Seasonal Aerosol Regimes and Processes Observed in Mountainous Terrain at Surface Atmosphere Integrated Field Laboratory (SAIL)

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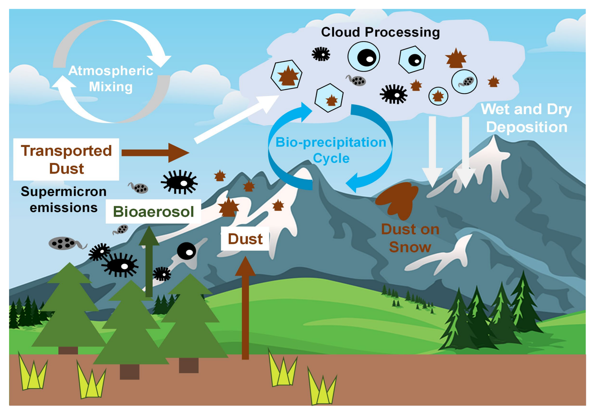
Aerosol Impacts within Mountainous Terrain

SUBMICRON AND SUPERMICRON

Regional and transported aerosols can impact climate in many ways, e.g., through direct and indirect radiative impacts, surface deposition, land-atmosphere and aerosol-cloud-precipitation interactions. Within complex high elevation mountainous terrain, these interactions become complicated due to orographic processes, how the particles are distributed within the boundary layer, and which ones deposit on the surface. Aerosol impacts in these regions are currently underconstrained due to a lack of observations. As such, the goal of this work is to explore the properties of aerosol, absorbing aerosol, supermicron and bioaerosol events and their diurnal variabilities in Colorado during SAIL.

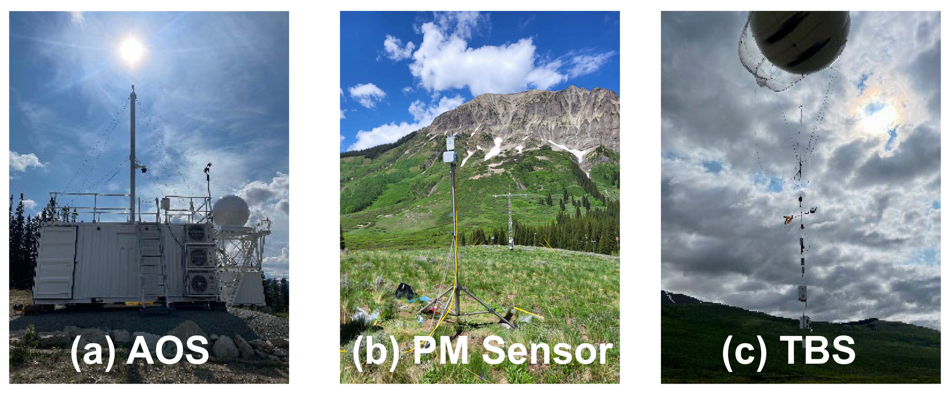


Caption: Schematic of supermicron and bioaerosol cycles and impacts to the atmosphere (e.g., interact with clouds and the water cycle) and the surface in mountainous terrain.

Measurements

ARM AND GUEST INSTRUMENTS

Aerosols were measured at numerous sites by ARM and guest instrument deployments coordinated by ARM that can be found on the SAIL Campaign Homepage. Here, we used the AMF2 Aerosol Observing System (AOS) data, our Supermicron Particulate Mass (PM) Sensors and Bioaerosol Sensor (WIBS) that were located on the ground at two sites and the ARM Tethered Balloon System (TBS) to compare with aerosol vertical profiles.



Caption: (a) ARM Aerosol Observing System (AOS), (b) Supermicron Particulate Mass (PM) Sensor, (c) ARM Tethered Balloon System (TBS). Photo credits: Aiken and Shawon.

Submicron Aerosol

AEROSOL OBSERVING SYSTEM

Multi-day transport events of absorbing supermicron dust were observed by the AOS in the spring, which can impact surface radiation, snowmelt and surface hydrology when deposited on the snowpack.

