Ambient Aerosol Size Distributions And Number Concentrations Measured At Pittsburgh (PAQS)

Authors

Charles Stanier
University of Iowa
Chemical and Biochemical Engineering
charles-stanier@uiowa.edu
Andrey Khlystov
Duke University
Civil and Environmental Engineering
andrey@duke.edu
Spyros Pandis
University of Patras, Greece
Carnegie Mellon University
Chemical Engineering
spyros@andrew.cmu.edu

Abstract

- 12 months of aerosol size distributions from 3 nm – 560 nm, measured using Scanning Mobility Particle Sizers (SMPS) are presented + 7 months of Aerosol Particle Sizer (APS) Data
- The measurements were made at the main sampling site of the Pittsburgh Air Quality Study from July 2001 – June 2002.
- Measurements at the main site were made continuously under both low and ambient relative humidity.
- The average Pittsburgh number concentration (3-500 nm) is 22,000 cm^{-3} with an average mode size of 40 nm.
- Strong diurnal patterns in number concentrations.
- New particle formation from homogeneous nucleation is significant on 30-50% of study days and over a wide area (at least a hundred kilometers).
- Rural number concentrations are a factor of 2-3 lower (on average) than the urban values due to urban ultrafine sources.

Published As: Stanier, C., Khlystov, A., and Pandis, S.N. , "Ambient Aerosol Size Distributions and Particle Number Concentrations Measured during the Pittsburgh Air Quality Study", Atmospheric Environment, Vol 38, 2004, pp. 3275-3284

Organization of This Poster

Panels 5-7

- **Sampling System**

Panels 8-12

- **Results – Monthly and Diurnal Summaries**

Panels 13-15

- **Ultrafine Sources**

Panels 16-19

- **Rural vs. Urban Size Distributions; Pittsburgh vs. Other Cities**

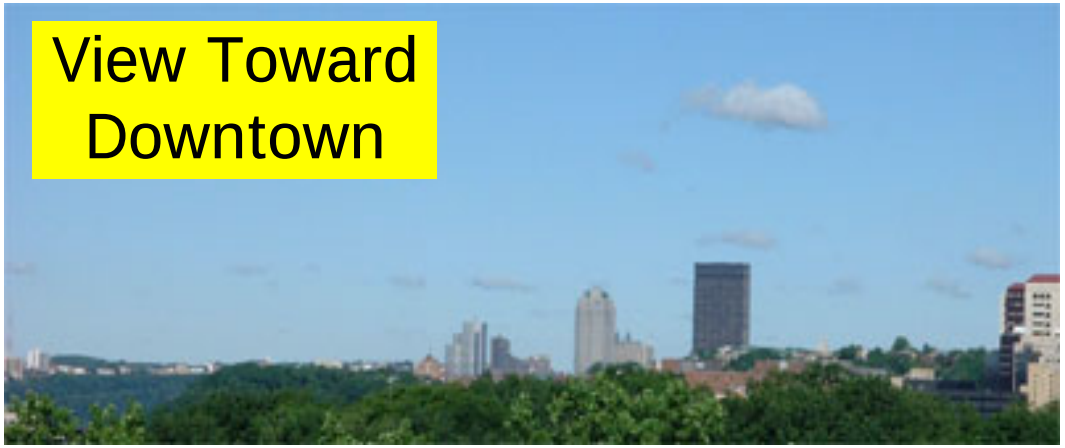
Pittsburgh Air Quality Study (PAQS)

- 2 Year Collaborative Study
  - 17 Participating Groups
  - Funded by
    - Environmental Protection Agency
    - Department of Energy
- Main goals
  - Characterize Pittsburgh aerosols
    - Sources
    - Atmospheric Processes
    - Instruments
- Measurements
  - Meteorology
  - Atmospheric gases
  - Aerosol parameters
  - Particle size distribution, ambient relative humidity
  - Particle size distribution, dried

Presented in this work

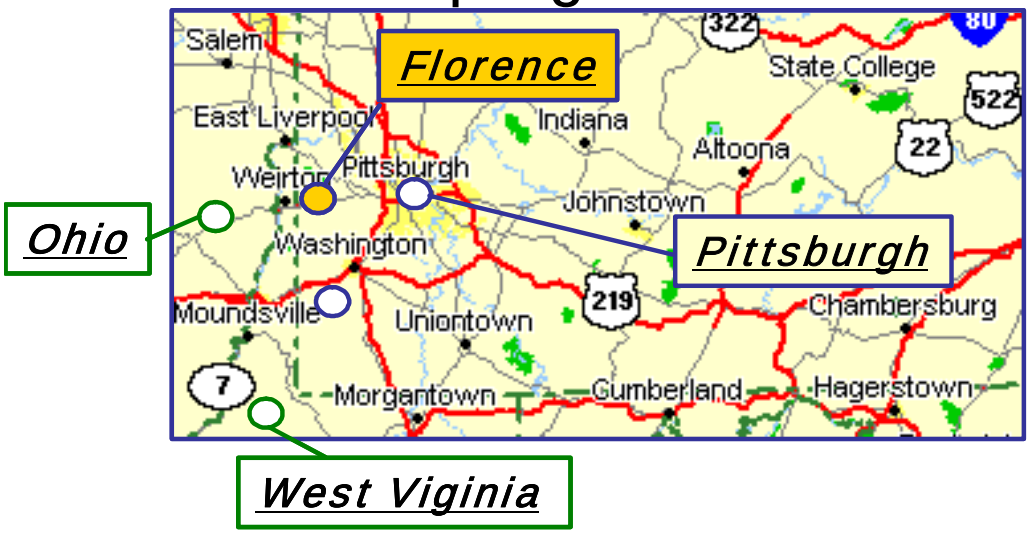
Pittsburgh Air Quality Study – Schenley Park Station

