Aerosol Lifecycle IOP at BNL

A. J. Sedlacek, L. Kleinmen, E. Lewis, Y. -N. Lee,
G. Senum, S. R. Springston, J. Wang

March 29, 2011

ASR
Atmospheric System Research

BROOKHAVEN NATIONAL LABORATORY
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Office of Science
U.S. DEPARTMENT OF ENERGY

Aerosol Lifecycle IOP: Motivation

FY09/FY10 ARRA-sponsored procurement of three new Aerosol Observing Systems (AOS) significantly increased DOE's aerosol science capabilities

Two Flavors: 'core' AOS and MAOS (See Springston Poster)

These new platforms need to be tested and, where possible, inter-compared

Proposal was put forth to DOE for an IOP that had three objectives:

- Develop new measurement strategies that reflect the addition to ACRF of 'research grade' instruments (MAOS)
- Maiden foreign deployment of MAOS will be GVAX, requiring the training of in-field technicians.
- Long Island offers a unique region for intensive aerosol observations

Aerosol Lifecycle IOP: Infrastructure Motivation

- Research grade instruments require new measurement strategies ("Think of the MAOS as the G-1 on the ground." Springston, 2009)
  - Subset of MAOS instruments are operator-intensive (PILS-IC-WSOC & PTR-ToF-MS)
  - Some instruments generate huge data sets (PTR-ToF-MS & SP2)
- Instrument Intercomparisons
  - Nephelometer: (Calculated versus observed scattering)
  - CPC/SMPS/UHSAS: (number conc., size distributions)
  - PSAP/PASS-3: (absorption intercomparison)
  - PILS/HR-AMS/ACSM: (composition)
  - HR-AMS/ACSM: (intercomparison)
  - SP2/Aethalometer: (BC mass conc. intercomparison)
  - CCN+Size distribution+composition ⇒ closure
- Conduct a 'shake out' of the MAOS platform prior to the GVAX

Aerosol Lifecycle IOP: GVAX Preparation

- MAOS will be deployed at Lucknow (India) for a 2-month IOP requiring the training of personnel for day-to-day, in-field operation
- Training will leverage the fact that all instrument mentors for operator-intensive systems are BNL staff
- Testing of MAOS measurement strategies

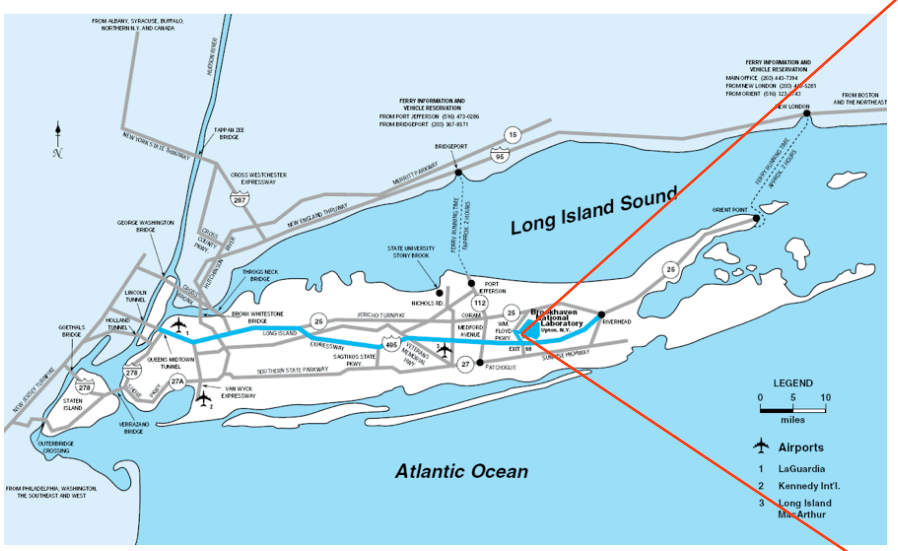
Aerosol Lifecycle IOP: MAOS Introduction

