



AQ-SPEC

Air Quality Sensor Performance Evaluation Center

AQ-SPEC Team

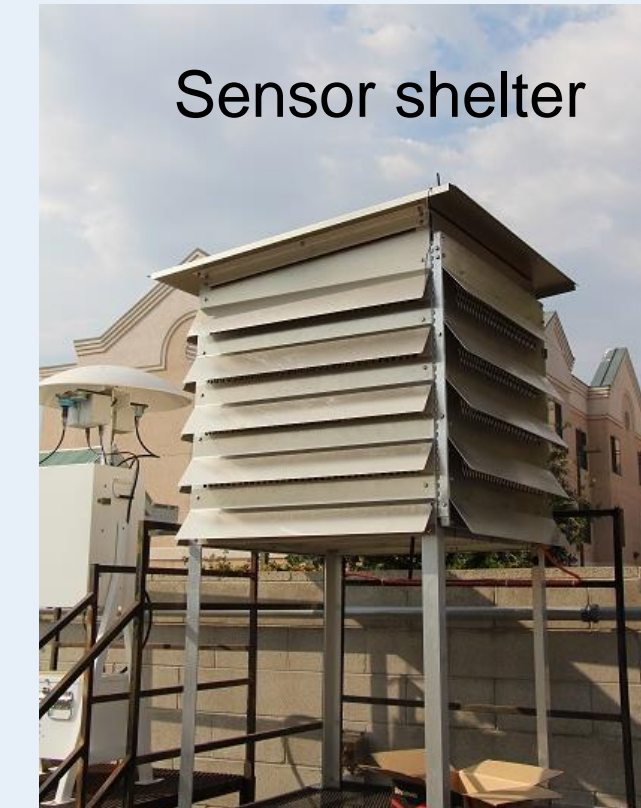
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Background

- Established in July 2014
- Main Goals & Objectives
 - Evaluate the performance of low-cost air quality sensors
 - Provide guidance and clarity for sensor technology and data interpretation
 - Catalyze the successful evolution, development, and use of sensor technology
- Sensor Selection Criteria
 - Commercially available
 - Real- or near-real time
 - Criteria pollutants & air toxics

Field Evaluation

- Sensor are tested in triplicate
- 2-month deployment
- SCAQMD's Air Monitoring Stations
 - Rubidoux location (main)
 - I-710 Near-Road location
- Evaluation parameters
 - Correlation coefficient with Federal Reference Method/Federal Equivalent Method instruments
 - Data recovery
 - Intra-model variability



Laboratory Evaluation

- Laboratory testing is conducted in a T/RH controlled environmental chamber
- Chamber is equipped with particle and gas generation systems
- Evaluation parameters:
 - Accuracy
 - Precision
 - Detection limit
 - Linear correlation coefficient
 - Interferents
 - Climate Susceptibility



Results (www.aqmd.gov/aq-spec)

