Sensor Performance, Data Quality, and Novel Applications

My Air Quality: Using Sensors to Know What's in Your Air

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Andrea Polidori, Ph.D.
QA Manager; South Coast AQMD

(apolidori@aqmd.gov)

Background

- Technology trend: smaller, faster, cheaper
  - Example: PCs have evolved into tablets, and cell-phones have become small PCs.

- Most traditional air monitoring instruments are following the same trend

Next?

- Safe to assume that the performance of “low-cost” sensors will soon match that of FRM/FEM instruments…..but when?

Next?

Background

- Many deciding factors, including:
  - Advancements in sensor technology
  - Performance & cost of microprocessors
  - Growing public interest
  - Large tech-company involvement

“Researchers turn Google Glass into health sensor”
–wired (Sept. 2014)

- How can governmental agencies help?
  - Engage, educate, and empower the public
  - Work with sensor manufacturers & developers
  - Characterize sensors performance & data quality


Community Air Sensor Network (CAIRSENSE) Project

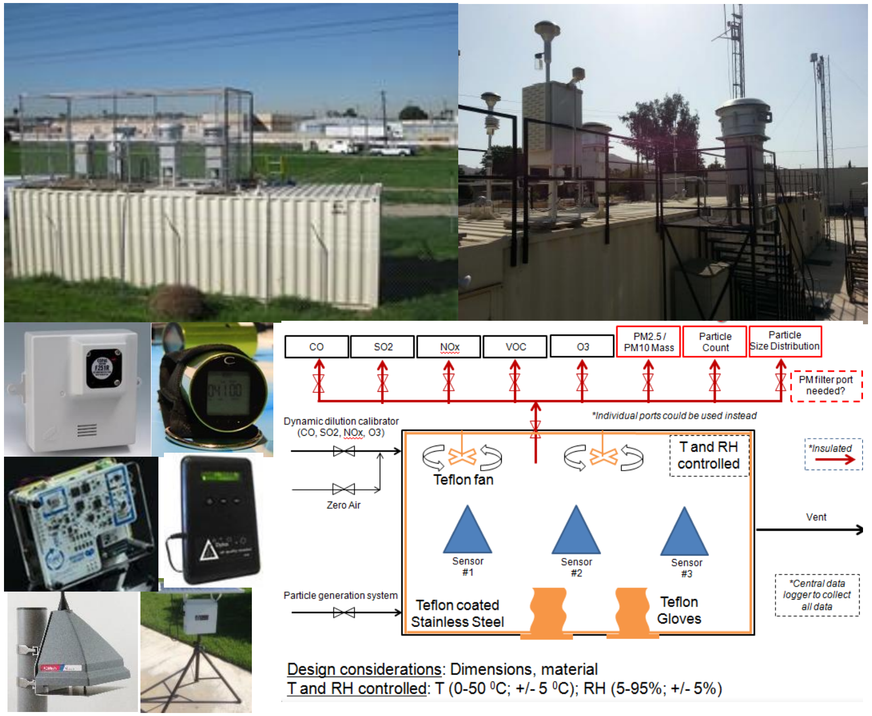
Ryan Brown[1], Daniel Garver[1], Gayle Hagler[2], Ronald Williams[2], Wan Jiao[2], Bobby Sharpe[3], Robert Judge[4], Motria Caudill[5], Josh Rickard[6], Michael Davis[7], Lewis Weinstock[8], Susan Zimmer-Dauphinee[9], and Ken Buckley[9]

1. US Environmental Protection Agency Region 4, Atlanta, Georgia; 2. US Environmental Protection Agency Office of Research and Development, Research Triangle Park, North Carolina; 3. ARCADIS US, Inc. Research Triangle Park, North Carolina; 4. US Environmental Protection Agency Region 1, Boston, Massachusetts; 5. US Environmental Protection Agency Region 5, Chicago, Illinois; 6. US Environmental Protection Agency Region 8, Denver, Colorado; 7. US Environmental Protection Agency Region 7, Kansas City, Kansas; 8. US Environmental Protection Agency Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina; 9. Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, Georgia

