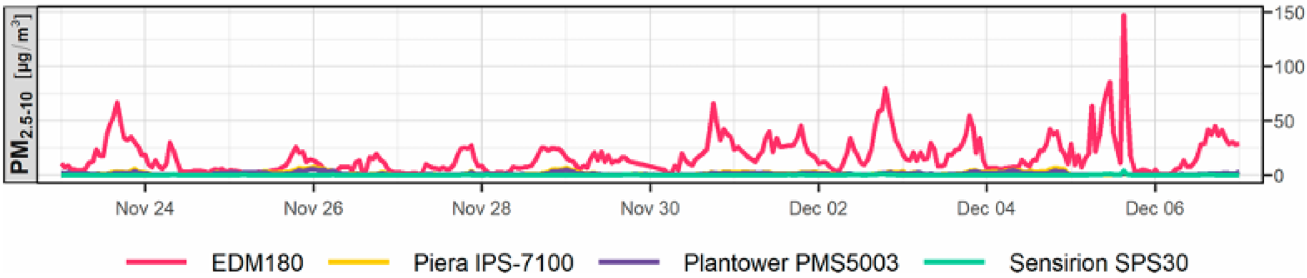
Measuring PM10 particulate matter

The Institute of Air Quality Management (IAQM) has highlighted problems when using Low Cost Sensors (LCS) for PM10 measurement, especially at concentrations near or above the action level of 190 µg/m^3. The IAQM September 2025 Position Statement on the *"Use of Low Cost Sensor Systems for PM10"* is available here.

Low-Cost Sensors for PM10 have the following drawbacks:

- They use a fan to pull the sample airflow through the sensor. The fan DOES NOT create enough pressure to force the air through an air filter to create clean air to protect the optics and fan. Consequently, the fan and optics quickly become blocked and obscured at high PM10 concentrations.
- They have no flow control mechanism to compensate for the fan becoming clogged with dust.
- They detect light scattered sideways by the particles, the intensity of the sideways scatter depends on whether the particles are black or white.
- They don't have a heated inlet to remove water droplets in mist.
- Their response to the larger PM10 particles is poor and PM10 readings are derived from extrapolated PM1 readings. When compared to a reference sampler, the regression analysis correlation coefficient R^2 for the PM10 size fraction is less than 0.3

For more performance related information, please see *"Size Resolved Field Performance of Low-Cost Sensors"*, available here.



The above chart illustrates how Low Cost Sensors lack sensitivity to the $PM_{2.5\text{-}10}$ size fraction when compared to the Grimm EDM180 reference instrument.

Turnkey® does not manufacture Low Cost Sensors for PM10 dust measurement. Our Osiris, Topas, DustMate and iPM instruments have these important distinguishing features:

- They use a positive displacement pump with air filter, not a fan. The air filter is used to generate a clean air-wash to prevent dust deposition in the pump and on the optical components. The filter can also be used to collect particles for material analysis.
- They have a volumetric flow controller, the latest iPM models even give a readout and record the airflow in their reports.
- They detect light scattered by the particles in the forward direction, through 10 degrees or less. This is the diffracted component of the scatter and is virtually the same for black or white particles of the same size.
- They have a heated sample inlet that can be operated at constant sample air temperature or constant sample air Relative Humidity. Particles can swell in size in humid conditions, so maintaining a constant RH is important. Without inlet heating, water droplets in the mist from dust suppression equipment could be recorded as exceeding action levels.
- The regression analysis correlation coefficient R^2 for PM10 is 0.99

An independent PM10 equivalence comparison took place between March 2014 and July 2015 at two sites in the city of Kuopio, 400 km northeast of Helsinki. The location represented inland conditions well away from maritime influences. The city is surrounded by lakes, forests and agricultural areas.

The study was undertaken by the Finnish Meteorological Institute and the full report is available from www.fmi.fi, *"Demonstration of the equivalence of PM measurements in Kuopio 2014-2015"*, Walden et al. Finnish Meteorological Institute Report 2017:1

Two Turnkey OSIRIS instruments and two approved PM10 reference samplers were co-located at the sampling sites for three seasons (winter, spring and summer). The reference samplers were Leckel SEQ47/50 sequential gravimetric samplers, designated as a PM10 reference method in accordance with CEN EN 12341.

