AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Field Evaluation Report for

QuantAQ MODULAIR-PM (2025 Evaluation)

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Performance Snapshot

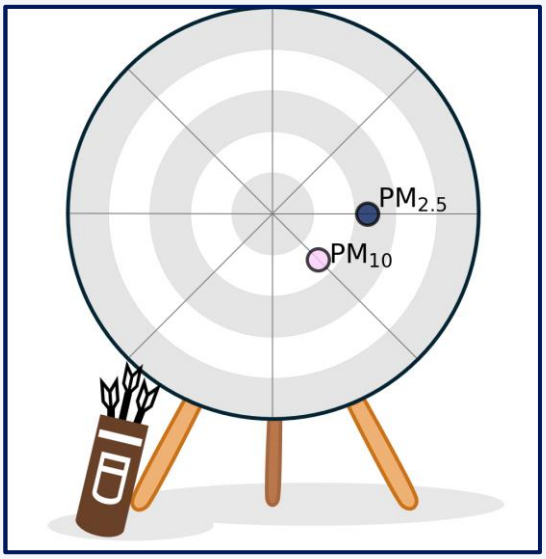
QuantAQ MODULAIR-PM

Tested: 07-11-2025 to 09-04-2025

○	CO	○	SO_2
○	CO_2	○	VOC
○	CH_4	●	PM_1
○	H_2S	✓	$PM_{2.5}$
○	NO	○	PM_4
○	NO_2	✓	PM_{10}
○	NO_x	○	UFP
○	O_3	○	BC

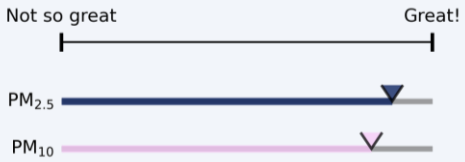
✓ Tested ● Not tested ○ Not available

Does it hit the target?



The closer the sensor lands near the center, the more accurate its readings were compared to the pollution levels.

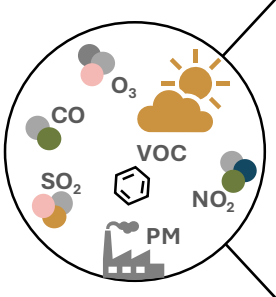
How well does it track?



A longer bar means the sensor did a better job of tracking the real changes in air pollution levels — going up when the concentration levels went up, and down when they dropped.

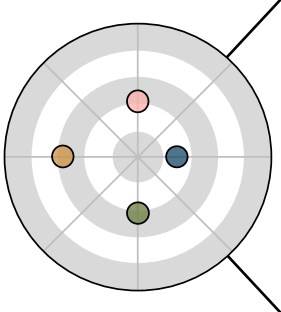
$$$ Cost	Web portal	4 lbs Weight	Display	Battery	Solar	Weatherproof
option Wi-Fi	Cellular	Bluetooth	Internal memory	Serial	USB	Ethernet

Performance Snapshot Guide



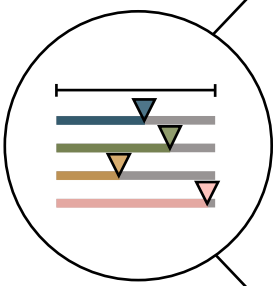
Pollutant List: This list shows the pollutants that the sensor is capable of measuring. Pollutants highlighted in blue with a check mark were tested for performance, those in gray were not tested, and those in white are not measured by the sensor.

◆ **CH_4** methane ◆ **CO** carbon monoxide ◆ **CO_2** carbon dioxide ◆ **H_2S** hydrogen sulfide ◆ **NO** nitric oxide ◆ **NO_2** nitrogen dioxide ◆ **NO_x** nitrogen oxides ◆ **O_3** ozone ◆ **SO_2** sulfur dioxide ◆ **VOC** volatile organic compounds ◆ **BC** black carbon ◆ **PM_1** mass of particles smaller than 1 micrometer ◆ **$PM_{2.5}$** mass of particles smaller than 2.5 micrometers ◆ **PM_4** mass or particles smaller than 4 micrometers ◆ **PM_{10}** mass of particles smaller than 10 micrometers ◆ **UFP** ultrafine particles, smaller than 0.1 micrometers



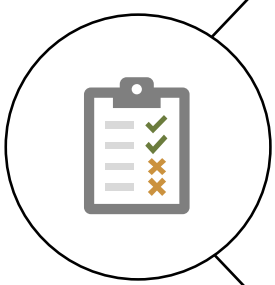
Target Graphic: The closer the sensor "hits" the center, the closer the sensor's readings were to the actual concentrations. If the sensor hit inside the center circle, its readings were within 20% of the actual concentration. Each ring going outward is another 20% further from the actual concentration. If the sensor falls off the target entirely, its readings were either zero, or more than twice the actual concentration!

More technically, the distance from the center is calculated from sensor-reference relative absolute errors, averaged across all 1-hour means, averaged across the number of sensor units tested. These distances are precise and not binned in 20% intervals.



Bar Graphic: The longer the bar, the better the sensor followed the ups-and-downs of the actual concentrations. A long bar doesn't always mean that the sensor exactly "matched" the actual concentration, but it does mean the sensor was responding when the air was clean or dirty. A long bar also means it's possible to adjust the sensor's readings to match the actual concentrations if you can gather data side-by-side with a reference monitor to make a formula to correct the readings!

More technically, the bar length ranges between 0 to 1 and is calculated from sensor-reference coefficients of determination (R^2; square of the Pearson correlation coefficient), with 1-hour means, averaged across the number of sensor units tested.



