Aerosol Lifecycle IOP
June 15 - August 15, 2011

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A. Freedman (Aerodyne);
D. Cziczo (MIT)

ARM
CLIMATE RESEARCH FACILITY

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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-wavelength PSAP
3-wavelength Neph
3-wavelength f(RH)
3-wavelength PASS
7-wavelength 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

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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

- 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


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

Education

5 summer interns participated in ALC-IOP

- *Assist research scientists during IOP*
- Lecture series given by visiting scientists and BNL staff

Qi Zhang

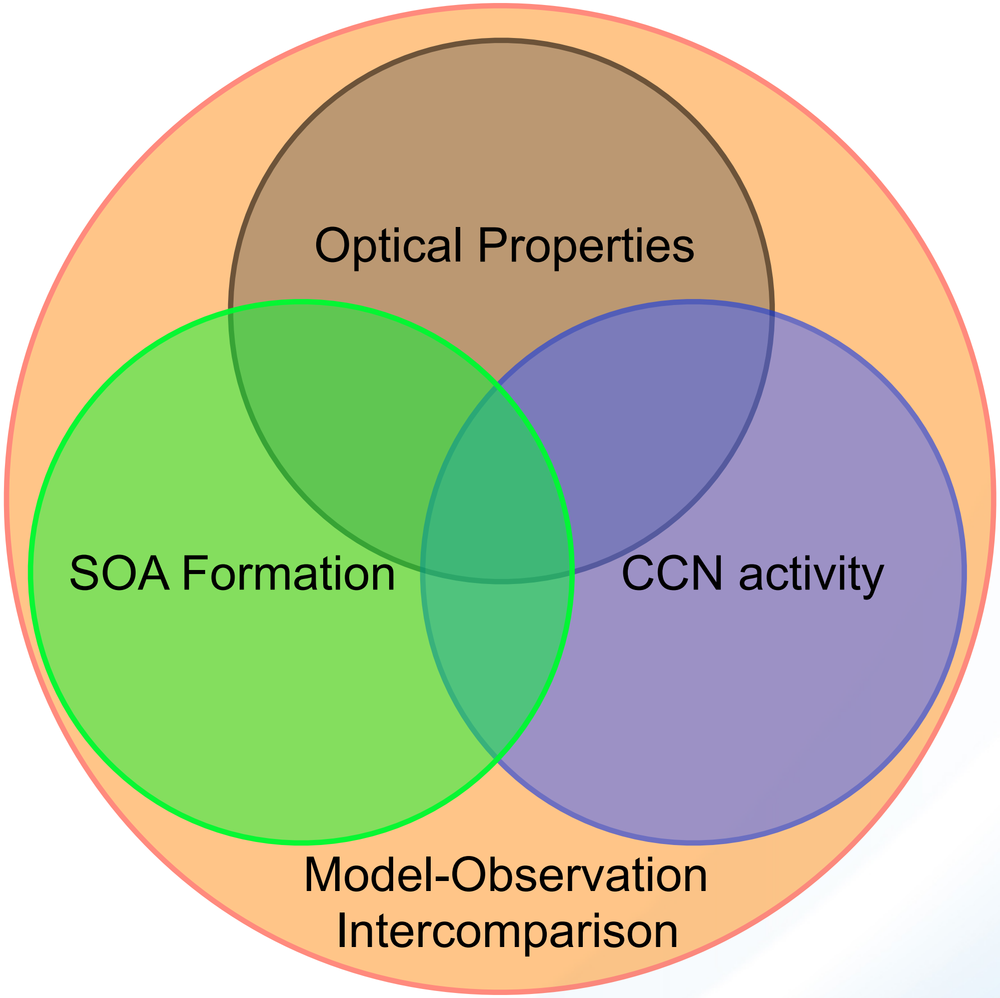
Gannet Hallar

Shanhu Lee

Steve Schwartz

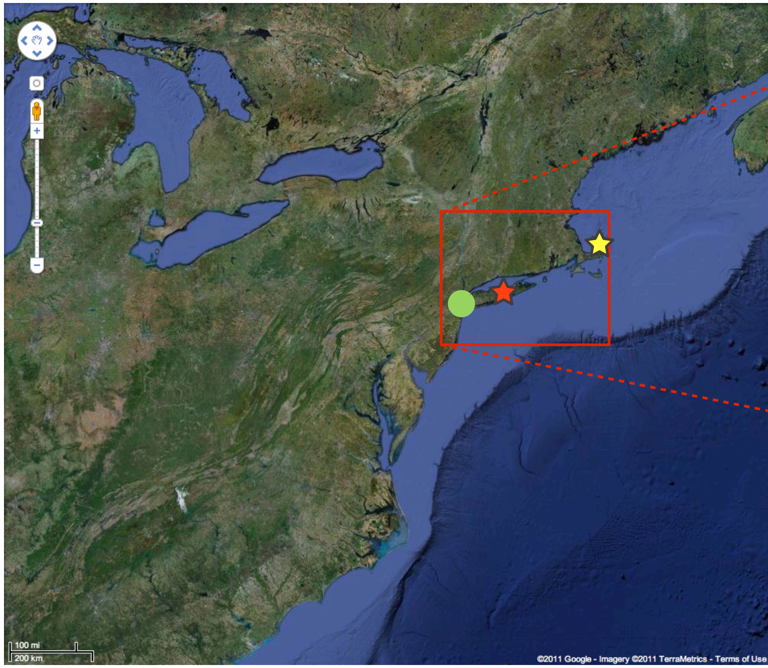
Seong-Soo Yum

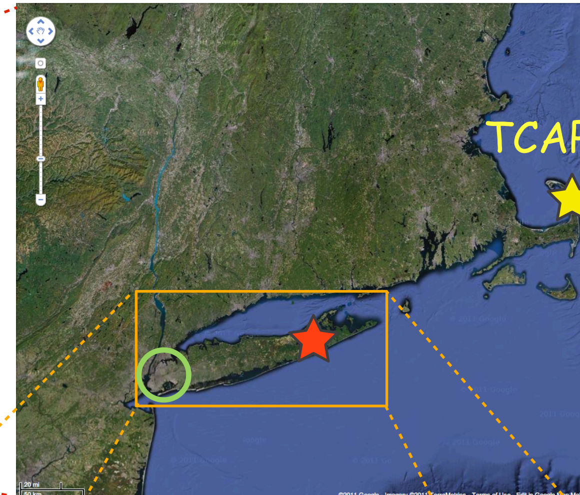
Scientific Foci of Aerosol Lifecycle IOP

