Using Low-Cost Monitors to Explore Air Quality in Chicago

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Dialog on Sustainability
Manhattan, Kansas
Air Quality is Important

• Annual premature deaths from air pollution
  – 3.7 million globally (WHO 2014)
    • Mostly in middle- and low-income countries
  – 200,000 in the US (Caiazzo et al. 2013)
    • 53,000 from tailpipe emissions (largest share)
    • 52,000 from electricity generation (second largest)
Air Quality is Important

• Annual social cost of air pollution
  – $3.55 trillion globally for PM$_{2.5}$ alone (WB 2016)
• Those losses are growing with urbanization
How do we know about our air?

- Federal Reference Monitors (FRMs) in Kansas
Original Low Cost Air Monitor

• Canary in a Coal Mine
Environmental Data Monitoring

• Key Technological Developments
  – Sensor miniaturization
  – Wireless connectivity
  – Cloud-storage
  – Internet delivery
  – Reduction in unit cost!
Environmental Data Monitoring

Old School

New School
Environmental Data Monitoring

- WU Stations
Potential of Low-Cost Sensors

• New market entrants
  – Individuals, non-profits, municipalities, schools
  – Democratization of information

• Higher deployment densities
  – No longer single point, but net
  – Fine-grained mapping of conditions

• Better environmental management (ideally)
Challenges of Low-Cost Sensors

- Managing new devices
  - Technologies still rapidly developing
  - Limited standardization
  - Extends digital divide

- Parsing torrent of data
  - ‘Big Data’ not easy to wrangle
  - Problem of errant readings

- New domain knowledge
  - No longer just for experts
# Eight Partners

<table>
<thead>
<tr>
<th>Type</th>
<th>Name</th>
<th>EJ</th>
<th>Mission</th>
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<tr>
<td>University</td>
<td>University of Illinois, Chicago</td>
<td>UIC</td>
<td>Environmental health disparities and risk assessment</td>
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<tr>
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<td>Kansas State University</td>
<td>KSU</td>
<td>Sustainability, remediation, community outreach</td>
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<td>Non-Profit</td>
<td>Delta Institute</td>
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<td>Sustainable development</td>
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<td>Respiratory Health Association</td>
<td>RHA</td>
<td>Advocacy and education related to lung disease</td>
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<td>Community</td>
<td>Alliance for a Greener South Loop</td>
<td>AGSL</td>
<td>Environmental improvement/ sustainability for South Loop</td>
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<td>Little Village Environmental Justice Organization</td>
<td>LVEJO</td>
<td>EJ, self-determination for Little Village</td>
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<td>Southeast Environmental Task Force</td>
<td>SETF</td>
<td>EJ/sustainable growth for Southeast community</td>
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<td>People for Community Recovery</td>
<td>PCR</td>
<td>EJ for Riverdale Community</td>
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Community Info

- Lower Income
- Far from monitors
- Many polluters
  - coal ash repositories
  - metal shredders
  - trucking and rail
  - landfills
- High rates of asthma among children
Key Points

- Lived environmental experience in these neighborhoods does not accord with existing (limited) information on air quality
- Low cost monitors can empower community members* to explore local air quality

*Note: While traditionally this would be called Citizen Science, we are reframing to community member to avoid the legal connotations associated with citizen
Low Cost Air Monitors (Stationary)
Low Cost Air Monitors (Mobile)
Solicitation Research Questions

• How can low-cost air pollution sensors be used by communities to understand and reduce the pollutant concentrations to which they are exposed?

• How do communities and individuals interact with low-cost portable air pollution sensors?
Approach

• Explore and evaluate the ability of residents in four very diverse communities to:
  – conduct air monitoring using low-cost portable air pollution sensors
  – effectively communicate, interpret and use the data that are generated to engage in activities that will improve environmental and human health in their communities.
Research Plan

• Test low-cost monitors in four neighborhoods over four weeks in winter and in summer
• Compare low-cost monitors with Federal Reference Method (FRM) or Federal Equivalent Method (FEM) samplers
Monitor Selection (Particulates)

- Particulate Matter
  - MetOne Neighborhood Monitor
  - PurpleAir PM Sensor
  - AirBeam
Monitor Selection (Gaseous)

- Carbon Monoxide and Nitric Oxide
  - Terrier
- Nitrogen Dioxide and Ozone
  - Aeroqual 500
Community Air Monitoring Plans
Community Air Monitoring Plans

- Diesel PM from NATA
F: Fixed air monitoring sites; M: Mobile routes; Pink Dots: Intersections/Roadways of concern to community; Green Text: Tiers of DPM concentrations (high to low); Orange Text: Tiers of toluene concentrations (high to low)
Monitoring

• Our Data Viewer
Data Quality

• A concern of low-cost sensors is the data quality, particularly for regulated pollutants

• Concerns
  – What readings are real?
  – How do we trim likely problems without over or underestimating air quality?
Data Quality

![Data Quality Chart](image)

- PM 2.5 (μg/m³)
- Possible Upper Bound
- Months: May, Jun, Jul, Aug, Sep, Oct, Nov
Data Quality – Good Alignment

![Graph showing data over time with peaks and troughs.](image)
Data Quality – Clear Divergence
Data Quality - Unclear

SASA_PA3_SL_S

Micrograms / Cubic Millimeter

Date

Sep 23  Sep 25  Sep 27  Sep 29  Oct 01  Oct 03
Making Data Meaningful

- Additional documentation on air quality
Thank you

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