Aerosol Lifecycle IOP
June 15 - August 15, 2011

A. J. Sedlacek, S. R. Springston, E. R. Lewis, G. Senum, Y.-N. Lee, L. Kleinman, F. Mei, C. Kuang, J. Wang, A. Cialella, M. Jensen, M. J. Bartholomew, R. Wagener (BNL);
B. Flowers, C. Dvonch (LANL);
Q. Zhang & J. Xu (U. C./Davis);
S. Lee, J. Yu & Y. You (Kent State);
G. Hallar, G. Chirokova & I. McCubbin (DRI);
A. Freedman (Aerodyne);
D. Cziczo (MIT)

ARM
CLIMATE RESEARCH FACILITY

BROOKHAVEN NATIONAL LABORATORY
a passion for discovery

Office of Science
U.S. DEPARTMENT OF ENERGY

ASR
Atmospheric System Research

Aerosol Lifecycle IOP - Motivation

New MAOS platforms need to be tested and inter-compared.

Thus a proposal was submitted to DOE for an IOP with three objectives:

- Develop new operational strategies that reflect the addition to ACRF of 'research grade' instruments (MAOS)
- Prepare for GVAX deployment, including training of technicians
- Conduct measurements in a unique location (Long Island) - exploratory dataset for TCAP

Aerosol Lifecycle IOP - Summary

June 15 to August 15, 2011

At Brookhaven National Laboratory, on Long Island NY

MAOS-A, MAOS-C, AMF2, BNL mobile laboratory

ACRF and guest instruments

Visiting scientists from Aerodyne, UC/Davis, DRI, Kent, MIT

Summer interns

IOP wikipage

Multiple intercomparisons

Four research foci

- characterization of secondary organic aerosol formation
- determination of cloud-activation properties of aerosol particles
- determination of aerosol optical properties
- model-observation intercomparison

MAOS (Mobile Aerosol Observing System)

Extends AOS capability with enhancements

Two units (MAOS-A & MAOS-C) for aerosol/chemical focus

Self-contained (minimal staging/de-staging time)

Plug and play

MAOS is Composed of Two Parts

MAOS-A (aerosols)

ACSM
3- λ PSAP
3- λ Neph
3- λ f(RH)
3- λ PASS
7- λ Aethalometer
CPC (>10 nm)
CPC (>3 nm)
Dual column CCN
HTDMA
MET
SMPS
SP2
UHSAS

MAOS-C (chemistry)

PILS
PTRMS
Trace Gas:
- O_3
- CO
- NO, NO_2, NO_y
- SO_2

Ancillary Components

SODAR
Wind profiler

ARM
CLIMATE RESEARCH FACILITY
BROOKHAVEN
NATIONAL LABORATORY

New Operational Strategies Required for MAOS

- Some instruments are operator-intensive
  - PILS-IC-WSOC (requires wet chemistry)
- Some instruments generate huge data sets
  - PTR-ToF-MS (~10 MB/hr)
  - SP2 (GB/hr)

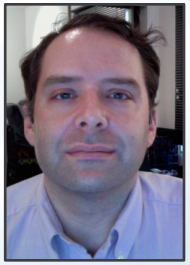
  Such high data rates challenge current ARM mechanisms for ingesting data.
- Some new, commercial instruments had shake-out problems

MAOS Preparation for GVAX

- MAOS contains 18 instruments, including research-grade instruments
  - require training of in-field operators
  - specialized training for the research-grade instruments
  - lack of remote (internet) access to MAOS containers

- Instrument mentors trained 7 operators (2-LANL/5-Indians)
  - Indians perform daily maintenance & operations tasks

  - LANL personnel oversee daily tasks on all instruments & systems, procure supplies, and provide maintenance



Los Alamos NATIONAL LABORATORY EST. 1943

BROOKHAVEN NATIONAL LABORATORY

MAOS Shake Out and Instrument Intercomparisons

System Shake Out

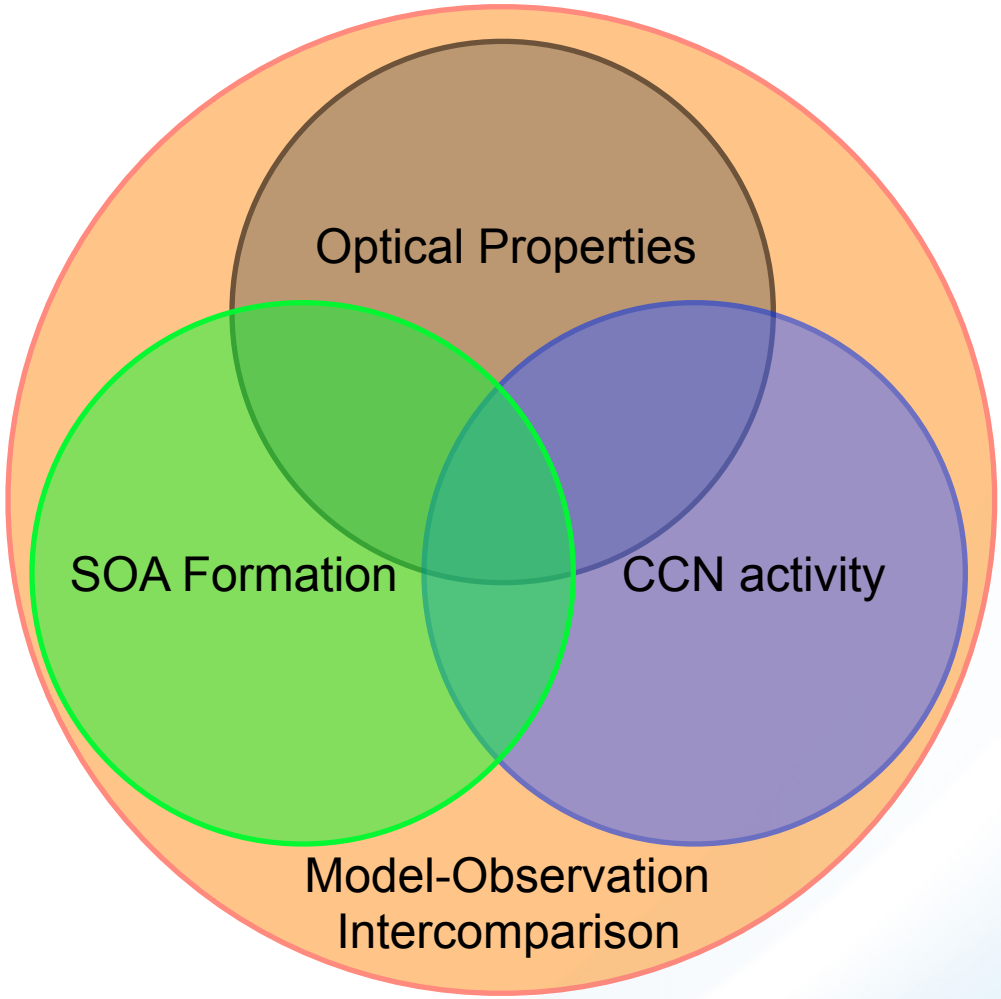
- electrical
- stack (aerosol and trace gas)
- computer control/acquisition
- communications
- logistics
- materials & supplies
- inlet

Instrument Intercomparisons (partial list)