Particle Size Sampling Instruments



Experimental Technique

Sampling Locations



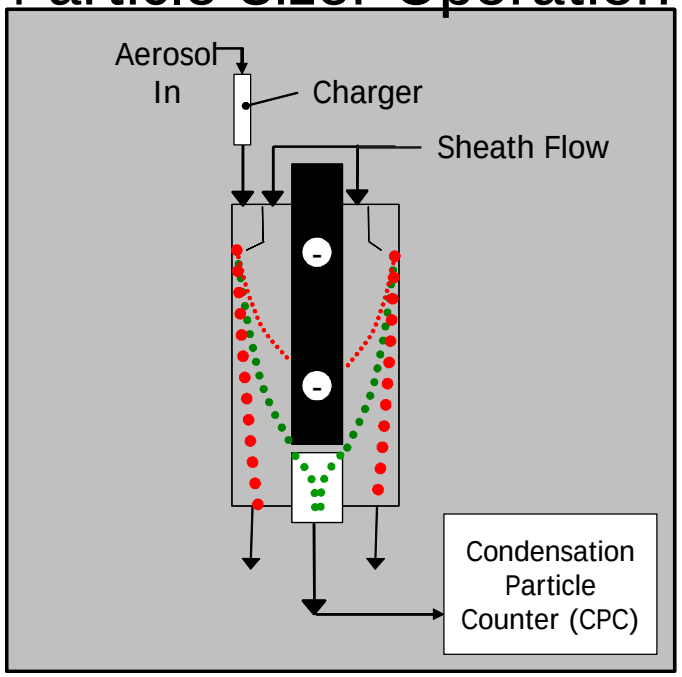
Pittsburgh (Urban Site) Jul '01 – Jun '02

- 3-80 nm by TSI 3936N25 Scanning Mobility Particle Sizer (SMPS)
- 15-680 nm by TSI 3936L10 Scanning Mobility Particle Sizer (SMPS)
- 0.53 – 10 µm by TSI 3320 & 3321 Aerodynamic Particle Sizer (APS)

Florence (Rural Site) 2/24/02 – 3/28/02

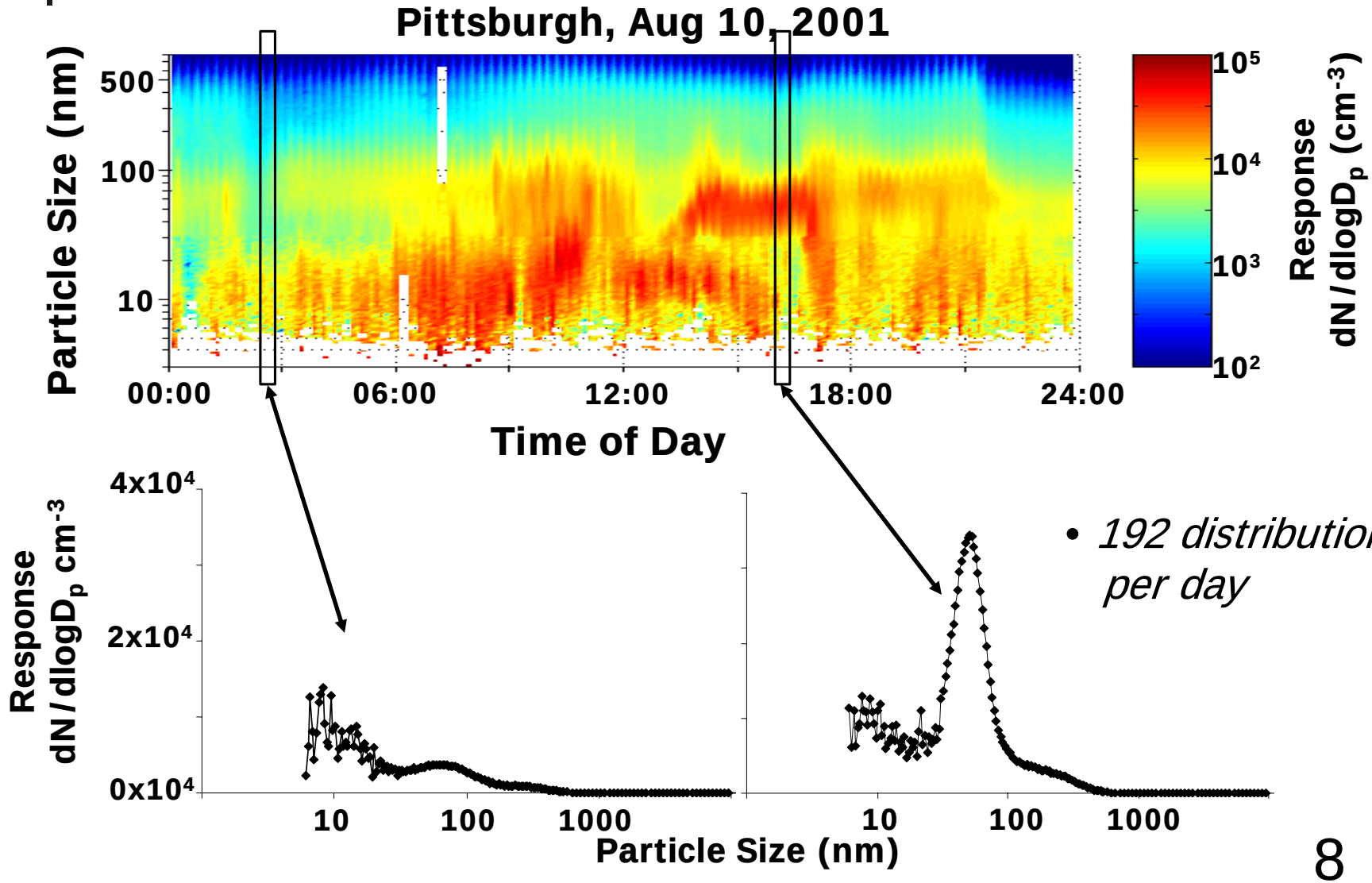
- 12-280 nm by TSI 3936 Scanning Mobility Particle Sizer (SMPS)

