AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Field Evaluation Report for

IKEA Vindstyrka

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Performance Snapshot

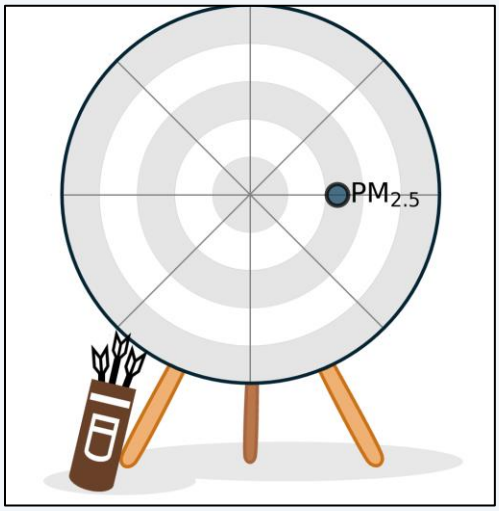
IKEA Vindstyrka

Tested: 08/21/2025 to 09/24/2025

○ 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

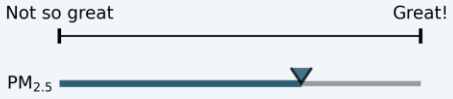
✓ Tested ● Not tested ○ Not available

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?

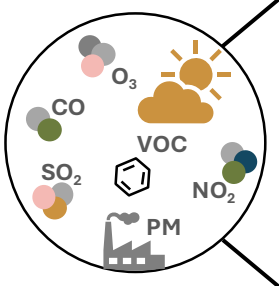


A longer bar means the sensor did a better job of tracking the real changes in air pollution levels — going up when the concentration levels went up, and down when they dropped.

~~$~~ Cost	~~Web portal~~	~~0.3 lb~~ Weight	~~Display~~	~~Battery~~	~~Solar~~	~~Weatherproof~~
~~Wi-Fi~~	~~Cellular~~	~~Bluetooth~~	~~Internal memory~~	~~Serial~~	~~USB~~	~~Ethernet~~

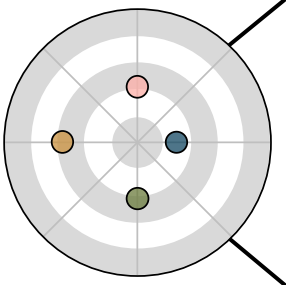
F20251201.0

Performance Snapshot Guide



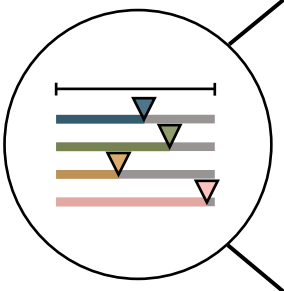
Pollutant List: This list shows the pollutants that the sensor is capable of measuring. Pollutants highlighted in blue with a check mark were tested for performance, those in gray were not tested, and those in white are not measured by the sensor.

◆ **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		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
Tested by	Emily Bermudez, Leslie Garcia, Randy Lam	09/24/2025
Analysis by	Ehsan Mosadegh	11/14/2025
Quality Control Review by	Namrata Shanmukh Panji	11/18/2025
Approved by	Wilton Mui	12/4/2025
Revision by		

Table of Contents

Section 1: Background

Three IKEA Vindstyrka (hereinafter IKEA) units (IDs: sensor1, sensor2, sensor3) were deployed at the South Coast AQMD stationary ambient monitoring site in Rubidoux, CA from 08/21/2025 to 09/24/2025. The evaluation period lasted 5 weeks. The sensor units were co-located with reference grade instruments as described below.