- Nephelometer: (calculated versus observed scattering)
- CPC/SMPS/UHSAS: (number concentration, size distributions)
- PSAP/PASS-3: (absorption)
- PILS/HR-AMS/ACSM: (composition)
- HR-AMS/ACSM: (composition, and mass concentration)
- SP2/Aethalometer: (BC mass concentration)

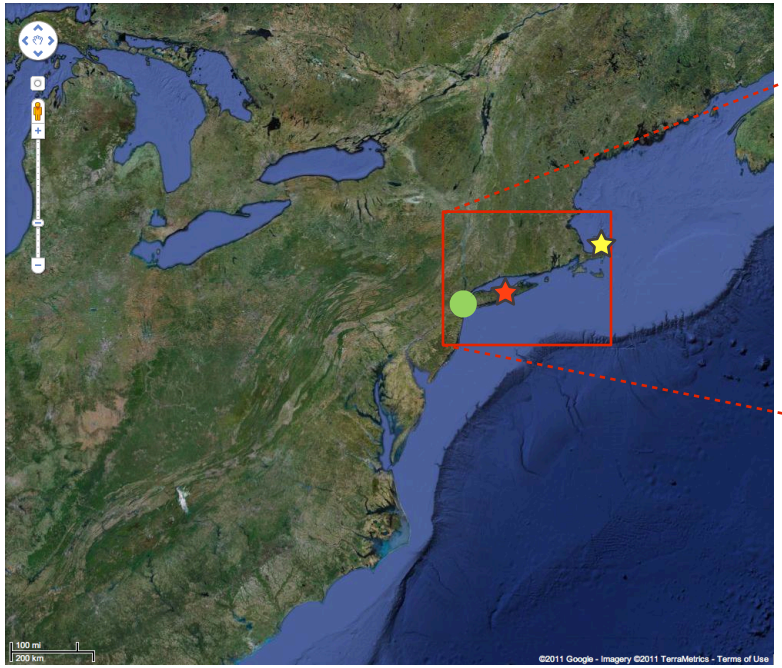
CCN+Size distribution+composition ⇒ closure

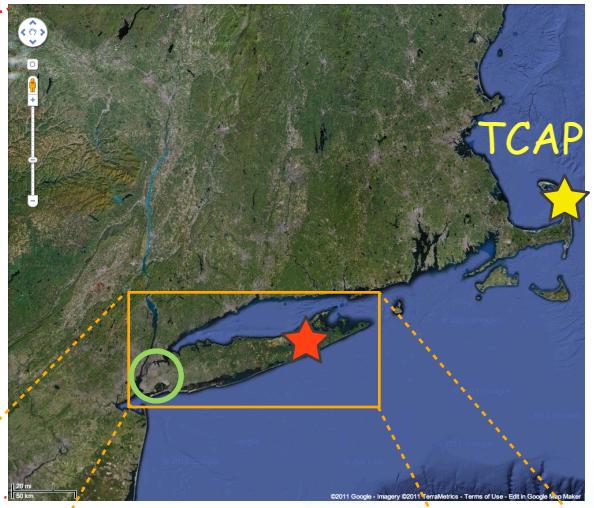
Scientific Foci of Aerosol Lifecycle IOP



Key objective: examination of aerosol properties and their dependences on atmospheric processing, chemical conditions, and source type.

IOP Site: Meteorology Field at Brookhaven



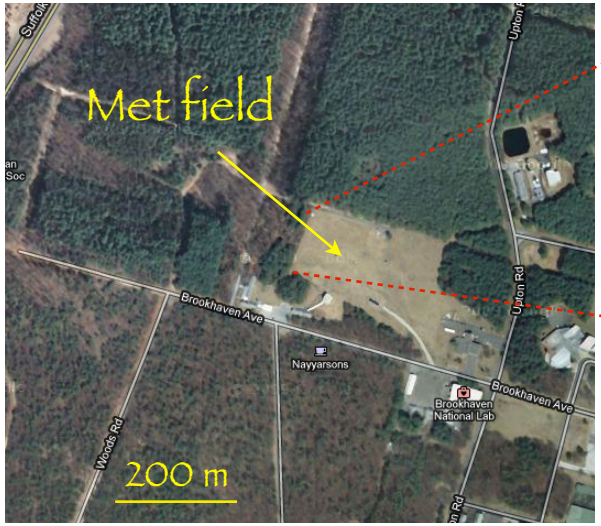


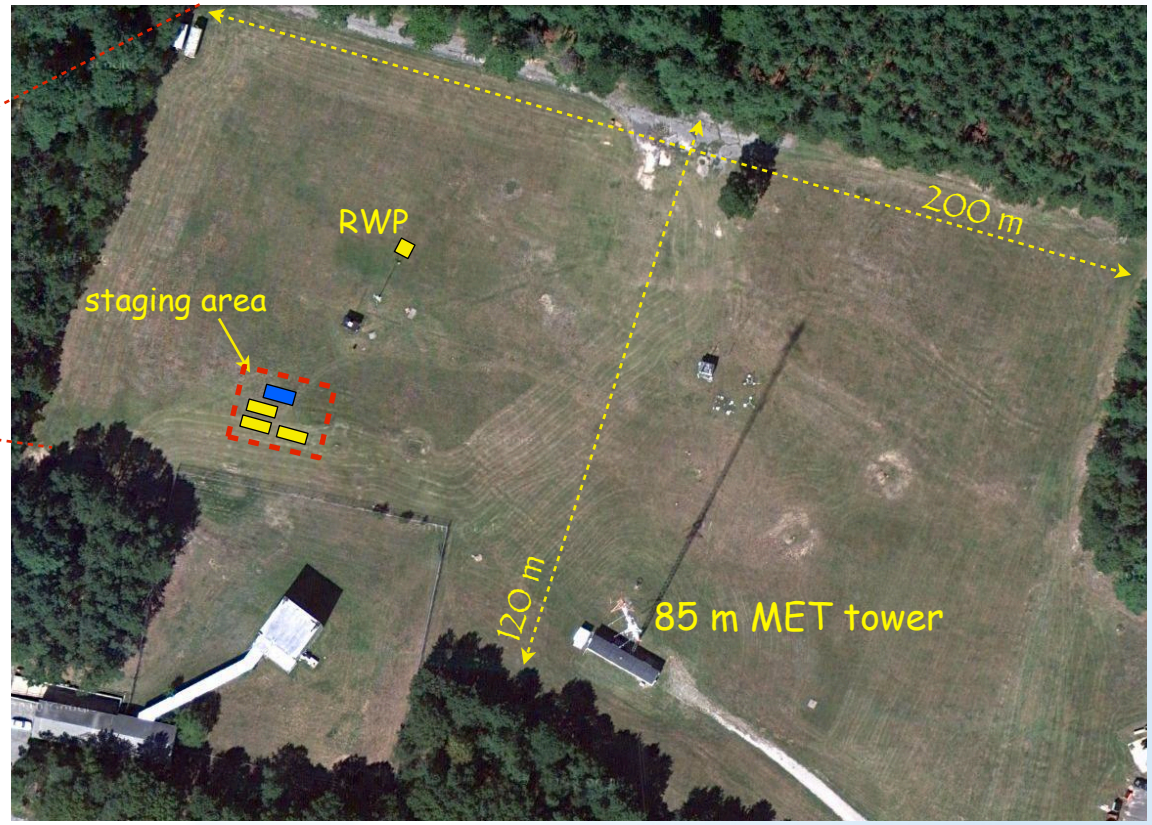
Several Aerosol Types Present

- Urban emission (W, SW)
- Biogenic emission (N, NW)
- Clean marine (S)
- Mixtures

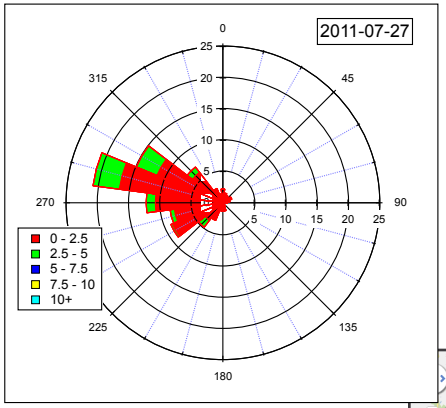
Earthquake & Hurricane too!