Scanning Mobility Particle Sizer Operation



Florence (Rural) Site

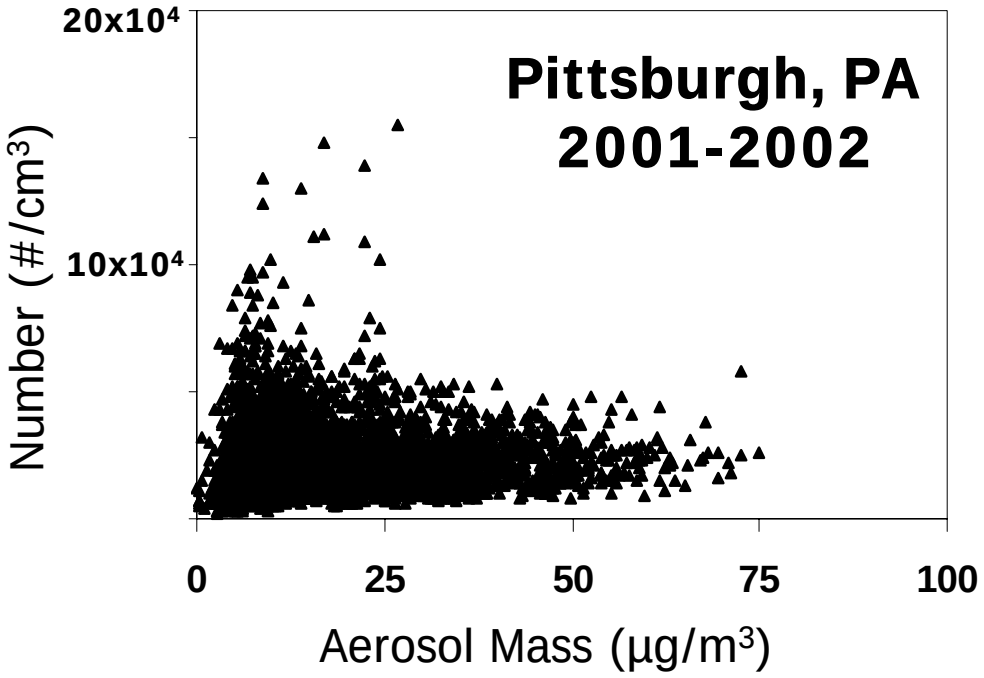
Example Results



- *192 distributions per day*

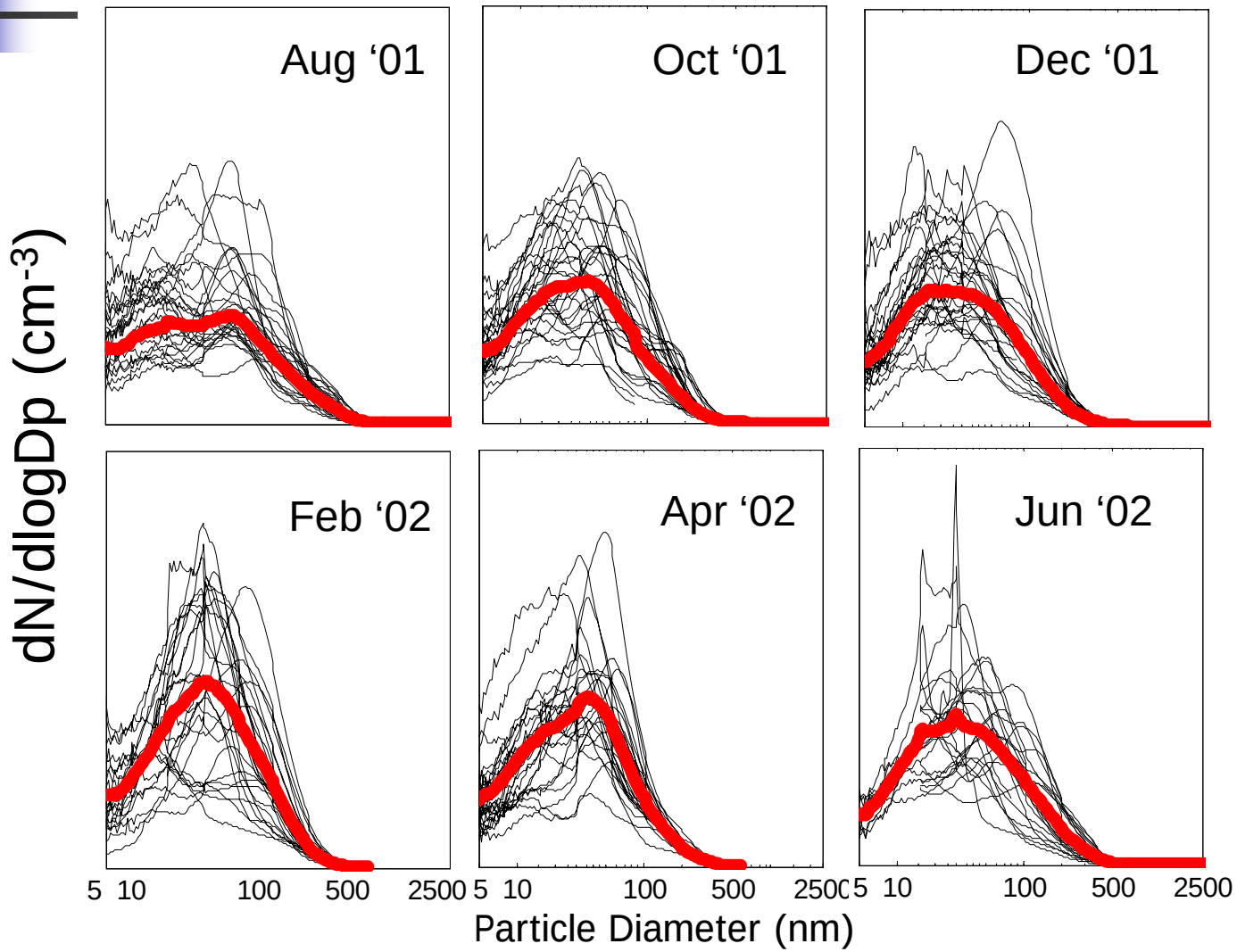
Results

- Average and Variation of Distributions
- Important Sources of Particles (Traffic, Nucleation)
- Upwind (Rural) vs. Urban Concentrations
- Diurnal Profiles
- Comparison to Other Studies



- *Number and mass inversely correlated*

24 hr Average Number Distributions: Schenley Park (Pittsburgh Urban)