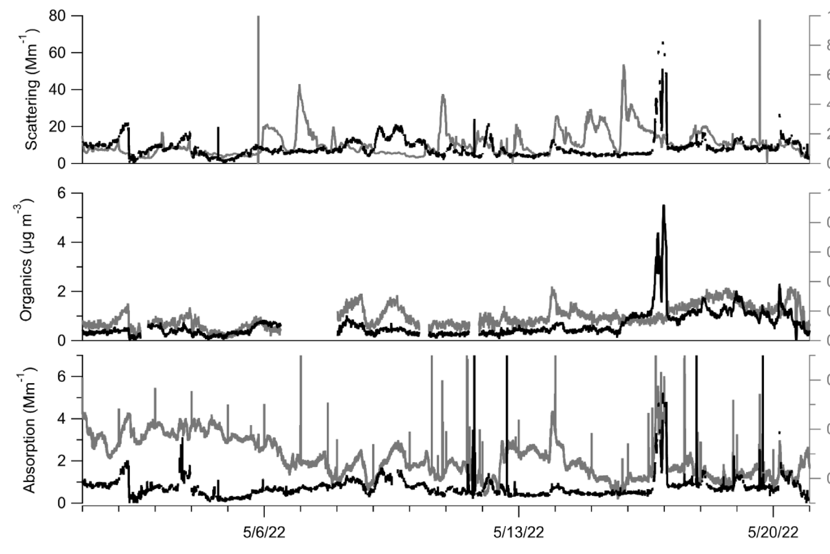


Figure 1: (a) Spring AOS data as included in Feldman et al., BAMS, 2023.

> *"What are the seasonal aerosol regimes and processes that impact mountain hydrology?"*

Supermicron Aerosol

SAIL SUPERMICRON BIOAEROSOL (SSB) CAMPAIGN

Year-round PM_{10} (PM for particles <10 μm) data from two real-time (1-minute time resolution) sensors in Gothic (AMF2 M1, el. ~9,500 a.s.l.) and on Crested Butte Mountain (AOS, S2; ~10,300 ft a.s.l.) had higher concentrations at the lower elevation site. Preliminary analysis also showed a diurnal cycle at the lower elevation site that was not observed at the higher elevation site in the summer.

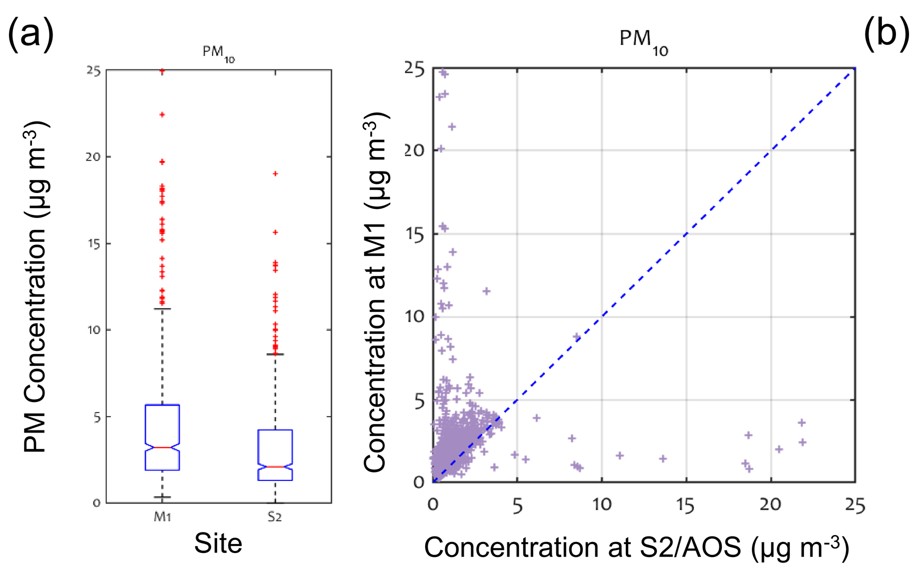


Figure 2: (a) Notch whisker box plots of average PM_{10} mass concentration, (b) scatter plot of PM_{10} mass from M1/AMF2 (Gothic, CO) vs S2/AOS (Crested Butte Mtn).

Bioaerosol

SUMMER 2022 AND SPRING 2023

We deployed the real-time single-particle measurement of bioaerosols (Wideband Integrated Bioaerosol Sensor, WIBS) in the summer of 2022 and spring of 2023 to investigate ambient trends in the physical properties of bioaerosol, regional sources and ambient trends in the spring and summer. To our knowledge, these are the first high-time resolution measurements of bioaerosol made within mountainous terrain. The WIBS reported 7 types of fluorescent particles (Perring et al., 2015, Savage et al., 2017). Fluorescent particles indicate the presence of biological material (Tryptophan, NADH).

