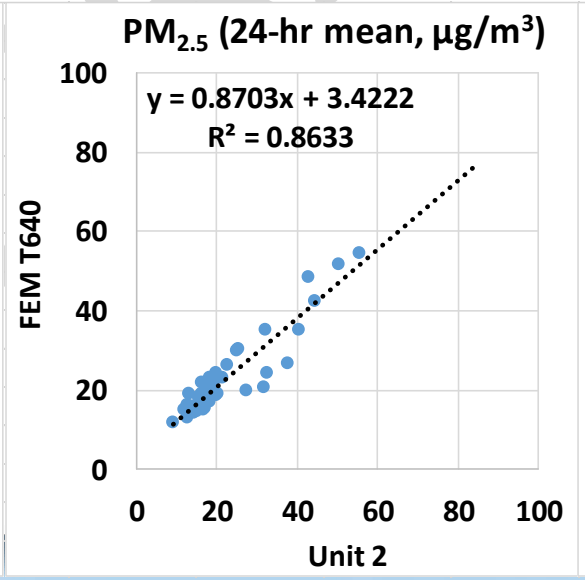


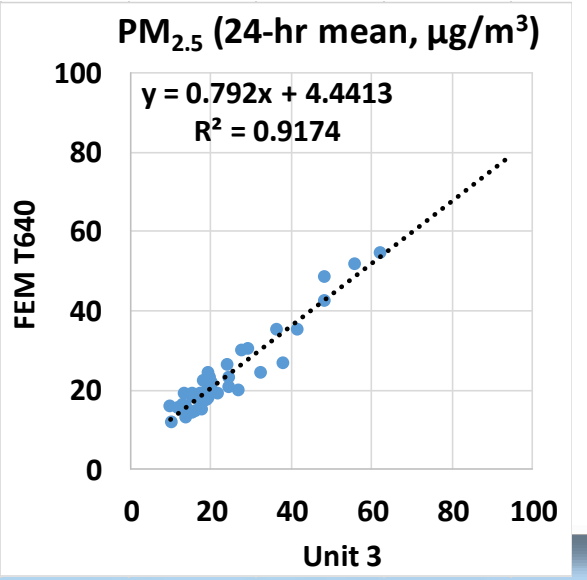
Temtop P20 vs FEM T640 ($PM_{2.5}$; 24-hr mean)



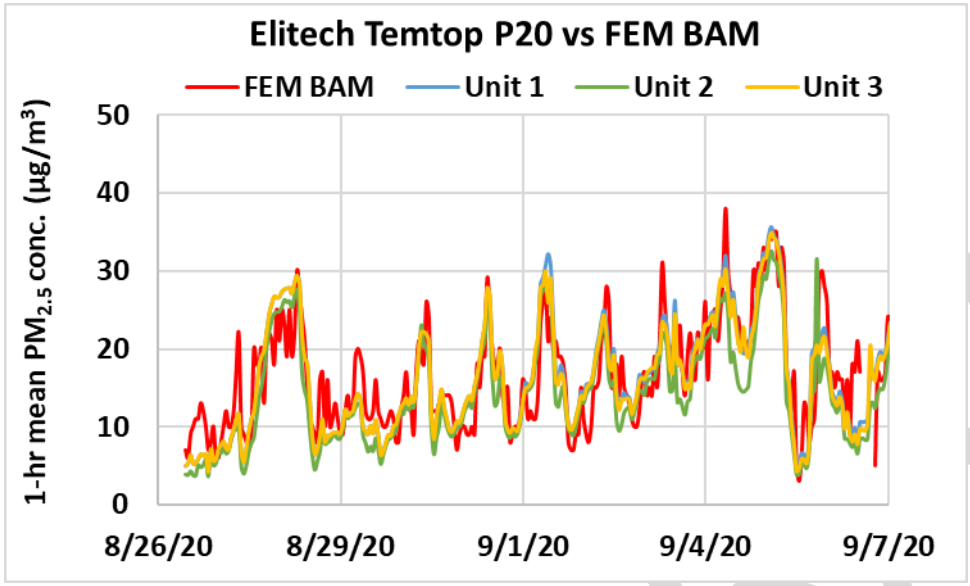
- The Temtop P20 sensors showed strong to very strong correlations with the corresponding FEM T640 data ($0.86 < R^2 < 0.92$)
- Overall, the Temtop P20 sensors overestimated the $PM_{2.5}$ mass concentrations as measured by FEM T640
- The Temtop P20 sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM T640



