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SAIL Aerosol Regimes and Processes with a Focus on Bioaerosols, Supermicron Particles and Vertical Profiles


AOS


PM Sensor

Bioaerosol


TBS

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Abu Sayeed Md Shawon

ASR Atmospheric System Research

ARM

LDRD LABORATORY DIRECTED RESEARCH & DEVELOPMENT

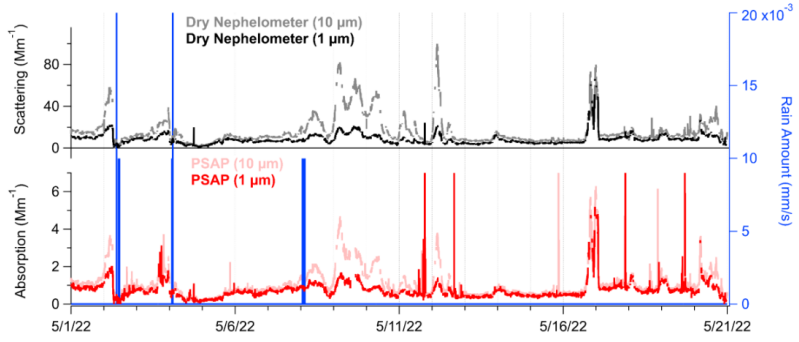
NNSA National Nuclear Security Administration Managed by Triad National Security, LLC, for the U.S. Department of Energy's NNSA.

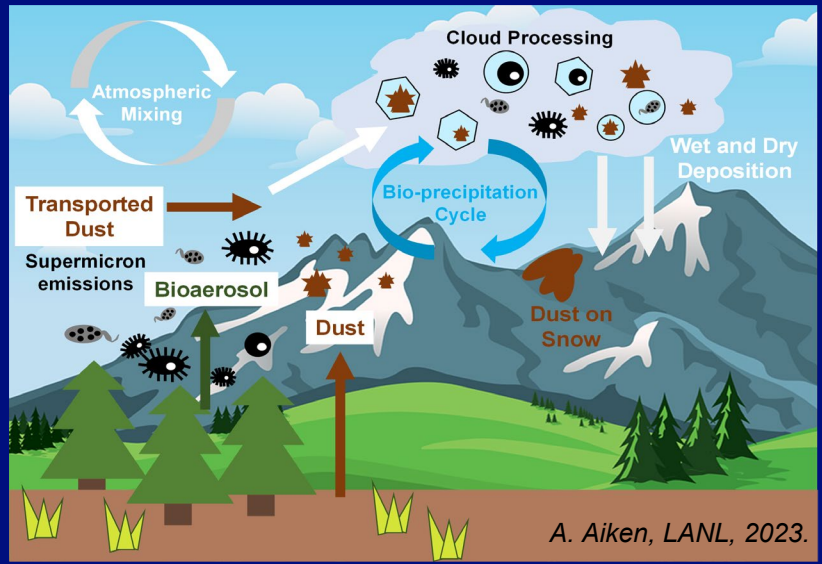
Questions? Contact Allison Aiken: aikenac@lanl.gov
NVCL Research Project Website: Aerosol Regimes and Processes with SAIL Data

Motivation: Supermicron and Bioaerosol Impacts within Complex Mountainous Terrain

- Lack of aerosol observations to understand the integrated mountain hydroclimate
- Known interactions with surface and atmospheric radiation, the water cycle and hydrology
- Goal: determine seasonal and diurnal cycles, sources and sinks, variability within the region

Absorbing supermicron dust event observed by the Aerosol Observing System (AOS)



