Advancing the Science of Air Monitoring: Research Priorities and New Approaches for Enhancing Monitoring Data

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National Ambient Air Monitoring Conference
November 9, 2006
Presentation Overview

- Monitoring Objectives and Research Priorities
- Monitoring Research in EPA’s Office of Research and Development (ORD)
- Approaches for Enhancing Ambient Monitoring
# Monitoring for Multiple Objectives

<table>
<thead>
<tr>
<th>Monitoring Purpose</th>
<th>Measurements Needed</th>
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<tbody>
<tr>
<td>Compliance with NAAQS</td>
<td>FRM / FEM</td>
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<td>Public Information/Reporting</td>
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<td>Air Quality Management Activities</td>
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<td>- Development of Emission Reduction Strategies</td>
<td>PM Speciation</td>
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<td>- Evaluation of Emission Reduction Strategies</td>
<td>Precursor species</td>
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<td>- Air Quality Trends</td>
<td>Air Toxics</td>
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<td>Continuous / semi-continuous sampling</td>
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<td>- Health Assessments</td>
<td>PM Speciation</td>
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<td>- Ecological Assessment</td>
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<td>- Source-Receptor Relationships</td>
<td>Air Toxics</td>
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<td>- Model Development and Evaluation</td>
<td>Deposition</td>
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Monitoring Priorities to Support EPA Programs

- NAAQS Development
  - PM Size Fractions
    - Coarse and Ultrafine
  - PM Speciation / Components
- NAAQS Implementation
  - FRM / FEM
  - Emission Reduction Strategies Development
  - Accountability
- Public Reporting
  - AirNOW and AQI
- National Ambient Air Monitoring Strategy (Dec 05 Draft)
  - Continuous Measurements
  - Multipollutant Measurements (NCORE Sites)
  - Increased integration with Science Objectives
  - Integration of Air Toxics into monitoring networks
  - Ecological Assessment
Monitoring Priorities from External Recommendations:
National Research Council Reports

  ▪ Challenge - Enhancing Air Quality Monitoring for Research
  ▪ Move from a focus on compliance with NAAQS toward multiple monitoring purposes
    • Continuous / semi-continuous measurements
    • PM species
  ▪ The report specifically mentions the need to measure ultrafine PM, soluble metals, and organic species.

• Air Quality Management in the US (2004)
  ▪ Recommendation – Enhance Air Pollution Monitoring
  ▪ Expanded to other important objectives beyond compliance
  ▪ Use of semi-continuous methods
  ▪ Develop more reliable methods and analytical procedures for chemical composition of PM

• Improve integration of atmospheric and health sciences to understand relationships between PM and public health impacts.
  ▪ “Health impacts based on epidemiological studies can only be derived for PM characteristics for which ambient measurements are available.”

• Improve the understanding of carbonaceous aerosols
  ▪ Chemical speciation
  ▪ Spatial and temporal resolution
  ▪ Composition

• Develop methods to identify important markers or tracer species to relate ambient concentrations to sources.

• Replace integrated measurements with continuous, real-time measurements for PM mass and composition, where feasible and as technology evolves.
Monitoring Research in EPA’s Office of Research Development (ORD)
ORD Monitoring Research

- Methods Development and Evaluation
- Source Apportionment Applications
- Exposure Assessment Applications
- Health Effects Applications
ORD’s Monitoring Research Program: Methods Development and Evaluation

- Sampling Methods
  - Coarse particles
  - Semi-continuous PM species
  - Air Toxics
    - Acrolein and 1,3 butadiene
    - Mercury dry deposition

- Analytical Methods
  - Inorganic and Organic Source marker compounds

- Research Grants
  - Carbonaceous PM
  - Source Apportionment
  - Continuous PM

- PM Supersites
ORD’s Monitoring Research Program: Source Apportionment and Exposure Applications

• Detroit Exposure and Aerosol Research Study (DEARS)
  ▪ PM Components and Size Fractions
  ▪ Air Toxics

• Steubenville Source Apportionment Study
  ▪ Integrated and Continuous PM
  ▪ Continuous Criteria Gases
  ▪ Deposition
  ▪ Ambient Mercury Speciation

• Coarse PM Methods Evaluation
  ▪ FRM / FEM
  ▪ Continuous Methods
  ▪ Saturation Samplers

• Near Roadway Exposures
  ▪ PM Composition and Size Fractions
  ▪ Mobile Source Air Toxics
Preliminary DEARS Results
(Concentration Ratios – Outdoor Residential to Community Central Site)

Increased Variability

Benzene

PM$_{2.5}$

Sulfur

Industrial, Diesel, Traffic, Highway, Regional

RESEARCH & DEVELOPMENT
Building a scientific foundation for sound environmental decisions
## Steubenville PMF Apportionment Results 2003 & 2004

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% Hg Explained | * | 2 | * | * | 5 | 74

* = Not Significant at 95% confidence interval

Source: Keeler et al, *Environment Science and Technology*, in press
ORD’s Monitoring Research Program: Health Effects Applications

- Epidemiological
  - Detroit Children’s Health Study
    - Childhood asthma and mobile sources
  - Multi-city
    - Compositional differences in Air Quality
  - Chronic exposures to PM

- Toxicological
  - Source-specific effects
  - Coarse particles

- PM Research Centers
  - Harvard University
  - New York University
  - University of Washington
  - Rochester University
  - UCLA
New Approaches for Enhancing Ambient Monitoring
Satellite Data

- Emerging source of air quality data
- Aerosol optical depth (AOD) used to estimate ground level concentrations
- Spatial and Temporal Gaps
  - Cloud cover
  - Reflective surfaces

MODIS Instrument on Terra Satellite in Orbit
Credit: NASA-GSFC
4 day sequence showing transport of regional pollution event. Posts show EPA PM2.5 ground-based measuring site. Color contours are MODIS aerosol optical depth (US EPA/NASA, 2003).
12 Sept. 2002-A close-up of Houston shows many of the hourly PM2.5 monitors recorded 24 averages in excess of 40.5 ug/m3, (AQI>100). High AOD extends into a large portion of TX.

Time Series shows agreement of hourly PM2.5 Concentrations (Surface Monitor) and Aerosol Optical Depth in Coincident MODIS pixel. Correlation Coefficient > 0.88.
“Data Fusion”

- Combining monitoring data with other sources of air quality data (e.g., modeled output, satellite) to generate air quality surfaces
  - Capitalize on the strengths of monitoring data (“true” measure) and modeling data (spatial and temporal coverage)
  - Minimize weaknesses of each data source
Data fusion results:
Spatially and temporally resolved surface enhanced with ground truth data from monitors

Monitors only
Interpolated from monitors
Modeled (CMAQ)

Data Fusion Example – PM Concentrations in NE US (Feb 14, 2001)
Summary

- Enhanced monitoring for multiple objectives
- Monitoring Priorities include
  - Continuous methods
  - PM species and size fractions
  - Air toxics
  - Increased integration with science objectives
- ORD Monitoring Research
  - Methods Development and Evaluation
  - Source Apportionment, Exposure, and Health Applications
- Approaches are emerging to enhance, not replace, ambient monitoring
  - Satellites
  - Data Fusion
For more information:

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