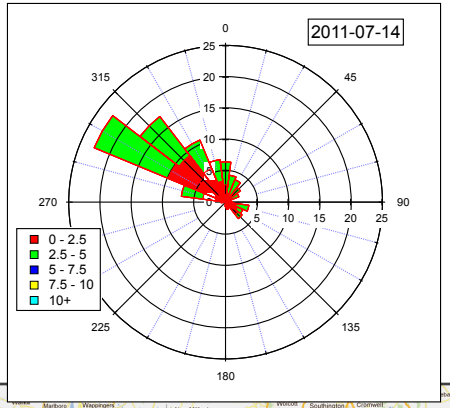
IOP Site: Meteorology Field at Brookhaven

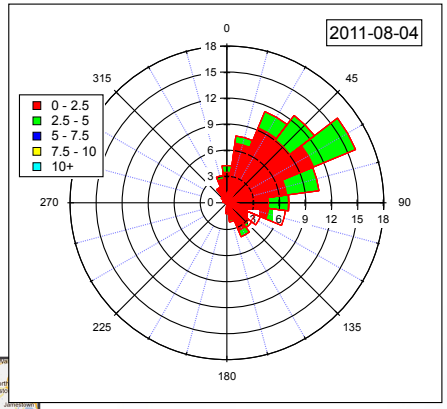


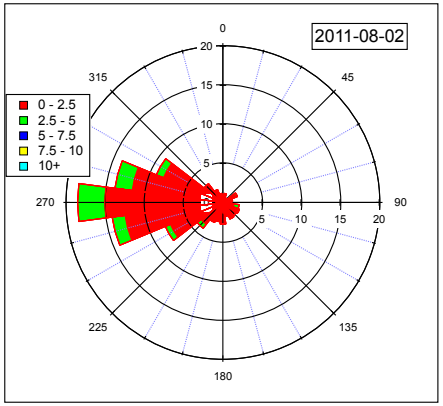


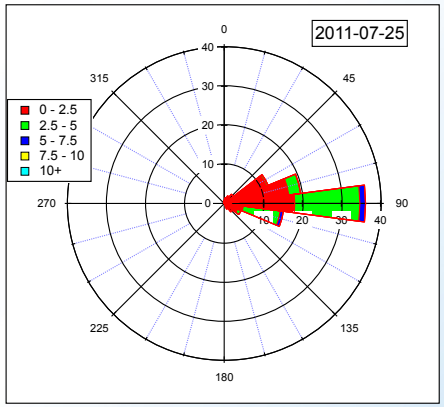
Wind Rose Plots: Synoptic Wind Patterns

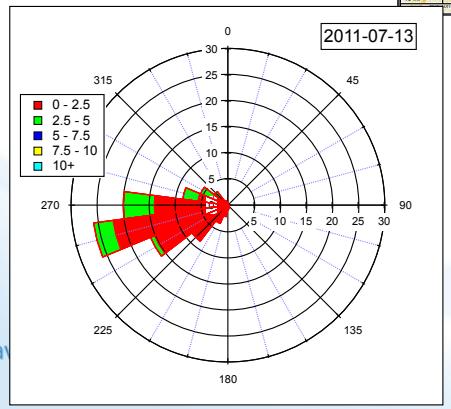


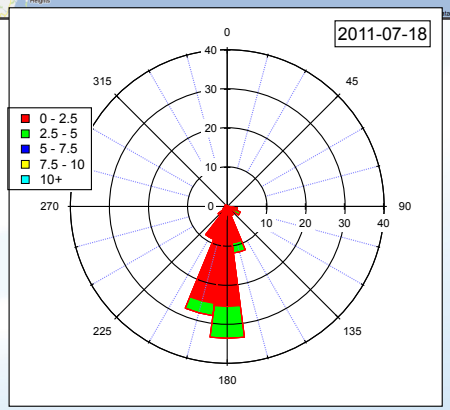