The maximum 24-hour average Osiris PM10 reading was nearly 300 µg/m^3. Note this is the 24-hour mean and peaks during the day would have been much higher. It is clear the response is linear and the PM10 correlation coefficient R^2 is 0.988

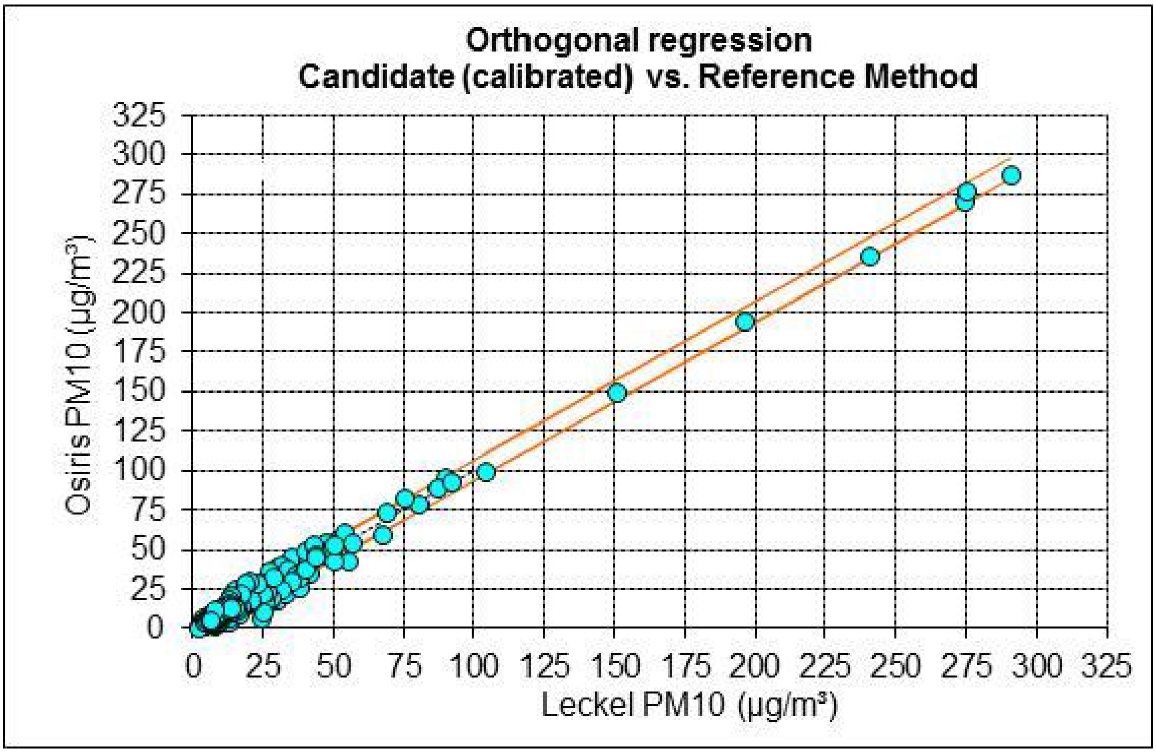
By way of comparison, the reported Low Cost Sensor correlation coefficients for PM10 are are less than 0.3 and LCS have little or no response to the $PM_{2.5\text{-}10}$ fraction.

After local calibration, the expanded relative uncertainty of the OSIRIS instruments when compared to the CEN reference method is 15.7%. This is much better than the 25% maximum measurement uncertainty required to meet the performance requirements of the EU Air Quality Directive 2008/50/EC.

