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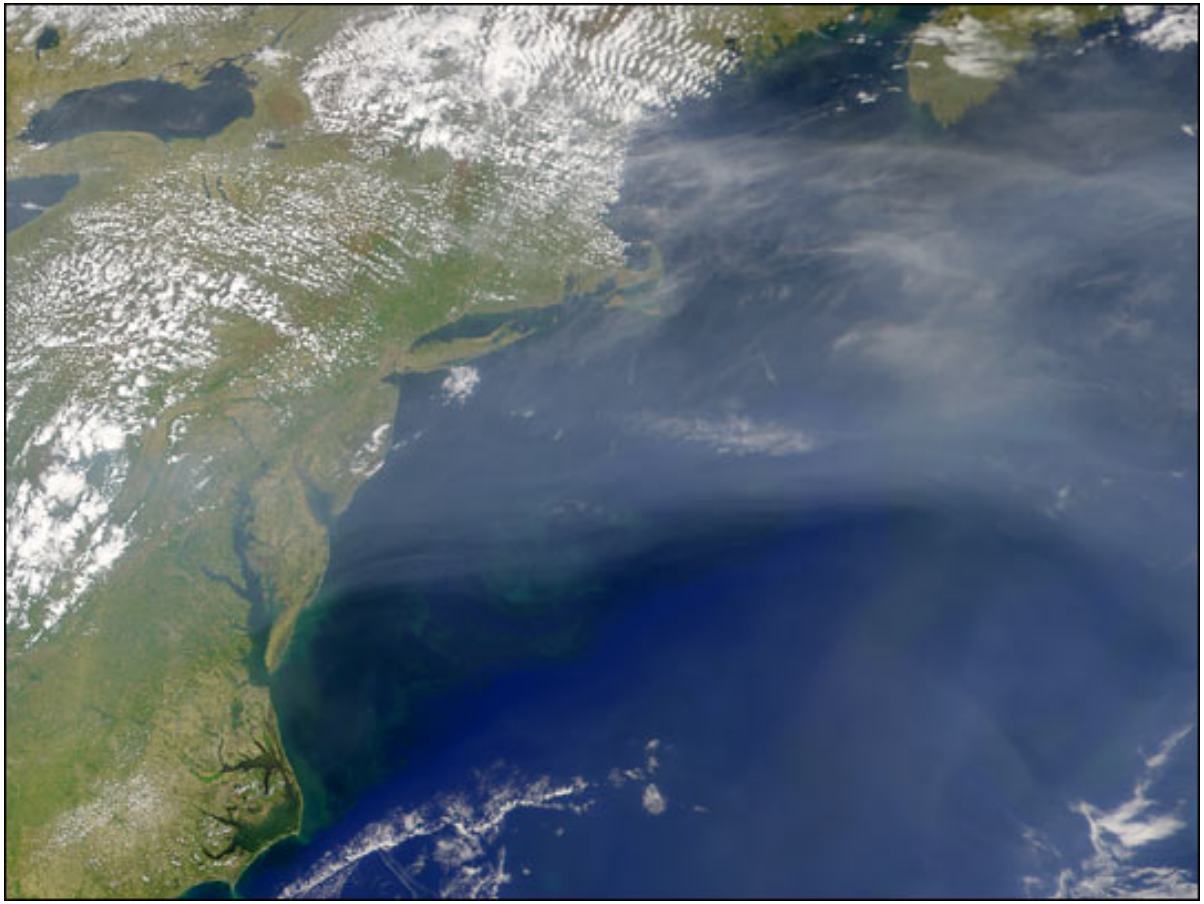
The Two-Column Aerosol Project (TCAP) Breakout Session

Agenda

1. Review of preliminary Research
2. Science questions
3. Status of instruments
4. Review logistics and flight plans

Preliminary Resarch: Why Cape Cod?



True-color Sea-viewing Wide Field-of-view Sensor (SeaWiFS) image from 4 May 2001
Image courtesy of the NASA EOS Project Science Office

Preliminary Research: Why Cape Cod?

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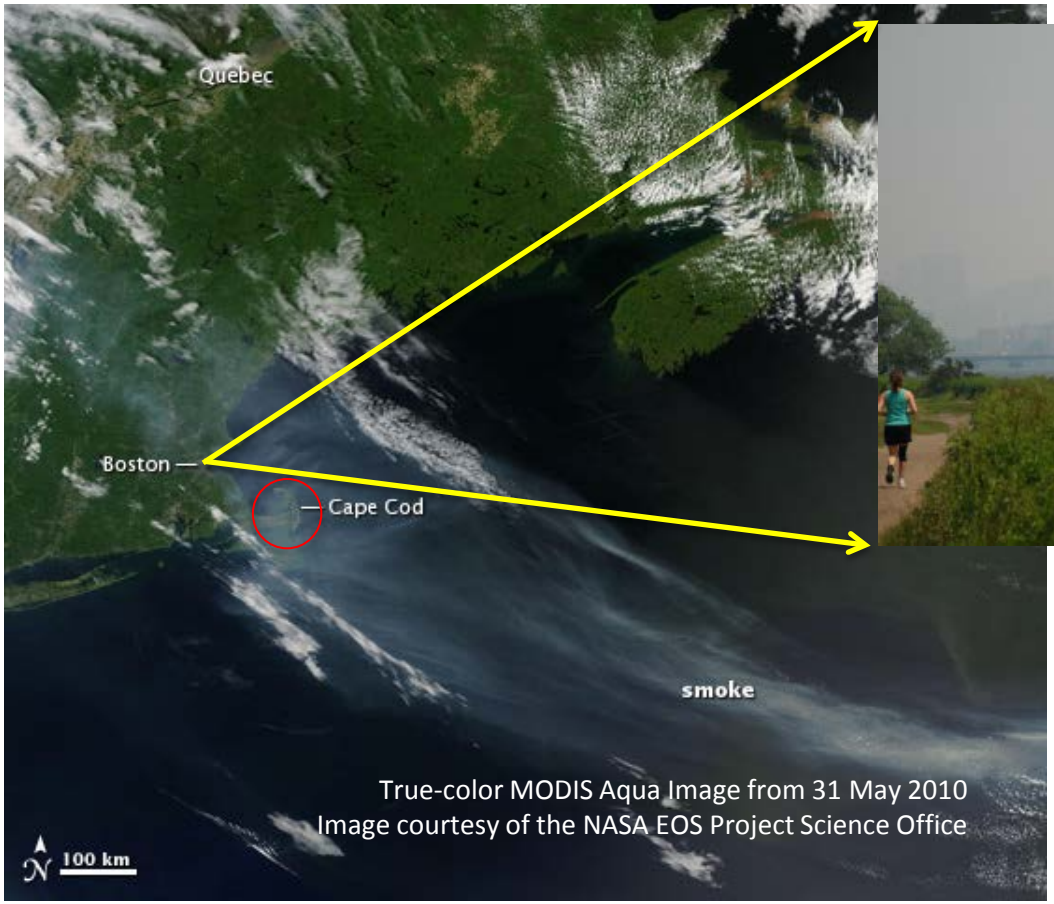

True-color MODIS Aqua Image from 31 May 2010
Image courtesy of the NASA EOS Project Science Office

Boston haze on 5/31/2010. Photo courtesy of www.wbur.org (Boston local news)

Preliminary Research: Why Cape Cod?