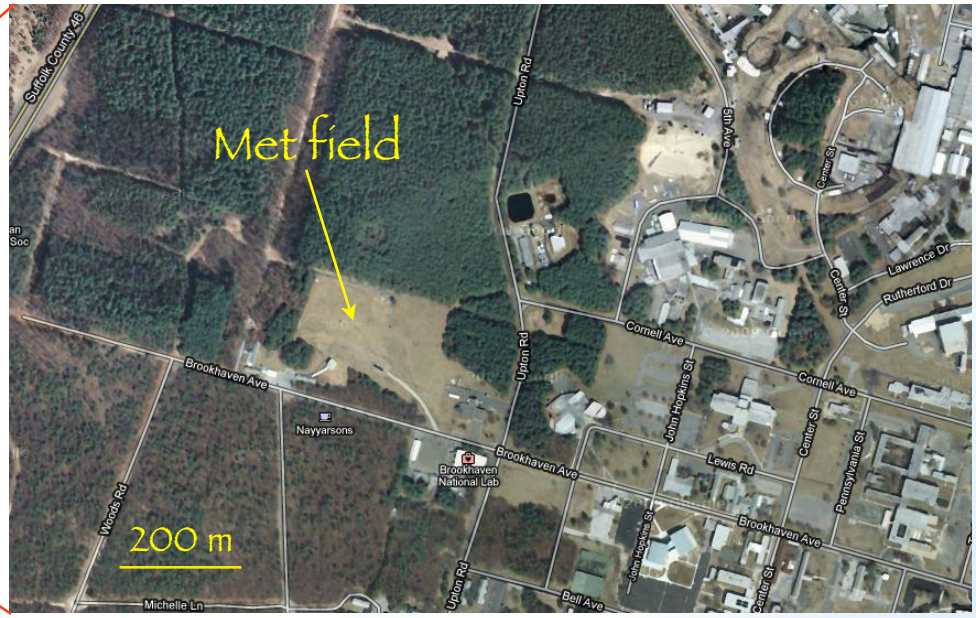
MAOS is composed of two 20' SeaTainers (MAOS-A & MAOS-C)

ACSM	Ozone
CCN-200	PSAP
CPC (> 10 nm)	PASS-3
CPC (> 2.5 nm)	PILS
CO	PTRMS
f(RH)	SMPS
HTDMA	SO_2
MET station	SODAR
Neph	SP2
NO, NO_2, NO_y	UHSAS
Radar Wind Profiler	

All items in red represent core AOS instrument suite (AMF-I, AMF-II, & TWP)

