

## **Understanding the Effect of Aerosol Properties on Cloud Droplet Formation during TCAP Field Campaign Report**

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May 2016

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## Acronyms and Abbreviations

AMF	ARM Mobile Facility
AMS	Aerosol Mass Spectrometer
AMT	Aerosol Modeling Testbed
ARM	Atmospheric Radiation Measurement Climate Research Facility
ASR	Atmospheric System Research program
CCN	cloud condensation nucleation
DOE	U.S. Department of Energy
MAOS	Mobile Aerosol Observing System
PCVI	pumped counterflow virtual impactor
SMPS	Scanning Mobility Particle Spectrometer
TCAP	Two-Column Aerosol Project

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## 1.0 Overview

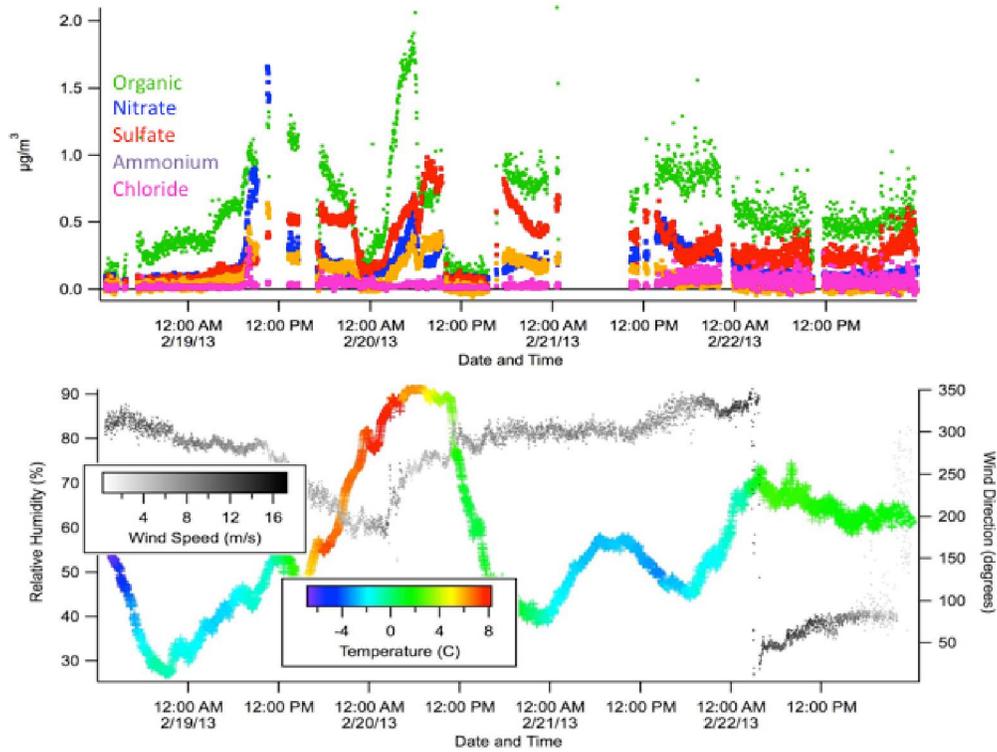
The formation of clouds is an essential element in understanding the Earth's radiative budget. Liquid water clouds form when the relative humidity exceeds saturation and condensed-phase water nucleates on atmospheric particulate matter. The effect of aerosol properties such as size, morphology, and composition on cloud droplet formation has been studied theoretically as well as in the laboratory and field. Almost without exception these studies have been limited to parallel measurements of aerosol properties and cloud formation or collection of material after the cloud has formed, at which point nucleation information has been lost. Studies of this sort are adequate when a large fraction of the aerosol activates, but correlations and resulting model parameterizations are much more uncertain at lower supersaturations and activated fractions.