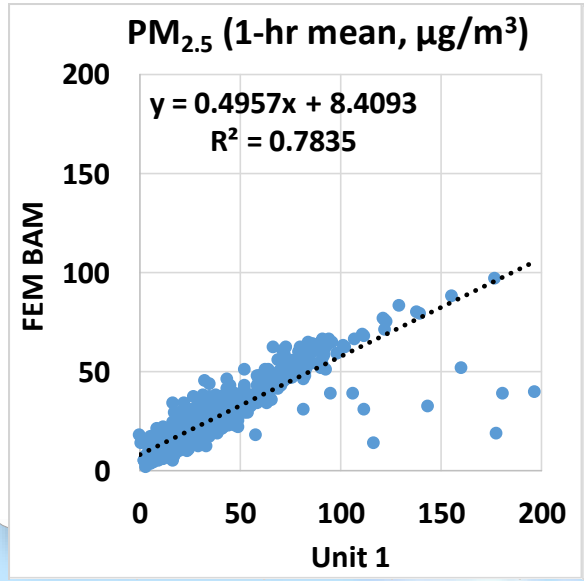


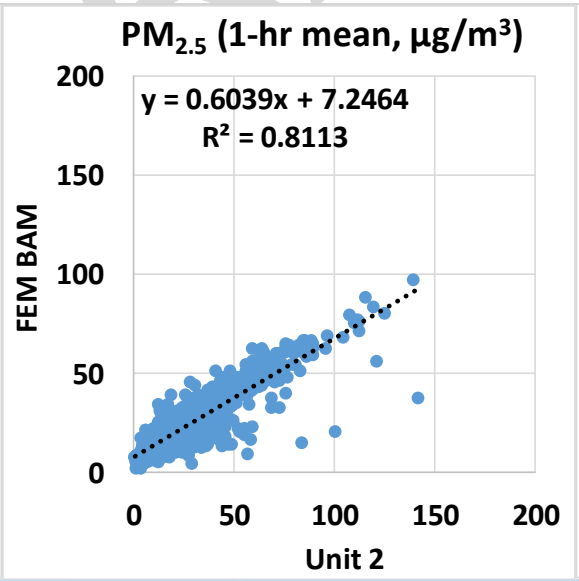


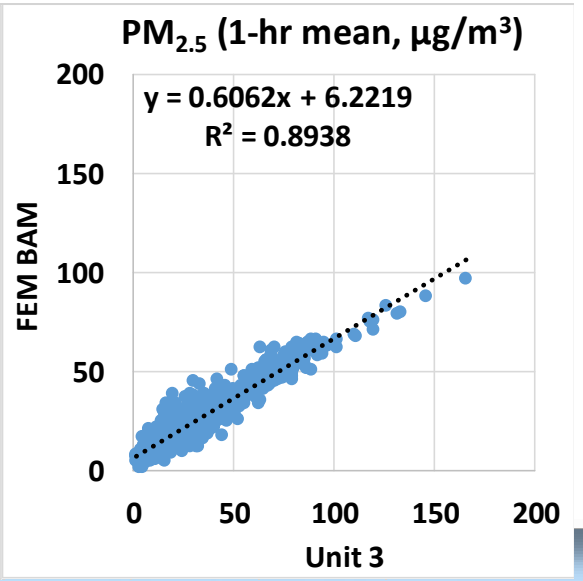
Temtop P20 vs FEM BAM ($PM_{2.5}$; 1-hr mean)