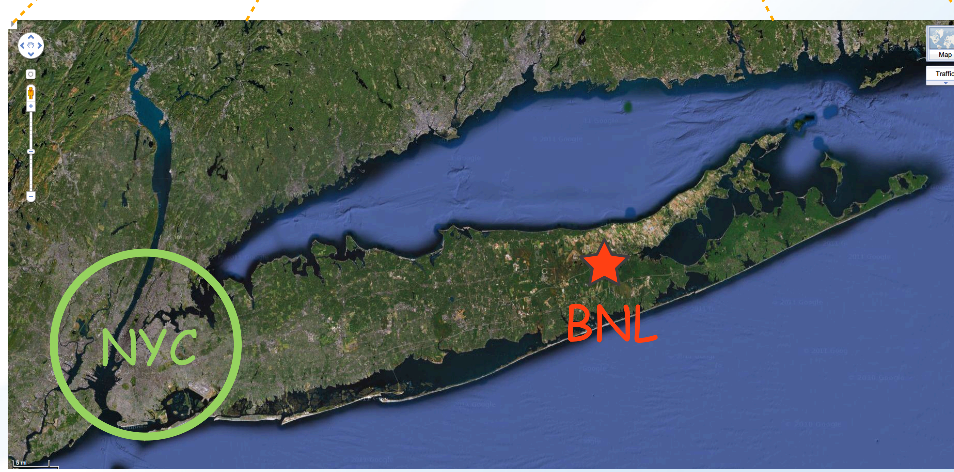


Key objective: examination of aerosol properties and their dependences on atmospheric processing, chemical conditions, and source type.

