

Science Objective 3: Aerosol Regimes and Radiation Aerosol Process Co-Investigators



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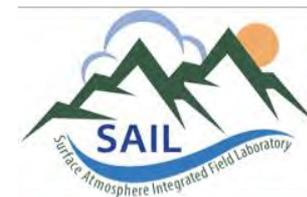
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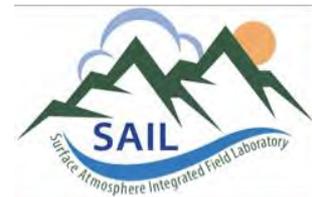
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Science Objective 3: Aerosol Regimes and Radiation Aerosol Process Science Questions



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SCIENCE QUESTION 1

- What are the dominant regimes of seasonal aerosol transport, formation, growth, and removal processes in the region?

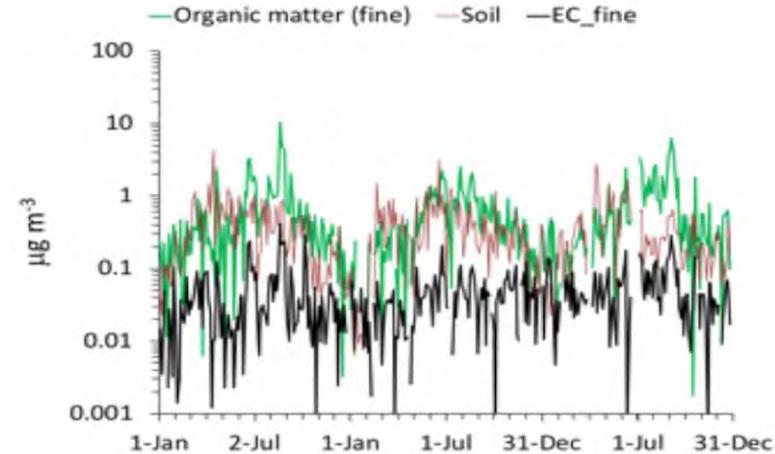
SCIENCE QUESTION 2

- Within these regimes, how do aerosol particles redistribute radiant energy, including warming the atmosphere and/or the surface radiative forcing

Aerosol Processes and Regimes



- Aerosol processes impact the atmospheric and surface radiative environments
 - Lifecycle (formation, growth, removal) and aerosol sources in the Colorado Rivershed
 - Local and long-range transported aerosol
 - Atmospheric particles and deposition to the surface
- Role of different aerosol sources on mountain hydrology
 - Area of interest identified in the ARM Mobile Facility Workshop Report (2019)
 - Evidence of new particle and secondary organic aerosol formation and growth events in mountainous terrain
 - Spring and summer dust events and wildfires
 - Radiative impacts have been poorly constrained by observations – most studies rely on models

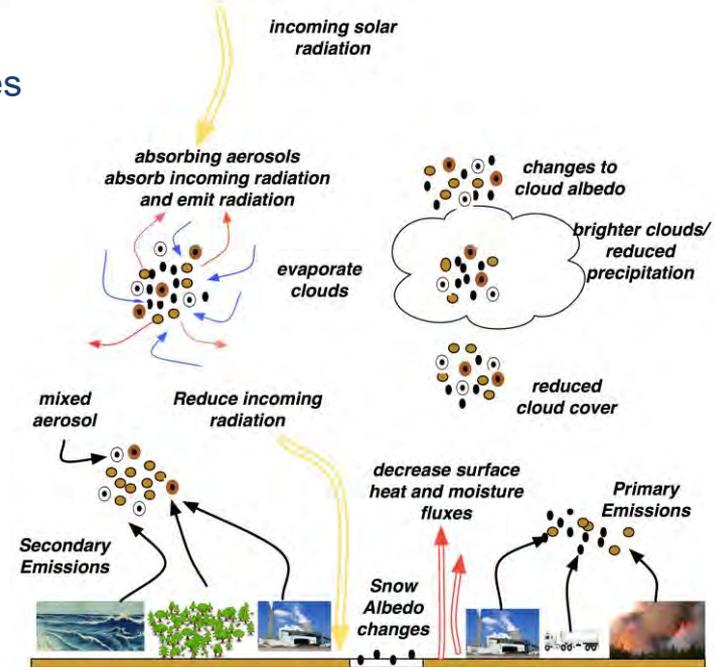


Annual cycles of aerosol mass concentrations of fine organic and elemental carbon, and soil dust at White River IMPROVE network [Malm, et al., 1994] site, located close to the proposed SAIL site, at 3413 m MSL, 39.1536 latitude, -106.8209 longitude. The time period shown is from January 1, 2015 to December 31, 2017.

