Air Quality - Innovative Technologies - Citizen Science/Advocacy Strategic Design Meeting
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Next-generation air measurement technologies

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Foreword

- The goal of this presentation is to give information on the following topics:
  - Technical perspective on next-generation air monitoring technologies
  - Potential application of sensors
  - Sensor data communication (and concern)

  This presentation is to the public and would be useful for a technical or non-technical individual wanting to understand the state of science on air sensor technologies.

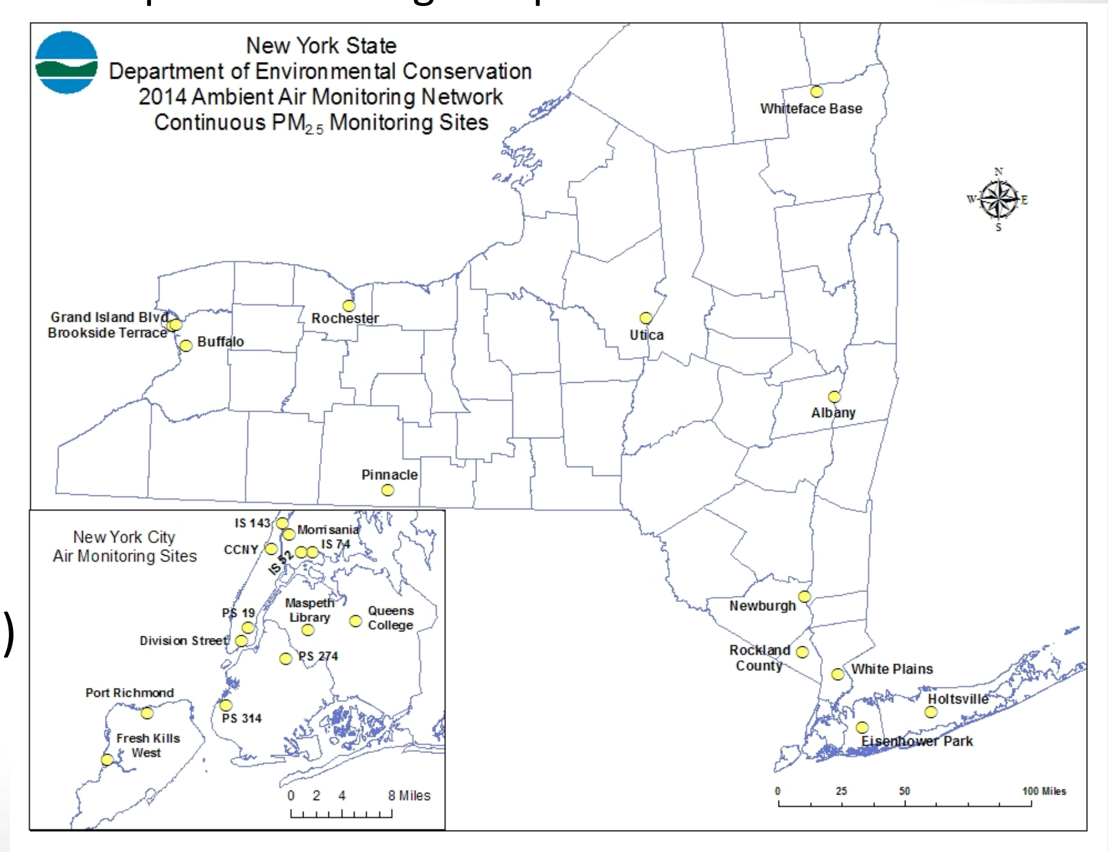
Measuring the air

In the United States, traditional paradigm for air quality monitoring:

Rigorous protocols and methods for regulatory applications

- Expensive instruments (>$10K)
- Specialized training required
- Large physical footprint
- Large power draw

Example: Measuring fine particles in New York



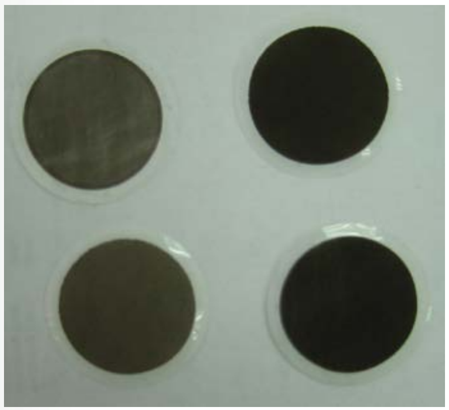
Map from: dec.ny.gov

EPA

Particulate matter (PM)

Detecting particles: well-established methods

Particle filter samples



Regulatory

Mass (gravimetric)