IOP Site: Meteorology Field at Brookhaven





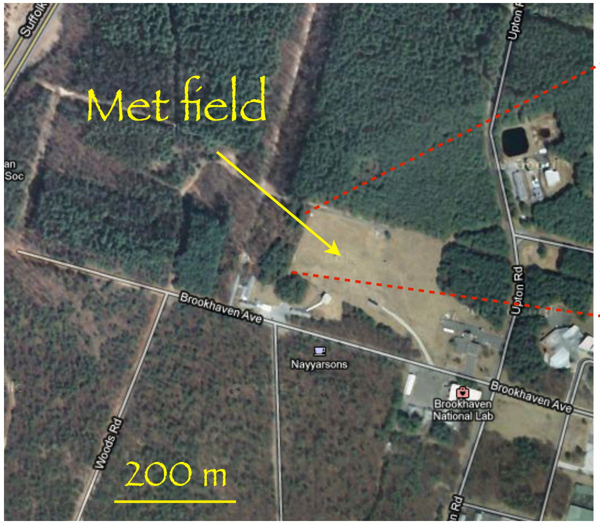


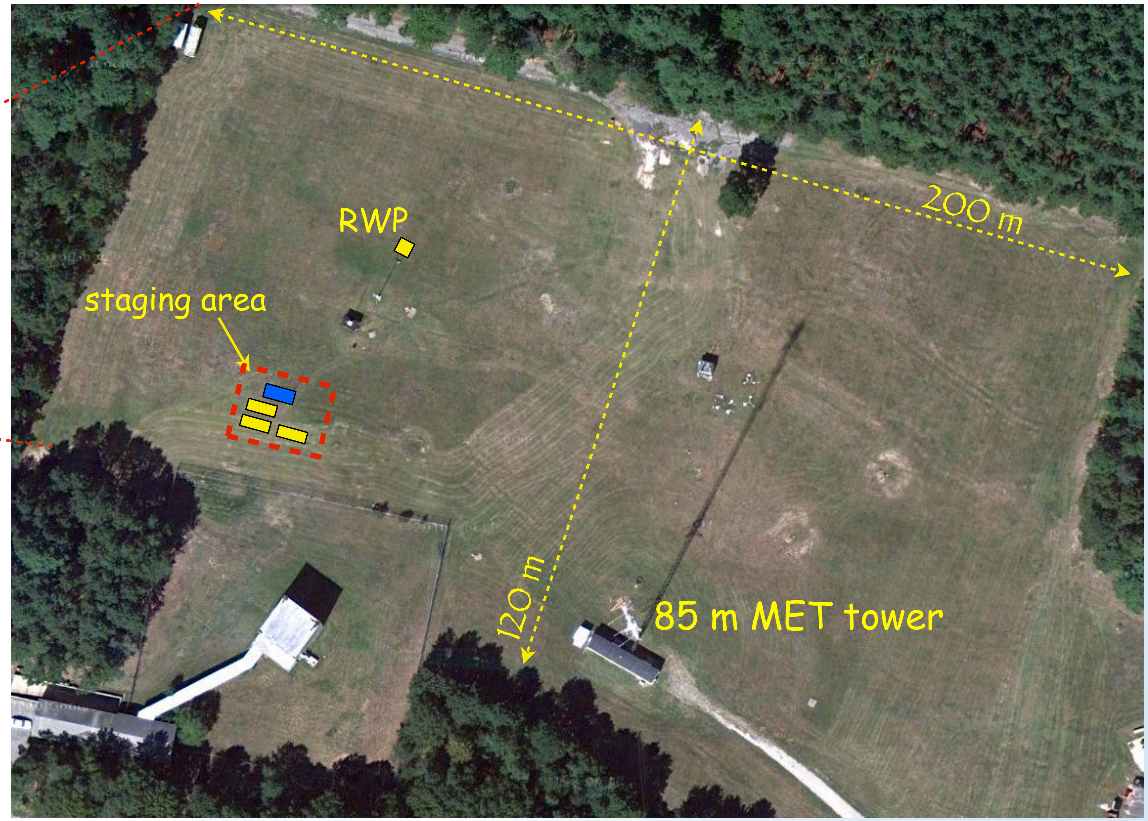
Several Aerosol Types Present

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

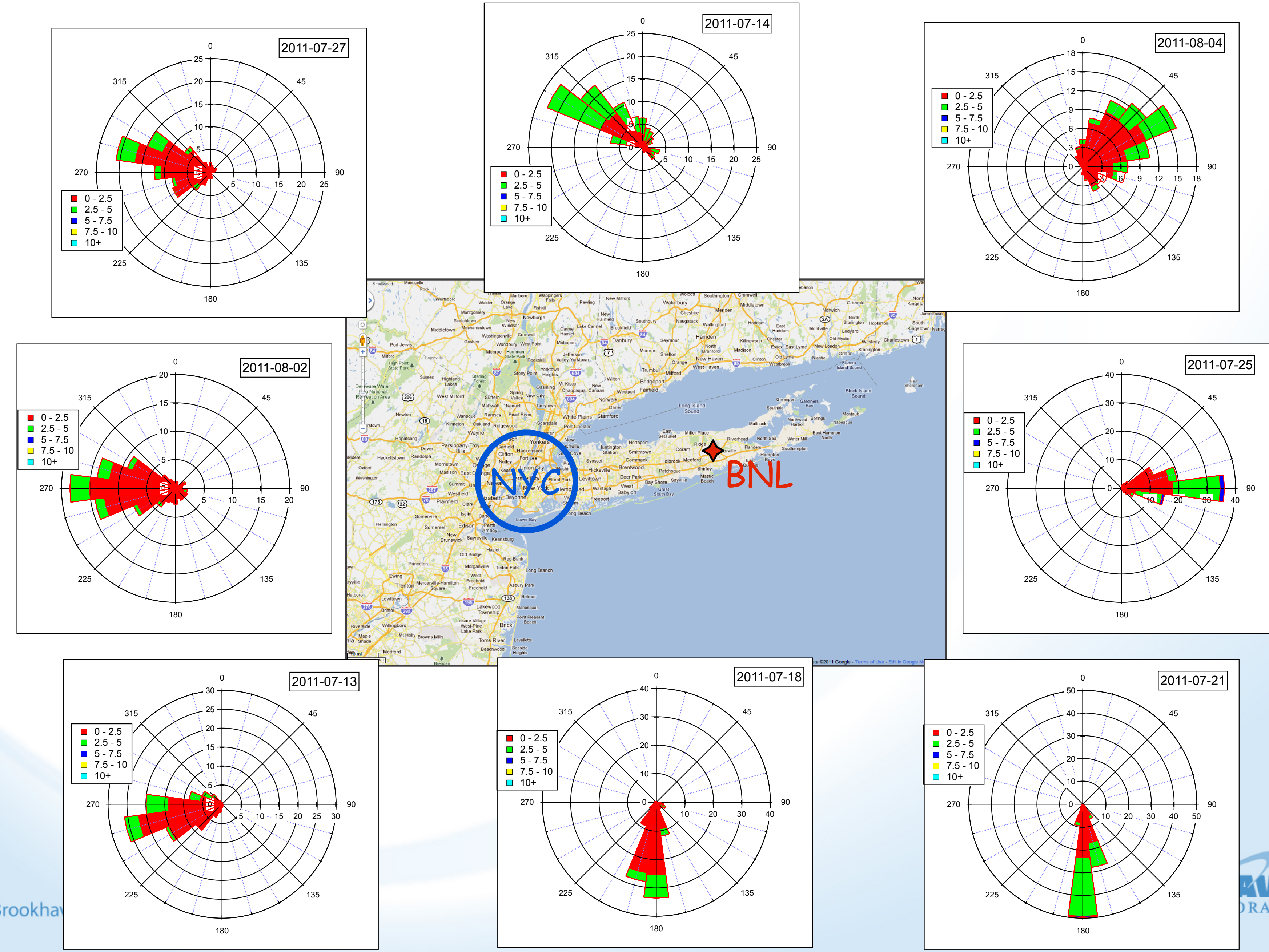
Earthquake & Hurricane too!

