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Two Column Aerosol Project (TCAP) Breakout Session

Agenda

- Review of Science Objectives
- Summary of IOPs
- Science Focus Areas
  - Aerosol Mixing State (Sedlacek and Zelenyuk)
  - Clouds (Kollias, Miller)
  - Remote Sensing of Aerosol Properties (Ferrare, Flynn, Michalsky, Volkamer)
- Discussion

Breakout Session Goal: To provide a high level overview of a subset of data products and to discuss next steps

TCAP Science Objectives

Two column, multi-season field study

- New instruments and multiple aircraft
- Year-long surface measurements

Designed to address a number of science questions:

- How do primary and secondary aerosol become internally mixed?
- What is the spectral dependence of aerosol optical properties?
- How critical is the particle chemical composition and mixing state in determining the CCN activity?
- What is the relative importance of aerosol indirect effects in maritime boundary-layer clouds?
- How do the aerosol chemical composition, mixing state, and optical properties vary seasonally?
- Can regional and global scale models accurately represent these aerosol properties?

Motivation: Space based aerosol climatology

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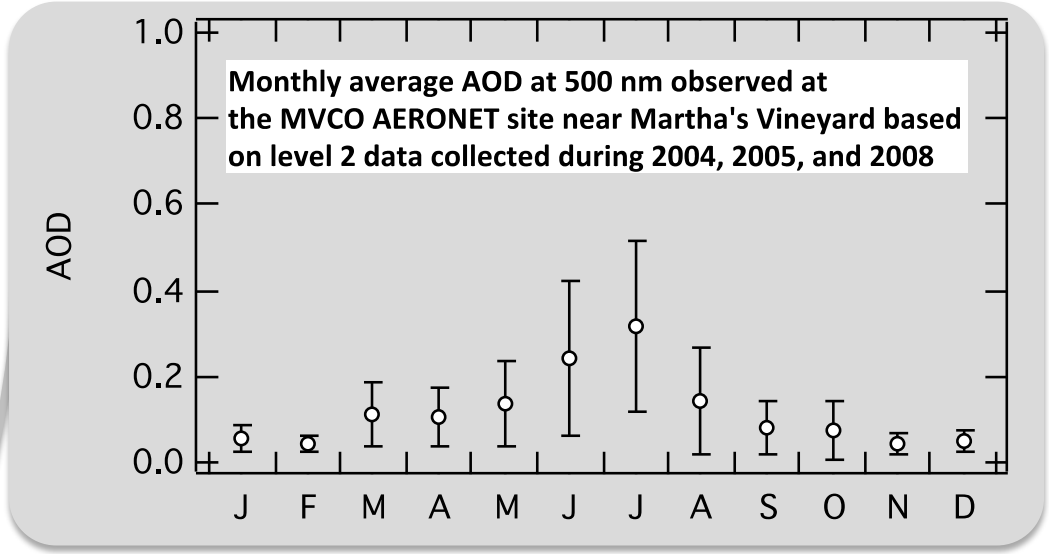
MODIS Terra Feb (2001-2010)

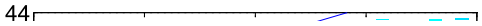
AOD
10:30

Mean AOD



Seasonal Differences

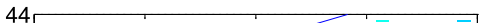
MODIS Terra Jul (2000-2010)



AOD
10:30

Mean AOD

MODIS Aqua Jul (2003-2010)



AOD
13:30

Mean AOD

Diurnal Differences

Analysis courtesy of D. Chand

TCAP: Design

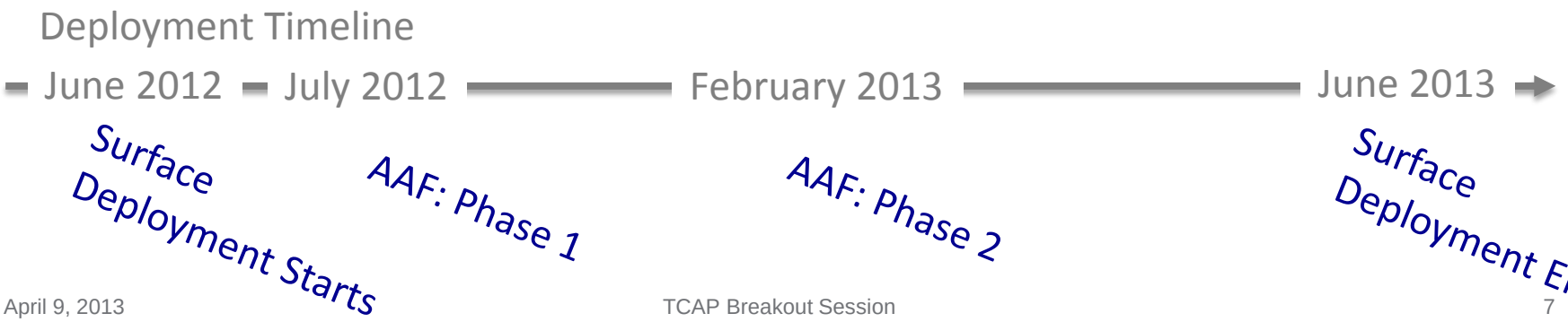
- Sample in two columns near the eastern edge of North America
  - First column fixed over Cape Cod—12 month deployment of DOE Atmospheric Radiation Measurement (ARM) Mobile Facility (AMF-including MAOS)
  - Second column moveable over the Atlantic—2 DOE ARM Aerial Facility deployments, 1 NASA deployment

TCAP IOPs

Multi-Season Study

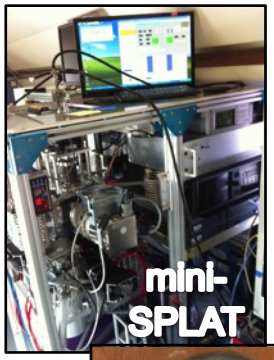
First Complementary deployment of AMF (including MAOS) and AAF

- AMF: Long-term observations with:
  - Cloud radars
  - Aerosol observing system
  - Radiometric measurements
  - Doppler Lidar
- AAF & AMF (MAOS): Short-term intensive field study
  - Detailed in-situ measurements of aerosol properties
  - Deployment of airborne remote sensors
  - MAOS operational during AAF deployment



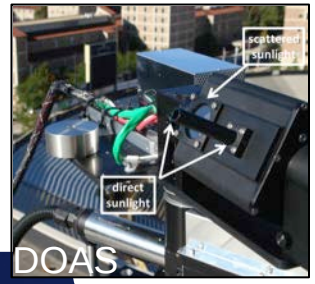
New Airborne Instruments

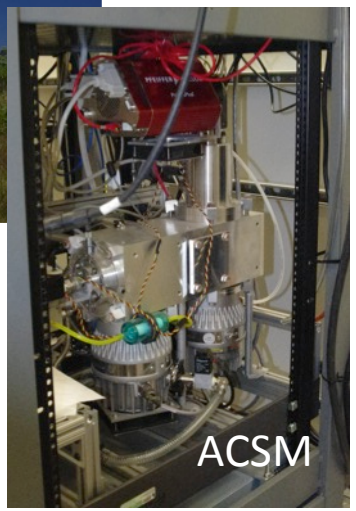
- TCAP was the first science deployment for a number of new instruments
  - Mini-SPLAT—single particle size and composition
  - NASA Spectrometers for Sky-Scanning, Sun-Tracking Atmospheric Research (4STAR)—AERONET-like capability
  - NASA High Spectral Resolution Lidar (HSRL-2)—Aerosol backscatter, extinction, depolarization, AOD (532 nm); aerosol backscatter, depolarization (1064 nm)
- Plus additional state-of-the-art instruments
  - Aerosol Mass Spectrometer—Aerosol composition
  - SP2—BC
  - PILS—Aerosol composition
  - Aerosol optical properties [scattering, absorption, f(RH)]
  - Aerosol size distribution
  - CCN
  - Research Scanning Polarimeter (RSP)
- CVI inlet