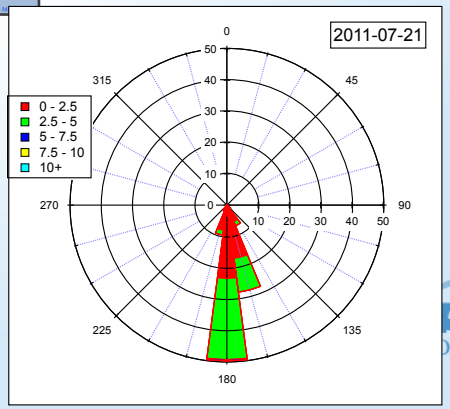






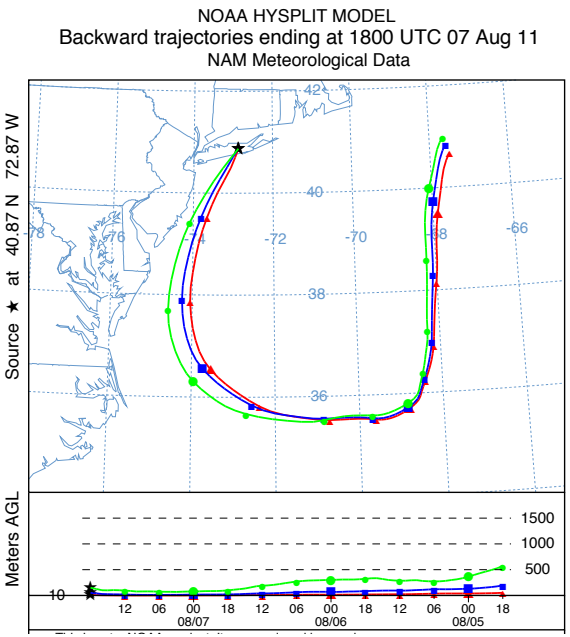




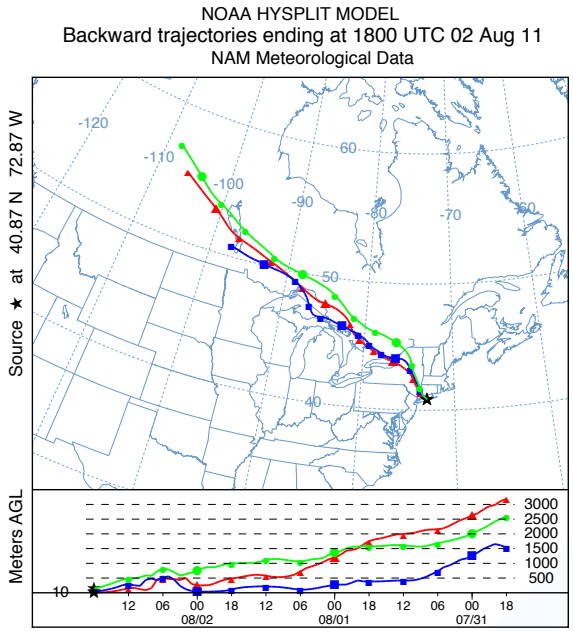


Additional Resources: HySplit Trajectories

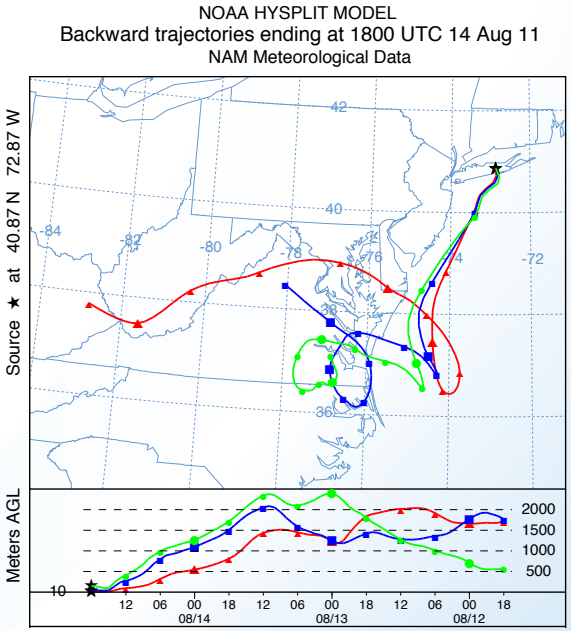
Variety of aerosol source regions



marine



urban

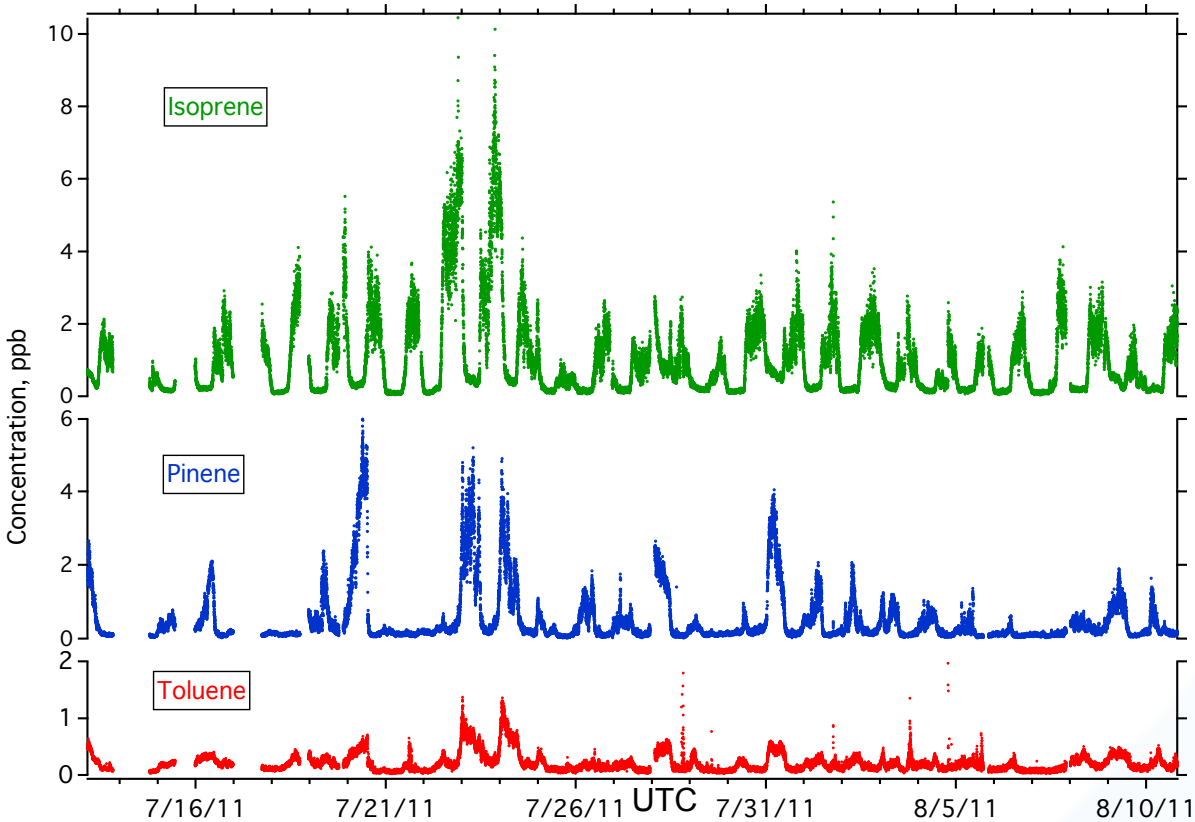


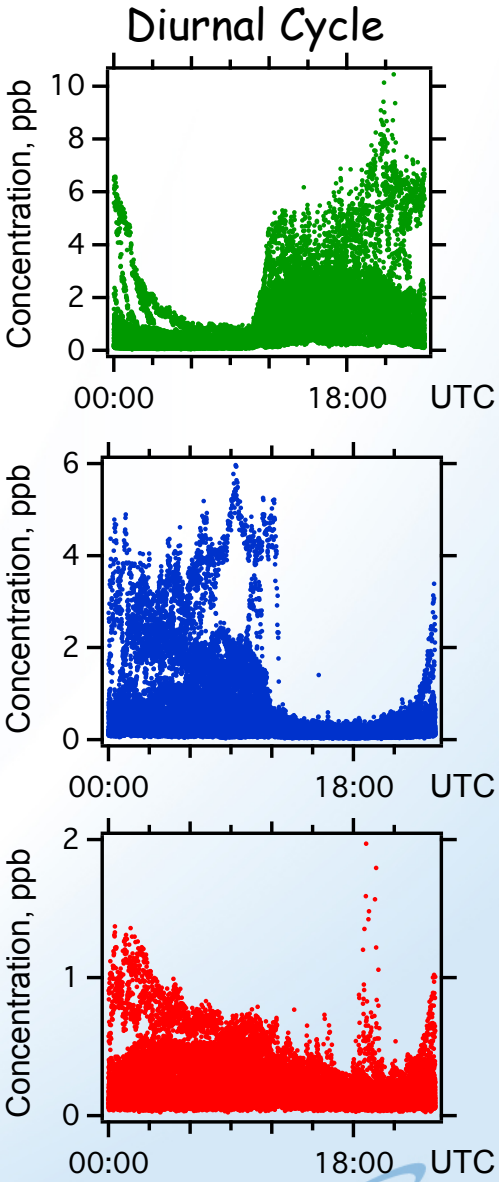
???

