PM2.5 Supersite Revisited – Queens College 2009 Summer Field Intensive

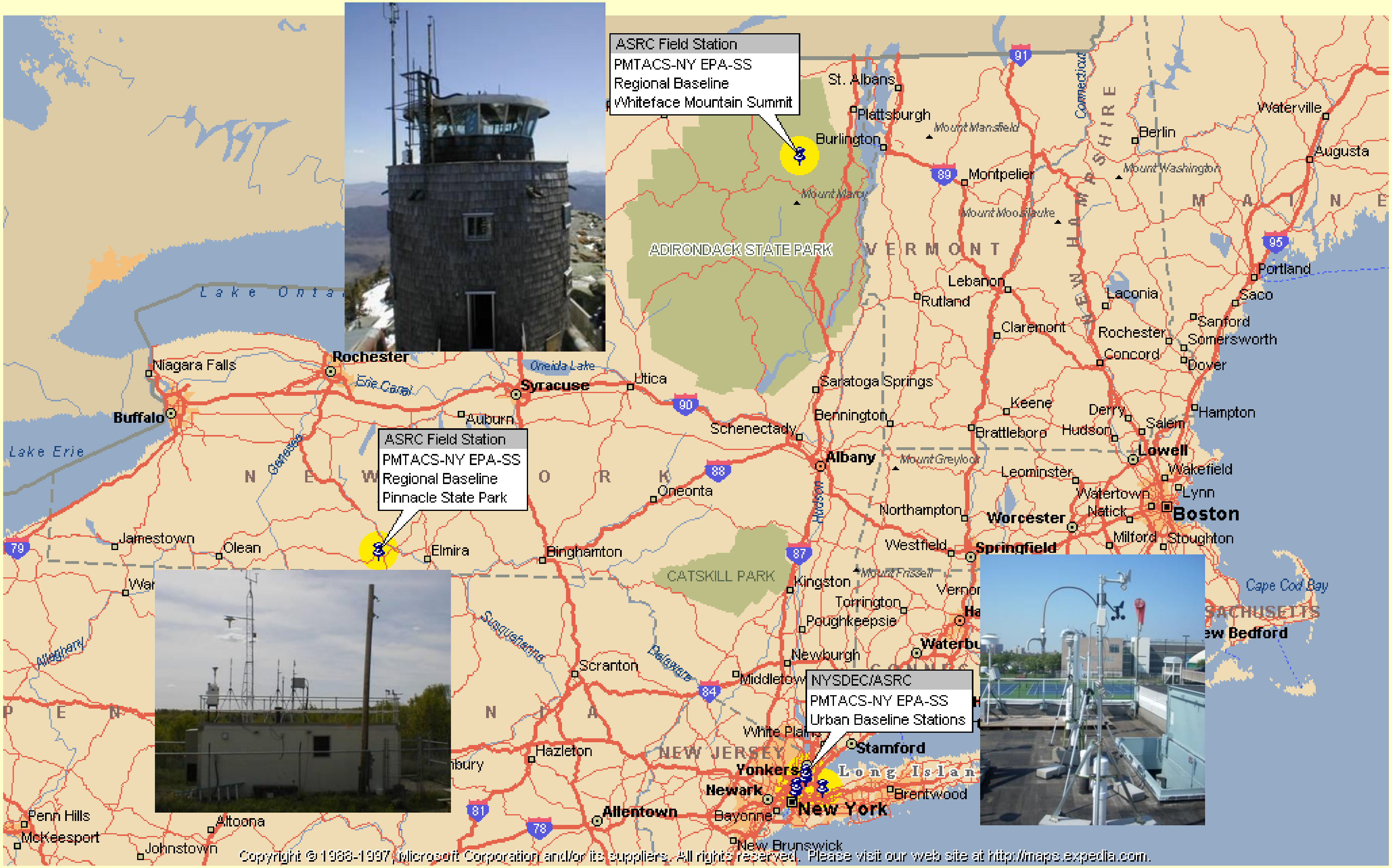
ENVIRONMENTAL MONITORING, EVALUATION, AND PROTECTION IN NEW YORK: LINKING SCIENCE AND POLICY
OCTOBER 14-15, 2009
The Albany Marriott • 189 Wolf Road • Albany, NY

Kenneth L. Demerjian
Atmospheric Sciences Research Center
University at Albany
State University of New York

Outline

- Brief history of PMTACS-NY PM2.5 Supersite
- Major Findings
- Long Term Measurements and Accountability
- Queens College Summer 2009 Revisit Objectives
- Measurement Platforms
- Preliminary Findings - 2009 Summer Intensive

PMTACS-NY Measurement Sites



PMTACS-NY Objectives

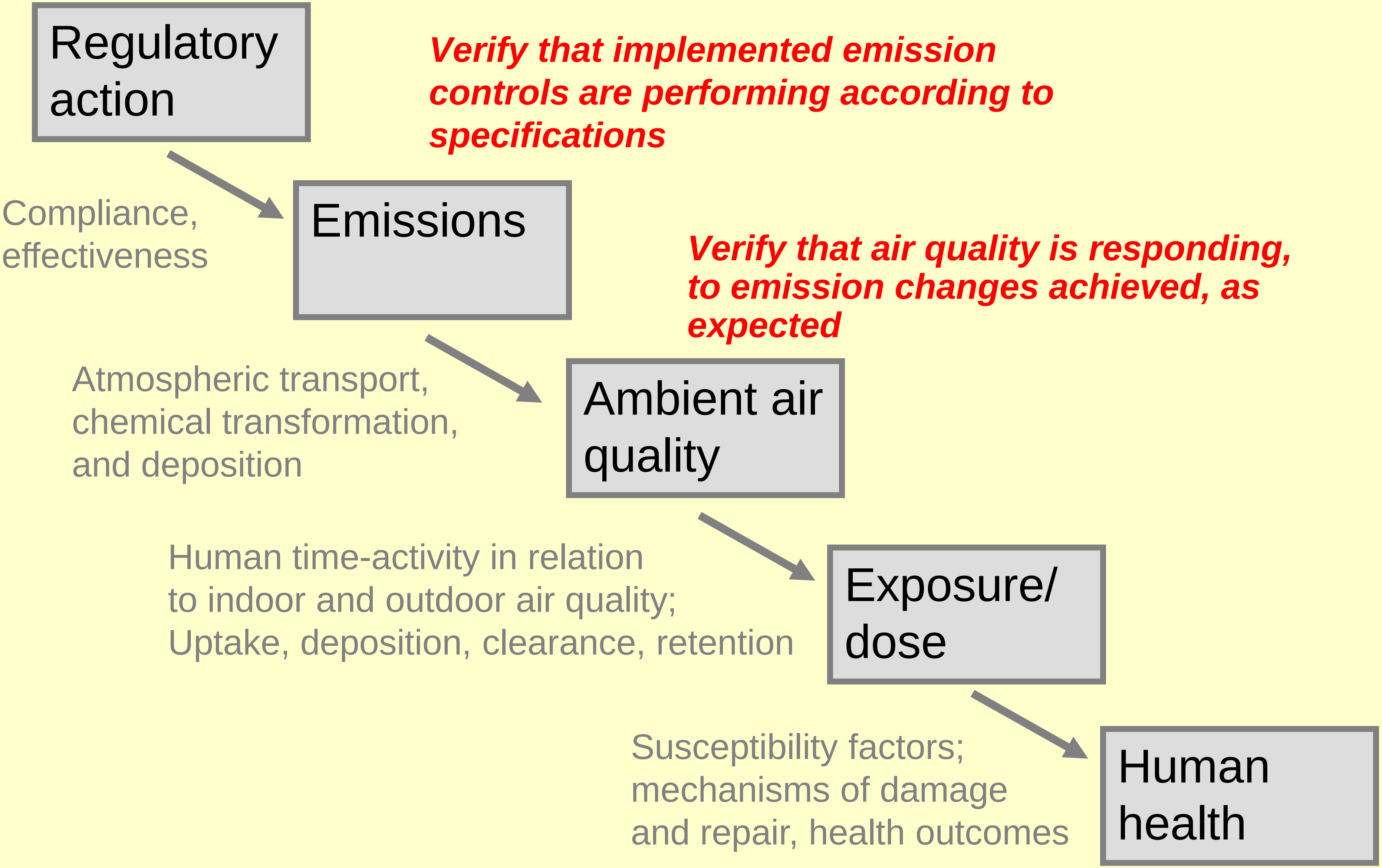
- Measure the temporal and spatial distribution of the PM2.5/co-pollutant complex including: SO_2, CO, VOCs/air toxics, NO, NO_2, O_3, NO_y, H_2CO, HNO_3, HONO, PM2.5 (mass, $SO_4^=$, NO_3^-, OC, EC, trace elements), aerosol number, size distribution and composition, OH and HO_2.

- Monitor the effectiveness of new emission control technologies [i.e. Compressed Natural Gas (CNG) bus deployment and Continuously Regenerating/Diesel Filter Trap (CR-DFT)] introduced in New York City and its impact on ambient air quality.

- Test and evaluate new measurement technologies and provide tech-transfer of demonstrated operationally robust technologies for network operation.