Feature Symbols: Some sensors can be configured with extra features. The price we list in the reports was the price for the product version we tested. Your price may vary from ours. If a symbol has the word option in it, it means the manufacturer offers that option at no extra cost. If a symbol has a small $ sign in it, that means it is a paid option.

The number of **$** signs used for sensor "cost" is based on the 2022 average cell phone price of $735 (https://www.wsj.com/business/telecom/how-much-is-too-much-for-a-smartphone-3a300905), adjusted for inflation for the year we tested the sensor. One **$** sign means the sensor cost less than an average cell phone; two **$$** signs means it cost less than twice an average cell phone; three **$$$** signs means it cost more than twice an average cell phone. For other options, only one $ sign is used for simplicity as it is too complicated to describe the variety of add-on costs through symbols.

Revision History

Version	Date	Note
0	10/24/2025	Original issued report

Disclaimer: All documents, reports, data, and other information provided are for informational and/or educational use only.

Some sensors evaluated by AQ-SPEC were field-tested inside a custom-made aluminum enclosure to protect the sensors from windblown rain, harsh sunlight, and animals. The field evaluation reports contain data collected at an air monitoring station during a specific 30- to 60-day period and cannot be duplicated at a different location, season, or time period. As sensor performance may be affected by time- and location-specific environmental conditions at the test site, replication and/or duplication of results may not be possible to achieve. The sensor assembly, installation, and use can also impact the performance of products evaluated by AQ-SPEC. No sensor calibration was performed by South Coast AQMD staff for this evaluation. Laboratory chamber testing may be necessary to fully evaluate the performance of these sensors under controlled temperature, humidity, pollutant, and interferent concentrations.

South Coast AQMD makes no claim, warranty, or guarantee that these devices will or will not work when operated by other users for their specific applications.

South Coast AQMD's AQ-SPEC aims at providing information to and for the benefit of the public to make informed purchasing decisions on air quality sensors. In accordance with this mission, the general policy of the Governing Board of the Agency is to exclude all commercial advertising and promotional material, including links which provide exclusive private or financial benefit to commercial, non-public enterprises and which do not promote or enhance a public benefit to the general public. As a Government Agency, the South Coast AQMD neither endorses nor supports individual private commercial enterprises through testing of products by AQ-SPEC or through providing links to the sites of such commercial enterprises.

Report Role	Name	Date Completed
Tested by	Leslie Garcia and Randy Lam	09/04/2025
Analysis by	Namrata Shanmukh Panji, Ph.D.	09/18/2025
QC Review by	Michelle Kuang, Ph.D.	10/01/2025
Approved by	Wilton Mui, Ph.D.	10/23/2025
Revision by	-----	-----

Table of Contents

Section 1: Background

Four QuantAQ MODULAIR-PM units (IDs: 1602, 1603, 1605, and 1606) were deployed at the South Coast AQMD stationary ambient monitoring site in Mecca, CA from 07/11/2025 to 09/04/2025. The evaluation period lasted 8 weeks. The sensor units were co-located with a Teledyne T640 as a reference instrument (hereinafter T640).

Note: *This evaluation differs from the previously published 2021 report for the QuantAQ MODULAIR-PM to reflect a sensor firmware update since then. PM_1 reference data was unavailable during this evaluation. Therefore, sensor performance evaluation in this report against the reference is limited to $PM_{2.5}$ and PM_{10}.*

QuantAQ MODULAIR-PM

Test site at Mecca, CA

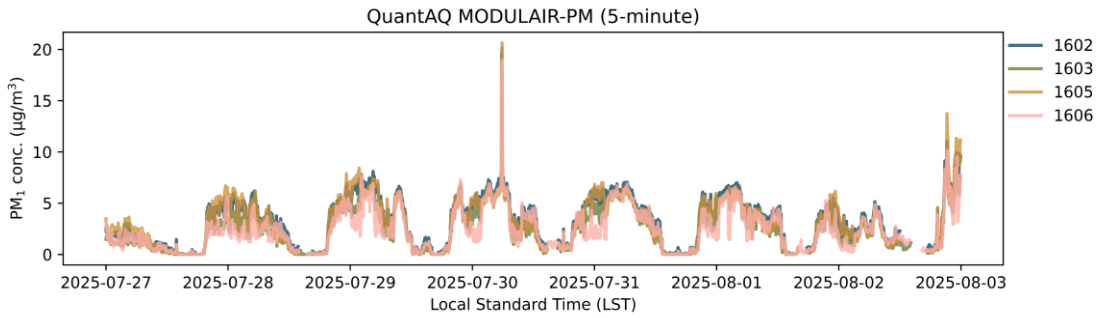
Section 2: Manufacturer Specs

Parameter	Sensor: QuantAQ MODULAIR-PM (raw sensor is Plantower PMS5003 + Alphasense OPC-N3)	Reference Instrument: Teledyne T640
Pollutant	PM_1, $PM_{2.5}$, PM_{10}	PM_1, $PM_{2.5}$ (FEM), PM_{10}
Cost	$2,495	~$21,000
Weight	4 pounds	19 pounds
Dimensions (LxWxH)	6.59 x 6.59 x 5.11 inches	7 x 17 x 14 inches
Power	5V, 2A (supply); 250 mA avg. consumption	100-240 VAC
Battery	No	No
Data transmission	Cellular (WiFi optional on some models)	Serial, Ethernet, USB
Internal memory	Yes	Yes; >1 year
Operating temperature range	-4 -113 degrees F	32-122 degrees F
Operating RH range	5-95% (non-condensing)	0%-100%
Product website	https://quant-aq.com/products/modulair-pm	https://www.teledyne-api.com/en-us/products/t640
Operating principle	Optical light scattering	Optical light scattering
Time resolution	1 minute (as-tested)	1 minute (as-configured)
Concentration range	0-2000 µg/m^3	0.1-10,000 µg/m^3

