Current Status of the National Ambient Air Quality Standards in the US

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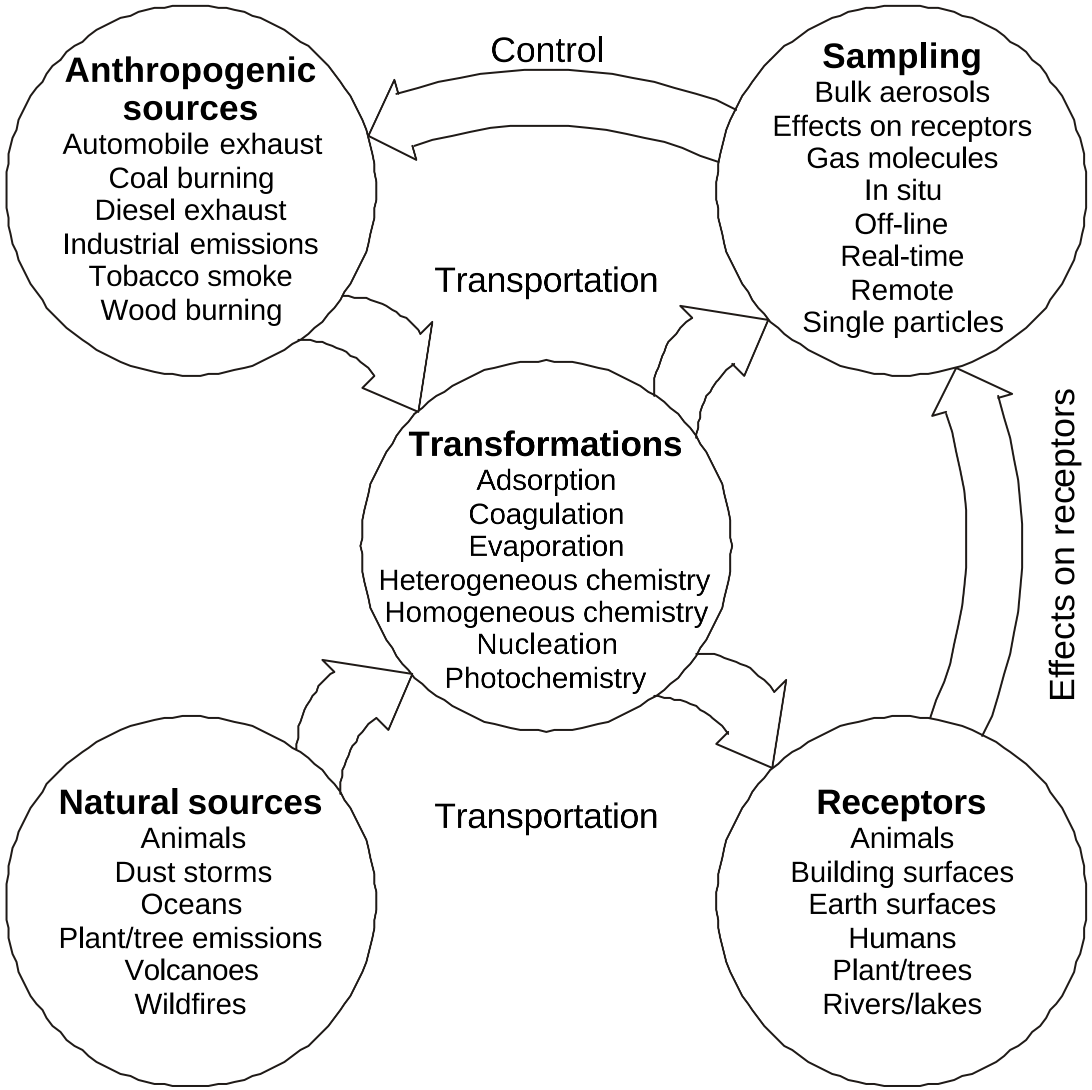
Objective

- To provide an overview of the US national ambient air quality standards (NAAQS), which are set by the US Environmental Protection Agency (EPA), focusing on current knowledge of particulate matter (PM)
  - Atmospheric chemistry and physics
  - Conventional measurements
  - Exposure-dose-response relationship
  - Novel measurements

Air pollution system



Noble *et al*. *Phys. World* **1998**, *11*, 39.

Impact of air pollution

- Human health effects
  - Human morbidity and mortality
  - US EPA primary standard—“public health”
- Environmental effects
  - Animals, vegetation, crops, soil, water, buildings, visibility, weather, climate, *etc*.—“public welfare”
  - US EPA secondary standard

US national ambient air quality standards

Pollutant	Standard
Carbon monoxide (CO)	9 ppm (8 hr average) 35 ppm (1 hr average)
Ozone (O_3)	0.12 ppm (1 hr average) 0.08 ppm (8 hr average)
Nitrogen dioxide (NO_2)	0.053 ppm (annual mean)
Sulfur dioxide (SO_2)	0.03 ppm (annual mean) 0.14 ppm (24 hr average) 0.50 ppm (3 hr average)
Lead (Pb)	1.5 $\mu g \cdot m^{-3}$ (quarterly mean)
Particulate (PM_{10})	50 $\mu g \cdot m^{-3}$ (annual mean) 150 $\mu g \cdot m^{-3}$ (24 hr average)
Particulate ($PM_{2.5}$)	15 $\mu g \cdot m^{-3}$ (annual mean) 65 $\mu g \cdot m^{-3}$ (24 hr average)

Key milestones in US air quality standards for PM

- 1971—promulgation of total suspended particulates (TSP) standard, which measures “total” PM mass concentration
- 1978—promulgation of particulate Pb standard
- 1987—promulgation of PM_{10} standard
- 1997—promulgation of revised PM_{10} standard and introduction of $PM_{2.5}$ standard (also a revision of the O_3 standard)

Recent developments in US air quality standards for PM

- 1997—promulgation of $PM_{2.5}$ and revision of PM_{10}
- 1998—$PM_{2.5}$ standard challenged in court
- 1999—US Court of Appeals remanded $PM_{2.5}$ standard back to EPA for revision
- 2001—US Supreme Court decision
  - EPA has the right to promulgate a $PM_{2.5}$ standard
  - Compliance costs should not be considered
  - PM_C should replace PM_{10}

Complexity and diversity of atmospheric PM

- Physical characteristics
  - Size distribution (aerodynamic, physical, *etc*.)
  - Concentration (mass or number)
- Chemical characteristics
  - Composition (chemical or elemental)
  - Acidity/alkalinity
- Temporal characteristics
- Spatial characteristics

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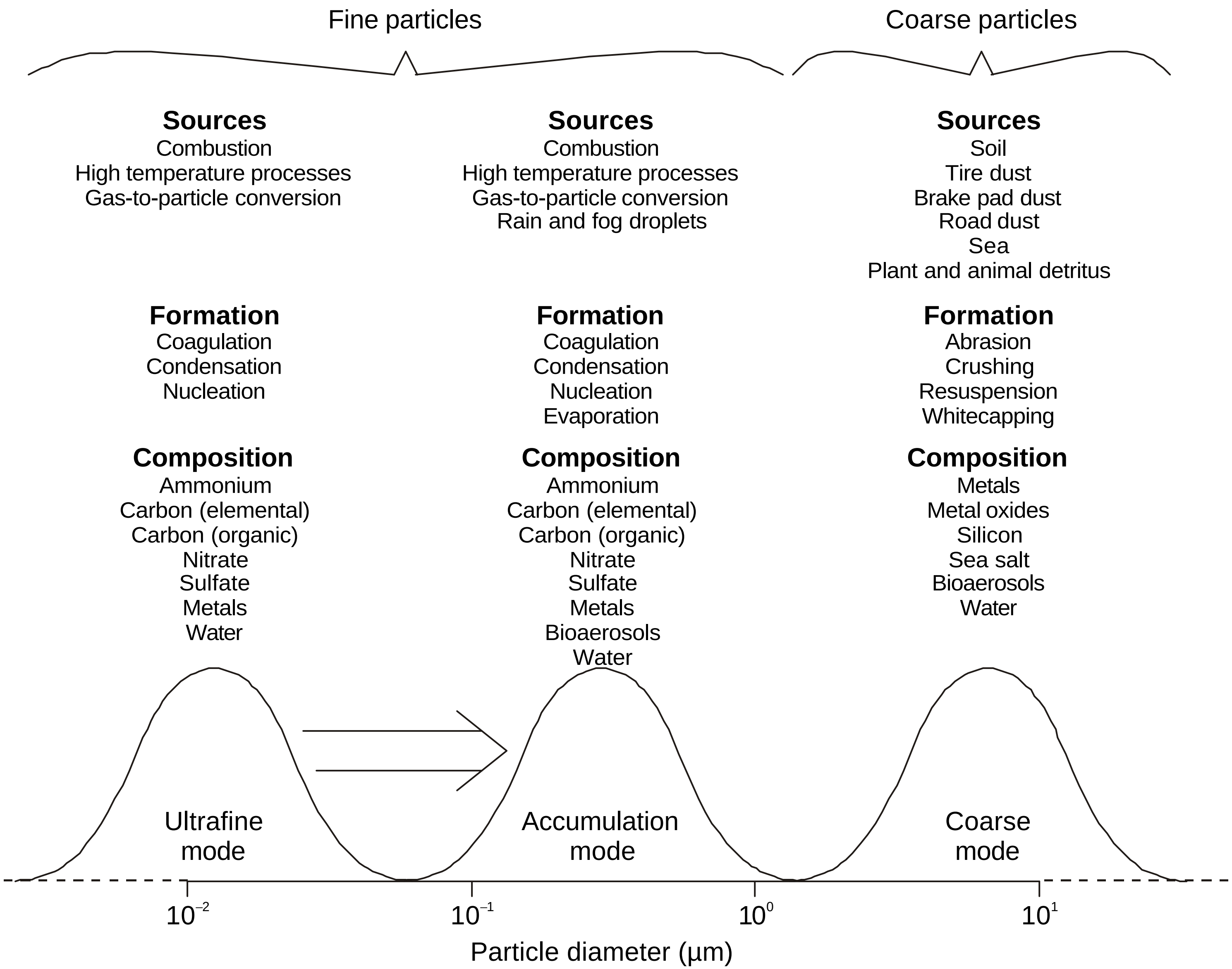
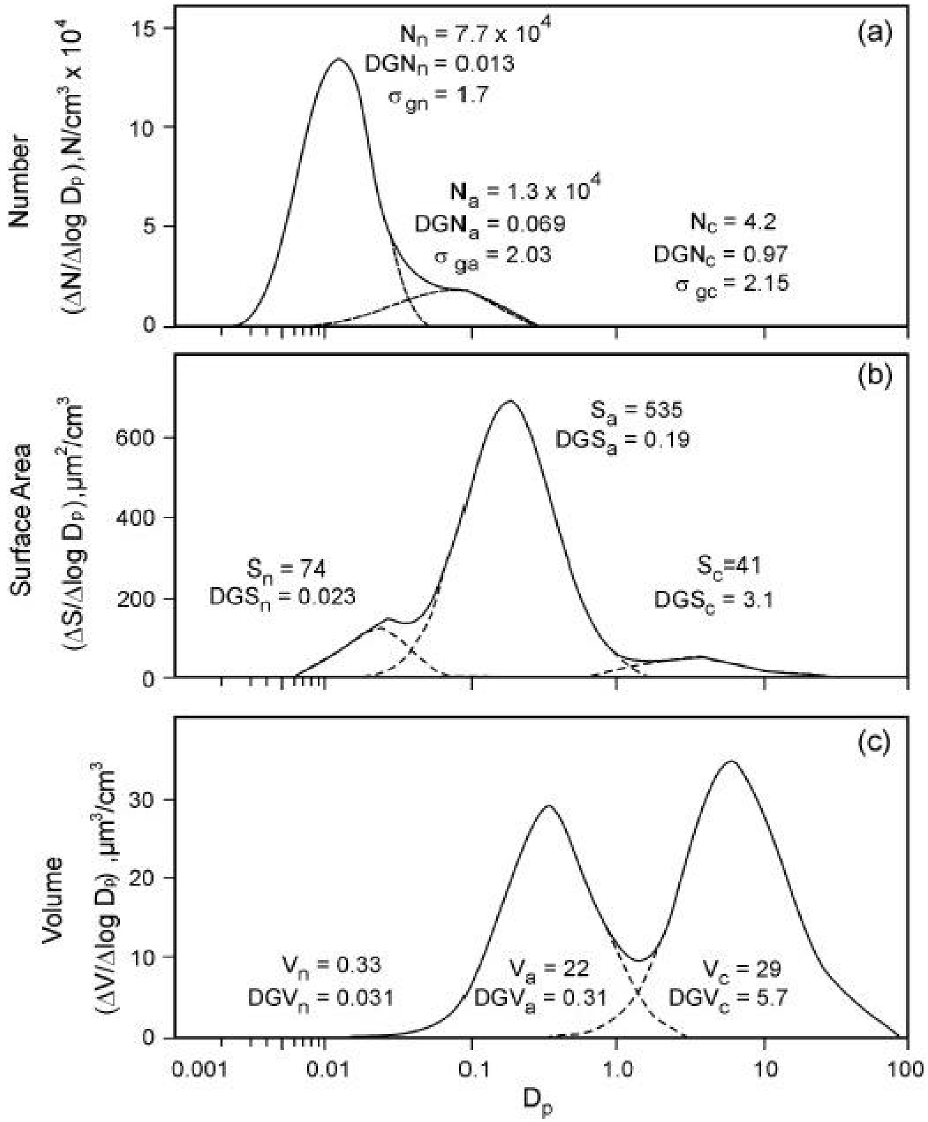
Physical and chemical characteristic of atmospheric PM