IOP Site: Meteorology Field at Brookhaven



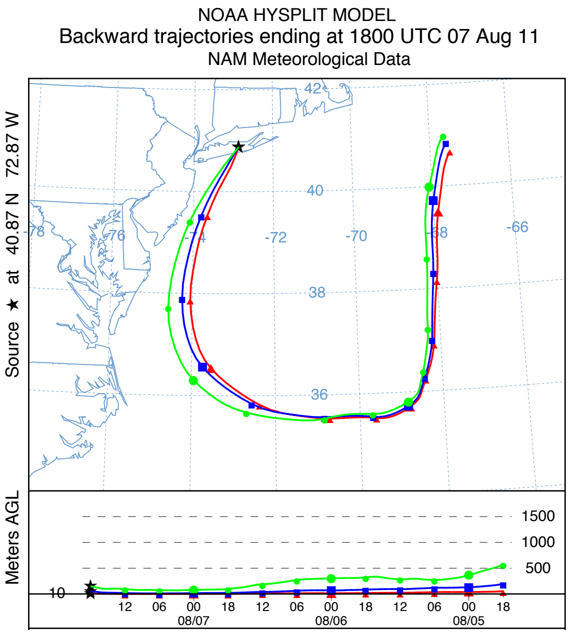


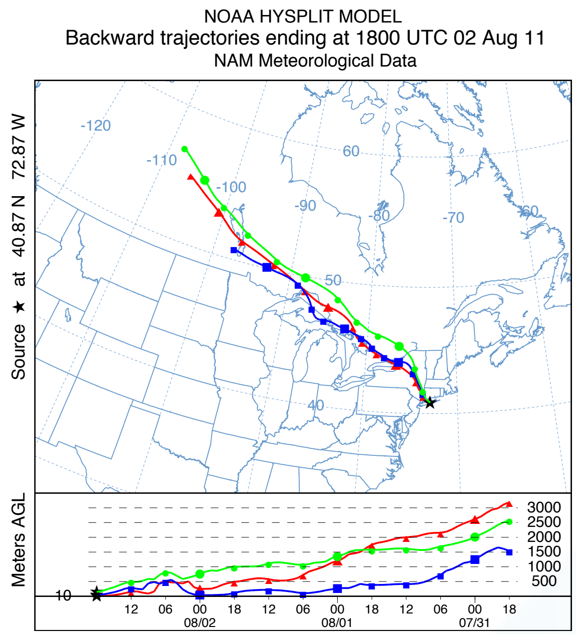
Wind Rose Plots: Synoptic Wind Patterns

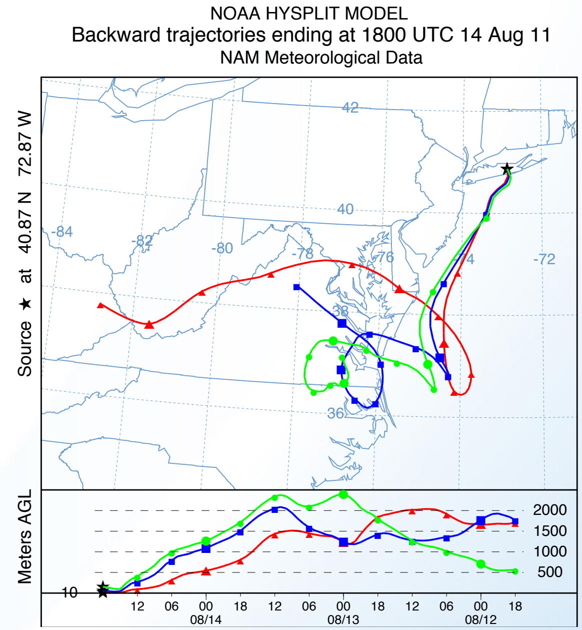


Additional Resources: HySplit Trajectories

Variety of aerosol source regions







marine

urban

???

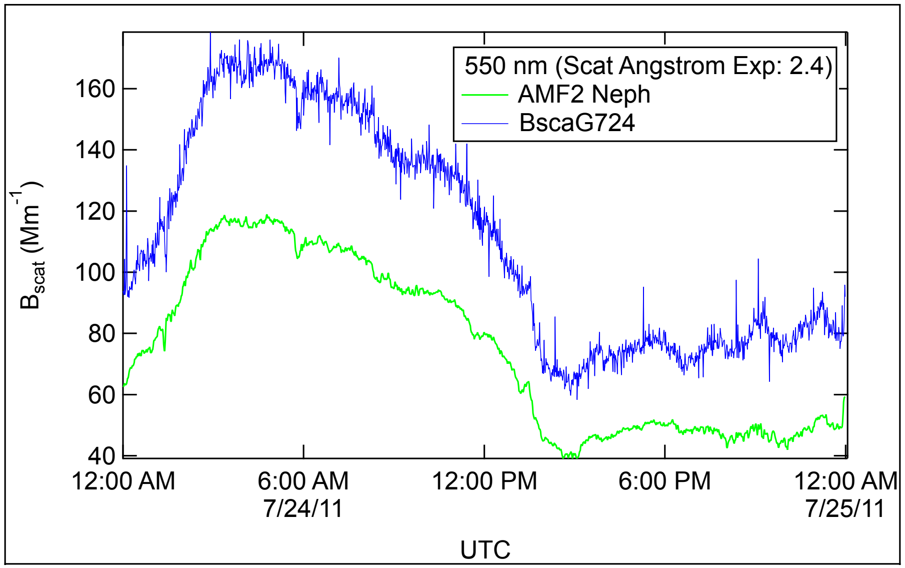
Danielle Weech (UIUC)

Intercomparisons of Optical Properties

PASS = Photoacoustic Absorption Spectrometer System

PSAP = Particle Soot Absorption Photometer

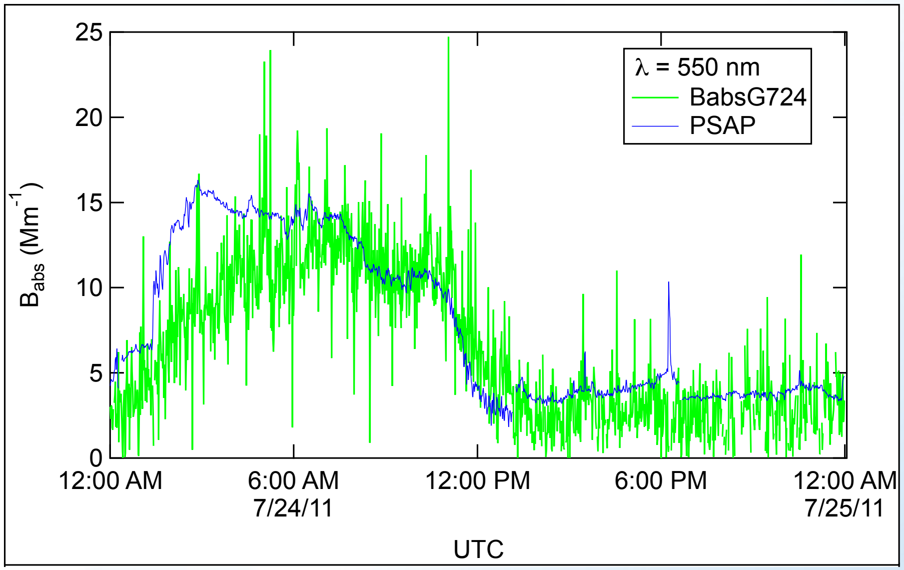
Nephelometer vs PASS scattering



Similar trends, but factor 1.5-2 difference

- possible calibration issue (under investigation)

