ORD Research Activities as the "6th PM Center"

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Air Research Program
Office of Research and Development
US Environmental Protection Agency

PM Centers Kick-off-RTP
November 30, 2005

EPA PM Research Program

Epidemiology

Clinical and Animal Toxicology Studies

Molecular

Intramural Program

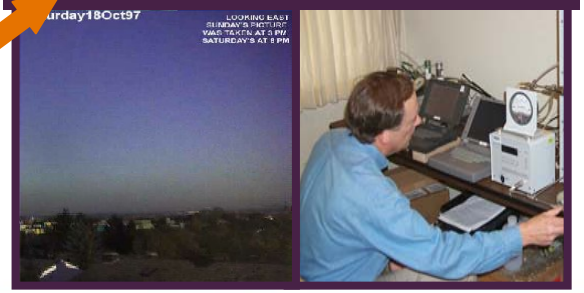
EPA STAR Program (PM Centers)

EPA Partners:

- *Other Federal Agencies*
- *Health Effects Institute*
- *National Research Council*
- *Academia*
- *Industry laboratories*

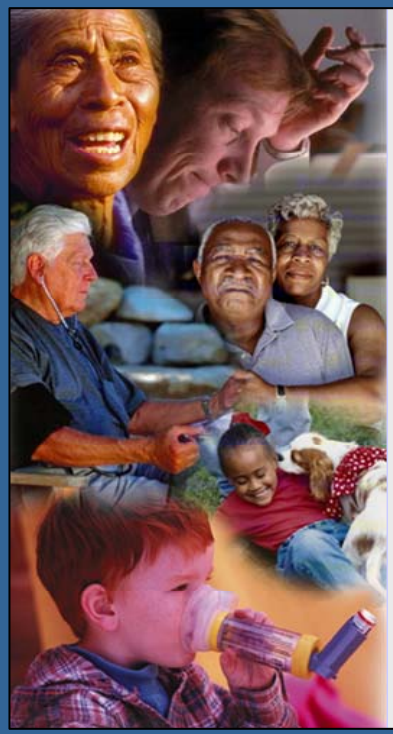
Emission Source Characterization

Exposure, Atmospheric Measurement and Models



Supersites and EPA Monitoring Network

PM Program Must be Responsive



Clean Air -- EPA Goal 1

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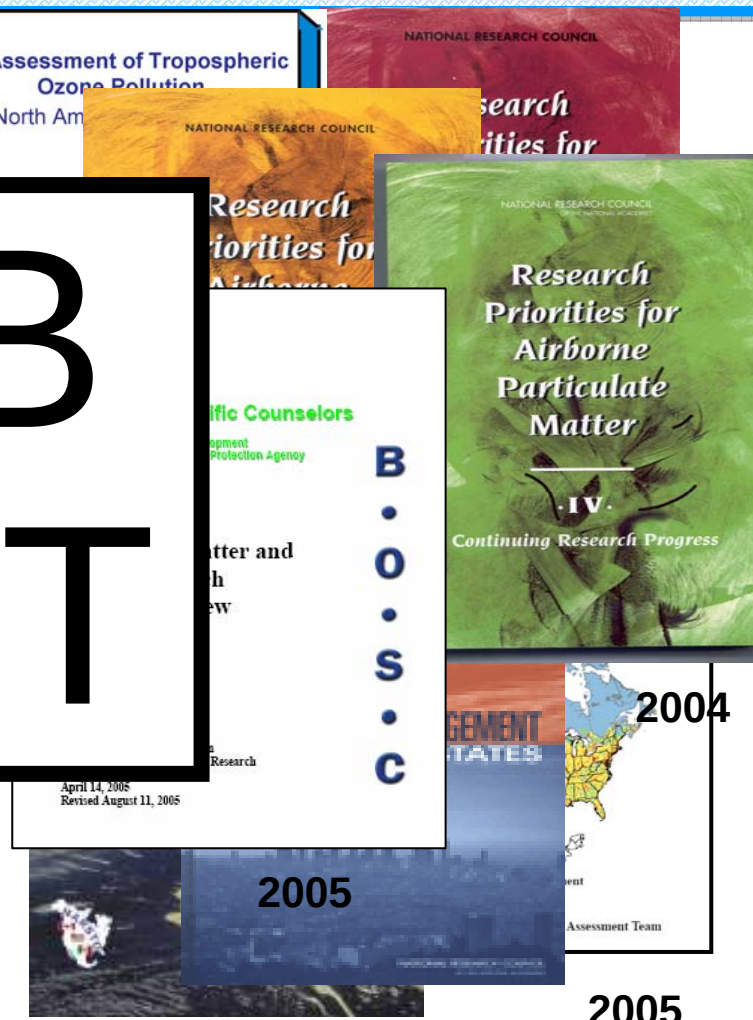
OMB PART