Particle size distribution by different PM properties



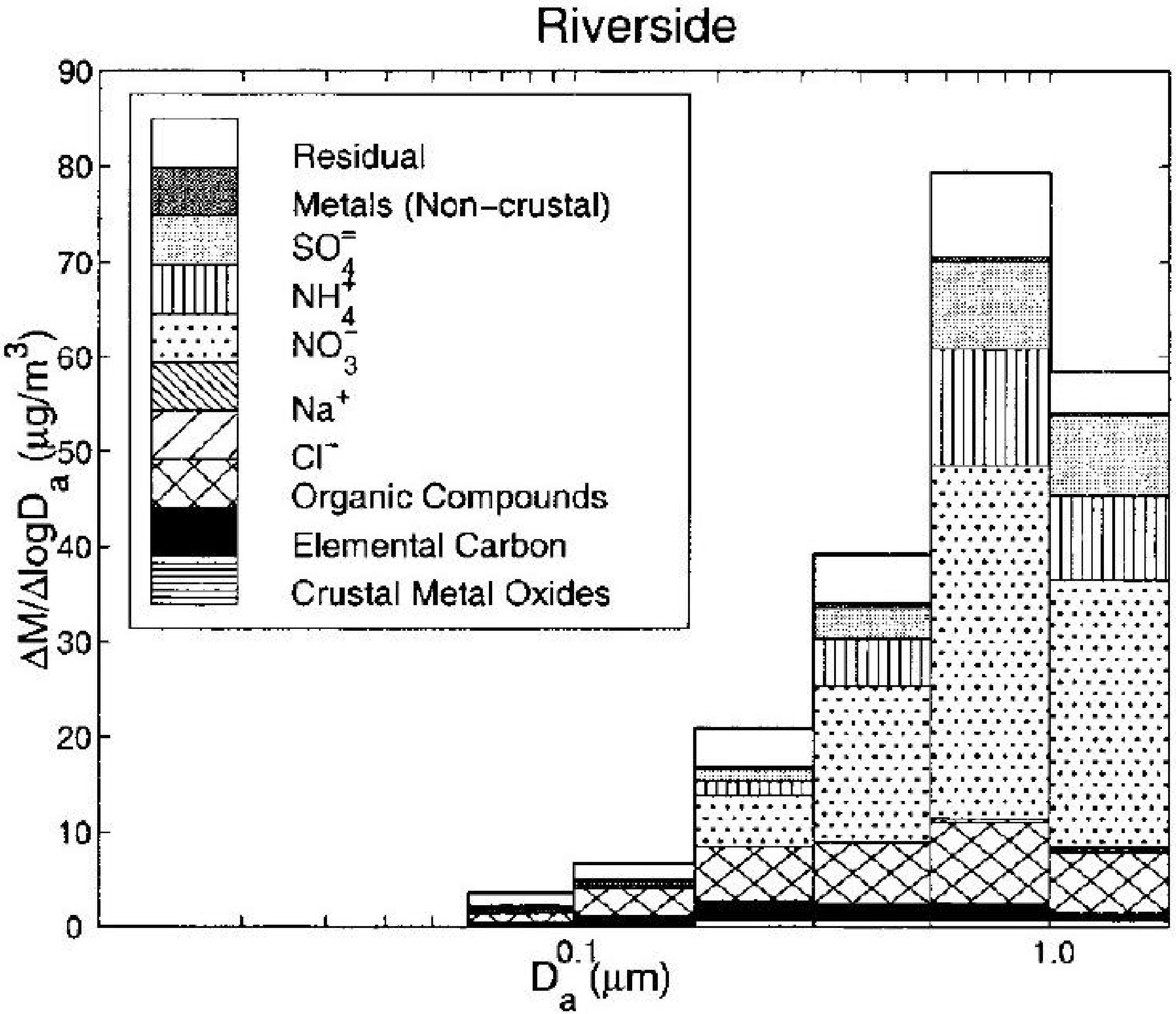
Number

Surface area

Volume (or mass)

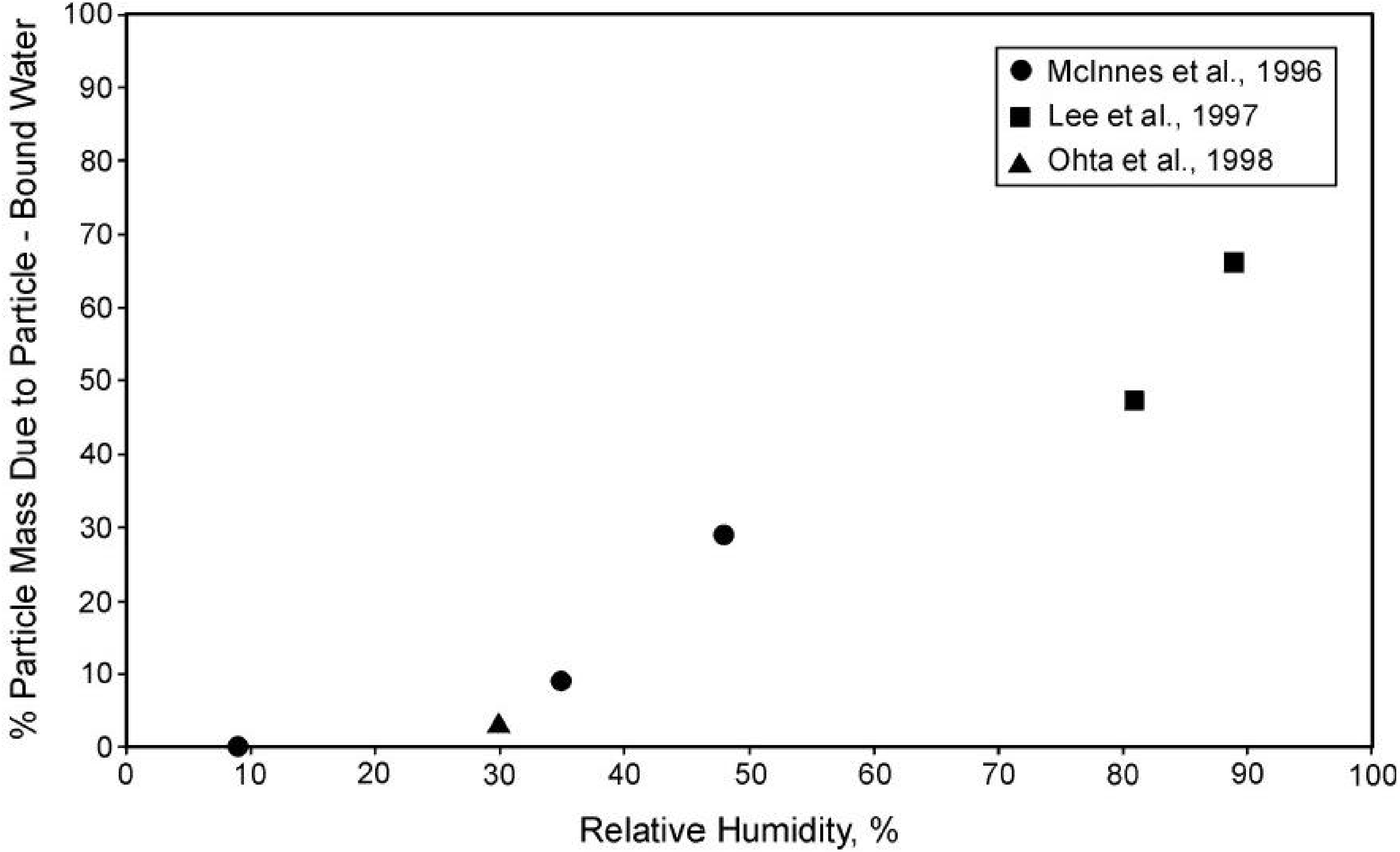
Whitby. *Atmos. Environ*. **1978**, *12*, 135.

