Advancing Atmospheric Process Studies in High-Altitude Complex Terrain with the Surface Atmosphere Integrated field Laboratory (SAIL) Campaign

2020 ARM/ASR PI Meeting Breakout Session
June 25, 2020

Co-Hosts: Dan Feldman (LBNL) and Scott Collis (ANL)
Panelists: Chandra (CSU), Allison Aiken (LANL), Jiwen Fan (PNNL), Ryan Sullivan (ANL), Dave Gochis (NCAR)

Breakout Session Logistics

- For questions during presentations, please use the chat function.
- During discussion, please raise your hand (*9 for phone calls) and hosts will enable you to speak.

- Schedule:

  - SAIL Campaign Overview (Dan Feldman)
  - Precipitation processes (Chandra)
  - Aerosol processes (Allison Aiken)
  - Aerosol-precipitation interactions (Jiwen Fan)
  - Land-atmosphere interactions (Ryan Sullivan)
  - Testing process models and state/local/national partnerships (Dave Gochis)
  - Discussion

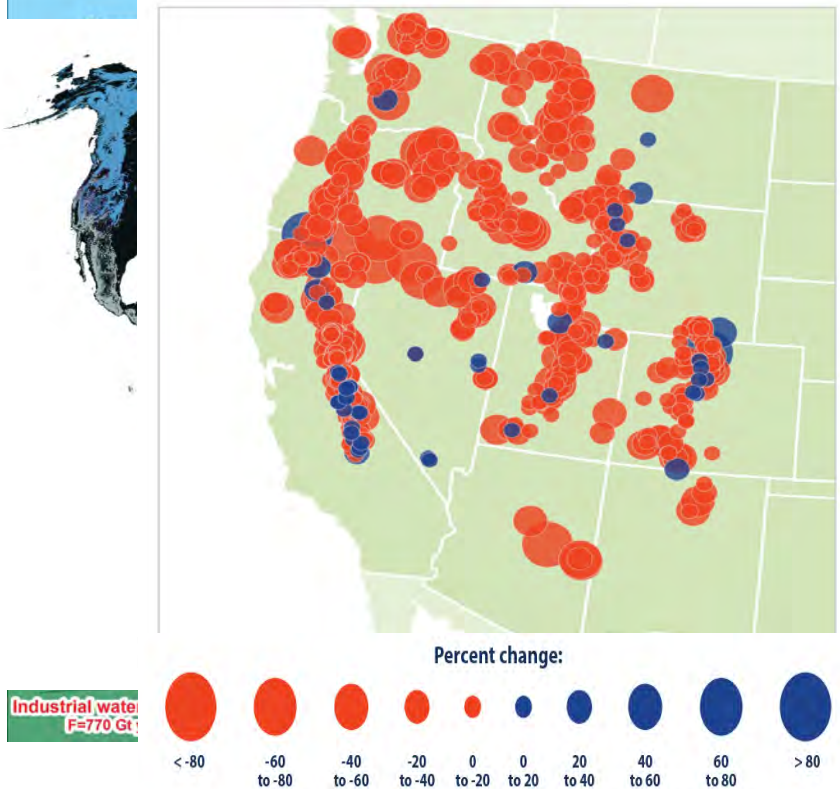
Background: Water Resources are Threatened

- Half of the world depends on water from mountains, but these resources are dwindling.
- From AMF Workshop Report:

  “aerosols can exert large influences on orographic precipitation.”