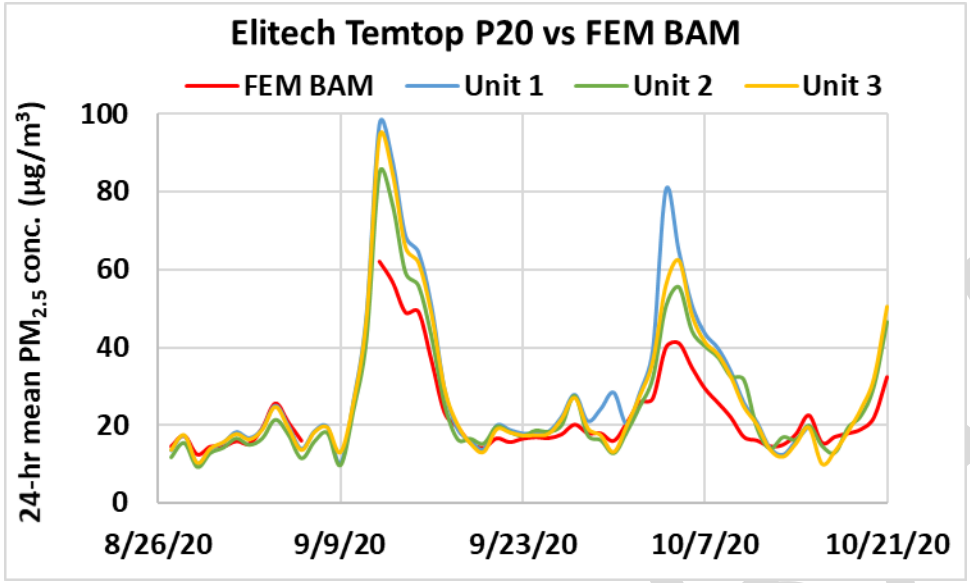
- The Temtop P20 sensors showed strong correlations with the corresponding FEM BAM data ($0.78 < R^2 < 0.90$)
- Overall, the Temtop P20 sensors overestimated the $PM_{2.5}$ mass concentrations as measured by FEM BAM
- The Temtop P20 sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM BAM



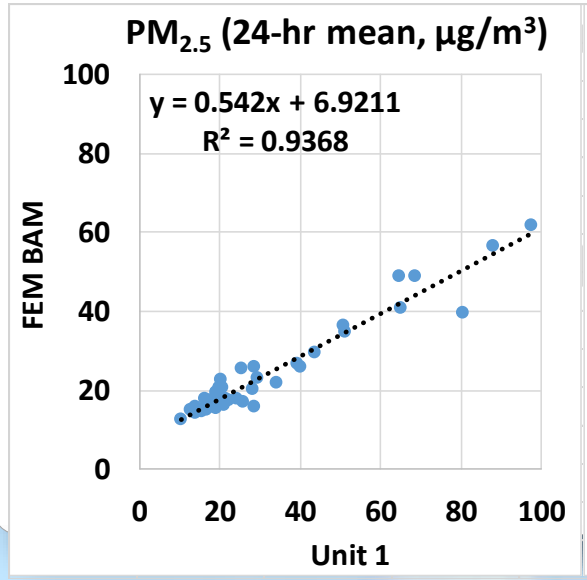


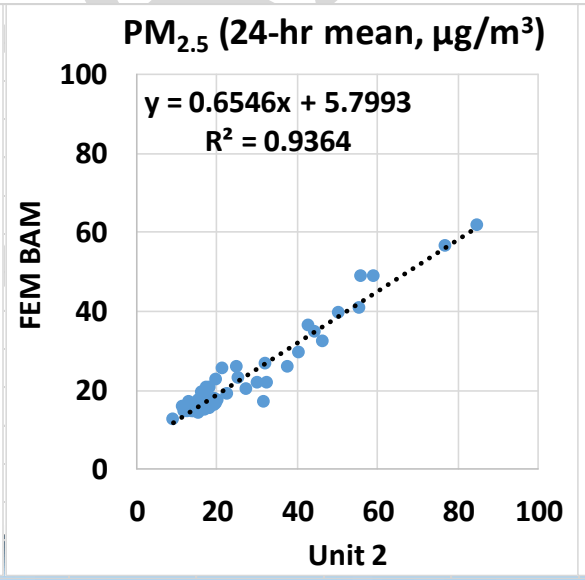


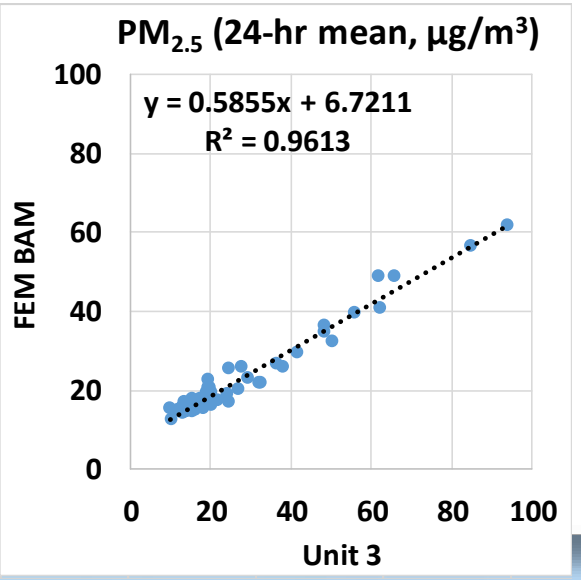
Temtop P20 vs FEM BAM ($PM_{2.5}$; 24-hr mean)