Chemical characteristics of atmospheric PM



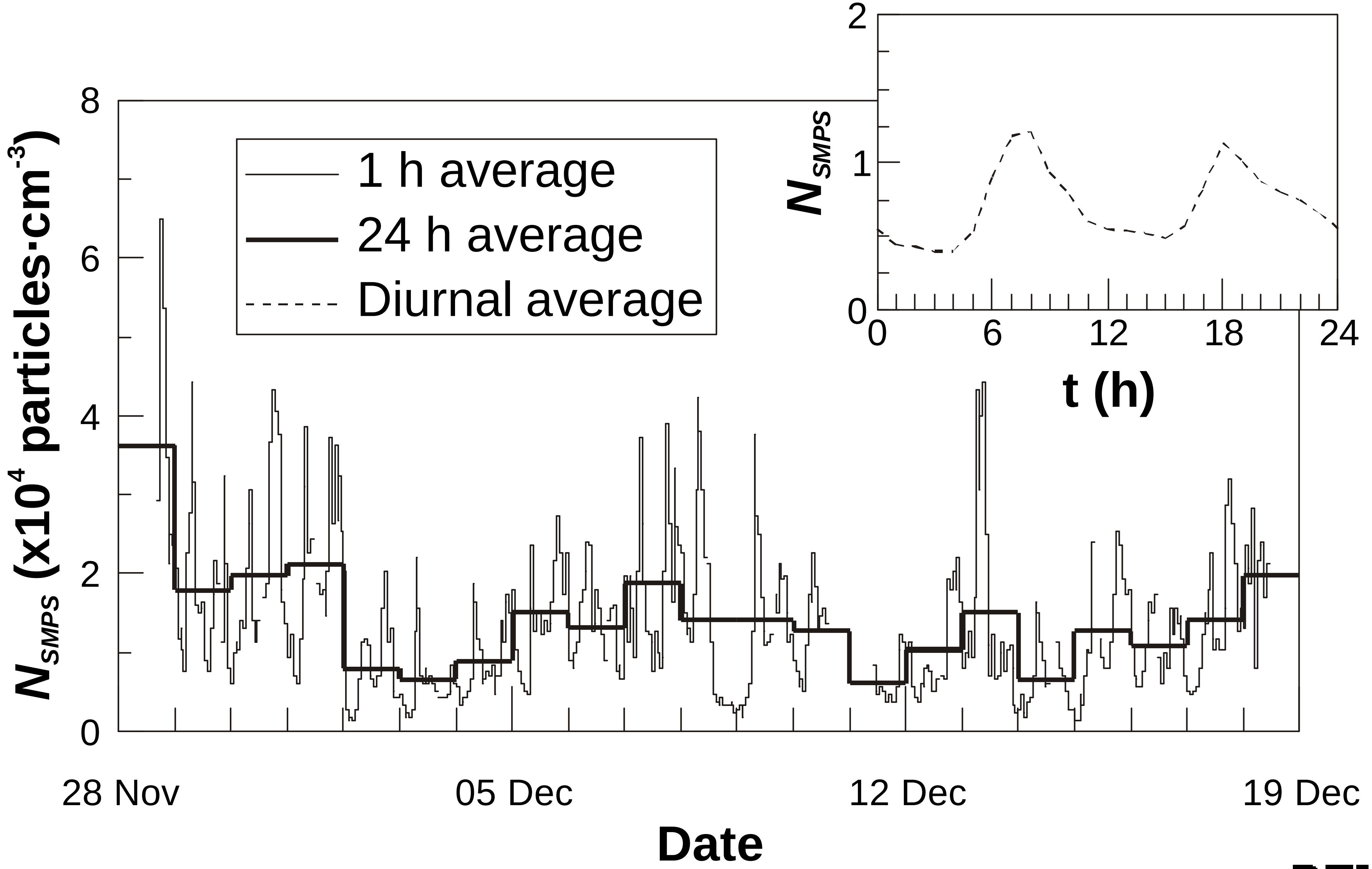
Hughes *et al*. *Environ. Sci. Technol.* **1999**, *33*, 3506.

Particle-bound water as a function of humidity



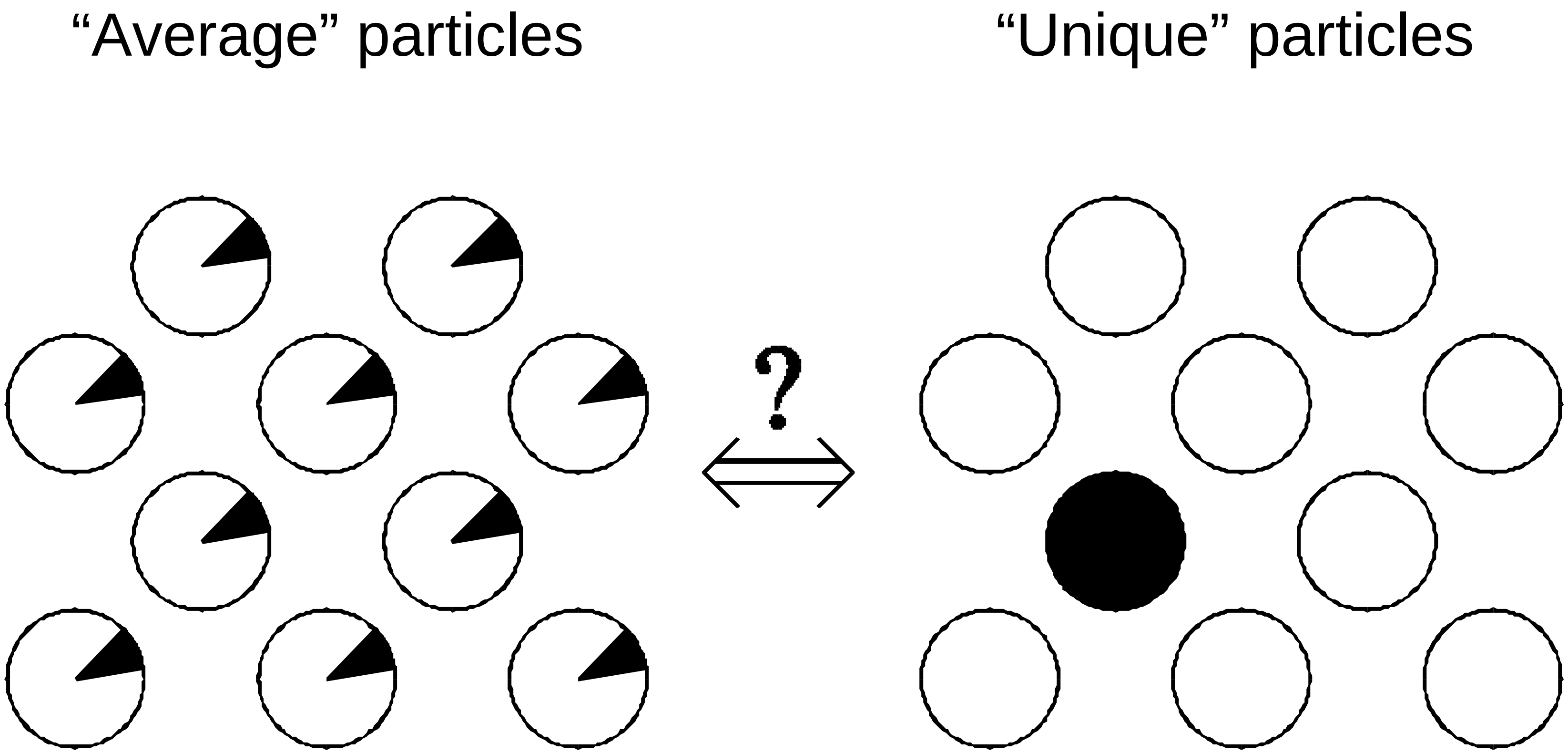
US Environmental Protection Agency. Report EPA-600/P-99-002aB; 2001.

Temporal characteristics



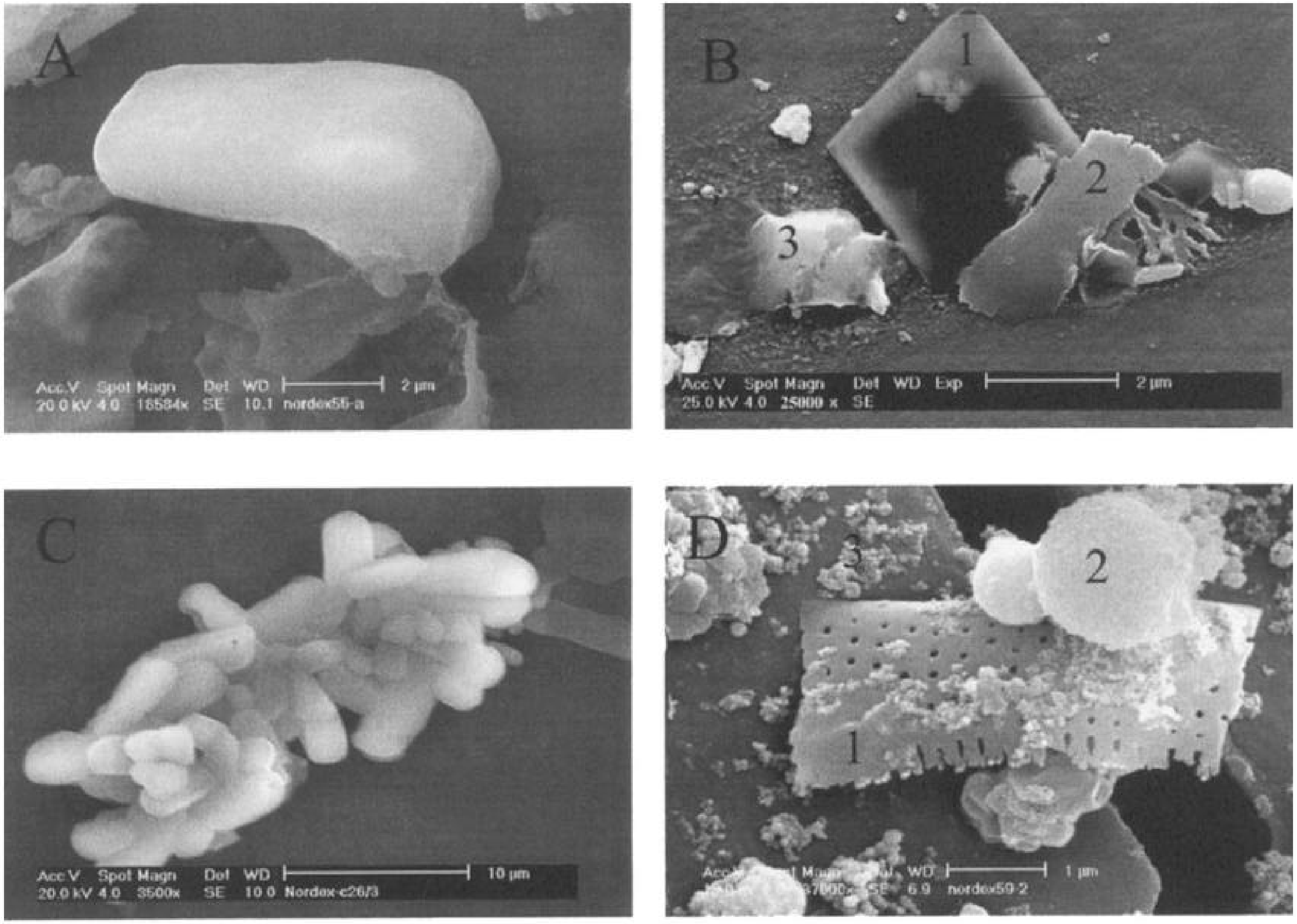
Noble *et al*. manuscript in preparation.

Atmospheric PM homogeneity



Noble *et al*. *Appl. Occup. Environ. Hyg .* **1998**, *13*, 439.