Absorbing Aerosols Alter Atmospheric and Surface Radiation



- Atmospheric presence reduces solar radiation at the surface, increases atmospheric stability and decreases turbulent fluxes
 - Absorbing dust species
 - Black carbon (BC, aka “soot”)
 - Brown carbon and secondary organics
- Brown carbon, implicated in high-altitude melt, understudied
- Transported atmospheric particles versus surface deposition

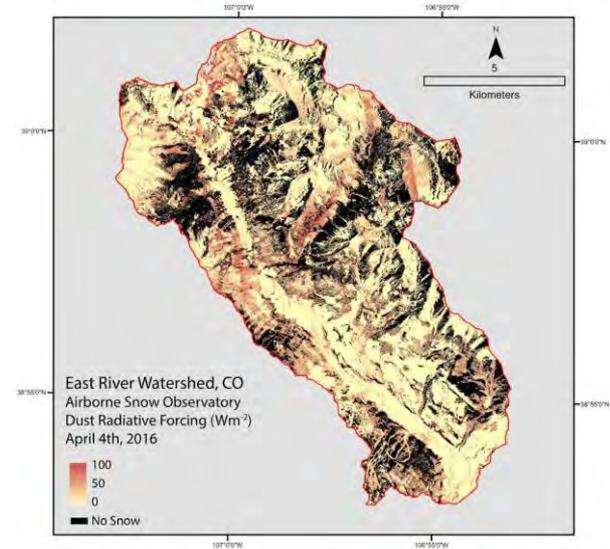
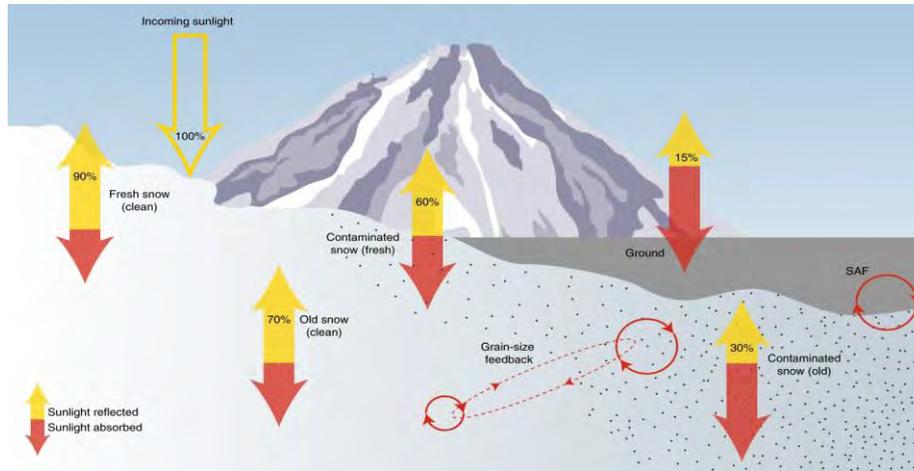


U.S. DOE BER Absorbing Aerosols Workshop Report (2016): Absorbing aerosols in the atmosphere and the various ways they interact with incoming solar radiation, clouds, and the dynamic and thermodynamic state of the atmosphere.

Absorbing Aerosols Alter Atmospheric and Surface Radiation



- Deposited on the snow
 - Absorbed solar radiation increases at the surface
 - Snowmelt enhanced by lower surface albedo
 - Surface hydrology and watershed
- Observations to constrain modelled radiative impacts in complex mountainous terrain, e.g. Colorado East River Watershed

