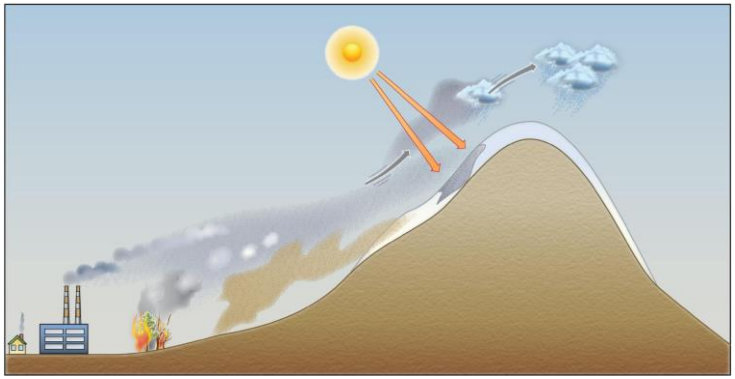
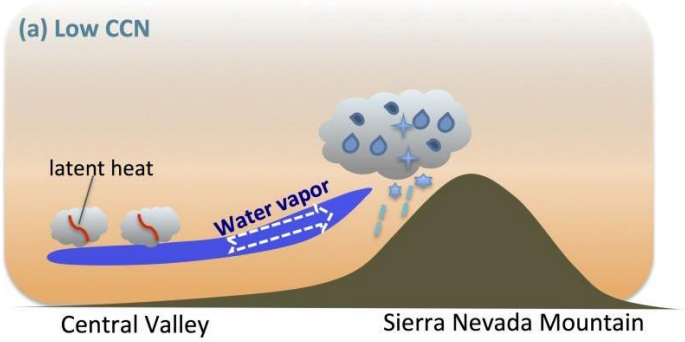
SAIL and Community Aerosol Observations and Science Opportunities

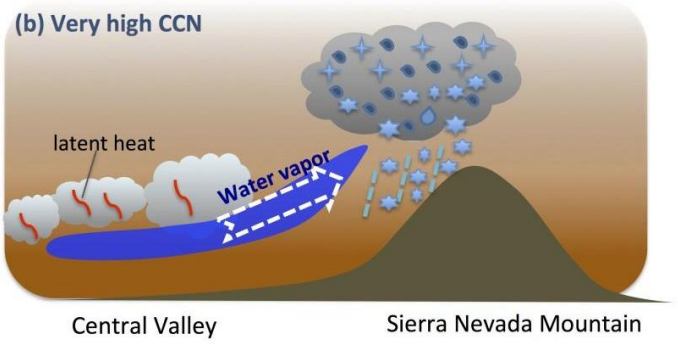
Allison C. Aiken[1], Paul DeMott[2], Jiwen Fan[3], McKenzie Skiles[4], Jim Smith[5], Dan Feldman[6]

[1]Los Alamos National Laboratory, [2]Colorado State University, [3]Pacific Northwest National Laboratory, [4]University of Utah, [5]University of Califorina–Irvine, [6]Lawrence Berkeley National Laboratory

Aerosol Regimes and Radiation







SCIENCE QUESTIONS

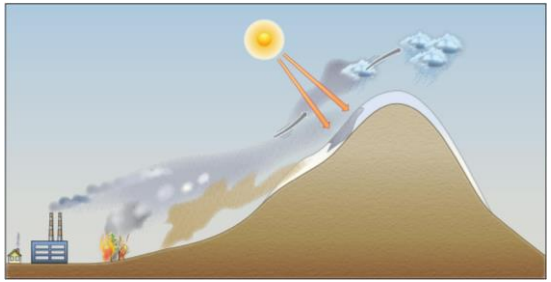
1) What are the dominant regimes of seasonal **aerosol transport, formation, growth, and removal processes** in the region?

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

3) How strongly do aerosols affect the surface energy and water balance by **altering and clouds and precipitation**?

