

Field Evaluation Qingping - Air Monitor



Background

- From 11/07/2022 to 01/07/2023, three **Qingping – Air Monitor** 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
- Qingping Air Monitor (3 units tested):
 - Particle sensor: **optical; non-FEM (Grandway, Model P5500)**
 - Each unit reports: PM_{2.5} (µg/m³), T (°C), RH (%)
 - **Unit cost: \$135**
 - Also measures: CO₂ (ppm) and tVOC (ppb)
 - Time resolution: 1-min
 - Units IDs: 39F5, 37DA, 3956



- GRIMM EDM180 (reference instrument):
 - Optical particle counter (**FEM PM_{2.5}**)
 - Measures PM_{1.0}, PM_{2.5}, and PM₁₀ (µg/m³)
 - **Cost: ~\$25,000 and up**
 - Time resolution: 1-min
- Teledyne API T640 (reference instrument):
 - Optical particle counter (**FEM PM_{2.5}**)
 - Measures PM_{1.0}, PM_{2.5} and PM₁₀ (µg/m³)
 - **Cost: ~\$21,000**
 - Time resolution: 1-min
- Met Station (T, RH, P, WS, WD):
 - **Cost: ~\$5,000**
 - Time resolution: 1-min



FEM GRIMM



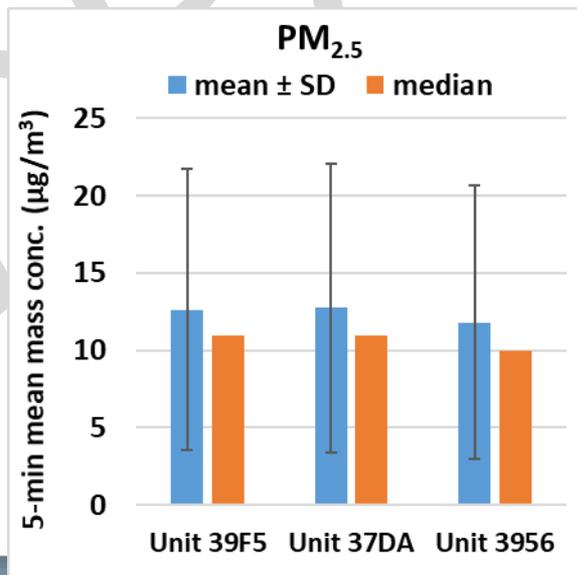
FEM T640

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 all units was $\sim 100\%$ for $\text{PM}_{2.5}$ mass concentration measurements

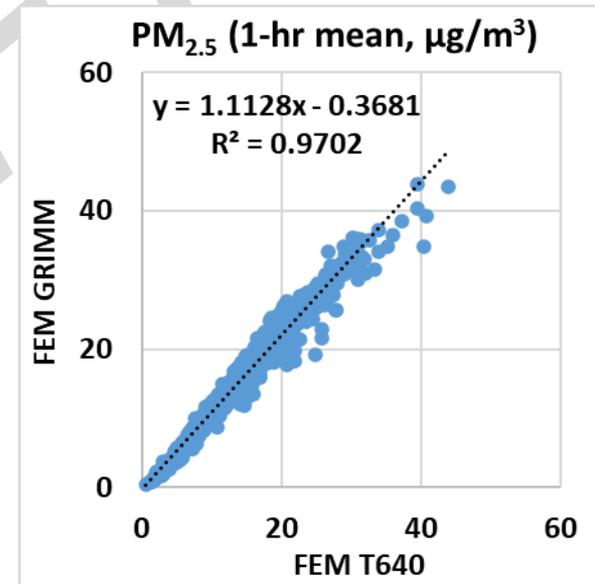
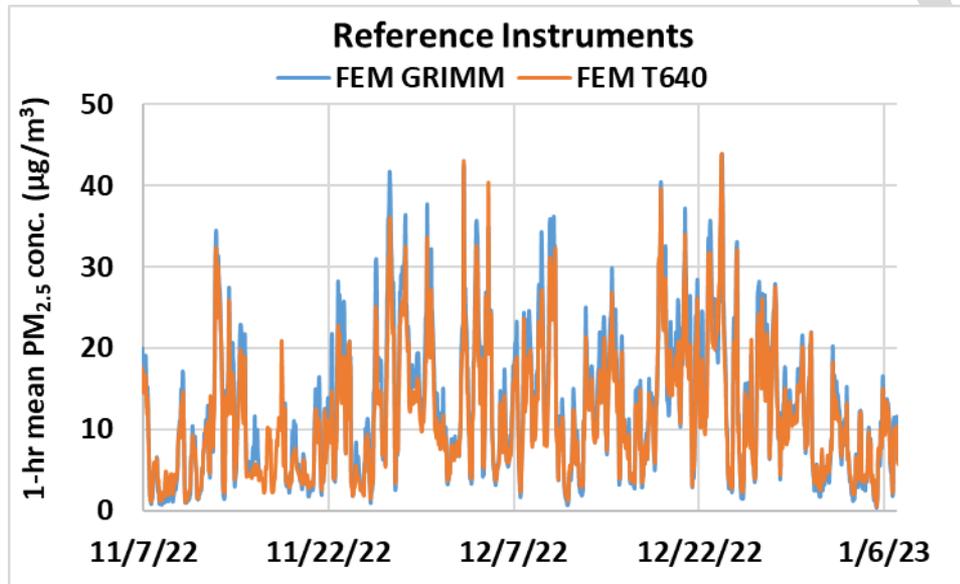
Qingping Air Monitor; intra-model variability

- Absolute intra-model variability was $\sim 0.43 \mu\text{g}/\text{m}^3$ for $\text{PM}_{2.5}$ mass concentration measurements (calculated as the standard deviation of the three sensor means)
- Relative intra-model variability was $\sim 3.4\%$ for $\text{PM}_{2.5}$ mass concentration measurements (calculated as the absolute intra-model variability relative to the mean of the three sensor means)