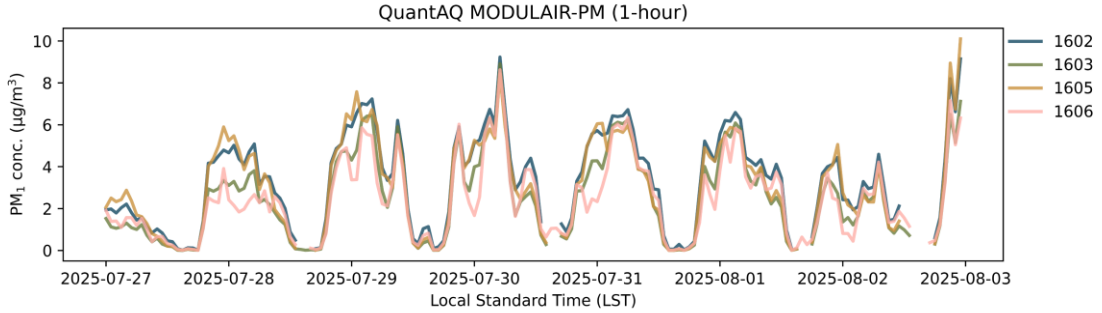
Section 3: PM_1

Section 3.1: Data Overview

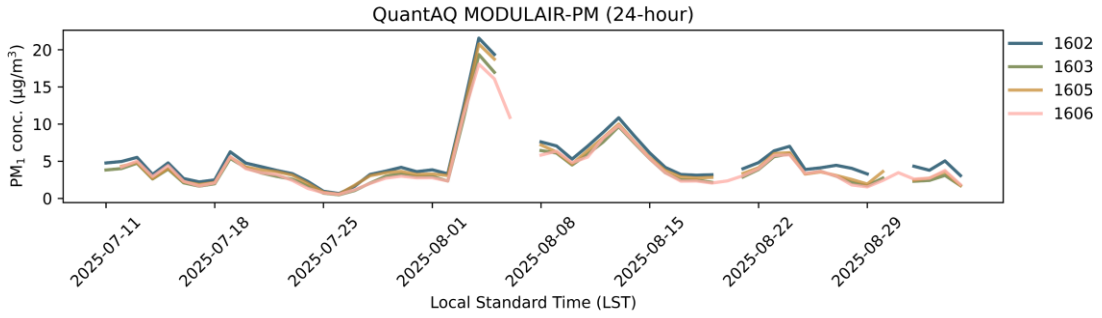
Timeseries of a 1-week subset of the 8-week evaluation



Timeseries of a 1-week subset of the 8-week evaluation



Timeseries of the 8-week evaluation



Section 3: PM_1

Section 3.2: Data Recovery

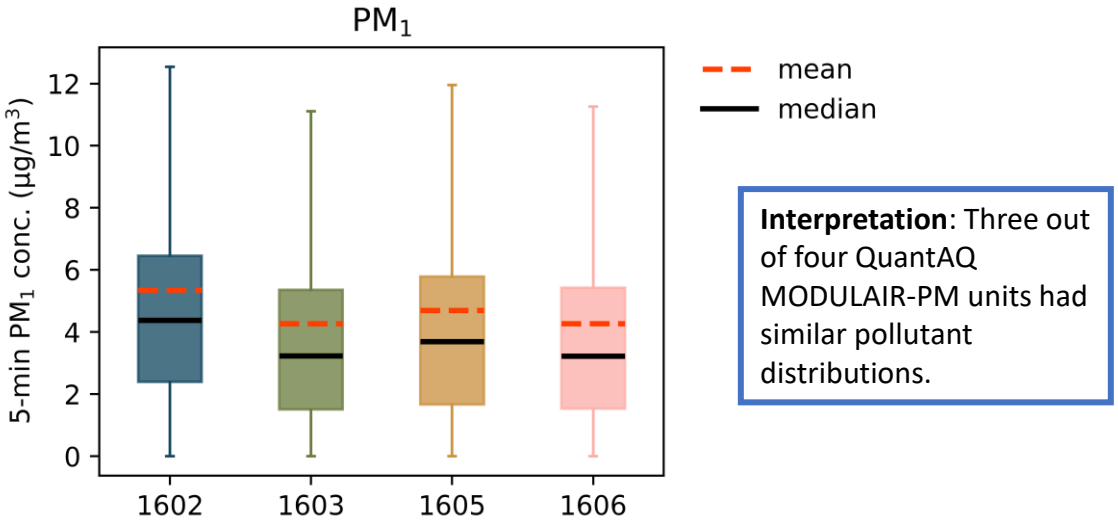
Basic QA/QC procedures such as removal of duplicate records was performed. Nulls, negatives, out of instrument bounds as specified by the manufacturer, and values flagged as invalid by the sensor were considered invalid. Data recovery was calculated as the percent of valid readings through the entire evaluation.

Parameter	1602	1603	1605	1606
PM_1	99.4%	99.5%	98.6%	98.7%

Section 3.3: Intra-Model Variability

Absolute intra-model variability was calculated as the standard deviation of the mean values of the sensors. Relative intra-model variability was calculated as the absolute intra-model variability divided by the sensor grand mean. Calculations were performed using data resampled to a 5-minute averages.