AMF Surface Instrumentation

- TCAP was the first science deployment for a number of new instruments
  - CU 2D GMAX-DOAS—Aerosol extinction, trace gases (summer)
  - MIT CCN-CVI-AMS—Composition of particles that form CCN (winter)
- Plus additional MAOS instruments
  - Aerosol Chemical Speciation Monitor (ACSM)—Aerosol composition
  - SP2—BC
  - Photoacoustic—BC
  - PILS—Aerosol composition
  - Particle size distribution
  - CCN
  - Trace gases
  - Radiation, both broad band and spectrally resolved





TCAP Flights

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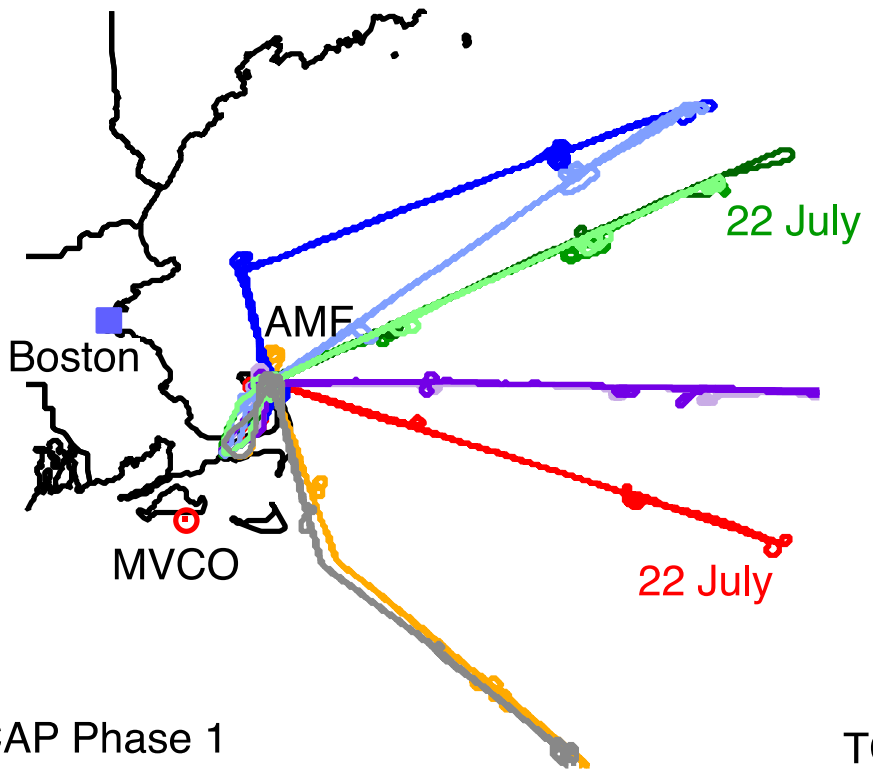
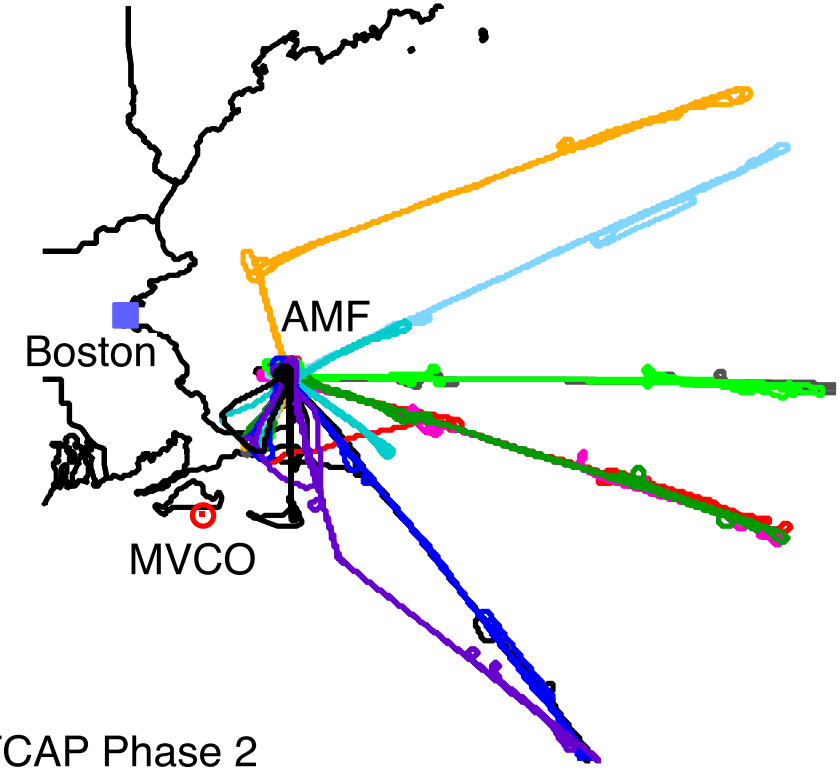
Clear air flights



TCAP Phase 1

10 Flights

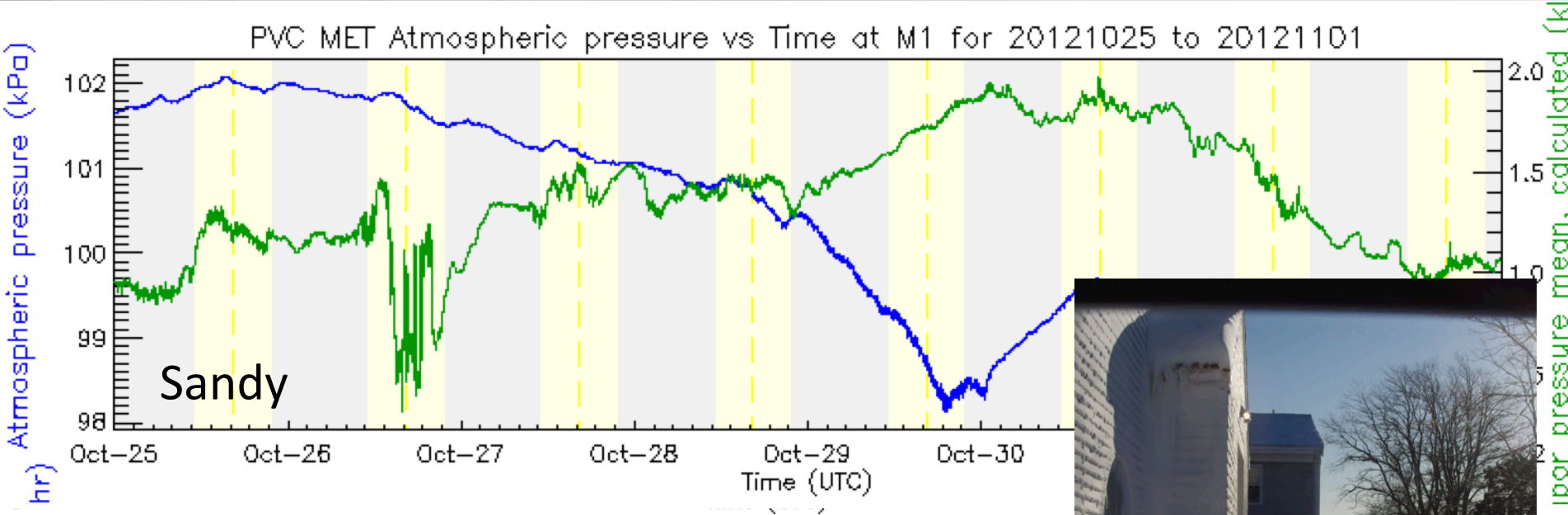
Mixture of clear air and cloudy flights
Clear: 5 Cloudy: 9