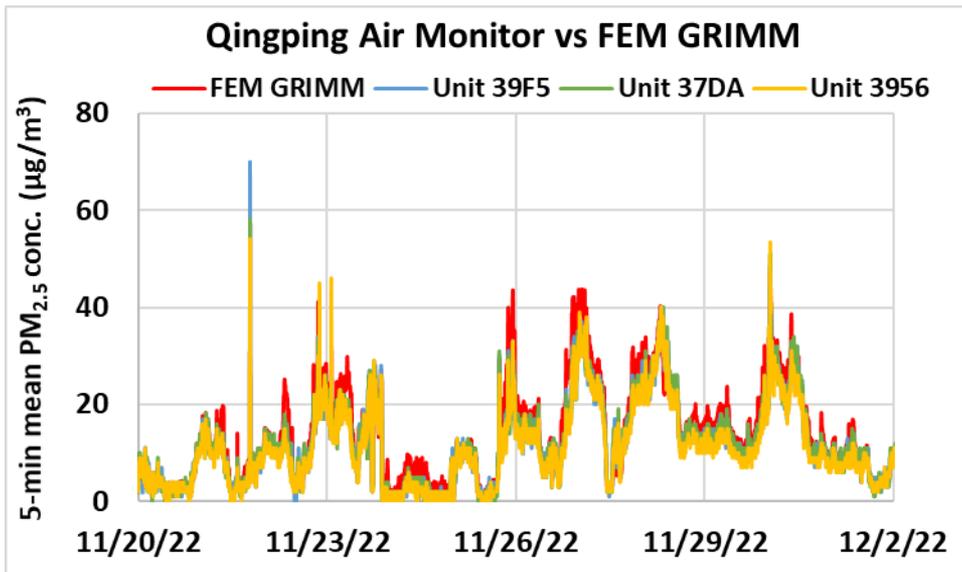


Reference Instruments: PM_{2.5} FEM GRIMM and FEM T640

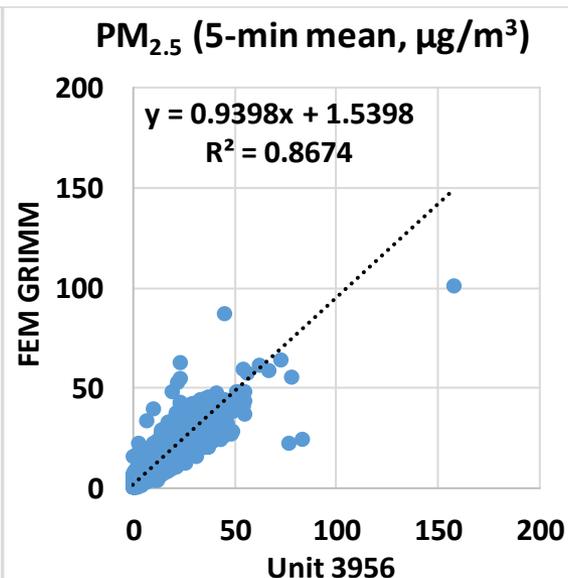
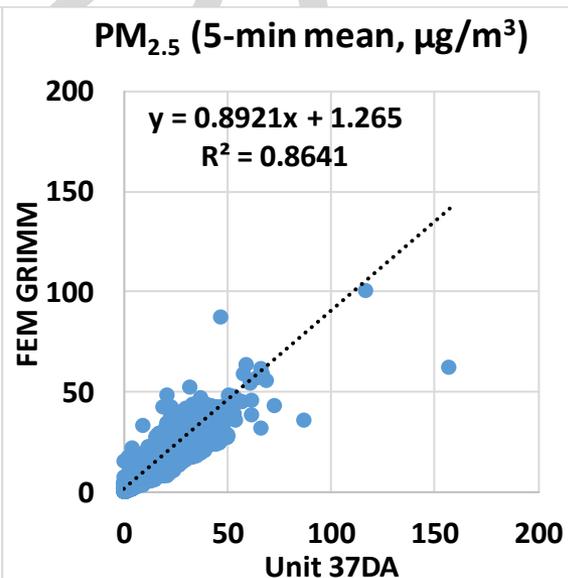
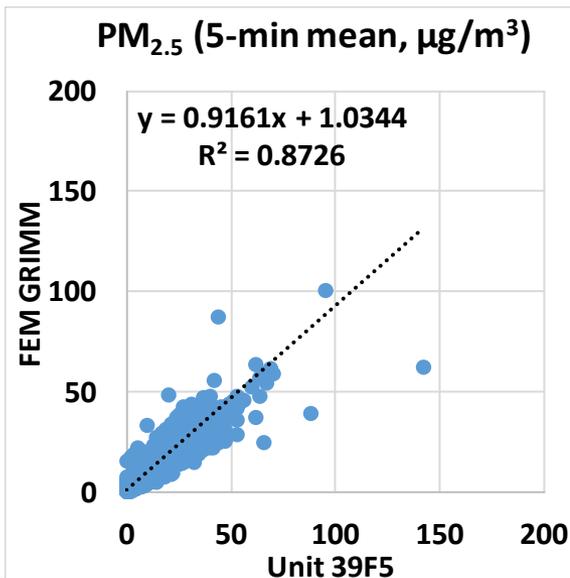
- Data recovery for PM_{2.5} from FEM GRIMM and FEM T640 was ~96.7% and ~100%, respectively.
- Very strong correlations between the reference instruments for PM_{2.5} measurements ($R^2 \sim 0.97$) were observed.



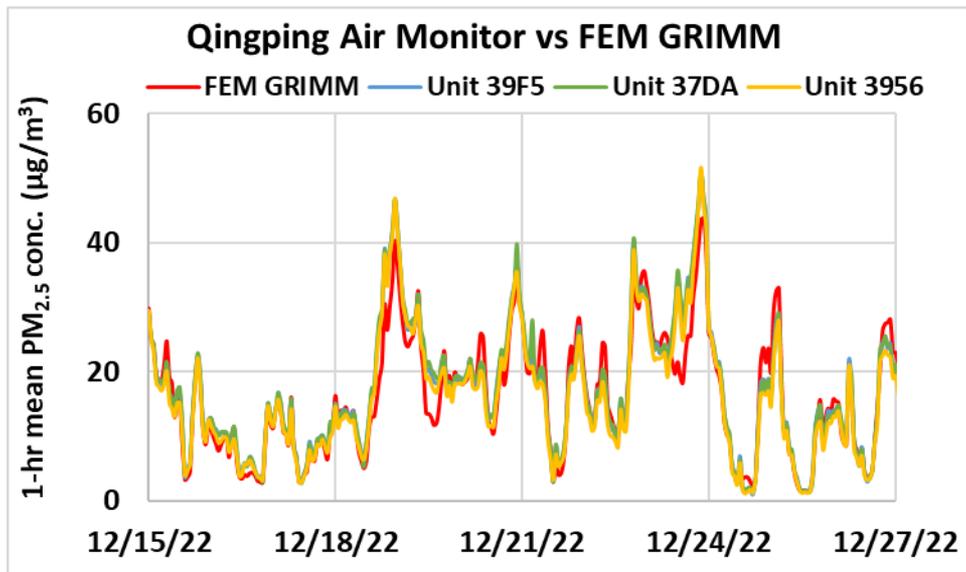
Qingping Air Monitor vs FEM GRIMM (PM_{2.5}; 5-min mean)