Parameter	Absolute intra-model variability (µg/m³)	Relative intra-model variability (%)
PM_1	0.5	10.7

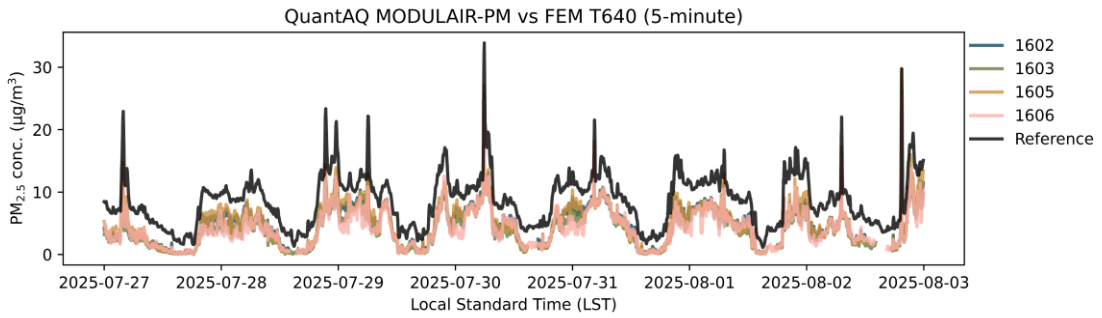


Interpretation: Three out of four QuantAQ MODULAIR-PM units had similar pollutant distributions.

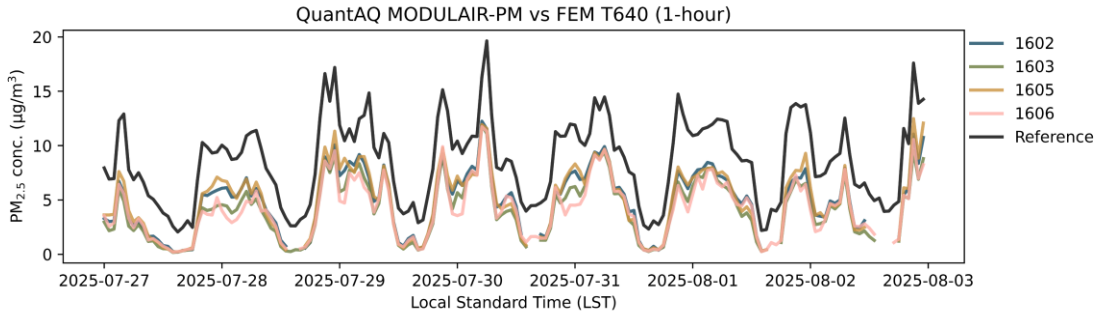
Section 4: $PM_{2.5}$

Section 4.1: Data Overview

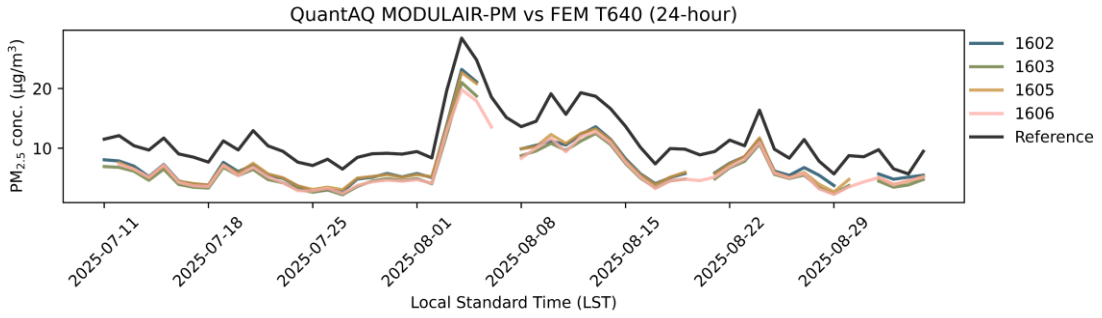
Timeseries of a 1-week subset of the 8-week evaluation



Timeseries of a 1-week subset of the 8-week evaluation



Timeseries of the 8-week evaluation



Section 4: $PM_{2.5}$

Section 4.2: Data Recovery

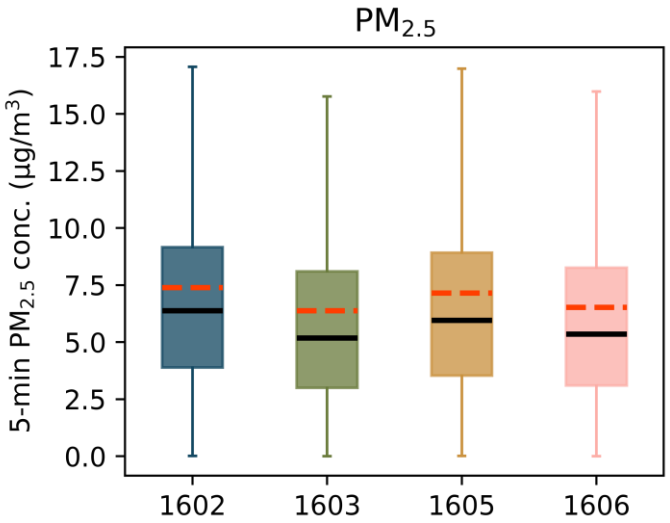
Basic QA/QC procedures such as removal of duplicate records was performed. Nulls, negatives, out of instrument bounds as specified by the manufacturer, and values flagged as invalid by the sensor were considered invalid. Data recovery was calculated as the percent of valid readings through the entire evaluation.