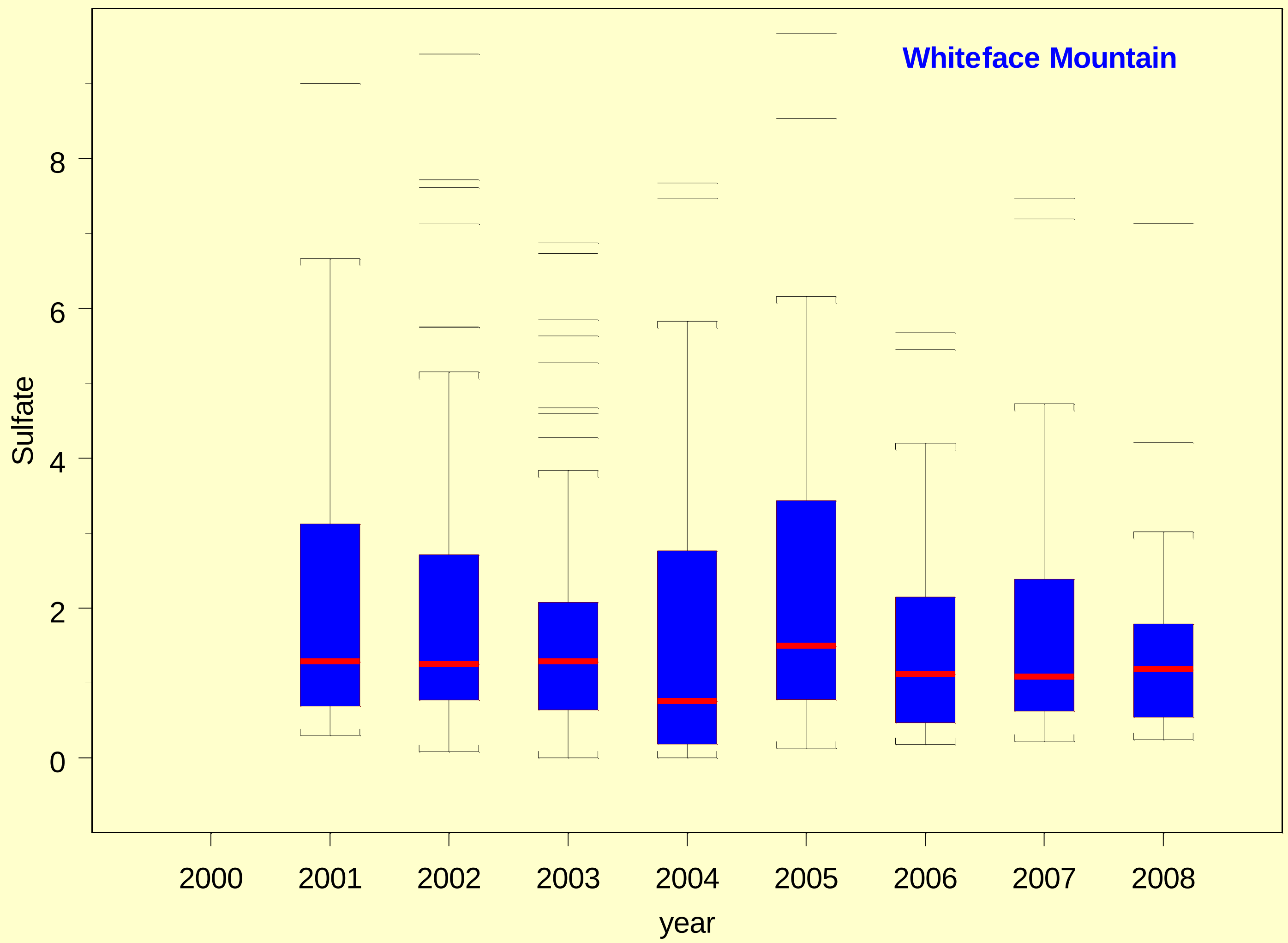
Key Findings of PMTACS-NY

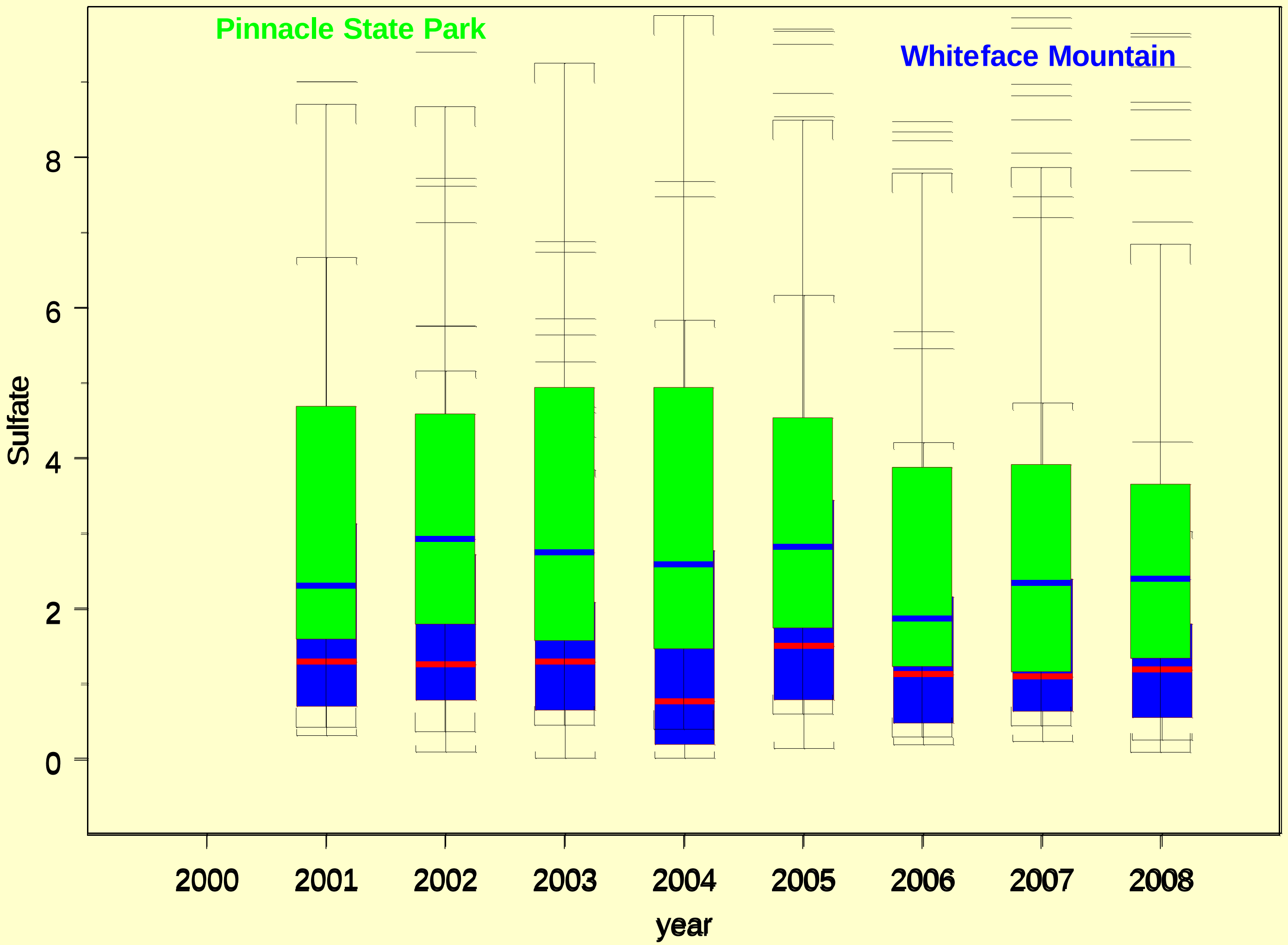
- Carbon contributes ~40% of the annual PM2.5 mass at NYC urban sites (while non-urban sites in NY report contributions of ~ 30%
- The carbon contribution to PM2.5 varies with season, where it is highest in summer and lowest in winter
- The main source of the season difference is summer secondary organic aerosol (SOA) production involves photochemical reactions with VOC compounds typically >C6 (isoprene the only exception)
- Major elemental carbon (EC) particle emissions in urban environments typically include diesel and gasoline powered internal combustion engines, and oil combustion for residential heating.
- These same EC sources have accompanying primary organic carbon emissions (OC), with one additional source, cooking.
- PM2.5 sulfates and nitrates with accompanying ammonium contribute ~50% of the annual PM2.5 mass at NYC sites.
- PM2.5 nitrates vary seasonally (temperature equilibrium effects), while sulfate and ammonium show little seasonal differences.



Verify that changes in identified health outcomes agree with expectations given observed changes in air quality.

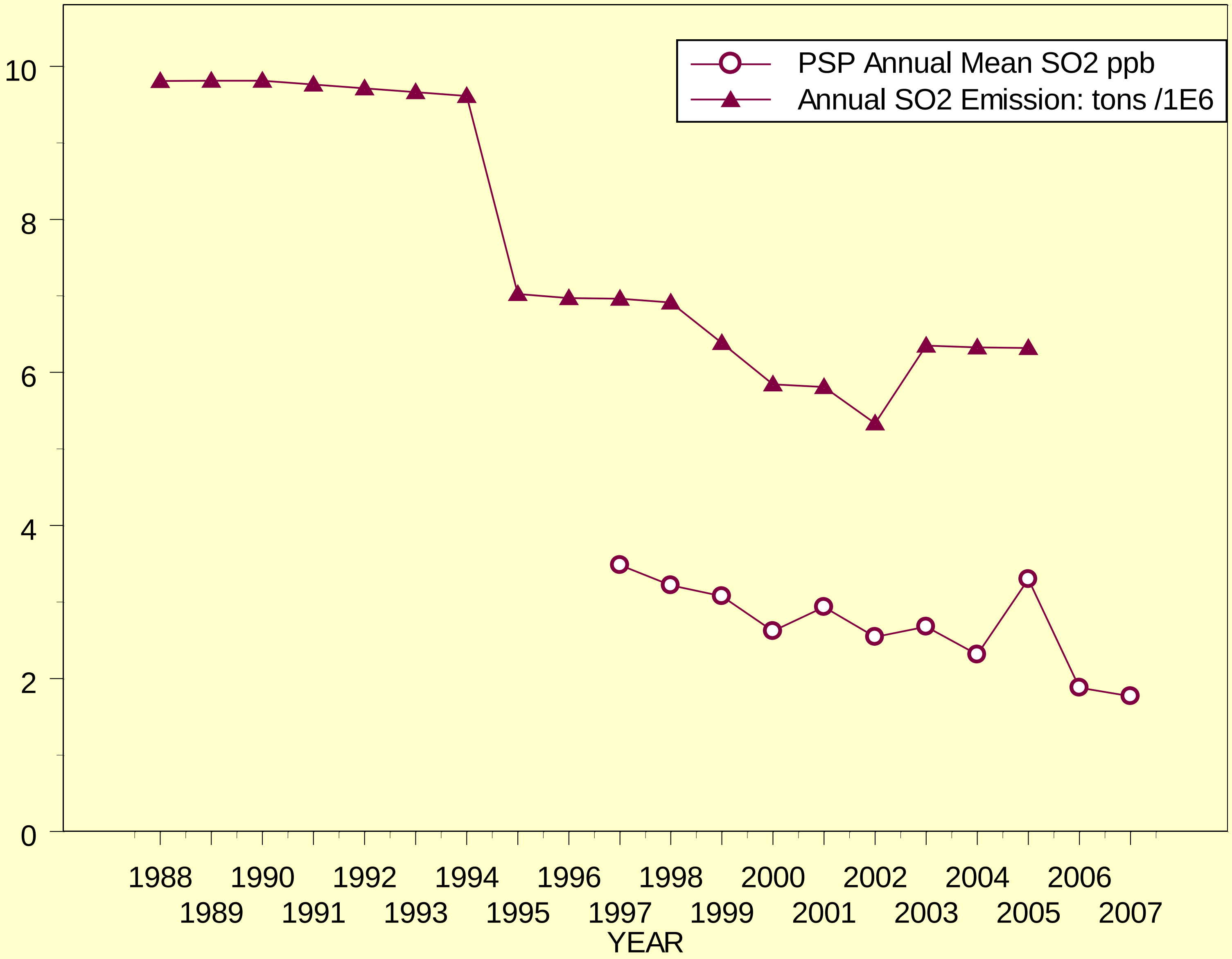
Chain of Accountability. *HEI Communication 11, 2003*