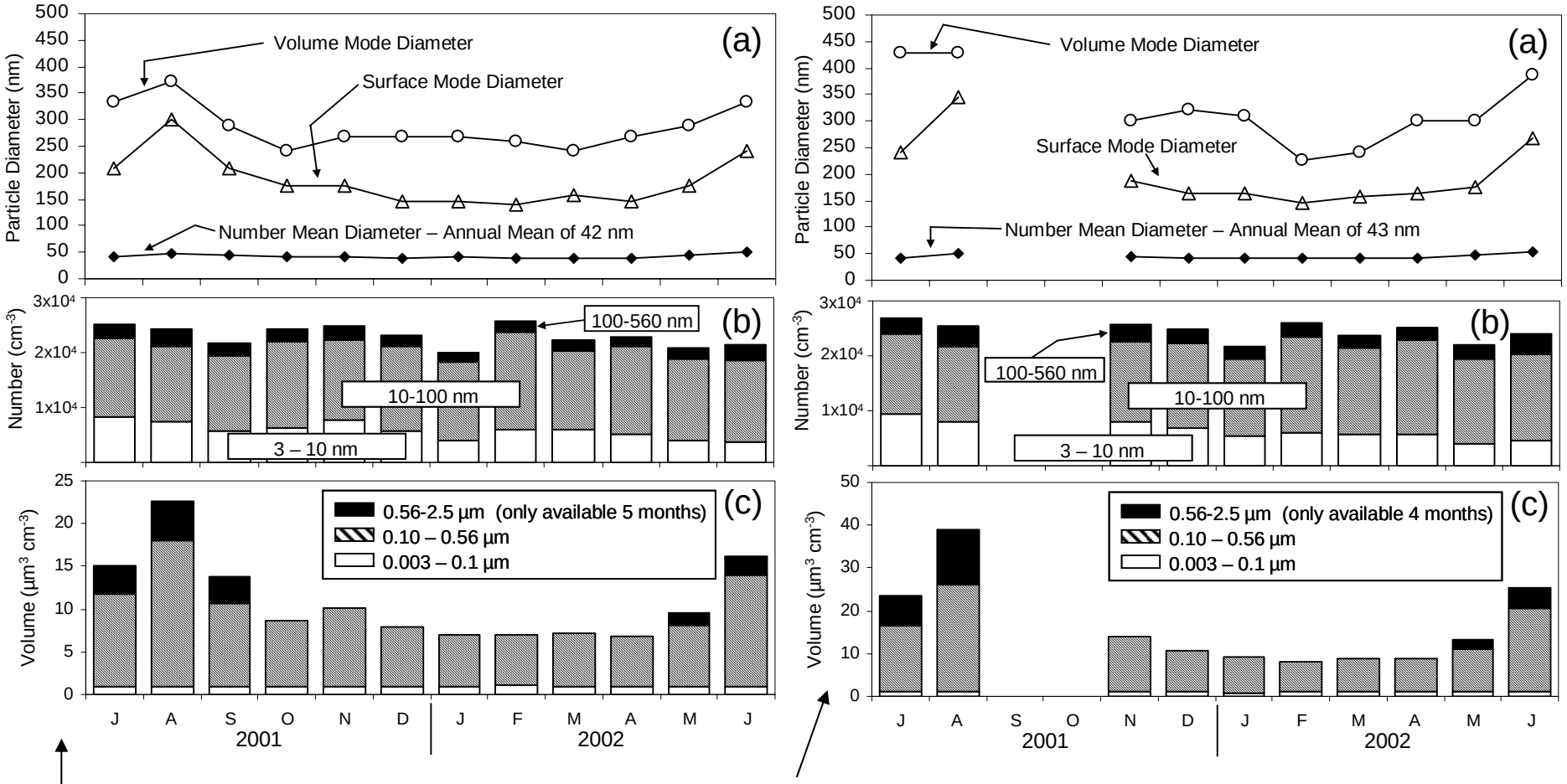


- *Average number distribution has minimal seasonal pattern*
- *Variation at sizes < 50 nm due to changes in nucleation frequency*