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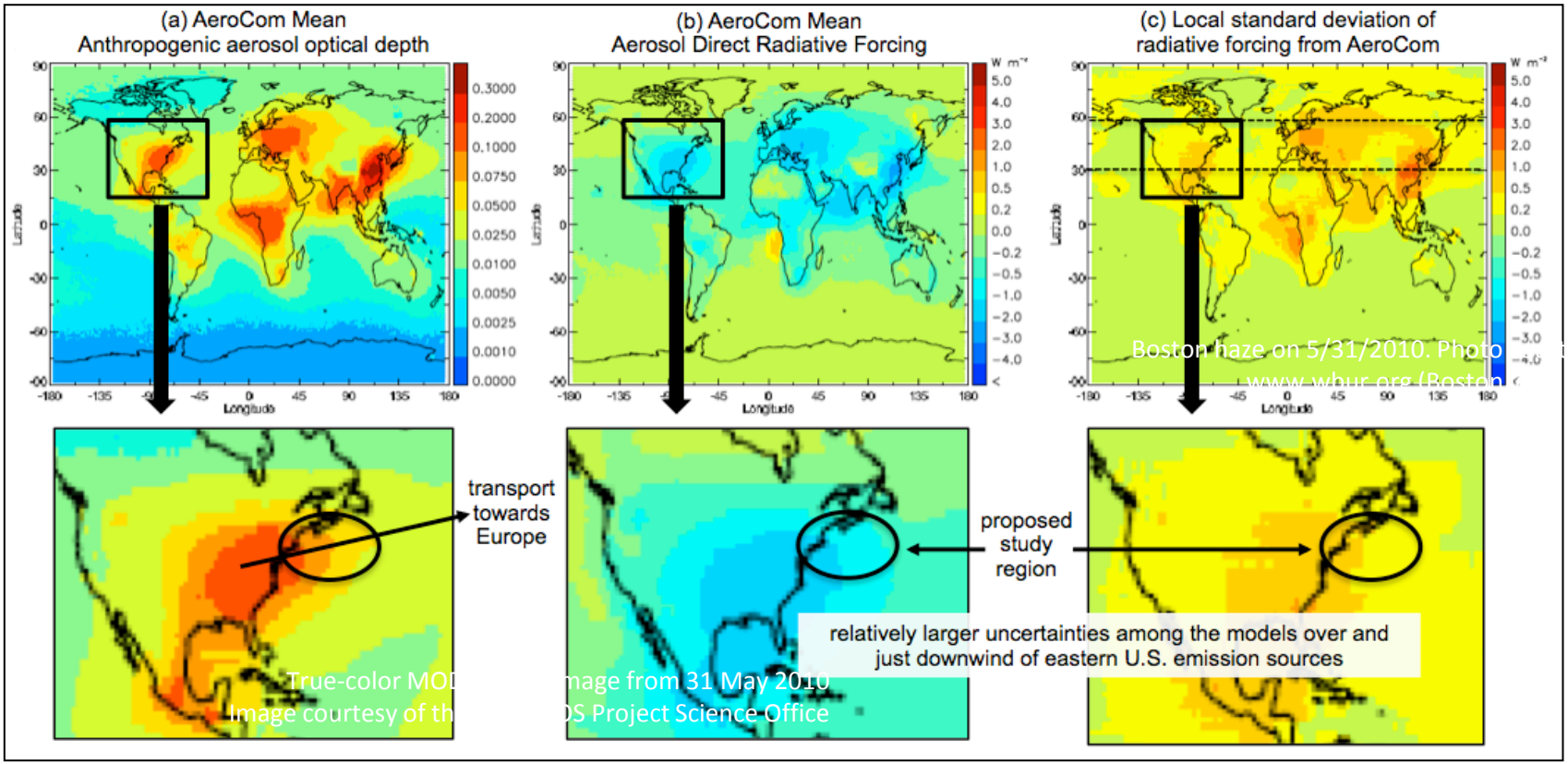
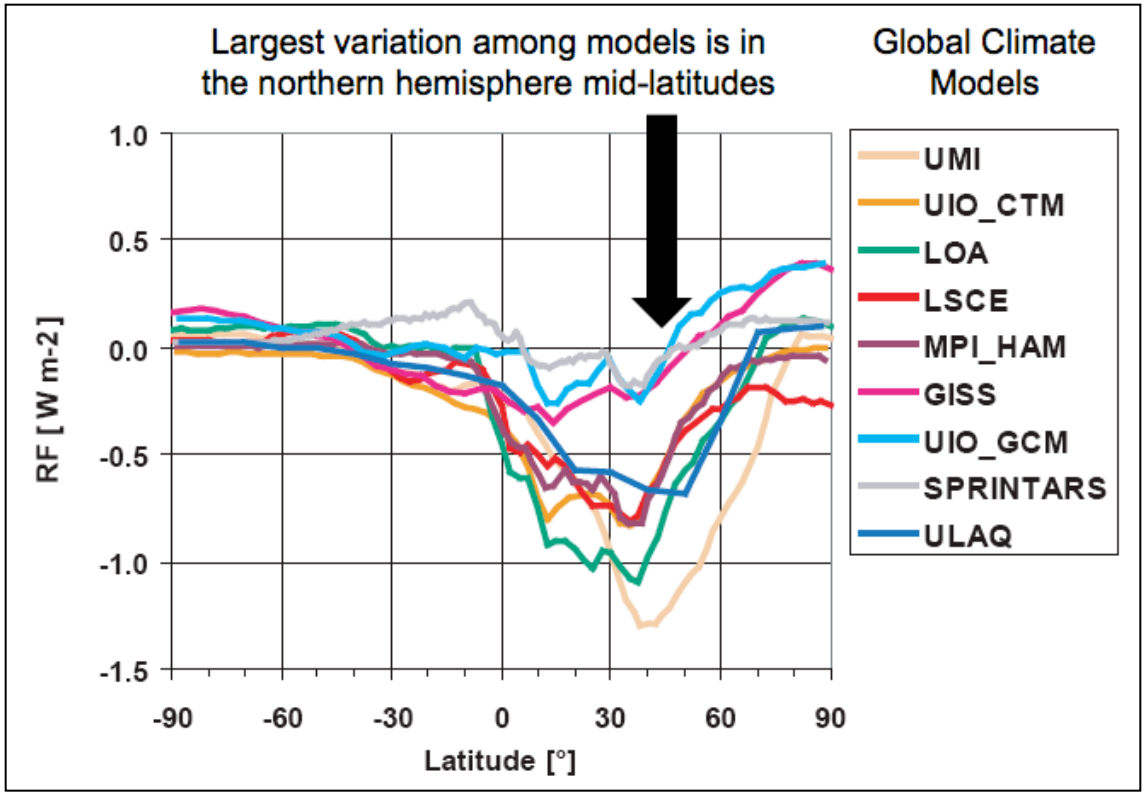
- Large variations in the magnitude of predicted aerosol forcing



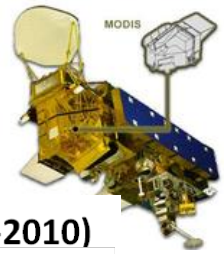
Preliminary Research: Why Cape Cod?

- Large variation in the magnitude of predicted aerosol forcing



Preliminary Research: Aerosol Climatology-July

- Horizontal gradients in AOD
  - Larger in the morning
- Diurnal variations in AOD

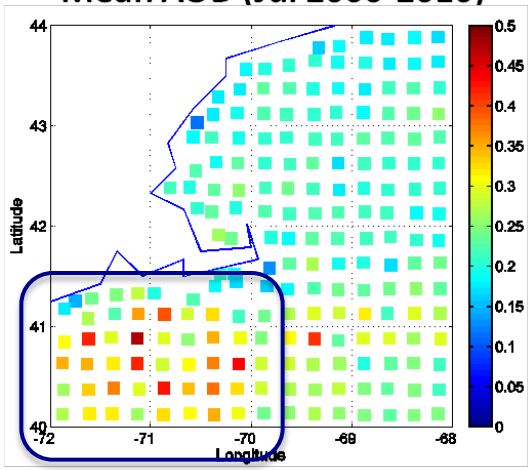


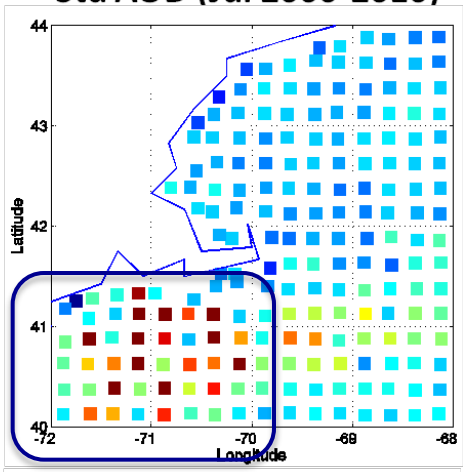
Mean AOD (Jul 2000-2010)

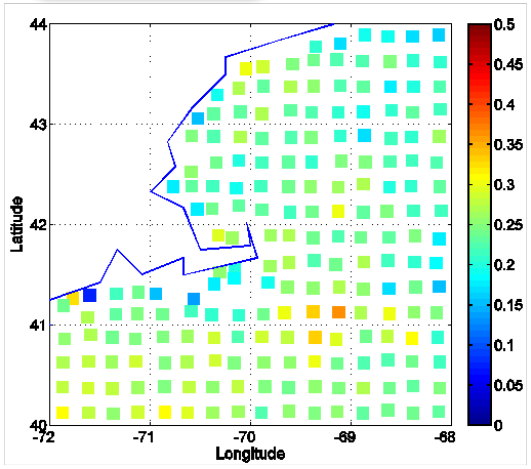
Std AOD (Jul 2000-2010)