Parameter	1602	1603	1605	1606
$PM_{2.5}$	99.4%	99.5%	98.6%	98.7%

Section 4.3: Intra-Model Variability

Absolute intra-model variability was calculated as the standard deviation of the mean values of the sensors. Relative intra-model variability was calculated as the absolute intra-model variability divided by the sensor grand mean. Calculations were performed using data resampled to a 5-minute averages.

Parameter	Absolute intra-model variability (µg/m³)	Relative intra-model variability (%)
$PM_{2.5}$	0.5	6.8



Interpretation: The QuantAQ MODULAIR-PM units had similar pollutant distributions.

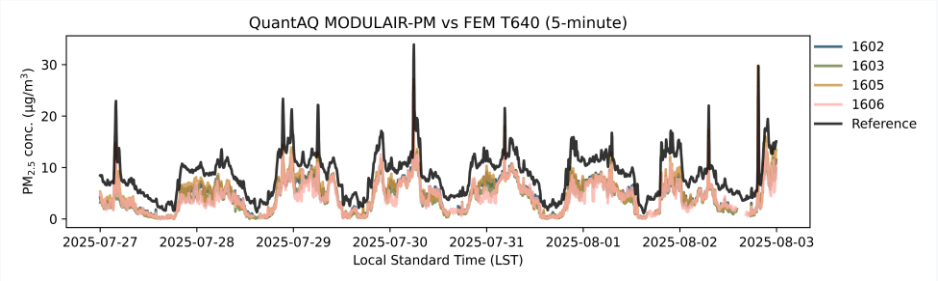
Section 4: $PM_{2.5}$

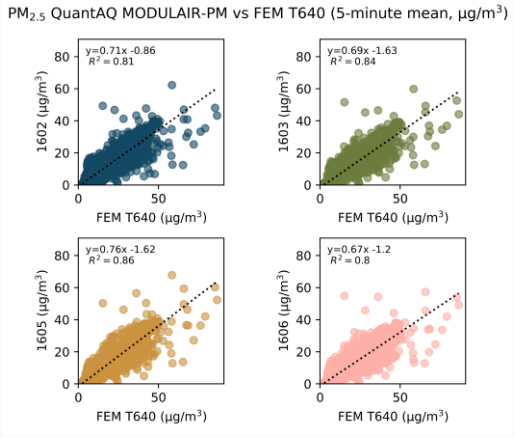
Section 4.4: Linearity (R^2)

Basic QA/QC procedures were used to validate the collected data (i.e., obvious outliers, negative values, readings flagged by the sensor, and invalid data-points were eliminated from the data-set).

A summary of the mean R^2 between the sensor and FEM T640 across all units tested.

Parameter	Time Resolution	FEM T640 (mean ± SD)
$PM_{2.5}$	5-minutes	0.83 ± 0.03
	1-hour	0.89 ± 0.03
	24-hours	0.96 ± 0.01

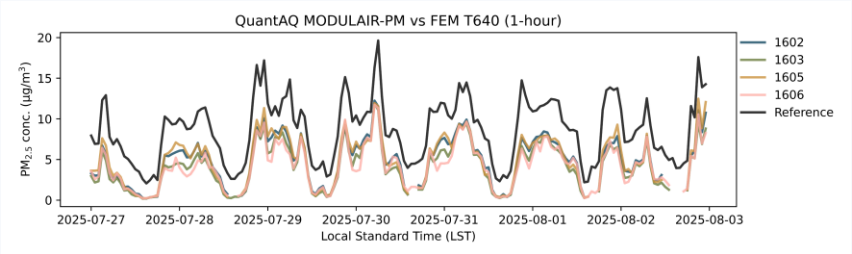


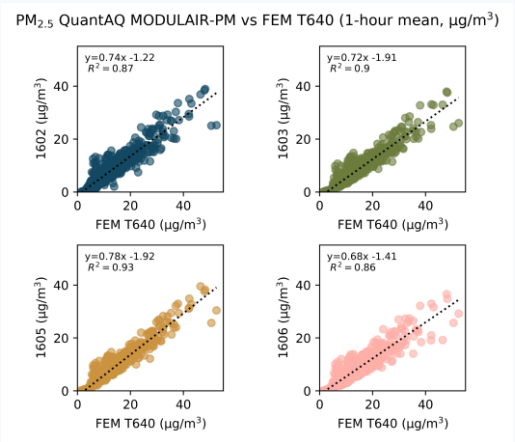


Interpretation: The QuantAQ MODULAIR-PM units showed strong correlation with the corresponding FEM T640 data ($0.8 < R^2 < 0.86$) for 5-minute averaging.

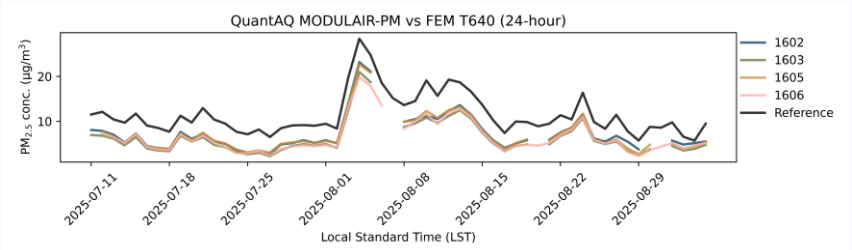
Section 4: $PM_{2.5}$

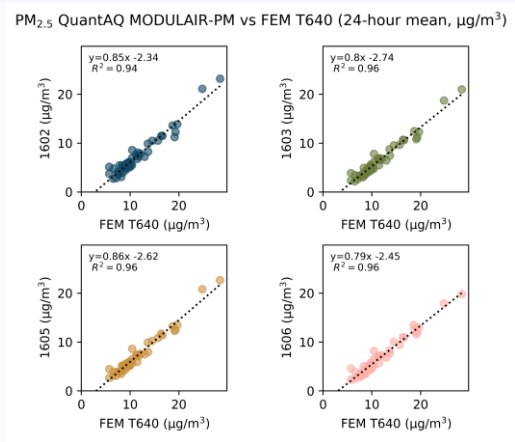
Section 4.4: Linearity (R^2)