Danielle Weech (UIUC)

Proton Transfer Reaction Mass Spectrometer: PTRMS

Preliminary Data



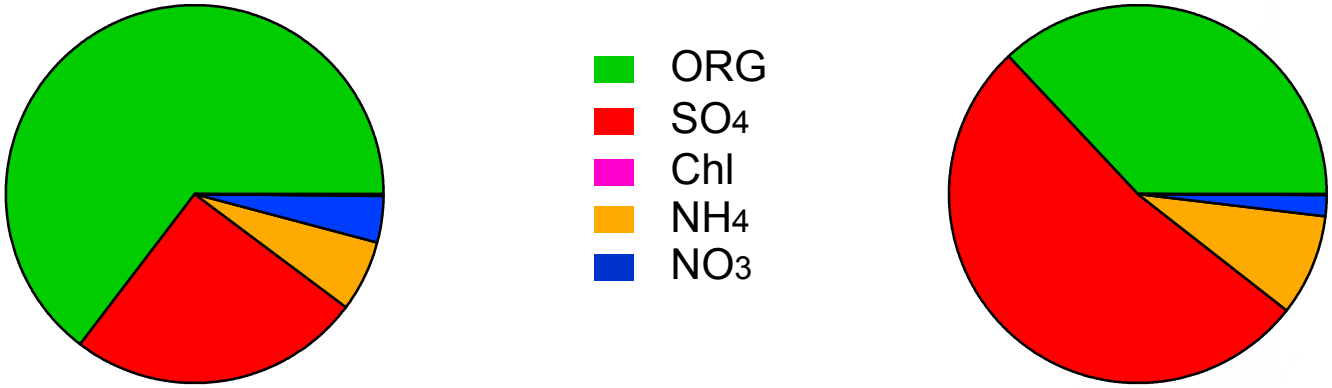


- VOCs primarily biogenic
- VOCs exhibited strong diurnal cycles
  - isoprene high during day
  - pinene high at night

Y.-N. Lee (BNL)

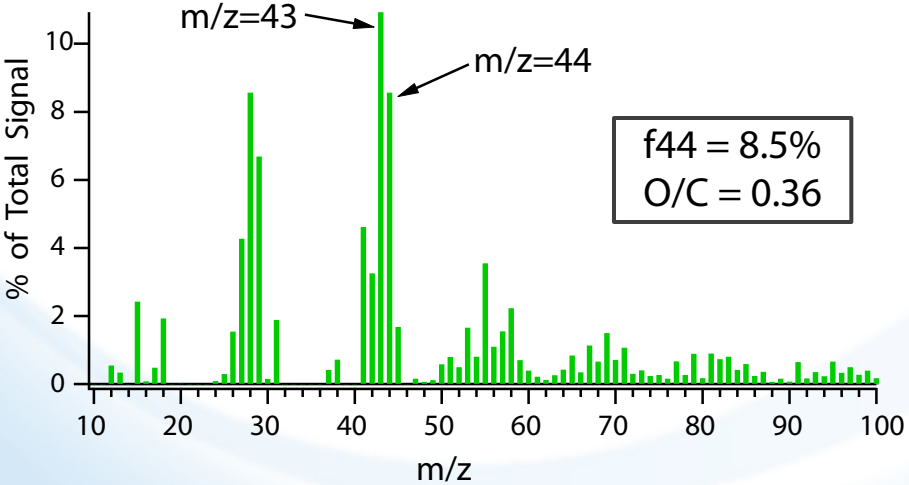
Average Mass Spectra During Two Time Periods

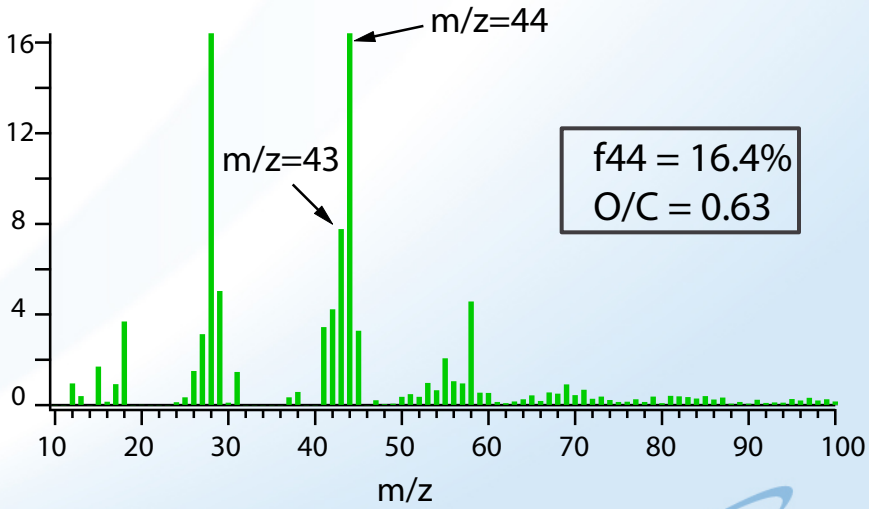
Higher m/z 44:43 ratio indicative of a more oxidized and less volatile component