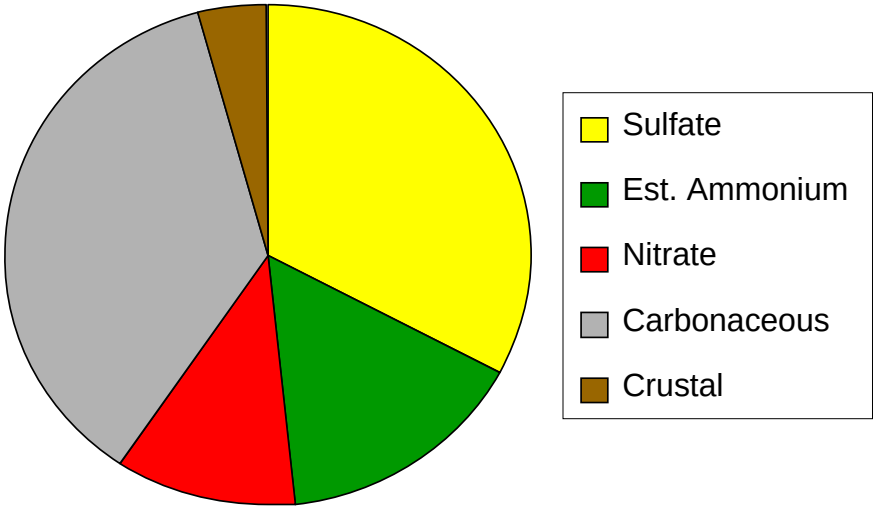


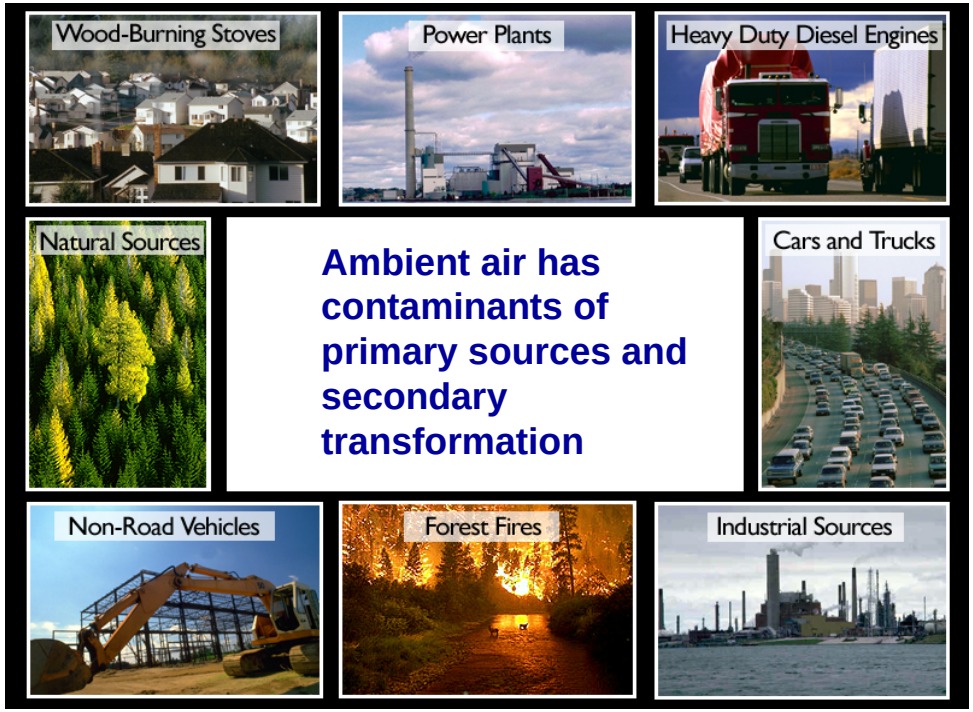
OAR, Regions, States, Tribes

Scientific Community

Public

Reality: Multiple Sources & Pollutants ► PM/Oz/AT





Pollutants contributing to $PM_{2.5}$ and Ozone

SO2 – Sulfate particles
NOx – Nitrate PM, acid gases, formation of ozone and organic PM
VOC – formation of ozone and organic PM
VOC(C6unsat) – secondary organic PM
NH3 – Ammonium
Direct emissions of carbonaceous PM, crustal materials, metals
CO – weak contribution to ozone formation

Overlap of source types, VOC/PM components and 'toxic' air pollutants

NRC Guides EPA's Research Priorities for PM

1. Outdoor Measures vs. Personal Exposure

2. Exposure of Susceptible Populations to PM Components

3. Characterization of Sources

4. Air Quality Model Development & Testing

5. Assessment of Hazardous PM Components

6. Dosimetry & Fate of Deposited PM

7. Combined Effects of PM and Gaseous Pollutants

8. Susceptible Subpopulations

9. Mechanisms of Injury

10. Analysis & Measurements

PM Research Needed to Minimize Health Risks

11. Technical Support– Atmospheric Measurements and Methods

12. Source to Health Outcome

Focus on Long Term Goals

Long-term Goal 1

- **Progress toward reducing uncertainty in standard setting and air quality management decisions due to advances in understanding in the air pollution sciences.**

Long-term Goal 2

- **Progress in assessing source to health linkages and reducing uncertainties that obscure these linkages.**

Major In House Research Areas Tied to the LTGs

- **Health Research**
  - Hazardous components
  - Susceptible subpopulations
  - Exposure-dose-response
- **Exposure Research**
  - Data and models to bridge source to effects
- **Atmospheric Science Research**
  - Emissions characterization
  - Measurement and modeling tools

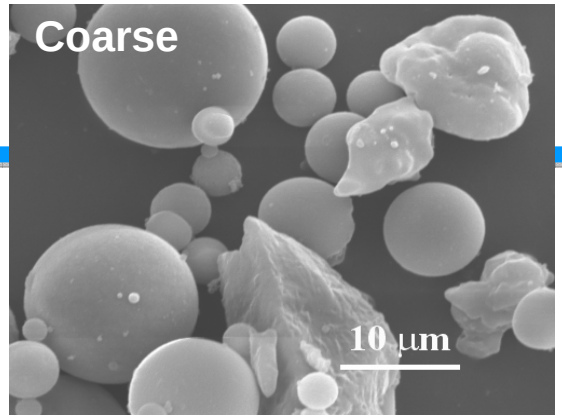
So What are the Research Issues?

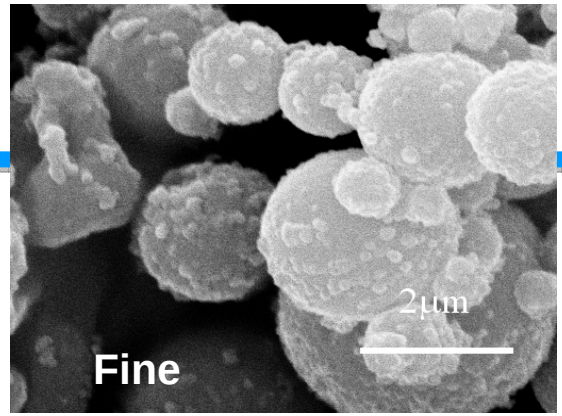
- **Develop a systematic approach (NRC) - "Hazardous Components"**
  - Link - PM attributes to sources thru to health effects
  - Multicity-multipollutant approaches (e.g., NCore proposal)
- **Support OAR and clients – emerging NAAQS issues**
  - Near Highway (pressing client need)
  - Tool and model development (implementation)
  - Coarse PM – sources to health (urban vs non-urban)
  - Accountability (Are we making a difference?)
  - Emission Inventory development (update current databases and novel sources: open-burning, aircraft)

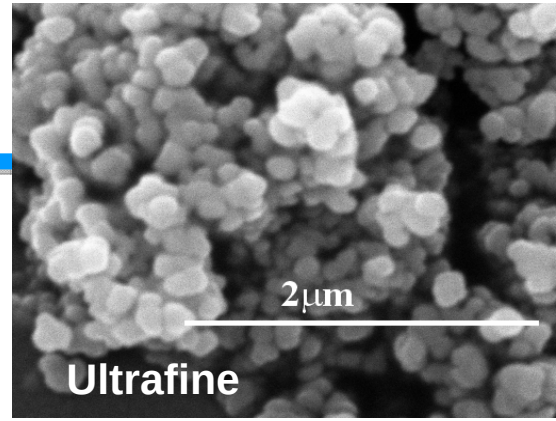
So What are the Research Issues?