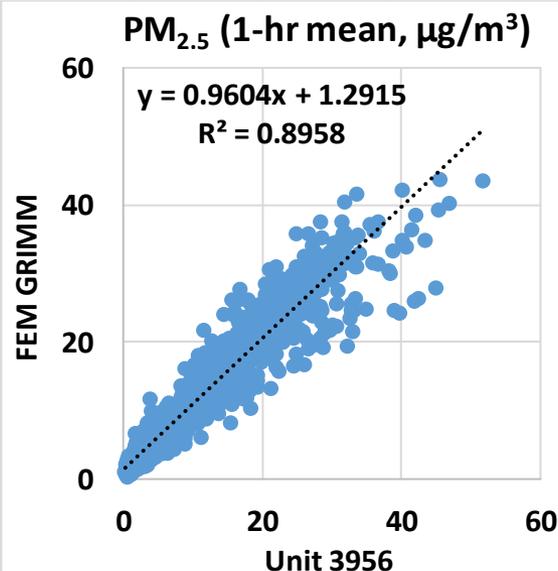
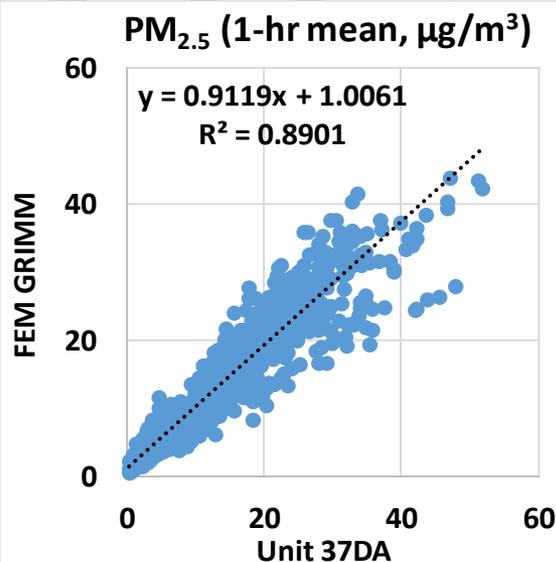
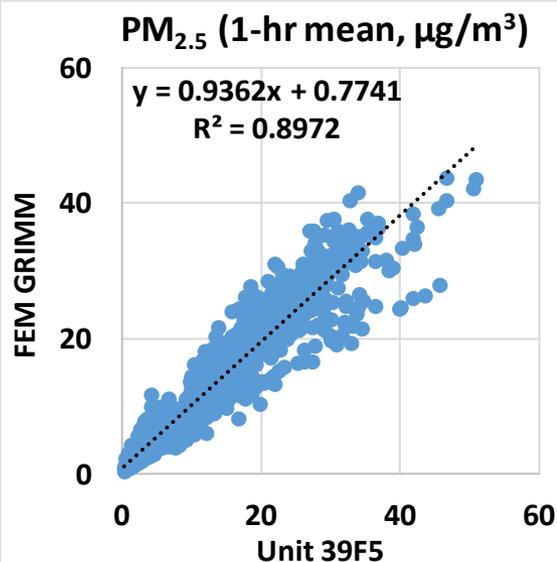
- The Qingping Air Monitor sensors showed strong correlations with the corresponding FEM GRIMM data ($0.86 < R^2 < 0.88$)
- Overall, the Qingping Air Monitor sensors underestimated the PM_{2.5} mass concentrations as measured by FEM GRIMM
- The Qingping Air Monitor sensors seemed to track the PM_{2.5} diurnal variations as recorded by FEM GRIMM



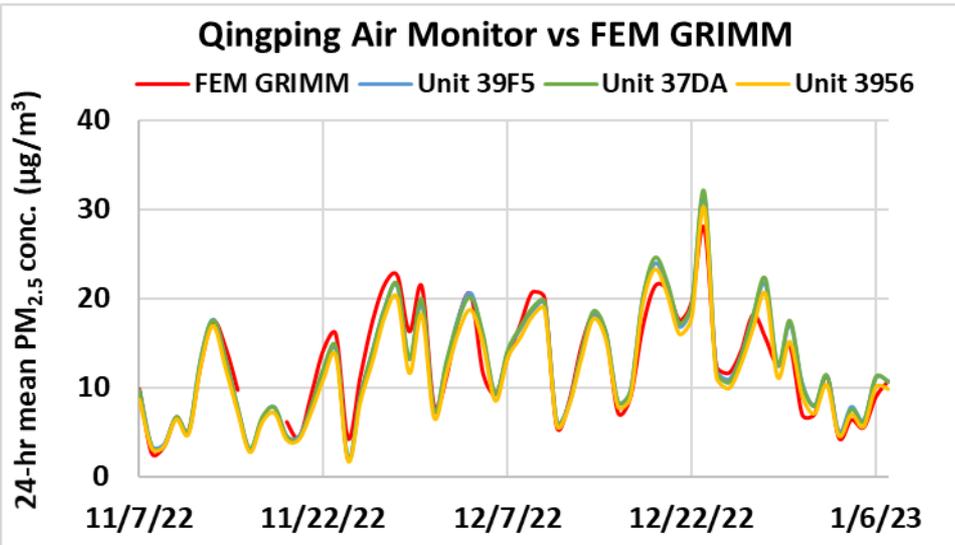
Qingping Air Monitor vs FEM GRIMM (PM_{2.5}; 1-hr mean)