EPA United States Environmental Protection Agency

AQ-SPEC

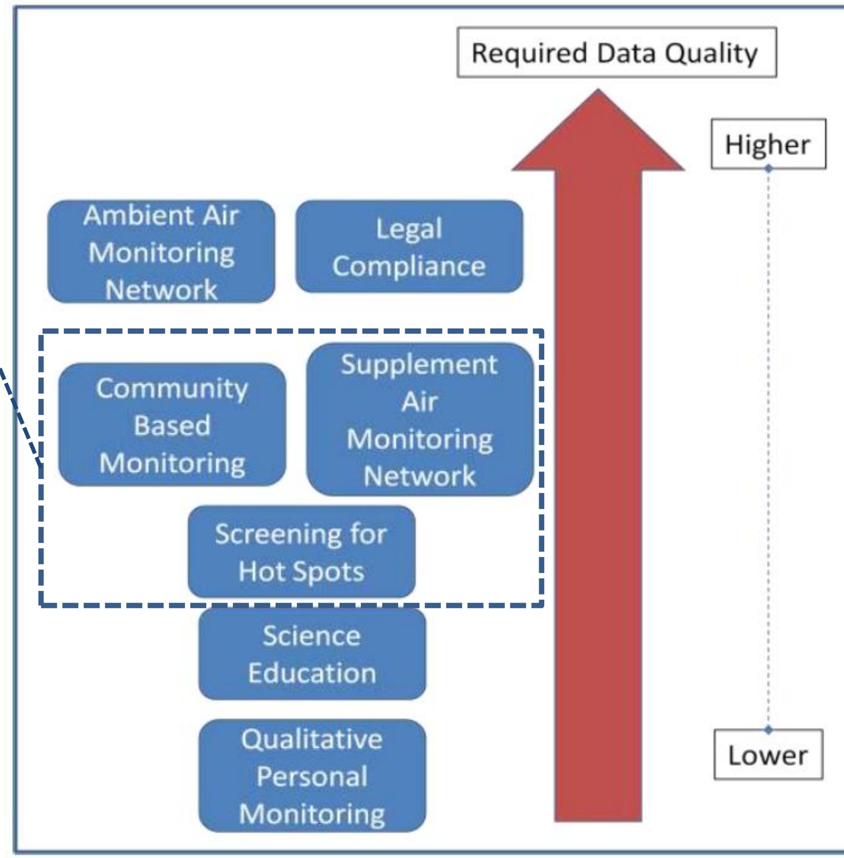
- Evaluation (<u>not certification</u>) program
- Field and chamber testing
- Determine parameters affecting sensor performance and data quality:
  - *Detection range*
  - *Linearity*
  - *Detection limit*
  - *Accuracy*
  - *Precision*
  - *Response time*
  - *Intra-model variability*
  - *Co-pollutant interference*
  - *RH and T influences*
  - Durability



Categorize sensors based on performance

Several novel applications

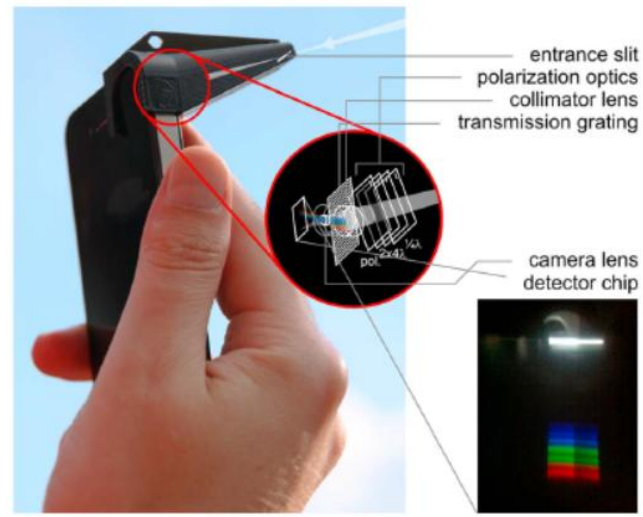
- Characterize spatial variations
  - Wide area coverage
- Improve network design
  - Identify high concentration areas
- Permitting
  - Monitor before and after construction
- Fence-line monitoring
  - Large refineries and emission sources
- Community concerns
  - Local impact of freeways, airports, refineries, etc.
- Aerial measurements
  - Stack sampling, plume profiling, and much more