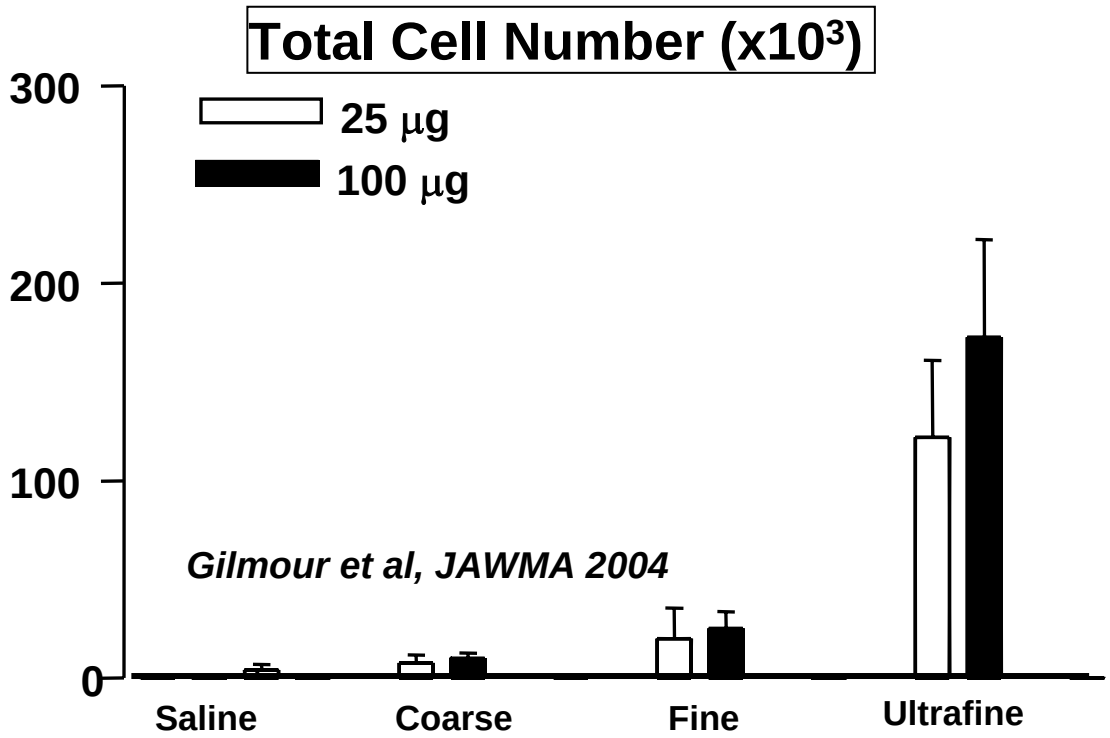
- **Apply advanced cutting-edge technologies (e.g., ‘omics)**
- **Assess long-term health implications of PM**
- **Improve exposure models: components (1º/2º) & sources**
- **Refine of atmospheric models – for SIP use and as predictive tools for public health application**
- **Develop remote sensing technologies**
- **Broaden PM-Ozone Program to “one-atmosphere”**
  - Integrate AT field program
  - Leverage AT toxicology with PM & HH (e.g., asthma)

Examples of ORD Research Program Efforts to Address These Issues



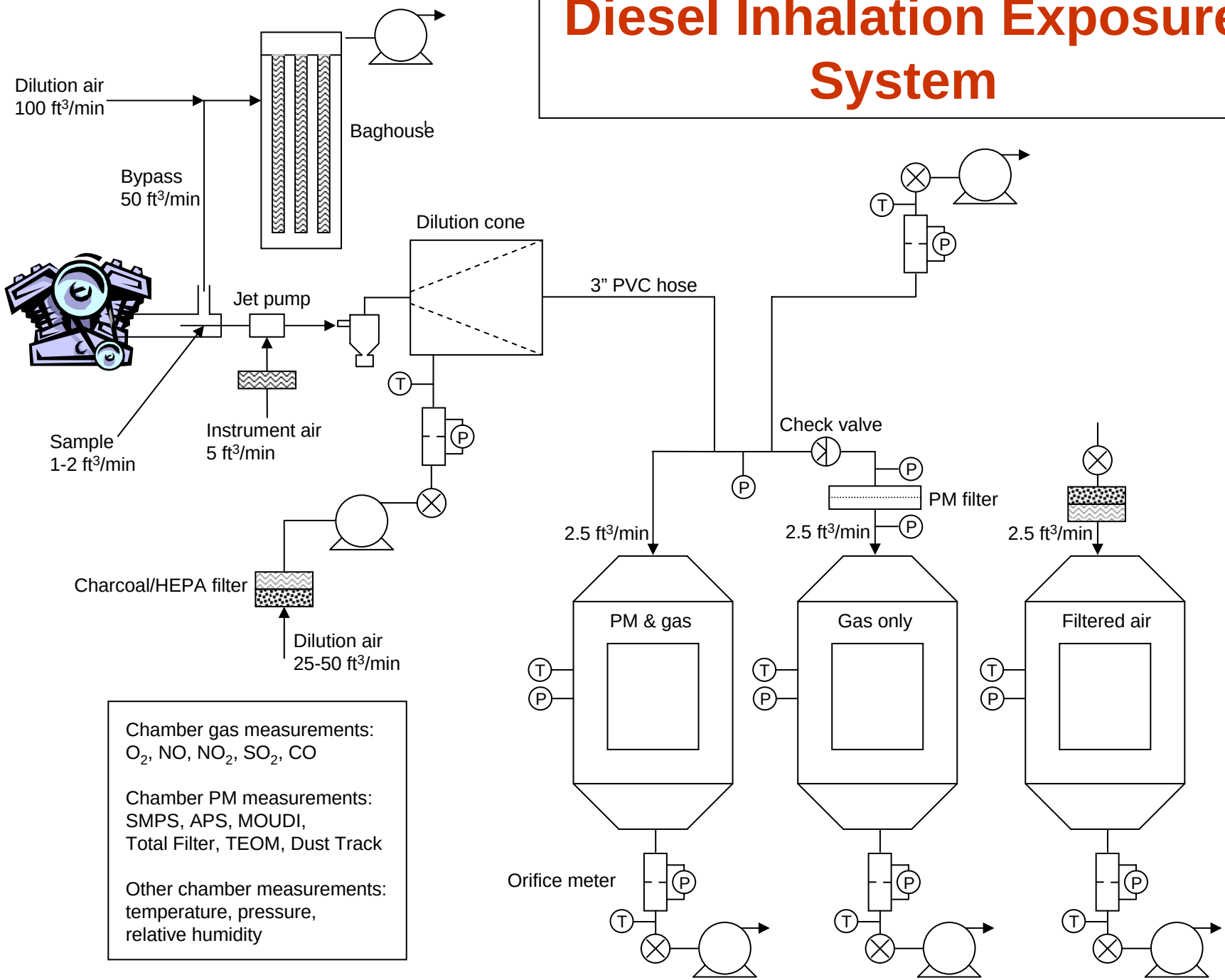






Size-related Toxicity with Source-Derived Particles (Coal)