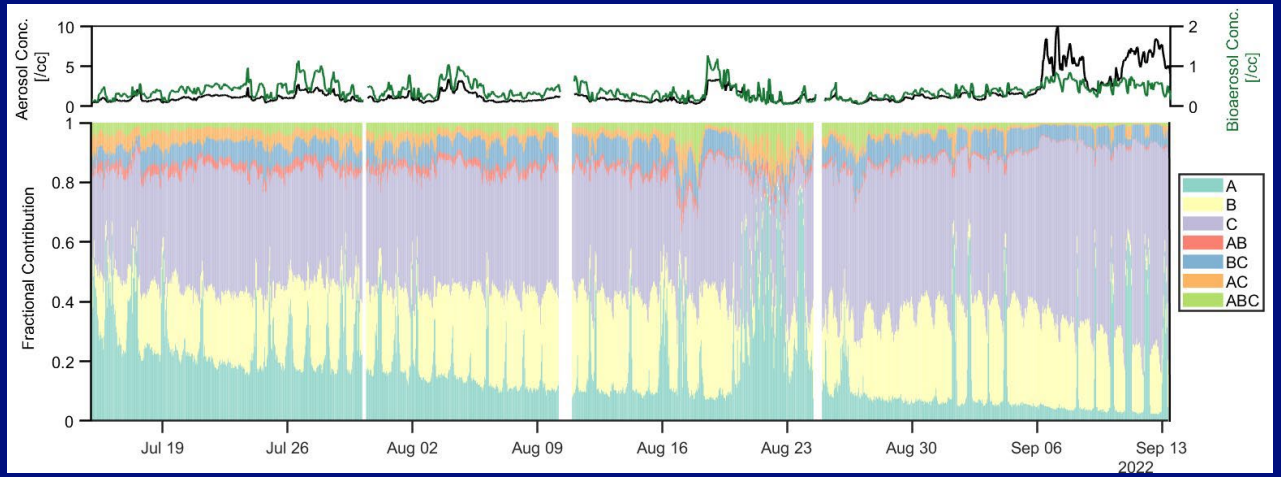


Supermicron and bioaerosol cycles and impacts to the atmosphere (e.g., interact with clouds and the water cycle) and the surface in mountainous terrain.

Feldman, Aiken et al., BAMS, 2023.

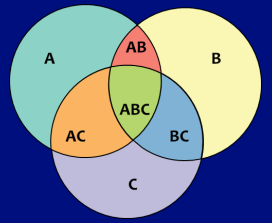
Real-Time Single-Particle Bioaerosol Data

- Two deployments in 2022 and 2023
- Seasonal and diurnal trends observed for the different fluorescent particle types
- Size and shape information (asymmetry factor) also collected (not shown)



Shawon et al., in prep, 2023.

Bioaerosol: directly emitted particles from plants and the microbiome that contain biological material.



Fluorescent particle types by Perring et al. 2015.

Bacteria, pollen and fungi detected by the fluorescence of biological material due to the presence of tryptophan and NADH in the particles.

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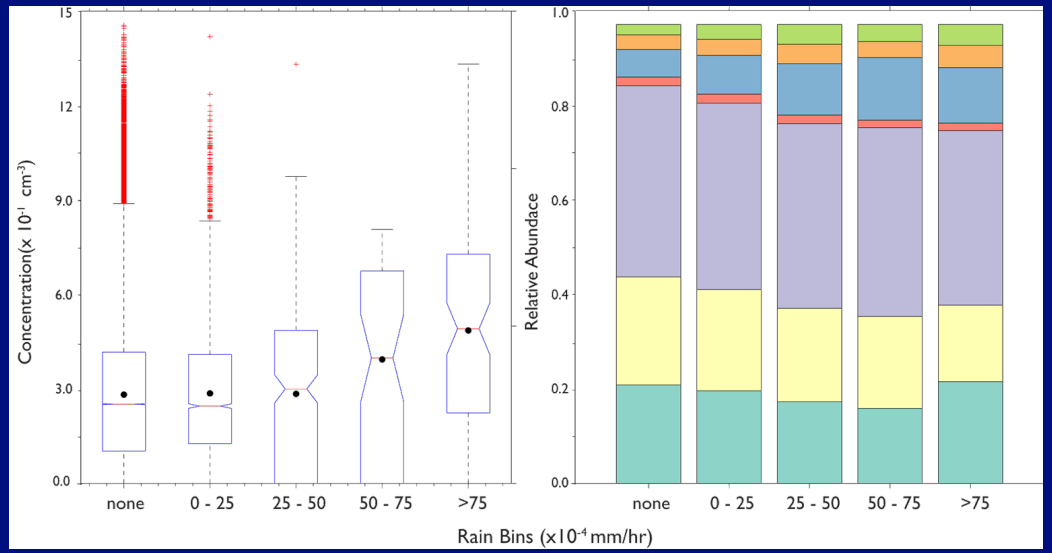
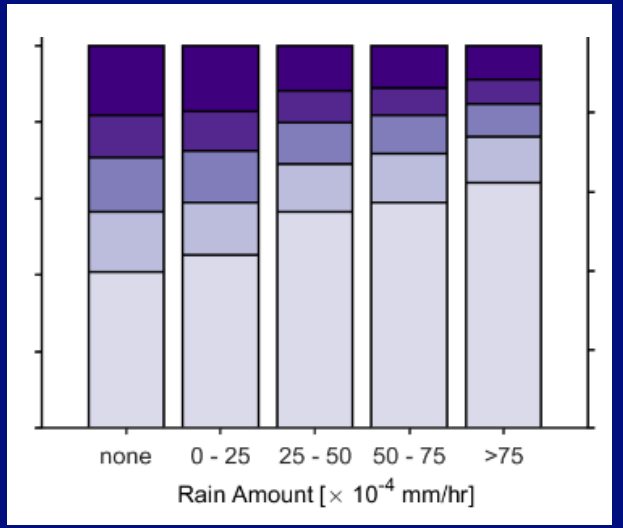
Bioaerosol Trends with Meteorology