Whiteface Mountain
Sulfate
0
2
4
6
8
2000
2001
2002
2003
2004
2005
2006
2007
2008
year

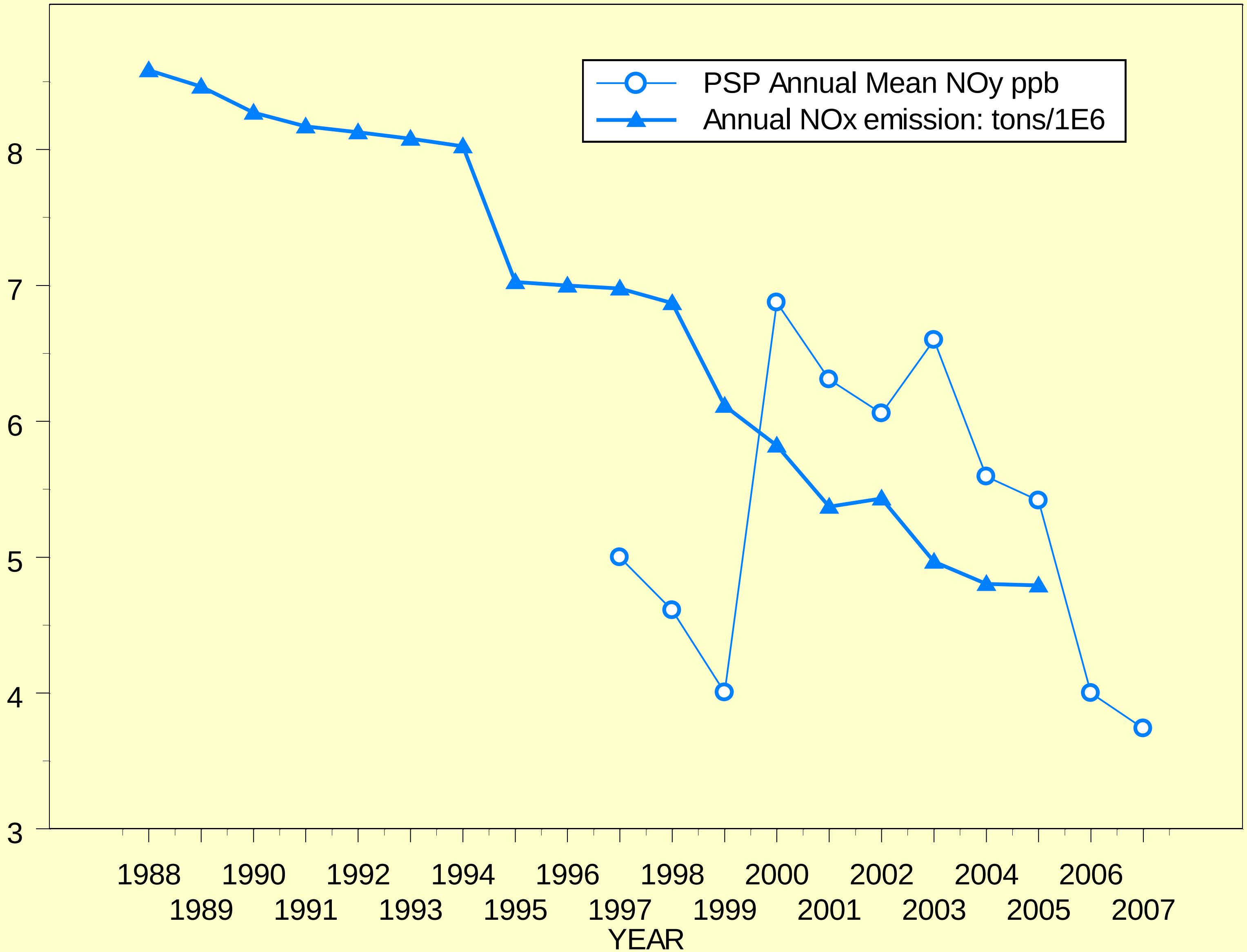


Pinnacle State Park
Whiteface Mountain
Sulfate
0
2
4
6
8
2000
2001
2002
2003
2004
2005
2006
2007
2008
year

Tracking Emission and Air Quality



Tracking Emission and Air Quality



Revisiting Queens College Summer Intensive 2009

- Objectives
  - 1. Conduct AMS measurements and analyses similar to those performed during the “PM Supersite” summer 2001 field intensive to detect if changes have occurred in aerosol size and composition over the intervening years.
  - 2. Conduct measurements to characterize concentration gradients in the vicinity of major highways and adjacent residential communities to improve our understanding of population exposures.
  - 3. Evaluate advanced measurement technologies (e.g. QCL-TDLAS, HR-tof-AMS, PASS, FMPS, SP-AMS and ACSM).

Sampling Period: July 14 - August 3, 2009

A: DEC fixed site

- ASRC: SMPS, PILS-IC, PILS-TOC ($PM_{2.5}$), SMPS, APS
- Aerodyne: ACSM ($PM_{1.0}$)

B: Parking Lot 6 (~140 m from A)

- ASRC Mobile Van
- Aerodyne Mobile Van

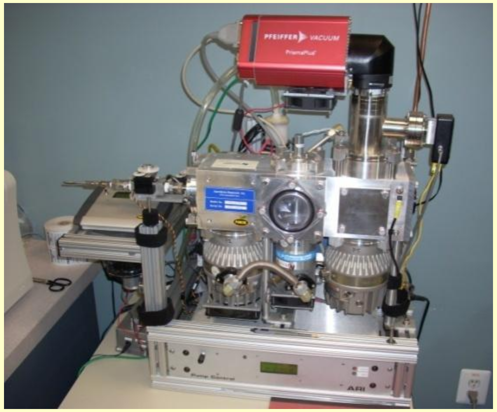
C: Parking Lot 15 (~40 m from LIE)

