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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?**



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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

#### **Preliminary Research: Why Cape Cod?**



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# **Preliminary Research: Why Cape Cod?**

#### Large variations in the magnitude of predicted aerosol forcing



Pacific Northwest

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Large variation in the magnitude of predicted aerosol forcing





### **Preliminary Research: Aerosol Climatology-July**

Pacific Northwest NATIONAL LABORATORY Preliminary Research: Aerosol Climatology-Feb. Pacific Northwest

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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**



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- 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

ASR Science Team 2012 TCAP Breakout

### **Cloud Radars**



#### New cloud radars

Scanning cloud radars provide unprecedented information about the spatial distribution of clouds

Image courtesy of Pavlos Kollias

Example from AMF deployment in the Azores





### **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





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



### **AMF/MAOS Site**



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#### **Discussion**



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# **AMF 1 Instruments**



- □ 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?

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- 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





Berkowitz et al. 2011

Third Conference on Weather, Climate, and the New Energy Economy



### **Atmospheric Aerosol—Images from Space**

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#### 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

isor (SeaWiFS) m 4 May 2001 Science Office

# Why Do We Care?



MODIS



- 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)



MO\_MI\_GO

-30 -20 -15 -10 -8 -6 -4 -2 0 5 Wm<sup>-1</sup>

# 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



### **Science Goal 4: High Resolution Modeling**

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- 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



# **The Two-Column Aerosol** Pacific Northwes **Project (TCAP): Measurements**





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# **Mobile Aerosol Observing System (MAOS)**



- Particle chemical composition
  - Mass loading (NO<sub>3</sub>, SO<sub>4</sub>, NH<sub>4</sub>, CI, Organic)
  - Composition, anions, cations, water soluble OC
  - Black carbon
- Trace gases
  - CO/N<sub>2</sub>O/H<sub>2</sub>O, SO<sub>2</sub>, NO/NO<sub>2</sub>/NO<sub>Y</sub>, O<sub>3</sub>
  - VOC concentration (PTR-MS)



Pacific Northw

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Aerodyne Research Aerosol Chemical Speciation Monitor



Deployment of MAOS at BNL

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

TCAP Science Workshop

# **Mobile Aerosol Observing System (MAOS)**



- 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

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### **Radiation Measurements**



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









Date and Time (UTC)

TCAP Science Workshop

#### March 7, 2012

#### TCAP Science Workshop



Pacific Northwes

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### **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



#### Collaboration

Learn about ARM's efforts.

The Atmospheric Radiation Measurement

(ARM) Climate Research Facility is a U.S.

and international research community.

Department of Energy scientific user facility for

the study of global climate change by the national



- Data collected during ARM deployments is freely available to the public
  - Approximately 6 months delay for some data
- Maximize data use 000 ARM Climate Research Facility About 4 + AMM http://www.arm.gov/ LabWeb Infosource: Macintosh Managed Har...re Program Managed Sof...re Program Apple Yahoo! CART | Home | People | Site | ARM and the second s CLIMATE RESEARCH FACILITY Campaigns Sites Data About Science Instruments Measurements FEATURE 01.31.2012 **Recovery Act**

Research



#### ARM Data Archive

Data collected through the routine operations and scientific field experiments of the ARM Climate Research Facility are stored at and distributed through the Archive. These data are available free of charge to the public and can be accessed through any of the interfaces below. Upon selection of an interface, a new window will ask you to sign in, or, if not already registered with the Archive, to complete the free and easy registration process.

#### Get routine ARM data

#### Data Browser [?]



Select datastreams, view quality information about the data and order data files with the Data Browser. The "Novice Interface" guides new users through the process, while the "Datastream Interface" is designed for users experienced with ARM data.

#### Thumbnail Browser [?]

View prepared plots of data to quickly find data of interest to you. The thumbnail browser uses location, measurement type and date range selections to retrieve data plot thumbnails that the user can browse. You can also download high-resolution images of the data plots, or download the data files

#### Plot previously ordered data

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1.0	

#### NCVWeb [?]

NCVWeb is an interactive NetCDF data plotting tool users can use to plot the data they have ordered from the archive, or plot regular standing data orders, eliminating the need for separate visualization software. It has many powerful features such as producing detailed tables of NetCDF file contents, data extraction, generating statistics, and plotting one variable against another.

#### Get special data



#### IOP Data PI Data Evaluation Data Showcase Data [?]

load data generated from ARM Intensive Operation Periods or "IOPs". Data is

#### Showcase Data

The following data products represent "best estimates" derived from several instrume and/or VAPs.

- >> Climate Modeling Best Estimate (CMBE)
- >> View CMBE plots and Extra Data using Statistical Brow

We are interested in your feedback for these products; please contact us.

#### Featured Data

02.22.2012 Help Us Help You; ARM Data Survey Available Now



#### **Five Years of** Radiatively Important Parameters Best Estimate (RIPBE) Data No Available

01.31.2012 It's Official Now-Cloud **Microphysical Properties** Value-Added Product Changes Status



Expanding Horizons for Climate

#### Summary



- ARM data is freely available to everyone
- TCAP is designed to improve our understanding of cloud-aerosolradiation 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



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#### 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





- 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





Cold air outbreak—1/26/07



#### 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?