Interpretation: The QuantAQ MODULAIR-PM units showed strong to very strong correlation with the corresponding FEM T640 data ($0.86 < R^2 < 0.93$) for 1-hour averaging.



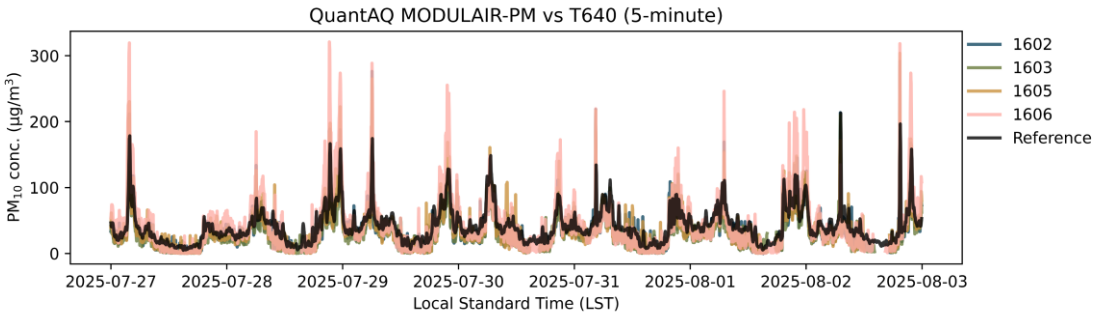


Interpretation: The QuantAQ MODULAIR-PM units showed very strong correlation with the corresponding FEM T640 data ($0.94 < R^2 < 0.96$) for 24-hour averaging.

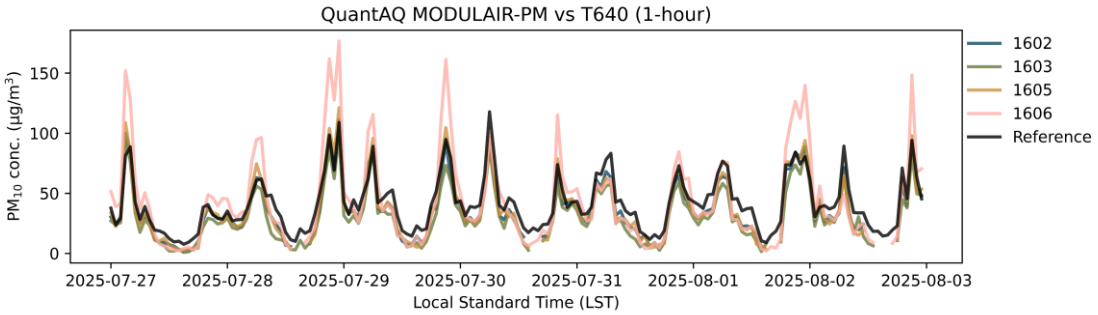
Section 5: PM_{10}

Section 5.1: Data Overview

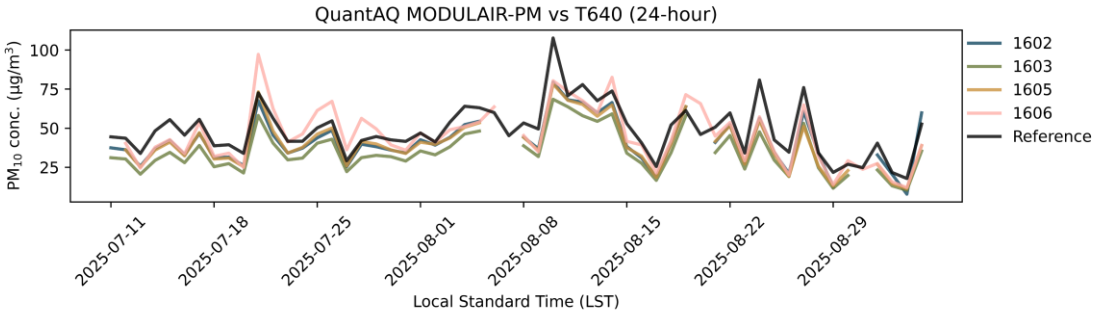
Timeseries of a 1-week subset of the 8-week evaluation



Timeseries of a 1-week subset of the 8-week evaluation



Timeseries of the 8-week evaluation



Section 5: PM_{10}

Section 5.2: Data Recovery

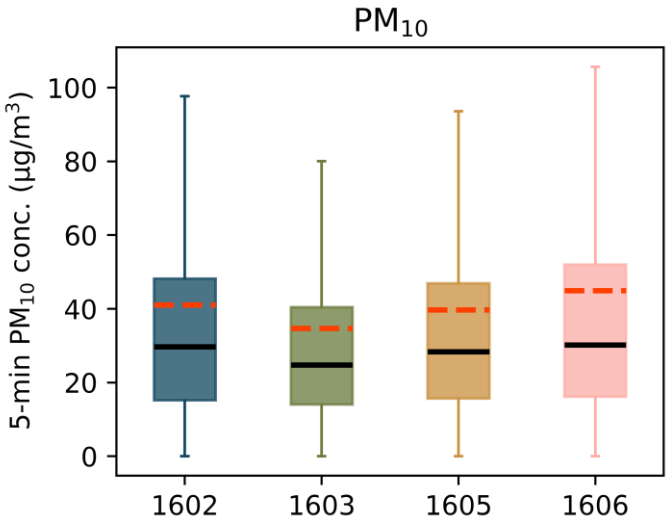
Basic QA/QC procedures such as removal of duplicate records was performed. Nulls, negatives, out of instrument bounds as specified by the manufacturer, and values flagged as invalid by the sensor were considered invalid. Data recovery was calculated as the percent of valid readings through the entire evaluation.