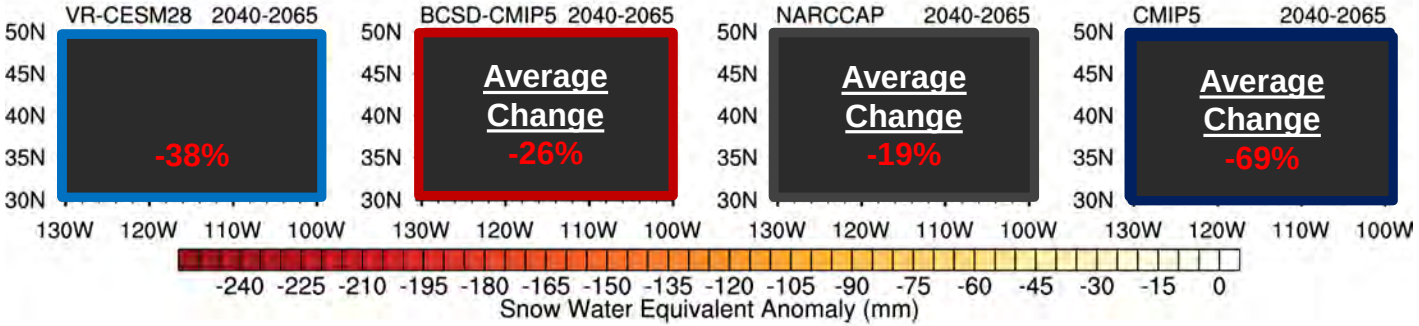
  “Understanding the interactions between atmospheric (clouds, precipitation, and radiation) and land-surface processes (snowpack, soil moisture, and runoff) in mountain regions is critical to understanding variability and changes in water availability on weather-to-climate timescales.”

SNOTEL SWE Trends

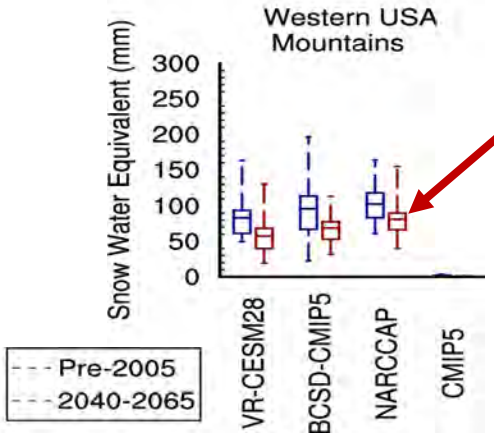


Mote and Sharp, 2016, BAMS

Background: ESM Development Needed in Complex Terrain



Regional Downscaling Ensemble Average
-27%



Western USA mountain SWE median values fall at-or-below the 25th percentile of historical by 2040-2065

Rhoades et al, 2018, Clim. Dyn.

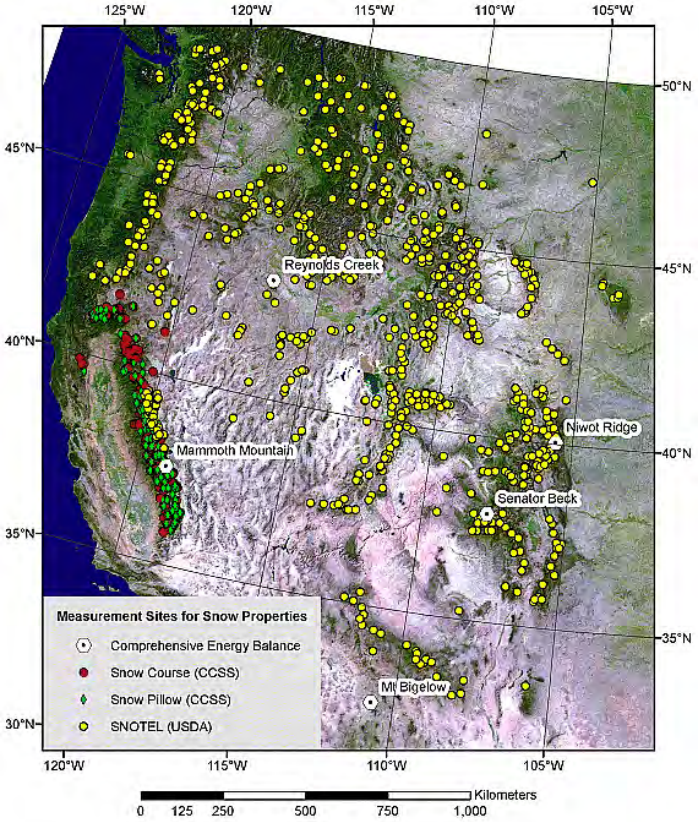
Background: Measurement-Process Model Controversy

Precipitation information in the Mountain West relies heavily on a sparse network of weather stations.