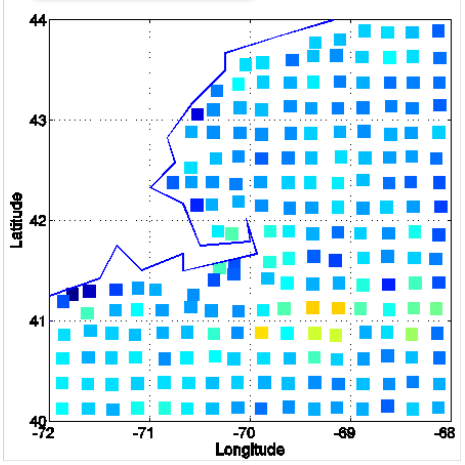
~10:30 EST → Terra

~13:30 EST → Aqua





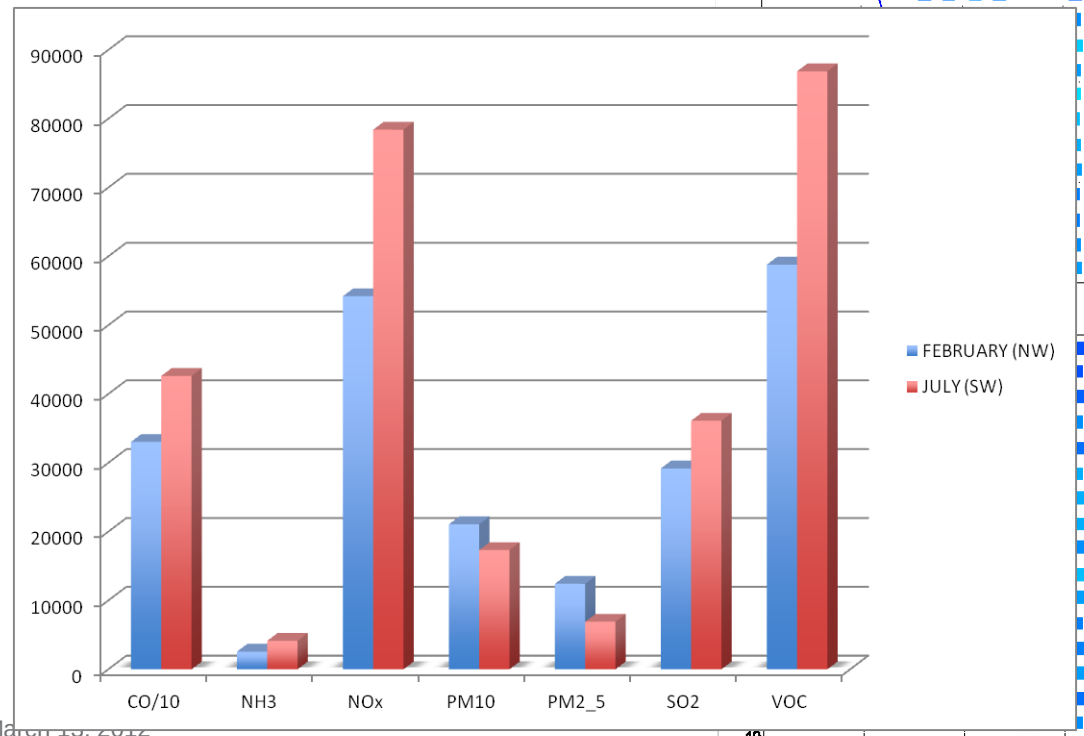


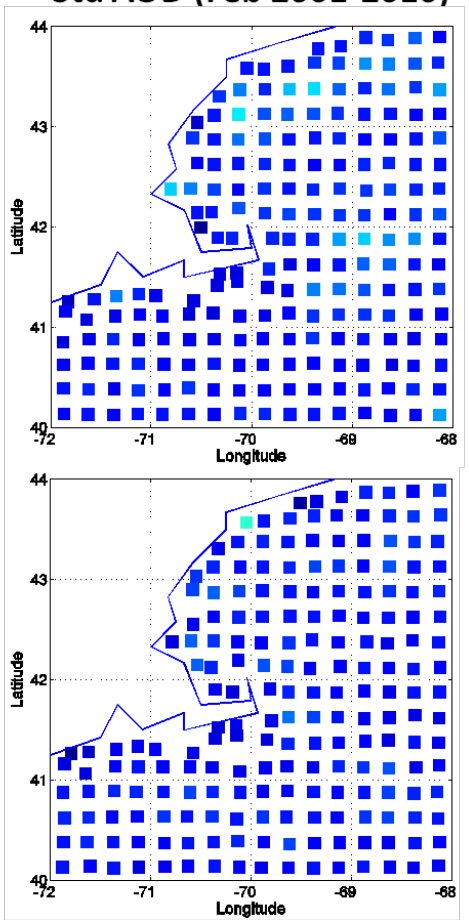


Work led by Duli Chand

Preliminary Research: Aerosol Climatology-Feb.

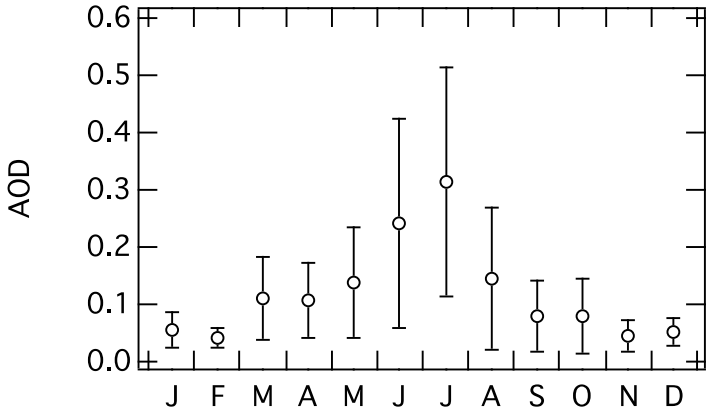
- Smaller aerosol loading
  - Changes in emissions and photochemistry
  - Small changes in PM





Deployment Details

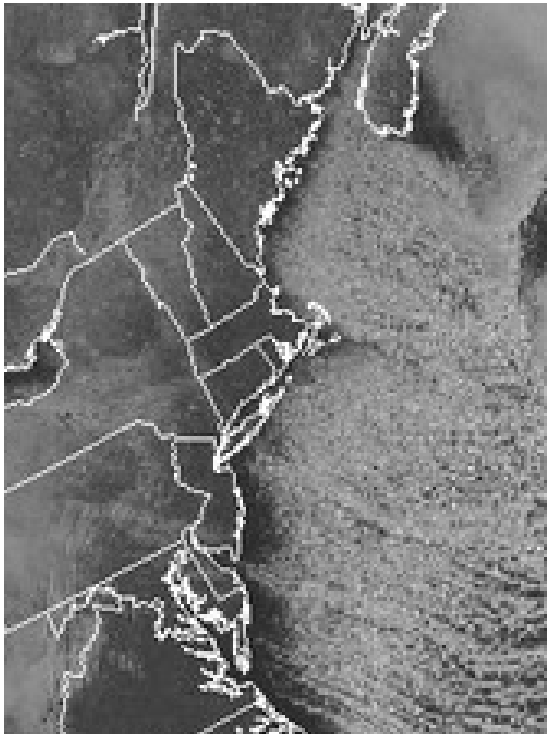
- One-year deployment of ARM Mobile Facility (AMF) and Mobile Aerosol Observing System (MAOS) starting in the summer of 2012
- Two aircraft intensive observation periods (IOPs)
  - July 7-30, 2012
  - Feb. 4-28, 2013



AOD from MVCO AERONET site

TCAP Science Goals

- Cloud Condensation Nuclei (CCN) studies
  - Does size or composition matter
- Local and Columnar radiation closure study
  - AOD will be measured with a range of different instruments
- Cloud-aerosol interactions
  - Long time series with detailed information about particles
- High resolution modeling
- Climate modeling
  - How well does a climate model represent horizontal and vertical variability of anthropogenic aerosols and their impact on scattering and absorption?
  - What are the important factors?

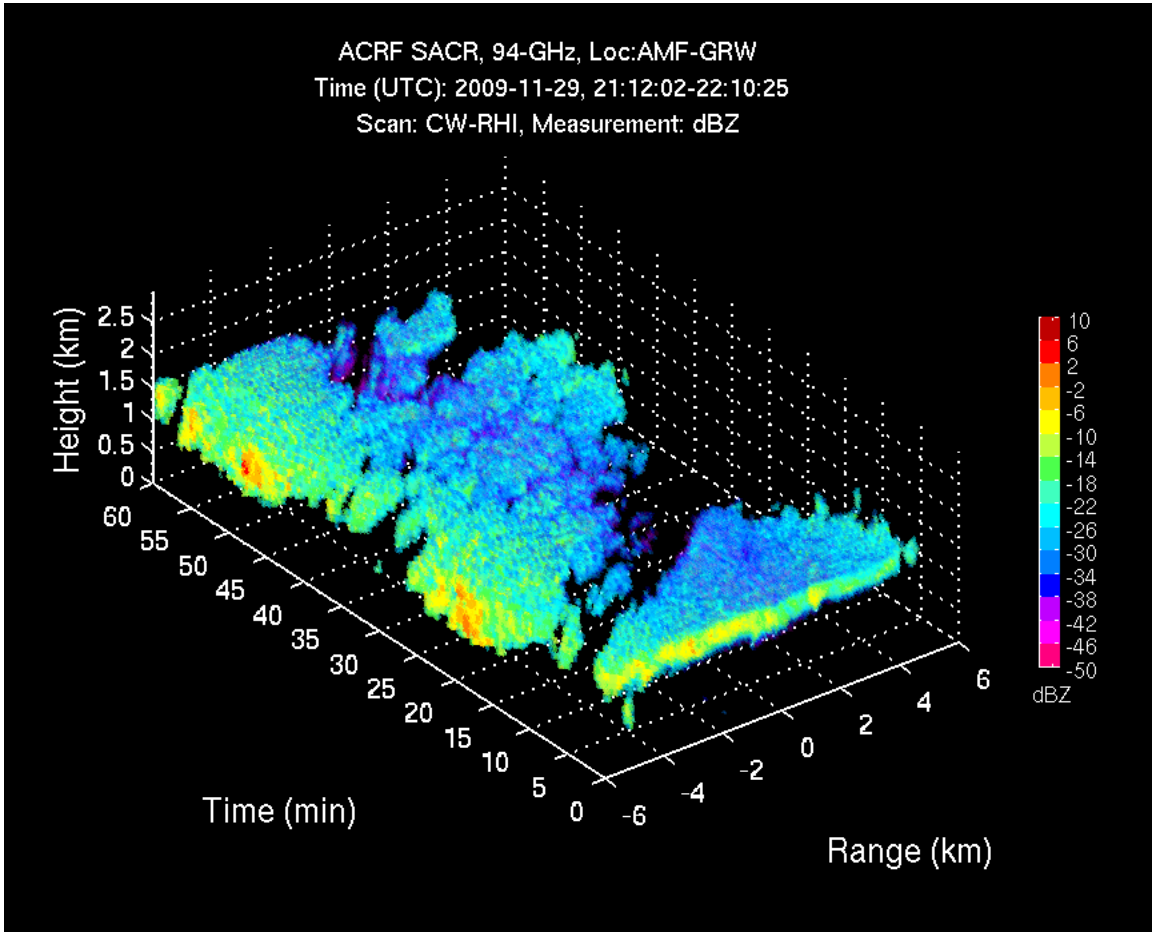


Cold air outbreak—1/26/07

Cloud Radars

- New cloud radars
  - Scanning cloud radars provide unprecedented information about the spatial distribution of clouds
  - Example from AMF deployment in the Azores

Image courtesy of Pavlos Kollias



Aircraft Measurements

- Measurements complement those made on the ground
  - Aerosol optical properties
  - Particle size distributions
  - Cloud properties
  - Solar radiation
- Airbone remote sensing
  - High Spectral Resolution Lidar (HSRL)
    - Aerosol backscatter, extinction, AOD
  - Research Scanning Polarimeter (RSP)
    - Aerosol optical properties
    - Information about particle size distribution