TCAP Phase 2

14 Flights

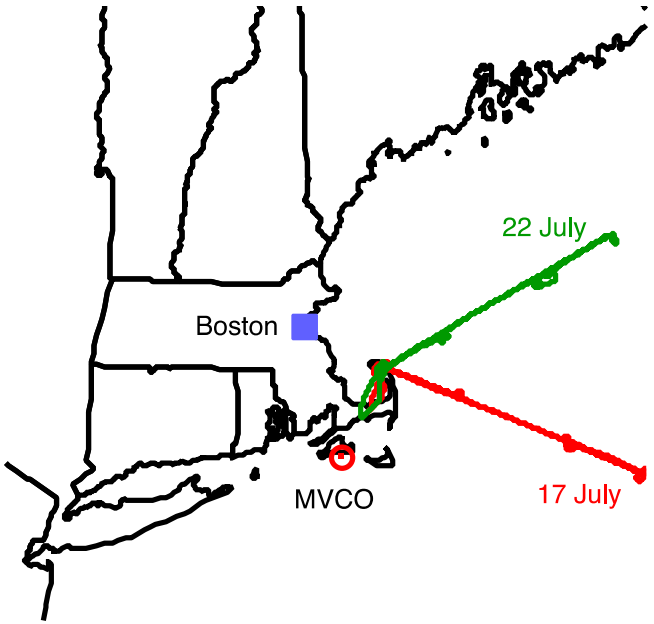
An Aside: Major Meteorological Events



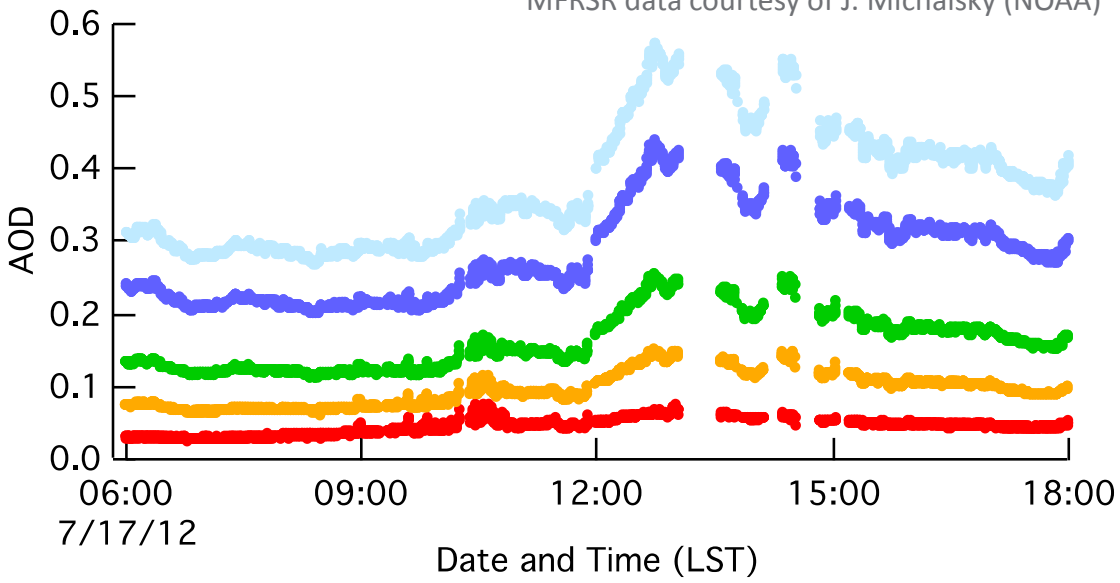
Sustained winds of 25 ms^{-1}

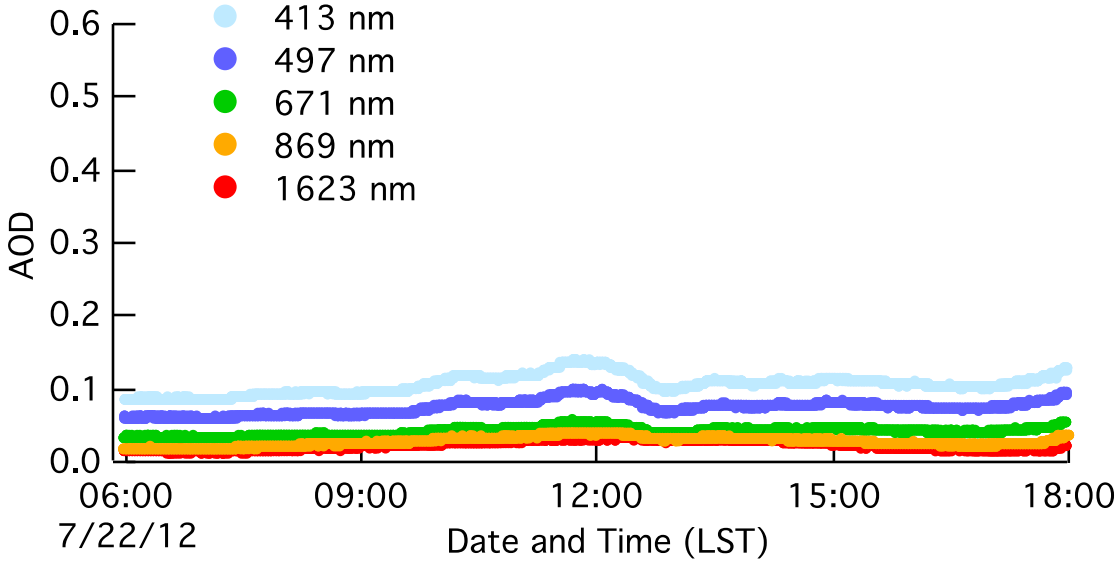
Phase 1: A tale of two days

- Two clear days were selected (no clouds over the AMF site)
- Much larger AOD on 7/17 than 7/22
  - Differences in aerosol loading or other aerosol properties?



