U.S. DEPARTMENT OF ENERGY | Office of Science

DOE/SC-ARM-15-052

STORMVEX: Ice Nuclei and Cloud Condensation Nuclei Characterization Field Campaign Report

D Cziczo

March 2016

ARM CLIMATE RESEARCH FACILITY

DISCLAIMER

DOI/SC-ARM-15-052

STORMVEX: Ice Nuclei and Cloud Condensation Nuclei Characterization Field Campaign Report

D Cziczo, Massachusetts Institute of Technology
Principal Investigator

March 2016

Work supported by the U.S. Department of Energy,
Office of Science, Office of Biological and Environmental Research

Acronyms and Abbreviations

CCN	cloud condensation nuclei
SPL	Storm Peak Lab
SPLAT	Single Particle Laser Ablation Time-of-Flight mass spectrometer
STORMVEX	Storm Peak Lab Cloud Property Validation Experiment

Contents

Figures

1.0 Background

The relationship between aerosol particles and the formation of clouds is among the most uncertain aspects in our current understanding of climate change. Warm clouds have been the most extensively studied, in large part because they are normally close to the Earth's surface and only contain large concentrations of liquid droplets. Ice and mixed-phase clouds have been less studied even though they have extensive global coverage and dominate precipitation formation. Because they require low temperatures to form, both cloud types are infrequently found at ground level, resulting in more difficult field studies. Complex mixtures of liquid and ice elements, normally at much lower concentrations than found in warm clouds, require precise separation techniques and accurate identification of phase. Because they have proved so difficult to study, the climatic impact of ice-containing clouds remains unresolved.

In this study, cloud condensation nuclei (CCN) concentrations and associated single particles' composition and size were measured at a high-elevation research site—Storm Peak Lab, east of Steamboat Springs, Colorado, operated by the Desert Research Institute. Detailed composition analyses were presented to compare CCN activation with single-particle composition. In collaboration with the scientists of the Storm Peak Lab Cloud Property Validation Experiment (STORMVEX), our goal was to relate these findings to the cloud characteristics and the effect of anthropogenic activities.

2.0 Notable Events or Highlights

Particle composition was dominated by sulfate-containing particles. We also observed biomass burning, sea salt, and organic particles. CCN activation of ambient particles largely followed the behavior of the sulfate-containing particle types. Biomass burning particles and newly formed particles may have impacted CCN activation. Hygroscopicity parameter, kappa, was observed within the range of continental kappa values.

3.0 Results

Key results of our research are summarized below.