Diesel Inhalation Exposure System

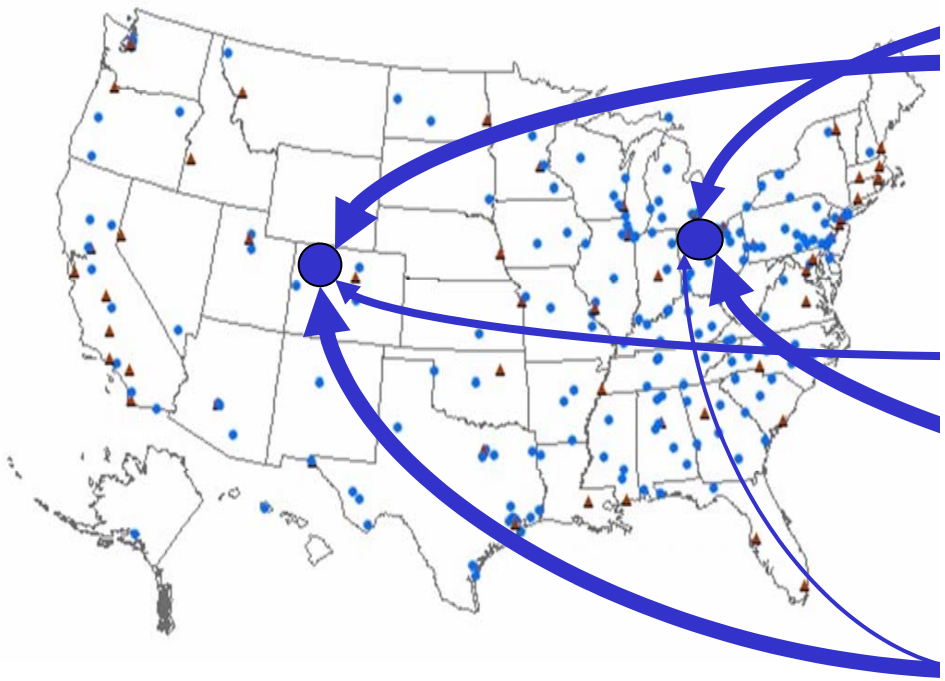


Chamber gas measurements:
O_2, NO, NO_2, SO_2, CO

Chamber PM measurements:
SMPS, APS, MOUDI,
Total Filter, TEOM, Dust Track

Other chamber measurements:
temperature, pressure,
relative humidity

MultiPollutant / MultiCity Studies to Link to Sources and Health Outcomes

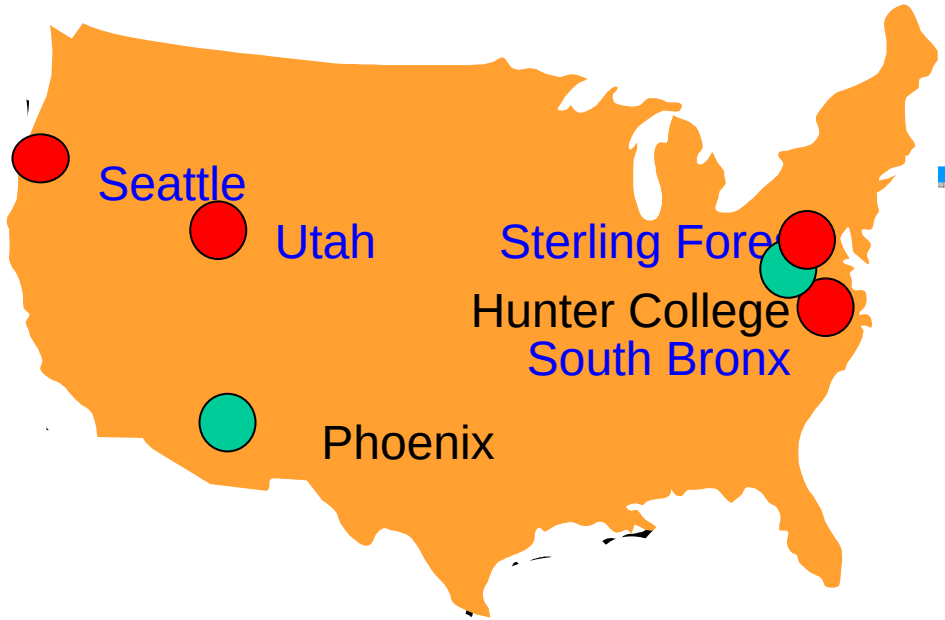


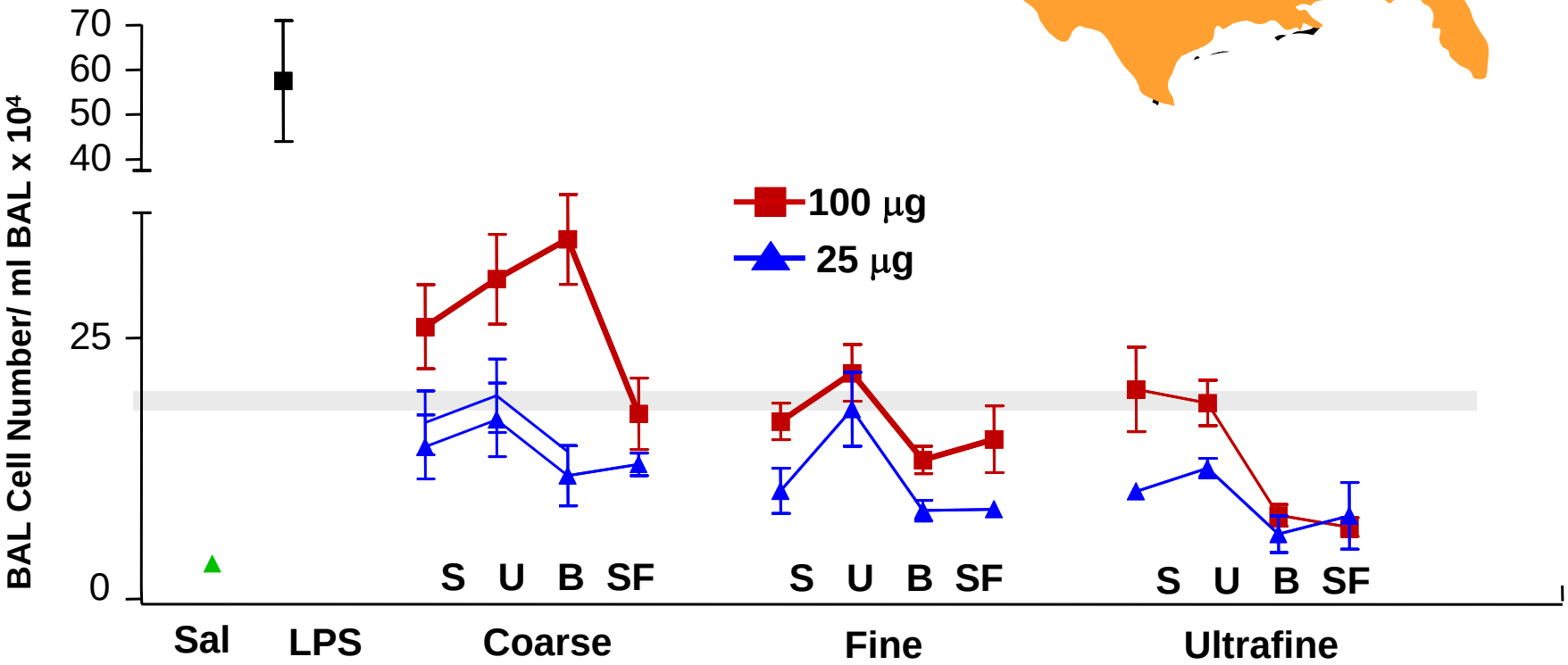
Associating health outcomes with different source types provides additional information about source-related toxicity

Merging source apportionment techniques with epidemiology and ambient monitoring can yield important information about source to health outcome linkages.

Multicity Multipollutant Approaches

Linked to NCore Monitoring Program





Near Roadway Effects – Pressing Regional Need with PM and Air Toxic Implications

Significant changes occur in size distribution of PM with distance from the roadway.

Zhu et al., 2002

- **Asthma**
- **Birth defects**
- **CV effects**
- **Cancer**

- **What do we really know about exposure?**
- **Implications are significant**
- **Interventions exist – value?**

- The percentage of people living in the ‘burbs more than doubled from 1950 to 2000.
- People spend 31% more time commuting than in 1950’s