Are process models better than the observational network?

OUR SKILL IN MODELING MOUNTAIN RAIN AND SNOW IS BYPASSING THE SKILL OF OUR OBSERVATIONAL NETWORKS

JESSICA LUNDQUIST, MIMI HUGHES, ETHAN GUTMANN, AND SARAH KAPNICK



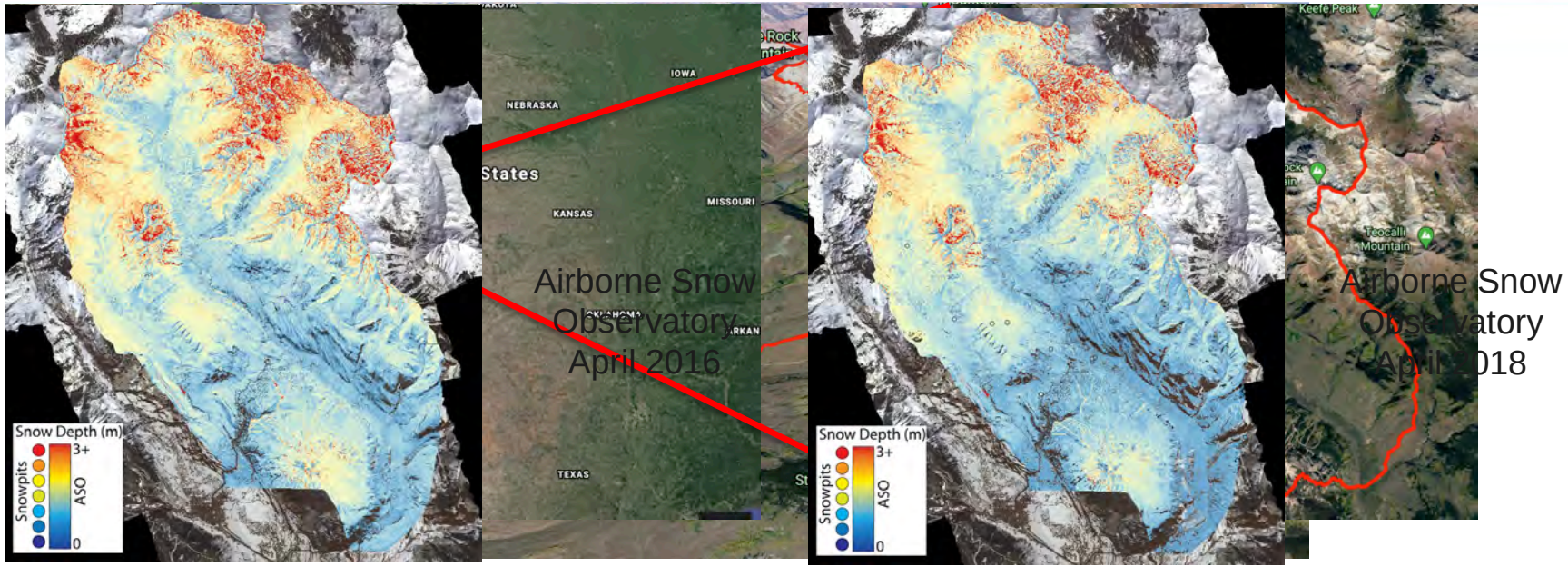
Bales et al., 2006, WRR

SAIL: Sending the AMF2 to the East River Watershed

- Uncertainties in atmospheric inputs to watersheds complicate mountainous hydrology research.
- SAIL will directly address these uncertainties by integrating atmospheric observations with surface and surface researchers to achieve atmosphere-through-bedrock observations.
- SAIL will deploy the AMF2 to the East River Watershed near Crested Butte, Colorado from 09/2021 – 06/2023.
- Goal: characterize atmospheric processes that impact energy and mass budgets of Upper Colorado River watersheds.

