Community Air Sensor Network (CAIRSENSE) Project

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Traditional Air Monitoring Approaches

- Traditional approaches to air monitoring can be resource (cost and trained staff) intensive and complex.
- Spatial resolution can be limited by complexity and costs.
- Long-term monitoring may not be practical

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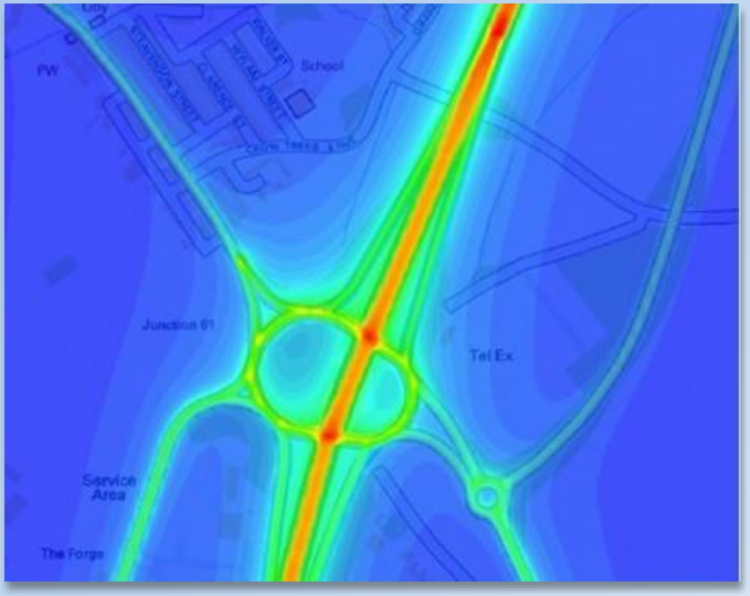
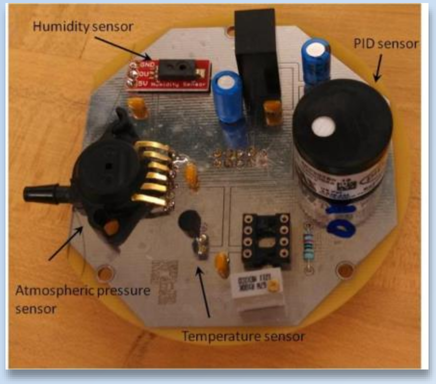
Potential Benefits of Low-Cost Sensor Technology

- Ability to conduct monitoring in situations/locations where it is currently cost-prohibitive
- Improved engagement for communities with air quality concerns
- Improved spatial resolution of air monitoring networks
- Better understanding of local-scale air quality issues, such as near-source applications





Example near-road pollution gradient, GIM International

Low cost VOC sensor set-up (EPA ORD – Eben Thoma)

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Assessing and supporting new technology

Emerging air monitoring systems (informal classification)

Group 1: Regulatory or regulatory-equivalent air monitoring stations
Cost: $100Ks, Data reliability = A+

existing

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emerging

Group 2: Smaller-footprint monitoring systems for community screening and research studies
Cost: $1-10Ks, Data reliability = B+ (target)

Group 3: Very small, very low cost systems enabling dense sensor networks, citizen science
Cost: $0.1-1Ks, Data reliability = ?

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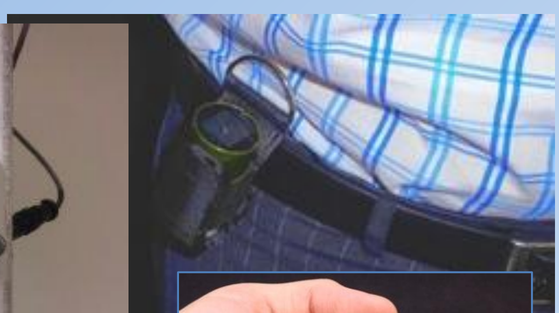
Traits of low cost sensors

Key air sensing technology attributes	Additional attributes for certain applications
Direct readings	Accelerometry
High time resolution	Global positioning system
Low cost	Biometric sensors
Minimal maintenance	Meteorological sensors
Low power demand	Network communications
Wireless data transmission	Public or private data display
Turnkey operation	Unobtrusive or value-added design