- ASRC Mobile Van

SMPS, APS

PILS-IC, PILS-TOC

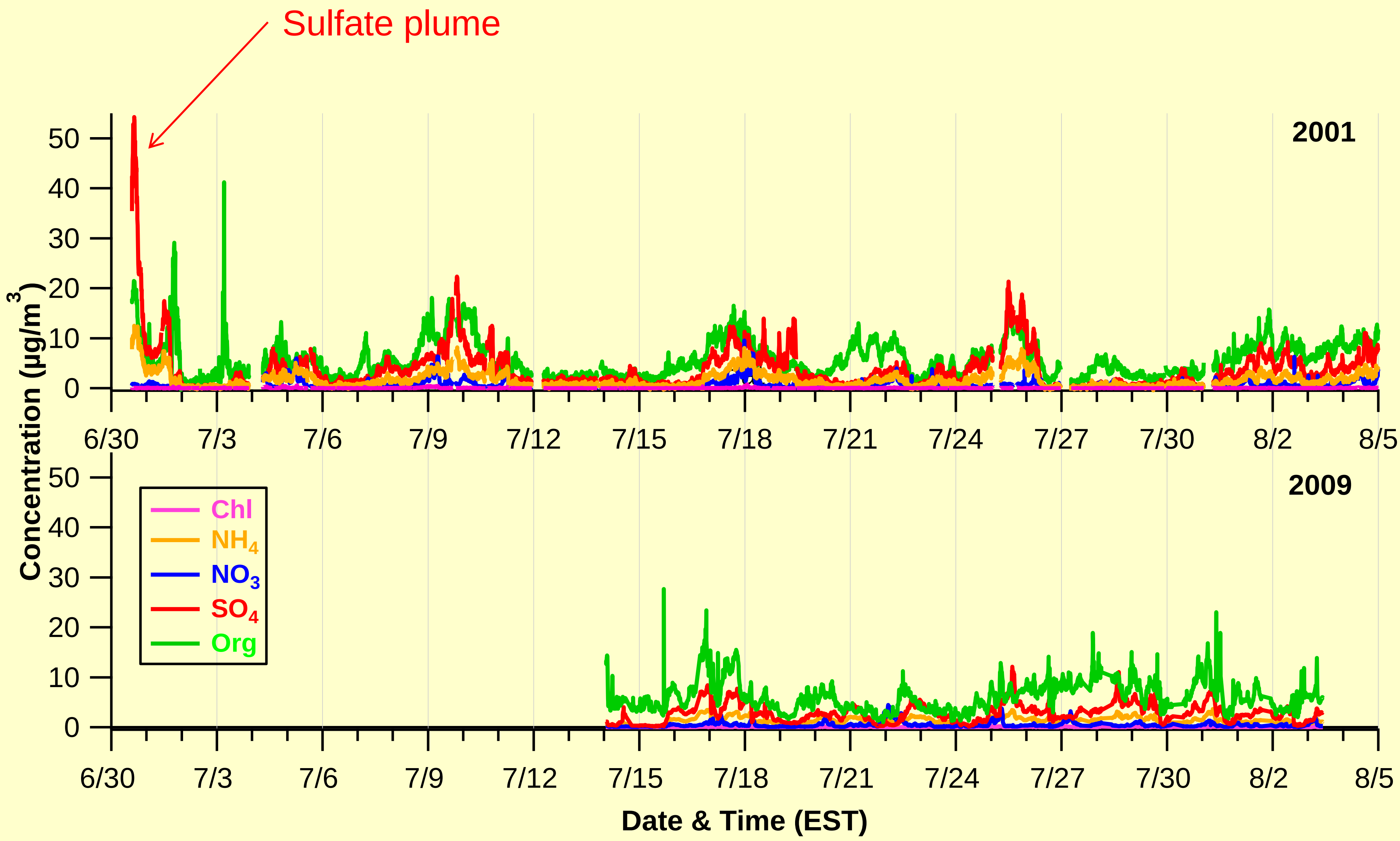
ACSM



Measurement Systems

Instrument	Parameter	Location
Hi Res Tof AMS	Non-Refrac PM	UA Mobile Van
QCL - TDLAS	H2CO & NO2	UA Mobile Van
DMT PASS-1	Soot (EC)	UA Mobile Van
FMPS	PM size distribution	UA Mobile Van
2B technologies	NO, NO2, O3	UA Mobile Van
BTEX HC	Select Aromatics	UA Mobile Van
LiCor	CO2	UA Mobile Van
CPC Water based	Particle number	UA Mobile Van
SMPS	PM size distribution	QC Shelter
Nano SMPS	PM size distribution	QC Shelter
APS	PM size distribution	QC Shelter
CPC 3022	Particle number	QC Shelter
CPC Water based	Particle number	QC Shelter
PILS	PM2.5 ± ions and TOC	QC Shelter
ThermoFisher(TF) 5020	PM2.5 SO4	QC Shelter
TF TEOM FDMS	PM2.5 mass	QC Shelter
TF TEOM	PM2.5 mass	QC Shelter
Sunset Labs EC/OC	EC/OC	QC Shelter
Photolytic NO2[1]	NO2	QC Shelter
AlphaOmega H2CO	H2CO	QC Shelter
API 300EU	CO	QC Shelter
TEI NOx	NOx	QC Shelter
TEI Pulsed Fluor	SO2	QC Shelter
TEI O3	O3	QC Shelter
Horiba THC	THC/NMHC/CH4	QC Shelter
STN PM Compos.	PM2.5 Composition	QC Shelter
PM2.5 FRM	PM2.5 mass	QC Shelter
Toxic/PAMS Cannister[3]	Toxics/C2-C12 nmhc	QC Shelter
ACSM	Non-Refrac PM	QC Shelter
SP- AMS	PM Organic & EC	ARI - Mobile Van
CAPS extinction	Aerosol Extinction	ARI - Mobile Van
MAAP	Black Carbon	ARI - Mobile Van
SMPS	PM size distribution	ARI - Mobile Van
CO2	LICor	ARI - Mobile Van
NO/NOx	TECO	ARI - Mobile Van

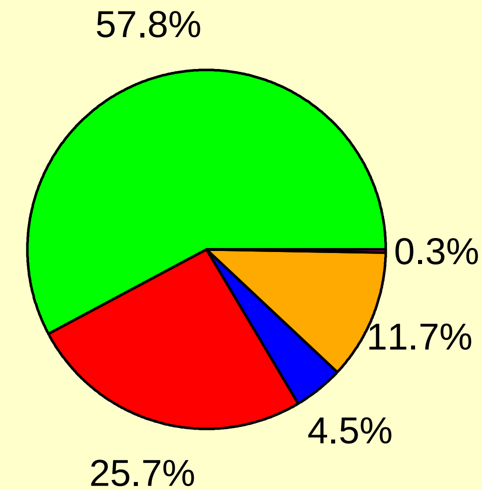
Time Series



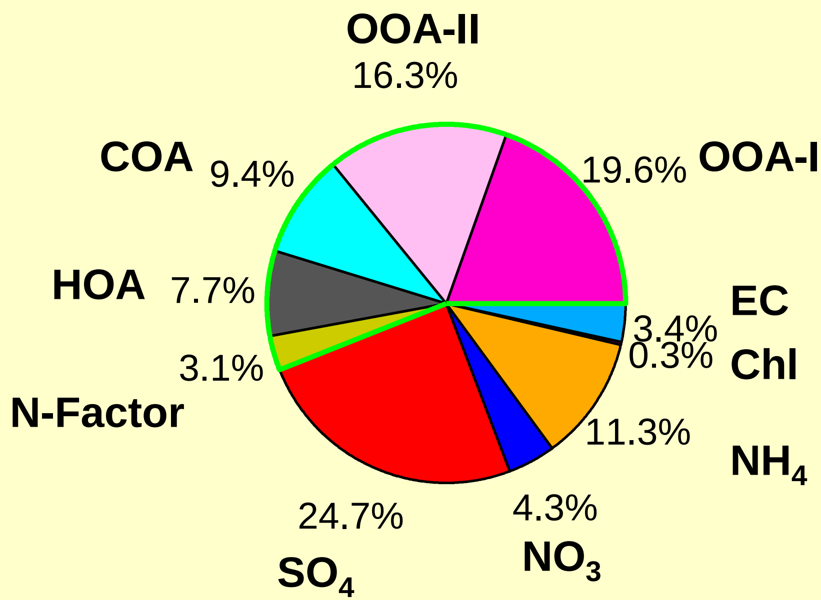
Sulfate plume
2001
2009
Concentration (μg/m3)
0
10
20
30
40
50
6/30
7/3
7/6
7/9
7/12
7/15
7/18
7/21
7/24
7/27
7/30
8/2
8/5
Chl
NH4
NO3
SO4
Org
Date & Time (EST)