PM Sensors							
Sensor Image	Manufacturer (Model)	Type	Pollutant(s)	Approx. Cost (USD)	*Field R ²	*Lab R ²	Summary Report
	AethLabs (microAeth)	Optical	BC (Black Carbon)	~\$6,500	R ² ~ 0.79 to 0.94		
	Air Quality Egg (Version 1)	Optical	PM	~\$200	R ² ~ 0.0		
	Air Quality Egg (Version 2)	Optical	PM	~\$240	PM _{1.0} : R ² ~ 0.79 to 0.85 PM _{2.5} : R ² ~ 0.31 to 0.40		
	Alphasense (OPC-N2)	Optical	PM _{1.0} , PM _{2.5} & PM ₁₀	~\$450	PM _{1.0} : R ² ~ 0.63 to 0.82 PM _{2.5} : R ² ~ 0.38 to 0.80 PM ₁₀ : R ² ~ 0.41 to 0.60	R ² ~ 0.99	PDF (1,291 KB)
	Dylos (DC1100)	Optical	PM _{1.0} , PM _{2.5}	~\$300	R ² ~ 0.65 to 0.85	R ² ~ 0.89	PDF (1,384 KB)
	Foobot	Optical	PM _{2.5}	~\$200	R ² ~ 0.55		
	HabitatMap (AirBeam)	Optical	PM _{1.0}	~\$200	R ² ~ 0.65 to 0.70	R ² ~ 0.87	PDF (1,144 KB)
	Hanvon (Hanvon N1)	Optical	PM _{2.5}	~\$200	R ² ~ 0.52 to 0.79		
	MetOne (Neighborhood Monitor)	Optical	PM _{1.0}	~\$1,900	R ² ~ 0.53 to 0.67		
	Mojji China (Airmut)	Optical	PM _{2.5}	~\$150	R ² ~ 0.81 to 0.88		
	Nanos (Partector)	Electrical	PM (LDS: Lung-Deposited Surface Area)	~\$7,000	PM _{1.0} : R ² ~ 0.1 PM _{2.5} : R ² ~ 0.2		
	Origins (Laser Egg)	Optical	PM _{2.5} & PM ₁₀	~\$200	PM _{2.5} : R ² ~ 0.58 PM ₁₀ : R ² ~ 0.0		
	Perkin Elmer (ELM)	Optical	PM	~\$5,200	R ² ~ 0.0		
	PurpleAir (PA-1)	Optical	PM _{1.0} , PM _{2.5} & PM ₁₀	~\$150	PM _{1.0} : R ² ~ 0.93 to 0.95 PM _{2.5} : R ² ~ 0.77 to 0.92 PM ₁₀ : R ² ~ 0.32 to 0.44	PM _{1.0} : R ² ~ 0.95 PM _{2.5} : R ² ~ 0.99 PM ₁₀ : R ² ~ 0.97	PDF (1,072 KB)
	PurpleAir (PA-II)	Optical	PM _{1.0} , PM _{2.5} & PM ₁₀	~\$200	PM _{1.0} : R ² ~ 0.96 to 0.98 PM _{2.5} : R ² ~ 0.93 to 0.97 PM ₁₀ : R ² ~ 0.66 to 0.70		PDF (1,087 KB)
	RTI (MicroPEM)	Optical	PM _{1.0}	~\$2,000	R ² ~ 0.65 to 0.90	R ² ~ 0.99	PDF (1,156 KB)
	Shinyei (PM Evaluation Kit)	Optical	PM _{1.0}	~\$1,000	R ² ~ 0.80 to 0.90	R ² ~ 0.93	PDF (1,156 KB)
	Speck	Optical	PM _{1.0}	~\$150	R ² ~ 0.32		
	TSI (AirAssure)	Optical	PM _{1.0}	~\$1,500	R ² ~ 0.82		

Gaseous Sensors							
Sensor Image	Manufacturer (Model)	Type	Pollutant(s)	Approx. Cost (USD)	*Field R ²	*Lab R ²	Summary Report
	2B Technologies (POM)	UV absorption (PEM Method)	O ₃	~\$4,500	R ² ~ 1.00	R ² ~ 0.99	PDF (1,295 KB)
	Aeroqual (S-500)	Metal Oxide	O ₃	~\$500	R ² ~ 0.85		
	Air Quality Egg (Version 1)	Metal Oxide	CO, NO ₂ & O ₃	~\$200	CO: R ² ~ 0.0 NO ₂ : R ² ~ 0.40 O ₃ : R ² ~ 0.85		
	Air Quality Egg (Version 2)	Electrochem	CO & NO ₂	~\$240	CO: R ² ~ 0.0 NO ₂ : R ² ~ 0.0		
	Air Quality Egg (Version 2)	Electrochem	O ₃ & SO ₂	~\$240	O ₃ : R ² ~ 0.0 to 0.20 SO ₂ : R ² n/a		
	AQMesh (v4.0) (Discontinued)	Electrochem	CO, NO, NO ₂ & O ₃	~\$10,000	CO: R ² ~ 0.0 to 0.80 NO: R ² ~ 0.0 to 0.44 NO ₂ : R ² ~ 0.0 to 0.46 O ₃ : R ² ~ 0.46 to 0.83		
	Perkin Elmer (ELM)	Metal Oxide	NO, NO ₂ & O ₃	~\$5,200	NO: R ² ~ 0.0 NO ₂ : R ² ~ 0.0 O ₃ : R ² ~ 0.89 to 0.96		
	Smart Citizen Kit	Metal Oxide	CO, NO ₂	~\$200	R ² ~ 0.50 to 0.85 NO ₂ : R ² ~ 0.0		
	Spec Sensors	Electrochem	CO, NO ₂ & O ₃	~\$500	CO: R ² ~ 0.0 to 0.30 NO ₂ : R ² ~ 0.0 to 0.16 O ₃ : R ² ~ 0.0 to 0.24		
	UNITEC (SENS-IT)	Metal Oxide	CO, NO ₂ & O ₃	~\$2,200	R ² ~ 0.33 to 0.43 NO ₂ : R ² ~ 0.60 to 0.65 O ₃ : R ² ~ 0.72 to 0.83	CO: R ² ~ 0.99 O ₃ : R ² ~ 0.82 to 0.90	CO: PDF (1,283 KB) O ₃ : PDF (1,177 KB)