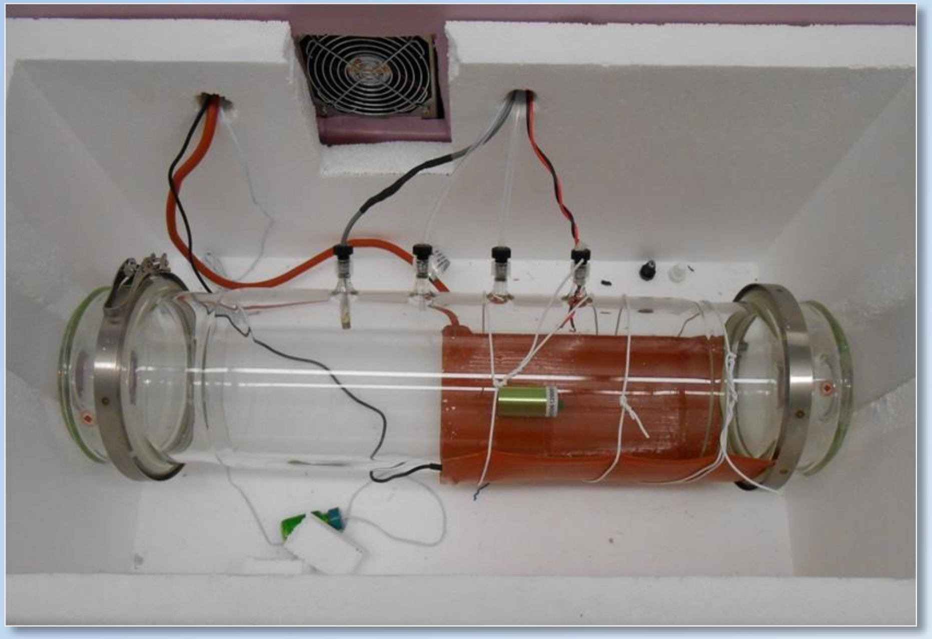
Small microprocessor

Image: Mike Hannigan – Univ. of Colorado

Winner of DHHS/EPA's My Health/My Air contest:
Kuller, Dockterman, and Kelly

Background: Low Cost Sensors

- ***Pros:*** Low cost allows for different applications than traditional monitors
- ***Cons:*** Without testing, questions about data quality, reproducibility, etc.
- Lots of current research on low cost sensors:
  - Calibration
  - Interferences
  - Drift
  - Reproducability



Typical sensor testing setup, EPA ORD

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Challenges and Opportunities of Low Cost Sensor Network

- Attributes of an ideal sensor network:
  - Collect high quality, continuous data
  - Accommodate many interchangeable sensors to measure different pollutants
  - Communicate data wirelessly and reliably to web interface
  - Network nodes would have low energy usage and be self-powered (e.g. solar or battery)
  - Network design and communication would be easily scalable to different numbers of nodes and distances between nodes
- Several challenges in implementing this design:
  - The end solution must still be low-cost!
  - Each sensor has different strengths and limitations
  - Wireless communication protocols have limitations (e.g. interference from nearby objects, or cost limitations of cellular communication)
  - Power and space demands of many interchangeable sensors vary
  - Sensor technology is more developed for some pollutants than others

Example air sensor app by AirCasting

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EPA Regional Methods Program

The Regional Methods Program is a mechanism used by EPA Office of Research and Development (ORD) to:

- Respond to high-priority, near-term methods development needs of EPA’s regional offices;
- Enhance interactions between regional and ORD scientists; and
- Improve ORD’s capacity to bring science to bear on practical environmental issues faced by Regions.

- EPA Region 4 proposed the CAIRSENSE project, with partnering Regions, ORD, and OAQPS

Community Air Sensor Network (CAIRSENSE) Project Overview

- **Participants:**
  - EPA Regions 4, 1, 5, 7, and 8; EPA Office of Research and Development (ORD); EPA Office of Air Quality Planning and Standards (OAQPS); and Georgia Environmental Protection Division (EPD).
- **Objectives:**

  1. Evaluate in situ the ***long-term comparability of several lower cost sensors of interest*** against regulatory monitors.

  2. Determine the capabilities and limitations of a ***long-term multi-node wireless sensor network applied for community air monitoring***, in terms of operational stability (communications, power) and long-term data quality under ambient conditions.
- **Year 1 Location:**
  - South Dekalb NCore site in Atlanta

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Regional Methods Project Team:
a collaboration across EPA and stakeholders

Lead Organizations:

EPA Region 4

Project coordination, site selection, some data analysis

EPA Office of Research and Development (ORD)

Experimental design, assistance with data analysis, contract management

Collaborators:

Project input and review of documents through regular conference calls and email

- EPA Region 1
- EPA Region 5
- EPA Region 7
- EPA Region 8
- EPA Office of Air Quality Planning and Standards (OAQPS)
- Georgia Environmental Protection Division (GA EPD)
- North Carolina Division of Air Quality (NC DAQ)