Dry vs. Ambient Monthly Levels

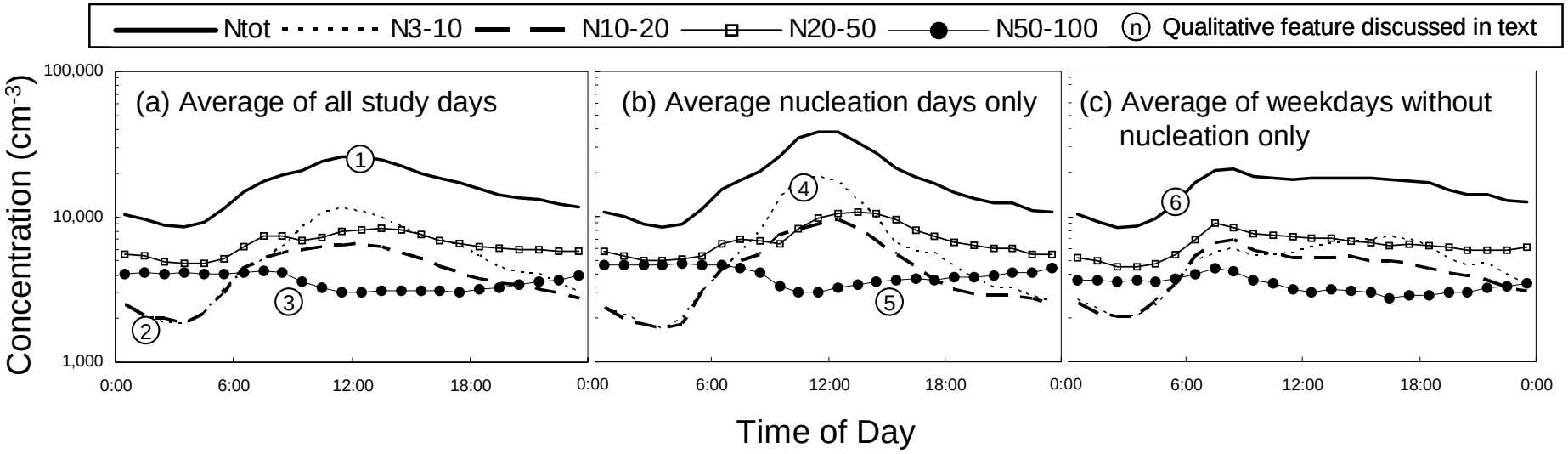
Dried to < 25% RH

Ambient RH



Note change of scale for aerosol volume

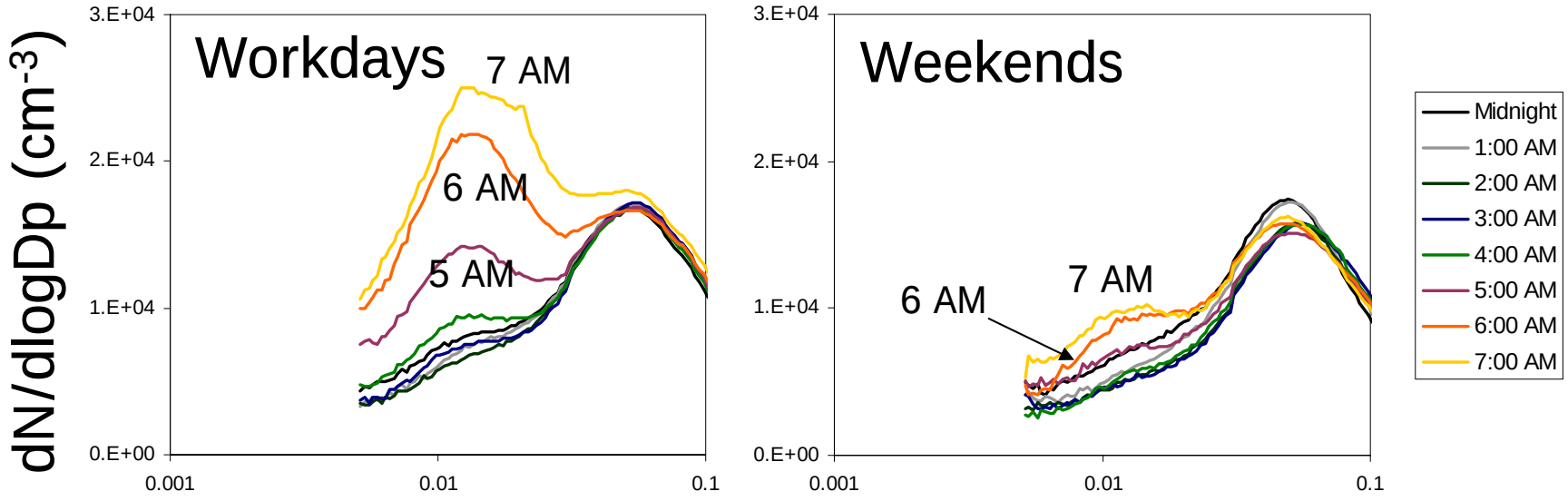
Diurnal Profiles (Urban Site)



1. Midday peak in average diurnal patter
2. Early morning minimum in 2-30 nm particles
3. Decrease in accumulation mode from boundary layer ventilation
4. Peak in 3-10 nm particles from midmorning nucleation
5. Gradual increase in accumulation mode following nucleation as particles grow
6. Weekday early morning traffic

Traffic as a Particle Source

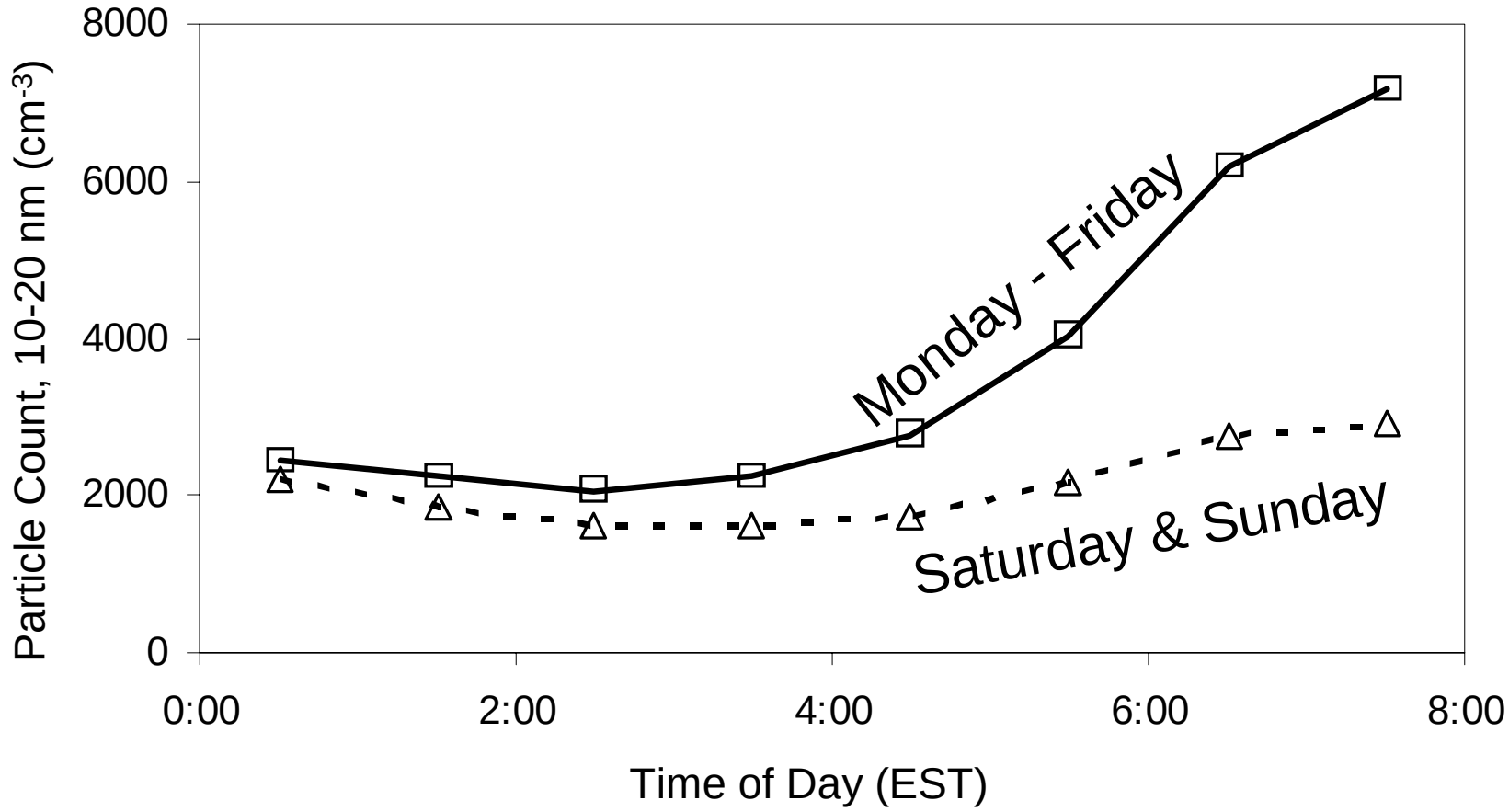
Hourly Averaged Number Distributions
Schenley Park (Urban Pittsburgh)