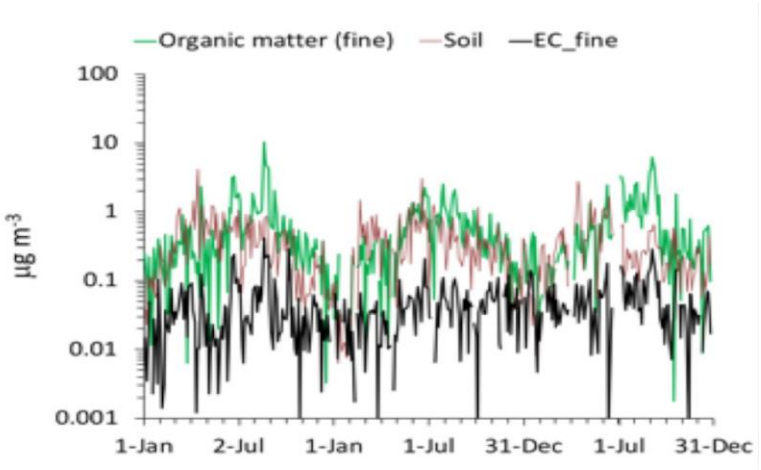
Aerosol Processes and Regimes

- **Aerosol processes impact the atmospheric and surface radiative environments**
  - Lifecycle (formation, growth, removal) and aerosol sources
  - Local and long-range transported aerosol
  - Atmospheric particles and deposition to the surface



- **Role of different aerosol sources on mountain hydrology**
  - Evidence of new particle and secondary organic aerosol formation and growth events in mountainous terrain
  - Spring and summer dust events and wildfires

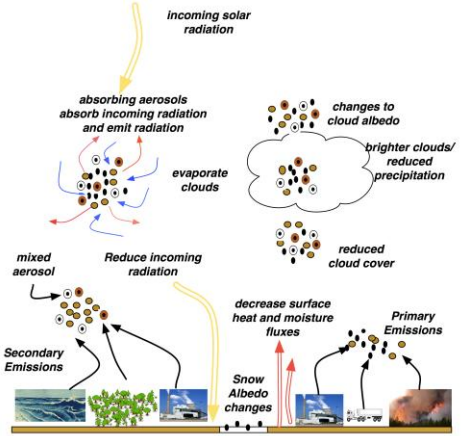
  → ***Radiative impacts have been poorly constrained by observations – most studies rely on models***



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

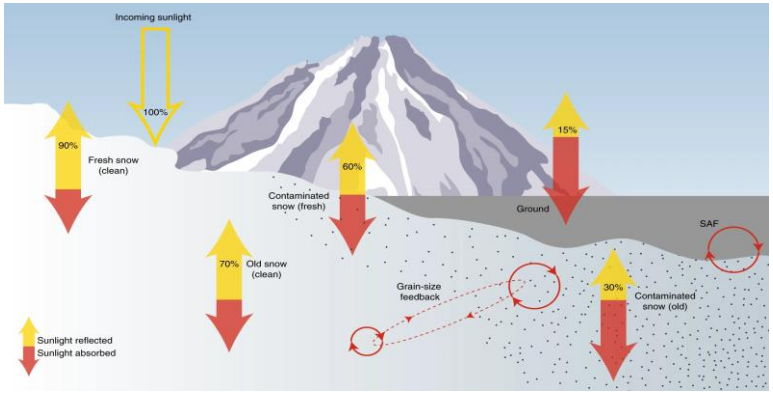
- **Atmospheric presence reduces solar radiation at the surface, increases atmospheric stability and decreases turbulent fluxes**
  - Absorbing dust species
  - Black carbon (BC, aka “soot”)
  - Brown carbon and secondary organics
- **Brown carbon, implicated but understudied in high-altitude melt**
- **Transported particles vs. surface deposition**
- **Snow pit observation and sampling (Skiles/Univ. Utah)**
  - Snow pit albedo, depth, density, temp profiles, etc.
  - *In situ* Black Carbon (SP2) deposition
  - Offline dust and BC in snow



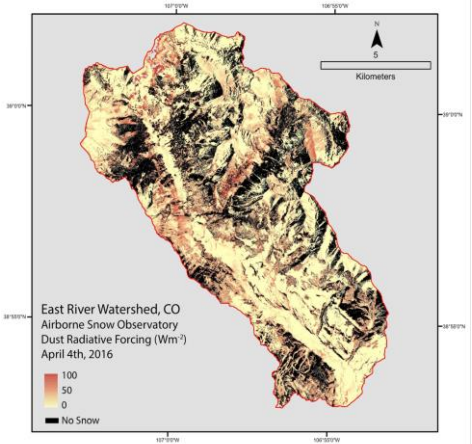
U.S. DOE BER Absorbing Aerosols Workshop Report (2016): Absorbing aerosols in the atmosphere and the various ways they interact with incoming solar radiation, clouds, and the dynamic and thermodynamic state of the atmosphere.