MFRSR data courtesy of J. Michalsky (NOAA)





Phase 2: Cloud-Aerosol Interactions

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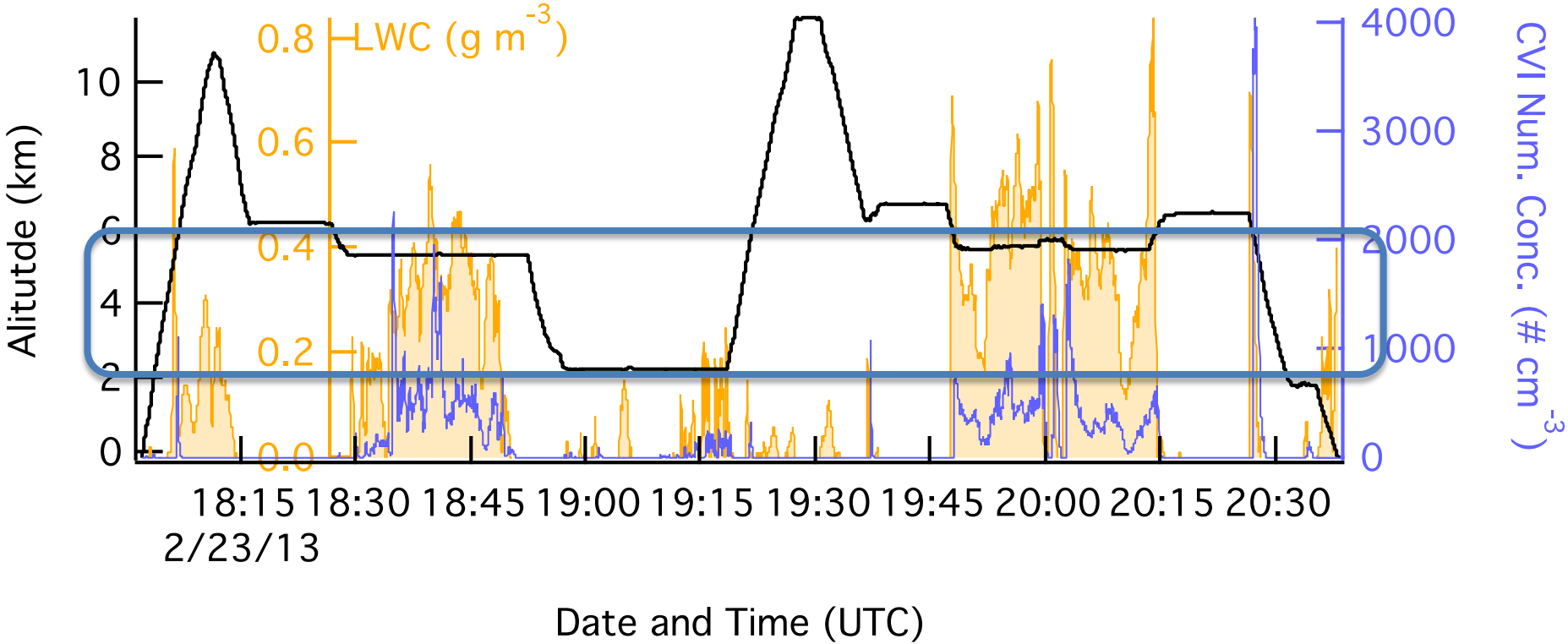
Specific Cloud-Aerosol Missions

- G-1 equipped to measure cloud microphysics during both Phase 1 and Phase 2.
- Added CVI for cloud missions
  - AMS and SPLAT switched between inlets



Thank you!

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TCAP Website—http://campaign.arm.gov/tcap/
ARM Data Archive—http://www.archive.arm.gov/

Discussion

- Planned data analysis
  - 4STAR radiative closure (Shinozuka—NASA)
  - Aerosol intensive properties (Chand—PNNL)
  - Optical closure studies (Kassinov—PNNL)
  - Investigations of aerosol mixing state
- Planned modeling studies
  - WRF-Chem (Fast—PNNL)
  - Nested modeling (Ghate/Miller—Rutgers)
- Data virtual meeting?
  - One was conducted in the fall—was it successful?

2-Line Header for New PNNL PowerPoint Presentation Template

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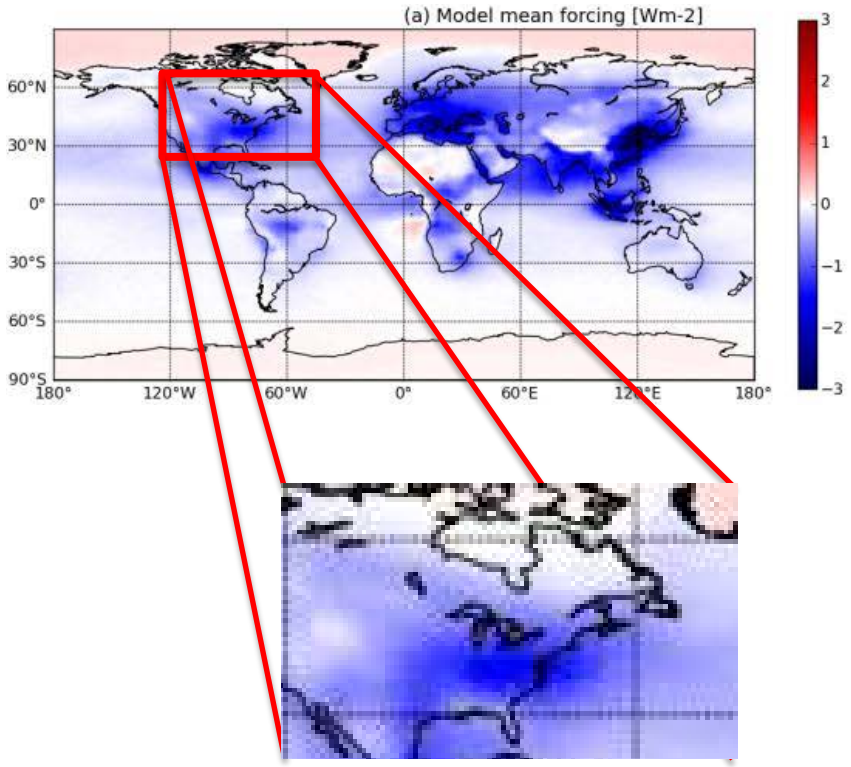
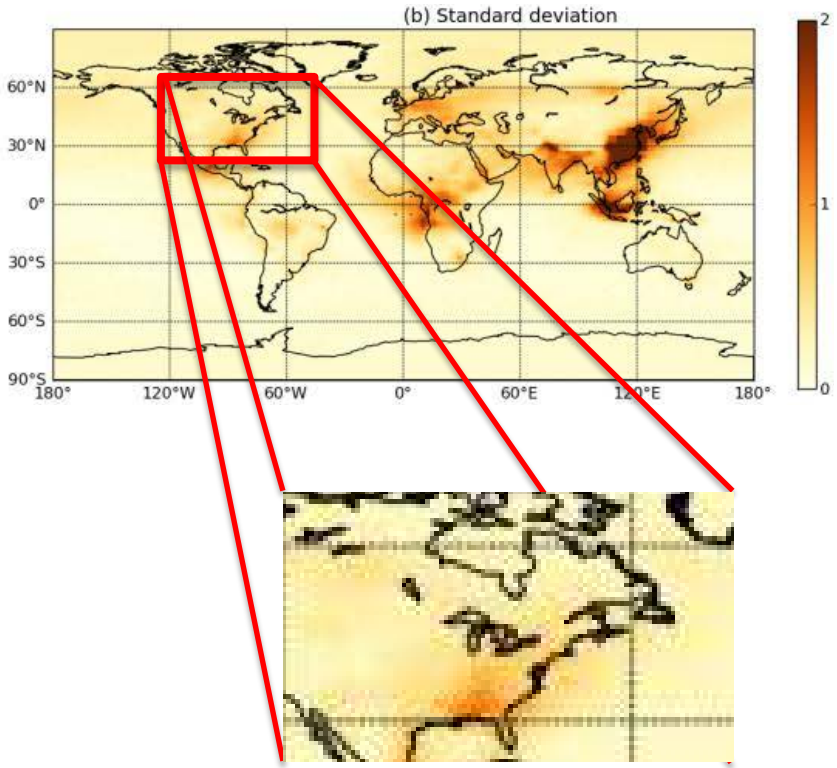
Motivation for TCAP

