The Two Column Aerosol Project “TCAP”

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The Goal

- To reduce modeling uncertainty associated with the numerical treatment of aerosol transformation and cloud-aerosol interactions in large-scale models.

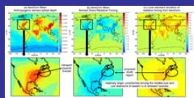
A simple flight plan, in conjunction with deployment of the AMF and MAOS is proposed to provide measurements that will meet the goals of investigators having a common interest in radiative forcing and aerosols.

We look forward to working with others in the ASR and broader scientific community to achieve these goals.

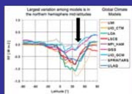
Panel 1

Relevance to U.S. Climate Science

- Regions with the highest anthropogenic emissions also have the highest aerosol loading and consequently the greatest cooling associated with aerosol radiative forcing.
- There are large variations in magnitude of the predicted aerosol radiative forcing



Schultz et al. (2006) presented a comparison of several general circulation model predictions of aerosol radiative forcing, illustrating the need to focus on measuring aerosol properties off the eastern coast of North America. As expected, regions with the highest anthropogenic emissions also have the highest aerosol loading (far left panel) and consequently the greatest cooling (center panel). The models produce a gradual decrease in AOD and aerosol radiative forcing over the northeastern Atlantic Ocean as particles are transported eastwards towards Europe. However, there are relatively large variations in the magnitude of the predicted aerosol radiative forcing in this region (right panel).

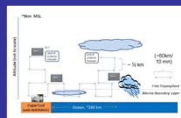


The mid-latitudes (including the TCAP study region) have the largest variations of forcing among the climate models.

Panel 2

Campaign Logistics

- One year deployment of ARM Mobile Facility (AMF) and the Mobile Aerosol Observing System (MAOS) on Cape Cod (MA) starting summer 2012
  - Objective: to quantify aerosol properties, radiation and cloud characteristics at a location subject to both clear- and cloud-conditions, and clean- and polluted conditions.
- Sampling during two aircraft intensive operation periods (IOPs)
  - One in the summer, a second in the winter
  - The summer IOP is designed to characterize particle composition during warm, photochemically active, relatively cloud-free periods of the year while the winter or early spring IOP is intended to characterize particle composition during cloudy, less photochemically active periods having a different mix of emissions than in the summer.
  - Sampling in two columns



Panel 3

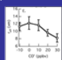
Science Goals 1-3

1. CCN Chemical Closure Study : Dan Cziczo, Barbara Ervens, Rahul Zaveri and Alla Zelenyuk
   - ✓ *This study will make extensive use of data single particle mass spectrometer, sequentially sampling ambient air through a counterflow virtual impactor and isokinetic line at different altitudes as the aircraft transits from the column over Cape Cod to the maritime column (see bottom figure, Panel 3).*
2. Local Radiation Closure Study: Evgueni Kassianov, Connor Flynn and Rahul Zaveri
   - ✓ *The slab-AOD will be defined from differences in the direct-beam irradiance (from ‘4STAR’; see Panel 6) that will then be compared with estimates based on in situ aircraft measurements of the aerosol scattering and absorption coefficients and measured particle size distributions, mixing state and shape to be provided by single particle mass spectrometer*
3. Columnar Radiation Closure Study): Evgueni Kassianov, Connor Flynn
   - ✓ *One experiment will integrate profiles of AOD measured by 4STAR (see Panel 6) and in situ instruments over the vertical domain of the aircraft flight path and compare these to the integrated values of AOD measured by the ARM Mobile Facility Multi-filter Rotating Shadowband Radiometer.*
   - ✓ *A second experiment will determine the column-integrated values of single scattering albedo (SSA) by weighting the individual values of SSA with measured profiles of the extinction coefficient, and contrast these column integrated values with values provided by the MFRSR.*

Panel 4

Science Goals 4-6

4. Cloud- Aerosol Interactions: Larry Berg, Carl Berkowitz
   - ✓ *Past studies of aerosol indirect effects have all been of short duration to investigate a specific cloud type. Here, we plan to extend the analysis done during the CHAPS campaign to look at a number of indirect aerosol effects, e.g., changes in the effective cloud droplet radius as a function of pollution level.*



Measured change in effective cloud droplet radius as a function of pollution loading with relatively fixed w’, during the ASR/ASP 2007 CHAPS campaign. From Berg et al, 2011.

5. High Resolution Modeling of the Measurements: Jerome Fast, Rahul Zaveri
   - ✓ *WRF-chem and the Aerosol Modeling Testbed (Fast et al., 2010) will be used to simulate the evolution of aerosols and their effect on CCN and aerosol direct and indirect radiative forcing, with an emphasis on how radiative forcing within the two TCAP columns were affected by secondary organic aerosols, aerosol mixing state and grid-resolution.*
   - ✓ *Measurements from the mass spectrometer, single particle mass spectrometer, and SP2 (see Panel 6) will be used to quantify aerosol mixing state of over the western North Atlantic Ocean and these used to evaluate a model recently developed at PNNL that describes the evolution of aerosol mixing state (Zaveri et al, 2011).*
6. Global-Climate Scale Modeling of the Measurements: Phil Rasch
   The CAM5 model will be used to address the following 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 to explain differences between the CAM5 simulations of aerosol direct radiative forcing/cloud-aerosol interactions and the TCAP measurements?*

Panel 5

Anticipated Measurements
(a partial list)

- From the ARM Mobile Facility/MAOS
  - ✓ *Measurements will describe annual cycle of aerosol mixing state, aerosol optical properties, cloud macroscale and microscale properties, and radiation, and cycle of columnar AOD in both clear and partly-cloud conditions during both clean and polluted periods. CO will also be measured at the site.*
- From an airborne platform (to include):
  - ✓ *Size, internal composition of particles (50 nm to 3 µm) for both refractory and non-refractory aerosol fractions in each particle. Sampling rates of up to 2000 particles per second with chemical characterization of ~20-50 particles/sec. Also provides information aerosol number concentration, and asphericity.*
  - ✓ *Size spectra, cloud droplets and precipitation (CAPS probe)*
  - ✓ *sun-tracking/sky-scanning photometer (“4STAR”) which measures the optical depth from the altitude of the aircraft to the top of the atmosphere. (see Russell et al, 2009)*
  - ✓ *Particle in Liquid Sampler (PILS)*
  - ✓ *Aerosol optical absorption via phothermal interferometry (see Sedlacek, 2006, Sedlacek & Lee, 2007)*

Panel 6

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