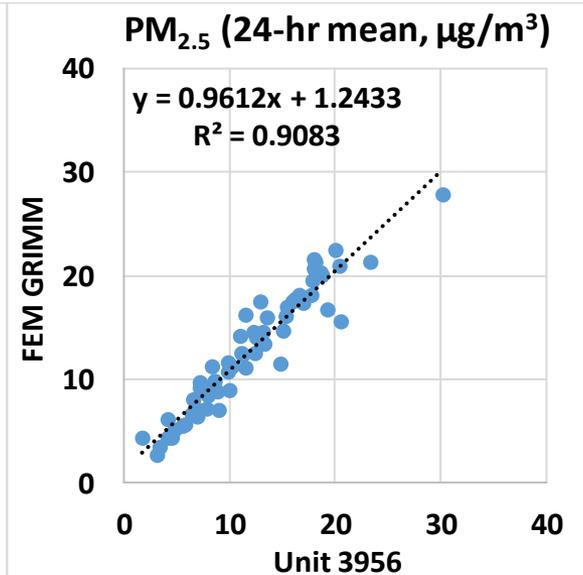
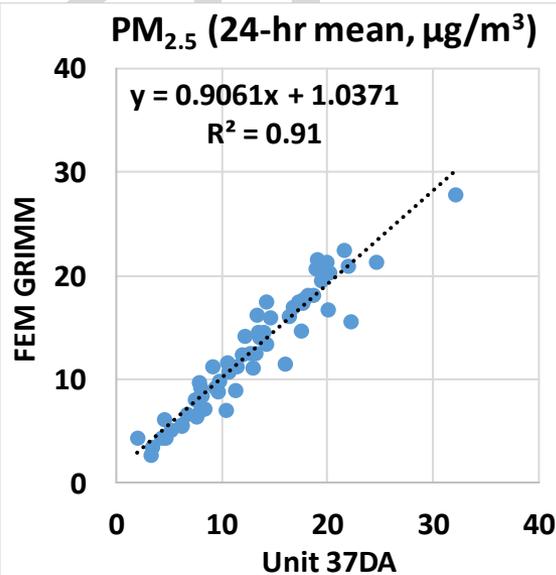
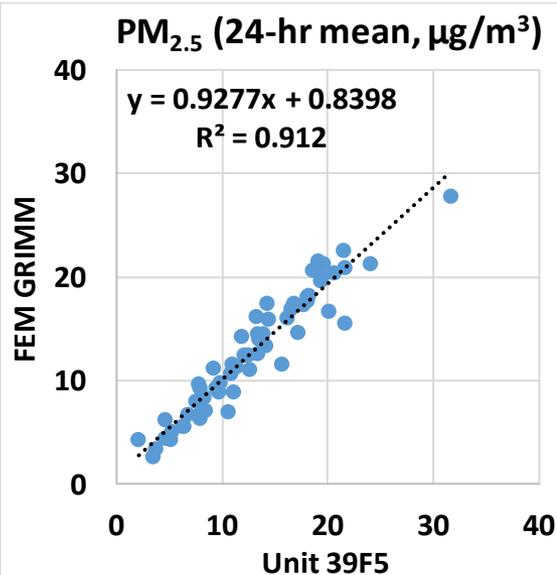
- The Qingping Air Monitor sensors showed strong correlations with the corresponding FEM GRIMM data ($0.89 < R^2 < 0.90$)
- Overall, the Qingping Air Monitor sensors underestimated the PM_{2.5} mass concentrations as measured by FEM GRIMM
- The Qingping Air Monitor sensors seemed to track the PM_{2.5} diurnal variations as recorded by FEM GRIMM



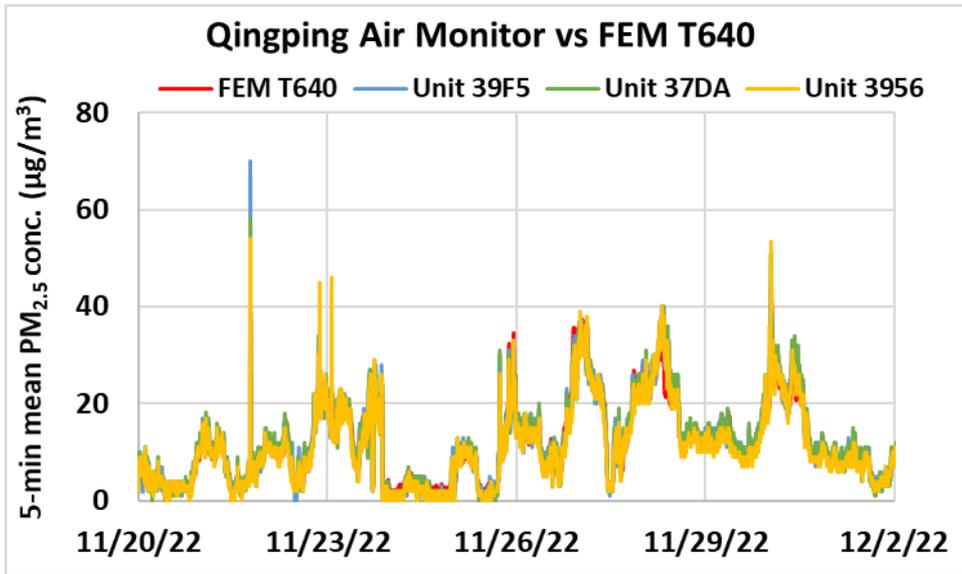
Qingping Air Monitor vs FEM GRIMM (PM_{2.5}; 24-hr mean)



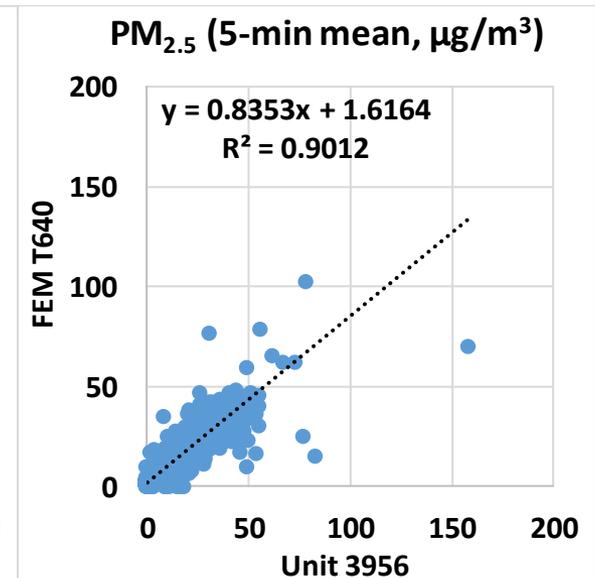
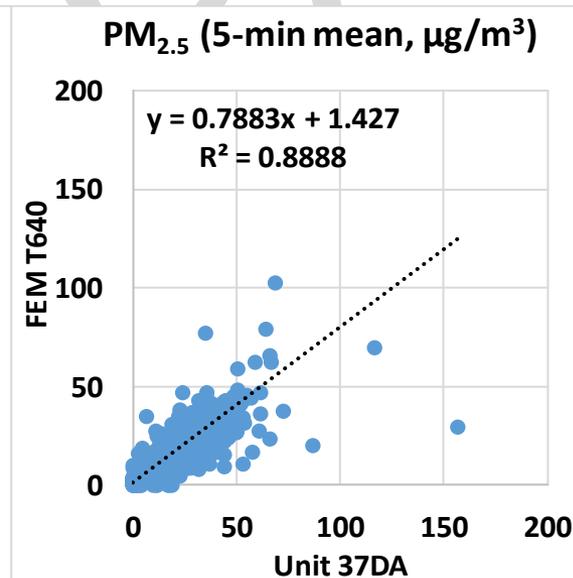
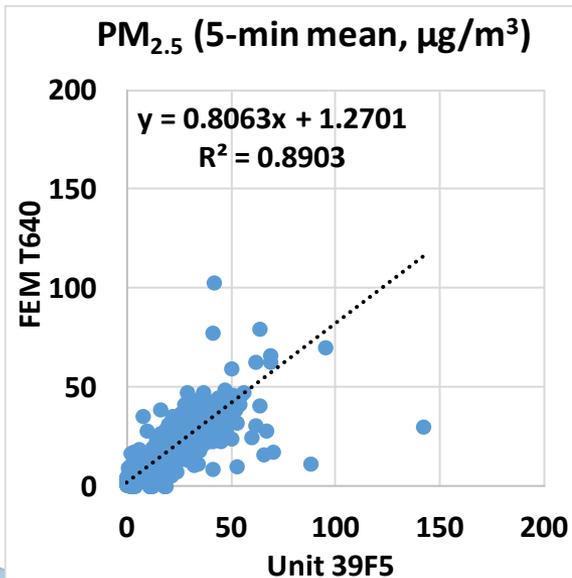
- The Qingping Air Monitor sensors showed very strong correlations with the corresponding FEM GRIMM data ($0.90 < R^2 < 0.92$)
- Overall, the Qingping Air Monitor sensors underestimated the PM_{2.5} mass concentrations as measured by FEM GRIMM
- The Qingping Air Monitor sensors seemed to track the PM_{2.5} daily variations as recorded by FEM GRIMM