- Emission characterization

- Exposure assessment
- Health effects

El Paso & Detroit (DEARS/DCHS)

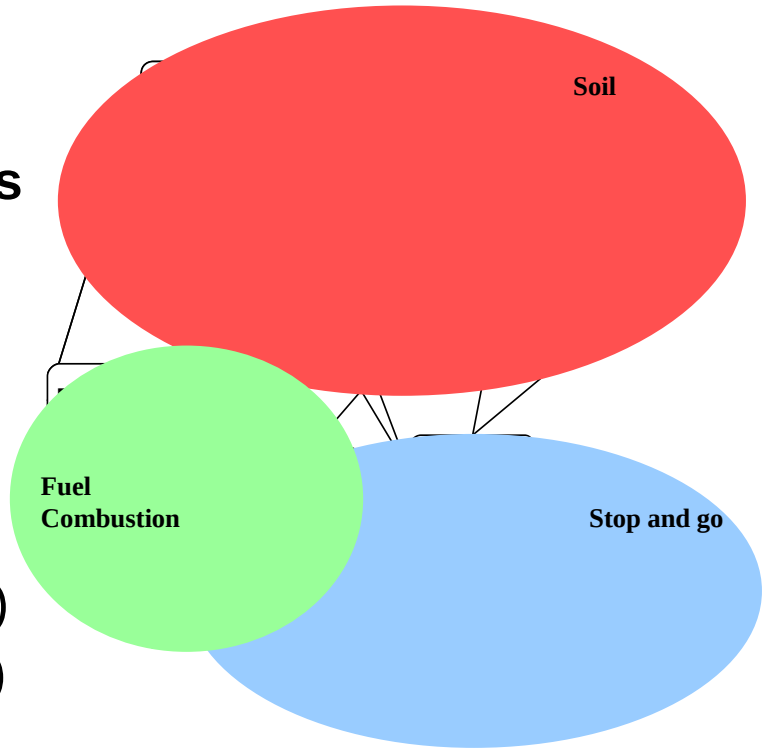
Sample collection for tox tests

Need for partnering (e.g., PM Ctrs., HEI, FHWA, CDC, others)

Linking specific sources or PM attributes to adverse health effects?

In-Vehicle North Carolina Highway Patrol Trooper study (COP Study)

- **Measured in vehicle, roadside, and ambient air pollutants**
- **Evaluated pollution source signatures**
  - Soil and Roads
  - Fuel Combustion
  - Stop and Go Traffic
- **Found:**
  - Pro-inflammatory & thrombotic(?)
  - HRV Changes: pre-arrhythmia(?)
  - Stop-and-go traffic pollutants appear to be the most potent.



Riediker et al., 2004

Source Apportionment / Atmospheric Chemistry Projects

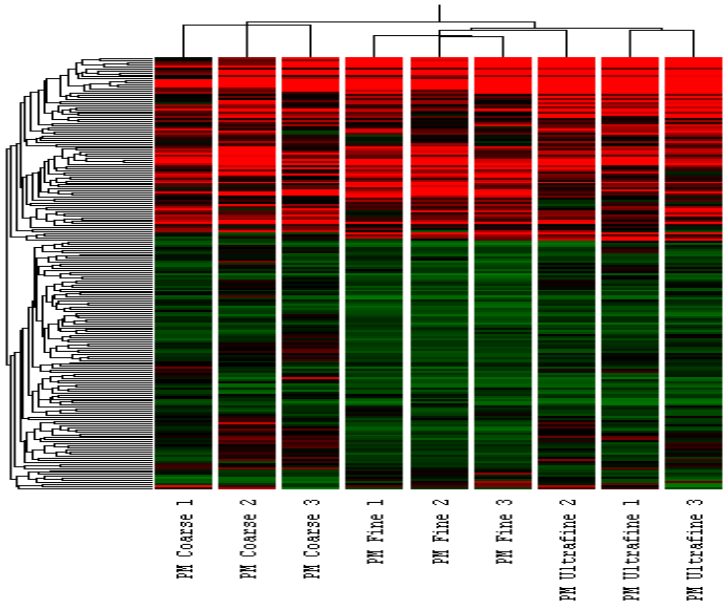
- **In house Source Apportionment (multiple projects)**
  - COPPs Study
  - DEARS
  - Receptor modeling
- **Source Apportionment (FY04/05) 11 grants**
  - Evaluate and improve receptor modeling for PM source apportionment (3)
  - Integrate receptor, source-based, and inverse modeling for PM source apportionment (4)
  - Improve tracer/measurement methods for source apportionment (4)
- **Continuous Measurement (FY 05) 3 grants**
  - Improve measurement methods for PM chemical composition (3)