Aerosol Lifecycle IOP Site: Meteorology Field





Surface: Precipitation

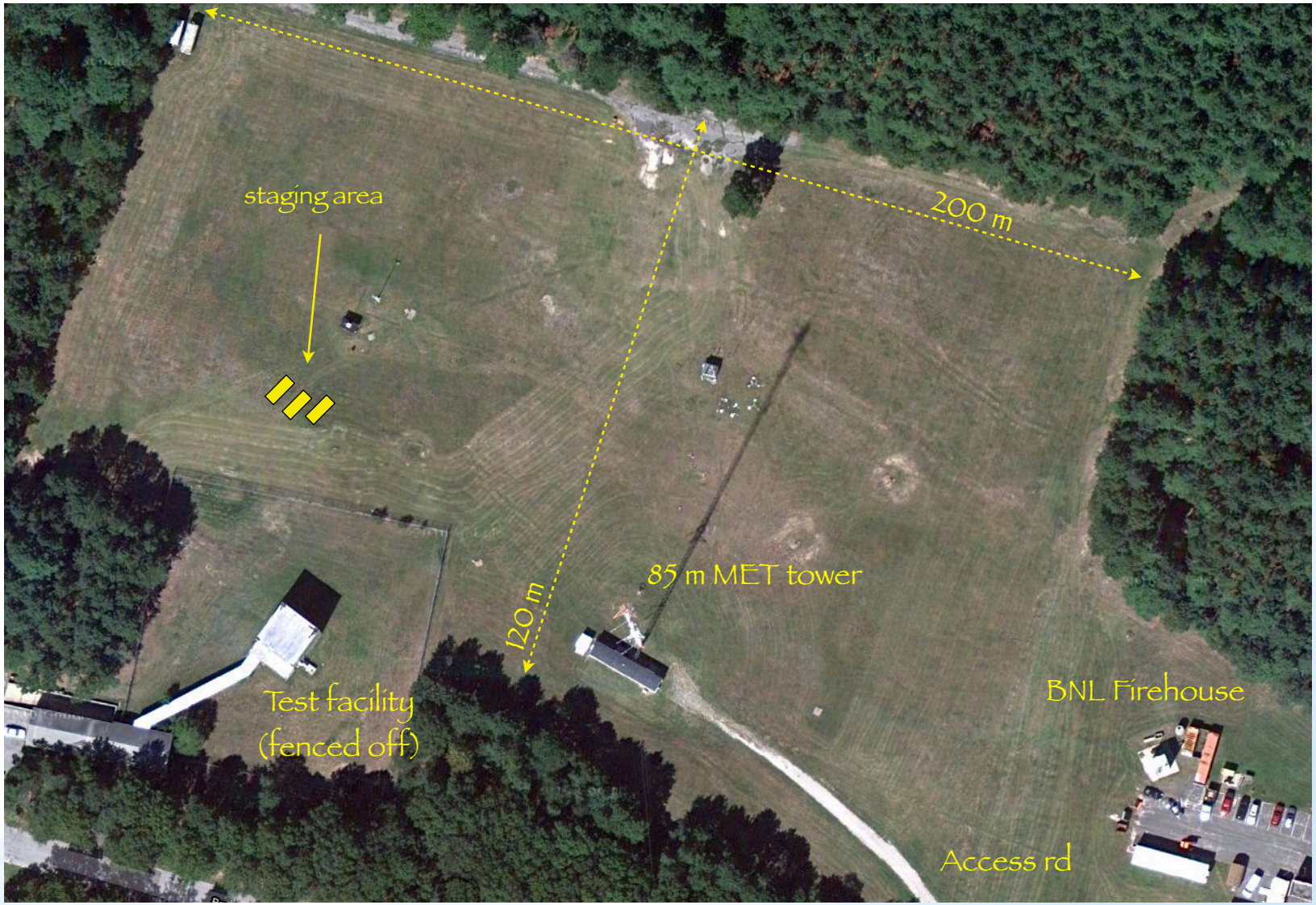
2 meters: Temp, RH, Pressure

10 meters: Temp, Wind Speed, Wind Direction

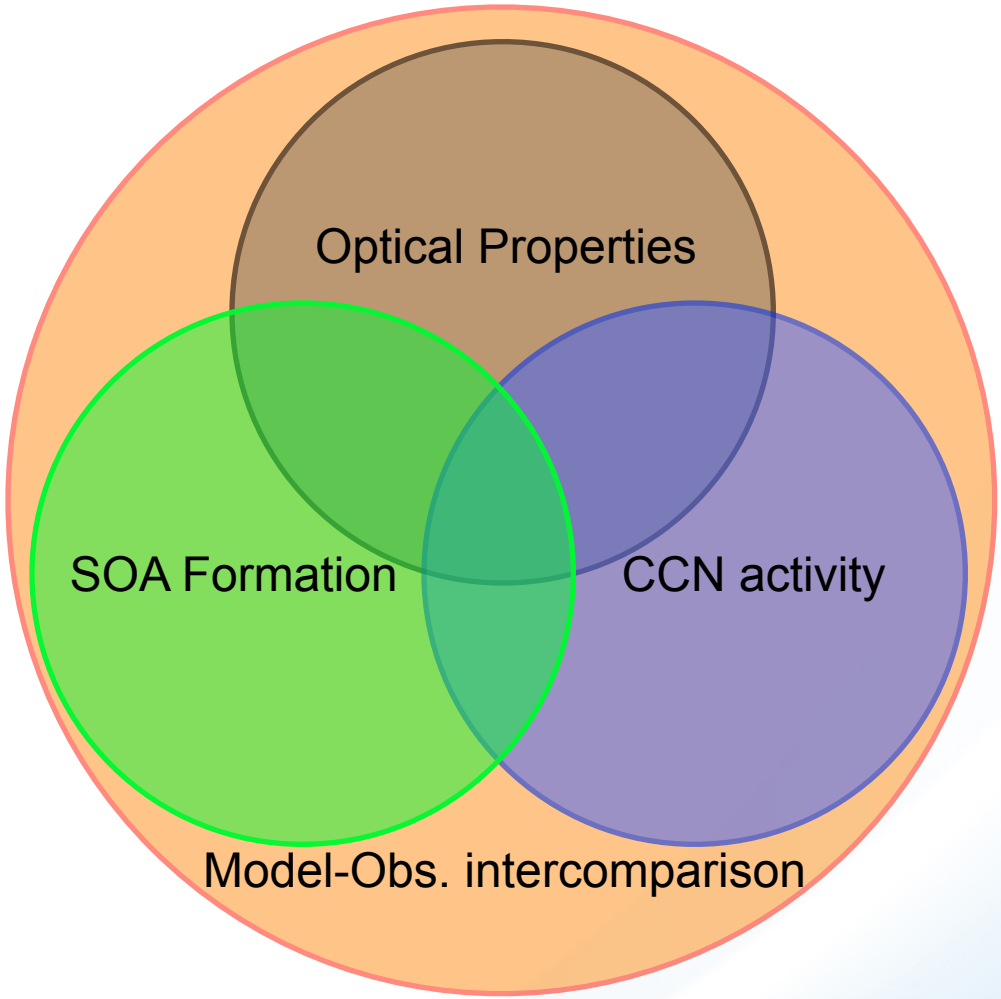
85 meters: Temp, Wind Speed, Wind Direction

New measurements of T, WS, & WD at 50 meters this summer

Aerosol Lifecycle IOP Site: MET field



Scientific foci of Aerosol IOP



A key component of these three focus areas is that aerosol properties will be determined as function of atmospheric processing, chemical conditions and source type.