3.1 Composition of Ambient Particles

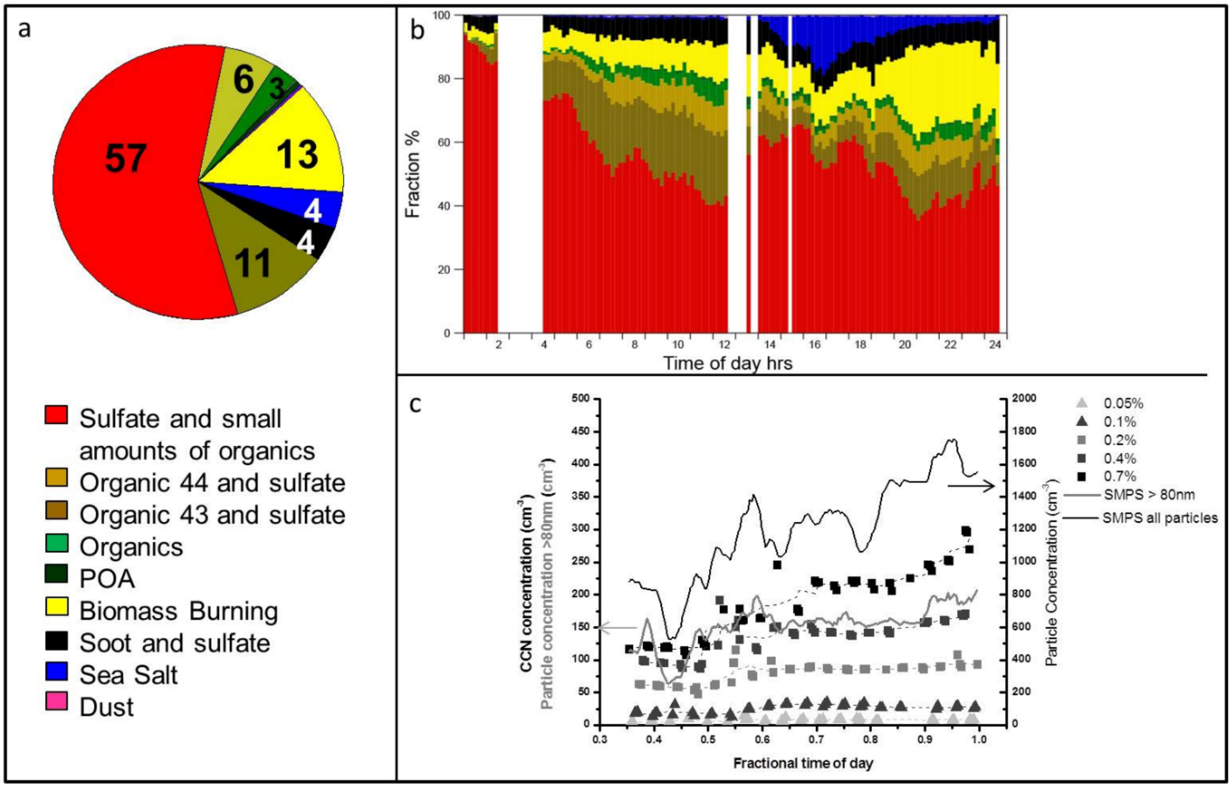

Figure 1. Composition of ambient particles.

Panel a of the pie chart above shows the percentage contribution of each cluster categorized by our Single Particle Laser Ablation Time-of-Flight mass spectrometer (SPLAT) to the total chemical composition for the day of March 5. Panel (b) shows the temporal evolution of clusters categorized by SPLAT throughout the day. The colors are the same as in panel a. Panel c shows CCN concentrations at each supersaturation studied during March 5, with each point representing the average of one individual CCN supersaturation scan (10 minutes), and the corresponding dashed lines showing the smoothed data. Total particle concentration (black line, right axis), and total particle concentration greater than 80 nm (grey line, left axis), are also shown for comparison. Note that the x axes of b and c are aligned.

3.2 CCN Concentration of Ambient Particles

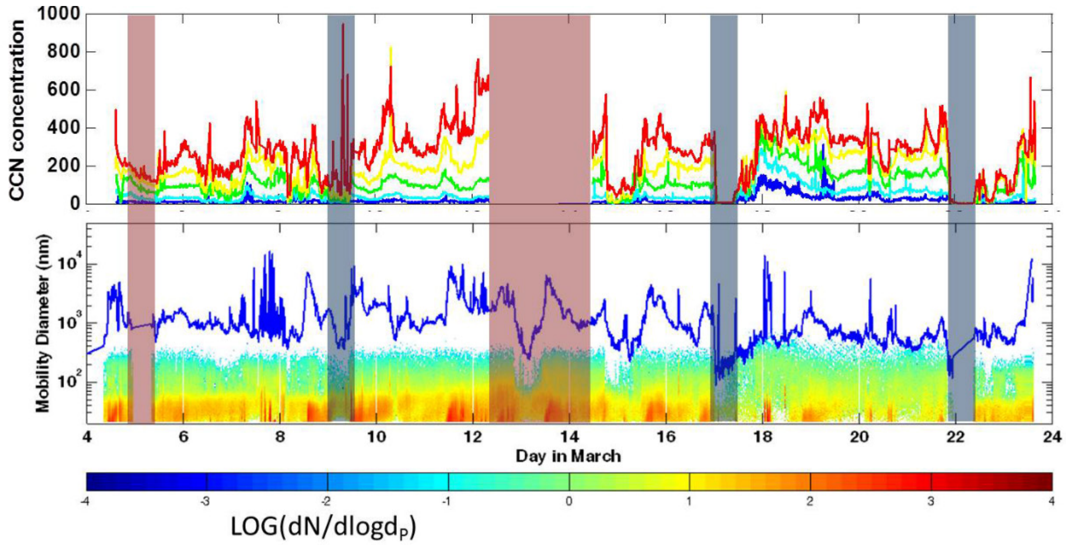

Figure 2. CCN concentration of ambient particles.