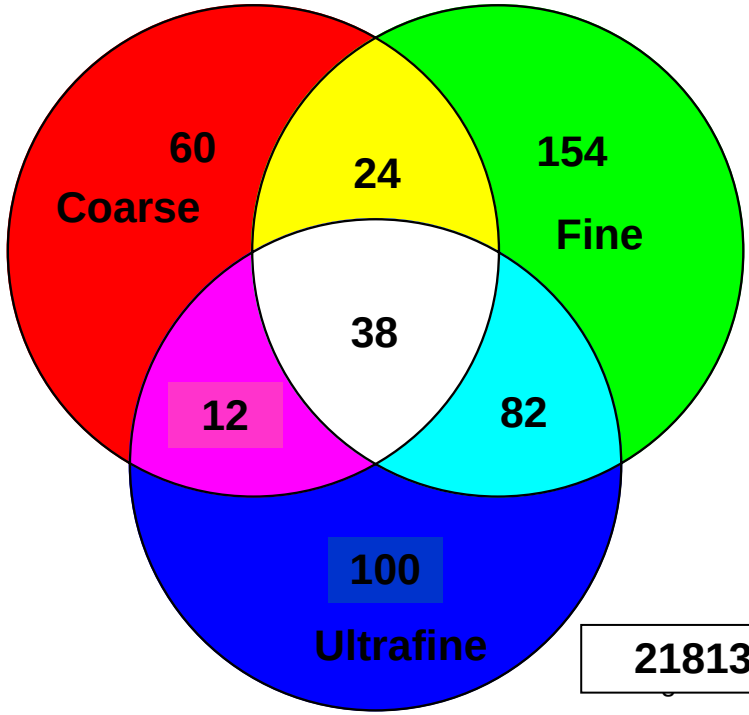
Health effects and Mechanism Research

- **CAPs studies in humans and animal models**
- **Susceptibility (genetic, age, disease)**
- **Cardiac, vascular, and other systemic outcomes (e.g., neural, developmental)**
- **Physiologic & cell/molecular approaches (e.g., 'omics)**
    - 6 STAR CVD grants (collaboration with NIEHS)
- **Chronic studies (STAR – MESA; other retrospective studies; limited animal studies)**
- **Initiate / develop "one-atmosphere" concept (MAPP)**

“Omics” May Change Everything

Genes Uniquely Expressed in Lung Cells Exposed to Either Coarse, Fine, or Ultrafine PM





Implications for linkage of health effects to PM components or sources

Partner with NIH Studies to Address the Long term Impacts of PM Exposure on CVD?

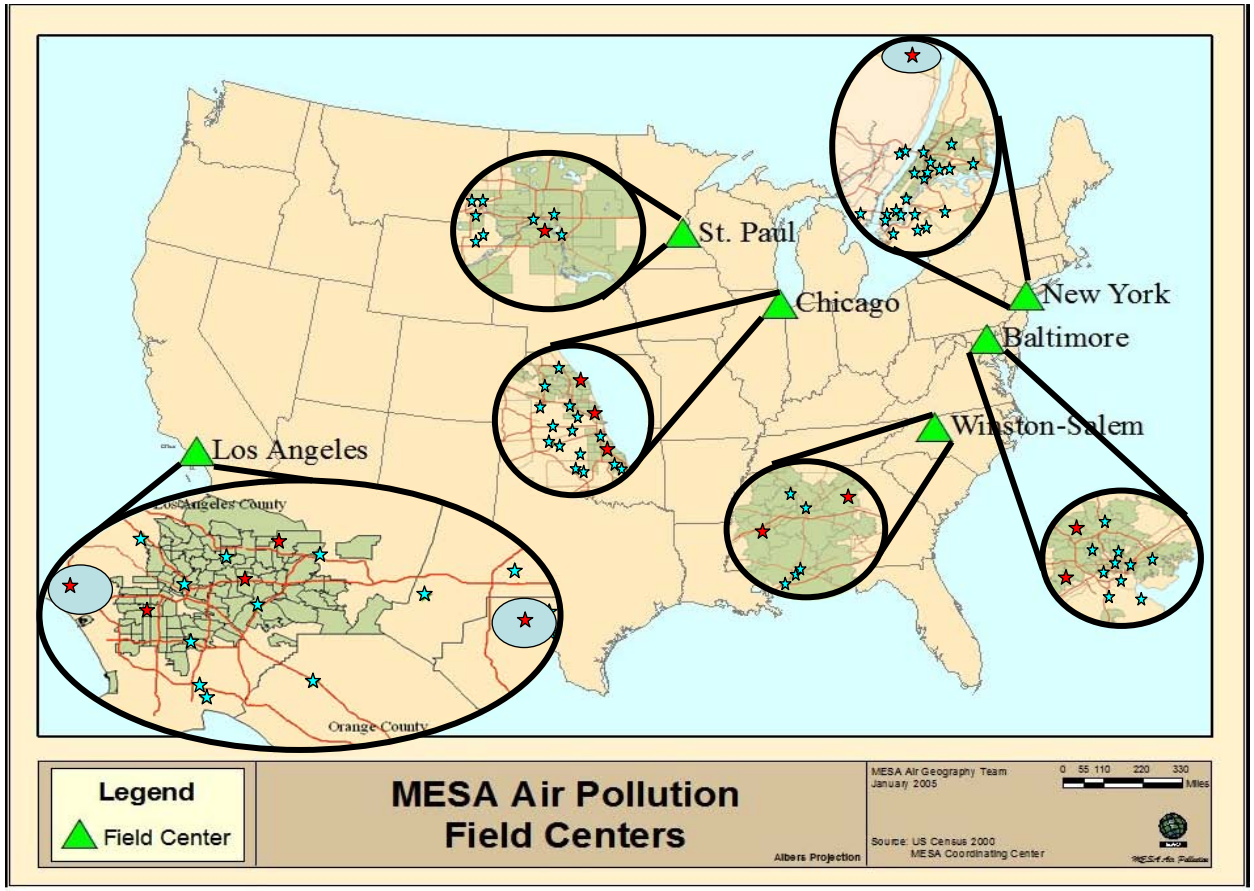
Opportunities to partner with other STAR grantees to enhance understanding of potential long term effects