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)? Utilize BNL nanoscience TEM/SEM facilities.

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 PNNL (Fast, Ghan, Xiahong)

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 LAC (rBC) measurement (5-min resolution averaged hourly)
Thermo Scientific 5020C aerosol sulfate
Met data

Aerosol Lifecycle IOP: NYC-based Studies

Aerosol Lifecycle IOP: NYC-based Studies

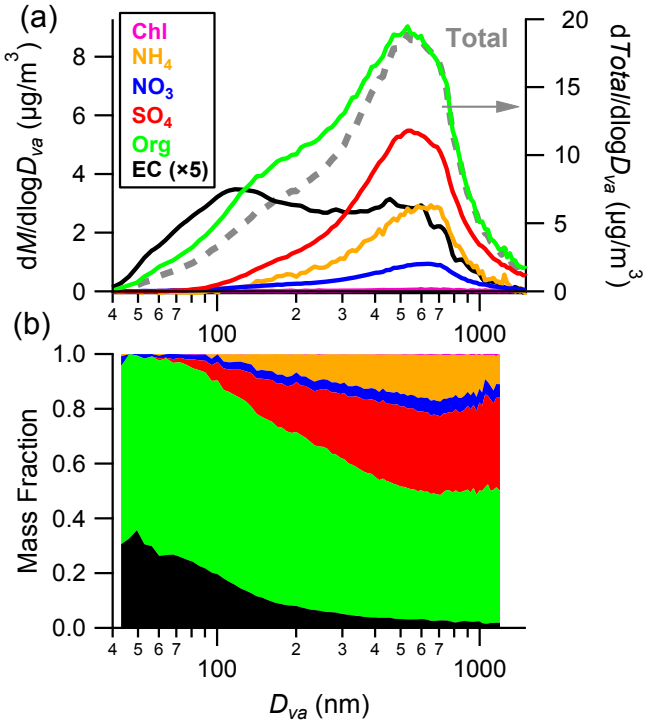
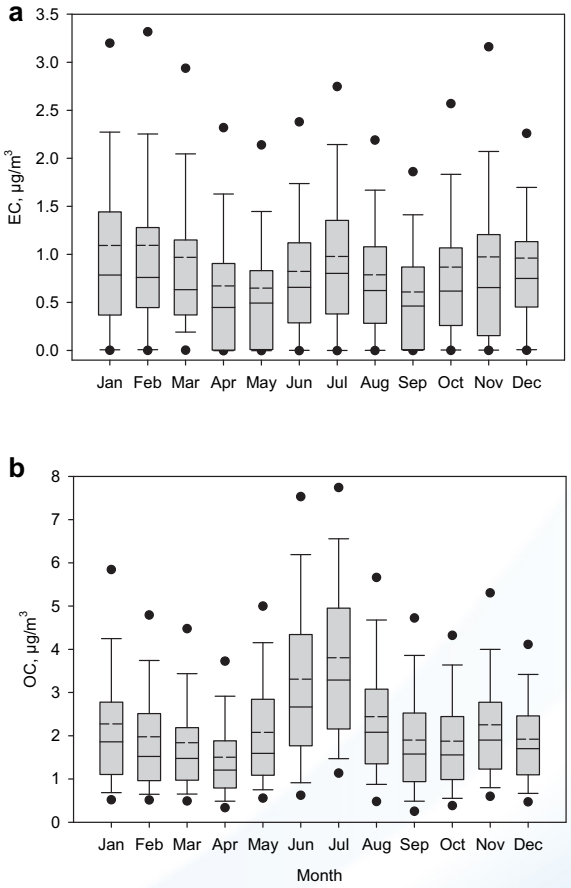
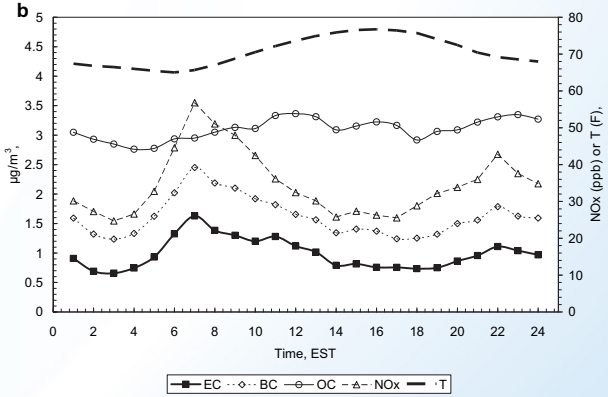


Fig. 6. Average size distributions of **(a)** mass concentrations and **(b)** fractional compositions of submicron aerosol species for the entire study. The size distribution of EC was estimated based on that of m/z 57 after removing the contribution of $C_3H_5O^+$.