- Global models show a large gradient and standard deviation of AOD along the coast (e.g. AeroCom II)
- Large Standard deviation between models

Myhre et al. 2012

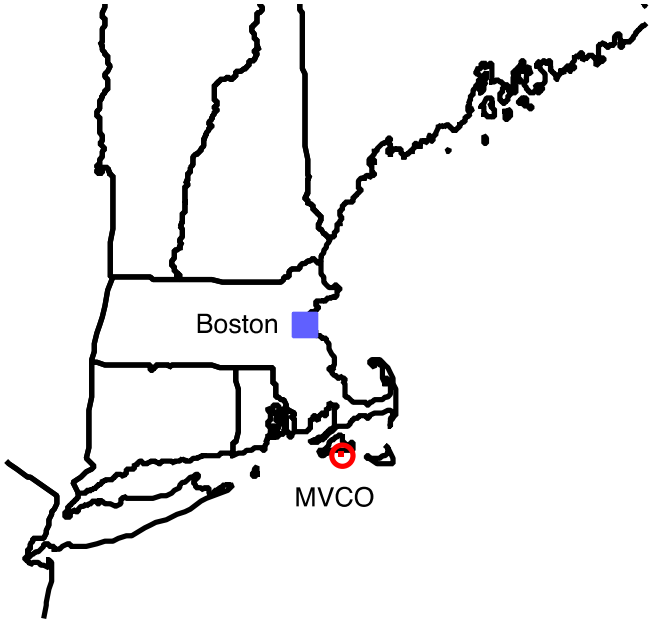


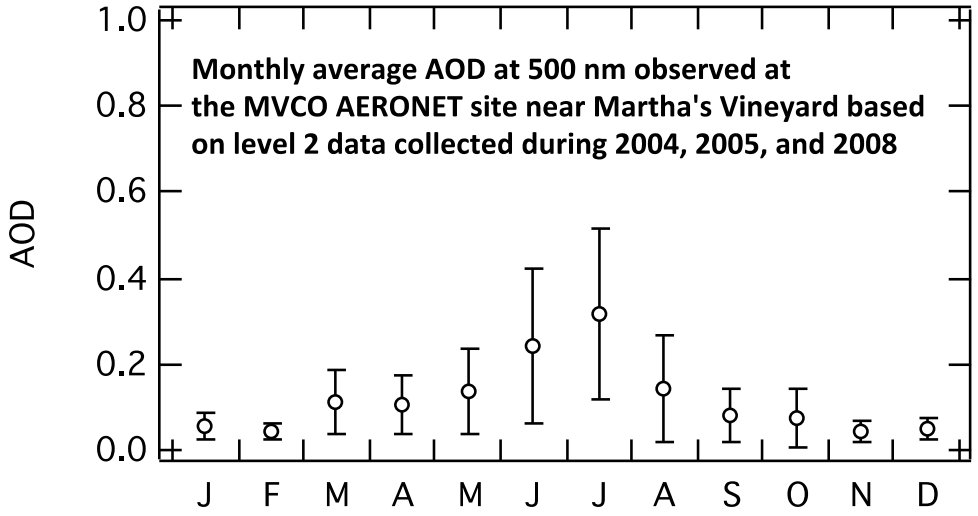


Research Need: Data to constrain models

Motivation: Surface based aerosol climatology

- AOD has a seasonal cycle
  - Related to emissions (both natural and anthropogenic) and available sunlight
- Role of near-surface vs. elevated aerosol in AOD