DOE Gulfstream 1

Instrument Status

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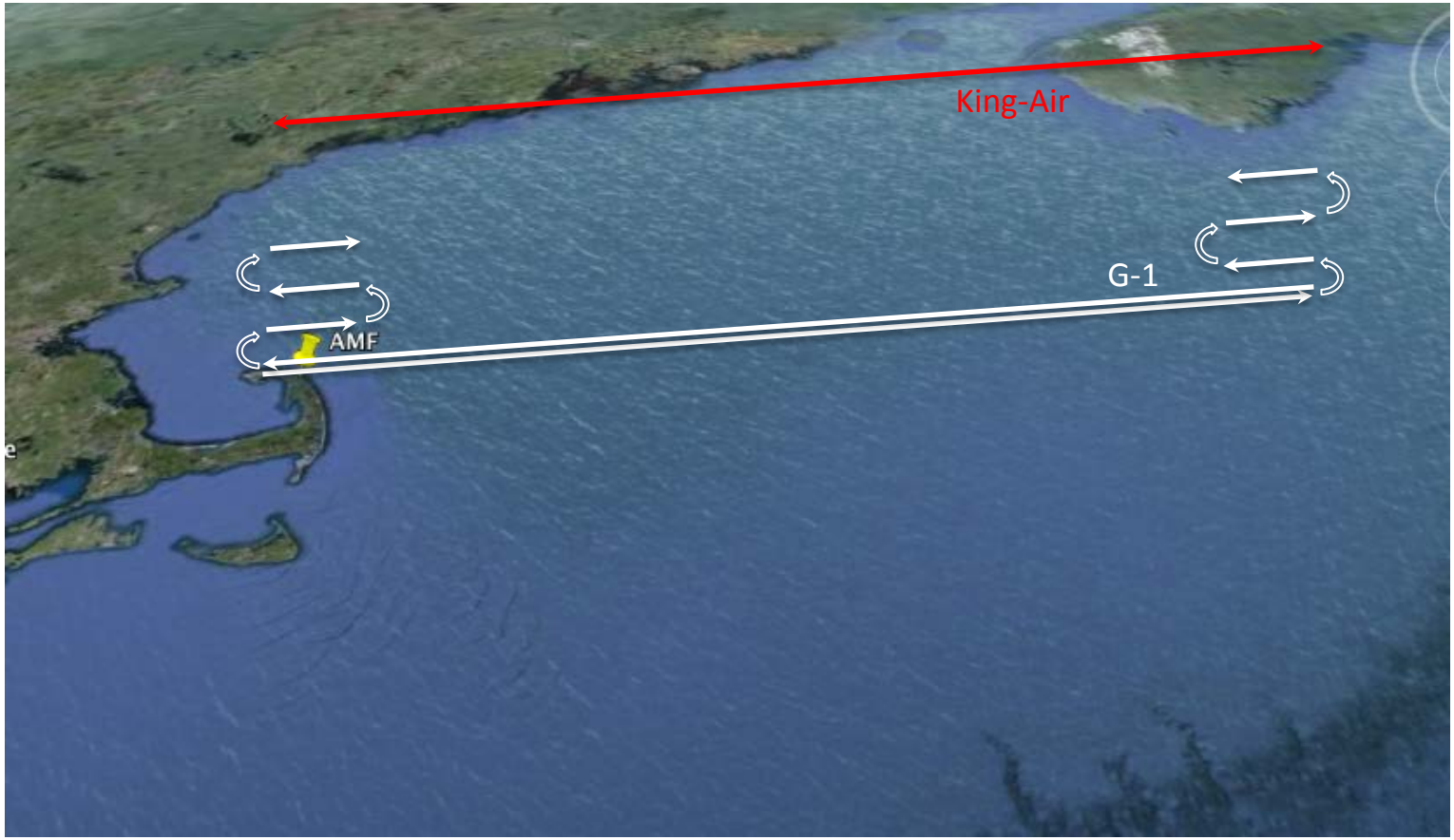
- SPLAT II —Alla
- 4STAR—Connor
- HSRL and RSP—Rich

Flight Plans

- Plans are being developed for both the G-1 and King Air



AMF/MAOS Site

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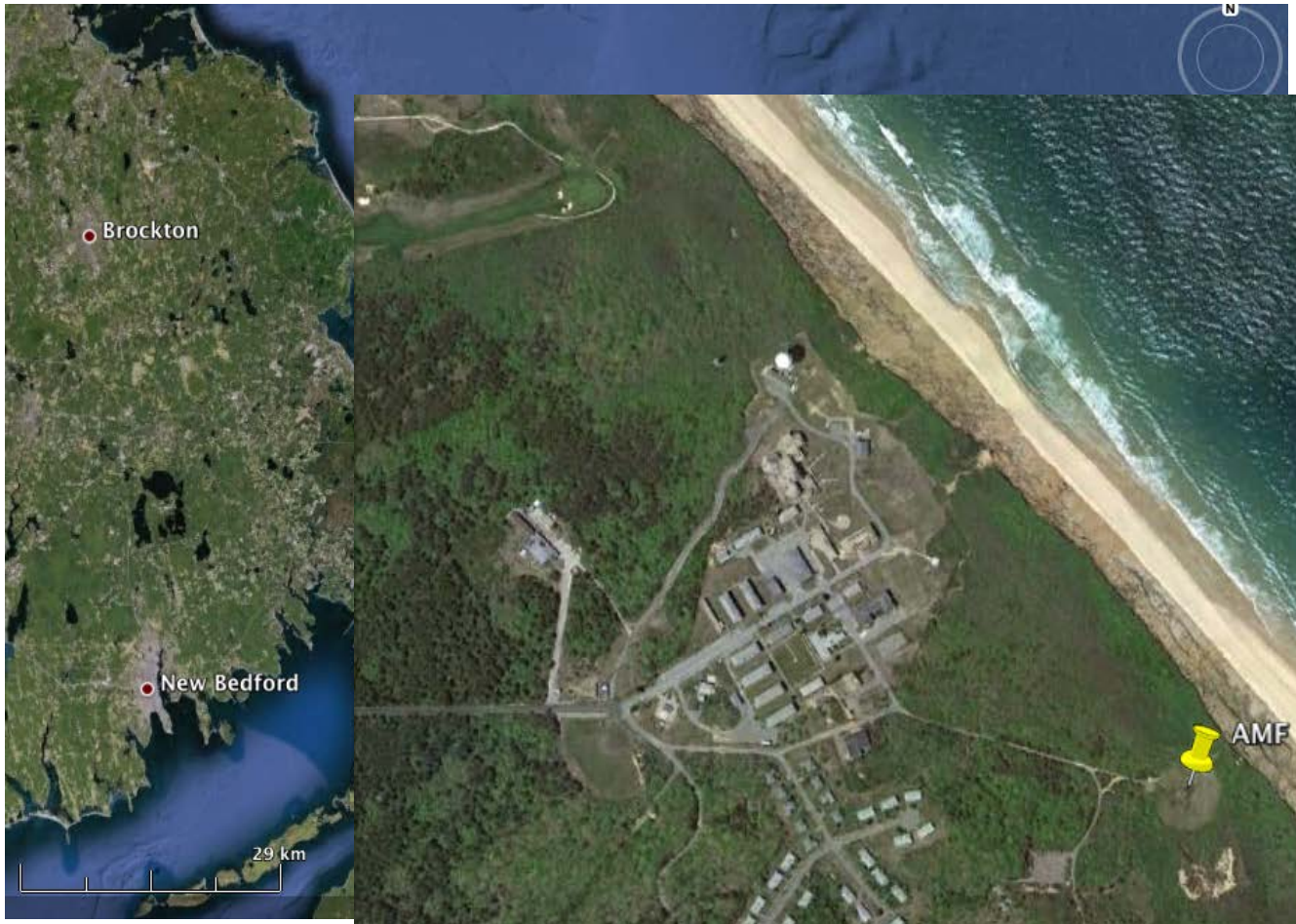

Discussion

AMF 1 Instruments

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- Precision Spectral Pyranometer (PSP) x 2
- Precision Infrared Radiometer (PIR) x 2
- Shaded Black & White Pyranometer (B/W)
- Shaded Precision Infrared Pyrgeometer (PIR)
- Normal Incidence Pyrhiliometer (NIP)
- Infrared Thermometer (IRT) x 2
- Multi-Filter Rotating Shadowband Radiometer (MFRSR)
- Narrow Field of View Zenith Radiometer (NFOV)
- Optical Rain Gauge (ORG)
- Anemometers (WND)
- Temperature/Relative Humidity Sensor (T/RH)
- Barometer (BAR)
- Present Weather Detector (PWD)
- Eddy Correlation Flux Measurement System (ECOR)
- Shortwave Array Spectrometer (SAS-He, SAS-Ze)
- Microwave Radiometer (MWR)
- Microwave Radiometer Profiler (MWRP)
- Microwave Radiometer 90/150 (MWR-HF)
- Doppler Lidar (DL)
- Ceilometer (CEIL)
- Balloon Borne Sounding System (BBSS)
- W-band ARM Cloud Radar - 95GHz (WACR)
- Ka-W Scanning ARM Cloud Radar (SACR)
- Atmospheric Emitted Radiance Interferometer (AERI)
- Total Sky Imager (TSI)
- Aerosol Observation System (AOS)
  - CCNC
  - PSAP
  - Nephelometers X 2
- Radar Wind Profiler – 1290MHz (RWP)
- Cimel Sunphotometer (CSPHOT)