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

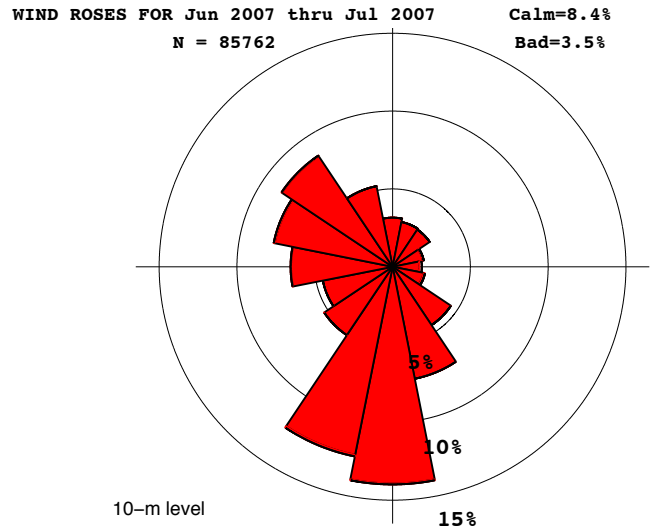


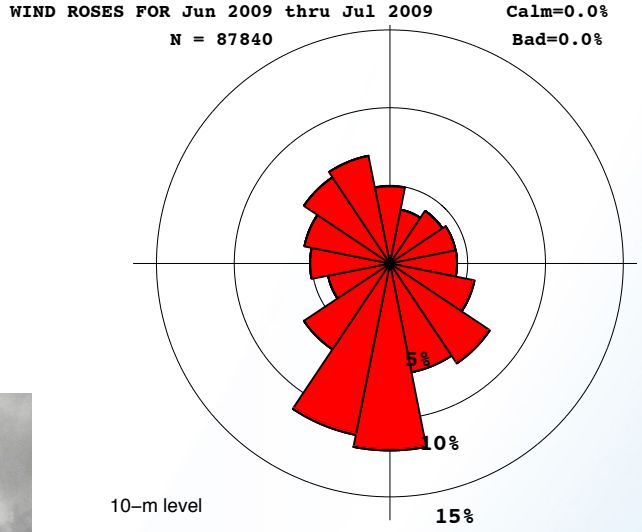
Rattigan et al., Atmos. Env. 2010

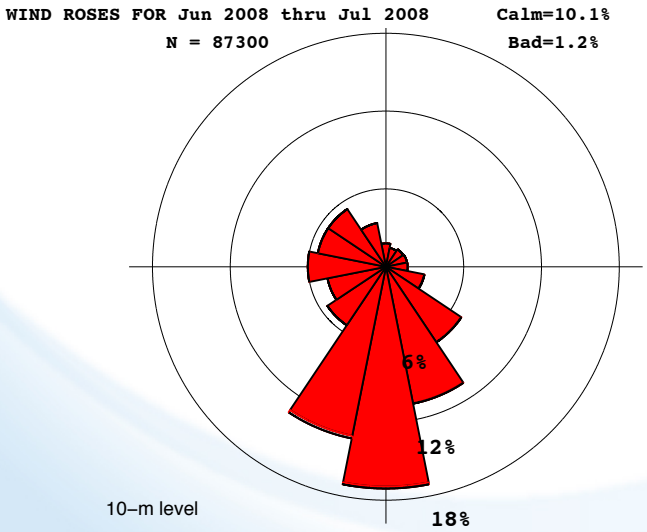


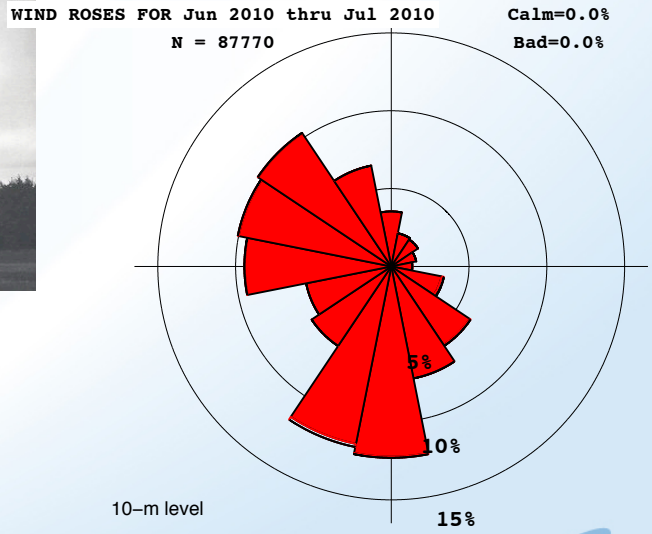
Aerosol Lifecycle IOP: NYC-BNL connection