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Aerosol loading

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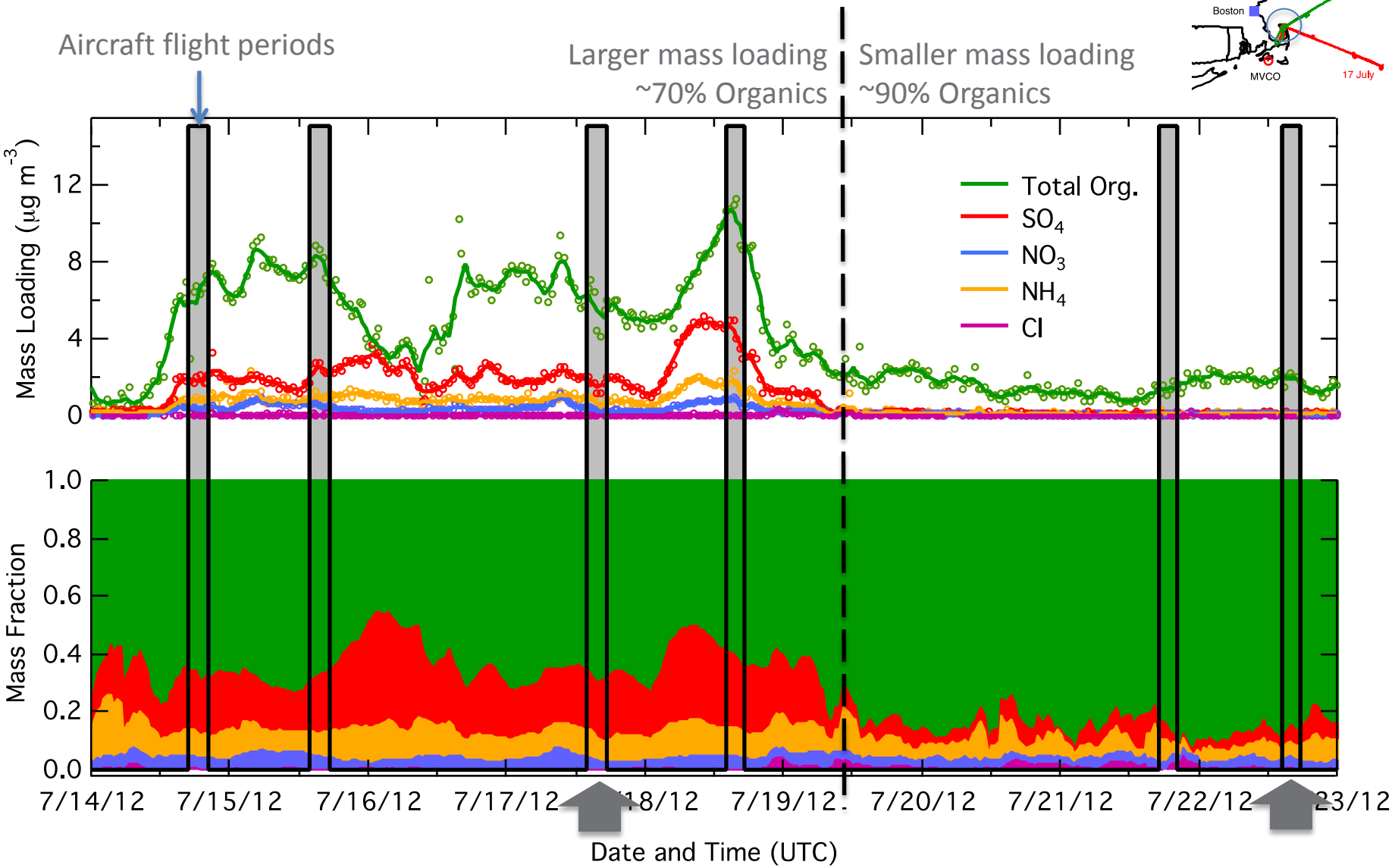
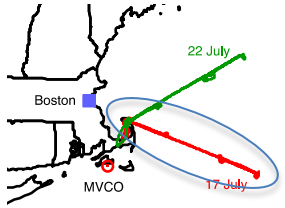
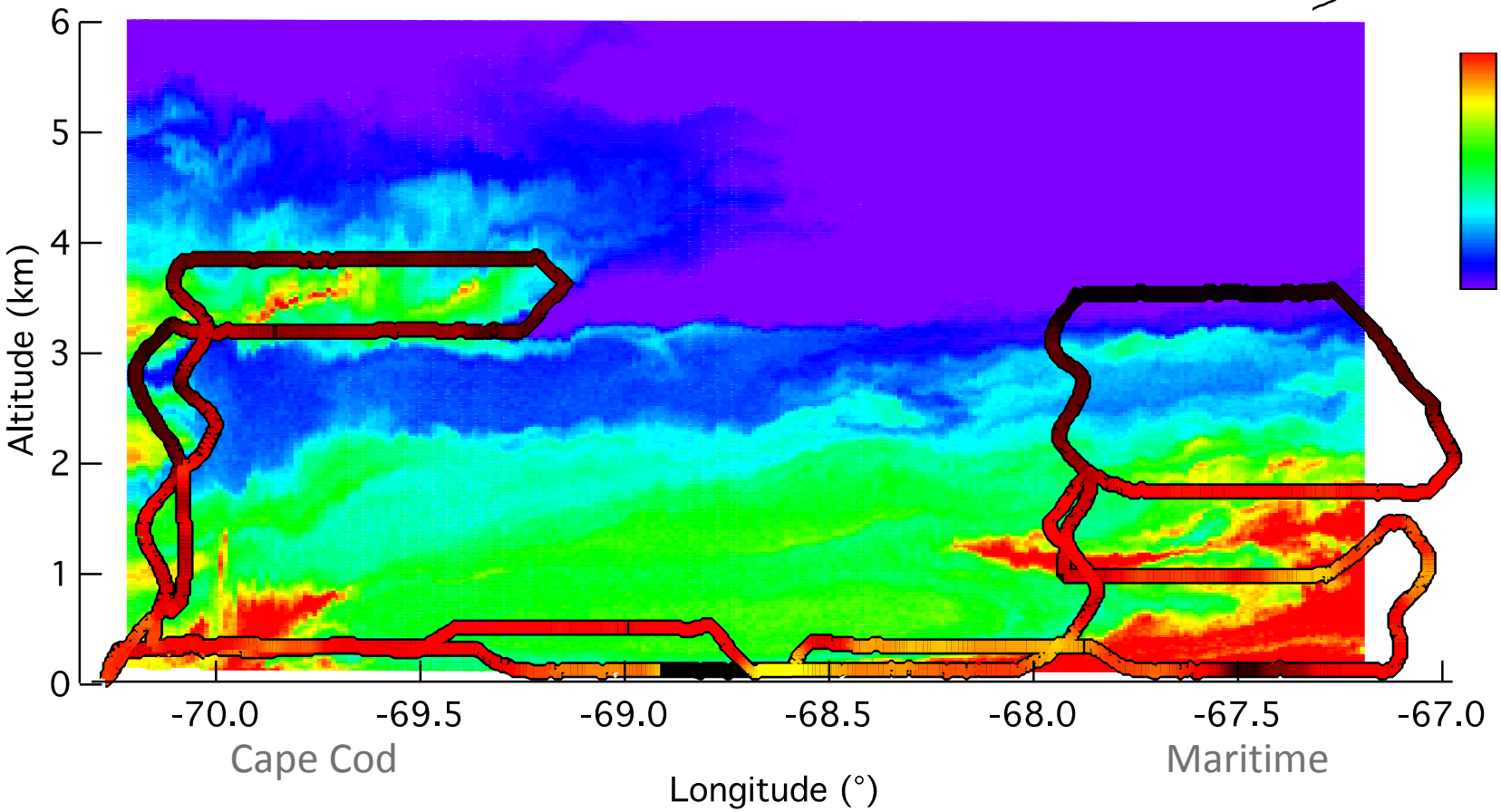
- Measurements from Aerosol Chemical Speciation Monitor



Aerosol layers: 17 July

- Deep residual layer over the ocean
- Some elevated layers aloft near Cape Cod





BC Mixing State: 17 July

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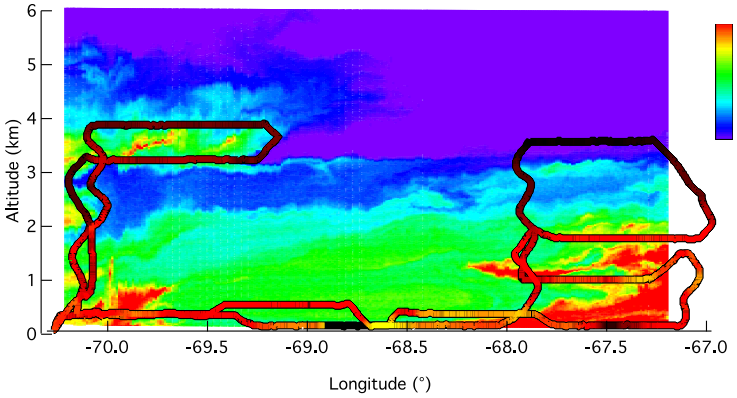
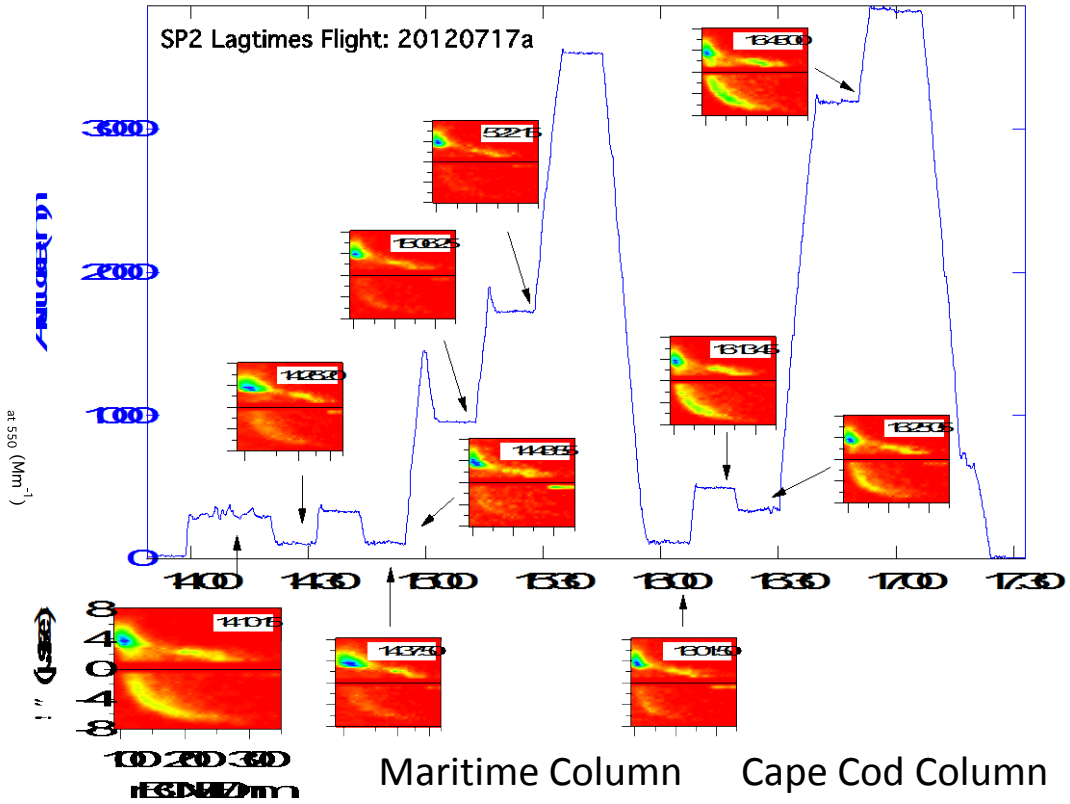
SP2