- The Temtop P20 sensors showed very strong correlations with the corresponding FEM BAM data (R^2 ~ 0.94)
- Overall, the Temtop P20 sensors overestimated the $PM_{2.5}$ mass concentrations as measured by FEM BAM
- The Temtop P20 sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM BAM







Summary: $PM_{2.5}$

	Average of 3 Sensors, $PM_{2.5}$		Temtop P20 vs Reference Instruments, $PM_{2.5}$						FEM BAM and FEM T640 ($PM_{2.5}$, $\mu g/m^3$)		
Temtop P20	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	27.4	24.2	0.42 to 0.87	0.41 to 0.77	4.9 to 13.9	-0.7 to 2.6	3.8 to 6.1	5.3 to 14.4	22.9	13.0	4.4 to 94.6
1-hr	27.4	22.3	0.69 to 0.91	0.50 to 0.80	4.3 to 9.0	-0.7 to 5.1	3.6 to 8.7	4.5 to 14.6	22.8 to 23.0	12.8 to 13.9	2 to 97
24-hr	27.7	18.5	0.86 to 0.96	0.54 to 0.87	3.4 to 6.9	-0.5 to 6.9	2.9 to 7.5	3.4 to 10.9	22.7 to 23.0	10.0 to 11.3	11.7 to 61.9

[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.

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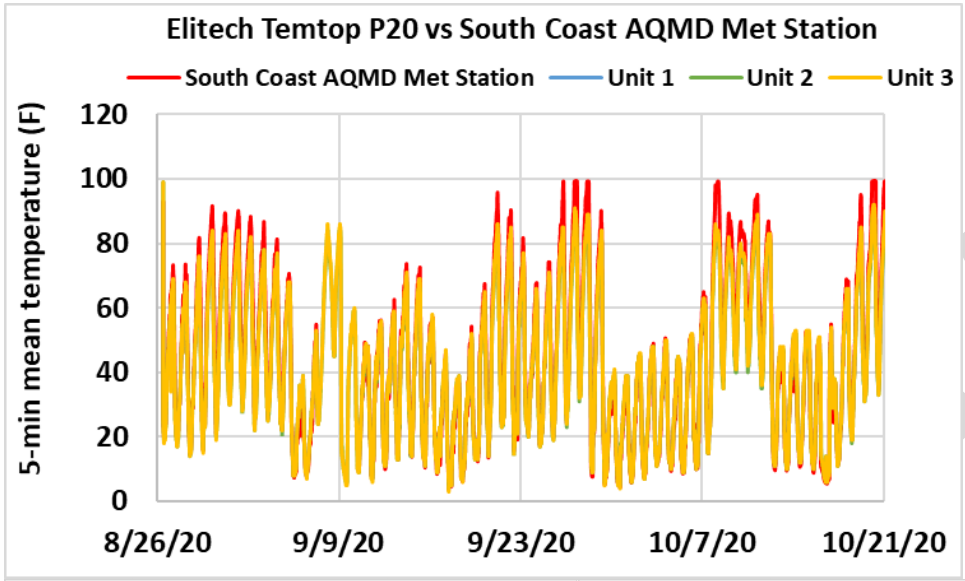
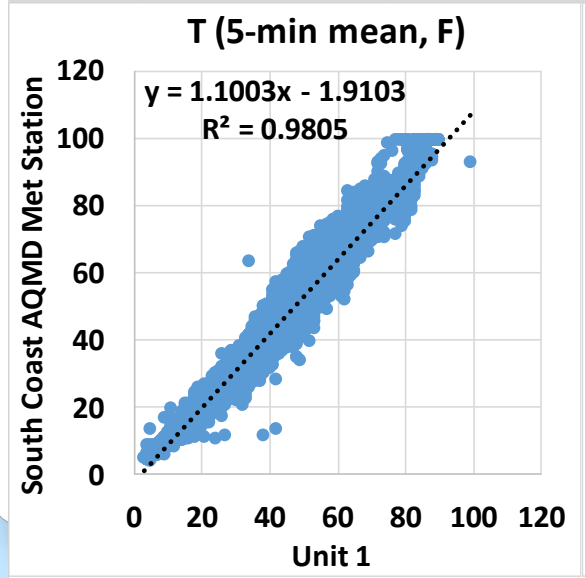
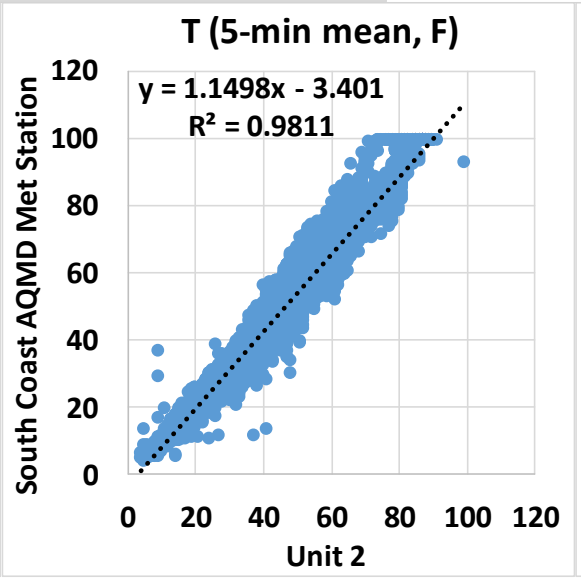
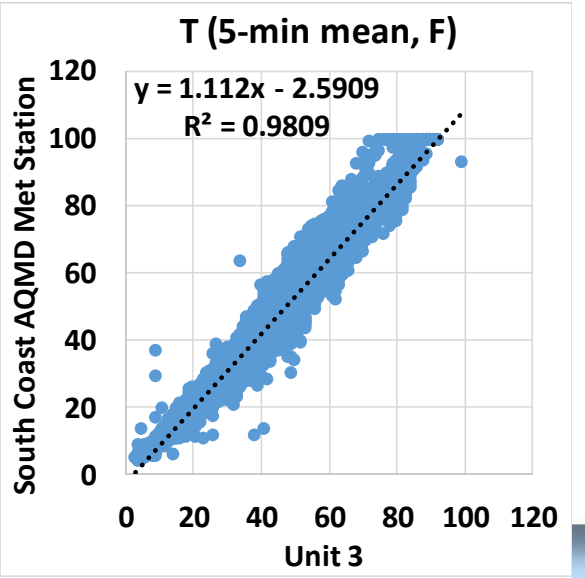
Elitech Temtop P20 vs South Coast AQMD Met Station (Temp; 5-min mean)