PSAP (filter) vs PASS (in situ) absorption



Similar trend and magnitude

- differences still present

Los Alamos NATIONAL LABORATORY EST.1943

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

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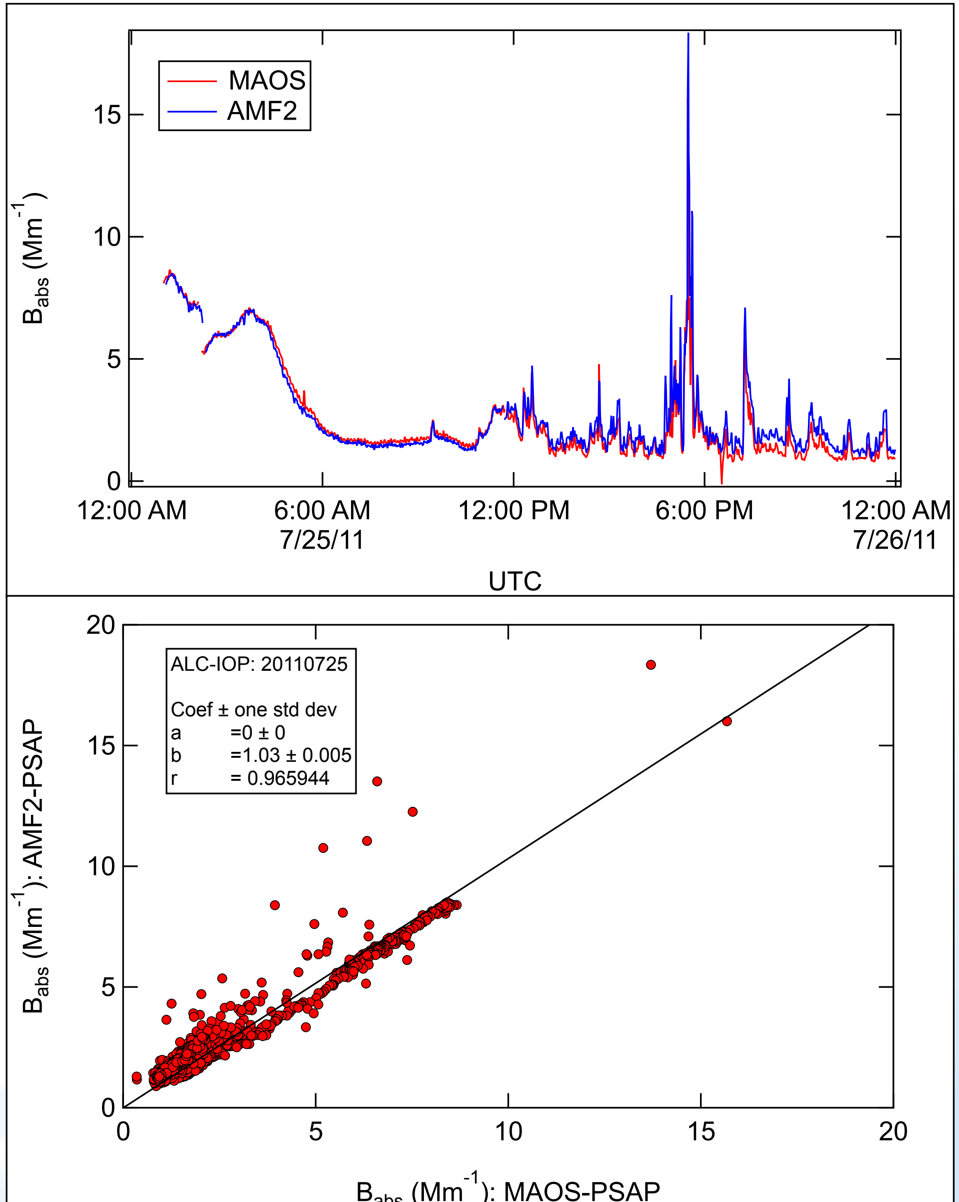
AMF2 PSAP and MAOS PSAP Comparison