Aerosol Lifecycle IOP: Wind Rose Plots



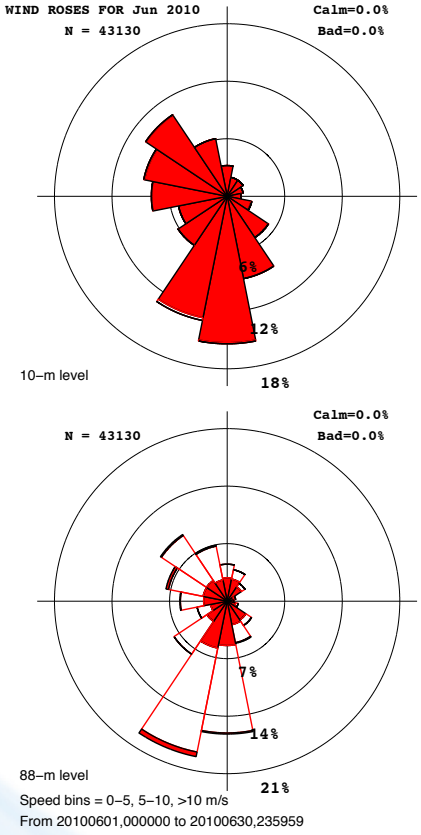




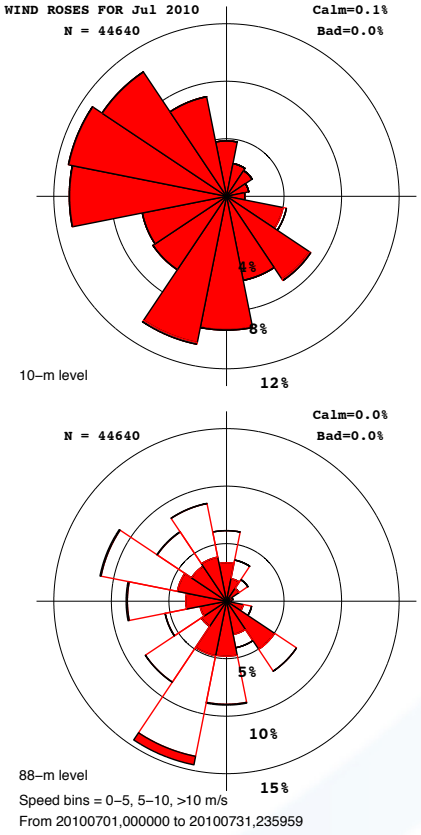


Aerosol Lifecycle IOP: Wind Rose Plots 2010

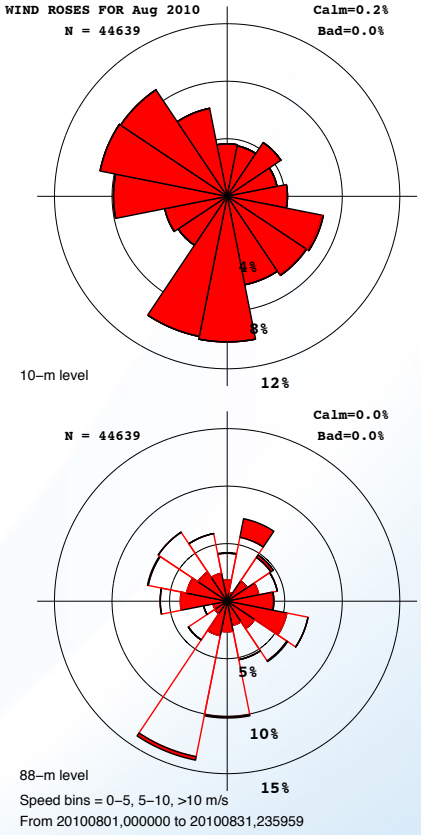
June



July



August



10 m

88 m

Aerosol Lifecycle IOP: Activities

Q. Zhang (U. Davis): High-Resolution Time-of-Flight AMS (HR-ToF-AMS):

- ACSM intercomparison
- SOA science: size resolved aerosol chemical composition and unambiguous elemental composition of organic mass fragments

D. Cziczo (MIT): Hygroscopicity Measurements During Aerosol Lifecycle IOP at BNL

- CCN science: conduct experiments that both complement and extend the super-saturated regime measurements proposed by J. Wang

G. Hallar (DRI): New Particle Formation

- Nano-SMPS

S. Lee (Kent State)

- Sulfuric Acid measurements (NPF)