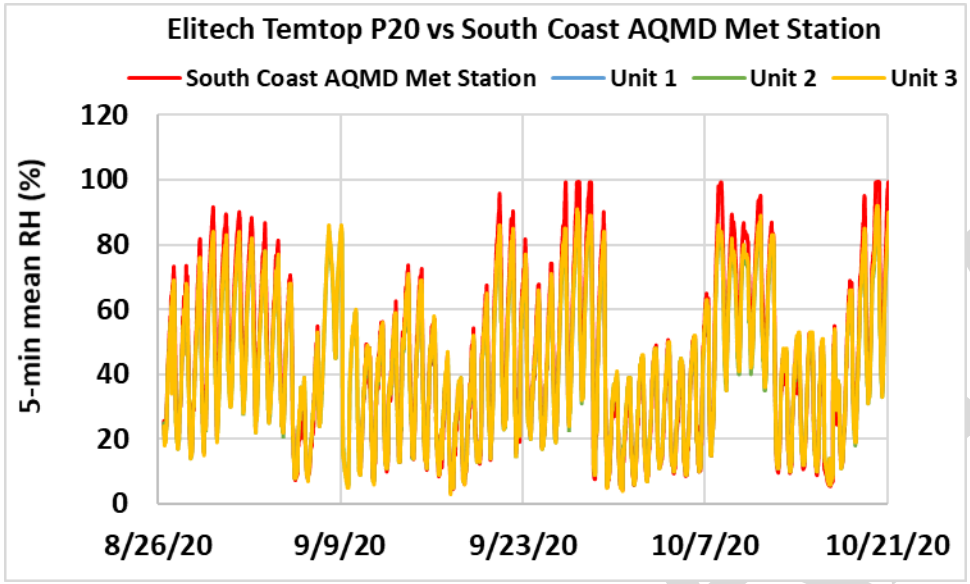
- The Temtop P20 temperature measurements showed very strong correlations with the corresponding South Coast AQMD Met Station data (R^2 ~ 0.98)
- Overall, the Temtop P20 temperature measurements underestimated the corresponding South Coast AQMD Met Station data
- The Temtop P20 sensors seemed to track well the temperature diurnal variations as recorded by South Coast AQMD Met Station