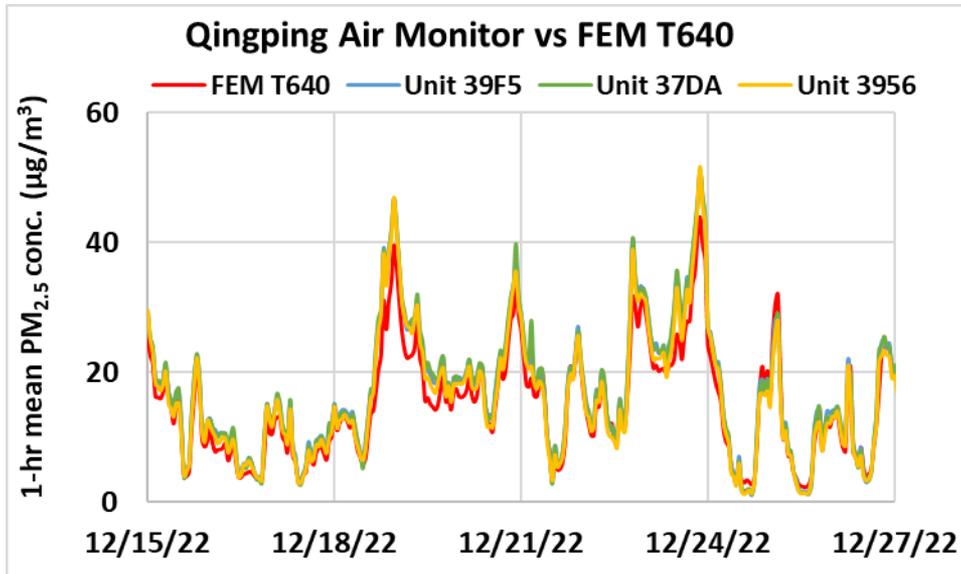
Qingping Air Monitor vs FEM T640 (PM_{2.5}; 5-min mean)



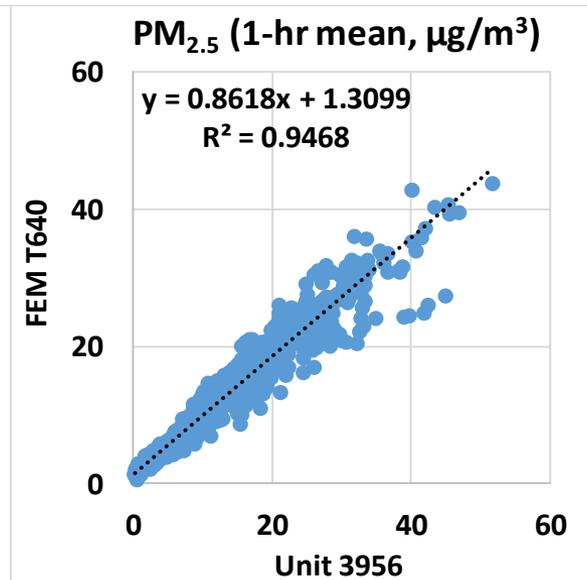
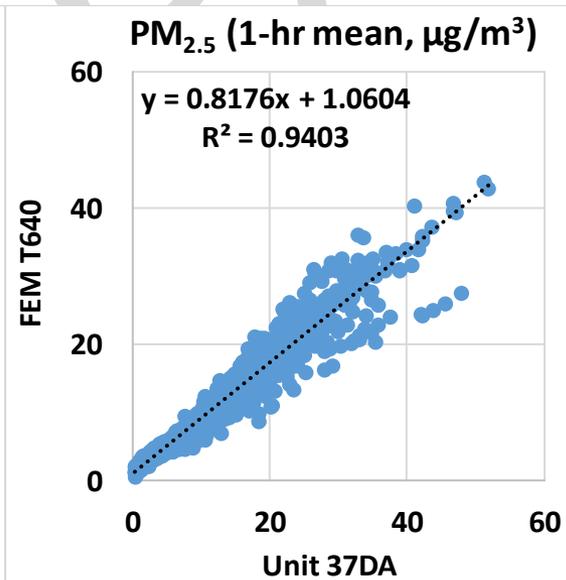
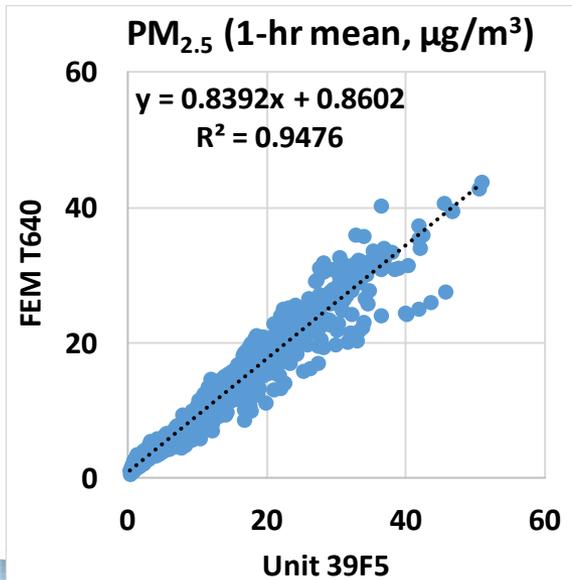
- The Qingping Air Monitor sensors showed strong to very strong correlations with the corresponding FEM T640 data ($0.88 < R^2 < 0.91$)
- Overall, the Qingping Air Monitor sensors overestimated the PM_{2.5} mass concentrations as measured by FEM T640
- The Qingping Air Monitor sensors seemed to track the PM_{2.5} diurnal variations as recorded by FEM T640