Single atmospheric particles

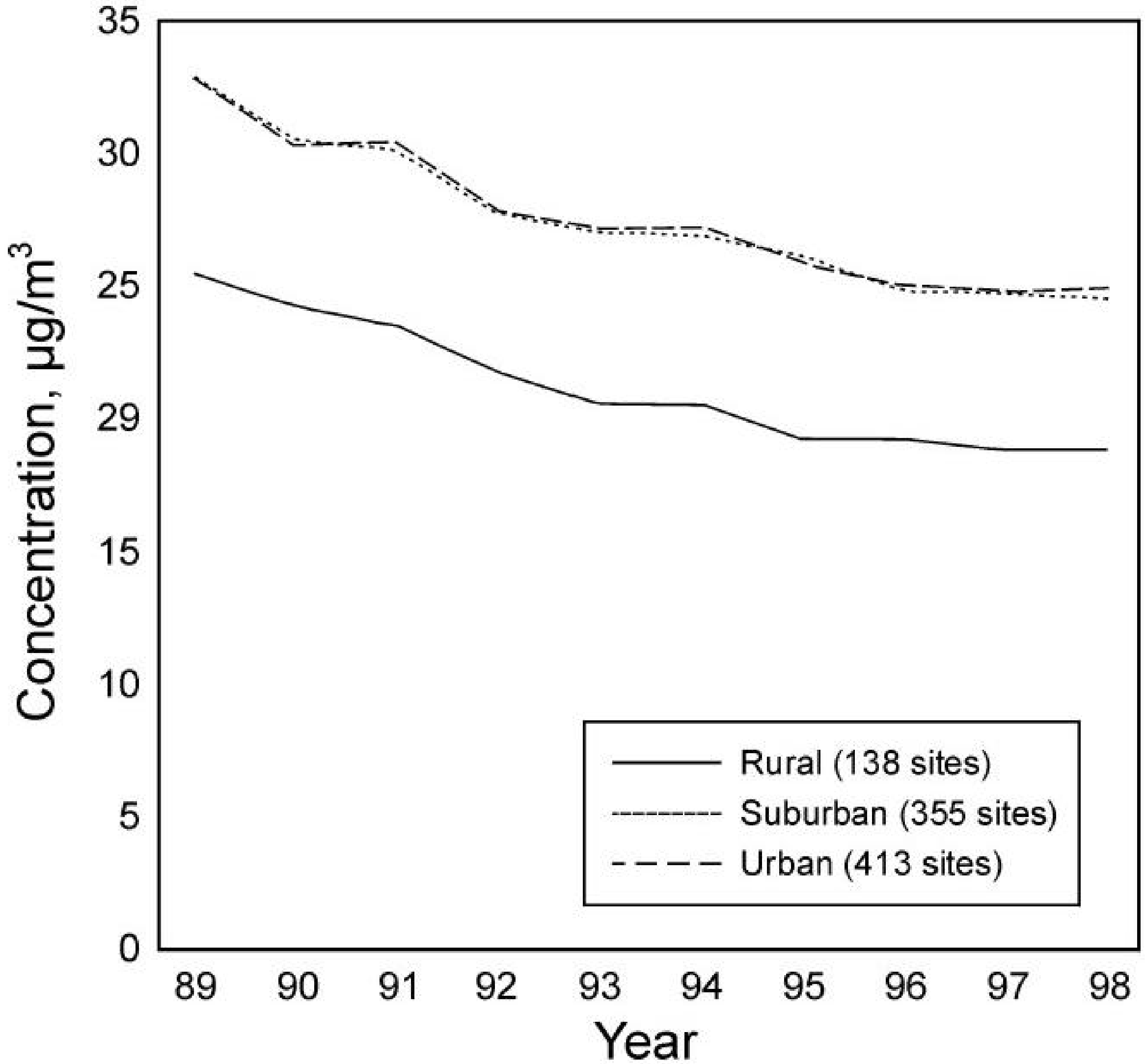


Ebert *et al*. *J. Aerosol Sci.* **2000**, *31*, 613.

Conventional PM monitoring

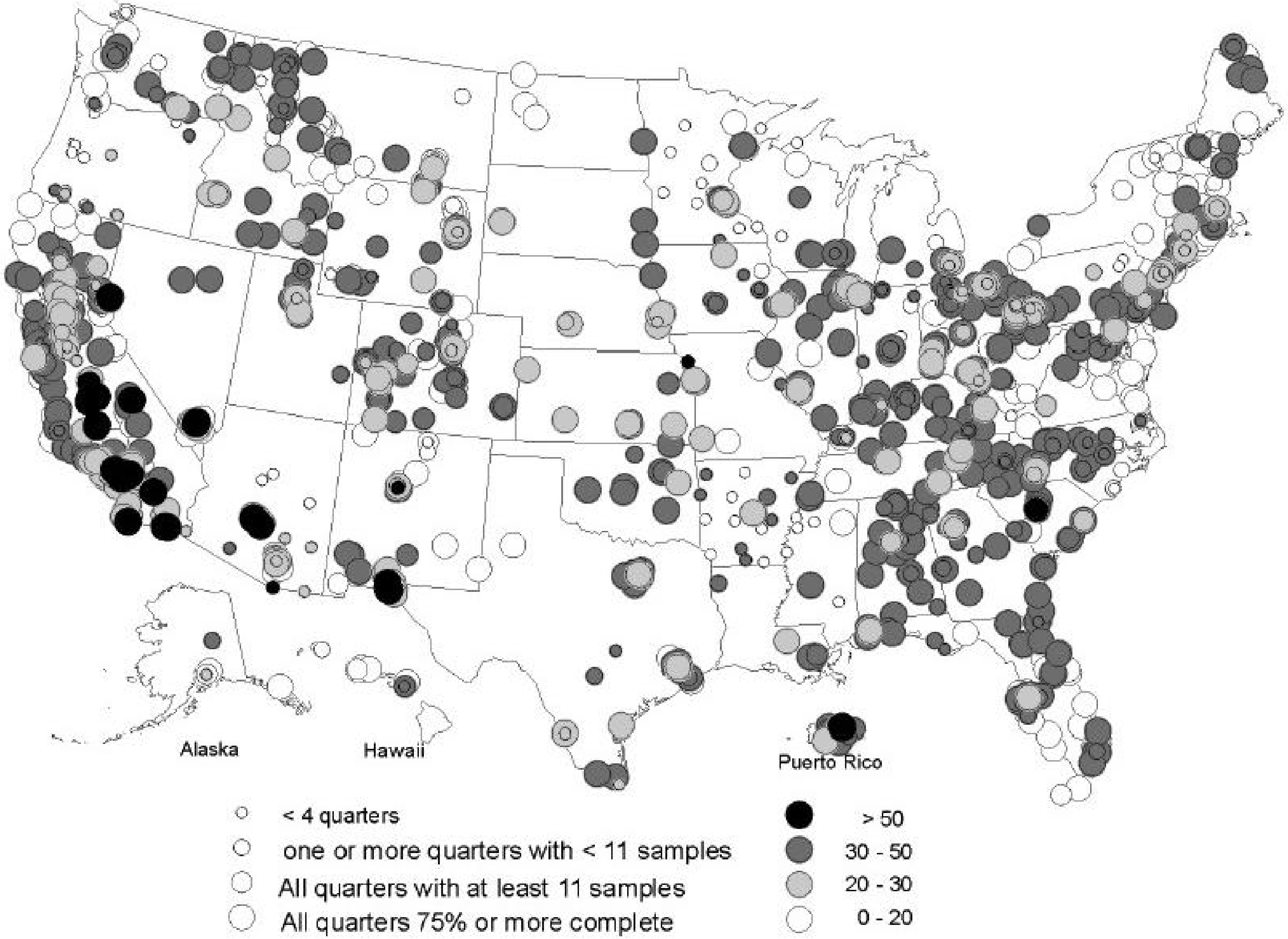
- Sample collection—filtration
- Physical characteristics
    - Size specific
    - Mass concentration
- Chemical characteristics—non-specific
- Temporal characteristics—24 h integrated sampling
- Spatial characteristics—PM measurement networks

US nationwide trend in ambient PM_{10} concentration



US Environmental Protection Agency. Report EPA-454/R-00-002; 2000.

Annual mean PM_{10} concentration in 1999

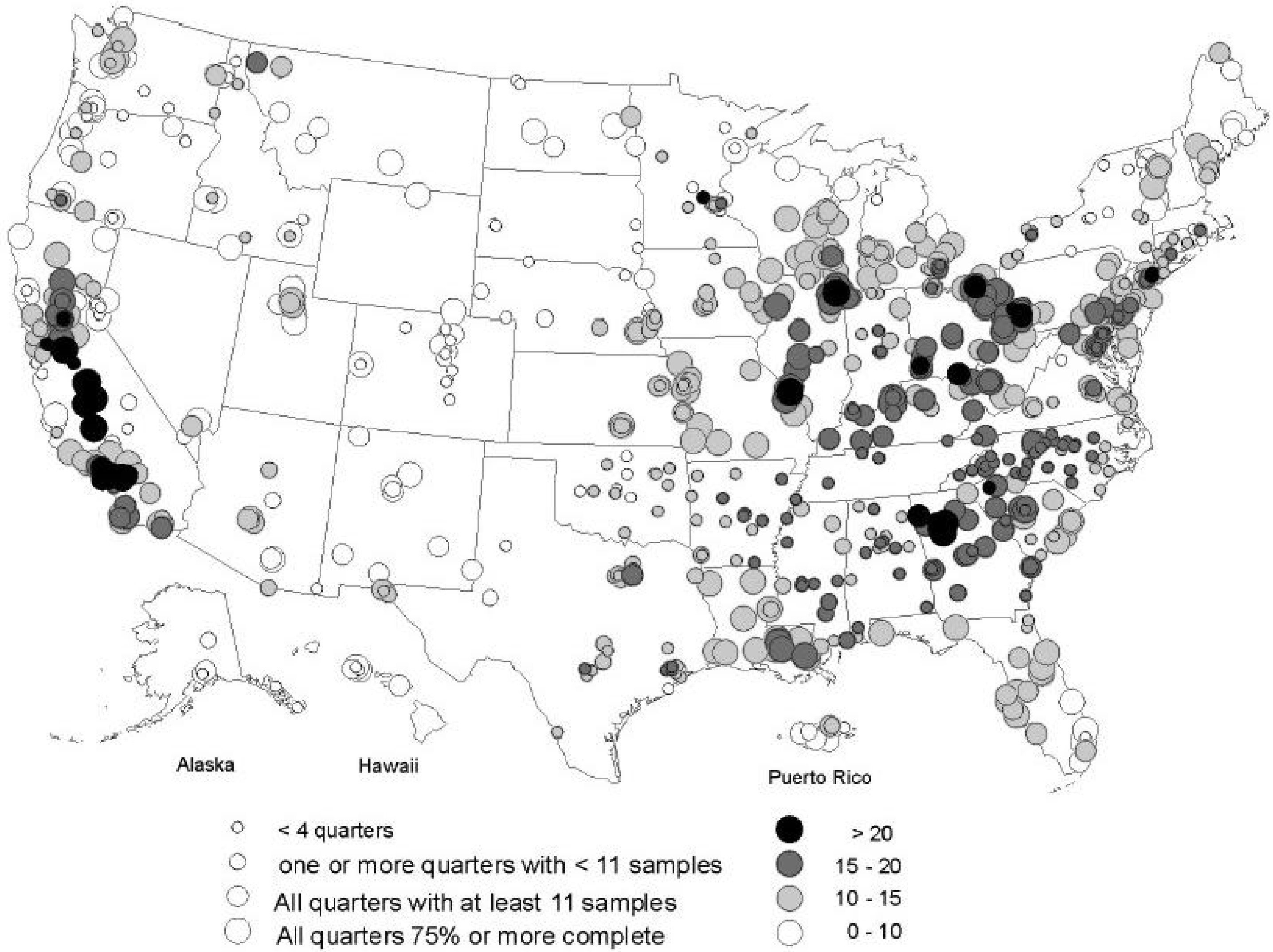


Fitz-Simons *et al*. *Analyses of 1999 PM data for the PM NAAQS review*; 2000.