V. A. Cassella (Kipp & Zonen) & M. J. Bartholomew (BNL):

- Microwave Temperature Profiler 5 (MTP-5) temperature profiles in the lowest 600-1000m at a resolution of 50 meters
- Large Aperture Scintillometer (LAS): path-averaged structure parameter of the refractive index of air over horizontal path lengths from 250 m to 4.5 km (Surface sensible heat flux) Net (SW and LW) radiometer (CNR-4)

R. Wagener & L. Gregory (BNL)

- Cimel sunphotometer: a multi-channel, scanning radiometer that measures the direct solar irradiance and sky radiance at 7 wavelengths (340, 380, 440, 500, 675, 870 and 1020 nm)

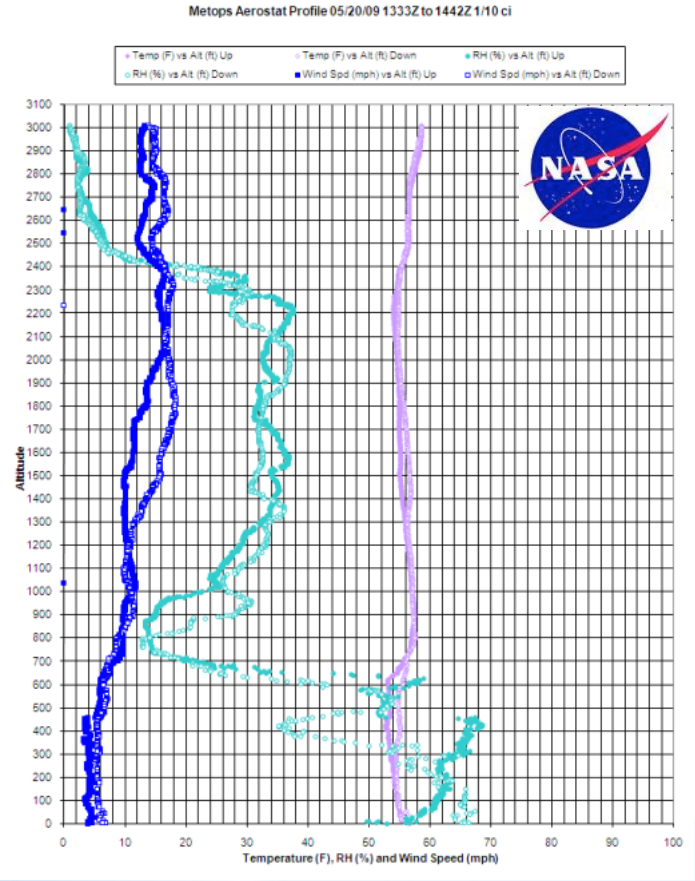
S. Smith (BNL)

- Multifilter Rotating Shadowband Radiometer: multi-channel scanning radiometer that measures total, diffuse, and direct irradiance at six wavelengths (415, 500, 615, 673, 870, and 940 nm) and includes one unfiltered broad-band silicon pyranometer.

Aerosol Lifecycle IOP: Activities

G. Bland (NASA-GSFC-WFF): Boundary Layer Profiling (1 week deployment in August)

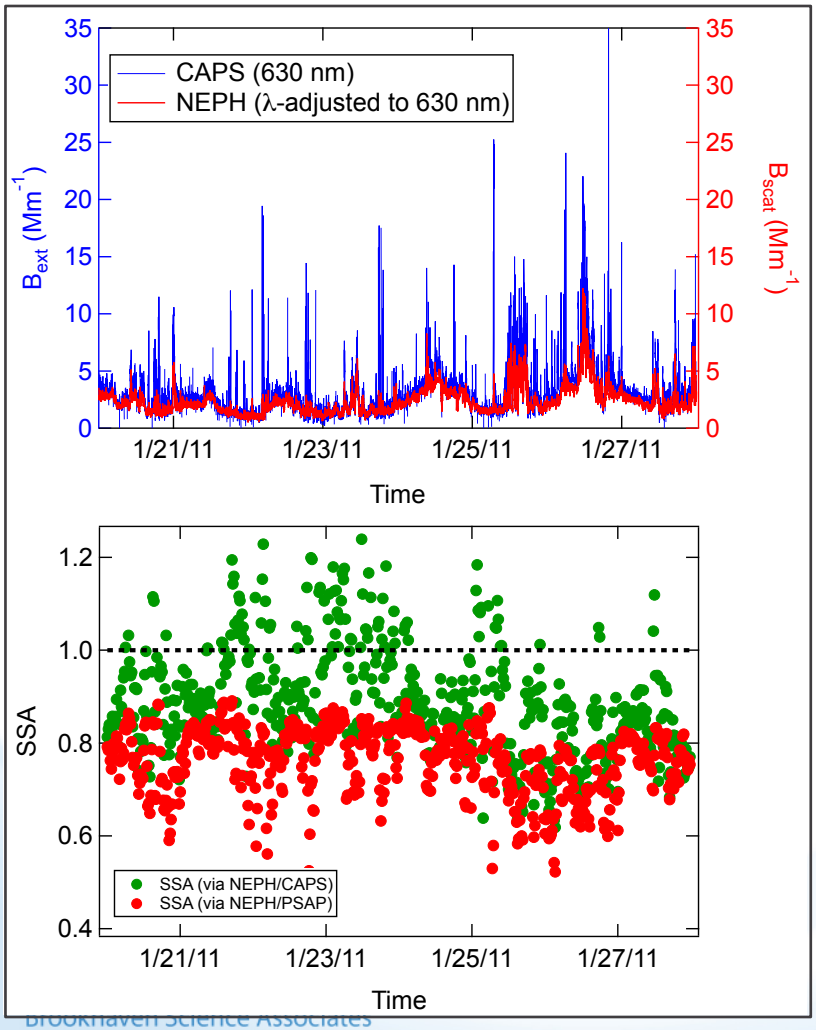
- Tethered blimps ("Aerostats") and kite-based measurements of T, RH and WS

