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

Seasonal Differences

- MODIS Terra Feb (2001-2010)
  - AOD 10:30
- MODIS Terra Jul (2000-2010)
  - AOD 10:30

Diurnal Differences

- Mean AOD
- Mean AOD

Monthly average AOD at 500 nm observed at the MVCO AERONET site near Martha’s Vineyard based on level 2 data collected during 2004, 2005, and 2008

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

Deployment Timeline
- June 2012 — July 2012
- February 2013
- June 2013
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
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

Clear air flights

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

TCAP Phase 1
10 Flights

TCAP Phase 2
14 Flights
An Aside: Major Meteorological Events

PVC MET Atmospheric pressure vs Time at M1 for 20121025 to 20121101

- Sandy
  - Sustained winds of 25 ms\(^{-1}\)

PVC MET Atmospheric pressure vs Time at M1 for 20130220

- Nemo
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)
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

![Graph showing LWC and CVI concentration over altitude and time](image-url)
Thank you!

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?
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

Research Need: Data to constrain models

Myhre et al. 2012
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
3-Line (or more) Header for New PNNL PowerPoint Template / Full-Color Background (if supported by content)
Aerosol loading

Measurements from Aerosol Chemical Speciation Monitor

- Larger mass loading ~70% Organics
- Smaller mass loading ~90% Organics

Aircraft flight periods

Date and Time (UTC)
Aerosol layers: 17 July

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

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

April 9, 2013 TCAP Breakout Session
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

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