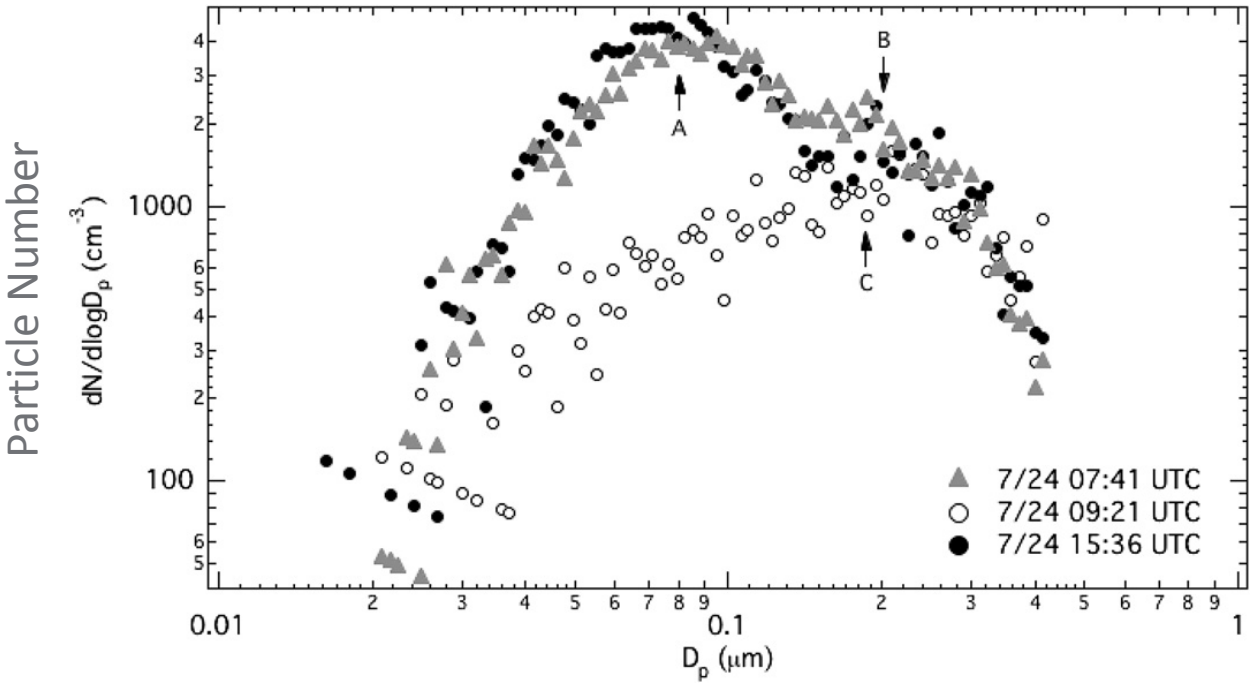
MAOS Instruments

Mobile Aerosol Observing System (MAOS) – 2 x 20' sea containers (MAOS-A & MAOS-C)

- SOnic Detection And Ranging (SODAR) System (1000 to 4000 Hz)
- Ultra-High Sensitivity Aerosol Spectrometer (enhanced)
- Dual Column Cloud Condensation Nuclei Counter (CCN)
- Single Particle Soot Photometer (SP2)
- Scanning Mobility Particle Sizer (SMPS)
- Photo-Acoustic Soot Spectrometer (PASS), 3 Wavelength
- Humidigraph (3 Relative Humidities with 3 single wavelength nephelometers)
- Humidigraph (Scanning Relative Humidity with 3 single wavelength nephelometers)
- Trace Gas Instrument System (Research-Grade)
- Particle Into Liquid Sampler-Ion Chromatography-Water Soluble Organic Carbon (PILS-IC-WSOC)
- Particle Soot Absorption Photometer (PSAP), 3 Wavelength
- Nephelometer, 3 Wavelength
- Condensation Particle Counter (CPC), 10 nm to >3000 nm particle size range
- Condensation Particle Counter (CPC), 2.5 nm to >3000 nm particle size range
- Hygroscopic Tandem Differential Mobility Analyzer (HTDMA)
- Proton Transfer Mass Spectrometer (PTRMS)
- 7-Wavelength Aethelometer
- Weather Transmitter (WXT-520)
- Aerosol Chemistry Speciation Monitor (ACSM)

What Are Atmospheric Aerosols?

- **Not** chemicals released from a spray can!
- Particles that occur in the atmosphere
  - Wide range of sources, some natural some man-made (anthropogenic)
  - Particle range in size from nm to μm and larger
    - Particle sizes less than 2.5 and 10.0 μm are regulated



The diameter of a human hair ranges between 17 and 180 μm

Berkowitz et al. 2011

Atmospheric Aerosol—Images from Space

- Aerosol is ubiquitous
  - Both natural and anthropogenic

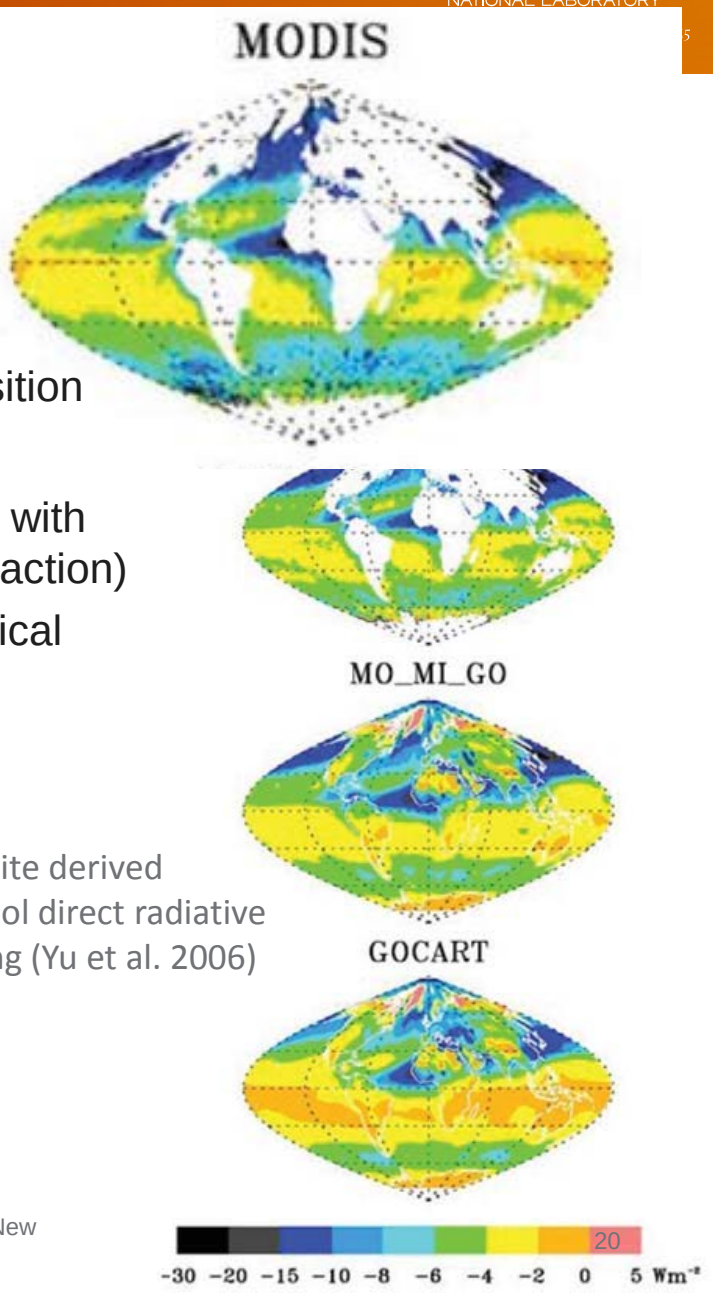
Haze over the East China Sea. Image courtesy of NASA

Arnica Fire (Yellowstone National Park), Sept. 2009. Image courtesy of NASA

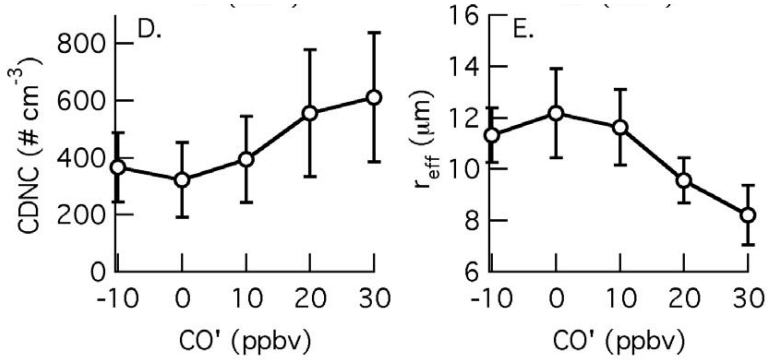
sor (SeaWiFS)
m 4 May 2001
Science Office

Why Do We Care?