## 2.0 Technical Approach and Research Objectives

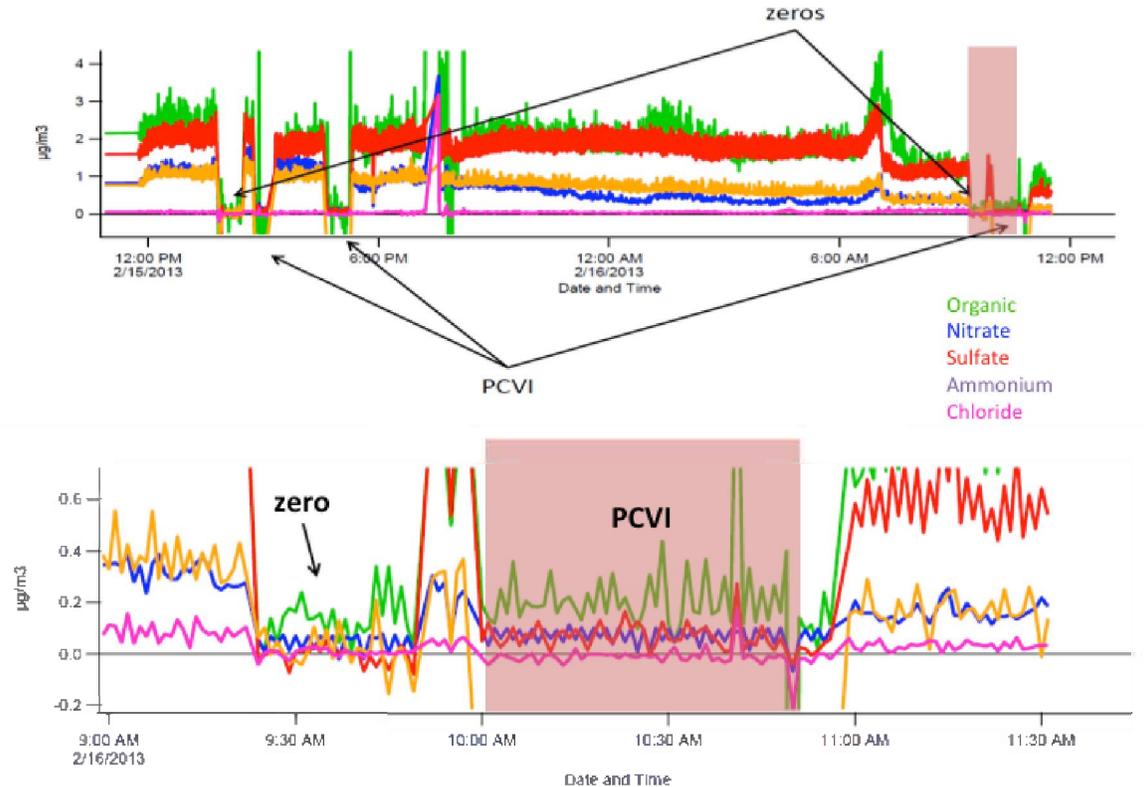
To determine the effect of aerosol properties on cloud droplet formation, we participated in the U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) Climate Research Facility's Two-Column Aerosol Project (TCAP). We combined a Cloud Condensation Nucleation (CCN) chamber with a pumped counterflow virtual impactor (PCVI) to separate droplets formed as a function of saturation and temperature from the un-activated aerosol in our laboratory. The composition of the droplet-forming aerosol was then determined with a PCVI to separate droplets formed as a function of saturation and temperature from the un-activated aerosol in our laboratory. The composition of the droplet-forming aerosol was then determined with an Aerosol Mass Spectrometer (AMS; Aerodyne Research, Inc., Billerica, Massachusetts). This laboratory method has been described in two recent publications (Slowik et al. 2007, Hiranuma et al. 2013; see also ARM, 2010), but to our knowledge, this was the first field study using this technique. A sum of \$24,699 was requested for this project; this was predominantly for travel/shipping, a rental trailer for instrument installation, and connection hardware to acquire sample from the Mobile Aerosol Observing System (MAOS).

## 3.0 Results

Data were successfully collected during the winter, 2013, portion of TCAP. Figure 1 details the chemical composition from the AMS instrument referenced to meteorological data from MAOS. Figure 2 shows a breakout of PCVI data where AMS was used to directly measuring the chemistry of the droplet-forming fraction of the ambient aerosol.



**Figure 1.** Aerosol mass loading, as determined by an AMS, during a portion of the TCAP study (upper panel). Individual species are color-coded according to the legend. Local meteorological parameters (wind speed, intensity, temperature, and relative humidity) from an ARM Mobile Facility (AMF) are shown in the lower panel. Note the common flow from the northwest. These data are currently preliminary and unpublished.



**Figure 2.** Upper panel: a period of the TCAP study where the AMS sampled from both the ambient aerosol and the CCNC-PCVI. Lower panel: expansion of the shaded region in the upper panel indicating a period when droplet composition is directly determined. Data are preliminary and unpublished.

## 4.0 Data Archiving, Future Work, and Publications

CCN data have been archived as of August 30, 2013. AMS data requires Scanning Mobility Particle Spectrometer (SMPS) data from MAOS which, as of this date, has not been archived. When SMPS data is available, approximately 2 weeks will be required to post final AMS data. We have been in communication with the ARM Data Archive.

Regarding future work, we have submitted a proposal to the recent Atmospheric System Research (ASR) Program call requesting funding for further data analysis and for follow-up laboratory work to understand these findings. Dependent on this funding we anticipate a publication from this work.

## 5.0 Concluding Statements

Per our original statement of work, we have acquired chemical composition information for the droplet-forming aerosol during the DOE TCAP study. To our knowledge, this is a first-of-a-kind study. We have archived CCN data and, when SMPS data is available, can archive AMS data. We have proposed future work to fully analyze and publish these data.

## 6.0 References

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