$PM_{1.0}$ Composition

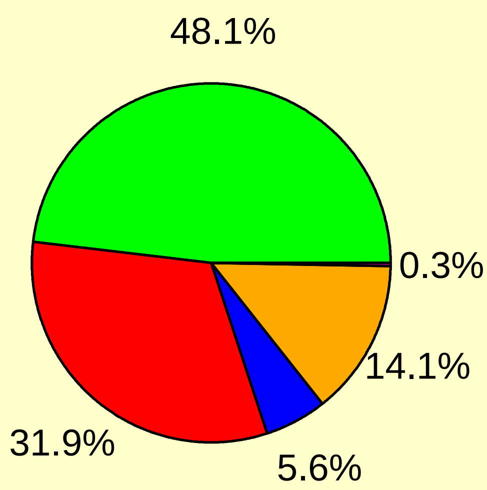
2009 Total = 10.98 µg/m^3



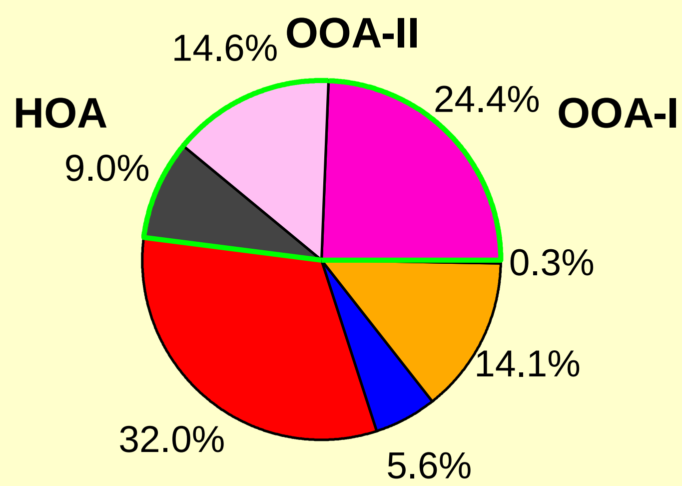
Total = 11.41 µg/m^3



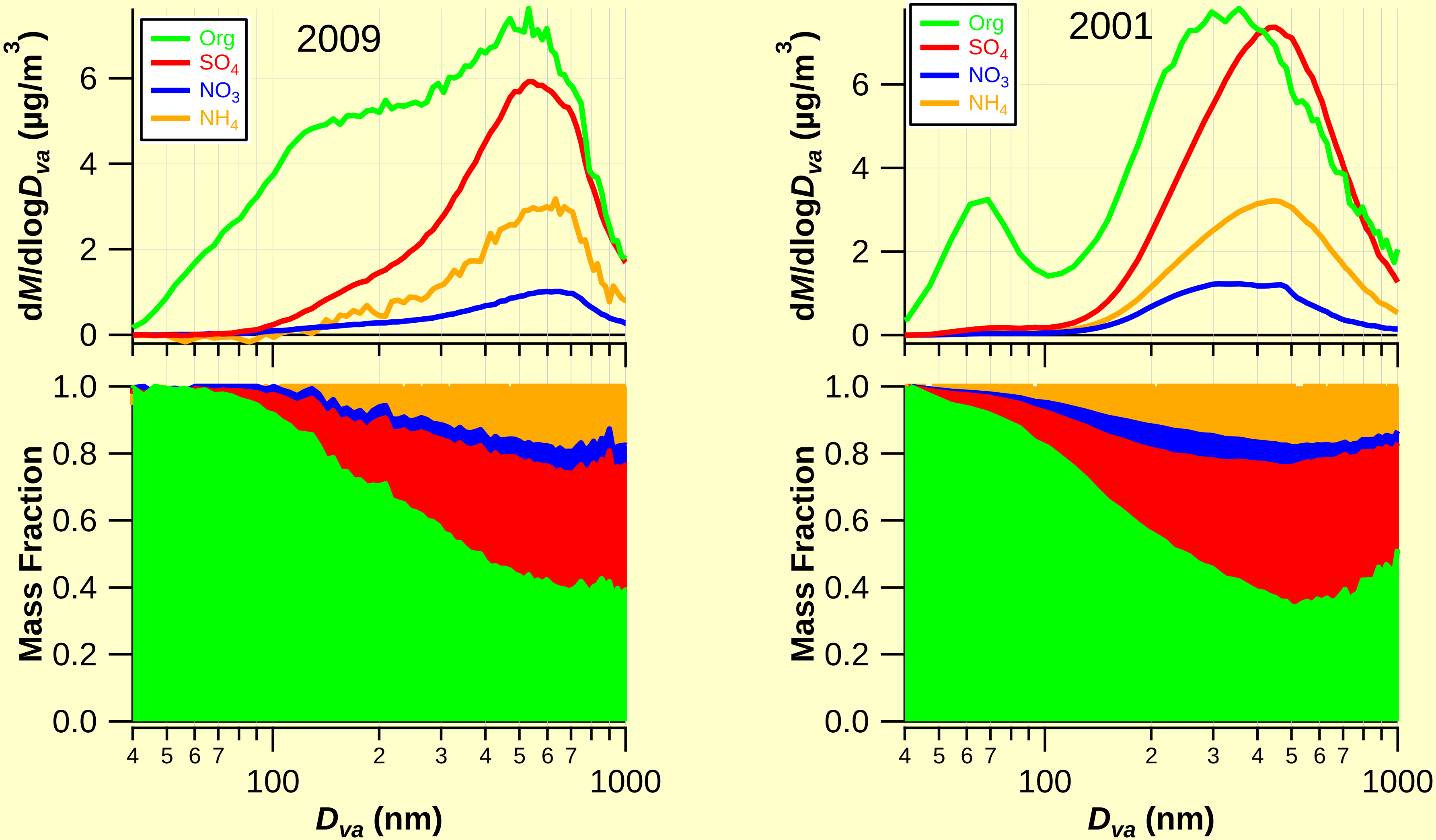
2001 Total = 12.06 µg/m^3



Total = 12.06 µg/m^3



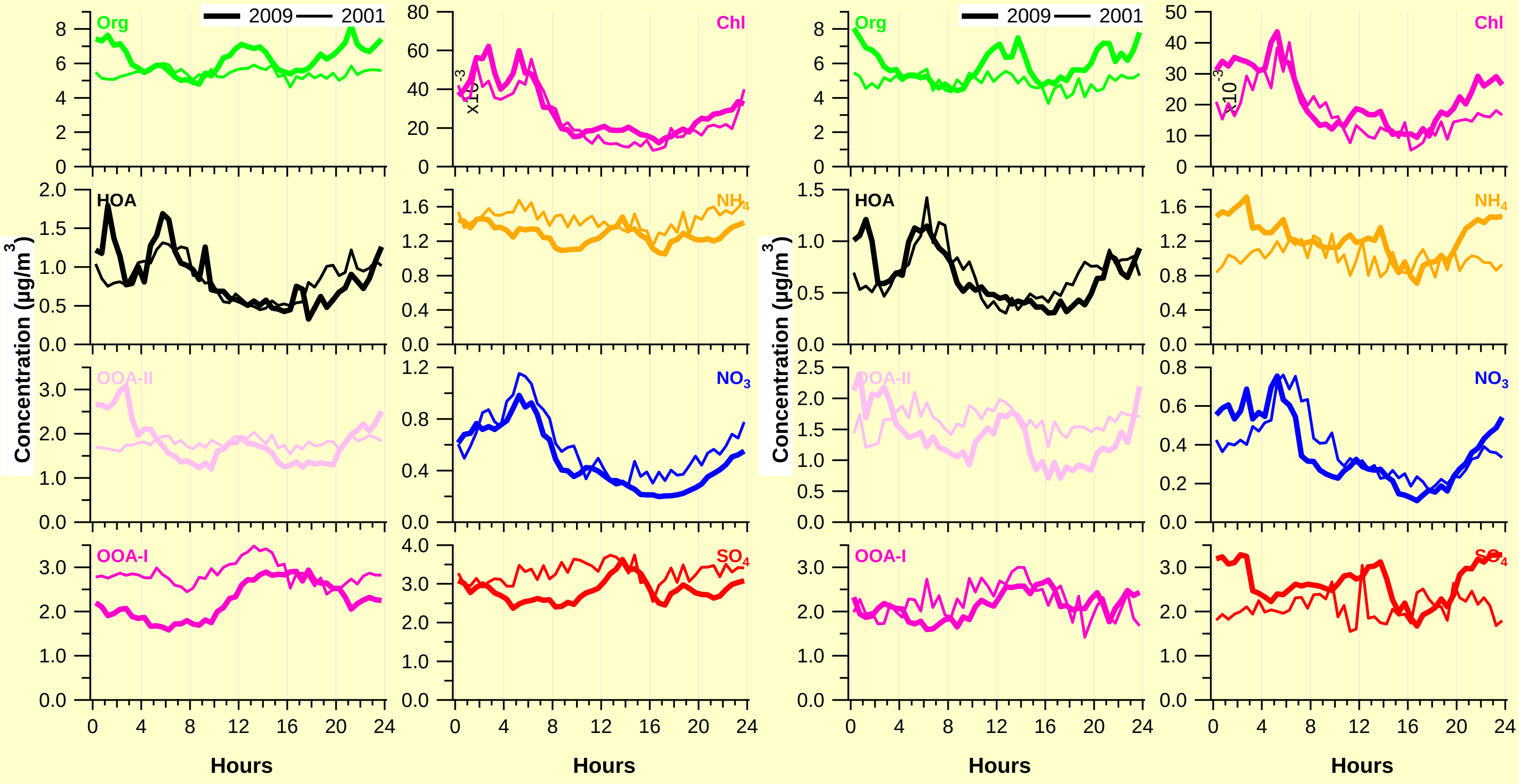
Size Distributions



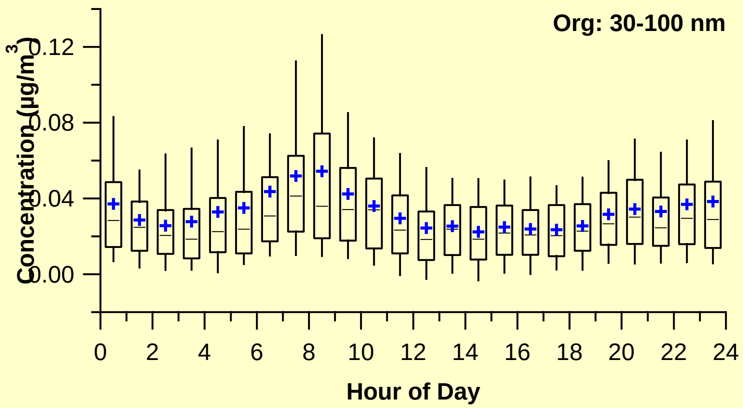
Diurnal Patterns: Using the same period, i.e., July 14 – August 3