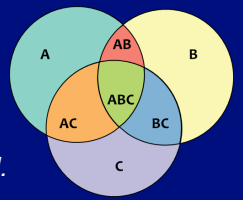
- 45 Precipitation events in 2022 categorized by rain rate
  - Increasing trend in bioaerosol number concentration with rain
  - More spherical particles during rain
- Also analyzed by wind direction, speed, temp, etc.



Shawon et al., in prep, 2023.

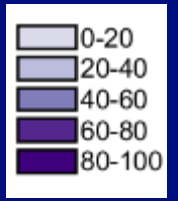
Asymmetry Factor





Fluorescent particle types by Perring et al.

Low numbers are most spherical



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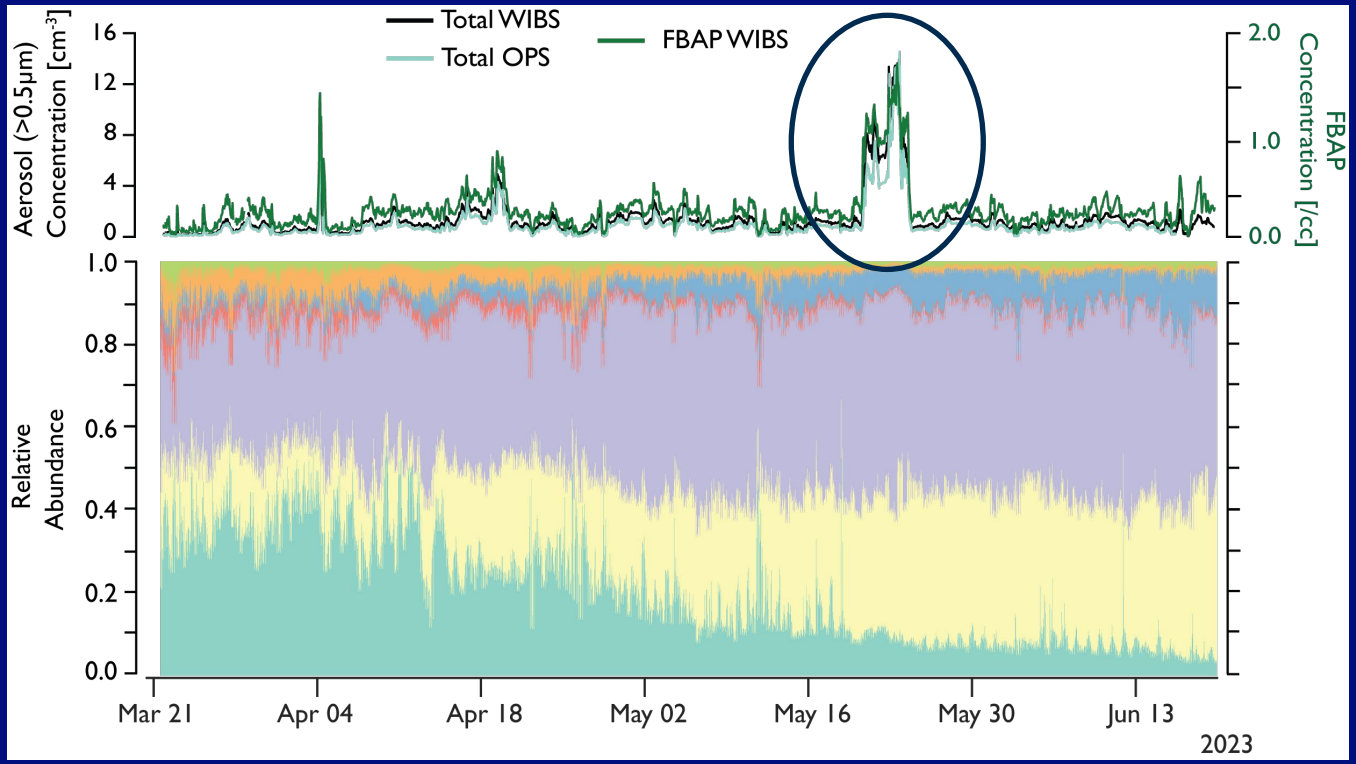
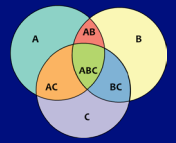
Real-time Bioaerosols – Spring 2023