Panel a of the pie chart above shows the percentage contribution of each cluster categorized by SPLAT to the total chemical composition for the day of March 5. Panel b shows temporal evolution of clusters categorized by SPLAT throughout the day. The colors are the same as in panel a. Panel c shows CCN concentrations at each supersaturation studied during March 5, with each point representing the average of one individual CCN supersaturation scan (10 minutes), and the corresponding dashed lines showing the smoothed data. Total particle concentration (black line, right axis), and total particle concentration greater than 80 nm (grey line, left axis), are also shown for comparison. Note that the x axes of b and c are aligned.

3.3 Hygroscopicity of Ambient Particles (Sulfate and Organic Particle Fraction)

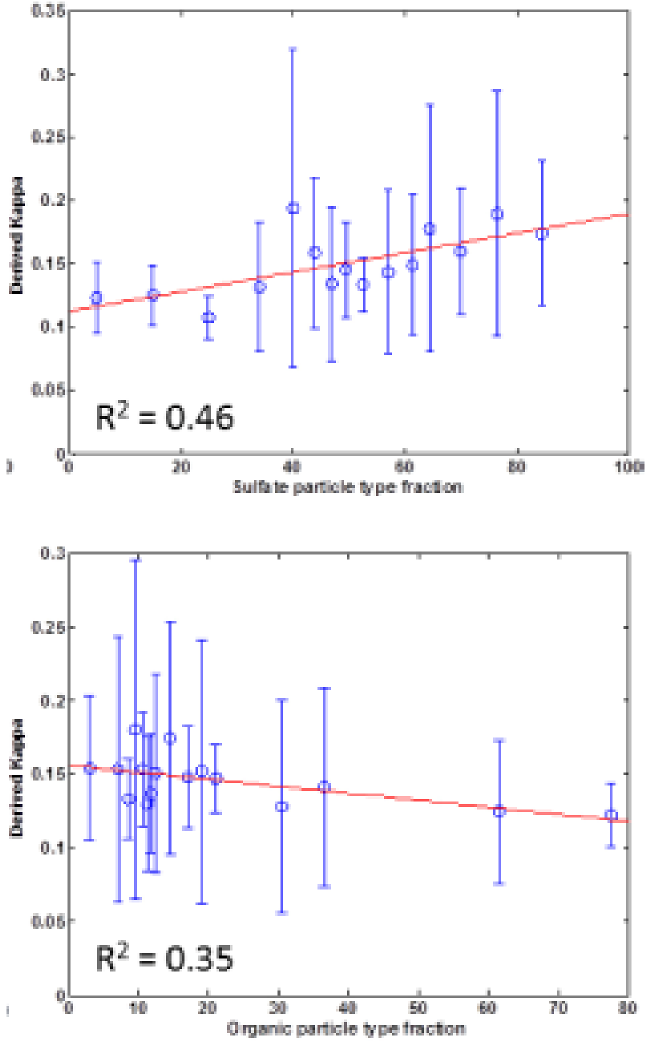

Figure 3. Hydroscopicity of ambient particles (sulphate and organic particle fraction).

The kappa parameter was inferred from CCN and size distribution measurements by determining the critical diameter at a given water vapor supersaturation. Lesser correlations between kappa and sulfate and organic particle type fraction was observed. This could be due to kinetic limitations of droplet growth, which may be contributing to the lower kappa (such as an organic coating on an inorganic particle).

4.0 Public Outreach

Findings from this study were published in a peer-reviewed journal article listed in References, below.

5.0 References

Friedman, B, A Zelenyuk, J Beranek, G Kulkarni, M Pekour, AG Hallar, IB McCubbin, AJ Thornton, and DJ Cziczo. 2013. "Aerosol measurements at a high-elevation site: composition, size, and cloud condensation nuclei activity." *Atmospheric Chemistry and Physics* 13: 11839-11851, doi:10.5194/acp-13-11839-2013.

CLIMATE RESEARCH FACILITY

www.arm.gov

U.S. DEPARTMENT OF ENERGY

Office of Science