Particle Diameter (µm)

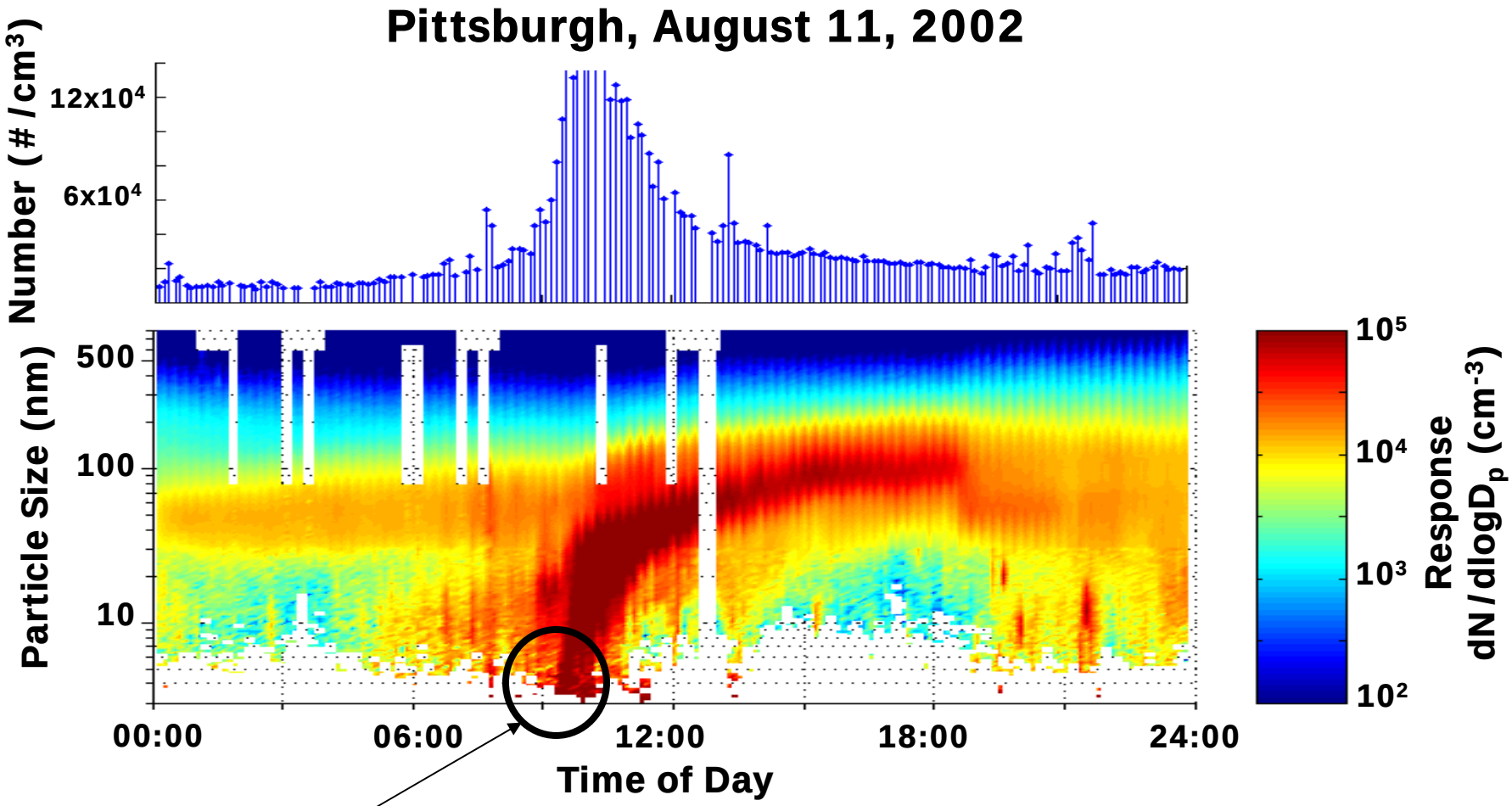
15 nm Mode for Auto Traffic Easily Distinguishable