Photo Credit: Connor Scalbom

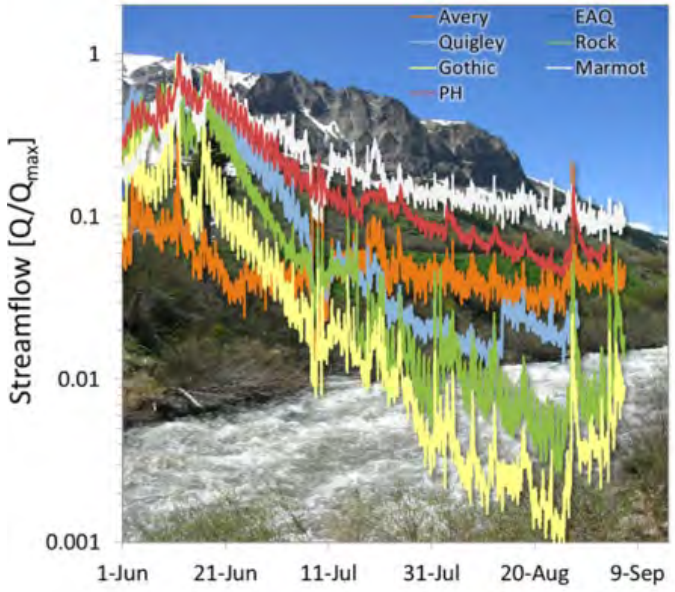
Background on East River Watershed

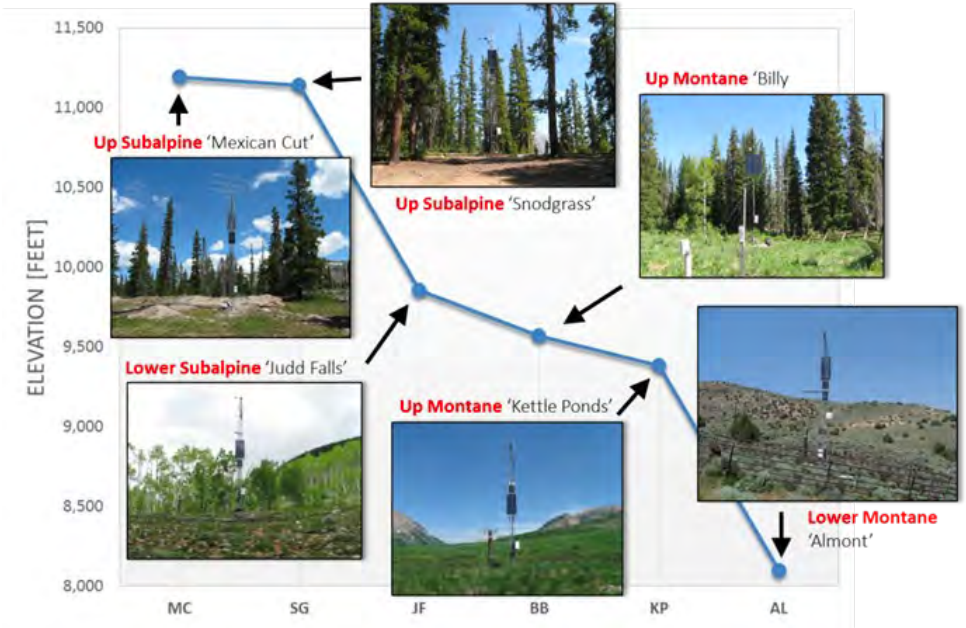


East River Watershed covers 300 km^2 of the Upper Colorado River Basin.
Elevation 2500-3500 masl, ~500-1000 cm snowfall/yr, ~66-124 cm liquid equivalent precip/yr
DJF DTR (-20°C,-1°C), JJA DTR (3°C, 23°C)

Collaborative Resources

SAIL will leverage resources and expertise from the Watershed Function SFA, which is an SBR-funded research program to characterize surface and sub-surface processes in mountainous watersheds.