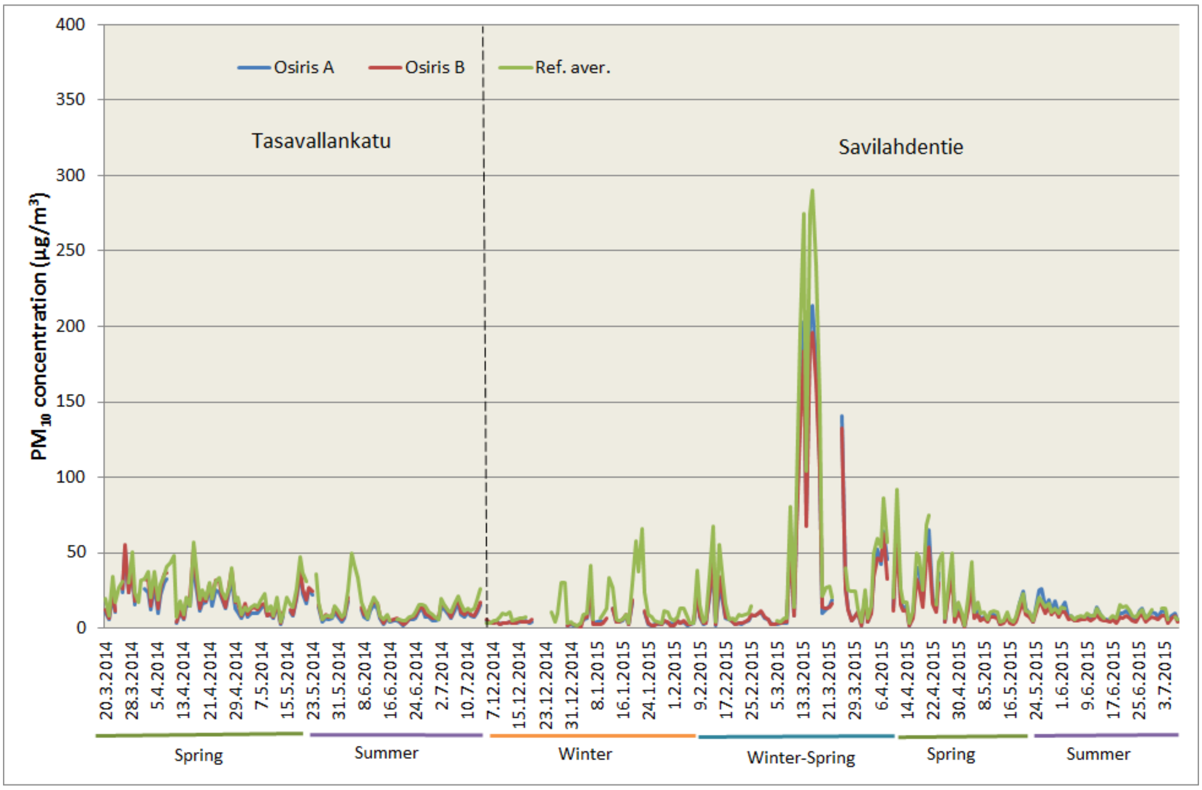
284 daily means were recorded over 3 seasons

A summary of the results of these trials is reproduced below

RAW DATA			RESULTS AFTER CALIBRATING		
Regression	1,401y + -0,153		N (Spring)	142	n
Regression (i=0)	1,398y		N (Summer)	73	n
N	284	n	N (Fall)	0	n
			N (Winter)	69	n
Outliers	15	n	Outliers	31	n
Outliers	5,3%	%	Outliers	10,9%	%
Mean CM	15,9	µg/m³	Mean CM	22,132	µg/m³
Mean RM	22,1	µg/m³	Mean RM	22,132	µg/m³
Number of RM > 0,6 * LV	48	n	Number of CM > 0,6 * LV	48	n
Number of RM > LV	19	n	Number of CM > LV	21	n
REGRESSION RESULTS (RAW)			**REGRESSION RESULTS (CALIBRATED)**		
Slope b	0,71389	significant	Slope b	1,002	
Uncertainty of b	0,005		Uncertainty of b	0,007	
Intercept a	0,10954		Intercept a	-0,045	
Uncertainty of a	0,200		Uncertainty of a	0,281	
r^2	0,988		r^2	0,988	
Slope b forced trough origin	0,715	significant			
Uncertainty of b (forced)	0,0040				
EQUIVALENCE TEST (RAW)			**EQUIVALENCE TEST (CALIBRATED)**		
Uncertainty of calibration	0,31	µg/m³	Calibration	1,401y -0,153	
Uncertainty of calibration (forced)	0,20	µg/m³	u(calibration)	0,310	µg/m³
Random term	2,71	µg/m³	Random term	3,93	µg/m³
Additional uncertainty (optional)	0,00	µg/m³	Additional uncertainty (optional)	0,00	µg/m³
Bias at LV	-14,20	µg/m³	Bias at LV	0,06	µg/m³
Combined uncertainty	14,45	µg/m³	Combined uncertainty	3,93	µg/m³
Expanded relative uncertainty	57,8%	**fail**	Expanded relative uncertainty	15,7%	***pass***
Ref sampler uncertainty	1,00	µg/m³	Ref sampler uncertainty	1,00	µg/m³
Limit value	50	µg/m³	Limit value	50	µg/m³



OSIRIS PM10 linearity



Comparative seasonal PM10 time series

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