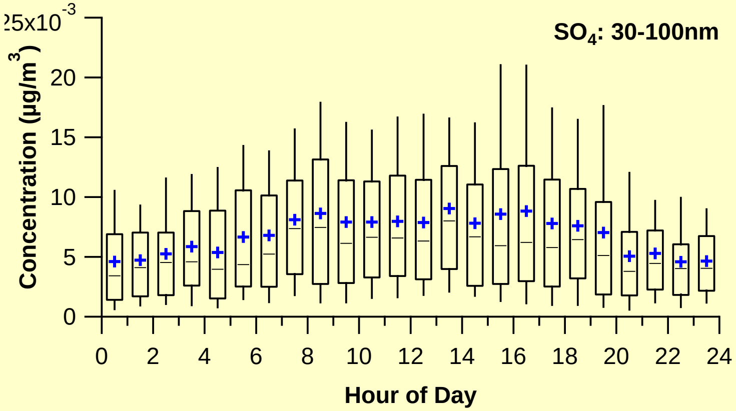
Mean

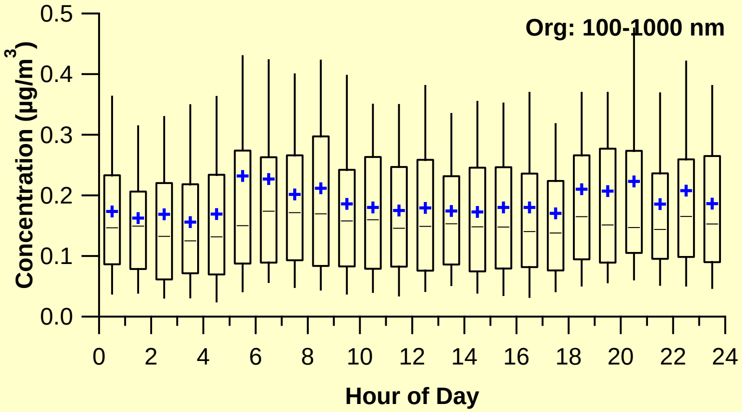
Median

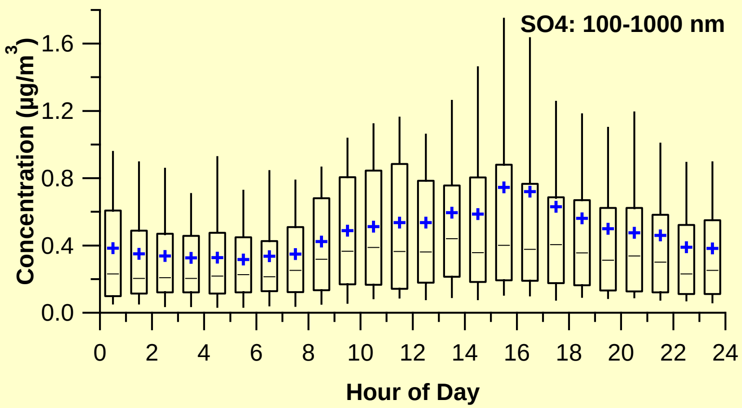


2001 Data: 30-100nm vs 100-1000 nm

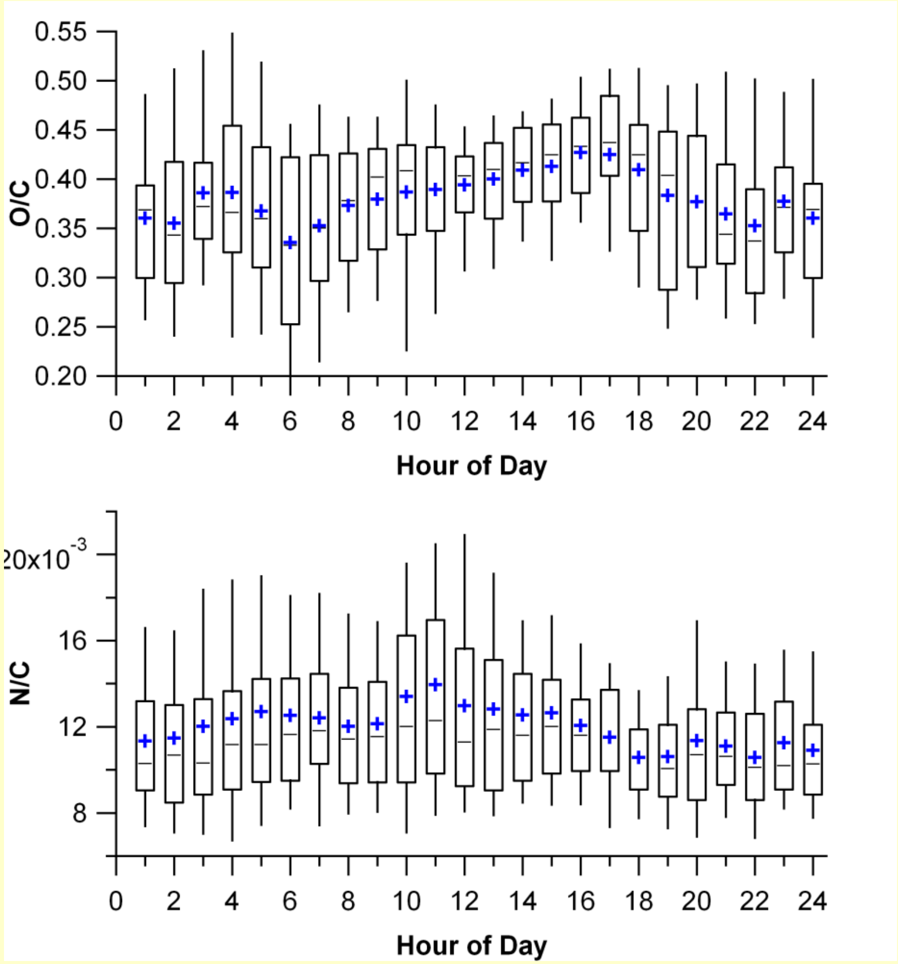


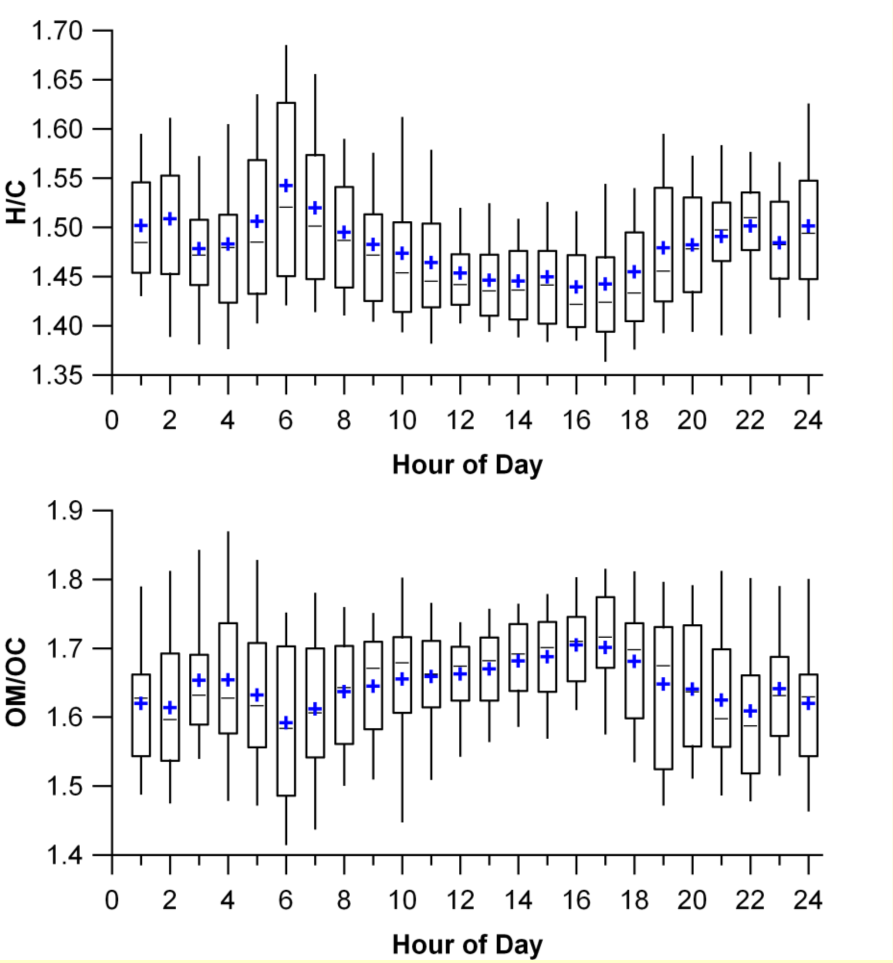




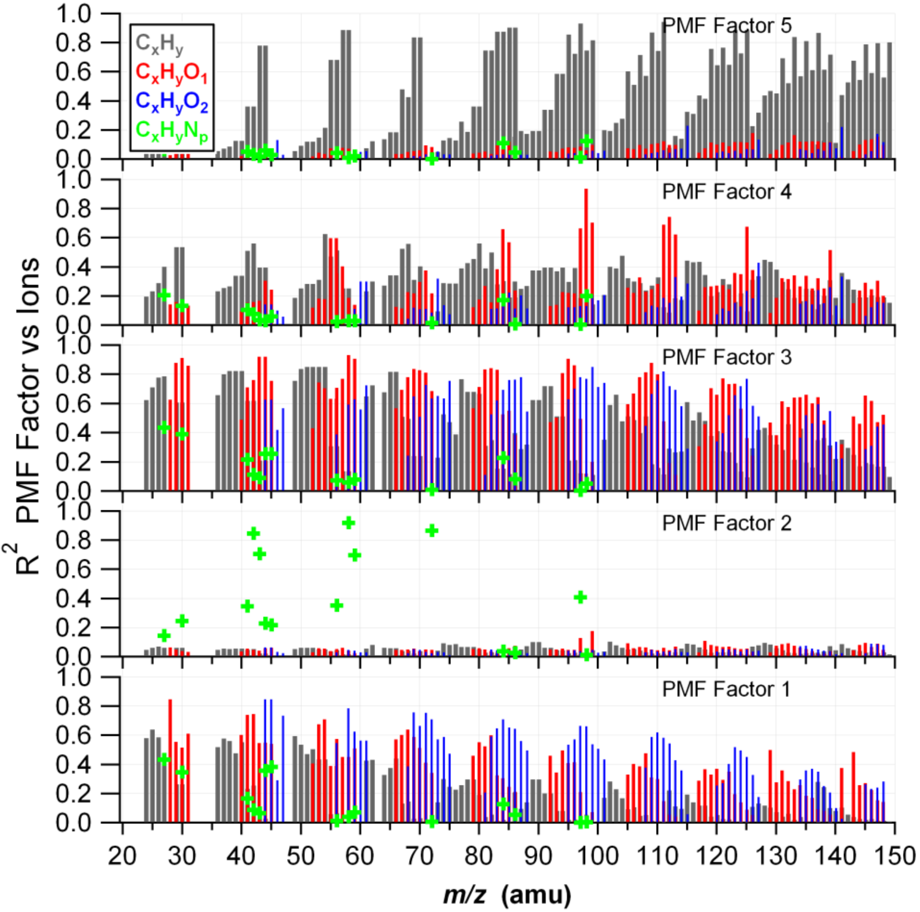


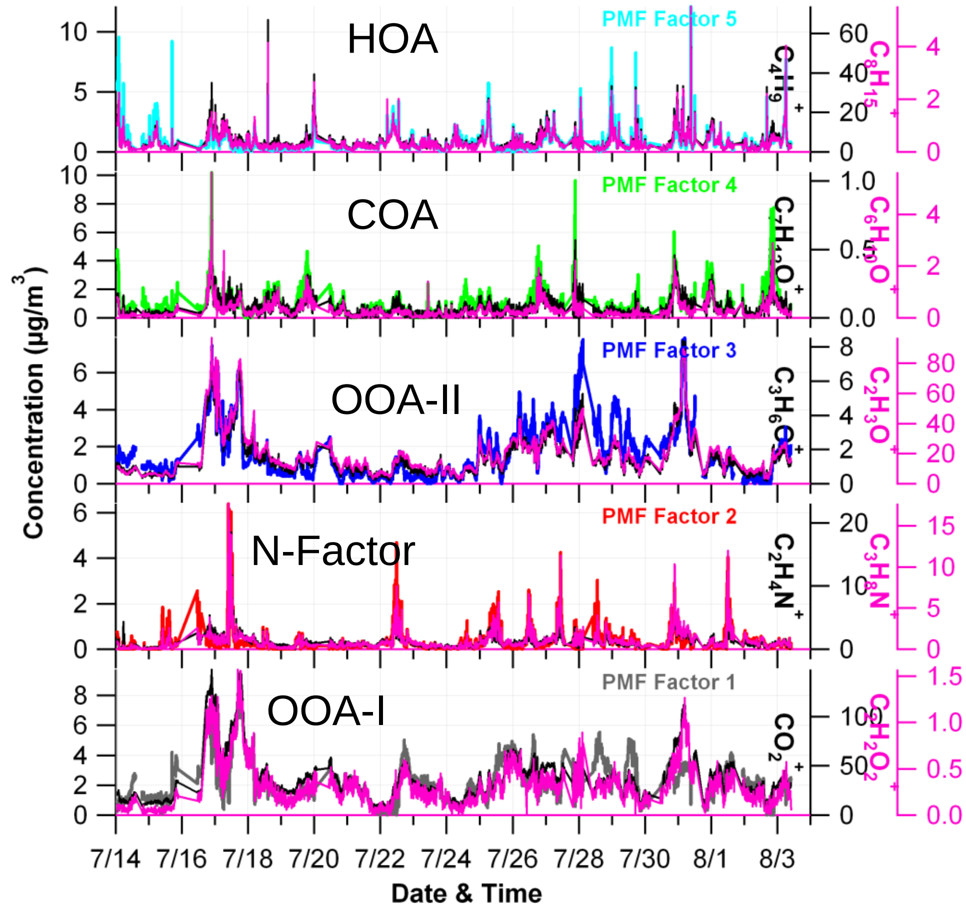
Elemental Composition: Diurnals





OA Components vs. HR Ions





OOA-I: $C_xH_yO_2^+ > C_xH_yO_1^+ > C_xH_y^+$

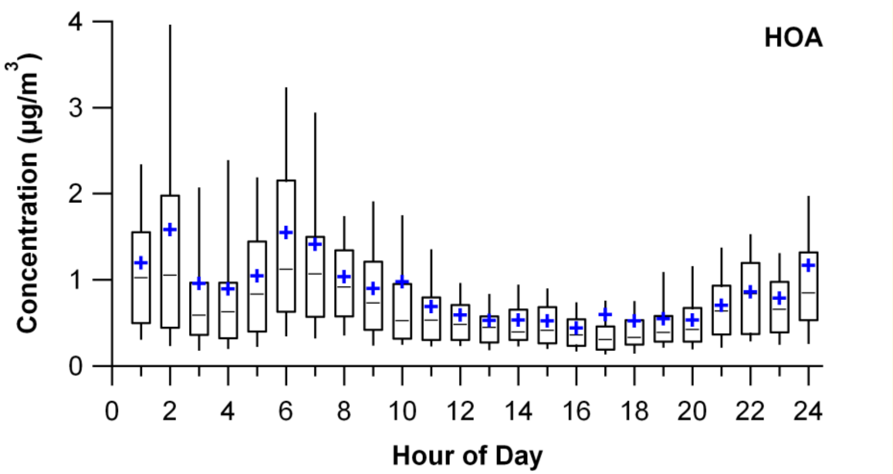
OOA-II: $C_xH_yO_1^+ > C_xH_yO_2^+ \approx C_xH_y^+$