- Aerosol impacts climate
  - Absorb/scatter sunlight
    - Direct impact on radiative forcing
    - Function of particle size and chemical composition
  - Impact on cloud microphysics
    - Indirect impact on radiative forcing associated with changes in cloud properties (including cloud fraction)
    - Function of particle size distribution and chemical composition
  - High amount of uncertainty



Satellite derived aerosol direct radiative forcing (Yu et al. 2006)



Changes in cloud microphysics (Berg et al. 2011)

The Two-Column Aerosol Project (TCAP)

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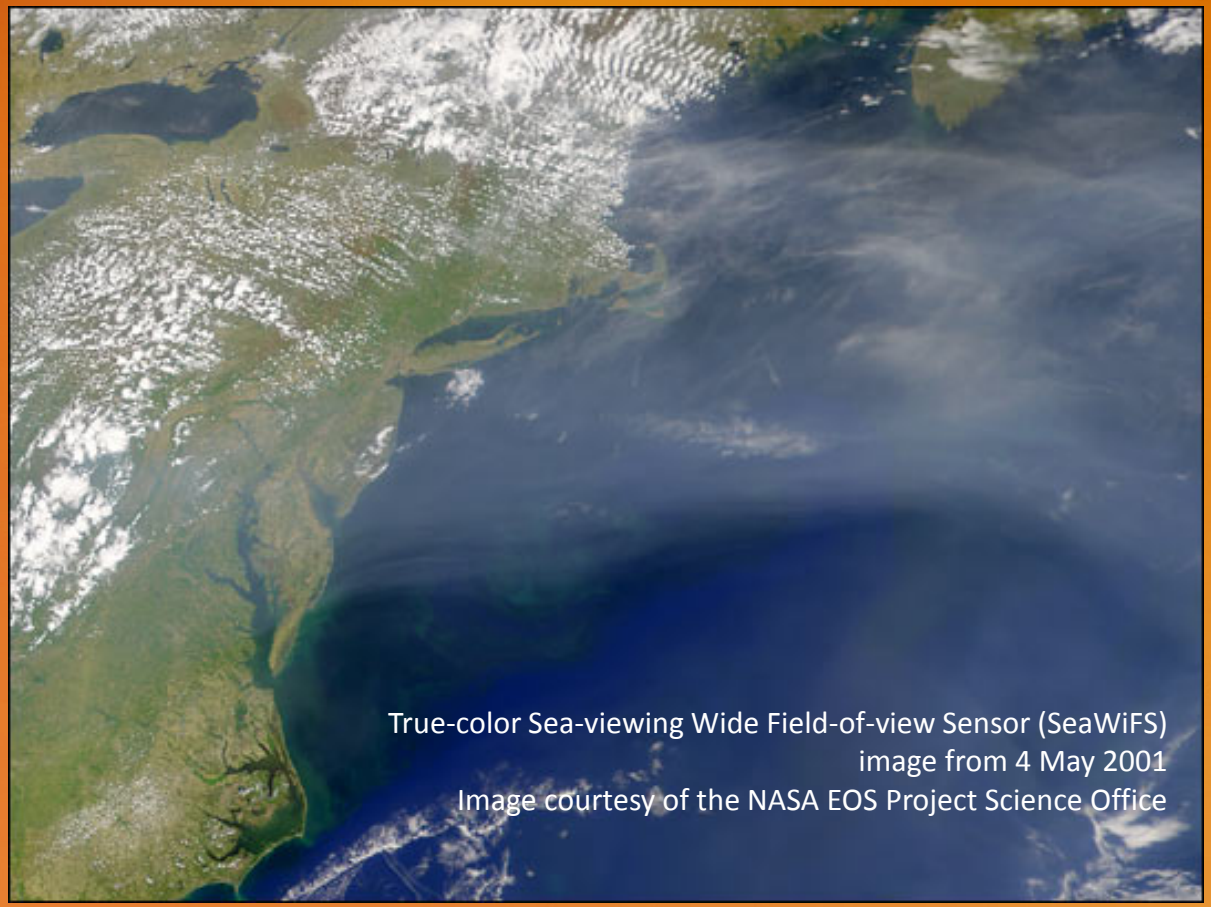
Overarching Goal: To understand the processes responsible for producing and maintaining aerosol distributions and associated radiative and cloud forcings off the coast of North America

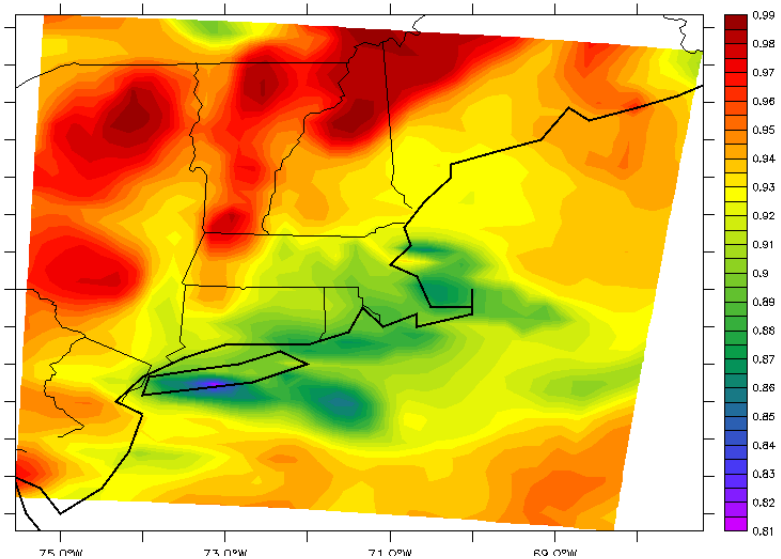


True-color Sea-viewing Wide Field-of-view Sensor (SeaWiFS) image from 4 May 2001
Image courtesy of the NASA EOS Project Science Office

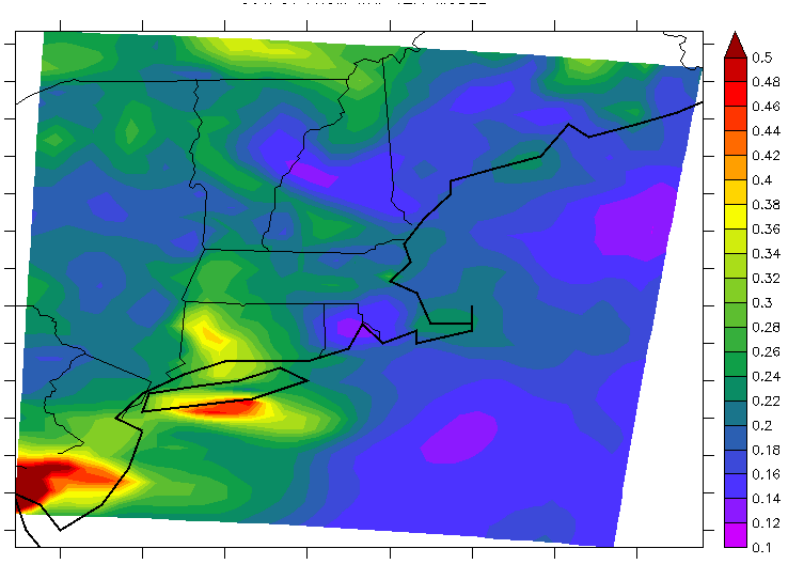
Science Goal 4: High Resolution Modeling

- Models that treat meteorology and chemistry
  - Evolution of aerosols and its effect on CCN, cloud/aerosol interactions
  - Emphasis on how radiative forcing within the two TCAP columns were affected by particle formation, mixing state, and grid resolution

Particle reflectivity at ~1 km



AOD



WRF-Chem predictions: NEAQS

- Detailed chemistry models
  - Recently developed model (Zaveri et al. 2010)

The Two-Column Aerosol Project (TCAP): Measurements

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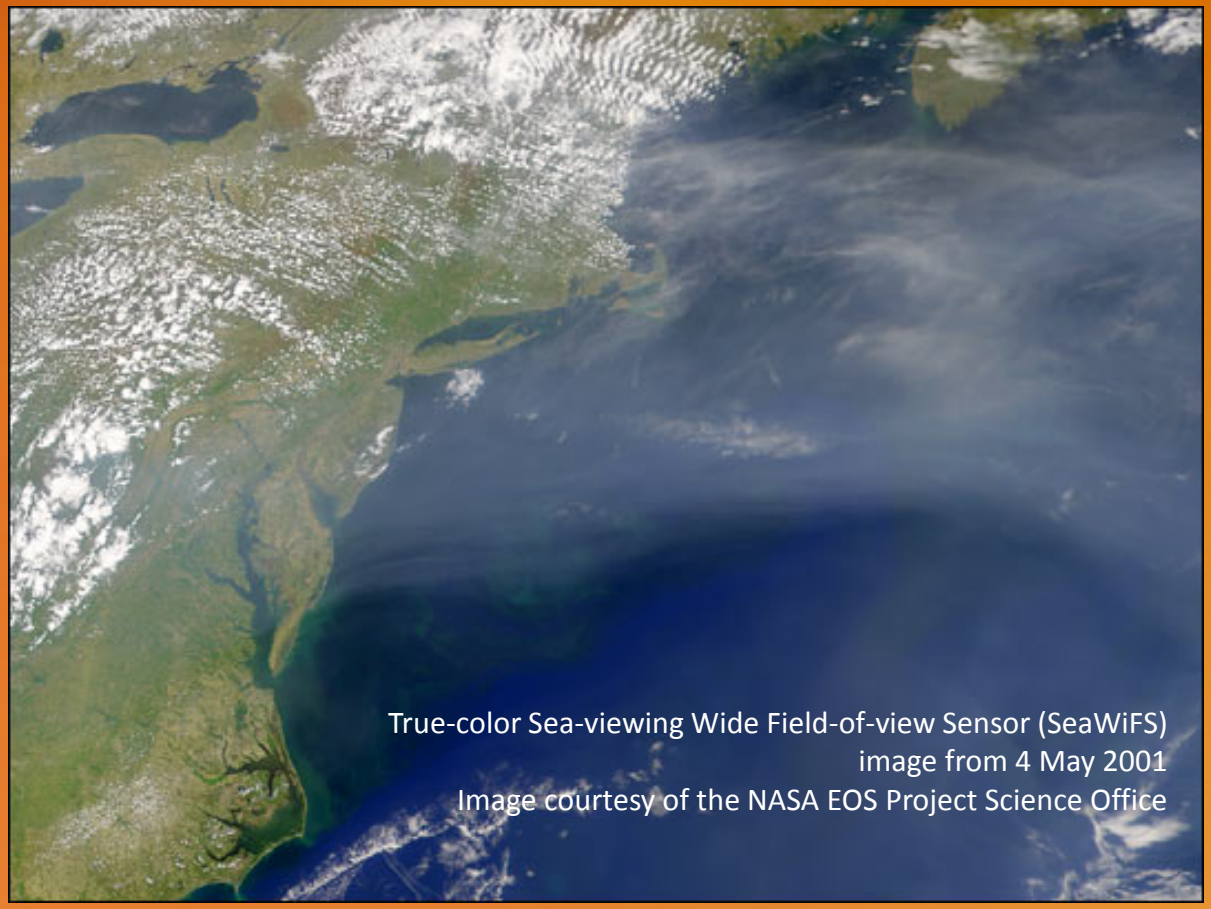