High ORG period, less oxidized

High SO4 period, more oxidized



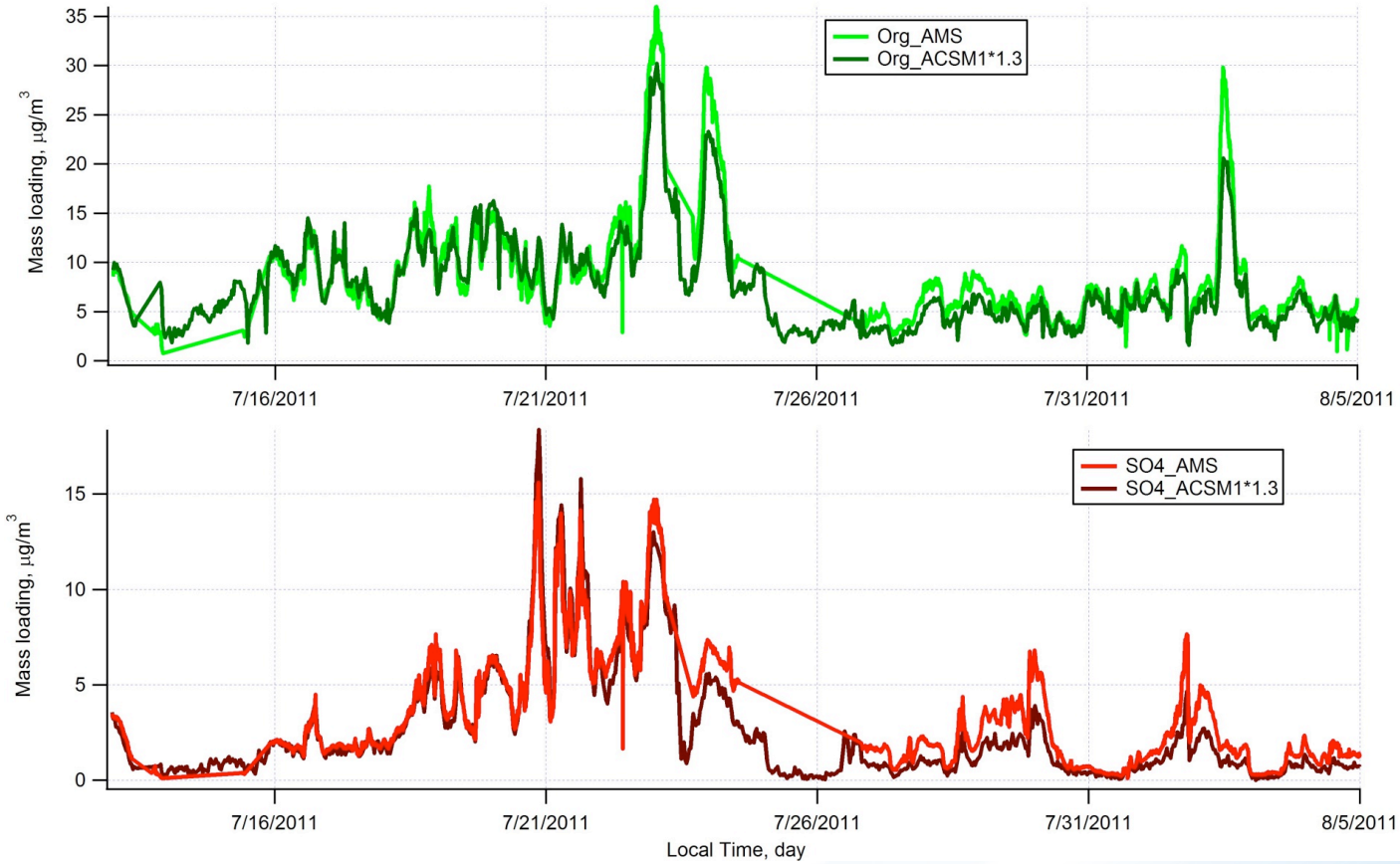


UCDAVIS UNIVERSITY OF CALIFORNIA

BROOKHAVEN NATIONAL LABORATORY

J. Xu & Q. Zhang (UC/Davis)

Intercomparison of HR-ToF-AMS & ACSM



- Good agreement for ORG and SO_4 mass loadings
- ACSM demonstrates good measurement quality

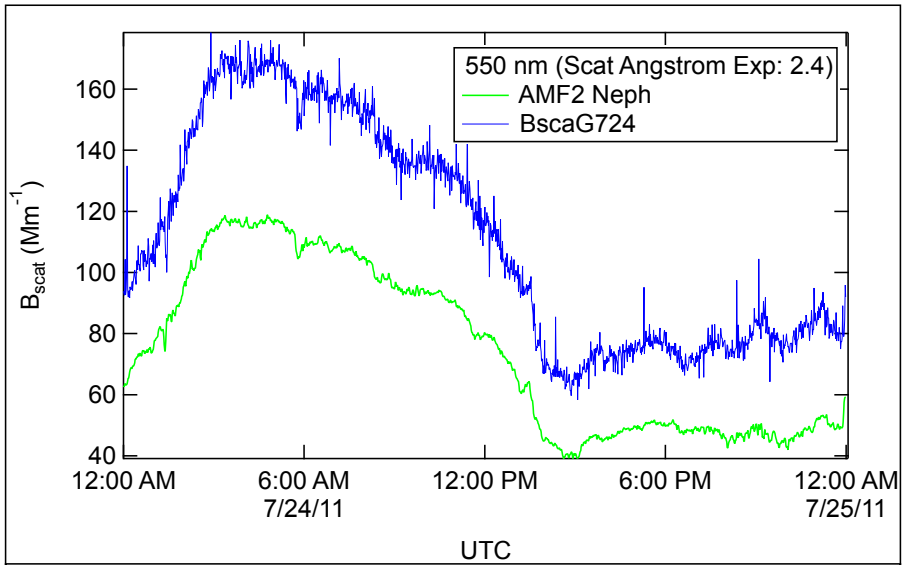
J. Xu & Q. Zhang (UC/Davis), F. Mei & Y.-N. Lee (BNL)

Intercomparisons of Optical Properties

PASS = Photoacoustic Absorption Spectrometer System

PSAP = Particle Soot Absorption Photometer

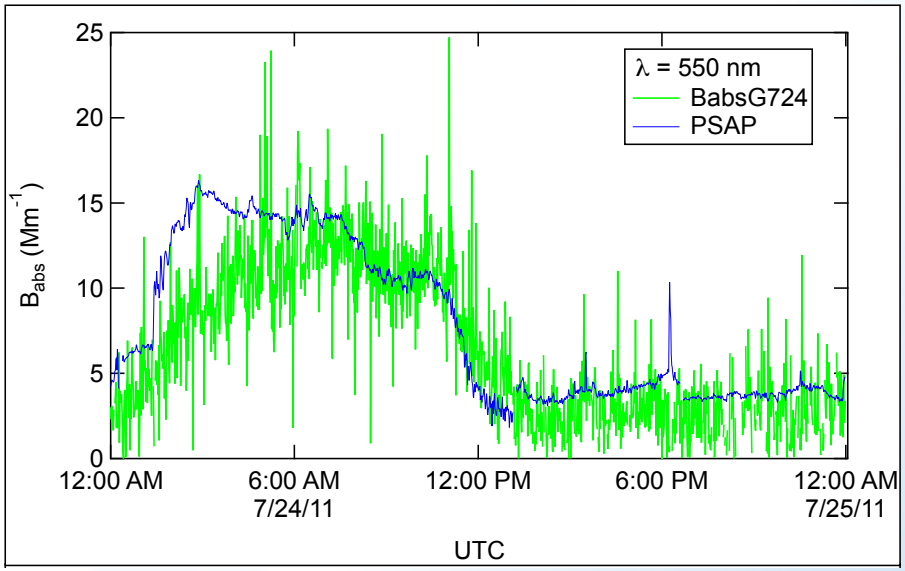
Nephelometer-PASS scattering



Similar trends, but factor 1.5-2 difference

- possible calibration issue (under investigation)

PSAP (filter)-PASS (in situ) absorption



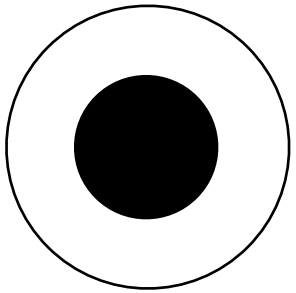
Similar trend and magnitude

- differences still present

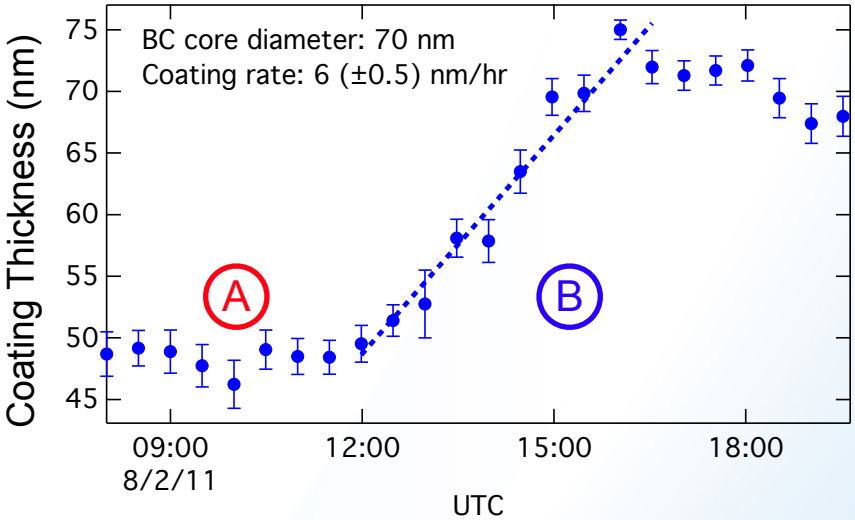
B. Flowers & M. Dubey (LANL), G. Senum & A. Sedlacek (BNL)