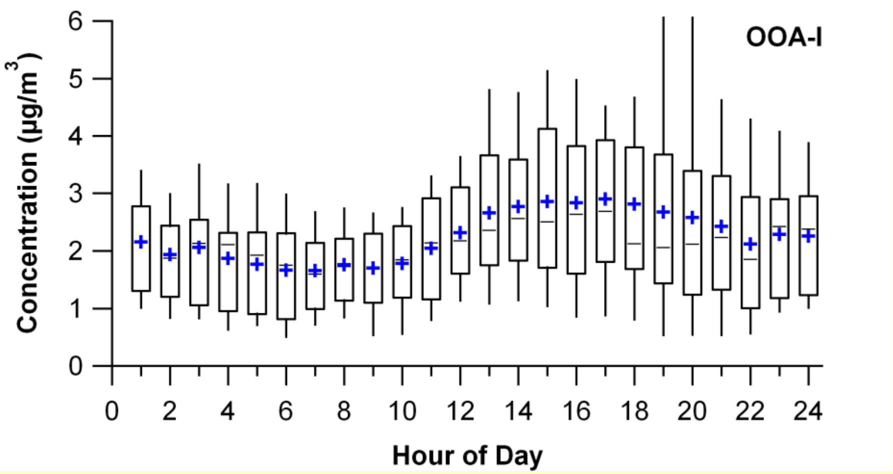
COA: $C_5H_8O^+$, $C_6H_{10}O^+$,$C_7H_{12}O^+$,$C_8H_{14}O^+$

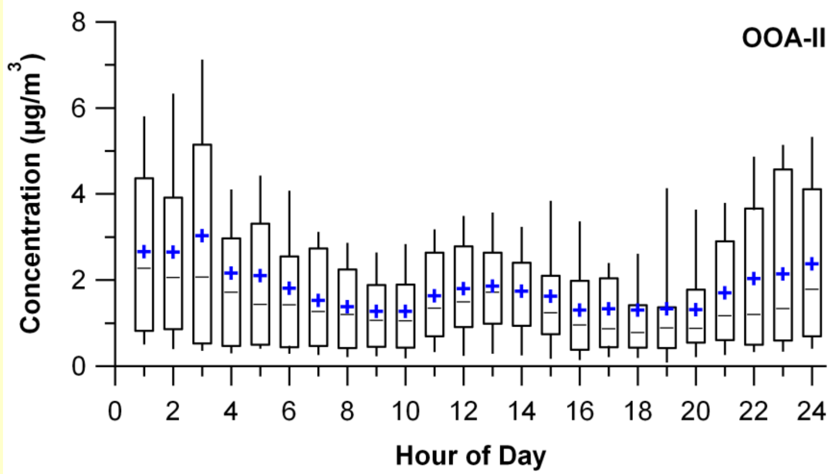
HOA: $C_xH_y^+ >> C_xH_yO_z^+$

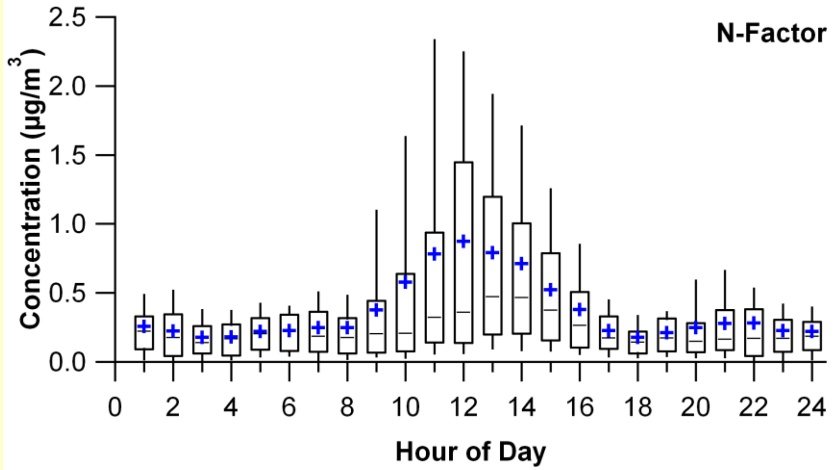
N-Factor: $C_2H_4N^+$, $C_3H_8N^+$, $C_4H_{10}N^+$

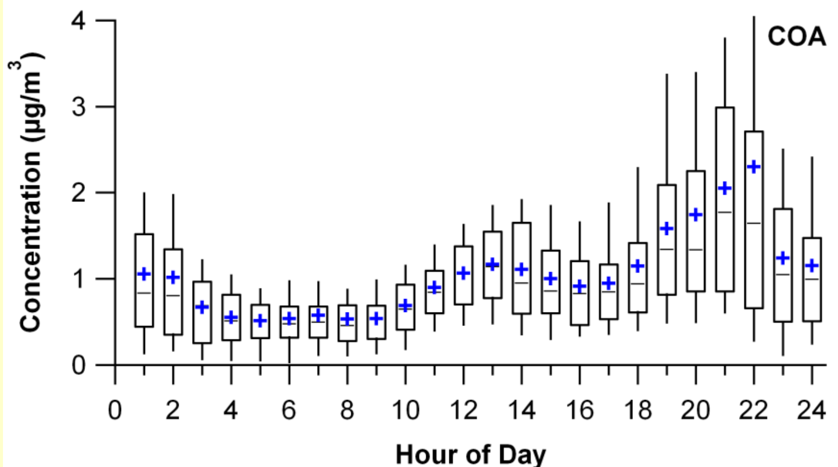
OA Components: Diurnals







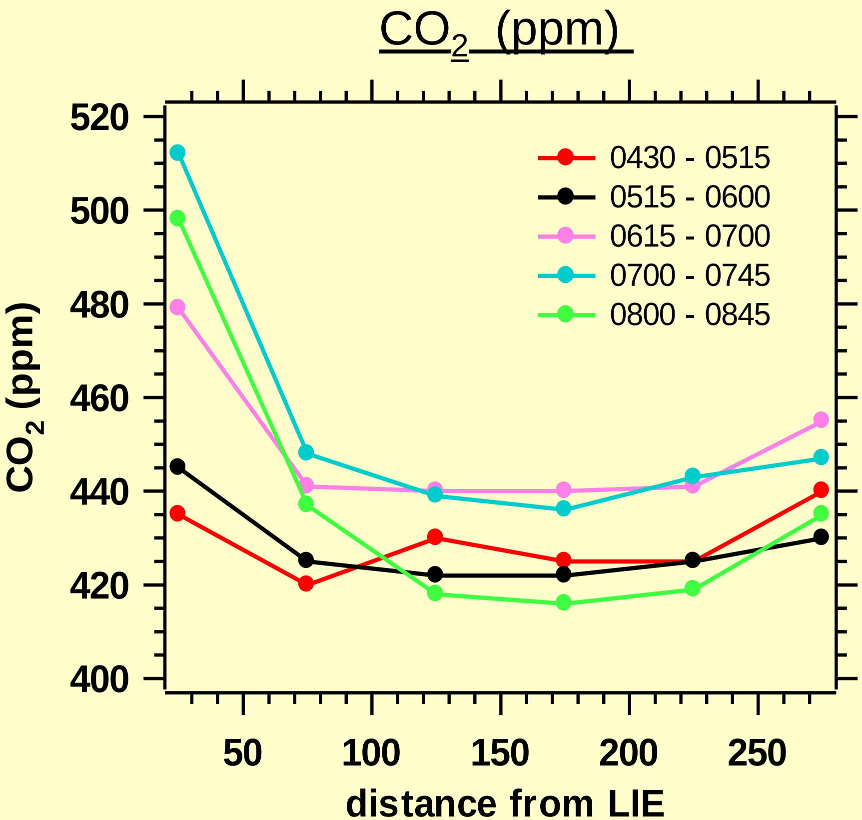


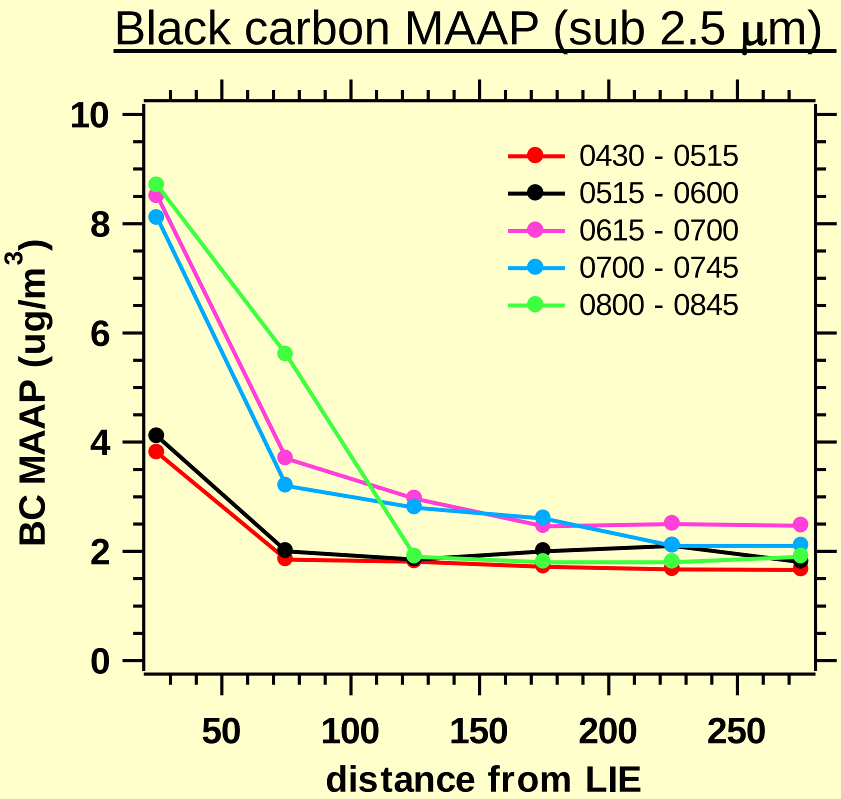


July 28th, 2009 (0430-0845)

- Drove between LIE frontage road and Memorial Drive (N-S, ~400 m) and between Main St and Kissena Blvd (E-W, ~500 m) completing five full loops.
- Winds were light and constant (S-SW, 2 m/s) - the north side of LIE is our “downwind side”
- Look at temporal and spatial evolution of gaseous and aerosols species on the downwind side (side roads have been excluded)
- Two loops on the upwind side also carried out.