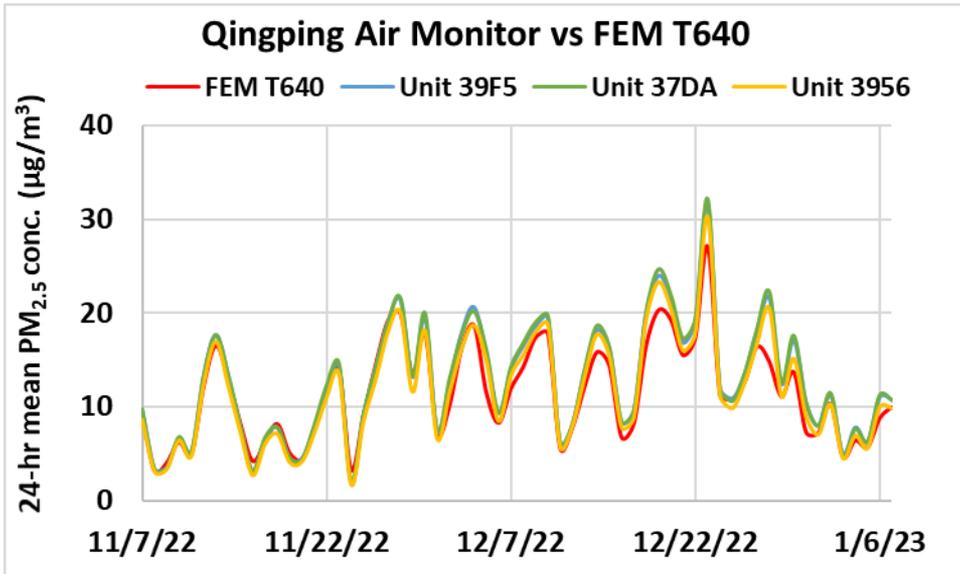
Qingping Air Monitor vs FEM T640 (PM_{2.5}; 1-hr mean)



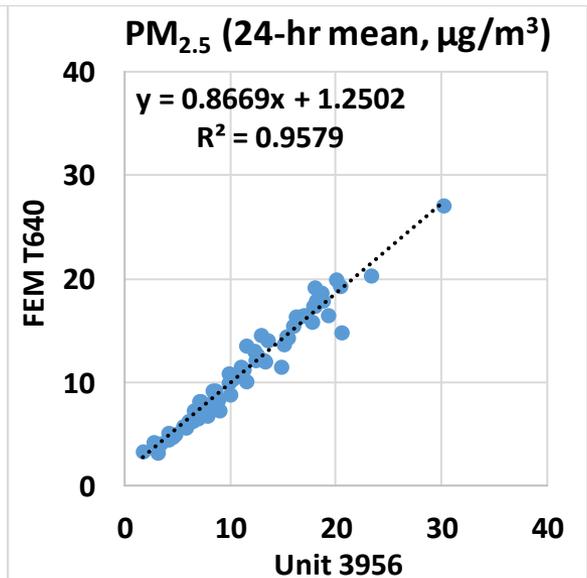
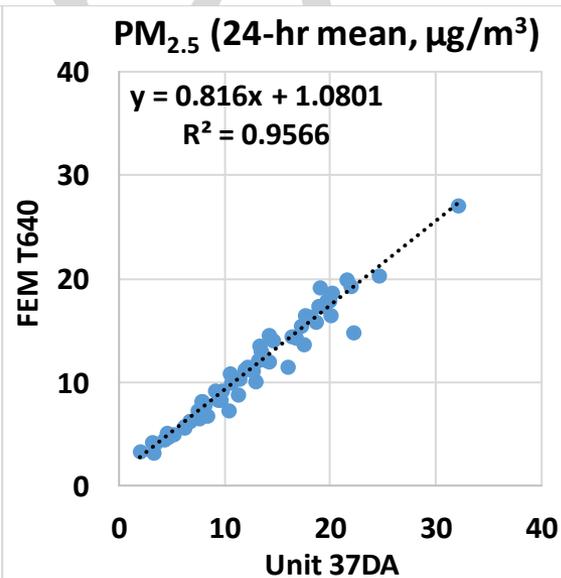
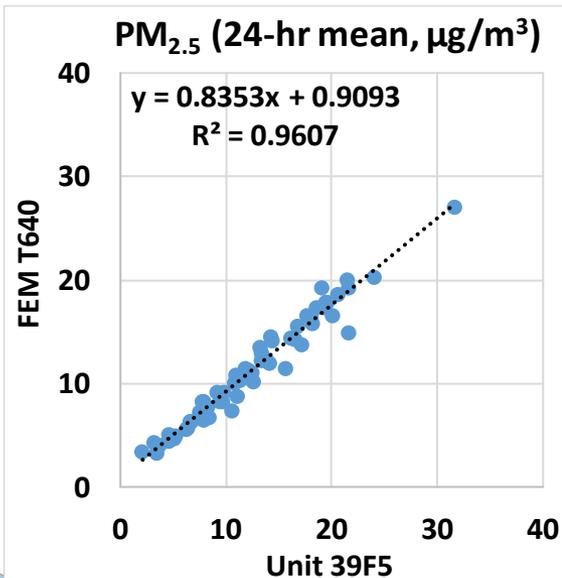
- The Qingping Air Monitor sensors showed very strong correlations with the corresponding FEM T640 data ($0.94 < R^2 < 0.95$)
- Overall, the Qingping Air Monitor sensors overestimated the PM_{2.5} mass concentrations as measured by FEM T640
- The Qingping Air Monitor sensors seemed to track the PM_{2.5} diurnal variations as recorded by FEM T640