- Measures scattering and incandescence from individual particles
- Lag time ($\Delta\tau$) — time difference between peak in scattering and incandescence
  - Negative values: BC near surface



Cape Cod Column

Maritime Column

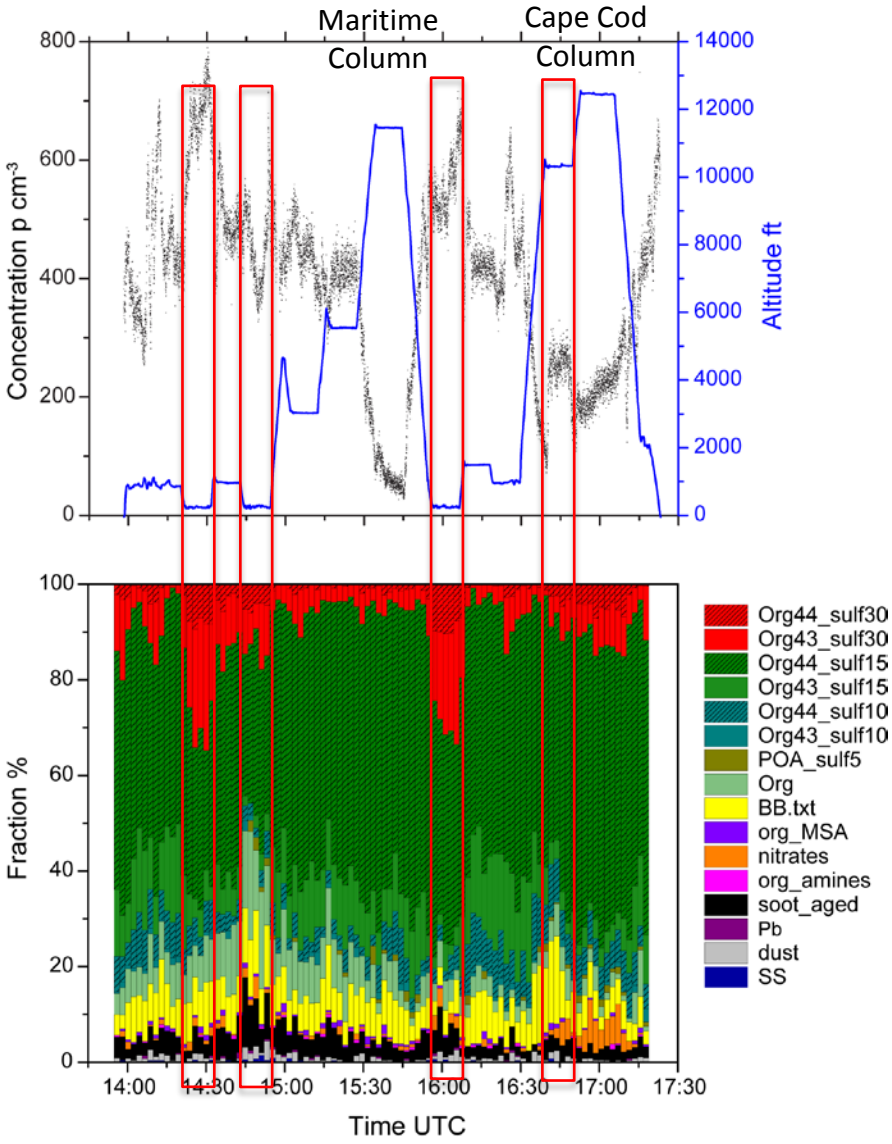


Maritime column has fewer negative values of $\Delta\tau$

Aerosol Mixing State: July 17

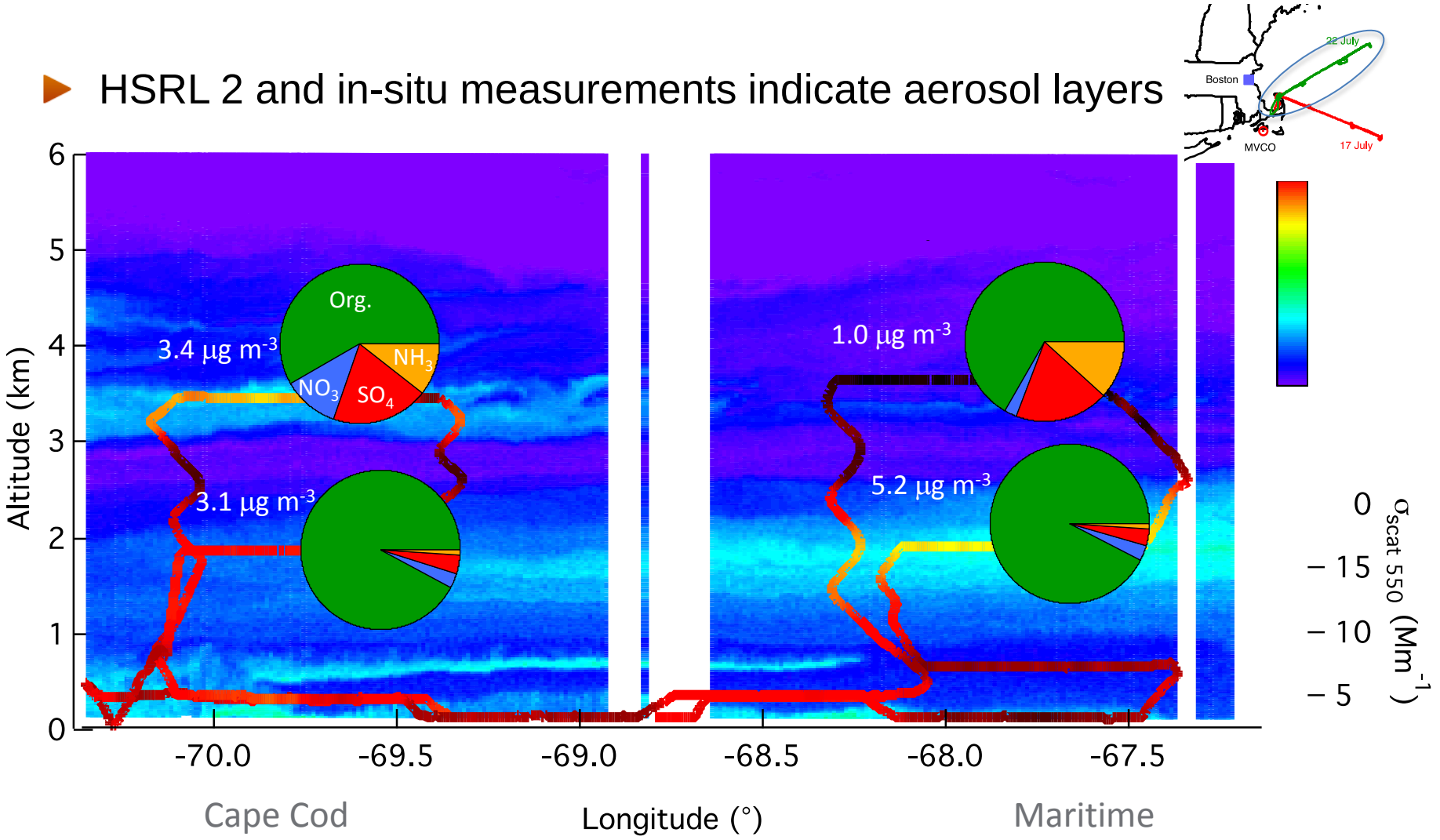
miniSPLAT

- Lower altitudes have higher fraction of sulfate mixed with the organics
- More aged soot in maritime column—consistent with SP2 measurements
- Elevated layer over over the AMF has increased biomass burning aerosol and nitrate



Aerosol layers: 22 July

- HSRL 2 and in-situ measurements indicate aerosol layers

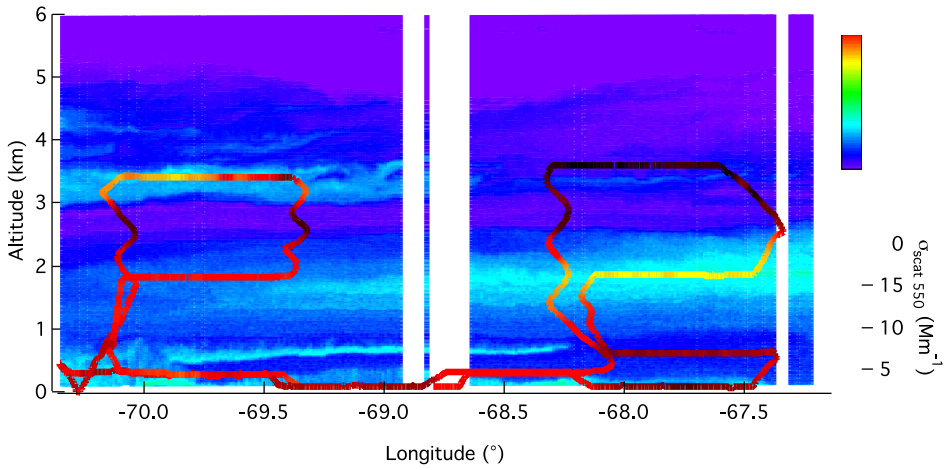


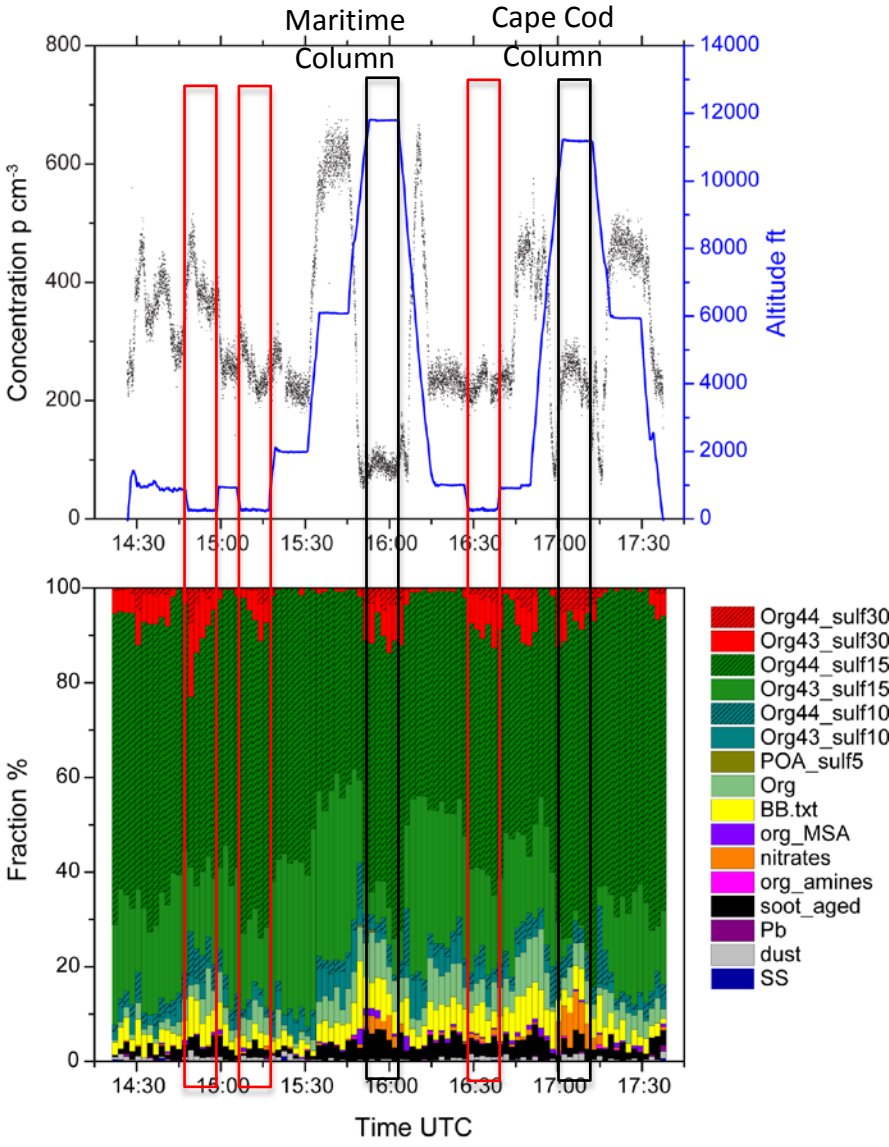
- AMS shows changes in chemical composition

Aerosol Mixing State

miniSPLAT

- Lower altitudes have higher fraction of sulfate mixed with the organics
- Elevated layer over over the AMF has increased biomass burning aerosol and nitrate





Conclusions and Future Work

- A high quality set of in situ and remote sensing data were and are being collected
  - Both IOPs have been completed
  - A wide range of aerosol loading was observed
- Case study of periods with clean and dirty conditions show a change in aerosol loading, chemical composition, mixing state, and arrangement of rBC
  - Ideal test cases for intercomparison of active and passive remote sensing techniques
  - Rigorous tests of a range of atmospheric models
- Data analysis is ongoing—radiative and CCN closure studies
- Evaluating regional and global scale models

ARM CLIMATE RESEARCH FACILITY

ASR Atmospheric System Research

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