Good agreement

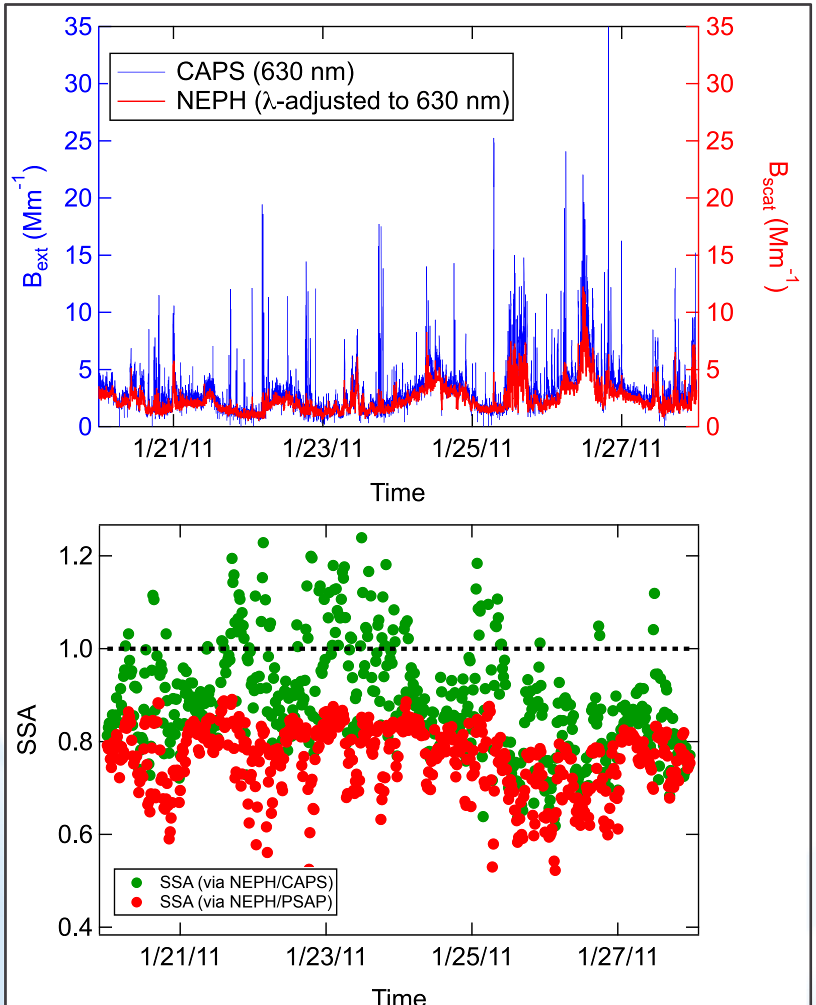


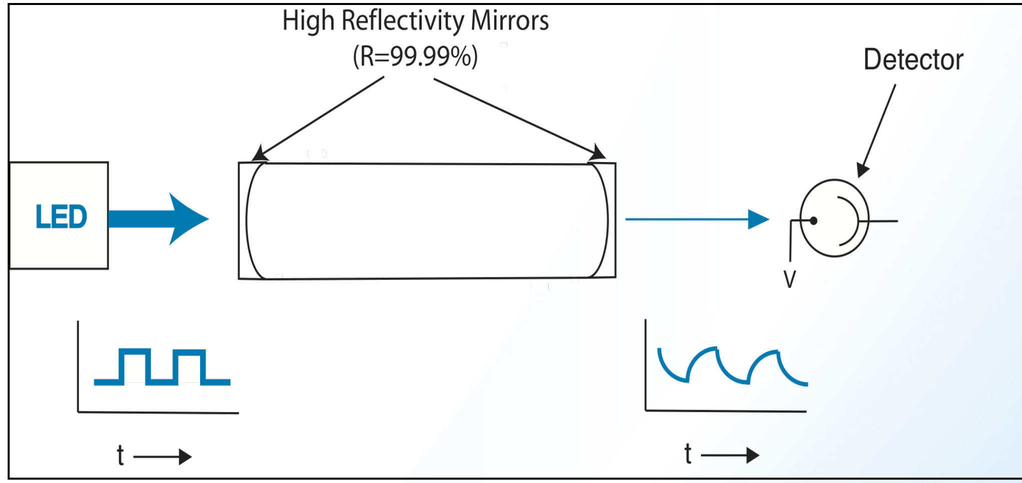
Aerosol Lifecycle IOP: Activities

STORMVEx

A. Freedman and P. Massoli (Aerodyne): Aerosol Extinction

CAPS PMex: Cavity Attenuated Phase Shift Particle Extinction Monitor





Massoli, et al., AST 44 (2010)

Measures the Phase Shift of the Modulated LED Light Source in the Cavity
Precise, Robust, Inexpensive
Simple Light Source = LED
High Reflectivity Optical Cell, Path length: ~2 km
Limit of Detection (LoD)= (3-sigma, 1s) < 2 Mm^{-1}

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Aerosol Lifecycle IOP: Previous Studies

Opportunity to conduct intensive aerosol observations in a region that offers biogenic, marine, and urban emissions.

- Urban emission predominately from the west and southwest
- Biogenic emission predominately from the north and northeast
- Clean marine atmosphere from the south
- Atmospheric transport time of hours to days
- Absent strong synoptic forcing, a sea breeze develops in the afternoon
- Haze events (pollution alerts) can be expected
- Good chance of catching an intense but distant biomass burning event

Examples of previous northeast corridor studies:

- 2004: New England Air Quality Study (NEAQS)
- 1998-2002: Northeast Oxidant and Particle Study (NE-OPS)
- 2000: North American Research Strategy for Tropospheric Ozone (NARSTO)
- 1999/2000: Maryland Aerosol Research and CHaracterization (MARCH-Atlantic)
- 1998: Tropospheric Aerosol Radiative Forcing Observational Experiment (TARFOX)

Aerosol Lifecycle IOP: NYC-based Studies

Queens College:

$PM_{2.5}$ Technology Assessment and Characterization Study- NY (PMTACS-NY)

- Queens college
- three deployments (summer 2001, winter 2004 & summer 2009)

Instrument Suite:

HR-ToF-AMS and Q-AMS
1-λ Photoacoustic spectrometer (B_{abs})
TSI fast mobility particle sizer
CCN
Aerodyne QCL (formaldehyde & NO_2)
Li-COR CO_2 analyzer
BTEX analyzer for benzene, toluene, ethylbenzene and zylenes
2B technologies analyzers for O_3, NO and NO_2

South Bronx:

Multi-year hourly measurements of EC and OC

- Ambient air monitoring site at NYC intermediate school (IS-52)

Instrument Suite:

Semi-continuous OCEC carbon analyzer (Sunset Labs) - hourly
880 nm Aethalometer for light abs. carbon (LAC) measurement (5-min resolution averaged hourly)
Thermo Scientific 5020C aerosol sulfate