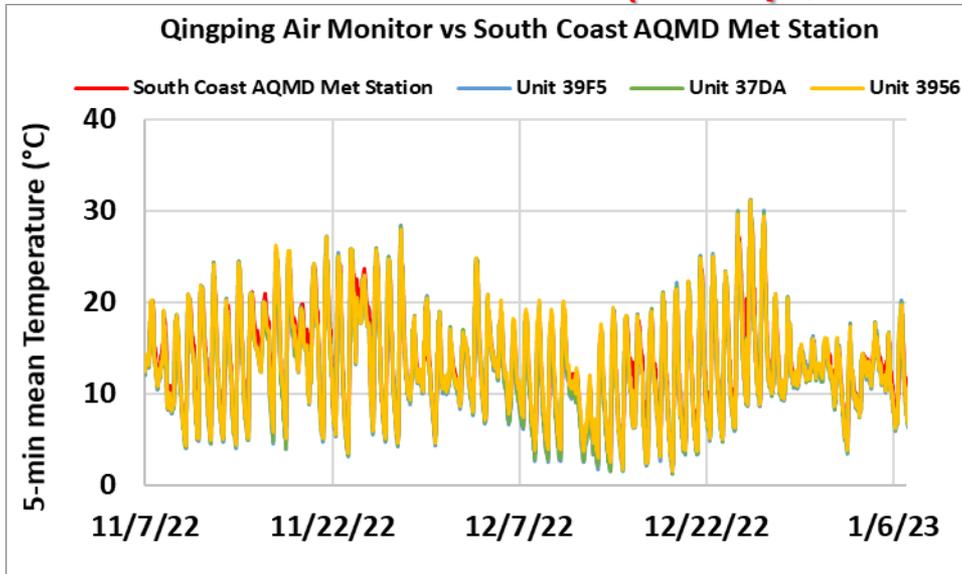
Qingping Air Monitor vs FEM T640 (PM_{2.5}; 24-hr mean)



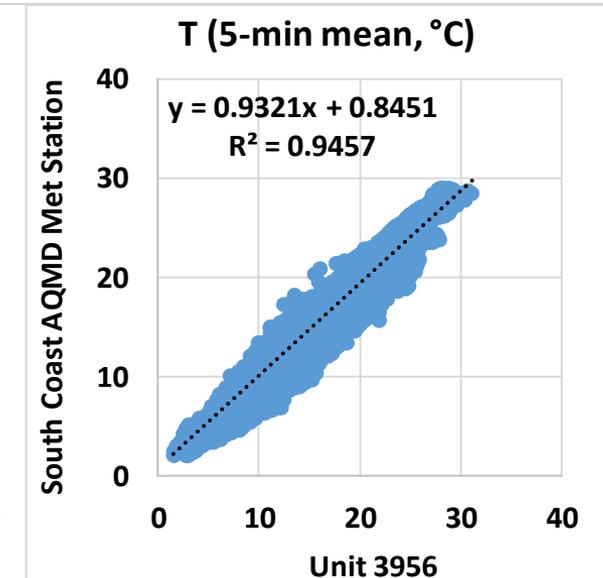
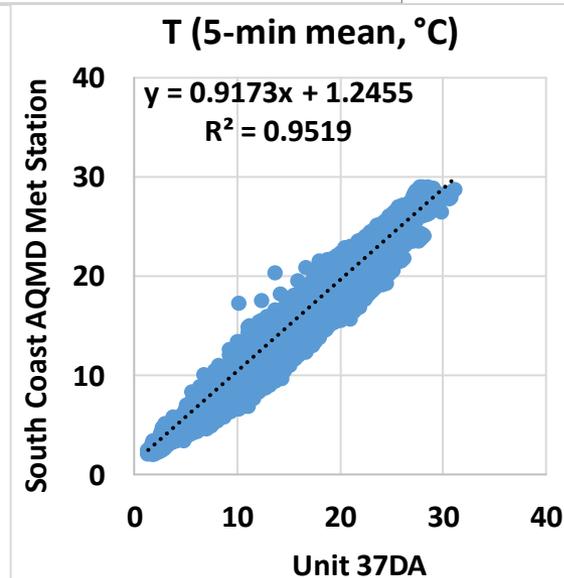
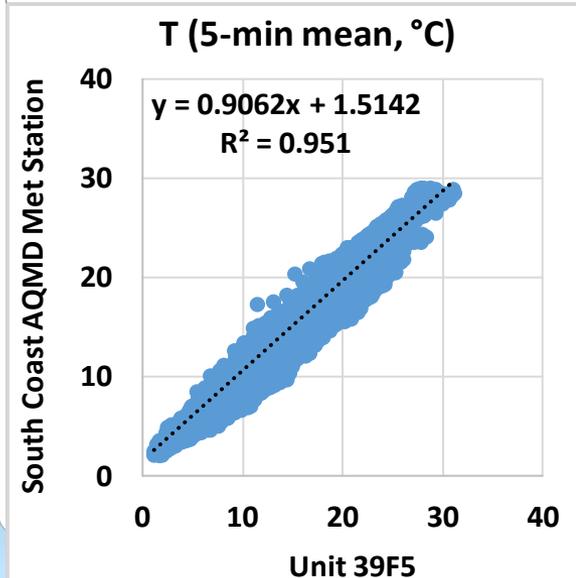
- The Qingping Air Monitor sensors showed very strong correlations with the corresponding FEM T640 data ($0.95 < R^2 < 0.97$)
- Overall, the Qingping Air Monitor sensors overestimated the PM_{2.5} mass concentrations as measured by FEM T640
- The Qingping Air Monitor sensors seemed to track the PM_{2.5} daily variations as recorded by FEM T640



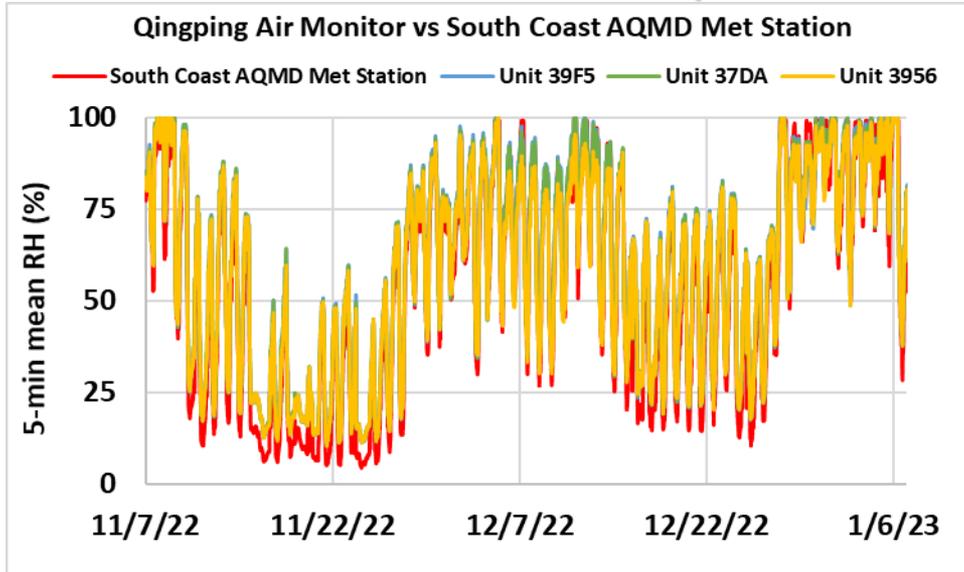
Qingping Air Monitor vs South Coast AQMD Met Station (Temp; 5-min mean)