Additional useful measurements

Ions

Metals

Organic and elemental (aka “black”) carbon

Trace organics

Light absorption (transmissometry)

Real-time or near-real time detection of components – most fairly costly (>>10K), required specialized knowledge

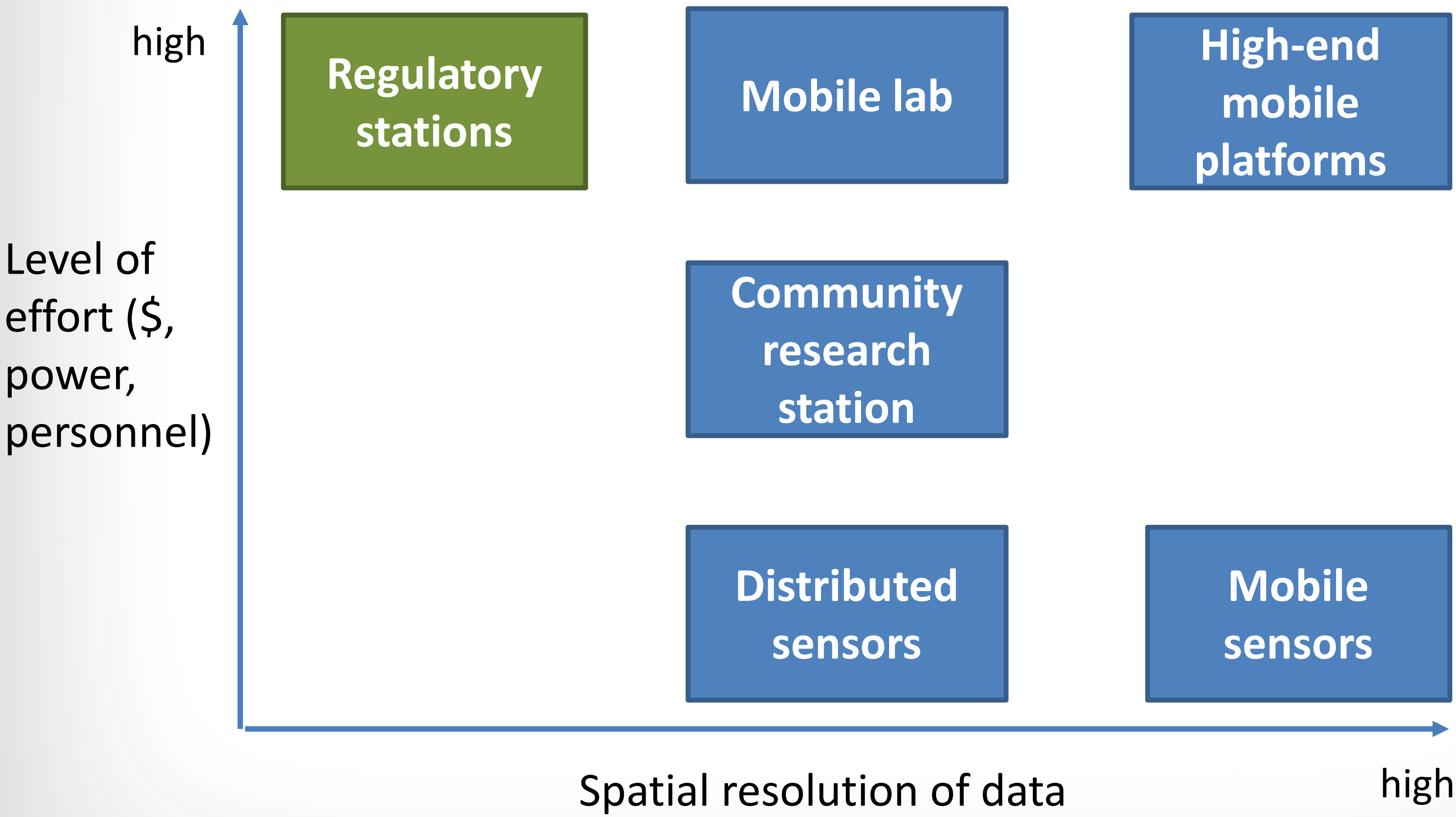
Exception (<10K)

What do we mean by “next-generation air measurement technologies?”