Most gaseous sensors showed:

- Acceptable data recovery
- Wide intra-model variability range
- CO; NO; O₃ (when measured alone): good correlation with FRMs
- O₃ + NO₂: low correlation with FRM (potential O₃/NO₂ interference)
- SO₂; H₂S; VOC: difficult to measure with available sensors

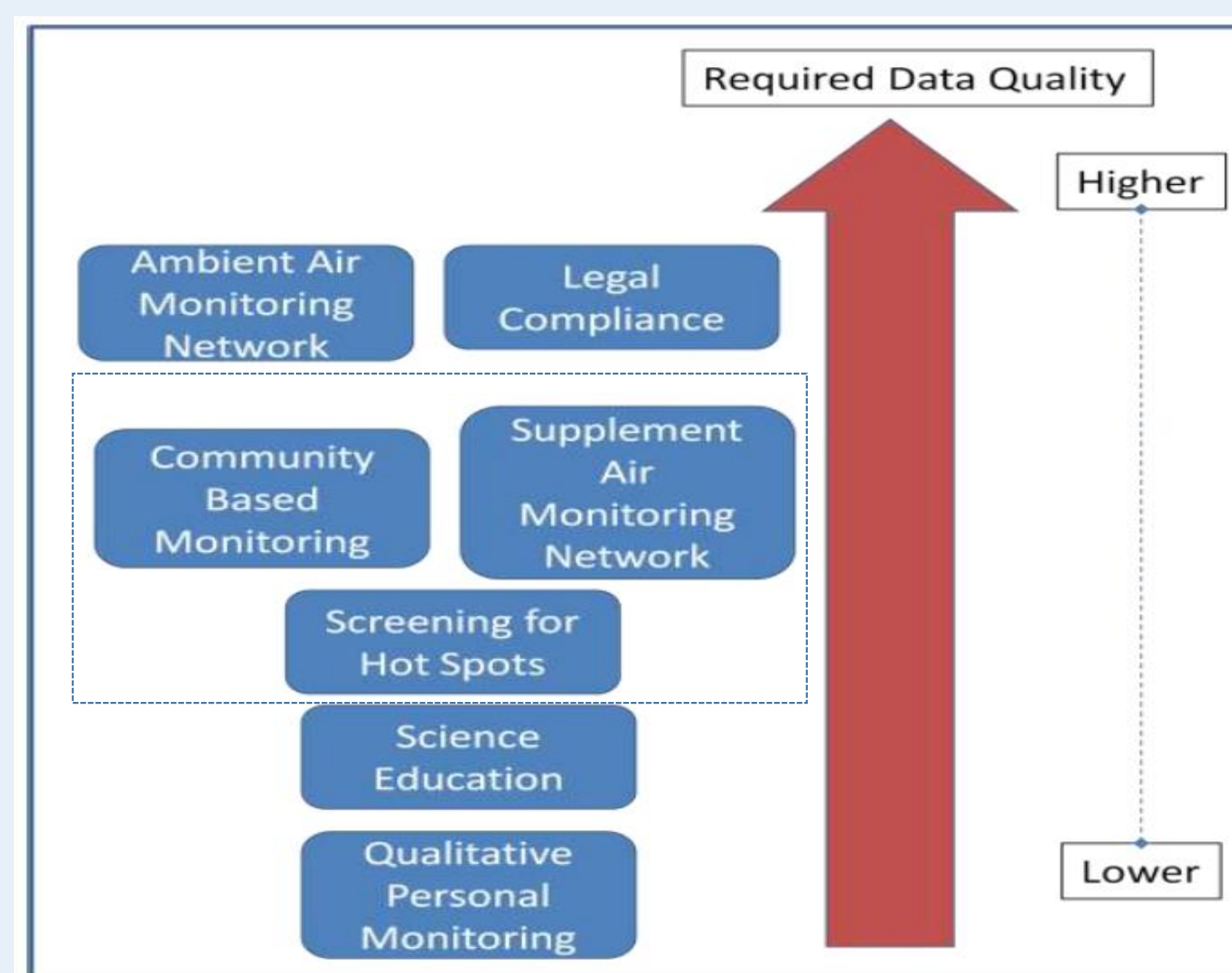
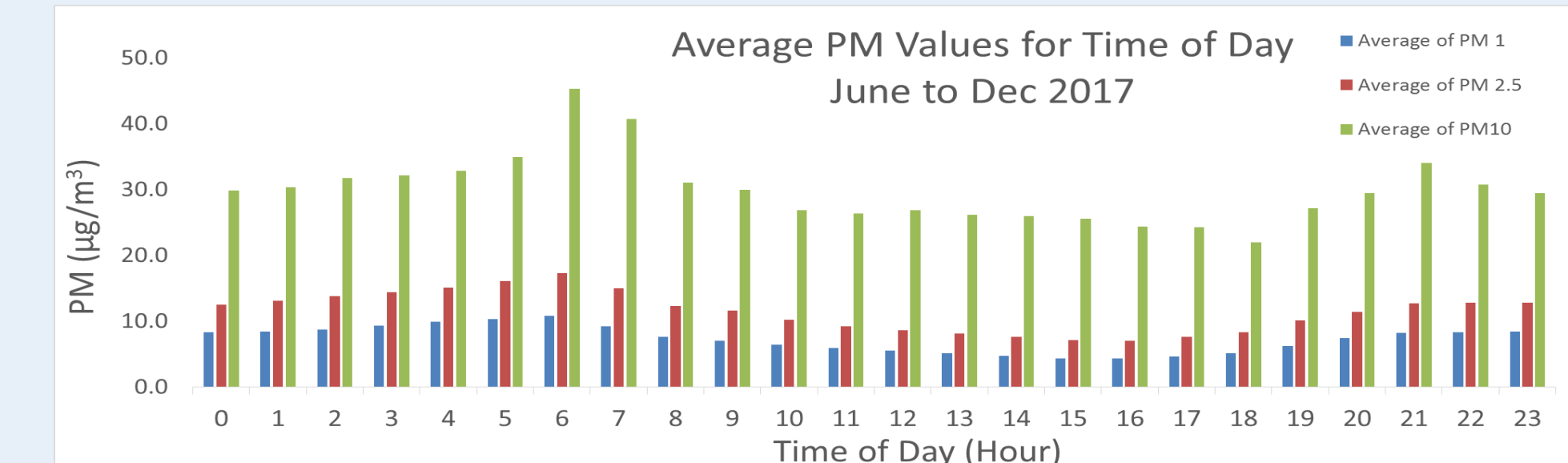
Most PM sensors showed:

- Minimal down time
- Moderate intra-model variability
- Strong correlation (R²) with FEMs

Sensor Application

Fence-line PM monitoring at a waste transfer facility

- 9 sensor nodes deployed at facility fence-line
- Wireless network and remote server
- Real-time PM₁, PM_{2.5}, and PM₁₀



EPA's "DRAFT Roadmap for Next Generation Air Monitoring"

- Categorize sensors based on performance
- Identify application(s) based on sensor capability
 - Characterize spatial and temporal variations
 - Improve air quality network design
 - Fence-line monitoring at large emission sources
 - Address community concerns

Community based PM monitoring

- 23 sensor nodes deployed in community
- Wi-Fi based data logging
- Real-time PM₁, PM_{2.5} and PM₁₀