Retrospective Studies

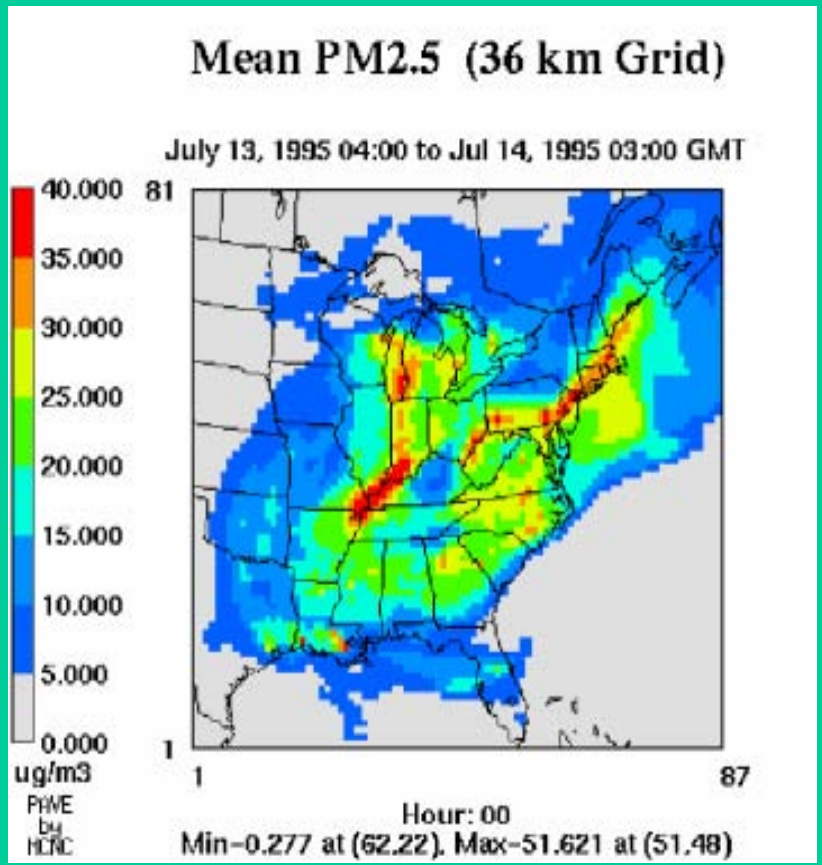
- Medi-Coh/Vet Study – JHU
- Nurses Study - HSPH
- M-Eth Study on Ath.(NHLBI) - UMich
- Adventist Study – LLU
- Wom Health Initiative Study - UW

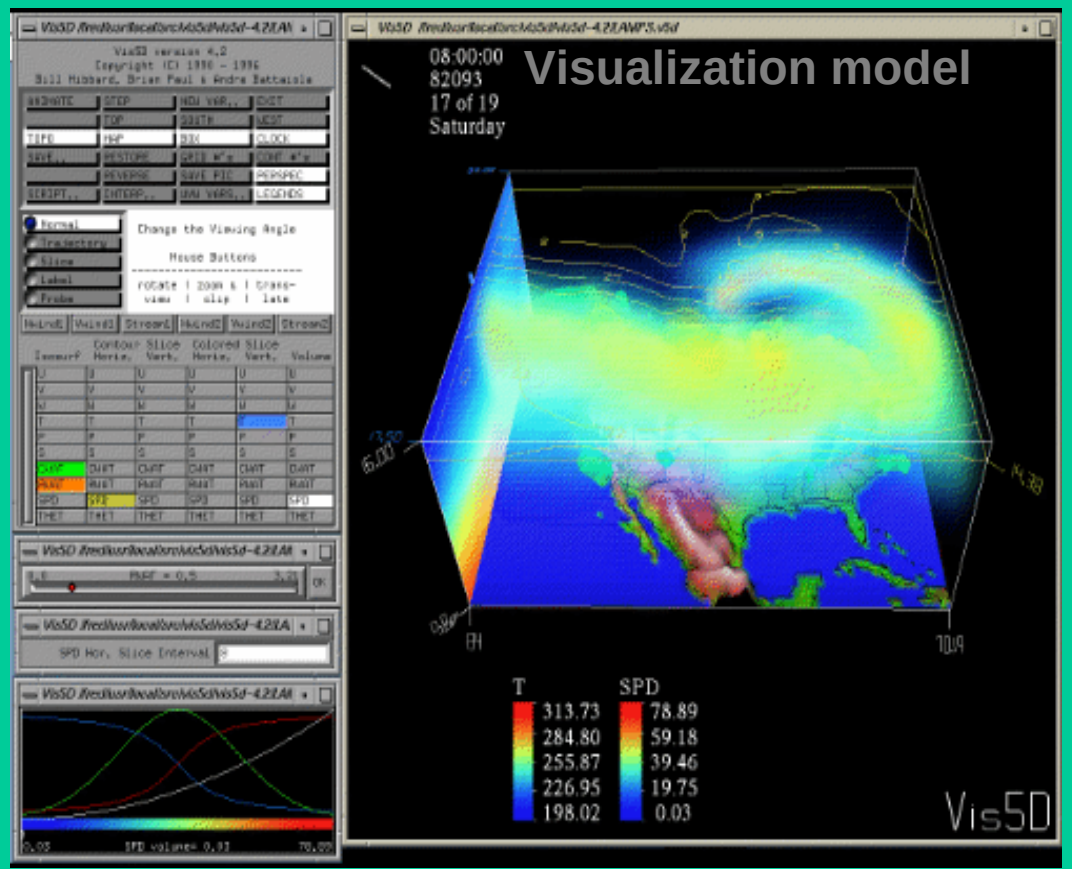
A New Prospective Study of Air Pollution and Cardiovascular Disease: "MESA Air Pollution"

Kaufman - Univ. of Washington



Advanced simulation tools (e.g., Community Multiscale Air Quality - CMAQ) are being developed to accurately model emission sources and atmospheric processes to design effective control strategies.