Note: *The IKEA sensors do not allow datalogging / data retrieval. A custom datalogging script was created in Python, which ran on a laptop to poll the data from the IKEA sensors at 1-minute intervals. The duration of this evaluation was only 5 weeks due to facility and laptop issues.*

Ikea Vindstyrka

Test site at Rubidoux, CA

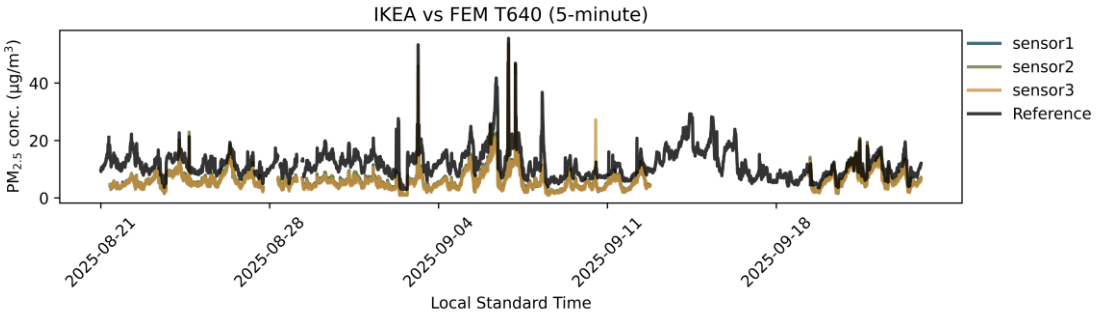
Section 2: Manufacturer Specs

Parameter	Sensor: IKEA Vindstyrka (raw sensor is Sensirion SEN54)	Reference Instrument: Teledyne API T640
Pollutant	$PM_{2.5}$	PM_1, $PM_{2.5}$ (FEM), PM_{10}
Cost	$60	~$21,000
Weight	0.3 pounds	19 pounds
Dimensions (LxWxH)	3.5 x 2 x 2.25 inches	7 x 17 x 14 inches
Power	5 VDC	100-240 VAC
Battery	No	No
Data transmission	None	Serial, Ethernet, USB
Internal memory	No	Yes (with USB flash drive)
Operating temperature range	14-122 degrees F	32-122 degrees F
Operating RH range	0-90%	0%-100%
Product website	https://www.ikea.com/us/en/p/vindstyrka-air-quality-sensor-smart-30498239/	https://www.teledyne-api.com/en-us/products/t640
Operating principle	Optical light scattering	Optical light scattering
Time resolution	N/A (see note above)	1 minute (as-configured)
Concentration range	0-1,000 µg/m^3	0.1-10,000 µg/m^3

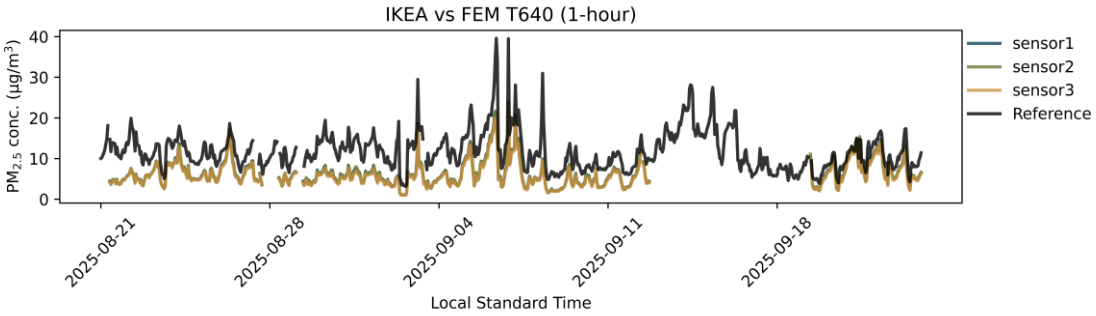
Section 3: $PM_{2.5}$

Section 3.1: Data Overview

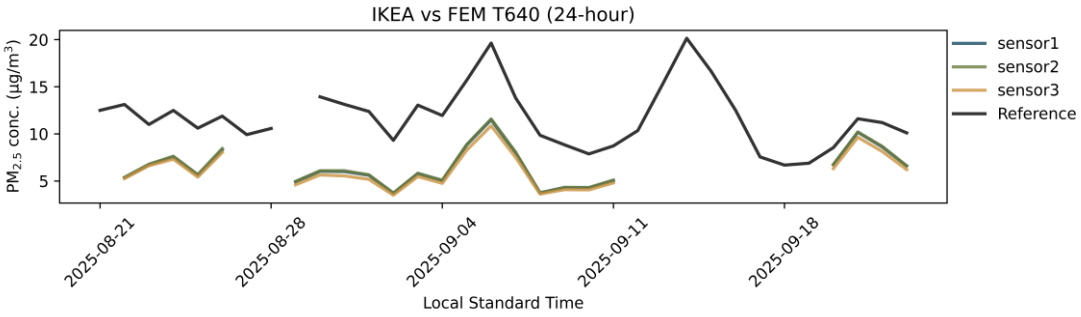
Timeseries of the 5-week evaluation



Timeseries of the 5-week evaluation



Timeseries of the 5-week evaluation



Section 3: $PM_{2.5}$

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.