Generally, traits of:

- Greater spatial coverage (mobile, distributed sensors)
- Greater temporal coverage (real-time measurement)
- Cost-effective

Emerging technologies to measure the air



Lower-cost PM measurement methods

Existing, commercially-available PM methods in the mid- ($2-10K) to low-cost (<$2K), and ultra-low cost (<$500) range

"Estimated, total PM"

"Particle component"

Black carbon

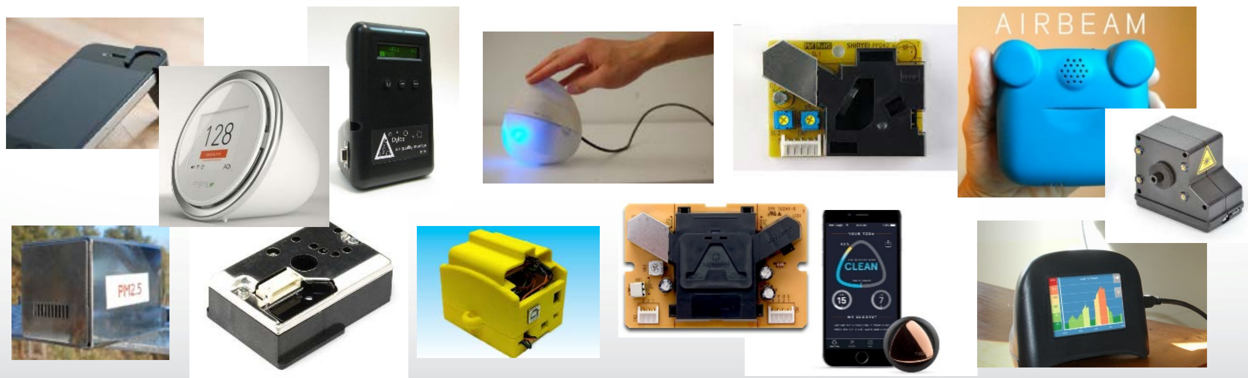
MID-COST


LOW-COST



<N/A>

ULTRA LOW-COST



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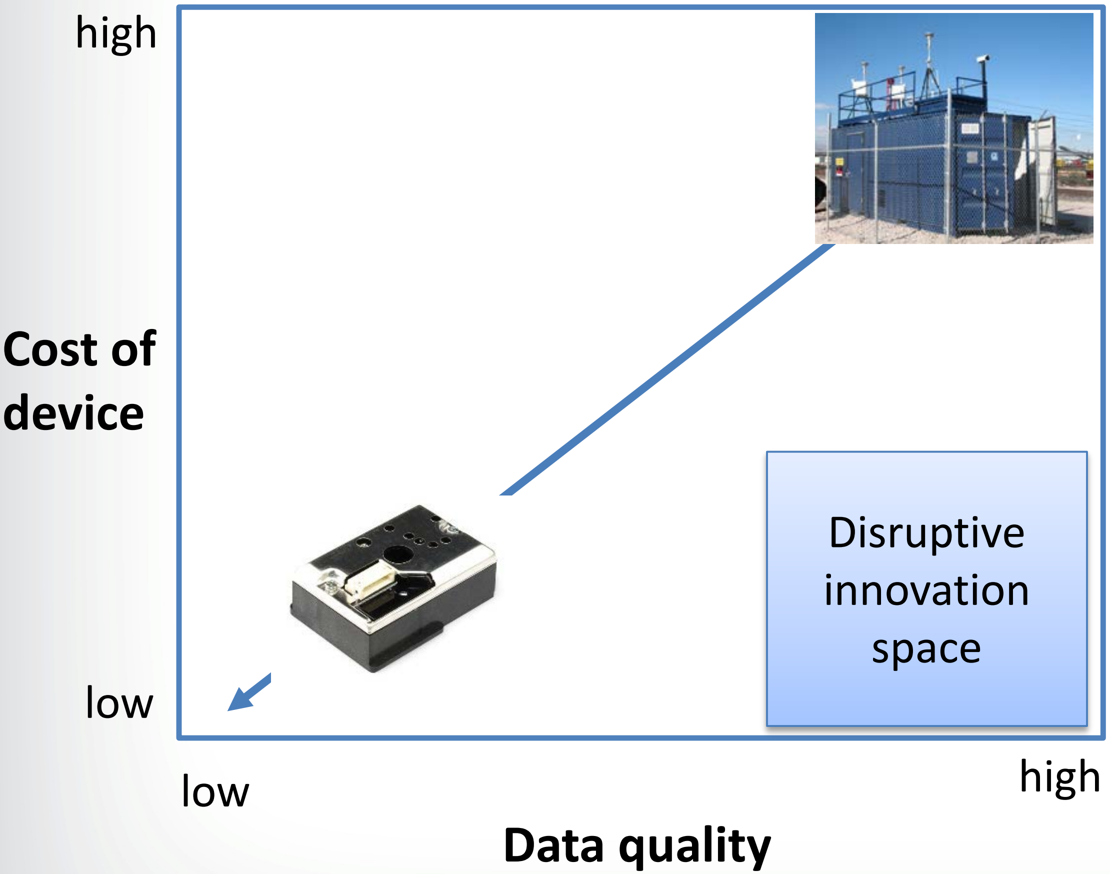
What is the difference?