$PM_{2.5}$ standard

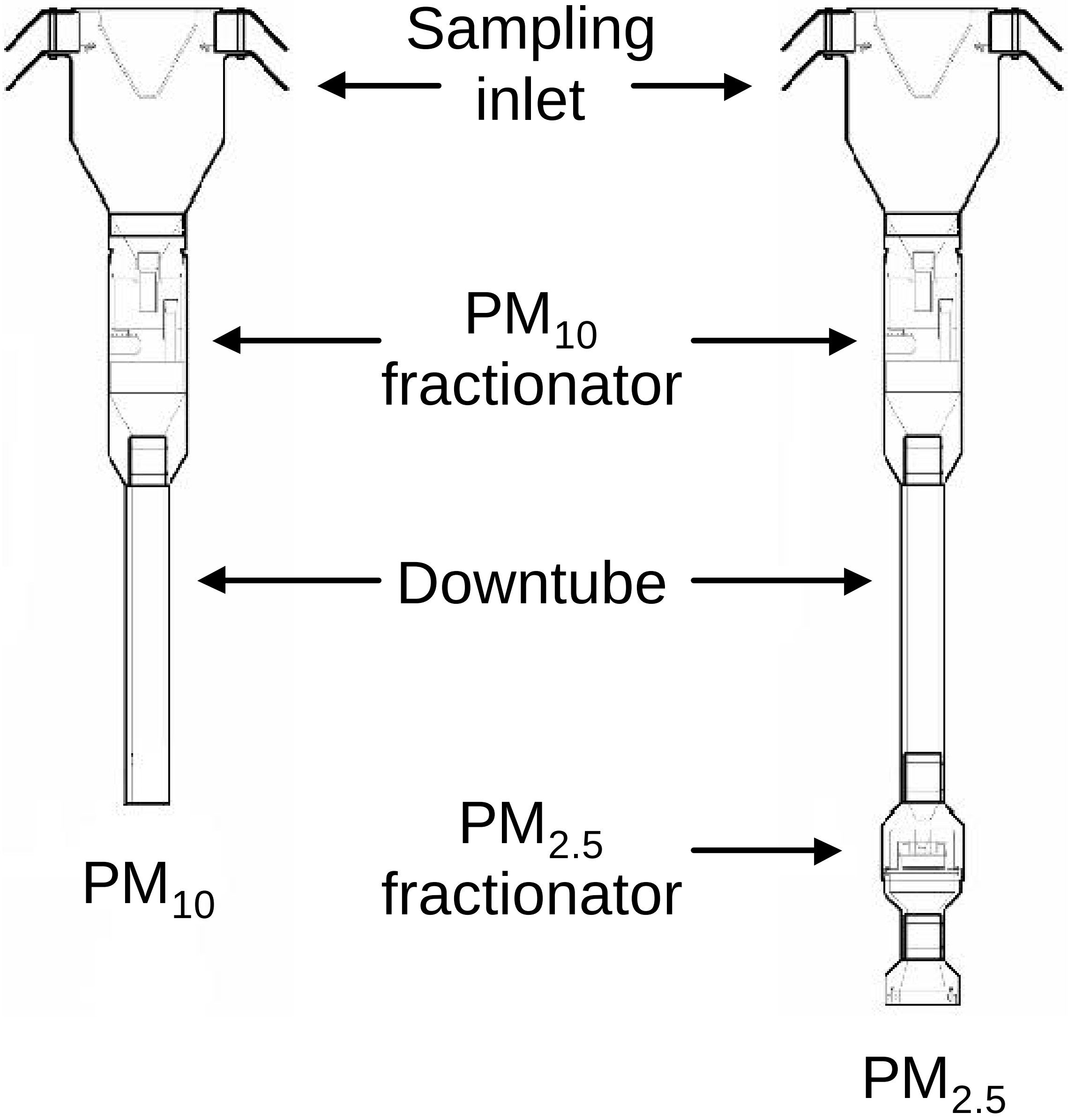
- Measurement performed by a federal reference method (FRM) or federal equivalent method (FEM)
- FRM explicitly specified
  - Design-based criteria
  - Performance-based criteria
- Improved quality control (QC)
- Increased sample precision

Annual mean $PM_{2.5}$ concentration in 1999



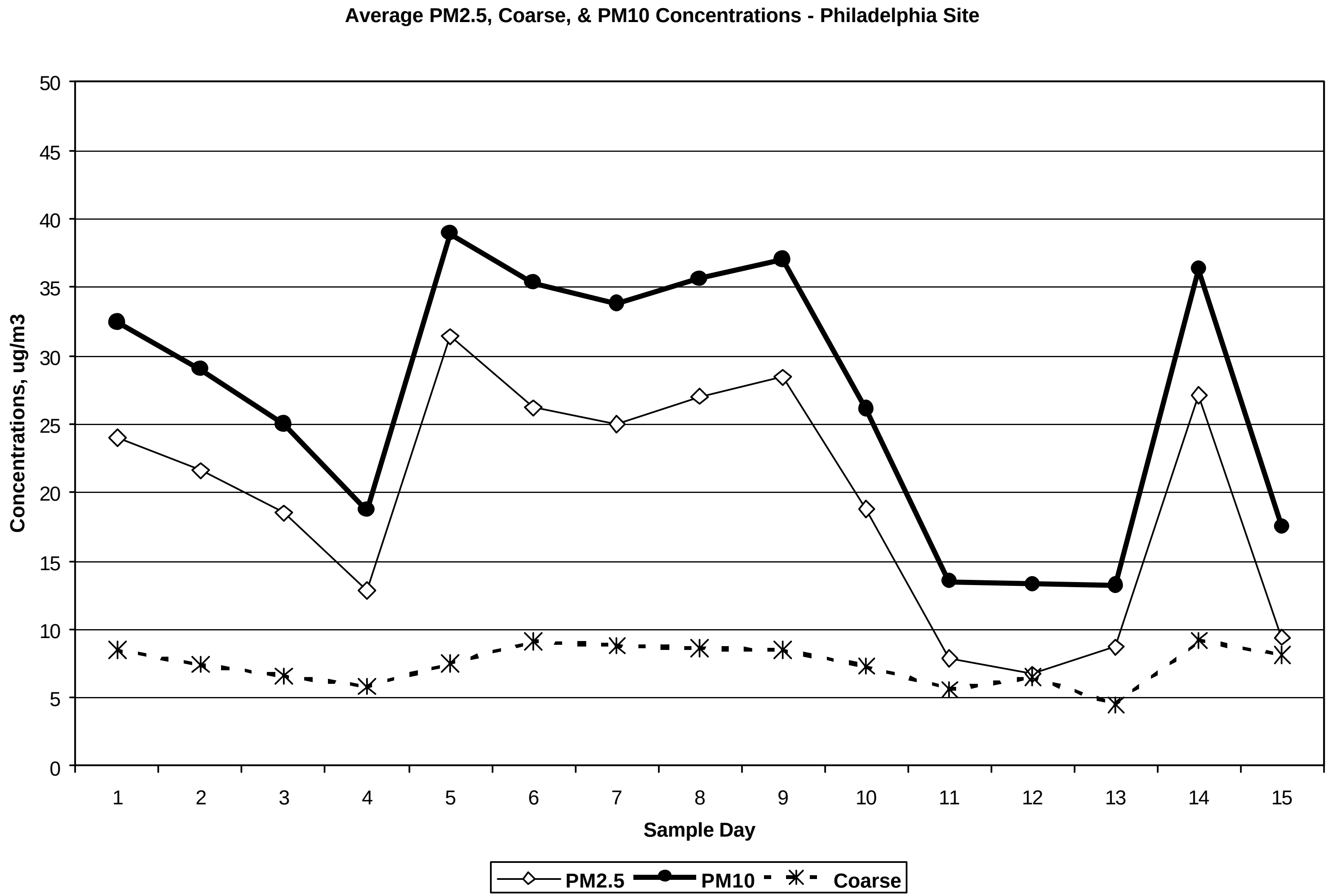
Fitz-Simons *et al*. *Analyses of 1999 PM data for the PM NAAQS review*; 2000.