Traffic as a Particle Source



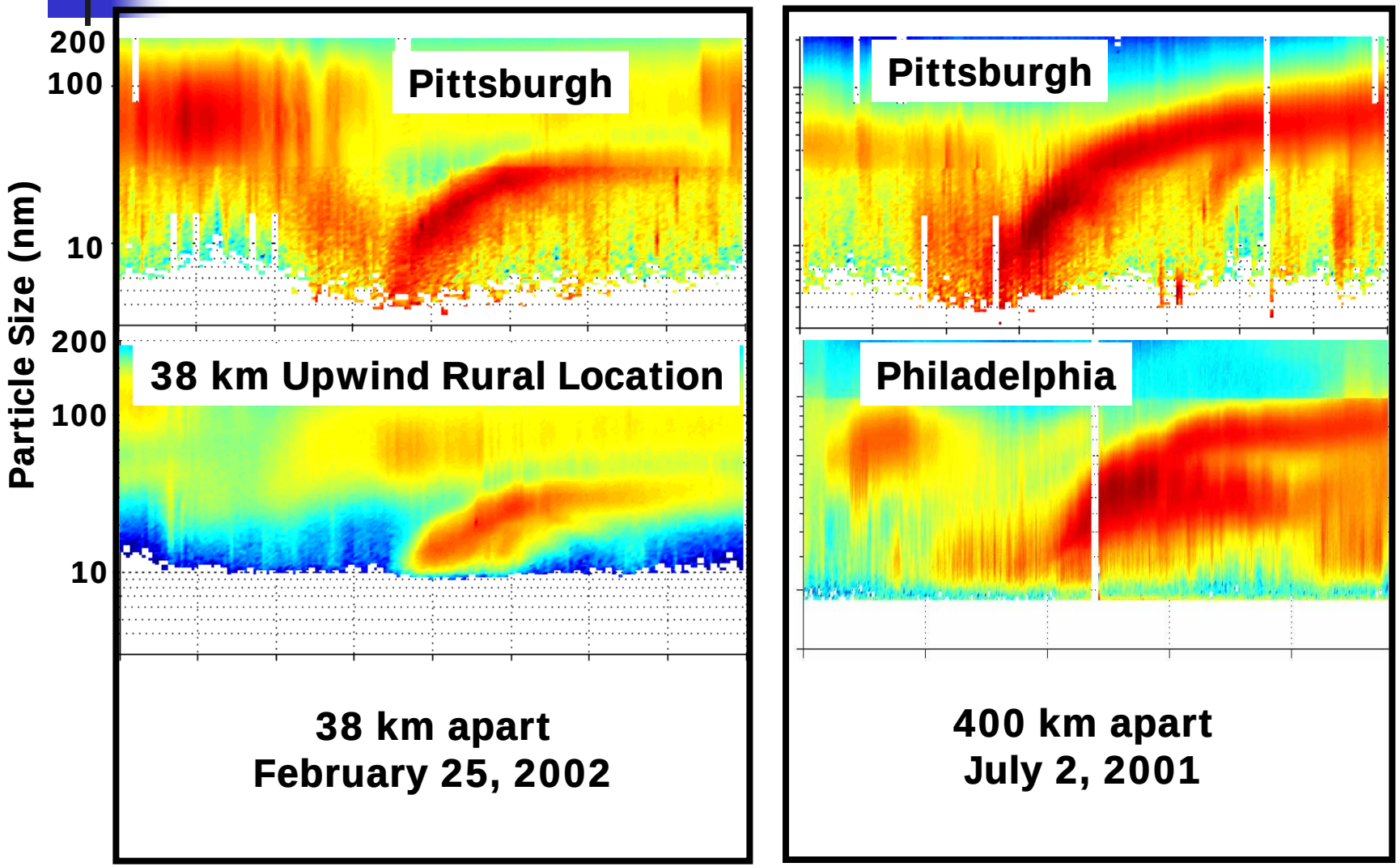
15 nm Mode for Auto Traffic Easily Distinguishable

Nucleation as a Particle Source



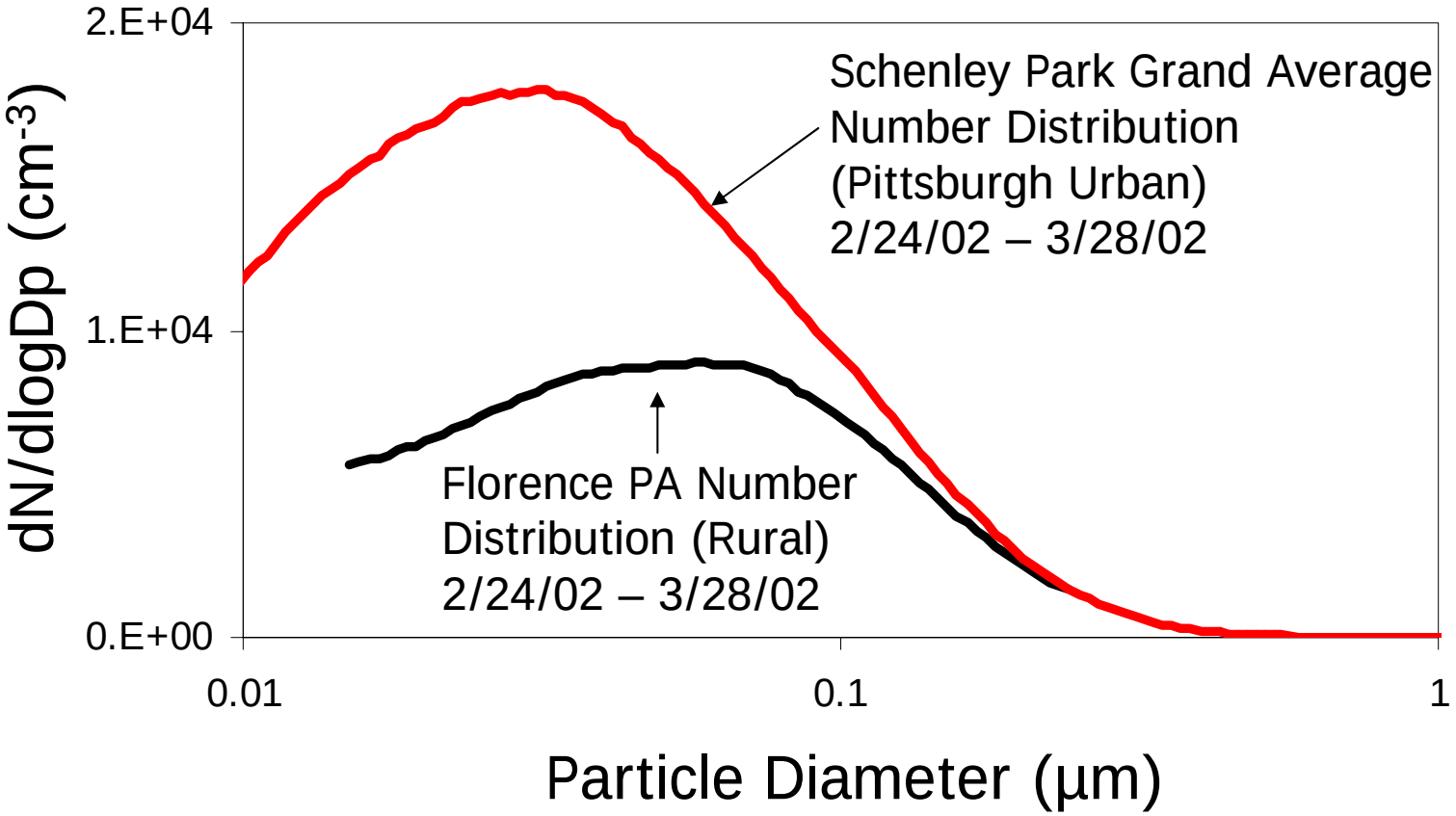
- *New Particles Apparent at 9 AM in smallest size channels*
- *Number concentration increase by 10X in 1 hour*