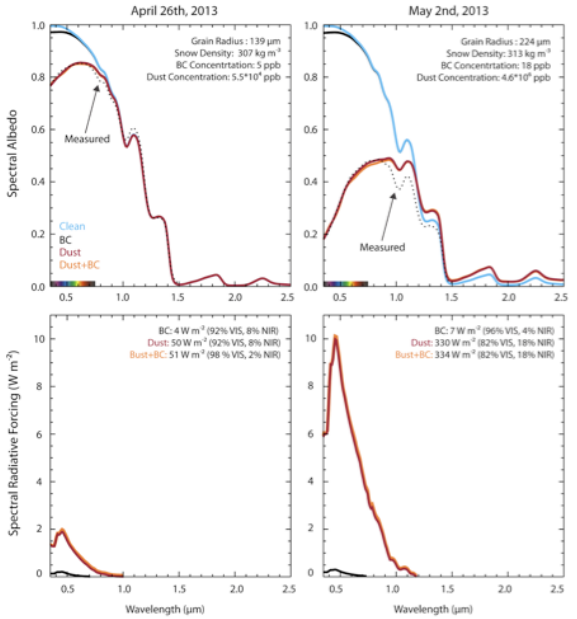
Absorbing Aerosols Alter Atmospheric and Surface Radiation

- **Absorbing aerosols deposit in/on 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



Skiles et al., Nature Climate Change, 2018.



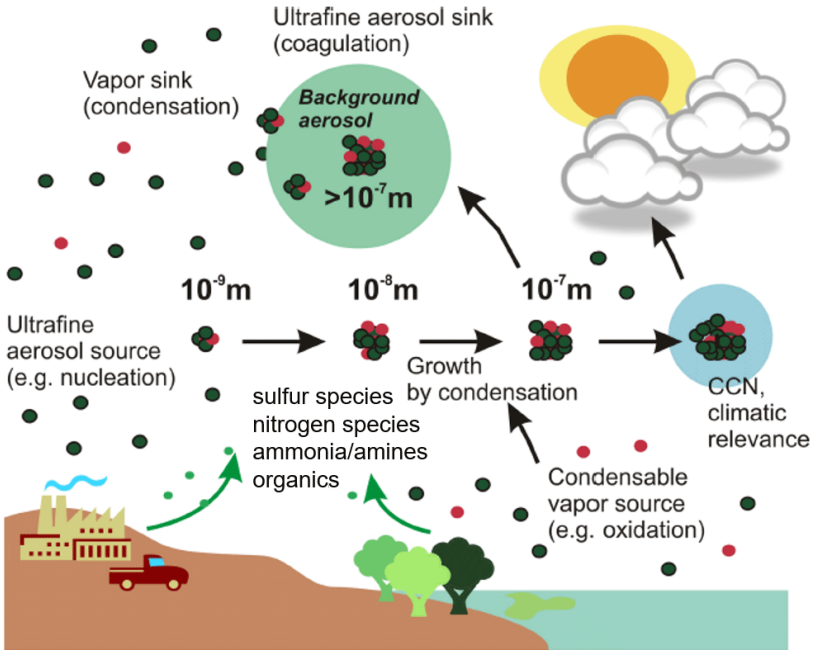


San Juan Mountain spectral albedo of snow. Lower plots associated SNICAR radiative forcing calculations.

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

Aerosol Lifecycle in Colorado

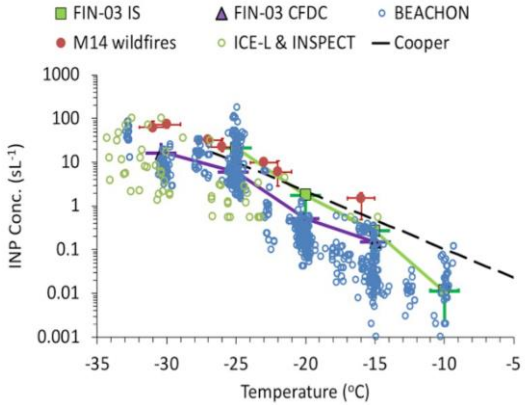
- **Aerosol lifecycles and the role of chemistry are key to understanding aerosol radiative impacts**
  - New Particle Formation and Growth
  - Removal (wet and dry deposition)
- **Are new particle events** on Colorado mountain terrain **observed when intrusions from the troposphere** mix with boundary layer trace gases?
- Do upslope valley winds transport **reduced nitrogen species to 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