- ***Preliminary Analysis – multiday event likely biomass burning***



Likely origin in the SW U.S. More backtrajectory analysis to be done.



Fluorescent particle types by Perring et al.

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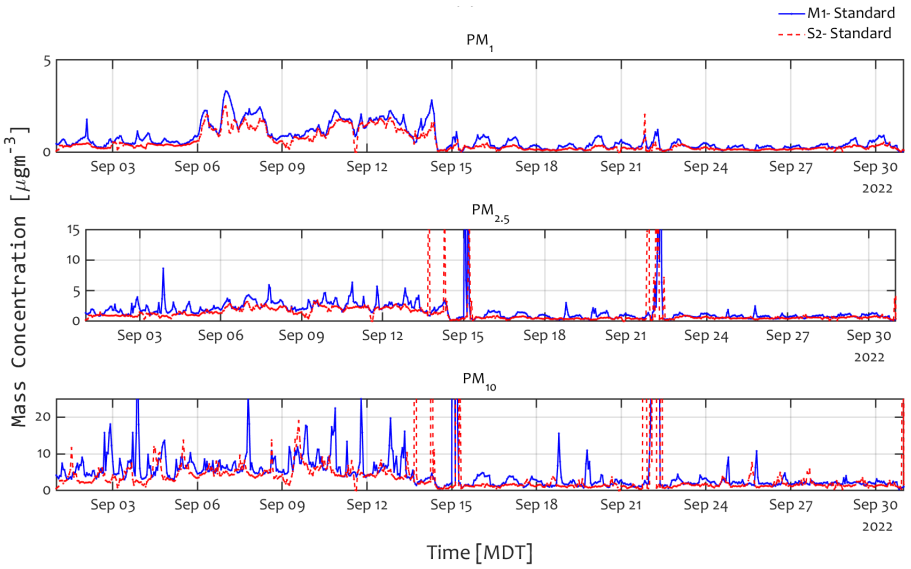
Particulate Mass (PM) Timeseries at 2 Sites (AMF2 and AOS)

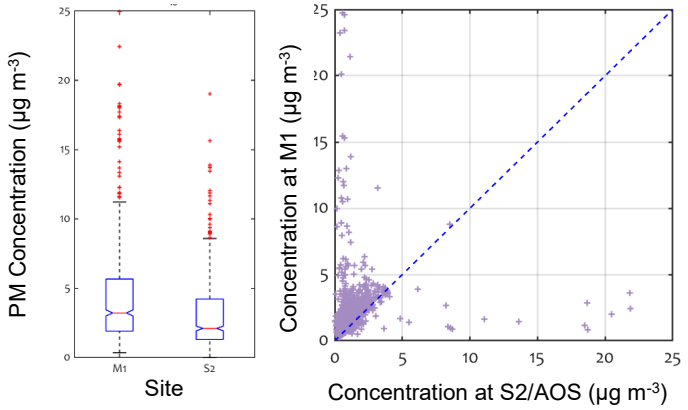
High-time resolution PM data



M1 in Gothic, CO at 9500 feet a.s.l.