Instrumental schematic PM_{10} and $PM_{2.5}$



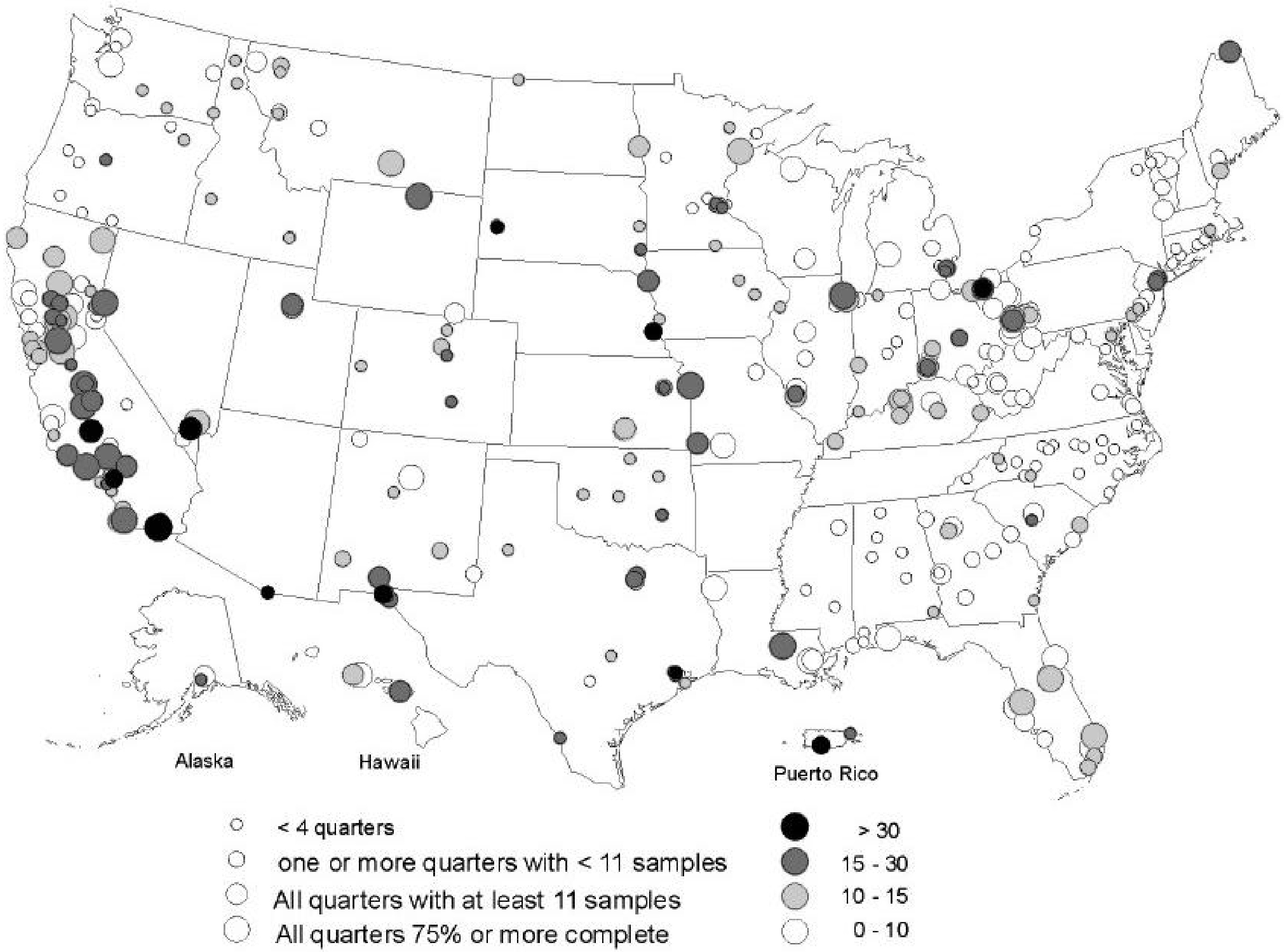
$PM_C = PM_{10} - PM_{2.5}$

PM_C data by subtraction of $PM_{2.5}$ from PM_{10}



Vanderpool *et al*. manuscript in preparation.

Annual mean PM_C concentration in 1999



Fitz-Simons *et al*. *Analyses of 1999 PM data for the PM NAAQS review*; 2000.

Some (of the many) remaining uncertainties

- “Major” uncertainties
  - What is the causal agent in PM for the observed health effects?
  - What is the injurious biological mechanism?
- “Minor” uncertainties
  - What should be done about particulate water?
  - What should be the temporal resolution of the ambient measurements?

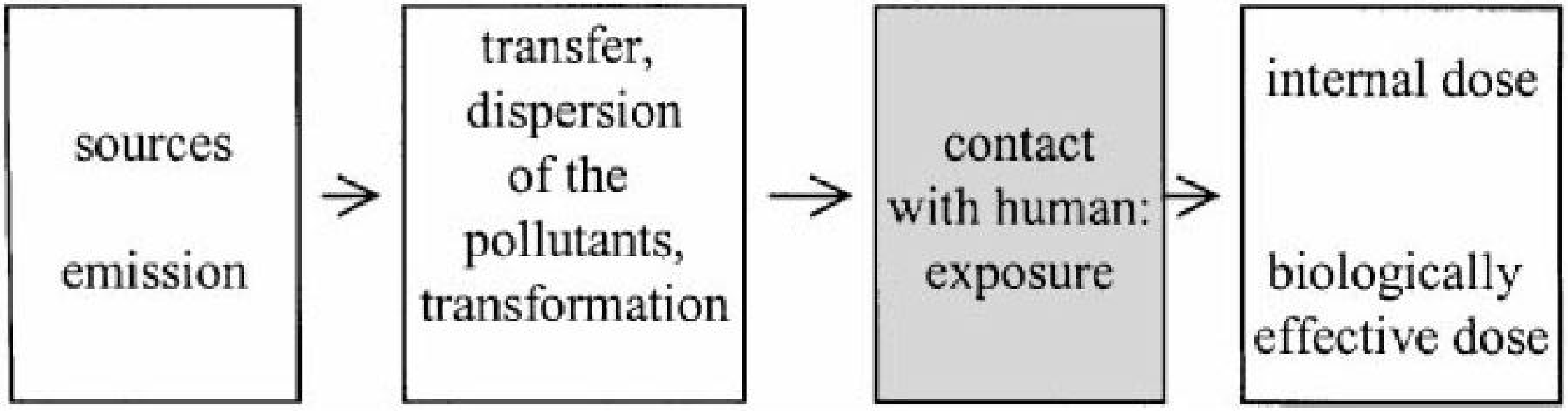
PM research priorities from National Research Council

- Investigate ambient levels vs. personal exposure
- Assess hazardous PM components
- Develop measurement and analysis tools
- Determine exposure to susceptible subpopulations
- Develop source-receptor measurement tools
- Develop modeling tools
- Examine combined effects of gaseous copollutants
- Study mechanisms of injury

Considerations for personal exposure determination

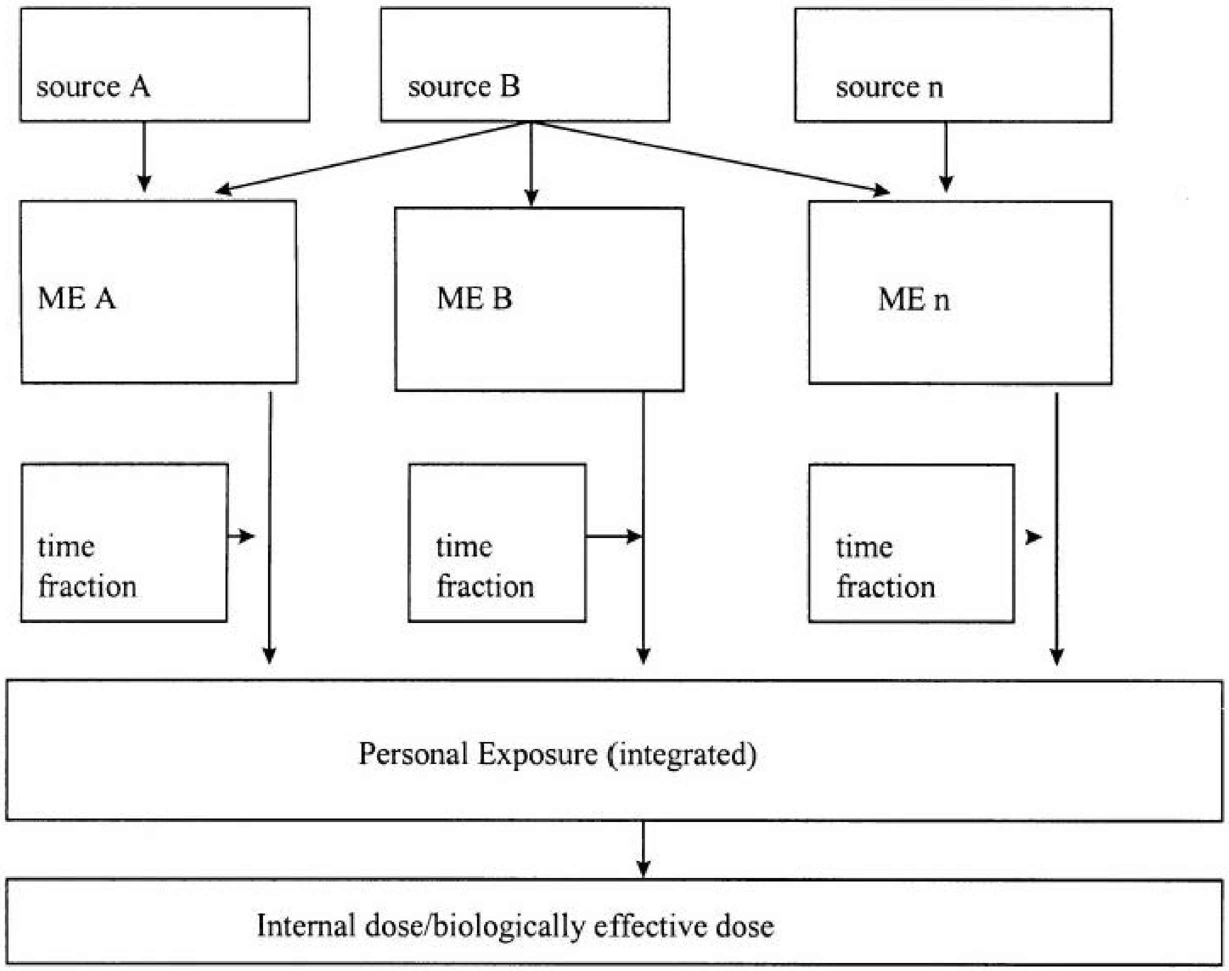
- Time spent in each microenvironment
  - Outdoor
  - Home
  - Office
  - Public buildings
- PM concentration in each microenvironment
  - Indoor sources
  - Building ventilation

Sequence of exposure



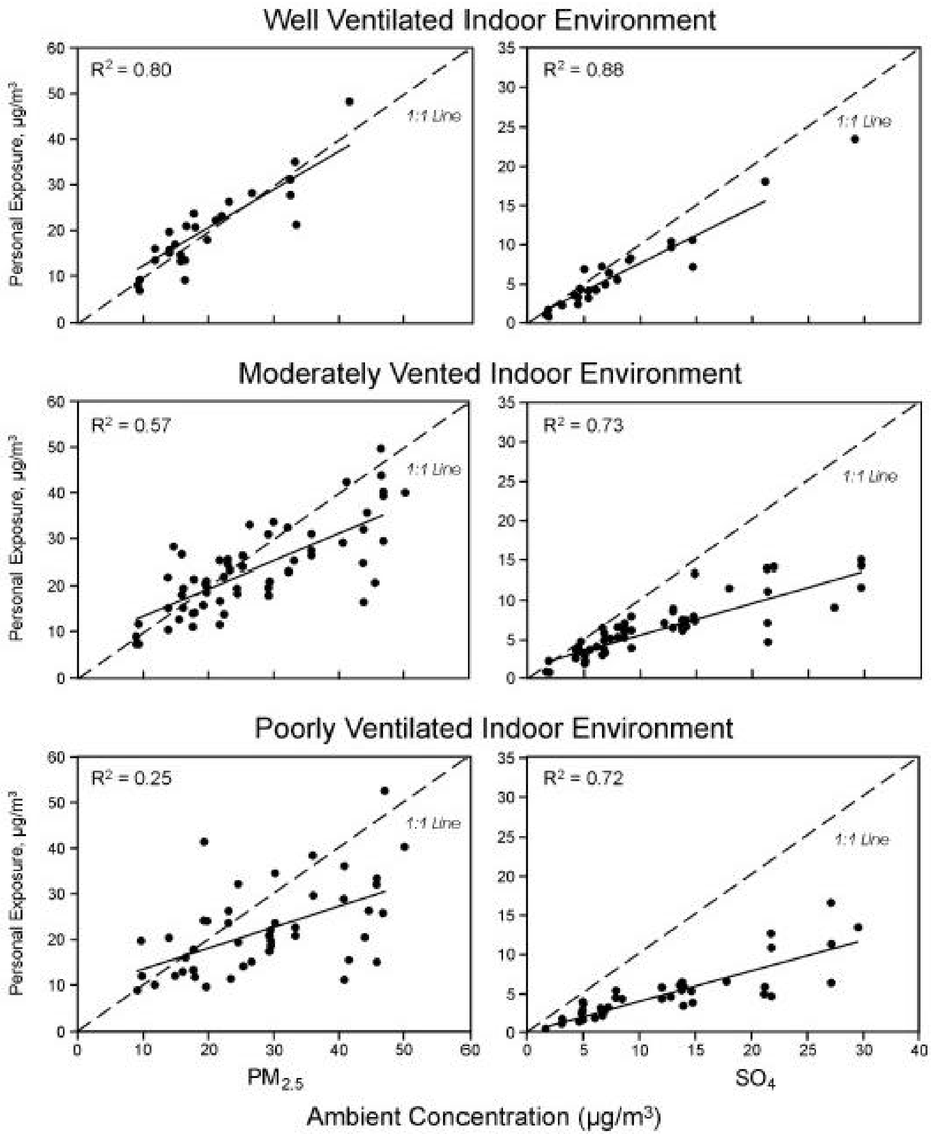
Monn. *Atmos. Environ*. **2000**, *35*, 1.