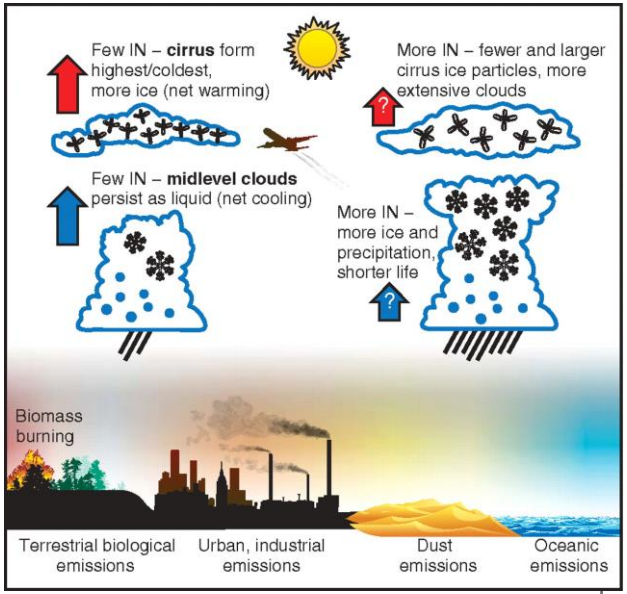
Riipinen, et al., ACP 2011.

Ice Nucleating Particles (INP)

- **Ice and mixed-phase clouds impact cloud radiative forcing, precipitation 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**?
- **Ice Nucleating Particle Sampler (Creamean+Hill/CSU)**
  - Immersion freezing measurements
  - Distinguish biogenic, inorganic and organic contributions



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



DeMott et al., PNAS, 2010.

AMF2 *In Situ* Aerosol Measurements: 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(RH)
  - Humidified Tandem Differential Mobility Analyzer (HTDMA)
  - Ice Nucleating Particle (INP) Sampler
- **Optical Properties**
  - Nephelometers
  - Particle Soot Absorption Photometer (PSAP)
- **Trace Gases and Meteorology**
  - CO Monitor
  - Ozone Monitor
  - Met Sensor
- **Physical Properties**
  - Aerodynamic Particle Sizer (APS)*
  - Condensation Particle Counter (CPC)
  - Scanning Mobility Particle Sizer (SMPS)*
  - Ultra-High Sensitivity Aerosol Spectrometer (UHSAS)

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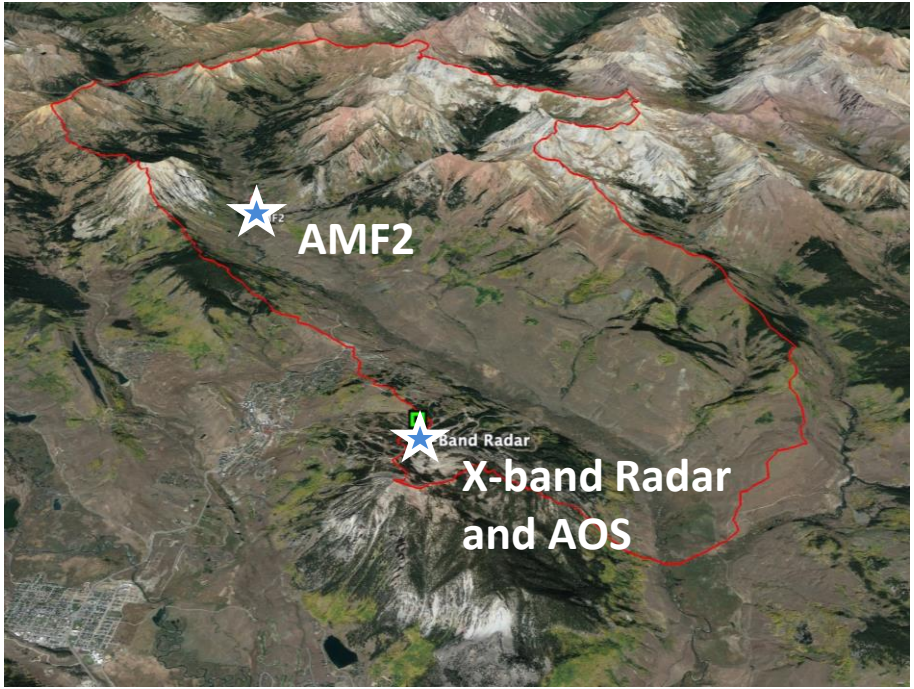
Uin, J., Aiken, A.C. et al. Atmospheric Radiation Measurement (ARM) Aerosol Observing Systems (AOS) for Surface-Based In Situ Atmospheric Aerosol and Trace Gas Measurements. *JAOT*, 2019. https://doi.org/10.1175/JTECH-D-19-0077.1