Aerosol Lifecycle IOP: Previous Studies

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Aerosol Lifecycle IOP: Previous Studies

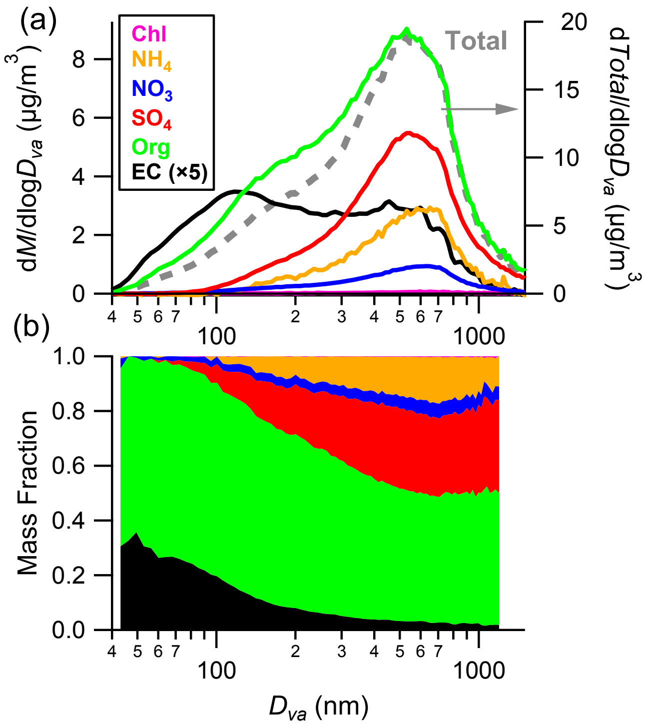
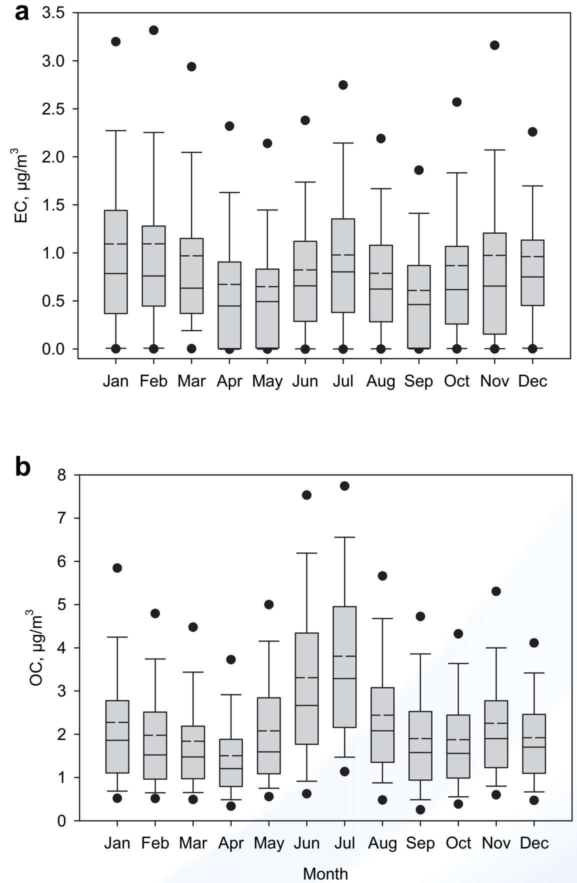
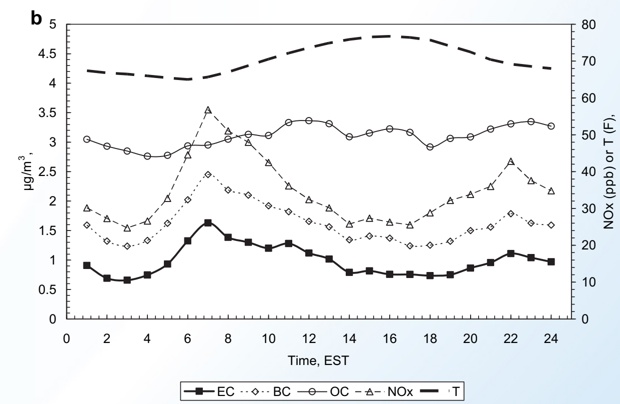


Fig. 6. Average size distributions of **(a)** mass concentrations and **(b)** fractional compositions of submicron aerosol species for the entire study. The size distribution of EC was estimated based on that of m/z 57 after removing the contribution of $C_3H_5O^+$.

Sun et al., Atmos. Chem. Phys. 2011



Rattigan et al., Atmos. Env. 2010



Aerosol Lifecycle IOP: NYC connection

Characterization of Secondary Organic Aerosol Formation (Lee)

- How good are the agreements between different SOA proxies: Δorg (over POA), OOA (PMF), and WSOC (PILS)?
- Does SOA formation rate depend on emission source types (anthropogenic vs natural)?
- Are there synergistic effects in SOA formation due to fast reacting biogenic organics?
- Is it possible to link SOA formation to cloud processing?
- Is it possible to identify oxygenated compounds (e.g., SVOC from HR-PTR-MS) that are responsible for SOA formation?

Cloud-Activation Properties of Aerosol Particles (Wang)

- What are the influences of size distribution, chemical composition, and mixing state on aerosol CCN spectrum?
- What are the CCN properties of organic species as functions of O:C ratios and photochemical age?
- Derive particle hygroscopicity (κ) from size-resolved measurements of CCN activation spectra.
- Derive/constrain the hygroscopicities of major organic classes (e.g. HOA, OOA, etc) by combining size-resolved CCN and composition measurements.