General Project Timeline

Year 1
Priorities defined, Study design

→ Site selection; Sensor selection; QAPP Development

→ Data Collection, Review, and Analysis; Develop Year 2 priorities

Winter 2014 **Summer 2014**

Year 2
Priorities defined, Study design

→ Site selection; Sensor selection; QAPP Amendment

→ Data Collection, Review, and Analysis; Disseminate results

Winter 2015 **Summer 2015**

CAIRSENSE Formats for Sensor Field Testing

Modules	Description	Notes
Local wireless sensor network	Install base station plus 3 small satellite sensor pods	Locate base station and one sensor pod at regulatory site to meet Objective 1; Objective 2 also met
Ad-hoc testing area for additional sensors of interest	Put in place small box + pole structure at regulatory site to allow opportunistic testing of commercial sensor packages	Would enhance research study addressing Objective 1

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CAIRSENSE sensor selection

Selection Criteria: Overarching goal to test sensors or sensor systems with potential near-term wide use

1. **Real time or continuous monitoring technologies** of gases and particulates were of interest (no laboratory analysis)
2. Priority on **criteria pollutants (NAAQS)**
3. Priority to test **commercially available** sensors, with potential near-term high degree of use
4. Priority to test sensors that are **turnkey** – lower priority to develop custom electronics for raw sensors.
5. General **upper cost limit at $2000 per pollutant** (e.g., $2000 for a one pollutant sensor device, $4000 for a two-pollutant sensor device, etc.)
6. Priority to test sensors **already in use by general public**.

Examples of Candidate Sensors to Test

Sensor type		Dimension	Detection Technique	Peripherals for field use
AQMesh: O_3, NO_2, NO, SO_2, CO		117 × 178 × 140 mm, < 2 kg	Electro-chemical	2yrs battery life
Cairpol CairClip: O_3 and NO_2,		32 mm (diameter) × 62 mm (lenth), 55 g	Amperome-tric sensor	Rechargeable battery with AC adaptor
Shinyei PM sensor		71 × 76 × 37 mm, 130 g	Light scattering	12V DC power supply, external microprocessor
Dylos DC1100 Particle Counter		178 × 114 × 76 mm, 1130 g	Laser light scattering	AC adaptor

Project Setup

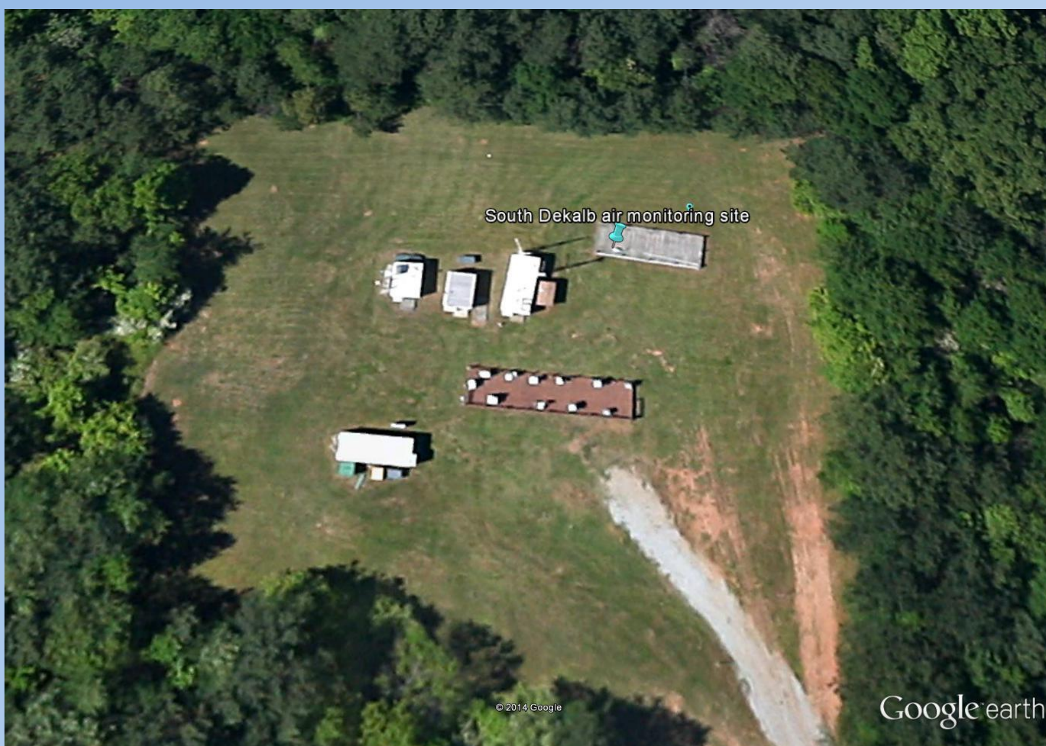
B Base station for local wireless network, measuring pollution in real-time, wireless communication (cellular and communication with nodes)