Microenvironment exposure-dose relationship



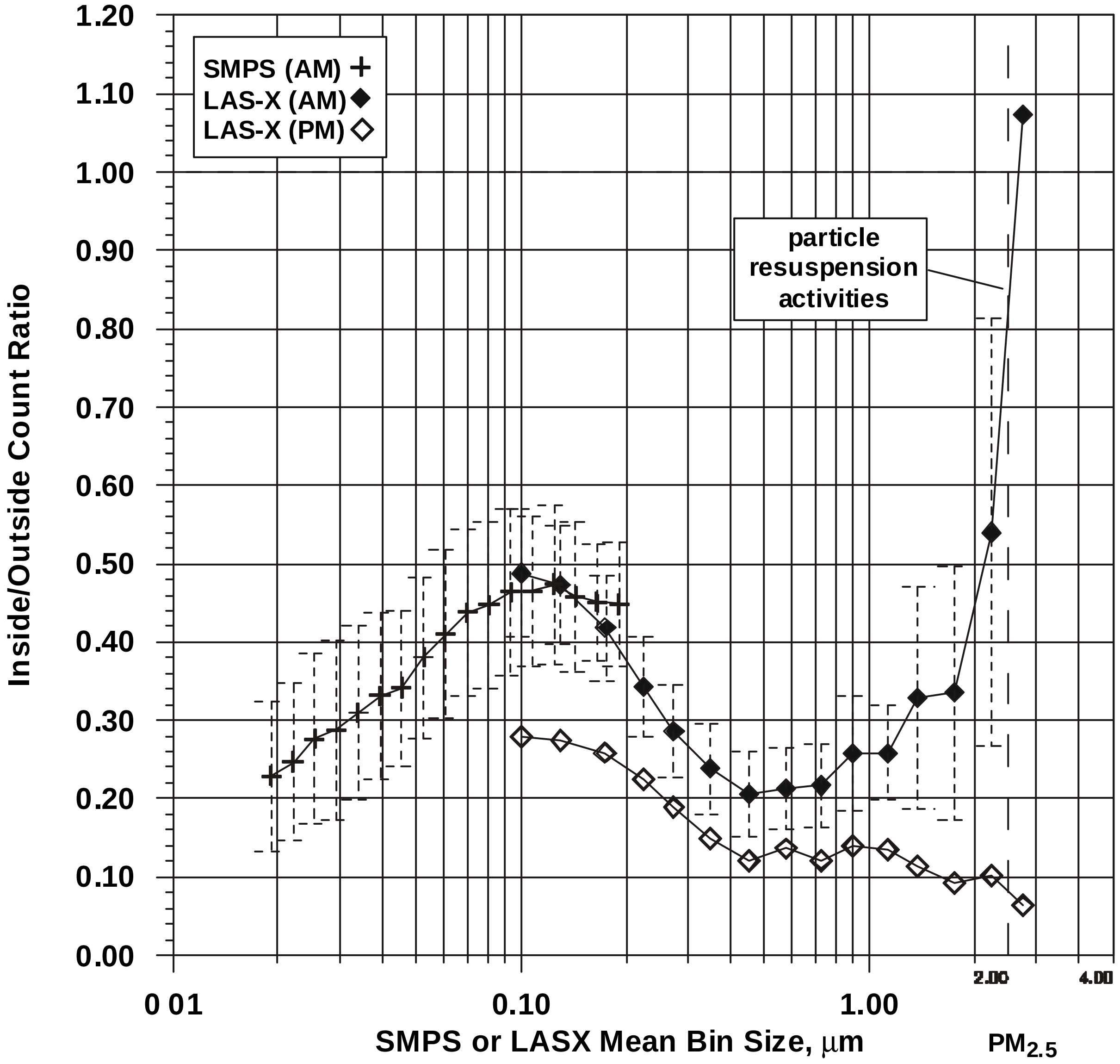
Monn. *Atmos. Environ*. **2000**, *35*, 1.

Indoor vs. outdoor concentrations



Sarnet *et al*. *J. Air Waste Manage. Assoc.* **2000**, *50*, 1184.

Influence of activity on indoor PM concentration



Rodes *et al*. In *Aerosol Measurement*; in press.

Novel research techniques for real-time measurements

- Physical characteristics

  Instrument dependent—size, concentration, *etc*.

- Chemical characteristics

  Instrument dependent—nitrate, metals, *etc*.

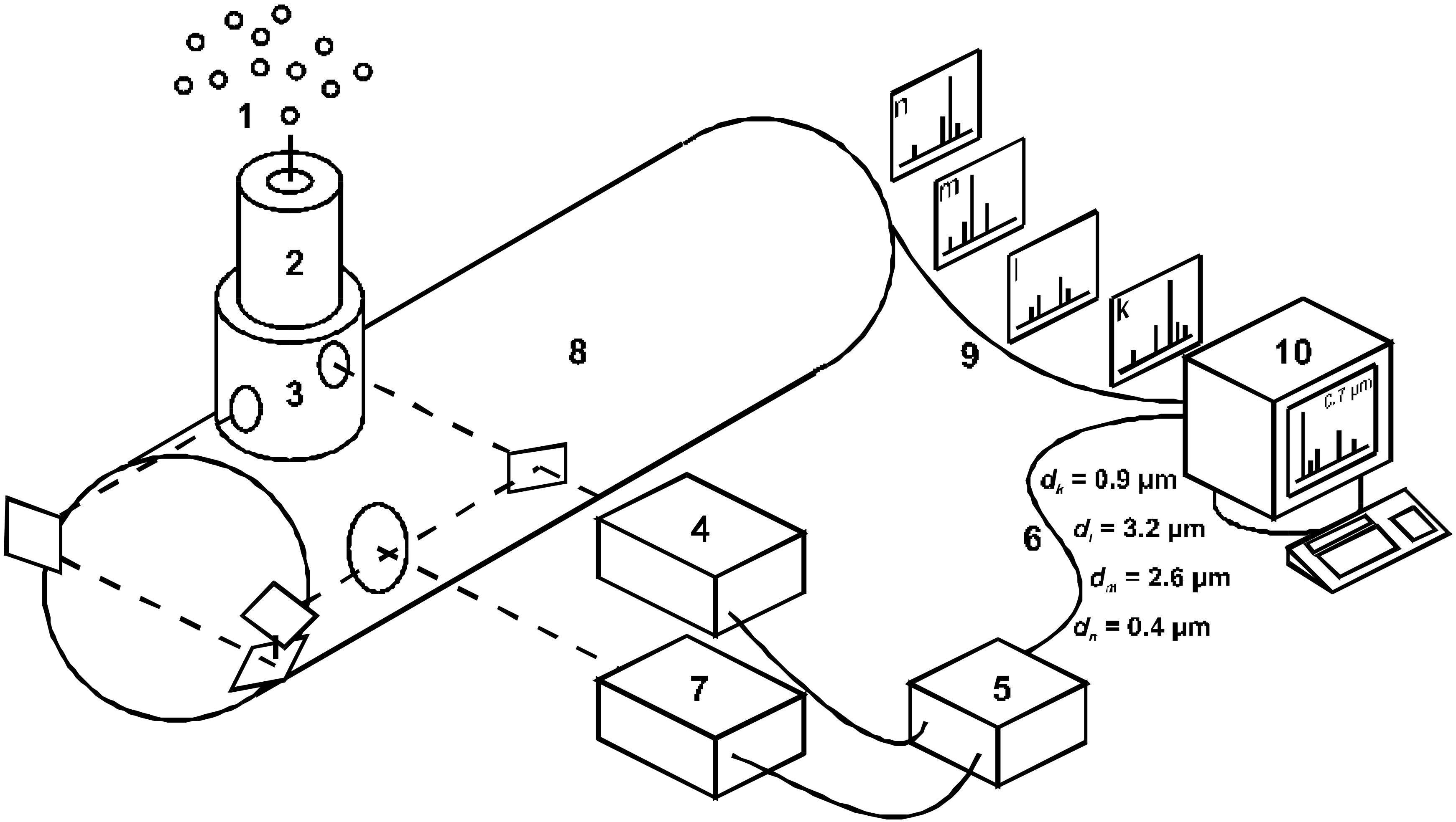
- Temporal characteristics

  Instrument dependent—real-time (<1 h)

- Spatial characteristics

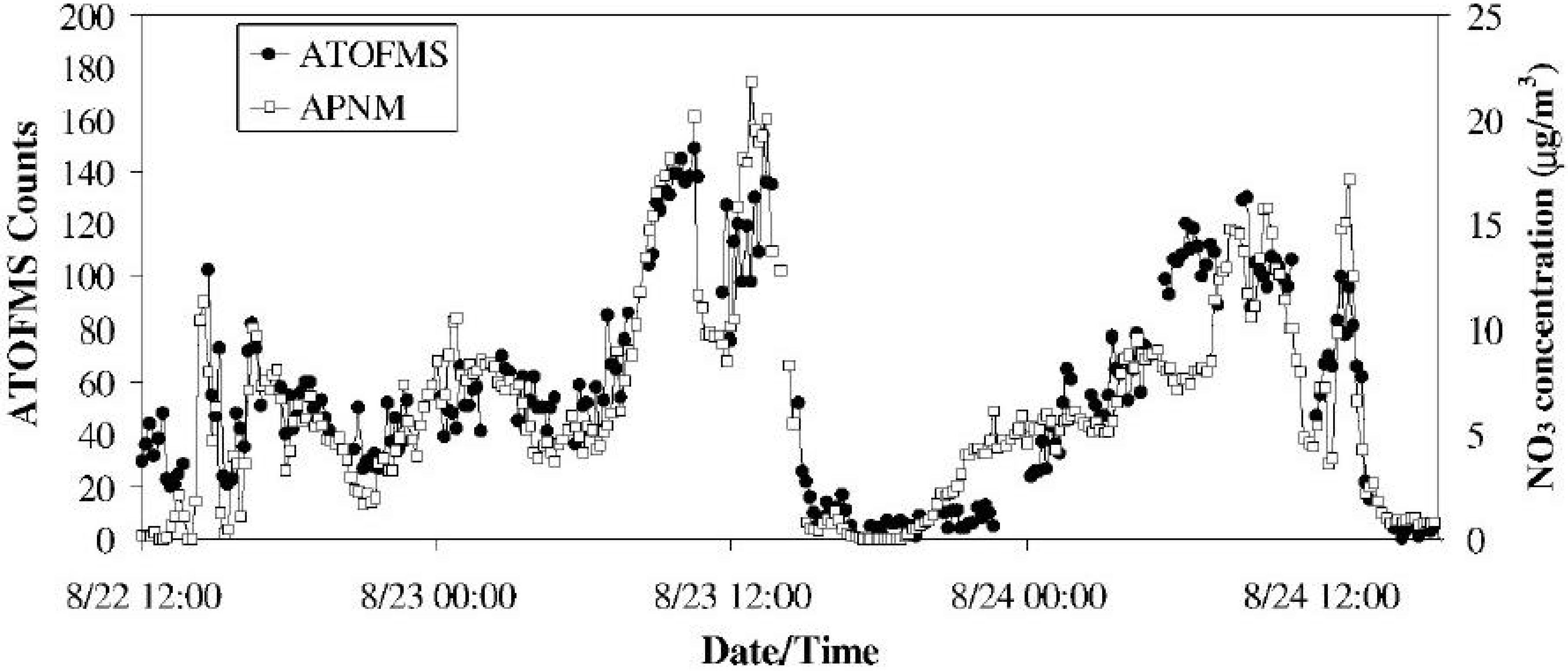
  Currently, single prototype instruments