Parameter	1602	1603	1605	1606
PM_{10}	99.4%	99.5%	98.6%	98.7%

Section 5.3: Intra-Model Variability

Absolute intra-model variability was calculated as the standard deviation of the mean values of the sensors. Relative intra-model variability was calculated as the absolute intra-model variability divided by the sensor grand mean. Calculations were performed using data resampled to a 5-minute averages.

Parameter	Absolute intra-model variability (µg/m³)	Relative intra-model variability (%)
PM_{10}	4.4	10.9



Interpretation: Three out of four QuantAQ MODULAIR-PM units had similar pollutant distributions.

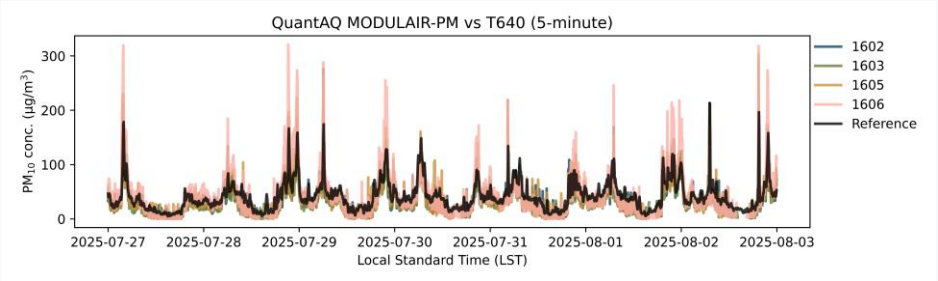
Section 5: PM_{10}

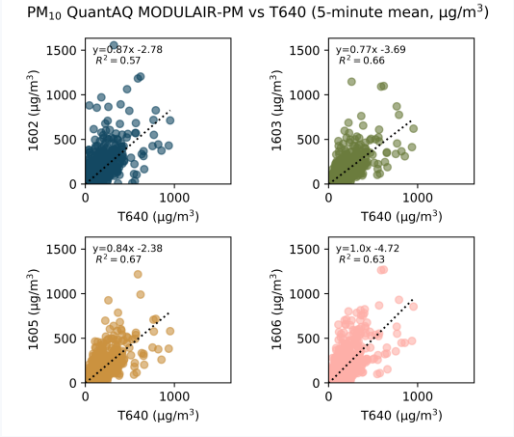
Section 5.4: Linearity (R^2)

Basic QA/QC procedures were used to validate the collected data (i.e., obvious outliers, negative values, readings flagged by the sensor, and invalid data-points were eliminated from the data-set).

A summary of the mean R^2 between the sensor and T640 across all units tested.

Parameter	Time Resolution	T640 (mean ± SD)
PM_{10}	5-minutes	0.63 ± 0.05
	1-hour	0.84 ± 0.06
	24-hours	0.85 ± 0.09

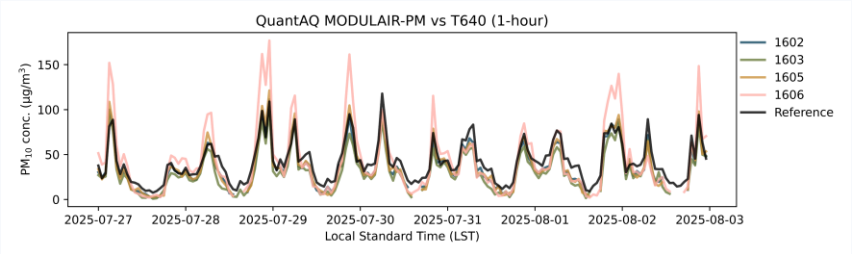


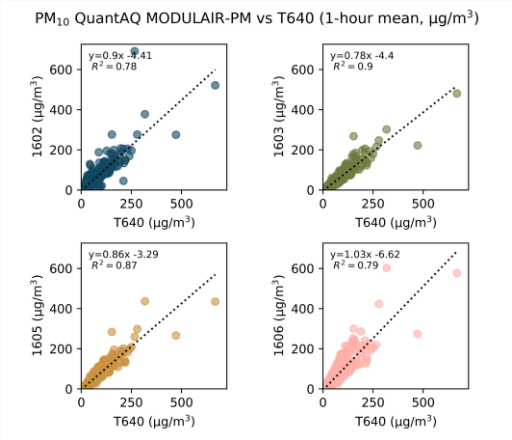


Interpretation: The QuantAQ MODULAIR-PM units showed moderate correlation with the corresponding T640 data ($0.57 < R^2 < 0.67$) for 5-minute averaging.