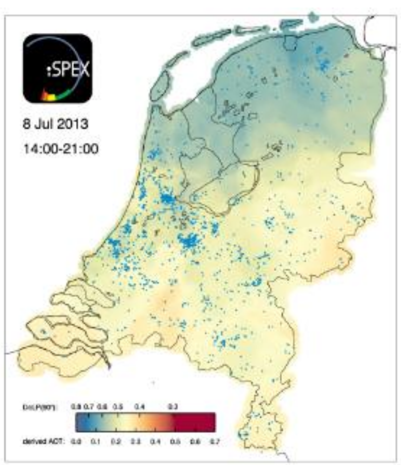


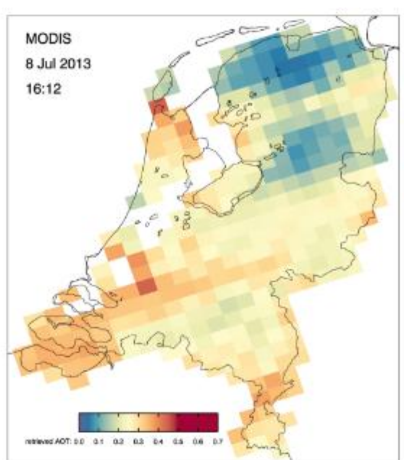
EPA's "*DRAFT Roadmap for Next Generation Air Monitoring*"

Novel Applications (example): Characterize Spatial Variations

- iSPEX
  - < $4 add-on for smart-phone cameras to measure Aerosol Optical Thickness to estimate atmospheric aerosols!!!
  - Spectropolarimetric method
  - Daytime, cloud-free measurements only
  - Project led by Frans Snik, Leiden University (Netherlands)







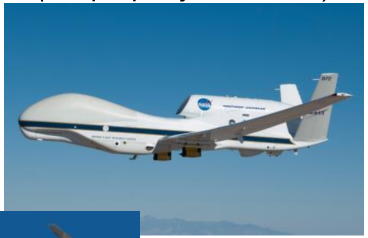
- Thousands of (free) iSPEX used to for three days in 2013
- Results comparable to ground-based, network, and satellite measurements

http://ispex.nl/en/

Novel Applications (example): Aerial Measurements

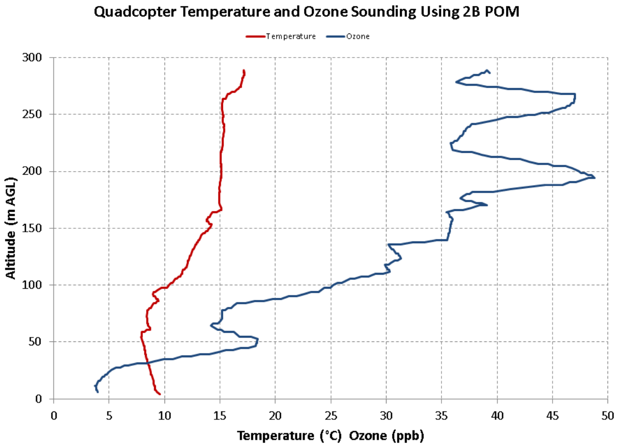
- <u>Unmanned Aerial Vehicles</u>
  - Provide stable X-Y-Z platform for sample collection
  - Sensors can be mounted to provide integrated and real-time data (e.g., GPS, meteorological, gaseous, and particulate)
  - FAA Restrictions (commercial vs. recreational) and flight time limitations
  - Many potential uses: stack sampling, plume profiling, fence-line monitoring, gradient studies, previously unreachable locations

NASA's Global Hawk UAV (not properly "low-cost")



T&B systems quadcopter (affordable!)

(…don't call me DRONE!)



Courtesy of

T&B Systems environmental research associates

Conclusions

- More comprehensive field and laboratory testing needed to:
  - Address sensor data quality issues
  - Correctly interpret sensor data
  - Appropriately select sensors for specific applications
  - Promote a more responsible sensor use
  - Improve performance of available sensors
  - Design the next generation sensor technology

- Available sensors are not as accurate and reliable as FRM/FEM (yet), but they can be used for many useful applications

- Many short- and long-term challenges, including:
  - Incorrect use of sensors and sensor data
  - Rapid proliferation
  - Dealing with “Big data”