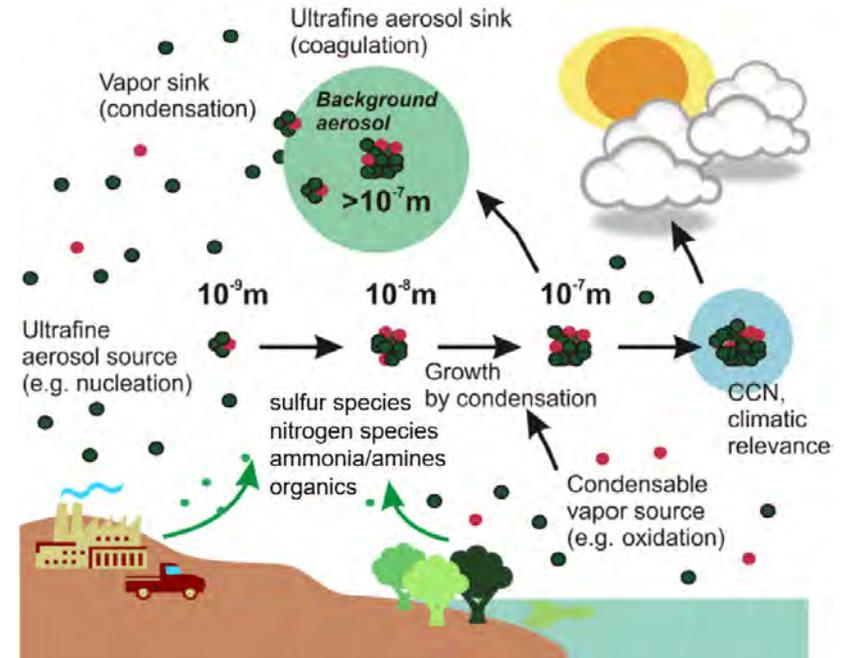


Radiative forcing map by deposited aerosols in snow from the NASA Airborne Snow Observatory (ASO), East River Watershed in April, 2016.

Aerosol Lifecycle in Colorado



- Aerosol lifecycles and the role of chemistry are key to understanding aerosol radiative impacts
 - New Particle Formation
 - Growth
 - Removal (wet and dry deposition)
- Are new particle events on Colorado mountain terrain observed when intrusions from the troposphere and boundary layer trace gases mix?
- Do upslope valley winds transport reduced nitrogen species that can form secondary organic aerosol and Brown carbon?
- What is the impact of regional versus long-range transported dust, pollution and wildfire events?
 - Black and Brown carbon
 - Secondary organic aerosols

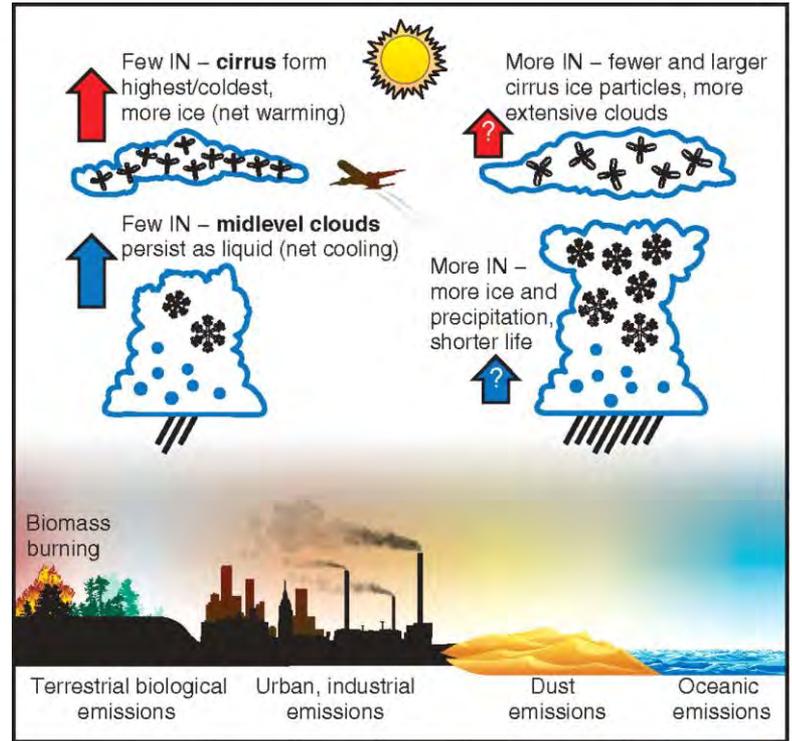


Riipinen, et al., ACP 2011.