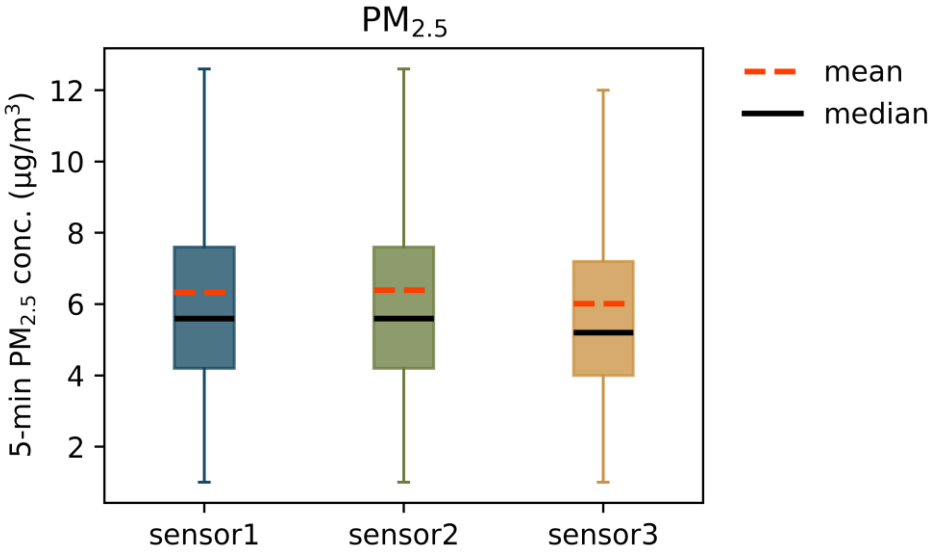
Parameter	sensor1	sensor2	sensor3
$PM_{2.5}$	NA	NA	NA

Note: *The IKEA sensors do not allow datalogging / data retrieval. Therefore, the data recovery metric is not calculable.*

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 5-minute averages.

Parameter	Absolute intra-model variability ($\mu g/m^3$)	Relative intra-model variability (%)
$PM_{2.5}$	0.2	3.2



Interpretation: Two out of three IKEA units had similar pollutant distributions.

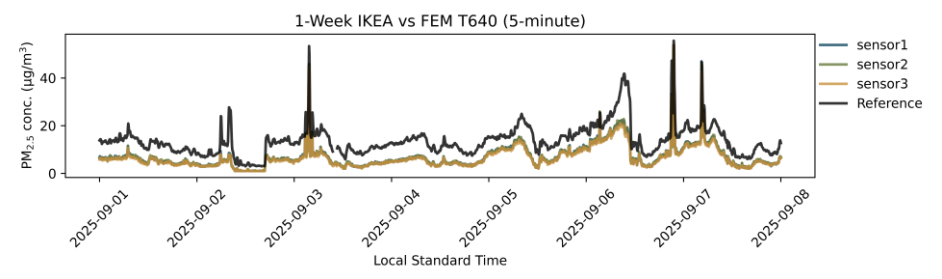
Section 3: $PM_{2.5}$

Section 3.4: Linearity (R^2)

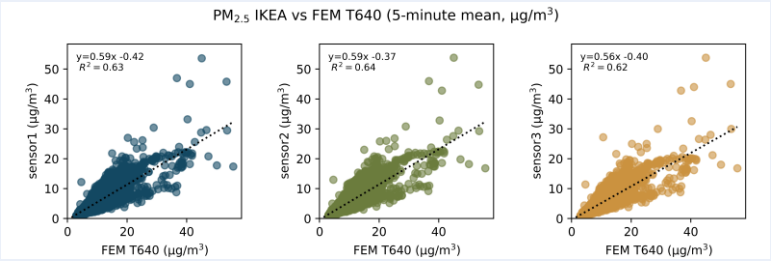
Basic QA/QC procedures were used to validate the collected data (i.e., obvious outliers, negative values, readings flagged by the sensor, and invalid data-points were eliminated from the data-set).