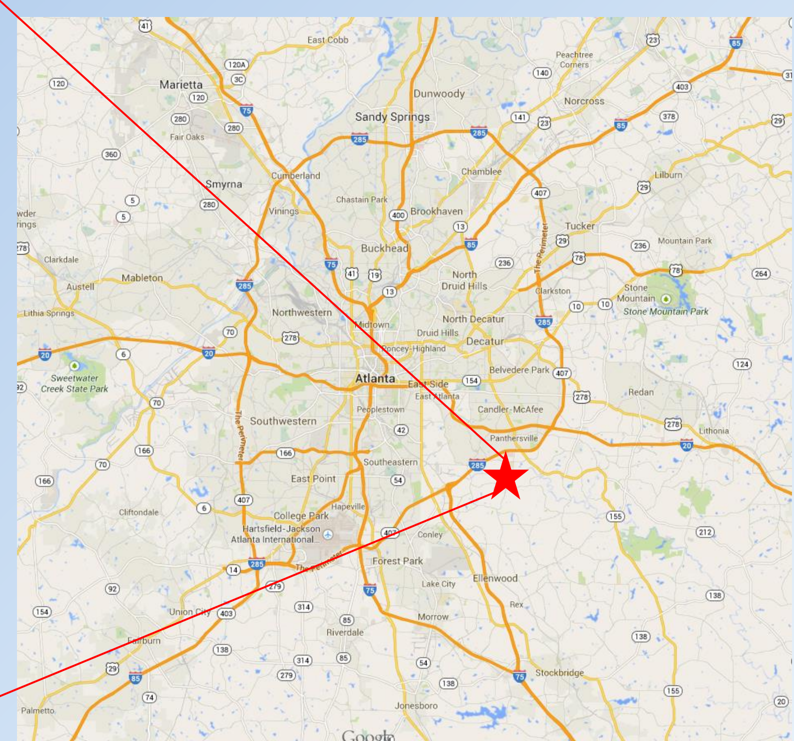
N Small multi-pollutant sensor node stations with communication back to the base station

AT Ad-hoc testing location for additional sensors: weatherproof, ventilated box + pole to support pole-mounted devices, power provided

South DeKalb Air Monitoring Site

- National Core (NCore) regulatory monitoring site in Atlanta
- Extensive suite of measurements including criteria pollutants and precursors, air toxics, and meteorology
- Long historical data record





Example Deployment Setup

△ = Regulatory site

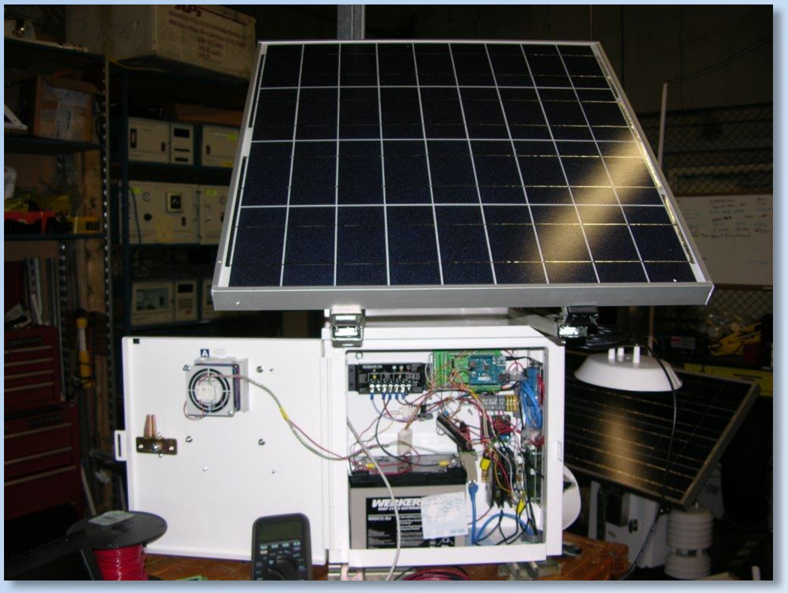
B Base station for local wireless network

N Small multi-pollutant sensor node stations

AT Ad-hoc testing location for additional sensors

Next Steps

- Installing equipment this week in Atlanta
- Sampling to continue for approx. 6 months
- After completion of Atlanta sampling, equipment will be moved to another location outside the southeast for further testing



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Questions?

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