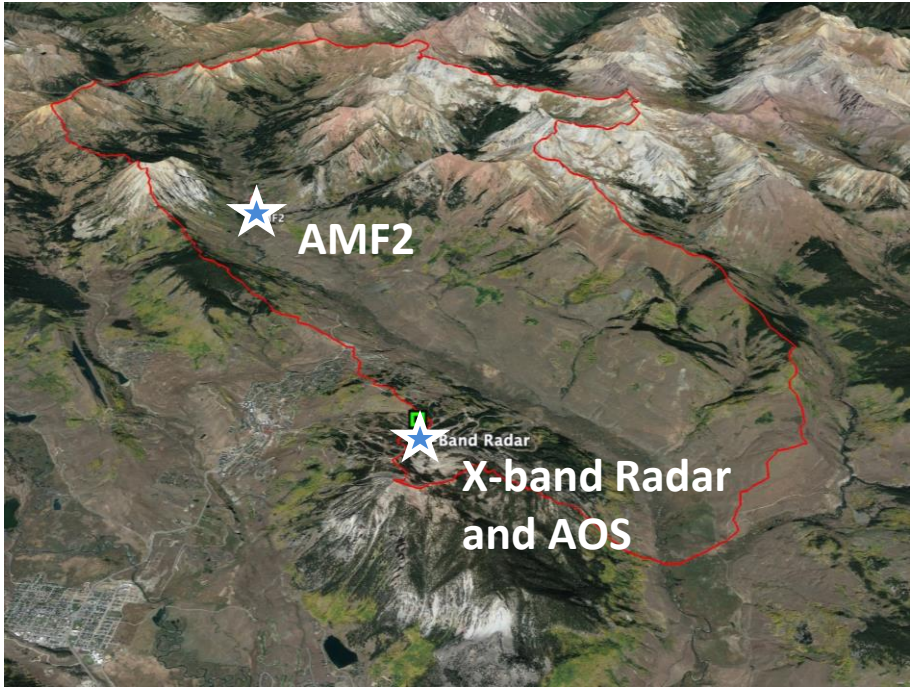
ARM Aerosol Measurements

- **ARM Mobile Facility 2 (AMF2)**
  - Located in the town of Gothic
  - Rocky Mountain Biological Lab (RMBL)
  - EPA CASTNET Site
- **Aerosol Observing System (AOS)**
  - Co-located with the Radar on Crested Butte Mountain
  - *In situ* aerosol measurements
  - Regional aerosol processes
  - Ability to capture long-range transport
  - Minimal local sources
- **Tethered Balloon System (TBS)**
  - Location and deployment TBD
  - Aerosol configuration (CPC and POPS)



ARM Aerosol Measurements

- **Additional SAIL aerosol projects submitted**
  - ASR FOA-0002391
  - DOE SBIR/STTR
  - ARM: Guest instrument
- **Undergraduate Research (Jennifer Herdman/W CO Univ)**
  - Absorbing aerosols – BC/soot
  - Rocky Mountain Biological Lab (RMBL)
- **Welcome new projects**



SAIL Aerosol Measurements Discussion

- **Intensive Operational Periods and Additional Guest Instrumentation Requests**
  - Survey of the ARM/ASR Aerosol Process Working Group (Jim Smith)
  - Large interest in participating
  - Logistics and coordination of deployment timing

- **Discussion Questions: Aerosol Process Measurements**
  - **Do we have the observational measurements needed?**
    - Aerosol process studies
    - Modeling efforts
    - Warm and cold season processes
  - **What partnerships are needed to coordinate with NOAA SPLASH to best inform campaign science objectives?**

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SAIL Aerosol Process Co-I Team

Thank you
for your participation!

Allison C. Aiken
LANL
aikenac@lanl.gov

Paul DeMott
Colorado State Univ.
paul.demott@colostate.edu

Jiwen Fan
PNNL
jiwen.fan@pnnl.gov

McKenzie Skiles
Univ. of Utah
Mckenzie.skiles@gmail.com

Jim Smith
UC-Irvine
jimsmith@uci.edu