True-color Sea-viewing Wide Field-of-view Sensor (SeaWiFS) image from 4 May 2001
Image courtesy of the NASA EOS Project Science Office

Mobile Aerosol Observing System (MAOS)

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- Operational during aircraft IOPs
- Particle chemical composition
  - Mass loading (NO_3, SO_4, NH_4, Cl, Organic)
  - Composition, anions, cations, water soluble OC
  - Black carbon
- Trace gases
  - $CO/N_2O/H_2O$, SO_2, $NO/NO_2/NO_Y$, O_3
  - VOC concentration (PTR-MS)

Aerodyne Research Aerosol Chemical Speciation Monitor

Deployment of MAOS at BNL

http://www.arm.gov/sites/amf/mobile-aos

Mobile Aerosol Observing System (MAOS)

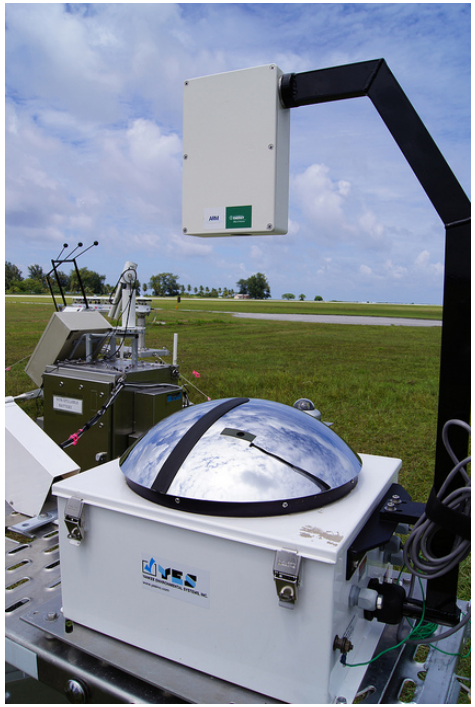
- Aerosol optical properties
  - Absorption
  - Scattering
  - Black carbon
  - Hygroscopicity—how particles grow with increasing RH
    - Two techniques: Humidified Tandem Differential Mobility Analyzer
    - Humidified scattering measurements
- Aerosol-cloud interactions
  - Cloud Condensation Nuclei Counter

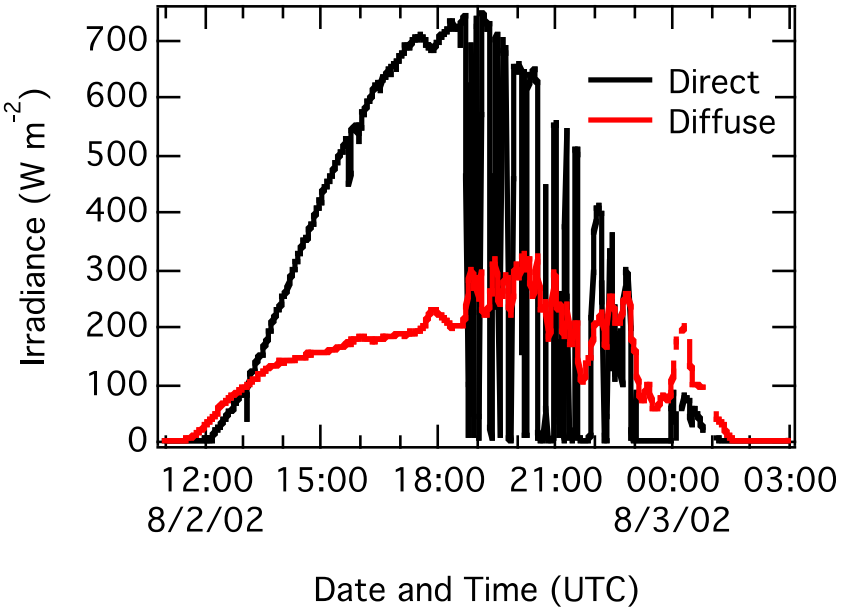
Deployment of MAOS at BNL

http://www.arm.gov/sites/amf/mobile-aos

Radiation Measurements

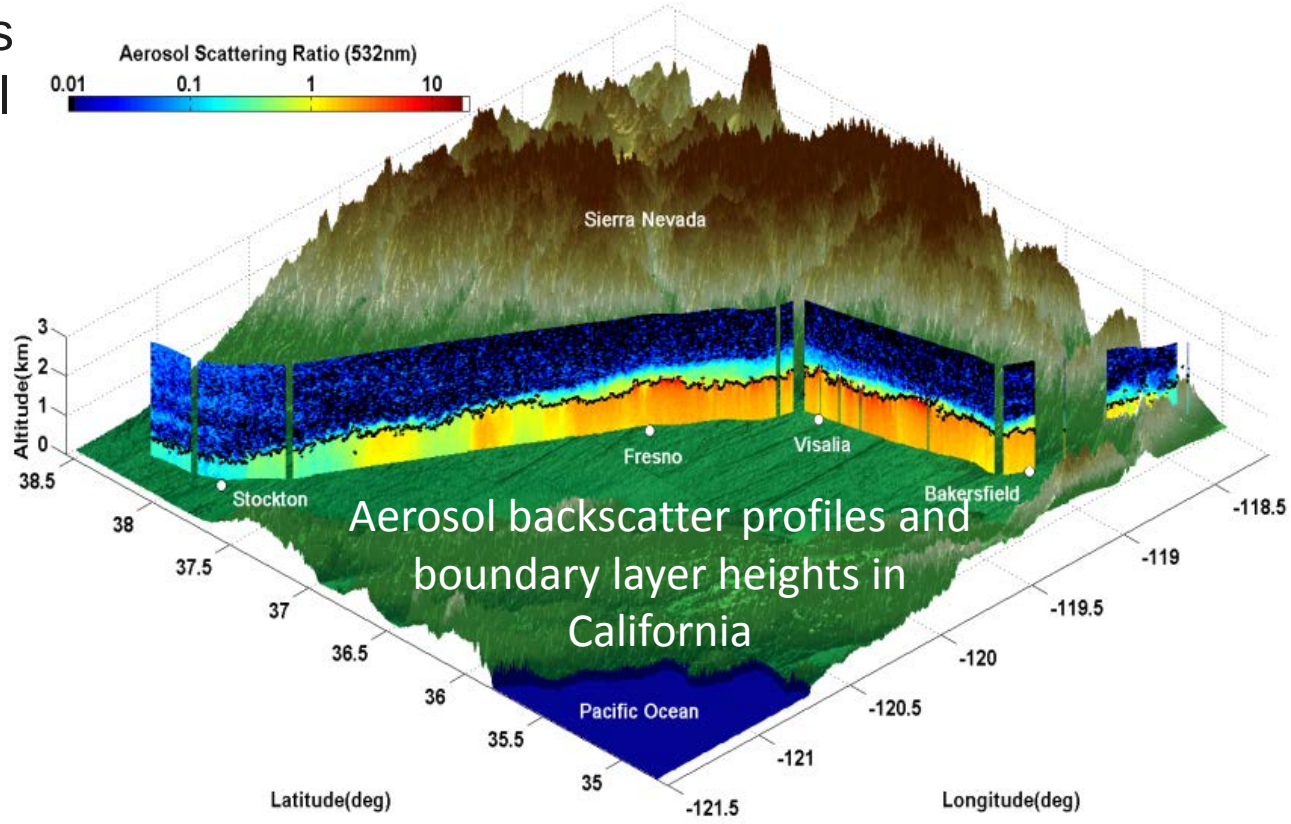
- Direct and diffuse shortwave radiation
  - Broadband and spectrally resolved
- Microwave Radiometer
  - Profiles of temperature and humidity
- Total Sky Imager
  - Cloud images





NASA High Spectral Resolution Lidar (HSRL)

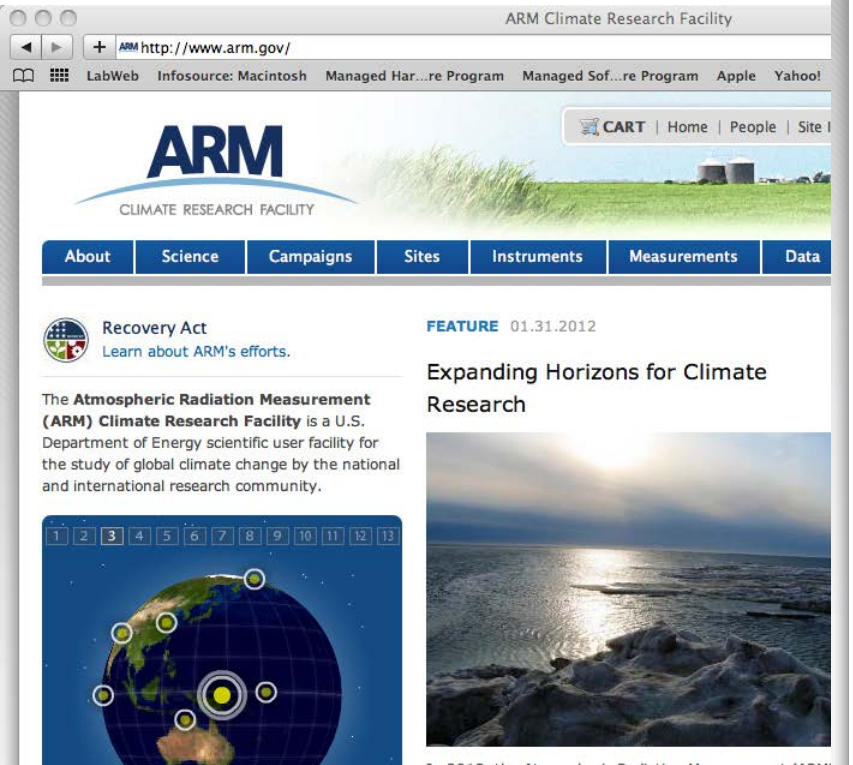
- Provides vertical context to G-1 in situ measurements
- Allows for determination of aerosol type and comparisons of AOD
- Remotely measures "curtains" of aerosol properties