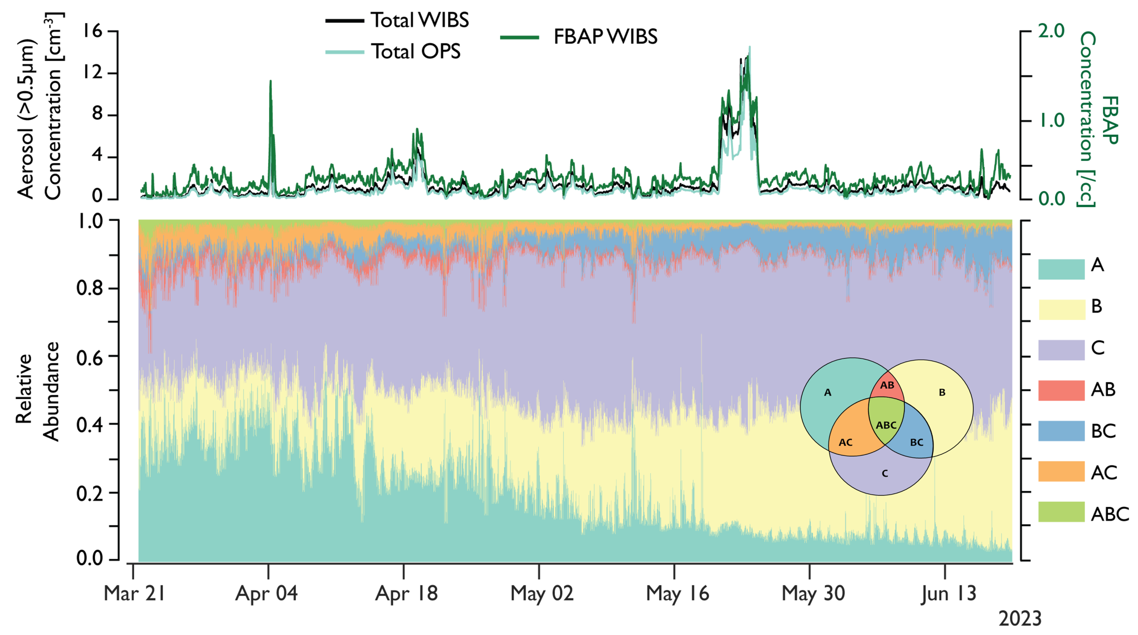


Fig 3: Time series of total bioaerosol detected as fluorescent particles and different categories based on fluorescence patterns during our second deployment in 2023.

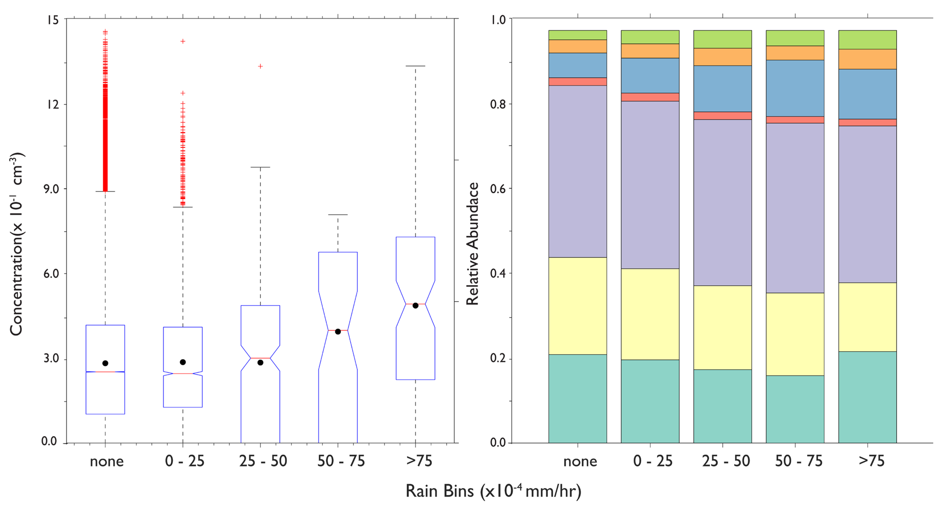


Figure 4: Investigating bioaerosol during precipitation. Bioaerosol (a) concentration and (b) fluorescent type (colors are the same as Fig. 3.) binned by precipitation rate as measured by the AOSMET. (Shawon et al., in prep, 2023.)

Vertical Aerosol Profiles and Chemical Analysis

WINTER, SPRING AND SUMMER 2023

Our Facilities Integrating Collaborations for User Science (FICUS) project funded the SAIL Aerosol Vertical Profiles (AVP) campaign during which the ARM TBS was successfully deployed four times in 2023 as well as chemical analysis of the filters by the Environmental Molecular Sciences Laboratory (EMSL) at PNNL. ARM data at the ground and aloft includes aerosol number concentrations, size distributions, imaging and meteorology and is available in ARM Data Discovery.