Ice Nucleating Particles (INP)



- Ice and mixed-phase clouds impact cloud radiative forcing, precipitation production and cloud lifetime
 - Biological INP often more important at higher temperatures (> -20 C)
 - Organic often dominate at lower temperatures
- Can we observe/verify increased INP during summer convective storm and wildfire events?
- What are the dominant INP components for Colorado?



DeMott et al., PNAS, 2010.

In Situ Aerosol Measurements: AMF2 Aerosol Observing System (AOS)



- Chemistry
 - Aerosol Chemical Speciation Monitor (ACSM)*
 - Single Particle Soot Photometer (SP2)*
- Cloud Formation - Water Uptake and Ice Nucleation
 - Cloud Condensation Nuclei Counter
 - $f(\text{RH})$
 - Humidified Tandem Differential Mobility Analyzer (HTDMA)
 - Ice Nucleating Particle (INP) Sampler
- Optical Properties
 - Nephelometers
 - Particle Soot Absorption Photometer (PSAP)
- Physical Properties
 - Condensation Particle Counter (CPC)
 - Scanning Mobility Particle Sizer (SMPS)*
 - Ultra-High Sensitivity Aerosol Spectrometer (UHSAS)



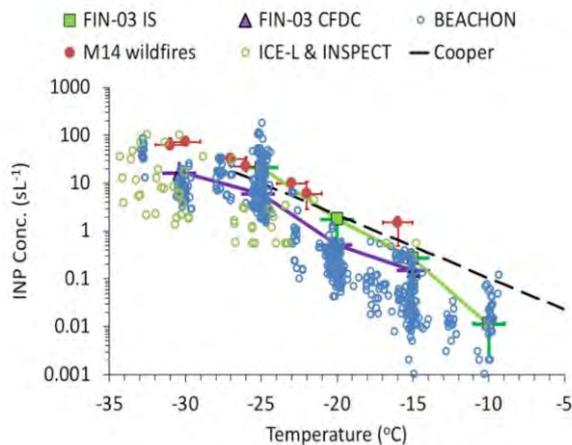
AMF2 AOS at AWARE (Antarctica)

- Trace Gases
 - CO Monitor
 - Ozone Monitor
- Meteorology Sensor

New and Guest Instrumentation

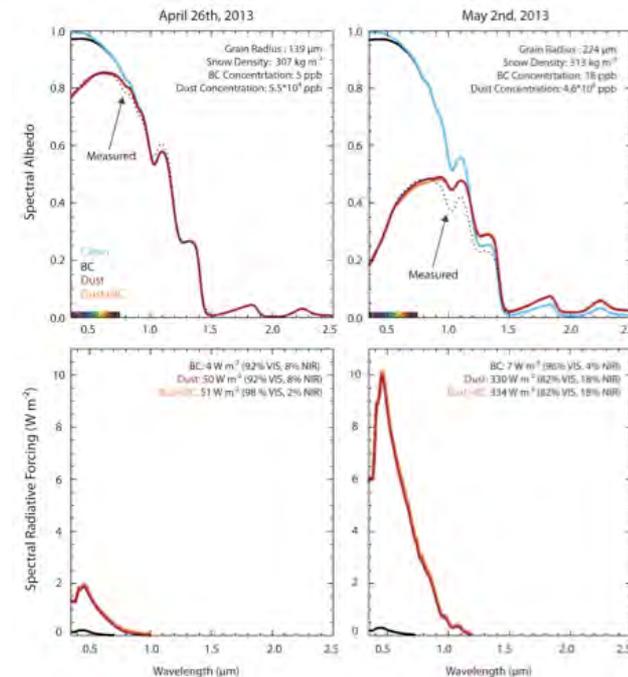


- Ice Nucleating Particle Sampler (DeMott/Colorado State Univ.)
 - Immersion freezing measurements
 - Distinguish biogenic, inorganic and organic contributions



INP concentrations via immersion freezing from several campaigns since 2000 in the Colorado Mountains.

- Snow pit observation and sampling (Skiles/Univ. Utah)
 - Snow pit albedo, depth, density, temperature profiles, etc.
 - *In situ* Black Carbon (SP2) deposition
 - Offline dust and BC in snow



Skiles *et al.*, 2018, San Juan Mountain spectral albedo of snow and SNICAR calculations. Lower plots are associated SNICAR radiative forcing calculations.