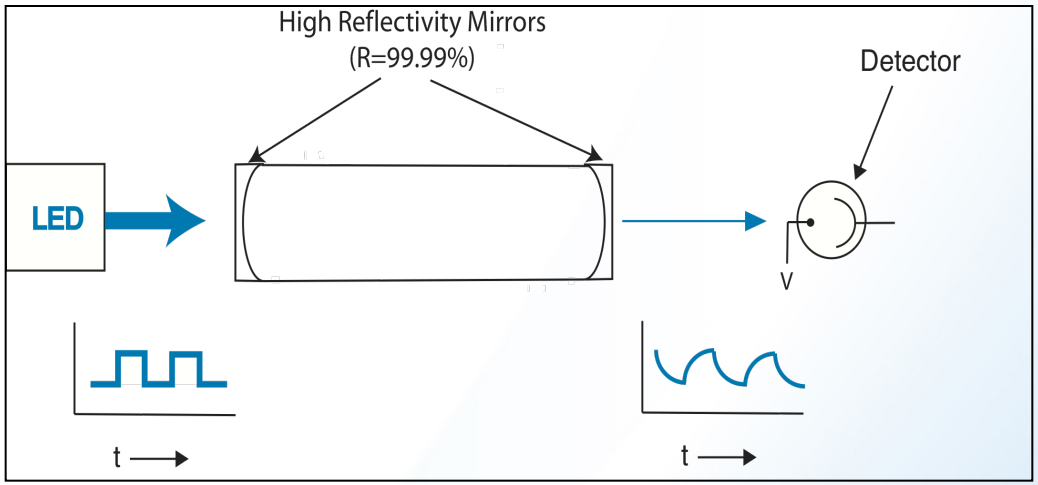


Aerosol Lifecycle IOP: Activities

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}

Aerosol Lifecycle IOP: Activities

GVAX Preparation:

B. Flowers and C. Dvonch (LANL; GVAX campaign)

- Training of technicians as part of the GVAX campaign

Lucknow MAOS Operations Personnel: (GVAX campaign)

- Training of technicians as part of the GVAX campaign

  Dr. Umesh Chandra Dumka, ARIES, Nainital
  Dr. Vimalesh Pant, ARIES, Nainital
  Mr. Anil Ravi, IISc, Bangalore
  Mr. Ajay S. Nair, IISc, Bangalore
  Mr. Arun Kumar V. H., VSSC, ISRO, Trivandrum
  Mr. Prijith S.S., VSSC, ISRO, Trivandrum
  Dr. Biswadip Gharai, NRSC, ISRO, Hyderabad

Educational Programs:

FaST (Faculty and Students Teams): Dr. Viviana Vladutescu (CUNY) & 2 students

- Aerosol optical properties; Aerosol Optical Depth

SULI (Science Undergraduate Laboratory Internship: 2 Students)

- Back-trajectories; intercomparisons; website

ACTS (Academies Creating Teacher Scientists): 1 HS teacher

- Documentation & training

Dr. Susan Oatis (SUNY/SB): Assist in tech. training and science (SP2/PTI)

Busy Place to Be

- Educators: 3
- Students (interns/summer): 4
- Technicians (for Ganga Valley expt): 9
- Collaborators: 12
- Plus BNL Researchers

Presentations given today can be found at the BNL IOP webpage:
http://www.ecd.bnl.gov/IOP.html