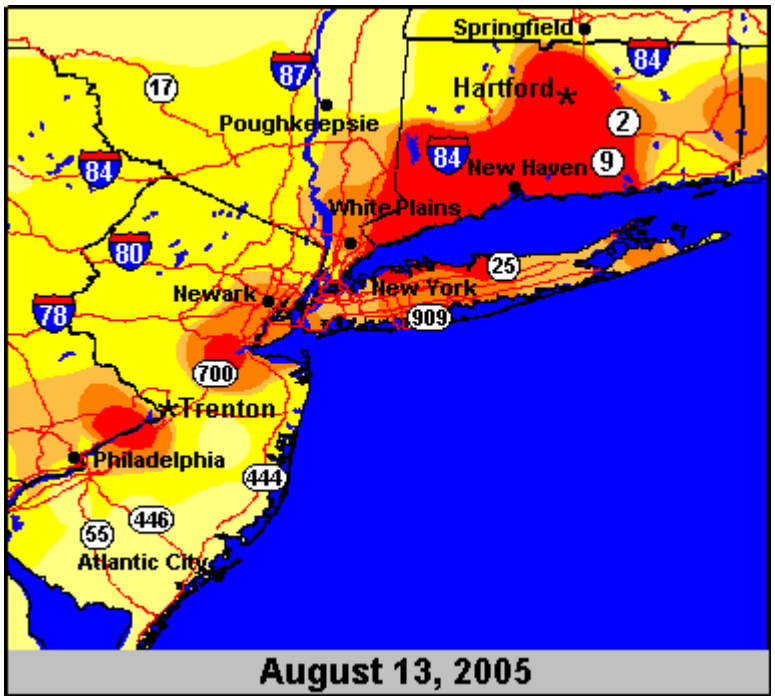




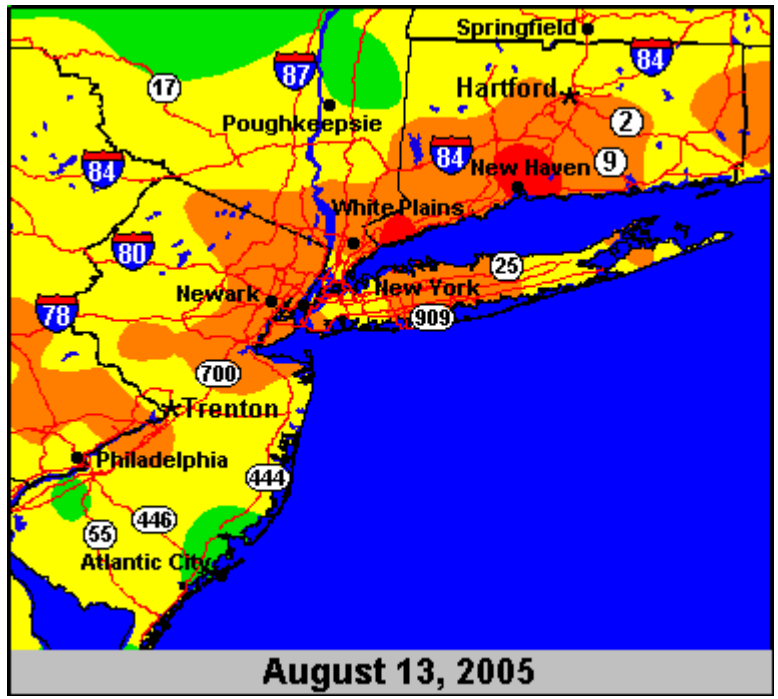
Accountability – An Example

Daily air quality forecasting and monitoring are producing an accountability database

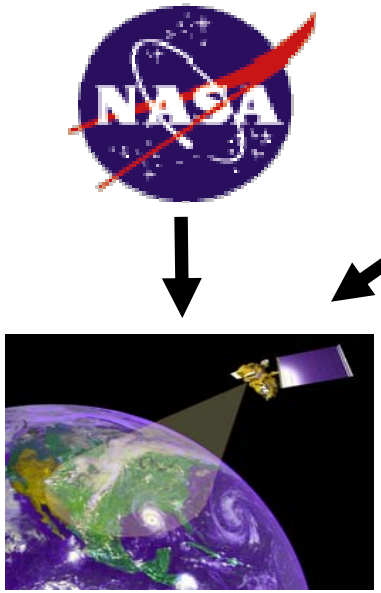
Ozone - Peak AQI

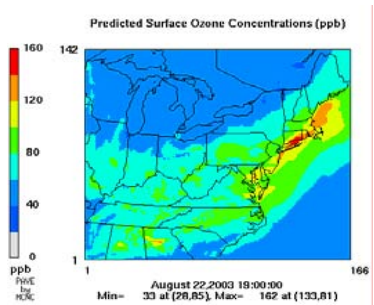


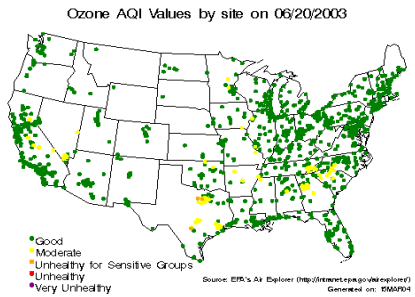
Ozone - 1-hour Average Peak Concentration



Partnerships in Characterizing Air Quality to Estimate Public Exposure

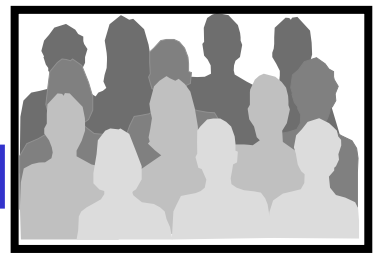






Satellite ⟷ Modeling ⟷ Monitoring

- **Assessment of risk**
- **Forecasting**
- **Public Communication**



Cross-cutting Issues for the Air Program

- **Increasing Number of Adverse Health Outcomes Associated With PM and Related Susceptible Subpopulations**
- **Increasing Emphasis on Exposure-Dose-Response Relationships**
- **Particle Toxicity In Relation To Different Particle Characteristics and Emission-Source Types (Source to Health Outcome)**
- **PM Health Effects Must be Considered Within the Broader Context of Other Pollutants Present in Ambient Air**
- **Use Atmospheric and Exposure Models as Research as well as Regulatory Tools**
- **Explore Opportunities to Leverage Across Research Programs and Agencies to Effectively Inform the Setting & Implementation of Standards**