SAIL and Community
Aerosol Observations and Science Opportunities

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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
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

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

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 \textit{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)

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**
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?

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
Thank you for your participation!