S2 with the AOS on Crested Butte Mountain at 10,300 ft.

Year-round comparison of PM_{10}



F. Gallo, J. Uin, K.J. Sanchez, R.H. Moore, J. Wang, R. Wood, F. Mei, C. Flynn, S. Springston, E.B. Azevedo, C. Kuang, and A.C. Aiken, "Long-range transported continental aerosol in the eastern North Atlantic: three multiday event regimes influence cloud condensation nuclei." *Atmospheric Chemistry and Physics* 23, 4221-4246. (2023) [DOI:10.5194/acp-23-4221-2023].

SAIL Aerosol Vertical Profiles (SAIL-AVP)

- **Funded by FICUS (ARM and EMSL)**
  - Title: “Seasonal vertical aerosol profiling for aerosol-cloud-precipitation interactions to advance mountainous hydrological process science”
  - PI Team: Aiken (PI), Dan Feldman (LBNL, Co-PI), Paul DeMott (CSU, Co-PI), Nick Bouskill (LBNL), John Christensen (LBNL), Jesse Creamean (CSU), Wenming Dong (LBNL), Jiwen Fan (ANL), Jim Smith (UCI)
- **Four Tethered Balloon System (TBS) deployments in 2023**
  - Winter Storm – January
  - Spring Melt and Biological Awakening – April and May
  - Summer Monsoon – June

TBS at SAIL in June. Photo by Aiken.

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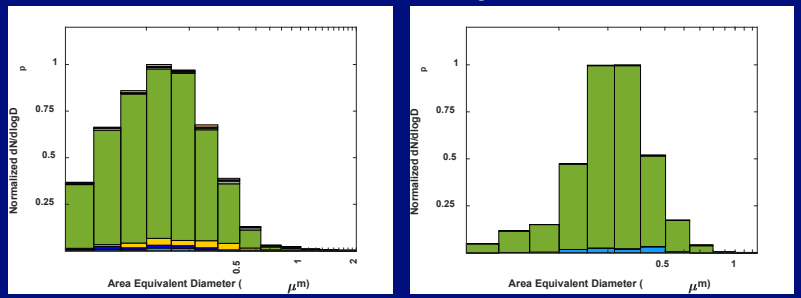
Feldman, Aiken and Dexheimer at the TBS during SAIL. Photo by N. Bilow

SAIL Aerosol Vertical Profiles (SAIL-AVP)

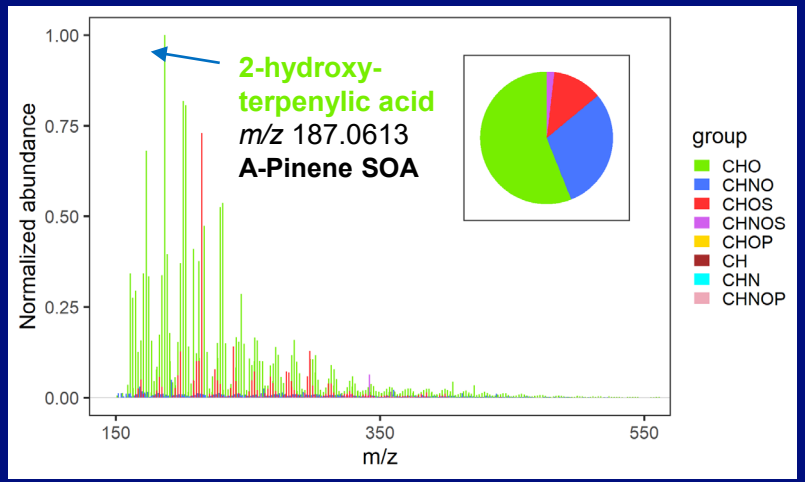
- **EMSL Imaging and Chemical Analysis**
  - Chemical composition and organic molecular composition, examples shown below
  - Coating analysis and heterogenous ice nucleation
- **Ice Nuclei analysis TBD (led by CSU)**

Elemental Composition



Size-selected elemental analysis using Scanning Electron Microscopy (SEM) from a Spring SAIL TBS Flight in 2023 by Zezhen (Jay) Cheng at EMSL.

Molecular Characterization of Organics



Bulk chemical analysis using mass spectrometry from a Summer SAIL TBS Flight in 2023 by Gregory Vandergrift at EMSL.