What is the difference between regulatory instrument, traditional research instruments, and emerging sensors?

Trait	Federal equivalent method	Mid-tier cost research instrument	Low-cost, emerging air sensor
Cost	~10-20K	~5-10K	~0.02K (or ~$20)
Isolates particles under 2.5 microns?	Yes – cyclone removes PM greater than 2.5	Yes – cyclone removes PM greater than 2.5	**No**
Active air flow?	Yes	Yes	**No**
True mass measurement?	Yes – e.g., beta-attenuation	**No – light-scattering**	**No – light scattering**
On-board humidity artifact correction?	Not needed	Yes	**No**
Data time resolution	**Hourly (or longer)**	Seconds to minutes	Seconds

Can math overcome what is sacrificed in the measurement?



Researchers using advanced data processing strategies to get meaningful information from low-cost (~$20) sensors:

"We're compensating for a bad sensor with machine learning…"

- Illah Nourbakhsh, sensor developer at Carnegie Mellon University, during a recent interview

"**…a separate model was selected for each sensor….Fifth order polynomial models** that included relative humidity (RH %) and temperature (C) was found to best convert PUWP signals into $PM_{2.5}$…"

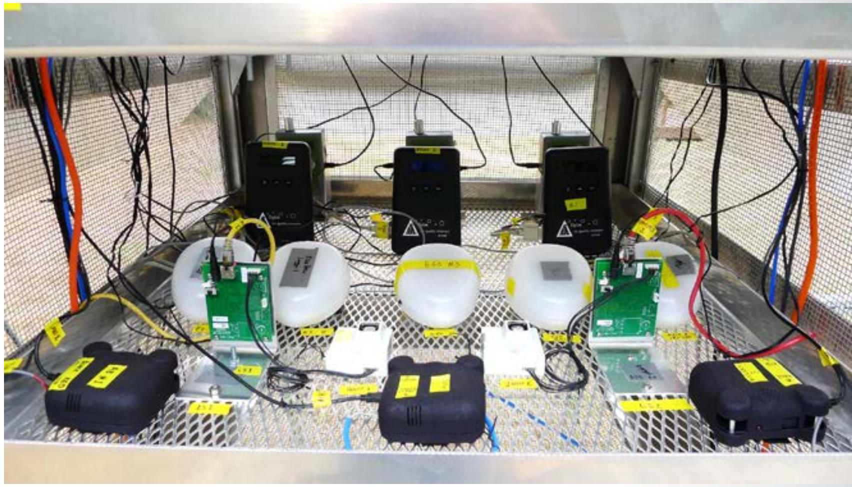
- Gao et al., 2015, A distributed network of low-cost continuous reading sensors to measure spatiotemporal variations of $PM_{2.5}$ in Xi'an China. Environmental Pollution

EPA activities

1. Testing air sensor performance in laboratory and field settings

- Atlanta, GA (2014-2015)
- Denver, CO (2015-2016)
- Research Triangle Park, NC (2014 – 2016)

- Emphasis on turn-key devices that are commercially available, measure regulated air pollutants (e.g., ozone, particulate matter), and <2K



- Sensor performance has varied widely – from very strong (r>0.9) to very poor performance (r=0)

EPA activities

2. Exploratory research studies

- High-concentration environments near sources
  - Example: balloon-lofted sensors within wildfire emissions plume
  - Example: drop-in-place solar-powered volatile organic compounds (VOC) sensor near a source fenceline

- Urban-ambient environments
  - Development of single- or multi-pollutant systems supporting citizen science
  - Development of long-term, resilient community monitoring systems

EPA activities

3. Convening and communicating

- Air Sensor Toolbox: http://www.epa.gov/heasd/airsensortoolbox/
  - Test reports on sensor performance
  - Citizen science guidance
- Workshops
- Community Air Monitoring Training (summer 2015)