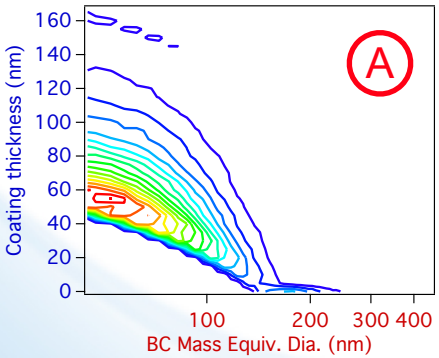
Evolution of BC Mixing State

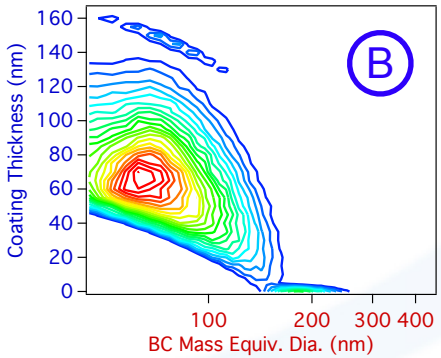
SP2 determines coating thickness and mass equivalent diameter

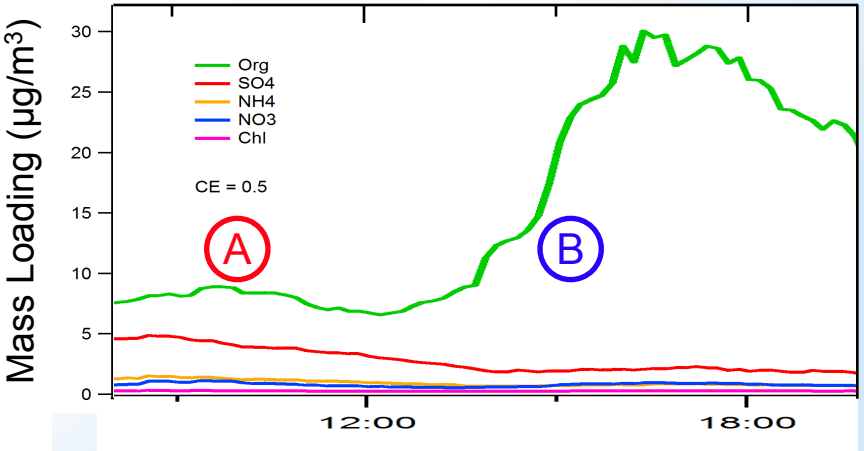


BC with coating







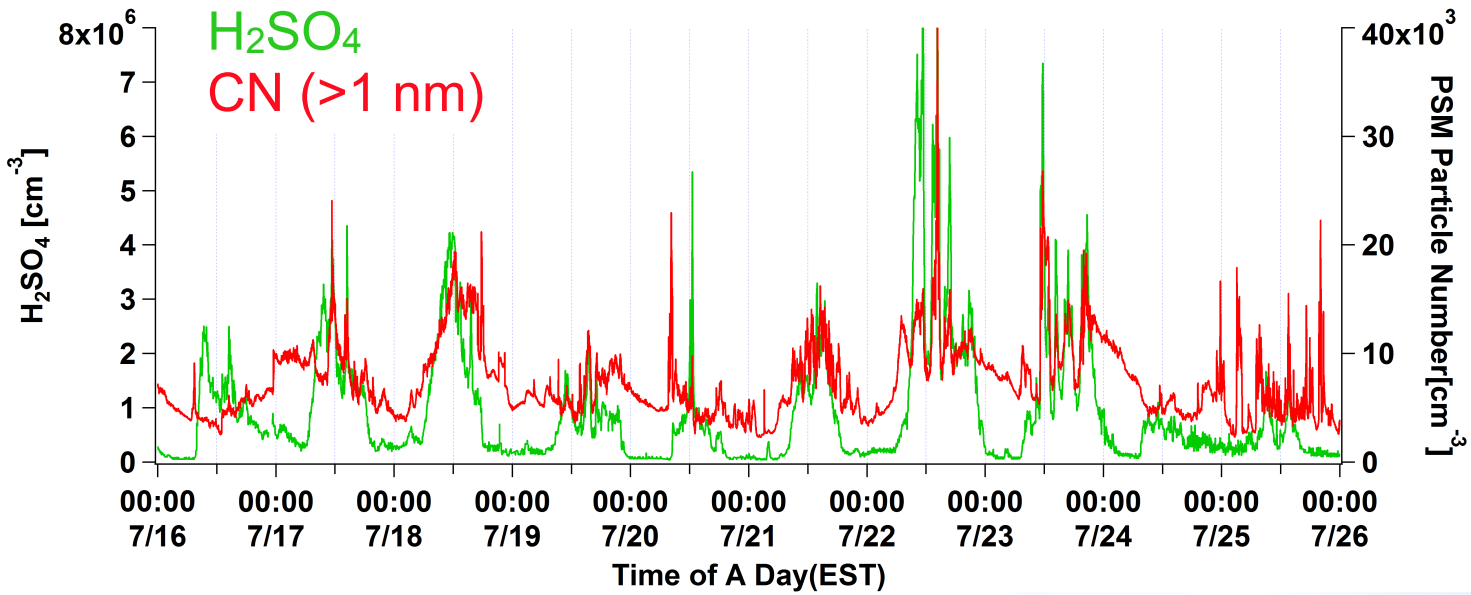


Sedlacek (BNL) & J. Xu & Q. Zhang (UC/Davis)

H_2SO_4 and CN (>1 nm) Diurnal Variation

H_2SO_4 measured by CIMS (Chemical Ionization Mass Spectrometer)