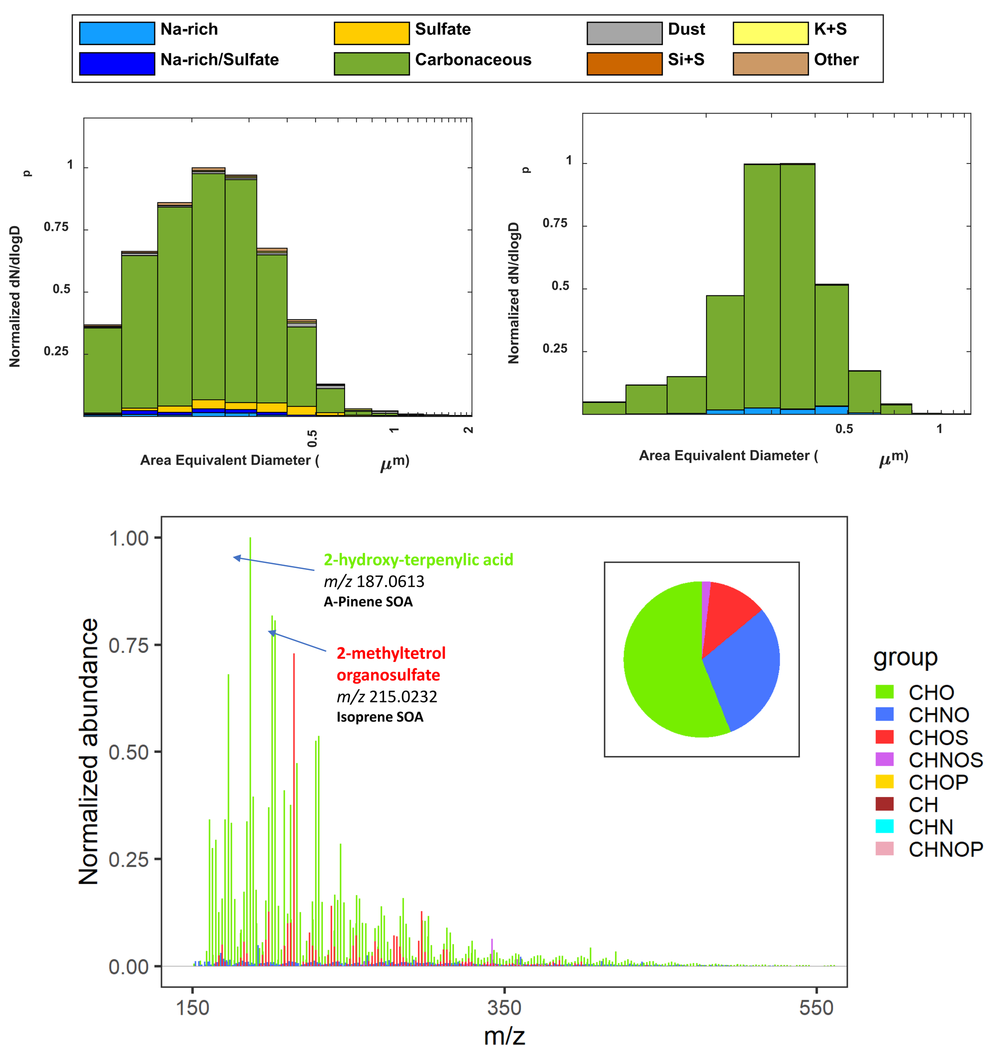


Figure 5: Preliminary chemical analysis showing (a, b) Scanning Electron Microscopy (SEM) from Spring 2023 by Zezhen (Jay) Cheng at EMSL, and (b) mass spectrometry (nano-DESI HRMS) from Summer 2023 by Gregory Vandergrift at EMSL.

Chemical analysis by EMSL has begun. Winter flights had very low loadings. Spring flights were dominated by organics that had different size distributions depending on the flight time and altitude (Fig. 4a,b). Summer analysis from the ground-based samples show differences in chemical composition that indicate the presence of both isoprene and alpha-pinene secondary organic aerosol as well as the presence of organosulfates (SOA, Fig. 4c).

Acknowledgments

- Field Instrument Deployments and Operations (FIDO) Site Operations Staff led by Heath Powers
- Jennifer Reithel, RMBL Science Lead
- FICUS science and management teams
- EMSL analysis team led by Swarup China
- ARM TBS team led by Darielle Dexheimer

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- NVCL Research Project Website, Aerosol Regimes and Processes with SAIL Data.

LA-UR-23-28265