Aerosol Light Absorption (Sedlacek)

- How does the aerosol mass absorption coefficient (absorption per unit mass of Black Carbon) vary with black carbon (BC) mixing state?
- How well do observations agree with the shell-core model when BC coating thickness estimates incorporate UHSAS, CPC, SP2, and AMS data?
- What is the relation between mixing state (age) & CCN activity? Measurement will utilize NO_x - NO_y as a proxy for age.
- What degree of morphological changes in BC take place as a function of air mass (marine, rural and urban)?

Model-Observation Intercomparison (Schwartz)

- Examine how well models can reproduce the observed optical properties when using the measured size dependent chemical composition as input.
- How does do the model predictions of optical properties - scat; abs; f(RH) - and CCN properties - number vs supersaturation - compare with observations?
- This will involve developing a modeled representation of the observed chemical and microphysical properties that can be used as input to the various models that will evaluated.
- Potential candidate models that will be examined include WRF-Chem, box model for MOSAIC and CAM5 (evaluate individual modules).
- Working with Vivana Vladutescu (CUNY).

Conclusions

New MAOS platforms were tested and inter-compared

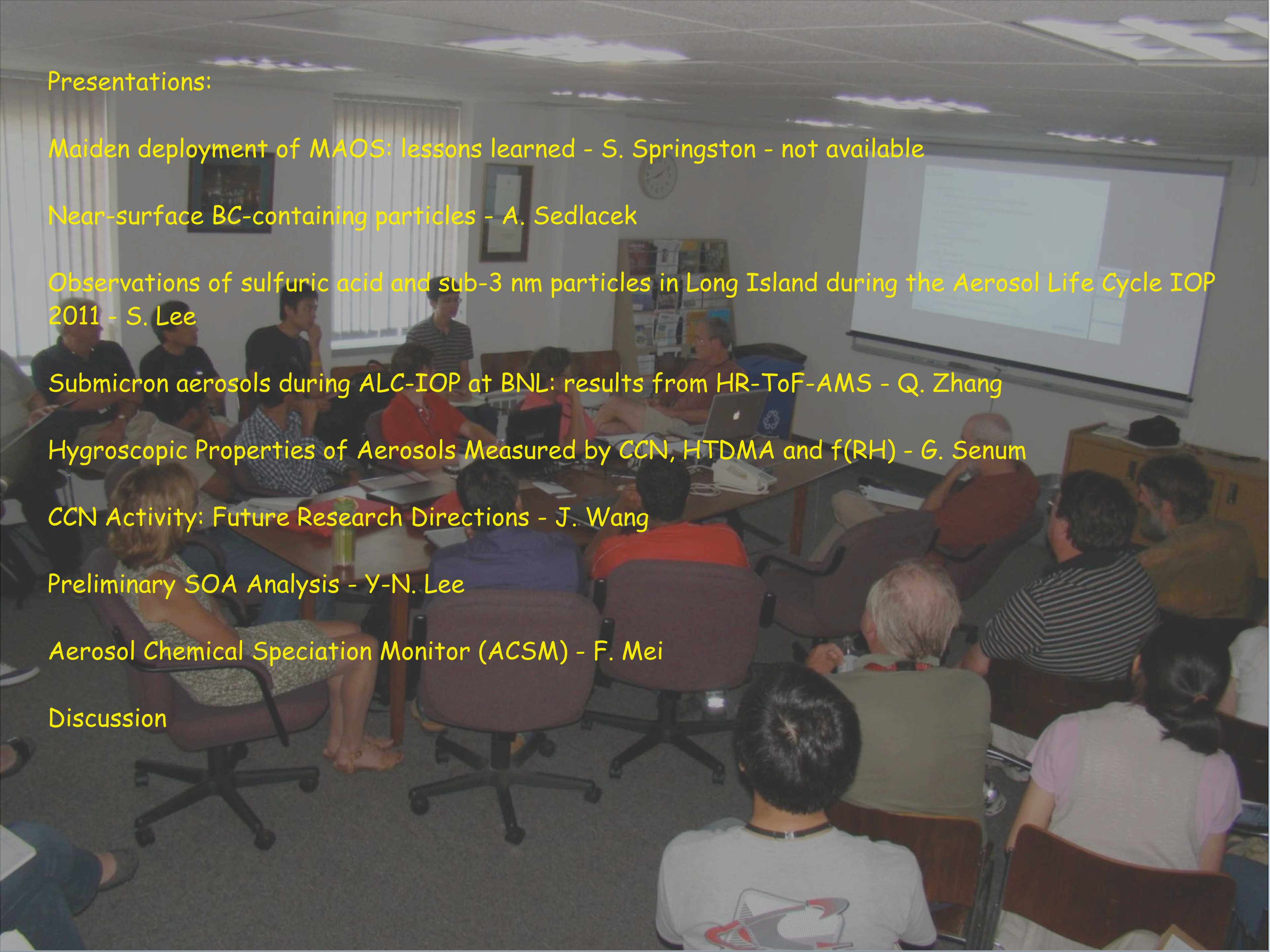
The three objectives were realized:

- 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

Publications

- ALC-IOP has already resulted in one publication
- Second manuscript under preparation (overview article for BAMS)
- Rich dataset should result in additional publications

IOP campaign will provide a useful dataset for TCAP



Presentations:

Maiden deployment of MAOS: lessons learned - S. Springston - not available

Near-surface BC-containing particles - A. Sedlacek

Observations of sulfuric acid and sub-3 nm particles in Long Island during the Aerosol Life Cycle IOP 2011 - S. Lee

Submicron aerosols during ALC-IOP at BNL: results from HR-ToF-AMS - Q. Zhang

Hygroscopic Properties of Aerosols Measured by CCN, HTDMA and f(RH) - G. Senum

CCN Activity: Future Research Directions - J. Wang

Preliminary SOA Analysis - Y-N. Lee

Aerosol Chemical Speciation Monitor (ACSM) - F. Mei

Discussion