ARI Mobile Laboratory track, 0430-0900





<u>< 50 m downwind LIE</u>

-CO_2 > 430 ppm

-Peak between 0700- 0745 (520 ppm)

<u>50 to 300 m downwind LIE</u>

- CO_2 < 450 ppm

-Gradient established 0700 – 0745

-Highest between 0615 – 0745

-CO_2 is lower by 0800

<u>< 50 m downwind LIE</u>

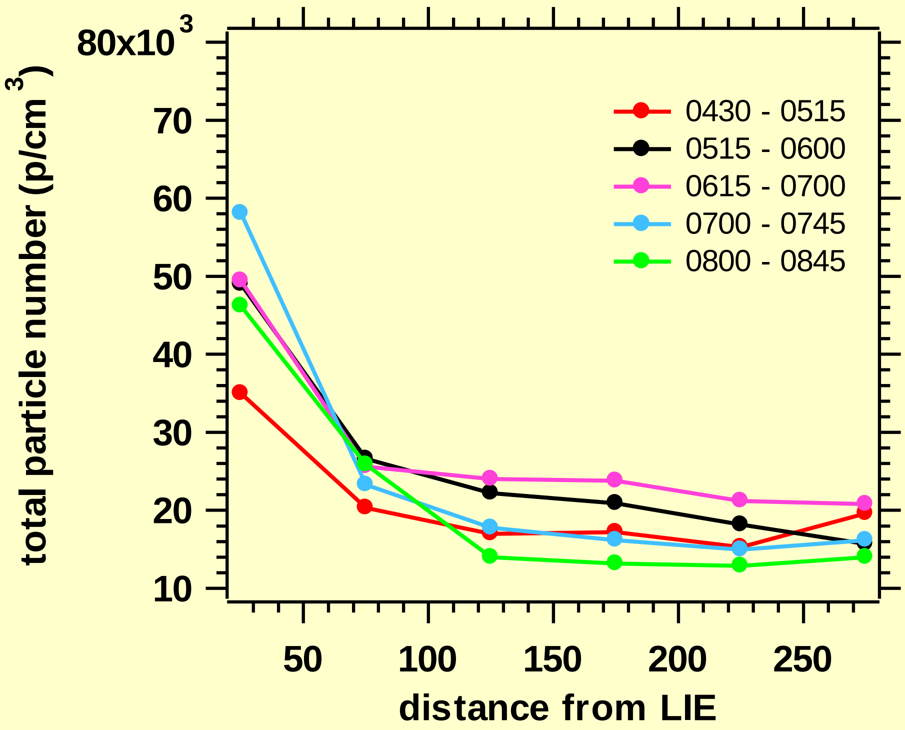
-BC between 4 – 10 ug/m^3

-Highest between 0800- 0845

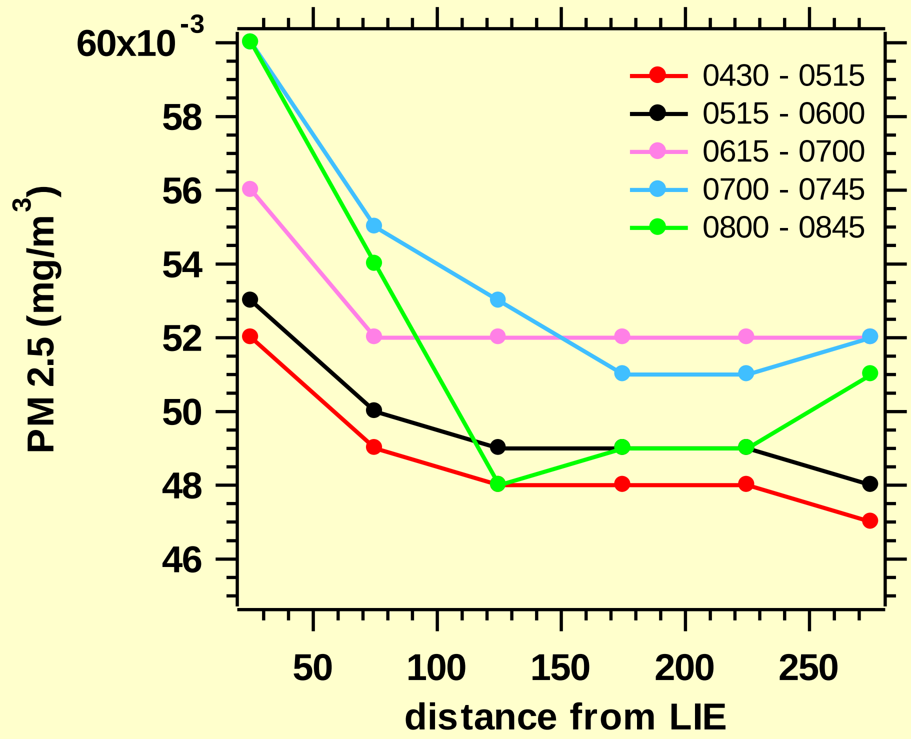
<u>50 to 300 m downwind LIE</u>

- **BC mostly < 4 ug/m^3**
- **Highest BC between 0615 - 0745**
- **Gradient established 0700- 0745**
- **BC returns to low levels by 0800**

CPC total counts (sub 1 μm)



PM 2.5 (sub 2.5 μm)



< 50 m downwind LIE

-Number between 35 and 65*10^3 p/cc

-Peak between 0700- 0745

50 to 300 m downwind LIE

-p/cc < 30*10^3

-Gradient established 0515 – 0600

-Highest p/cc between 0615 – 0700

-p/cc is lower after 0700

< 50 m downwind LIE

- PM2.5 between 50 and 60*10^{-3}

-Peak between 0700- 0745

50 to 300 m downwind LIE

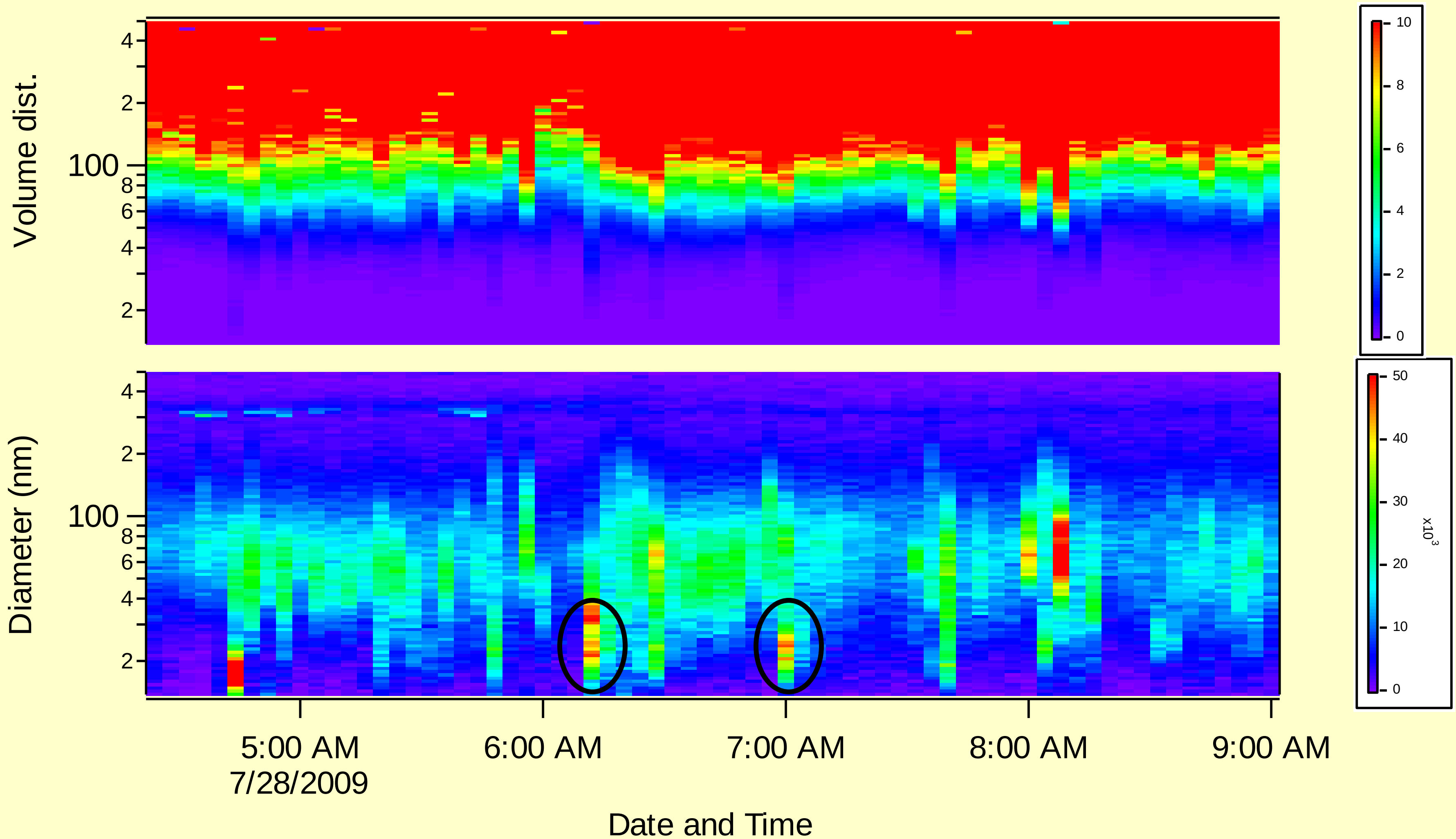
- PM2.5 ~ 50*10^{-3}

-Gradient established 0430 – 0600

-Highest PM2.5 between 0615 – 0745

-PM2.5 is lower by 0800

Size distribution data (SMPS, TSI)



1) Before 0800, particle number peaks at 20 nm (circled areas)
2) After 0800, particle number peaks at 60 nm (square)
3) Overall particle number peaks between 40-60 nm; volume is mostly above 80 nm

Acknowledgment of Participants

J. Schwab, G. Lala, M.S. Bae, U. Roychowdhury, O. Hogrefe, Y.Sun, Q. Zhang, W.N Chen[1], Y.C, Lin[1], H. Hung[2], Atmospheric Sciences Research Center, University at Albany, SUNY

D. Felton, O. Rattigan, B. Frank, NYS Department of Environmental Conservation

D. Worsnop, J. Jayne, P. Massoli, S. Ng, E. Fortner, L. He, L. Williams, C. Kolb, Aerodyne Research, Inc.

[1] Visiting Post Doctoral Scientist – Academia Sinica, Taiwan

[2] Visiting Scientist – National Taiwan University

Acknowledgment of Sponsors

This work was supported in part by

- U.S. Environmental Protection Agency (EPA) cooperative agreement # R828060010
- New York State Energy Research and Development Authority (NYSERDA), contract # 4918ERTERES99 and contract # 10602
- New York State Office of Science, Technology and Academic Research (NYSTAR) University Consortium contract # 3538479
- New York State Department of Environmental Conservation (NYS DEC), contract # C004210.