The Sensor Verification System – a novel way to check the performance of air sensors anywhere

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Outline

• Bay Air Center
• Purpose and need
• Solution
• Initial testing
• Example – Brightline Defense
• Other uses
• Contacts
Bay Air Center

Agency: Bay Area Air Quality Mgmt. District

Bay Air Center

- Provide technical assistance to communities interested in understanding air quality
- Build technical capacity in local organizations
- Provide accessible resources on best practices and methods
- Support Air District initiatives and staff

Team: TD Environmental, Kearns & West, T&B Systems, and InterEthnica,

Services

- Support community-led monitoring
- Data & information analysis
- Capacity building & training
- Awareness and outreach support
- Action development
- Grant support
Bay Air Center Projects

- **Data Analysis:** Processed 1 year of Purple Air and Clarity data to show that PM$_{2.5}$ was 23% high in the community than immediately outside.

- **Outreach Support:** Created a large tri-fold display board that is accessible to a wide audience & can be moved and used differently counties libraries. It includes a section on air pollution and equity.

- **Grant support:** Helped community group respond to EPA's recent ARP solicitation
Purpose and Need

• Bay Air Center was designed to help community groups in achieving their intended objective(s) of air monitoring.

• Community groups want to “validate” or “compare” their air sensors to high-quality instruments at sites run by the Bay Area Air Quality Management District.

• Challenges exist with locating at Air District sites:
  • Monitoring site access
  • Staffing requirements
  • Sites not located in environmental justice communities
Solution: Sensor Verification System

• The Sensor Verification System provides:
  • flexible approach to sensor QA/QC
  • better understanding of sensor response as deployed in the field
  • can check all sensors in a network over time

• Design specifications:
  • High-quality instruments
  • A rugged case that fits in a trunk and is watertight
  • Carried and set up by not more than 2 people
  • Quick set up (less than 5 minutes)
  • Powered by wall and battery (up to 24 hours)
  • Automate communications (cellular)
  • Onboard display screen to ensure it’s operating
Sensor Verification System
Sensor Verification System

• Include data and related services:
  • QA/QC
    • Data management and review
    • Quality Assurance Project Plan (QAPP)
    • Quick Start Guide
    • Training
    • Calibration and troubleshooting
  • Data management
    • Real-time display of air quality and meteorological data, as well as diagnostic data for samplers
    • Community access (password protected)
    • Online downloading of data
    • Data set generation for community groups
    • Data quality reports for groups who don't want to do it themselves
Sensor Verification System

Web-based data display / data review

Web-based (PM$_{2.5}$ and black carbon channels)
## Sensor Verification System

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Accuracy</th>
<th>Precision</th>
<th>Resolution</th>
<th>Range</th>
<th>Sample Flowrate (lpm)</th>
<th>Scan Rate</th>
<th>Operating Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate Matter (PM$_{2.5}$) Met One Model 212 2</td>
<td>+/- 10%</td>
<td>1.5 ppb or 2% of reading</td>
<td>0.5-10µm</td>
<td>1.0</td>
<td>1 - 60 seconds</td>
<td>0 - 40 °C</td>
<td></td>
</tr>
<tr>
<td>Ozone (O$_3$) 2B Tech Personal Ozone Monitor</td>
<td>1.5 ppb or 2% of reading</td>
<td>.1 ppb</td>
<td>0 ppb - 10 ppm</td>
<td>0.8</td>
<td>2, 5 seconds</td>
<td>0 - 50 °C</td>
<td></td>
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<tr>
<td>Nitrogen Dioxide (NO$_2$) 2B Tech Model 405</td>
<td>2 ppb or 2% of reading</td>
<td>.1 ppb</td>
<td>0 ppb - 10 ppm</td>
<td>1.5</td>
<td>5 seconds; 1, 5 min</td>
<td>10 -50 °C</td>
<td></td>
</tr>
<tr>
<td>Black Carbon (BC)  AethLabs Model 350</td>
<td>0.001 µg BC/m3</td>
<td>0.17</td>
<td></td>
<td></td>
<td>1, 5, 10, 30, 60 seconds</td>
<td>5 - 40 °C</td>
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<tr>
<td>Meteorology AIRMAR 220WX</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 second</td>
<td>-25 - 55°C</td>
<td></td>
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<tr>
<td>Wind Speed 5% at 10 m/s at 4 angles</td>
<td>.1 m/s</td>
<td></td>
<td>0 to 40 m/s</td>
<td></td>
<td></td>
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<tr>
<td>Wind Direction +/- 3° at 10 m/s</td>
<td>0.1°</td>
<td></td>
<td>0° to 359.9°</td>
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<td></td>
<td></td>
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<tr>
<td>Air Temperature ±1.1°C at 20°C ±5% RH at 0 to 90% RH at 20°C</td>
<td>0.1 °C</td>
<td>0 to 100%</td>
<td></td>
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<tr>
<td>Relative Humidity 0.1% RH</td>
<td>0 to 100%</td>
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<tr>
<td>Barometric Pressure ±0.5 hPa at 25°C</td>
<td>0.1 hPa</td>
<td>300 to 1100 hPa</td>
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<td>Data Logger/Comms Campbell Scientific CR6 Datalogger</td>
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<td>-40 - 70°C</td>
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<tr>
<td>Campbell Scientific CELL210 Cellular Modem</td>
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<td>-40 - 80°C</td>
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<tr>
<td>Campbell Scientific Mountable Display w/Keypad</td>
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<td>-40 - 85°C</td>
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<td>Rackmount Case/Enclosure</td>
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<td>Pelican Blackbox 7U</td>
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TD
Initial Testing

At the BAAQMD Air Monitoring Stations:
  • Evaluate set up and ease of use
  • Evaluate against the BAAQMD roadside monitoring locations

Deployed to:
  • Berkeley - Aquatic Park – 2 days
  • San Jose Knox Avenue (ozone not measured) – 19 days
Initial Testing

Very good agreement for ozone and NO$_2$
Initial Testing

- Good correlation for black carbon, though adjustment factor needed
- Optical PM$_{2.5}$ measurements potentially impacted by complexity of roadside PM emissions
Example Use

**Group:** Brightline Defense Project, San Francisco

**Need:**
- Want to measure NO₂ (BC and PM₂.₅) in San Francisco
- Need to calibrate NO₂ sensors (Clarity) against high-quality data
- NO₂ sensors collecting data for residents in eastern San Francisco for two years

**Approach:**
- Required collocation of eight (8) sensors; not possible at the Air District site
- Set up SVS in San Francisco
- Installed on an apartment balcony
- Operated for 4 weeks
- Validated data and provided to Brightline Defense and Clarity

"The Sensor Verification System has supported the expansion of air quality monitoring capacity for Brightline’s community-based network!" - Cecilia Mejia
Example Use

SVS collocated with eight Clarity sensors measuring NO$_2$
Clarity and Brightline used SVS data to calibrate sensor NO₂ data and control for baseline shift in the raw sensor data.
Other uses

**Parking Lot Check.** Deployment of multiple sensors at the same secure location within or near a specific community operating a sensor network. Secure location required.

**Field Check.** Deployment lasting less than one day and attended by someone in the field or for longer durations. Deployments to multiple sites in a network over time by moving the SVS.

**Demo and Training.** Used for several hours at meetings, schools, and training to demonstrate how instruments operate. It could be opened to show the different instruments and equipment.
Contacts

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