Aerosol time-of-flight mass spectrometry



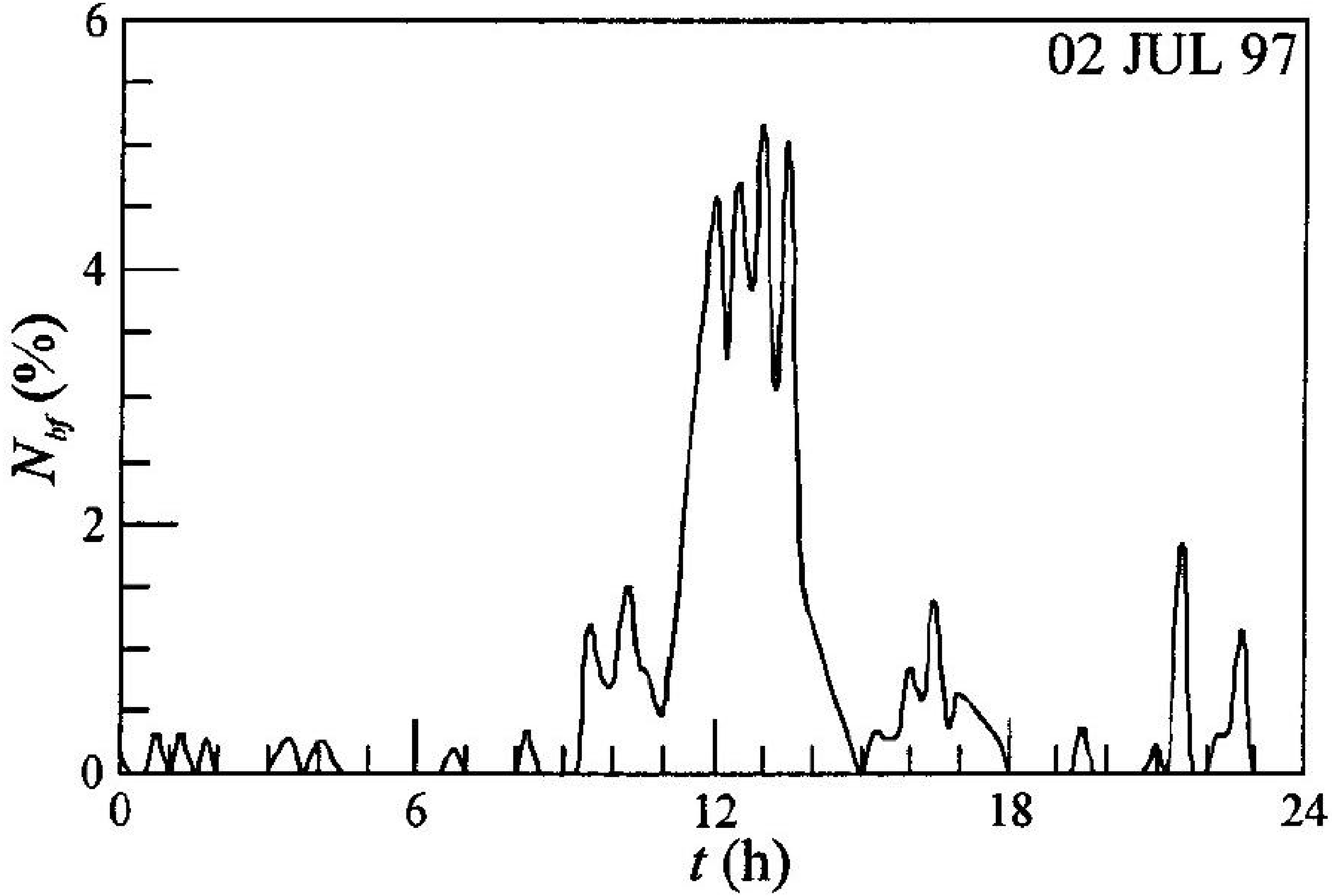
Noble *et al*. *Aerosol Sci. Technol*. **1998**, *29*, 294.

Real-time measurement of nitrate-containing particles



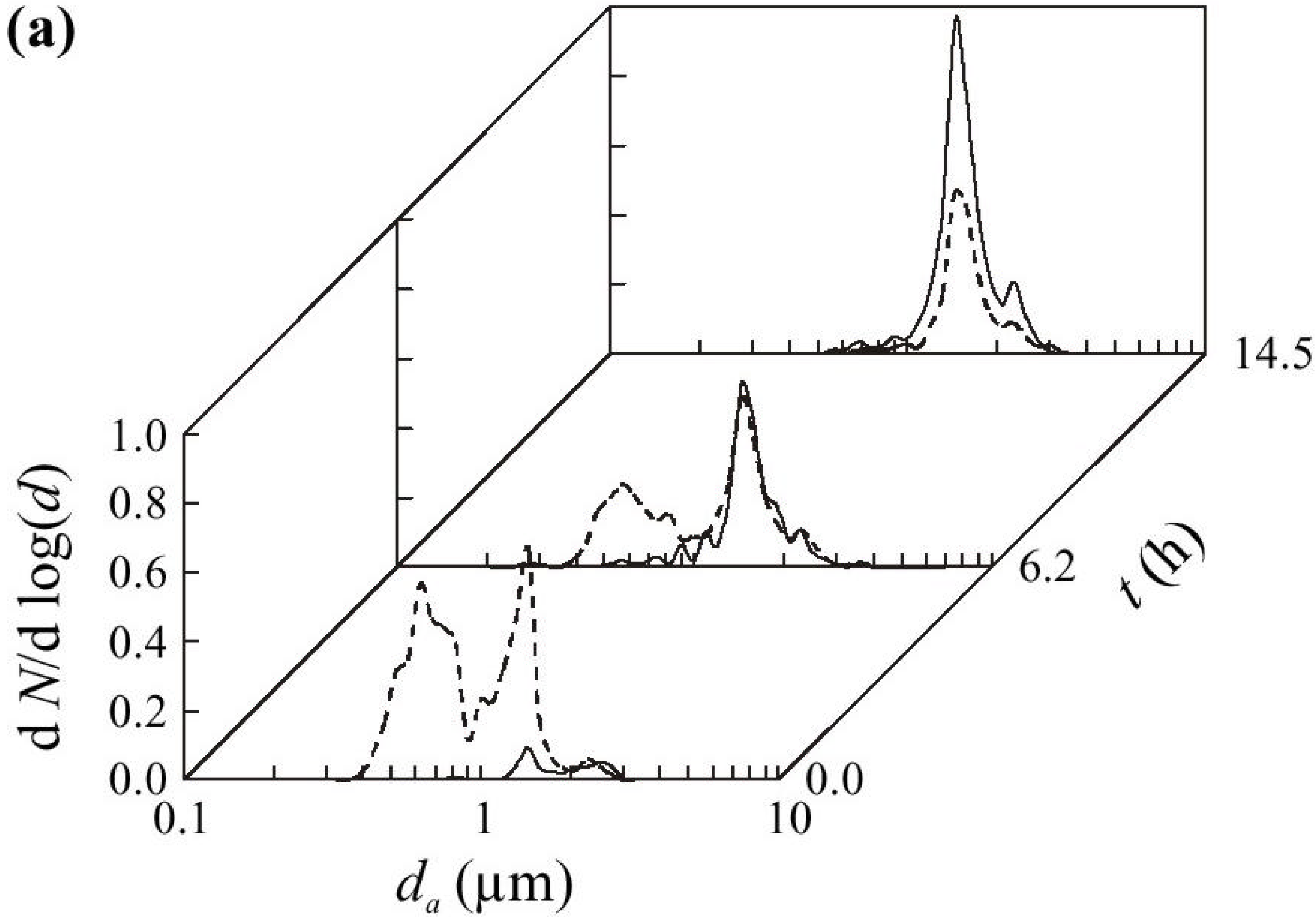
Liu *et al*. *Aerosol Sci. Technol.* **2000**, *33*, 71.

Real-time measurement of brushfire particles



Silva *et al*. *Environ. Sci. Technol*. **1999**, *33*, 3068.

Real-time measurement of sea salt particles



Noble *et al*. *Geophys. Res. Lett.* **1997**, *24*, 2753.

Conclusion

- US Supreme Court decided that EPA has the right to promulgate PM standards
- Air quality standards should be based on most current scientific knowledge
  - Atmospheric chemistry and physics
  - Conventional measurements
  - Exposure-dose-response relationship
  - Novel measurements

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Future directions of ambient PM monitoring

- US national ambient air quality standards
  - PM_{10}—will be phased out of NAAQS
  - $PM_{2.5}$—will remain a standard
  - PM_C—will “replace” PM_{10} standard
- EPA “PM Health Center” program
- EPA “PM Supersites” program
  - Characterize ambient PM
  - Conduct methods testing

Partial reference list

- US national ambient air quality standards
  - Noble *et al*. Federal reference and equivalent methods for measuring fine particulate matter. *Aerosol Sci. Technol*. **2000**, *34*, 219.
  - US Environmental Protection Agency. Report EPA-600/P-99-002aB; 2001. (http://www.epa.gov/ncea/partmatt.htm)
  - US National Research Council. *Research Priorities for Airborne Particulate Matter. I. Immediate Priorities and a Long-Range Research Portfolio*; 1998.
- Particulate matter sampling
  - Johnston *et al*. Mass spectrometry of individual aerosol particles. *Anal. Chem*. **1995**, *67*, A721.
  - Noble *et al*. Air pollution: the role of particles. *Phys. World* **1998**, *11*, 39.
  - Rodes et al. Indoor aerosols and aerosol exposure. In *Aerosol Measurement*; 1993, Chapter 30.

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