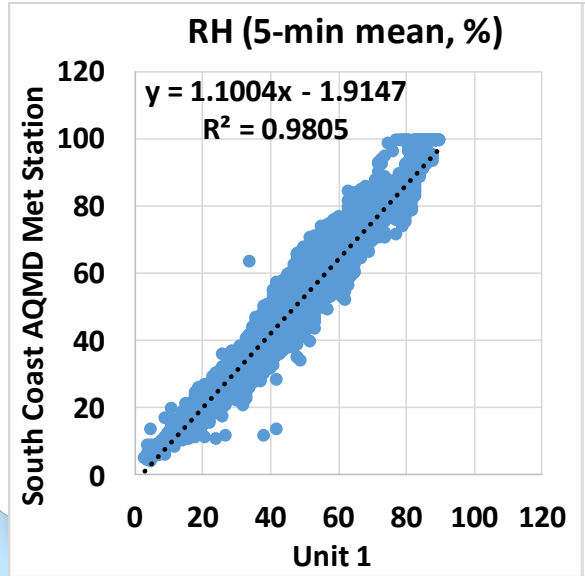


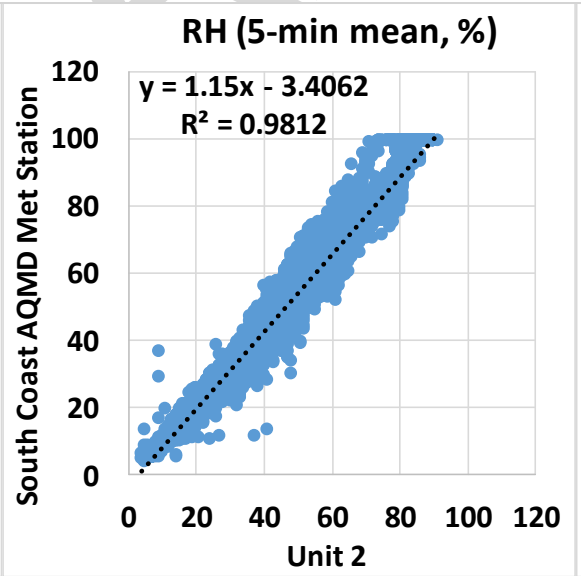


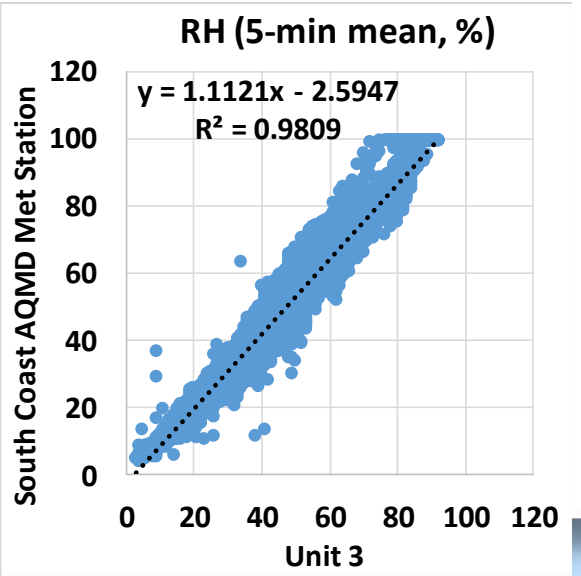
Elitech Temtop P20 vs South Coast AQMD Met Station (RH; 5-min mean)



- The Temtop P20 RH measurements showed very strong correlations with the corresponding South Coast AQMD Met Station data (R^2 ~ 0.98)
- Overall, the Temtop P20 RH measurements underestimated the corresponding South Coast AQMD Met Station data
- The Temtop P20 sensors seemed to track well the RH diurnal variations as recorded by South Coast AQMD Met Station







Discussion

- The three **Temtop P20** sensors' data recovery from units Unit 1, Unit 2 and Unit 3 was ~ 90%, ~ 100% and ~ 100% for $PM_{2.5}$ measurements
- The absolute intra-model variability was ~ 1.43 µg/m^3 for $PM_{2.5}$ measurements
- $PM_{2.5}$ mass concentrations measured by Temtop P20 sensors showed moderate to very strong correlations with the corresponding FEM T640 data ($0.68 < R^2 < 0.91$, 1-hr mean) and strong correlations with the corresponding FEM BAM data ($0.78 < R^2 < 0.90$, 1-hr mean). The sensors overestimated $PM_{2.5}$ mass concentrations as measured by FEM T640 and FEM BAM.
- 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

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