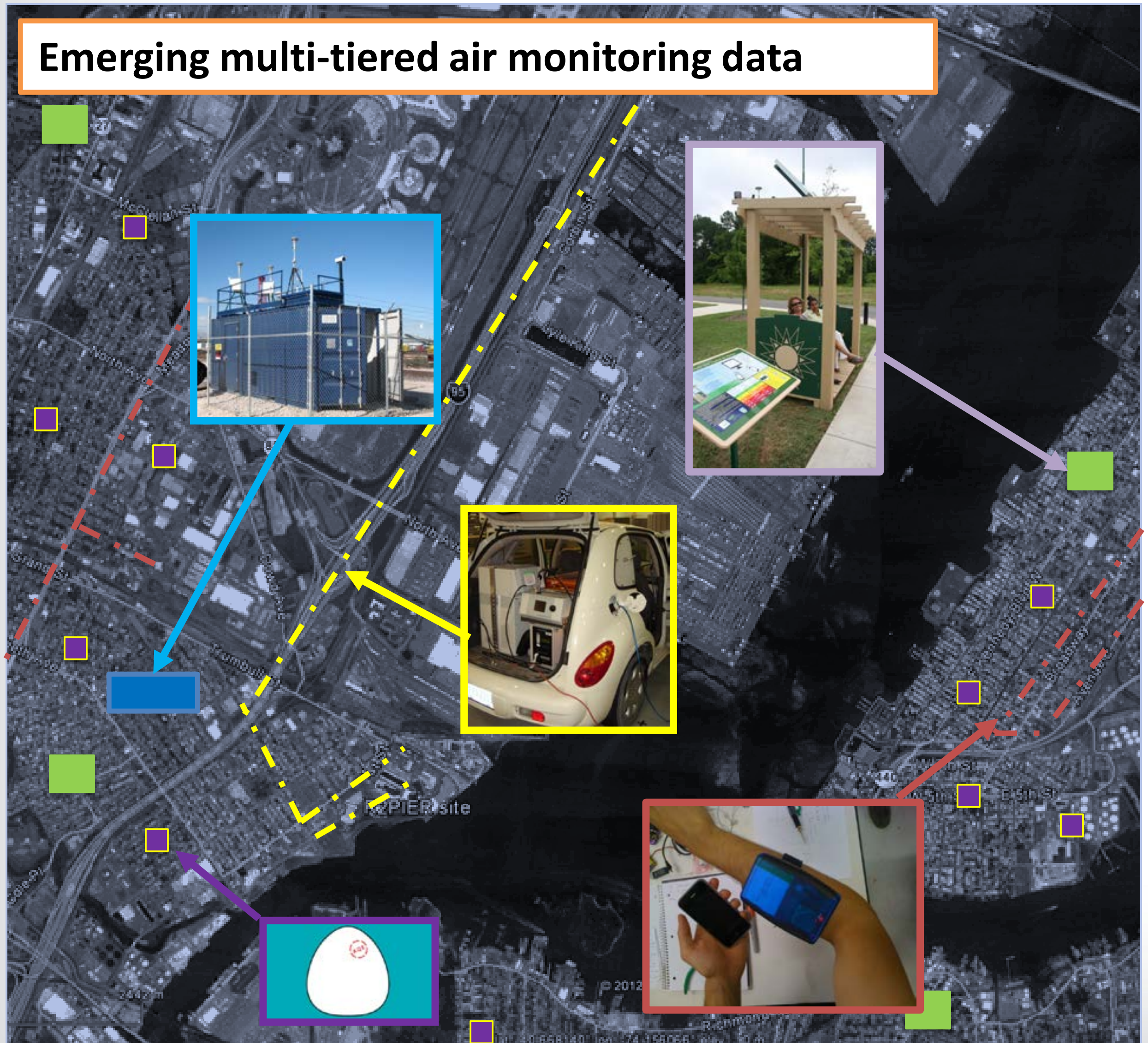
Sensor applications

- Very high bar to reach for regulatory application
  - Must be officially certified as a method, siting criteria applied, etc.
  - e.g., a federal-equivalent monitor for ozone is used on the Village Project System, *however,* not operated according to regulations (siting criteria, QA, temperature range)

- However, other important applications are envisioned:
  - Research studies
  - Screening – siting a monitoring station
  - Community monitoring
  - Individual monitoring
  - Educational purposes

- A major concern for EPA – public data communication practices

Where is this going?



<u>Opportunities:</u>

- Unprecedented access to data on neighborhood-scale air quality
- Lower cost strategies to achieve air monitoring goals
- Engagement with communities, schools, industry

<u>Challenges:</u>

- Data quality
- Data interpretation and public messaging
- “Big data” analysis
- Support for do-it-yourself/citizen science

Summary

- EPA is heavily involved in next-generation air monitoring research and engagement with the air monitoring community.
- The research and educational outreach potential is significant, and this technology is developing quickly. Data quality is a major area of concern for EPA.

For more information:

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