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-minute	0.63 ± 0.01
	1-hour	0.67 ± 0.00
	24-hour	0.45 ± 0.01



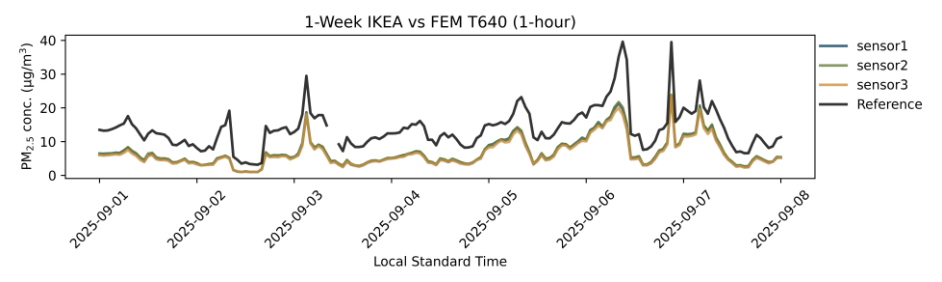
Timeseries of a 1-week subset of the 5-week evaluation



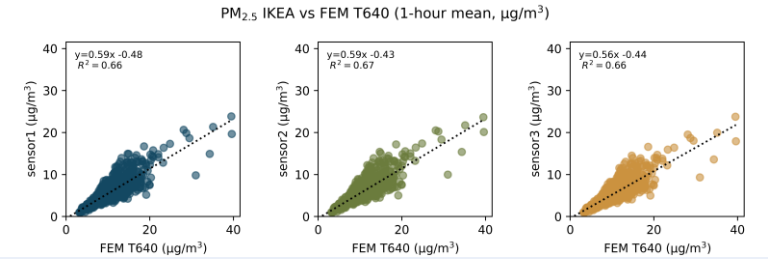
Interpretation: The IKEA units showed moderate correlation with the corresponding FEM T640 data ($0.62 < R^2 < 0.64$) for 5-minute averaging.

Section 3: $PM_{2.5}$

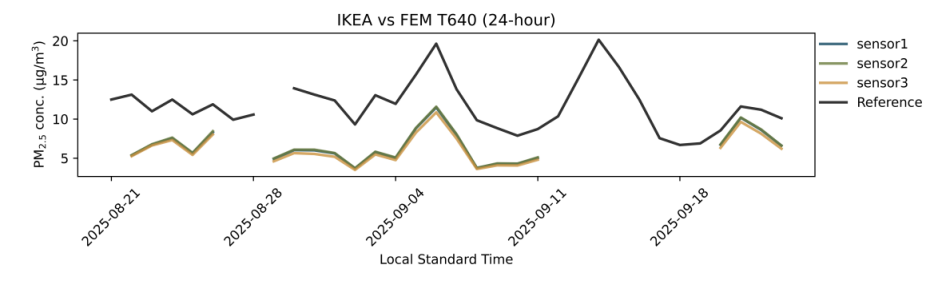
Section 3.4: Linearity (R^2)

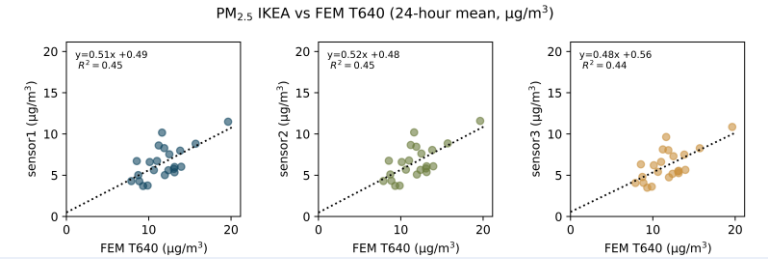


Timeseries of a 1-week subset of the 5-week evaluation



Interpretation: The IKEA units showed moderate correlation with the corresponding FEM T640 data ($0.66 < R^2 < 0.67$) for 1-hour averaging.