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Summary: SAIL Aerosol Regimes and Processes

- **Observed changes in different bioaerosols based on fluorescence patterns and physical properties (size and shape) throughout the sampling periods and in the monthly diurnal profiles. Manuscript in prep for submission this year.**
- **Supermicron mass concentrations collected at two site to determine regional variability.**
- **Collected vertical profile aerosol physical and chemical information using the TBS during 4 deployments. Analysis is underway and in collaboration with EMSL, LBNL/metal analysis and CSU/ice nuclei.**
- **FY24 Plans: Identify dates of interest, local vs regional vs transported sources, integration of AOS data, expanded bioaerosol analysis with the 2023 data. Presentations this fall at AAAR and AGU.**

Collaborations and Acknowledgements

- LANL/ARM Site Operations Staff for AMF2 (SAIL): Heath Powers, John Bilberry, Juarez Viegas
- Dan Feldman, SAIL PI, and the SAIL Science Team
- SAIL TBS/EMSL FICUS Science Team
- Paul DeMott and Jesse Creamean, CSU, Ice Nuclei analysis
- Dari Dexheimer, SNL, SAIL TBS deployments
- Swarup China and the EMSL analysis and coordination team, PNNL

BACKUP

3 Transported Aerosol Regimes Influence Cloud Condensation Nuclei in the Remote Marine Environment of the Eastern North Atlantic

Francesca Gallo
Former LANL Postdoc
Now at NASA

F. Gallo, J. Uin, K.J. Sanchez, R.H. Moore, J. Wang, R. Wood, F. Mei, C. Flynn, S. Springston, E.B. Azevedo, C. Kuang, and A.C. Aiken, "Long-range transported continental aerosol in the eastern North Atlantic: three multiday event regimes influence cloud condensation nuclei." *Atmospheric Chemistry and Physics* 23, 4221-4246. (2023) [DOI:10.5194/acp-23-4221-2023].

Objective

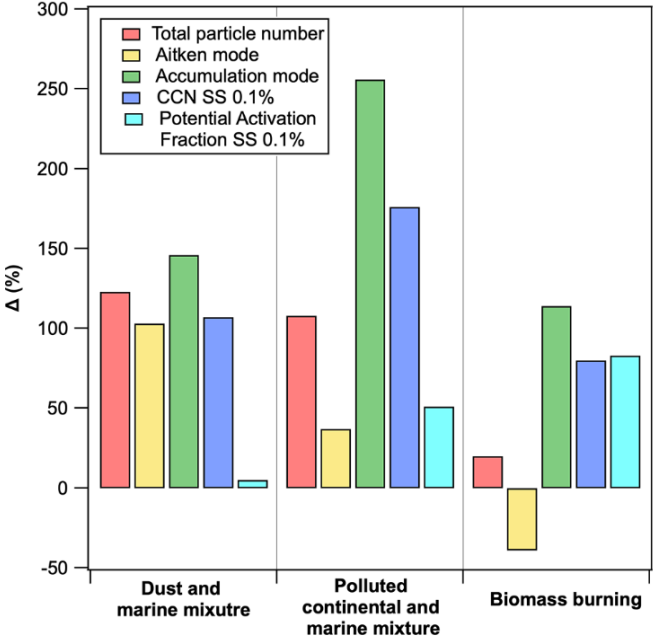
- Determine transported aerosol event impacts to the annual cloud condensation nuclei (CCN) budget in a mostly pristine remote marine environment dominated by marine boundary layer clouds

Approach

- Develop novel algorithms for the 1-minute Aerosol Observing System (AOS) data at Eastern North Atlantic (ENA) Atmospheric Radiation Measurement Facility
- Identify long-range transported aerosol events and define their different aerosol source regimes
- Determine the impact of the significant aerosol source regimes on CCN activation fractions

Impact

- 3 different types of transported continental events (dust/marine, polluted mix, biomass burning) increased CCN concentrations by 22% at 0.1% supersaturation in 2017 during 9 multiday events
- Biomass burning aerosol events had the largest impact on CCN potential activation fractions sampled at ENA



Mean percentage change of aerosol number concentration and CCN activation fractions for the three types of long-range transport aerosol events observed at ENA by the ARM AOS in 2017

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