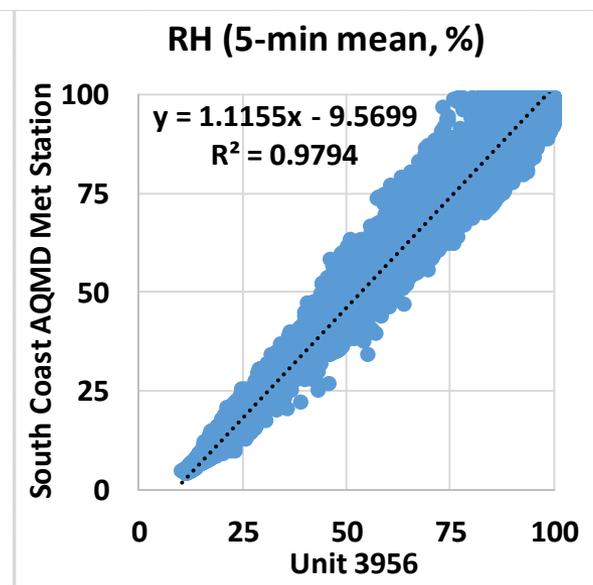
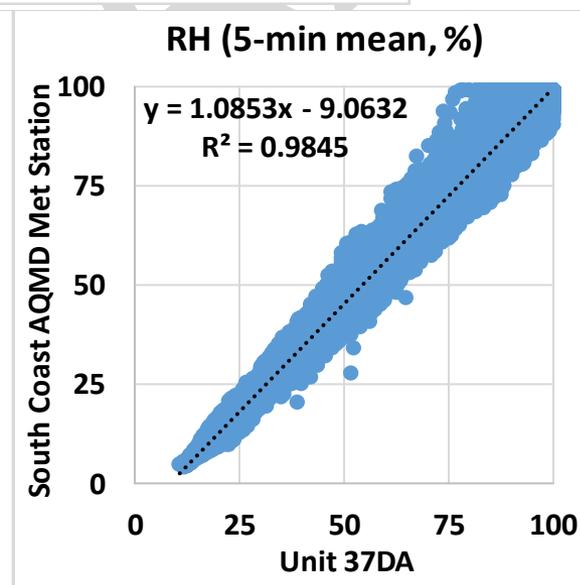
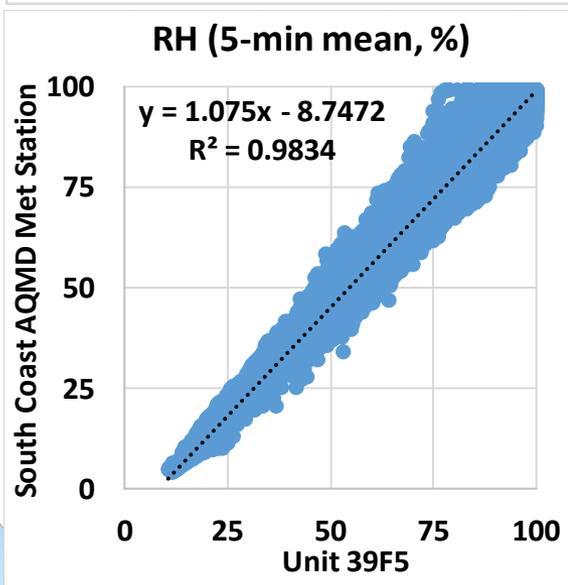
- The Qingping Air Monitor sensors showed very strong correlations with the corresponding South Coast AQMD Met Station data ($R^2 \sim 0.95$)
- Overall, the Qingping Air Monitor sensors underestimated the temperature measurement as recorded by South Coast AQMD Met Station
- The Qingping Air Monitor sensors seemed to track the diurnal temperature variations as recorded by South Coast AQMD Met Station



Qingping Air Monitor vs South Coast AQMD Met Station (RH; 5-min mean)



- The Qingping Air Monitor sensors showed very strong correlations with the corresponding South Coast AQMD Met Station data ($R^2 \sim 0.98$)
- Overall, the Qingping Air Monitor sensors overestimated the RH measurement as recorded by South Coast AQMD Met Station
- The Qingping Air Monitor sensors seemed to track the diurnal RH variations as recorded by South Coast AQMD Met Station



Summary

	Average of 3 Sensors, PM _{2.5}		Qingping Air Monitor vs FEM GRIMM & FEM T640, PM _{2.5}						FEM GRIMM & FEM T640 (PM _{2.5} , µg/m ³)		
	Average (µg/m ³)	SD (µg/m ³)	R ²	Slope	Intercept	MBE ¹ (µg/m ³)	MAE ² (µg/m ³)	RMSE ³ (µg/m ³)	Ref. Average	Ref. SD	Range during the field evaluation
5-min	12.4	9.1	0.86 to 0.90	0.79 to 0.94	1.0 to 1.6	-0.8 to 1.3	1.8 to 2.3	2.9 to 3.5	11.5 to 12.8	7.8 to 9.0	0.3 to 102.7
1-hr	12.4	8.8	0.89 to 0.95	0.82 to 0.96	0.8 to 1.3	-0.8 to 1.3	1.4 to 2.0	2.1 to 3.0	11.5 to 12.8	7.6 to 8.7	0.4 to 43.9
24-hr	12.4	6.0	0.91 to 0.96	0.82 to 0.96	0.8 to 1.3	-0.8 to 1.3	0.9 to 1.5	1.3 to 2.0	11.5 to 12.9	5.1 to 5.8	2.7 to 27.9

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.

Discussion

- The three **Qingping Air Monitor** sensors' data recovery was ~100% for PM_{2.5} mass concentration measurements
- The absolute intra-model variability was ~0.43 µg/m³ for PM_{2.5} mass concentration measurements
- Reference instruments: very strong correlations between FEM GRIMM and FEM T640 for PM_{2.5} (R² ~0.97, 1-hr mean) mass concentration measurements
- PM_{2.5} mass concentrations measured by the Qingping Air Monitor sensors showed strong to very strong correlations with the corresponding FEM GRIMM and FEM T640 data (0.89 < R² < 0.95, 1-hr mean). The sensors underestimated PM_{2.5} mass concentrations as measured by FEM GRIMM and overestimated PM_{2.5} mass concentrations as measured by FEM T640
- 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