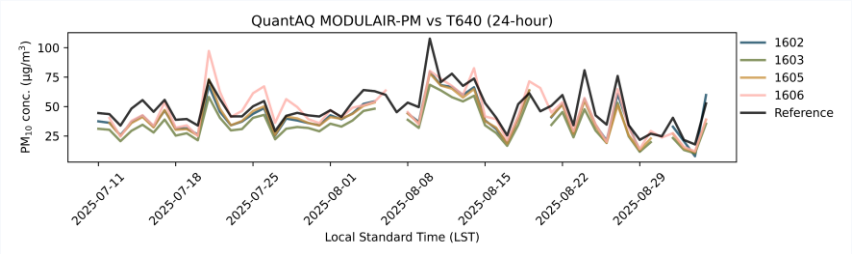
Section 5: PM_{10}

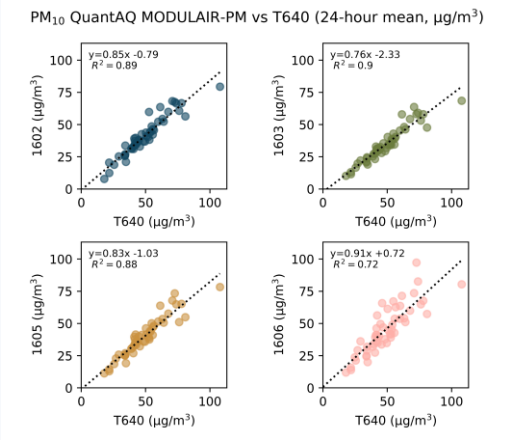
Section 5.4: Linearity (R^2)





Interpretation: The QuantAQ MODULAIR-PM units showed strong correlation with the corresponding T640 data ($0.78 < R^2 < 0.9$) for 1-hour averaging.





Interpretation: The QuantAQ MODULAIR-PM units showed strong correlation with the corresponding T640 data ($0.72 < R^2 < 0.9$) for 24-hour averaging.

Section 6: Summary Metrics

		PM_1		
		5-min averages	1-hr averages	24-hr averages
QuantAQ MODULAIR-PM	Average*	4.6	4.6	4.6
	SD*	4.6	4.5	3.6
	Range*	0.0 to 64.4	0.0 to 37.4	0.5 to 21.6
	PM_c Conc.*	-	-	-
	Fine Fraction	-	-	-
FEM T640	Average*	-	-	-
	SD*	-	-	-
	Range*	-	-	-
	PM_c Conc.*	-	-	-
	Fine Fraction	-	-	-
QuantAQ MODULAIR-PM vs. FEM T640	R^2	-	-	-
	Slope	-	-	-
	Intercept*	-	-	-
	MBE*	-	-	-
	MAE*	-	-	-
	RMSE*	-	-	-

*Units in $\mu g/m^3$

Section 6: Summary Metrics

		$PM_{2.5}$		
		5-min averages	1-hr averages	24-hr averages
QuantAQ MODULAIR-PM	Average*	6.9	6.9	6.8
	SD*	5.5	5.1	3.9
	Range*	0.0 to 67.8	0.1 to 39.5	2.2 to 23.2
	PM_c Conc.*	28.3 to 38.4	28.5 to 38.6	28.5 to 38.8
	Fine Fraction	0.24 to 0.31	0.2 to 0.25	0.16 to 0.19
FEM T640	Average*	11.5	11.5	11.5
	SD*	7	6.6	4.6
	Range*	1.0 to 86.5	1.3 to 52.5	5.7 to 28.4
	PM_c Conc.*	37.3	37.3	37.3
	Fine Fraction	0.28	0.27	0.24
QuantAQ MODULAIR-PM vs. FEM T640	R^2	0.8 to 0.86	0.86 to 0.93	0.94 to 0.96
	Slope	0.67 to 0.76	0.68 to 0.78	0.79 to 0.86
	Intercept*	-1.6 to -0.9	-1.9 to -1.2	-2.7 to -2.3
	MBE*	-5.2 to -4.3	-5.2 to -4.3	-5.0 to -4.1
	MAE*	4.4 to 5.3	4.4 to 5.3	4.1 to 5.0
	RMSE*	5.2 to 6.1	4.9 to 5.8	4.3 to 5.1

*Units in $\mu g/m^3$

Section 6: Summary Metrics

		PM_{10}		
		5-min averages	1-hr averages	24-hr averages
QuantAQ MODULAIR-PM	Average*	40.1	40.3	40.4
	SD*	52.2	40.5	15.6
	Range*	0.0 to 1556.4	0.6 to 691.5	7.8 to 97.2
	PM_c Conc.*	28.3 to 38.4	28.5 to 38.6	28.5 to 38.8
	Fine Fraction	0.24 to 0.31	0.2 to 0.25	0.16 to 0.19
T640	Average*	48.8	48.7	48.7
	SD*	46.8	40.3	16.8
	Range*	4.0 to 952.0	6.1 to 668.1	17.8 to 107.7
	PM_c Conc.*	37.3	37.3	37.3
	Fine Fraction	0.28	0.27	0.24
QuantAQ MODULAIR-PM vs. T640	R^2	0.57 to 0.67	0.78 to 0.9	0.72 to 0.9
	Slope	0.77 to 1.0	0.78 to 1.03	0.76 to 0.91
	Intercept*	-4.7 to -2.4	-6.6 to -3.3	-2.3 to 0.7
	MBE*	-15.3 to -5.0	-15.3 to -4.9	-14.2 to -3.6
	MAE*	17.3 to 19.2	12.3 to 15.8	8.5 to 14.2
	RMSE*	31.0 to 37.7	18.0 to 22.5	9.9 to 15.4

*Units in $\mu g/m^3$