Site-to-Site Comparison



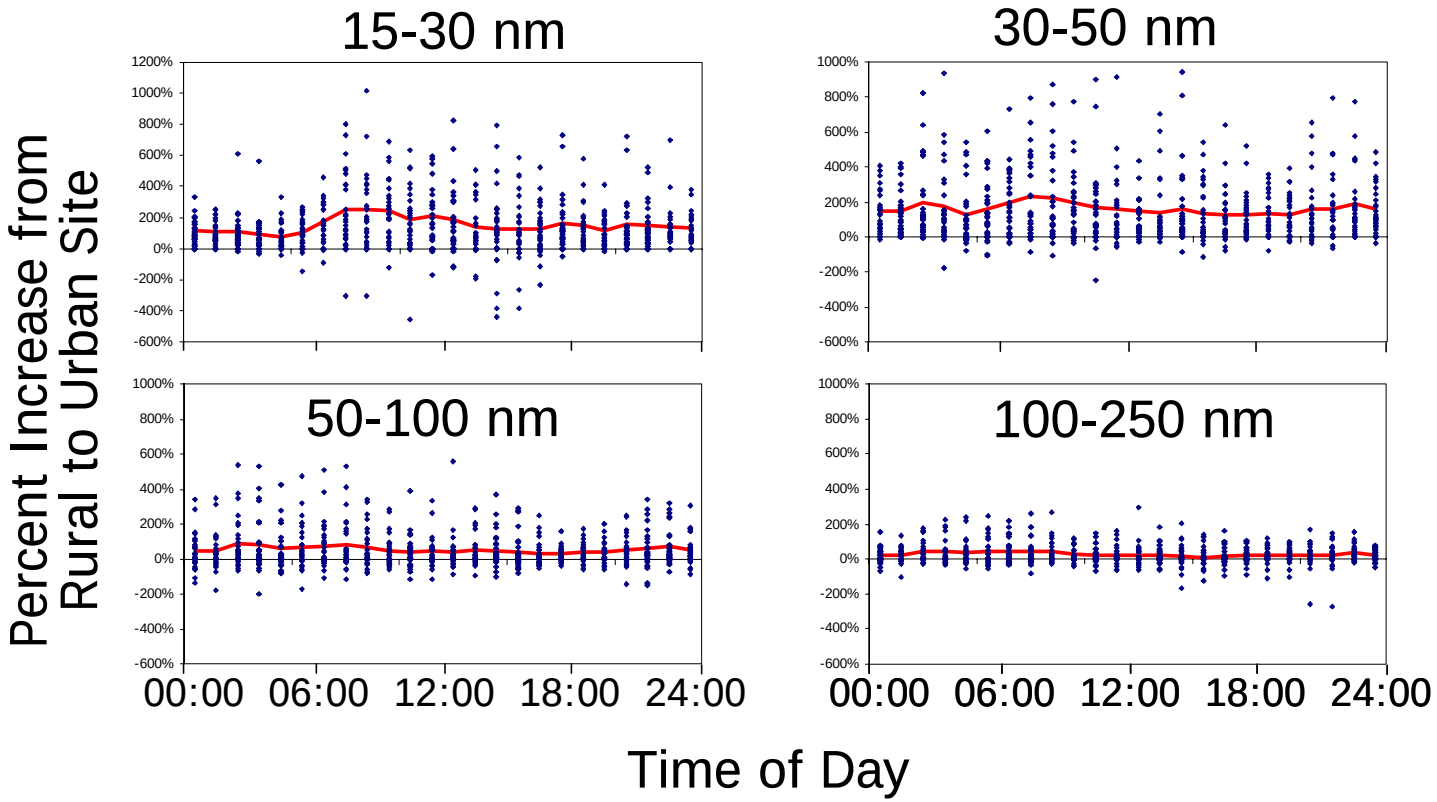
- *Often strong qualitative similarity over large distances*

Rural vs. Urban Pittsburgh



- *Rural concentrations lower, especially below 50 nm*

Diurnal Differences, Urban and Rural Sites



- *~ 200% increase from rural to urban sample in 15-50 nm bin*
- *rural / urban difference less apparent for larger particles*
- *15-30 nm bin increase shows AM rush hour pattern*
- *50-250 nm particles slightly elevated at night in urban inversion*

Comparison to Other Studies

Location	Number Concentration 10-100 nm (cm^{-3})	Number Concentration 100-500 nm (cm^{-3})	Source
Alkmaar, Netherlands	18,300	2,120	Russkanen (2001)
Erfurt, Germany	17,700	2,270	Russkanen (2001)
Helsinki, Finland	16,200	973	Russkanen (2001)
Pittsburgh, Urban	14,300	2,170	This work
Pittsburgh, Rural	6,500	1,900	This work

European Measurements from Ruuskanen et al., Atmospheric Environment 35 (2001) 3729-3738

Acknowledgements

- US Environmental Protection Agency Contract R82806101
- US Department of Energy National Energy Technology Laboratory Contract DE-FC26-01NT41017

- Related Presentations
  - Poster 12-PD16 Particle Density And Shape Factors Estimated From Merging Aerodynamic And Mobility Size Distributions
  - Talk 15-C2 (Thursday 11:00) Mass Balance Closure and the Federal Reference Method For PM-2.5 in Pittsburgh, Pennsylvania
  - Talk 19-C2 (Friday 10:20) Aerosol Water Content During Pittsburgh Air Quality Study: Observations And Model Comparison