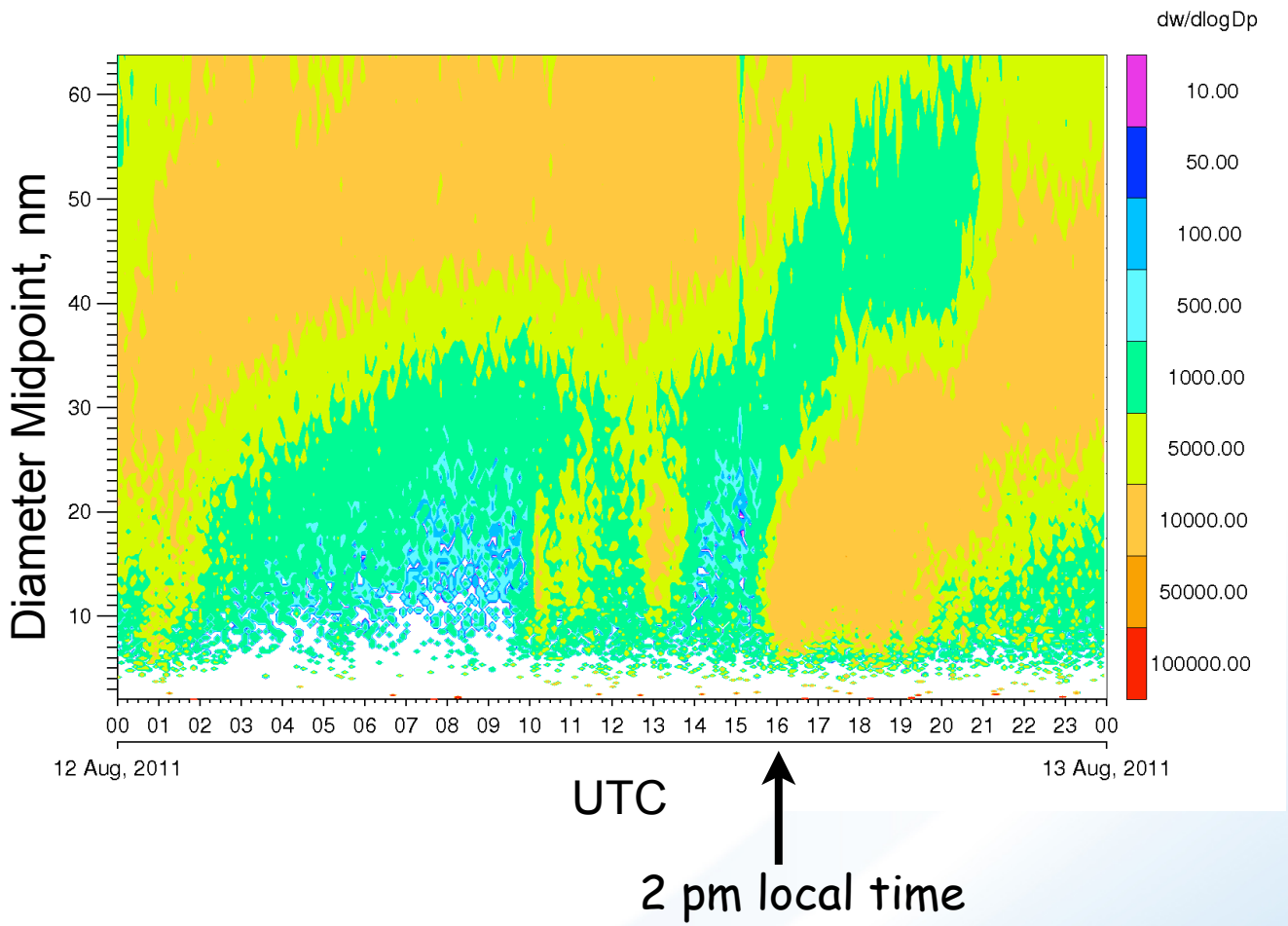
CN (> 1 nm) measured by PSM (Particle Sizing Magnifier)



- H_2SO_4 and CN (1-3 nm) are well correlated during day
  - Indicates H_2SO_4 is the main nucleation precursor
- Presence of CN (1-3 nm) at night in absence of H_2SO_4 suggests direct emissions
  - Possible sources: automobiles, unknown organic nucleation precursors – biogenic or marine

J. Yu, Y. You & S. Lee (Kent State)

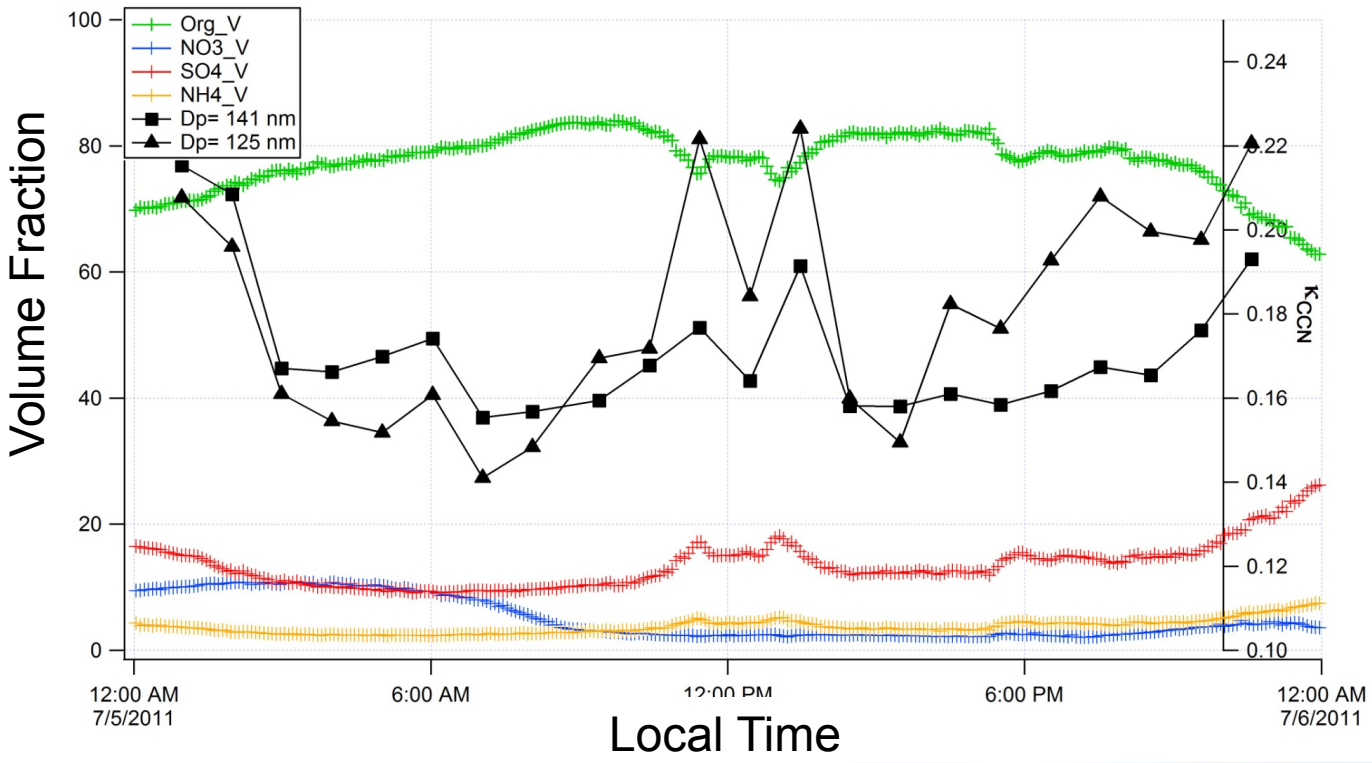
New Particle Formation Observed During IOP



- Local formation vs advection?

G. Hallar, G. Chirokova, & I. McCubbin (DRI)

Relationship Between Particle Hygroscopicity & Chemical Composition



- Hygroscopicity of particles strongly depends on the volume fraction of organic species, in agreement with previous studies (Wang et al., 2008)

F. Mei & J. Wang (BNL)

Conclusions

New MAOS platforms were tested and inter-compared.

The three objectives were realized:

- New operational strategies were developed
- Preparations were made for GVAX deployment
- Measurements were conducted
  - characterization of secondary organic aerosol formation
  - cloud-activation properties of aerosol particles
  - aerosol optical properties
  - model-observation intercomparison

These will provide a useful dataset for TCAP.