Interpretation: The IKEA units showed weak correlation with the corresponding FEM T640 data ($0.44 < R^2 < 0.45$) for 24-hour averaging.

Section 4: Summary Metrics

		$PM_{2.5}$		
		5-minute averages	1-hour averages	24-hour averages
IKEA	Average*	6.25	6.25	6.36
	SD*	3.34	3.16	2.00
	Range*	1.00 to 53.80	1.00 to 23.86	3.50 to 11.59
	CV (RSD, %)	53.55	50.57	31.43
FEM T640	Average*	11.75	11.75	11.75
	SD*	4.87	4.73	3.22
	Range*	2.97 to 55.62	3.16 to 39.60	6.69 to 20.15
	CV (RSD, %)	41.46	40.24	27.39
IKEA vs. FEM T640	Pearson R^2	0.62 to 0.64	0.66 to 0.67	0.44 to 0.45
	Spearman ρ	0.78 to 0.79	0.79 to 0.80	0.53
	Kendall τ	0.60 to 0.61	0.60 to 0.61	0.39 to 0.40
	Slope	0.56 to 0.59	0.56 to 0.59	0.48 to 0.52
	Intercept*	-0.42 to -0.37	-0.48 to -0.43	0.48 to 0.56
	MBE*	-5.47 to -5.10	-5.48 to -5.11	-5.57 to -5.18
	$nMBE_{mean}$	-0.48 to -0.44	-0.48 to -0.44	-0.47 to -0.44
	$nMBE_{range}$	-0.10	-0.15 to -0.14	-0.47 to -0.44
	MAE*	5.12 to 5.49	5.11 to 5.48	5.18 to 5.57
	$nMAE_{mean}$	0.45 to 0.48	0.44 to 0.48	0.44 to 0.47
	$nMAE_{range}$	0.10	0.14 to 0.15	0.44 to 0.47
	RMSE*	5.81 to 6.17	5.72 to 6.08	5.54 to 5.91
	$nRMSE_{mean}$	0.51 to 0.54	0.50 to 0.53	0.47 to 0.50
	$nRMSE_{range}$	0.11 to 0.12	0.16 to 0.17	0.47 to 0.50

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

Summary Metrics Guide

Average:	average or mean of the dataset
SD:	standard deviation (σ); measure of variation of the values about its mean
Range:	the highest and the lowest values observed
CV (RSD):	coefficient of variation (relative standard deviation); the ratio of the standard deviation to the mean of the dataset, expressed as a percentage
Pearson R^2:	the squared value of the Pearson correlation coefficient; the square of the covariance of the reference and sensor measurements divided by the product of their standard deviations (a value from 0 to 1)
Spearman ρ:	Spearman's rank correlation coefficient; a measure of how well the reference and sensor measurements follow a monotonic relationship, based on their ranked values (a value from -1 to 1)
Kendall τ:	Kendall's rank correlation coefficient; a measure of the agreement in ordering between paired reference and sensor measurements, based on how often the pairs are in the same vs. opposite order (a value from -1 to 1)
Slope:	change in the sensor's value per unit increase in the reference monitor's value
Intercept:	the sensor's value when the reference monitor observes zero
MBE:	mean bias error; mean of the differences between reference and sensor measurements
$nMBE_{mean}$:	mean bias error normalized with respect to the reference mean value
$nMBE_{range}$:	mean bias error normalized with respect to the difference of the highest and lowest reference values
MAE:	mean absolute error; mean of the absolute differences between reference and sensor measurements
$nMAE_{mean}$:	mean absolute error normalized with respect to the reference mean value
$nMAE_{range}$:	mean absolute error normalized with respect to the difference of the highest and lowest reference values
RMSE:	root mean square error; the square root of the average squared differences between reference and sensor measurements
$nRMSE_{mean}$:	root mean square error normalized with respect to the reference mean value
$nRMSE_{range}$:	root mean square error normalized with respect to the difference of the highest and lowest reference values