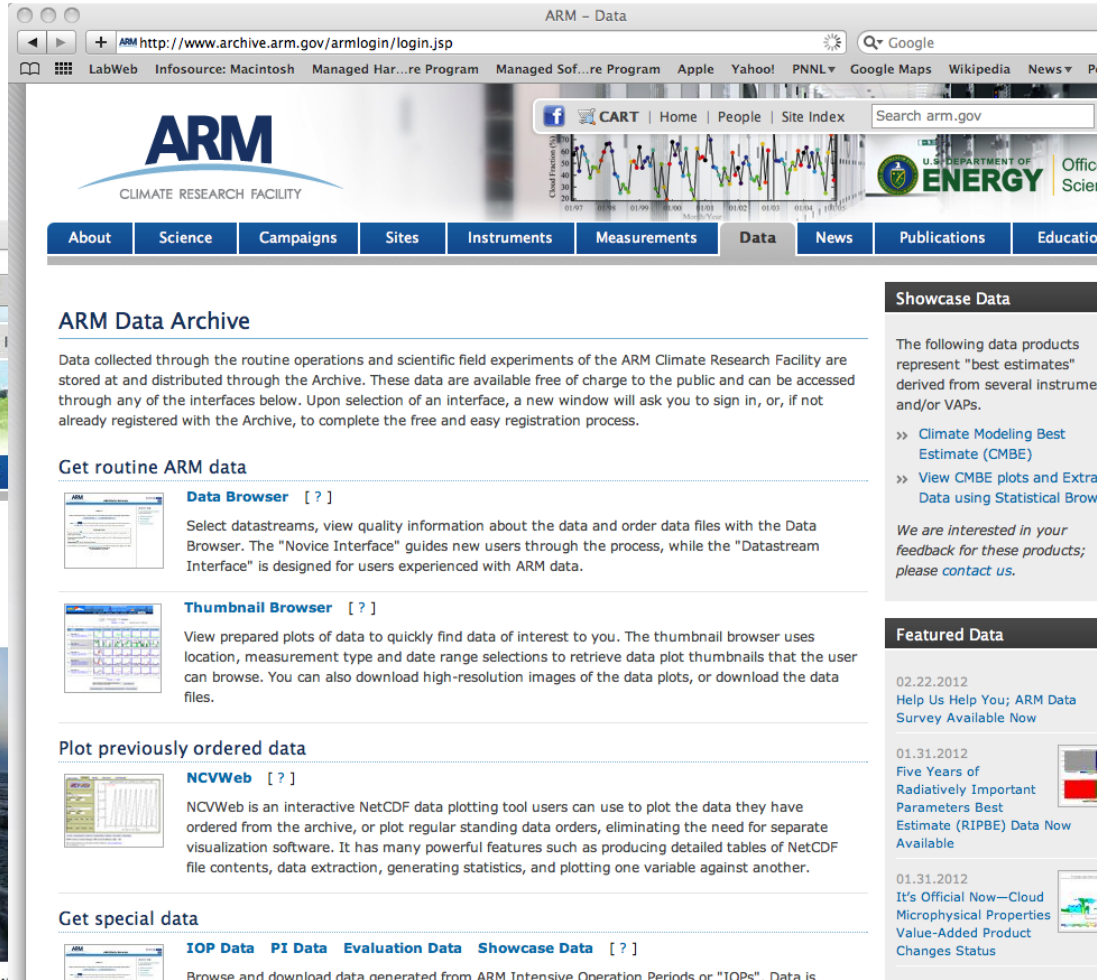


Aerosol backscatter profiles and boundary layer heights in California

Collaboration

- Data collected during ARM deployments is freely available to the public
  - Approximately 6 months delay for some data
- Maximize data use





Summary

- ARM data is freely available to everyone
- TCAP is designed to improve our understanding of cloud-aerosol-radiation interactions
- A large number of instruments will be deployed
  - Surface site
    - Particle and trace gas chemistry
    - Particle size distributions
    - Downwelling radiation
    - Cloud properties (from radar)
  - Aircraft IOPs
    - Particle and trace gas chemistry
    - Particle size distributions

Questions

- Contact Information: larry.berg@pnl.gov

Science Goal 1: CCN Chemical Closure Study

- Does size or composition matter?
- Single particle mass spectrometer
  - Details of the composition of individual particles, including mixing state
- CCN counter
- “Internal” pumped CVI (Pekour et al. 2008) downstream of CCN counter
  - Select particles that activate in the CCN counter
  - Has been applied in the lab—not yet on aircraft

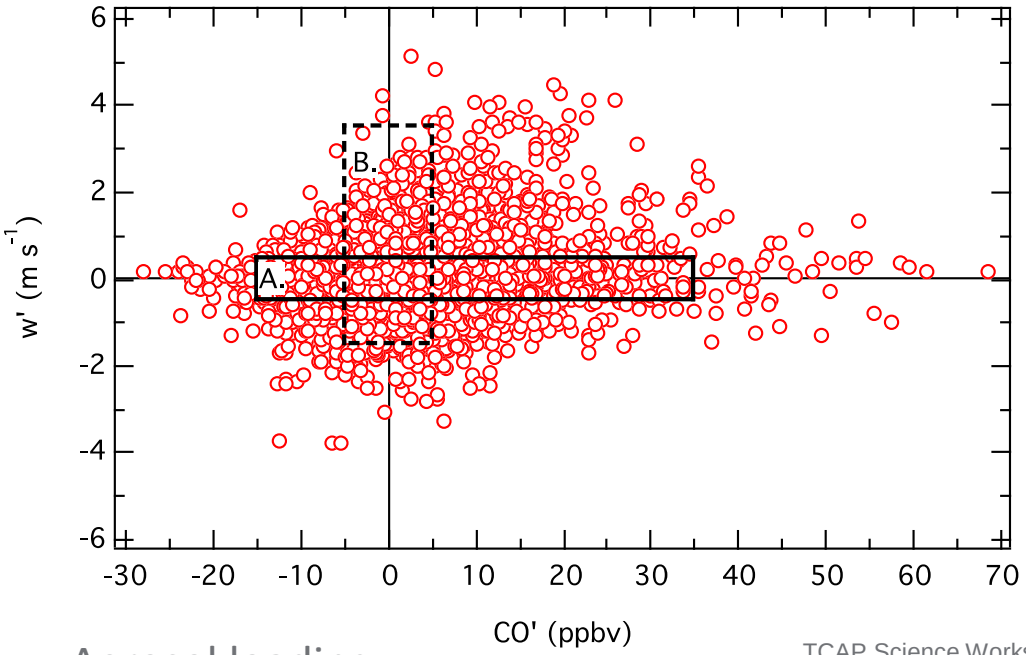
Science Goal 2: Radiative Closure

- Local Closure
  - Slab AOD measured by Spectometer for Sky-Scanning, Sun-Tracking Atmospheric Research (4STAR) will be compared to AOD estimates based on in situ aircraft measurements of:
    - scattering,
    - absorption,
    - size distribution and,
    - mixing state

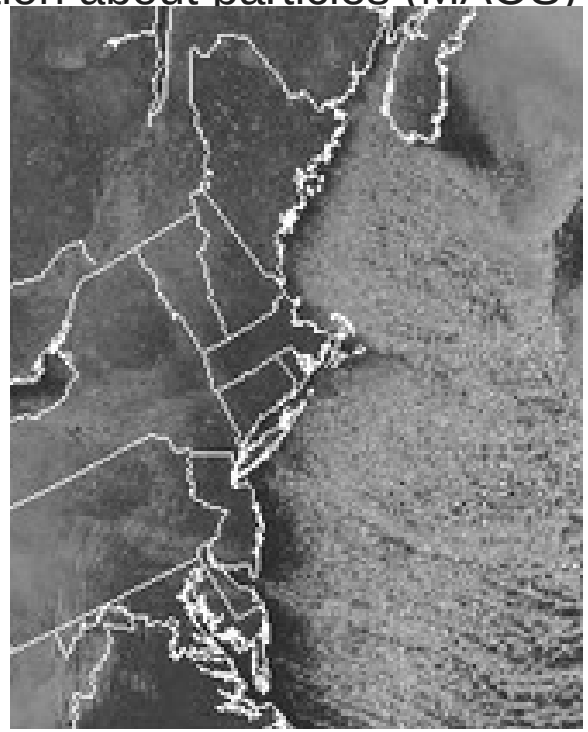
- Columnar closure
  - Experiment 1: Integrate 4STAR AOD profiles & in situ profiles and compare to AMF MFRSR
  - Experiment 2: Determine column-integrated values of SSA to SSA derived from the MFRSR

Science Goal 3: Cloud-Aerosol Interactions

- Most past studies have been of short duration
  - AMF deployment to Azores is an exception
- Extend CHAPS analysis to observations from the AMF, MAOS and G-1
  - Long time series with detailed information about particles (MAOS) and sub-cloud and cloud vertical velocity



Aerosol loading



Cold air outbreak—1/26/07

Science Goal 5: Global Modeling

- Two primary questions:
  - How well does CAM5 represent the horizontal and vertical variability of anthropogenic aerosols and their impact on extinction and AOD?
  - What are the primary factors that can be used to explain differences between CAM5 simulations of direct and indirect radiative forcing and the TCAP measurements?