SAIL Instruments and Team

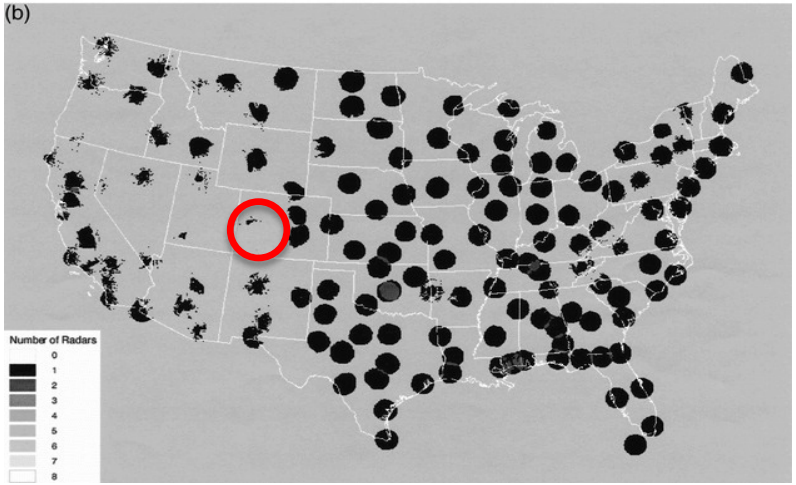
- SAIL campaign will have ~3 dozen AMF instruments + X-band scanning precipitation radar.
- The science team covers 4 National Labs, 10 universities, and 2 research centers.

SAIL Science Objectives

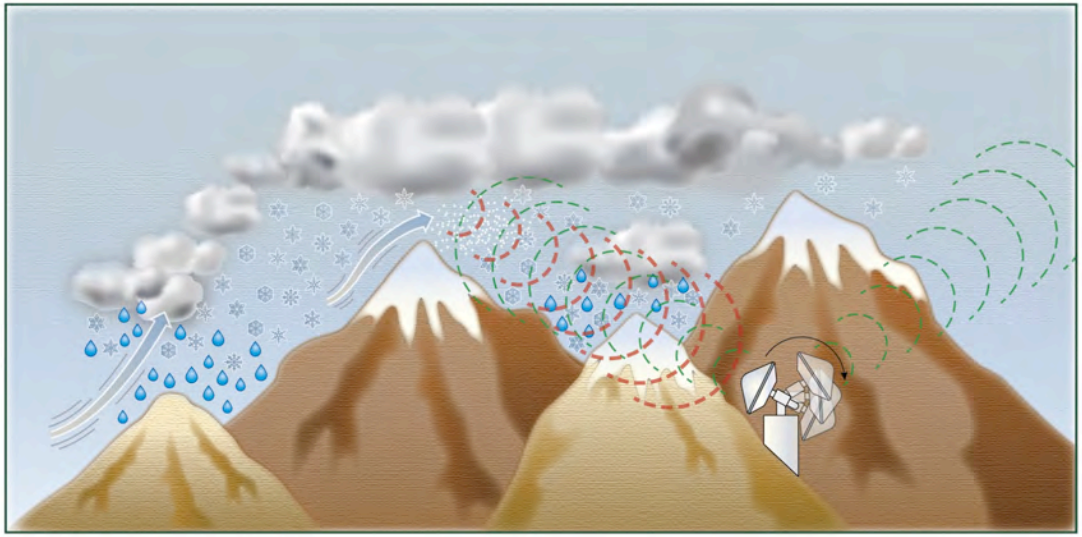
SAIL will characterize processes across seasons.

1. Precipitation: how and how much.
2. Winds: sublimation and snow redistribution.
3. Aerosols: surface and atmosphere radiative impacts
4. Aerosols: interactions with precipitation.
5. Surface fluxes: controls on the surface energy and mass balance.

Precipitation Process Studies (Chandra)



Maddox et al., 2002, BAMS



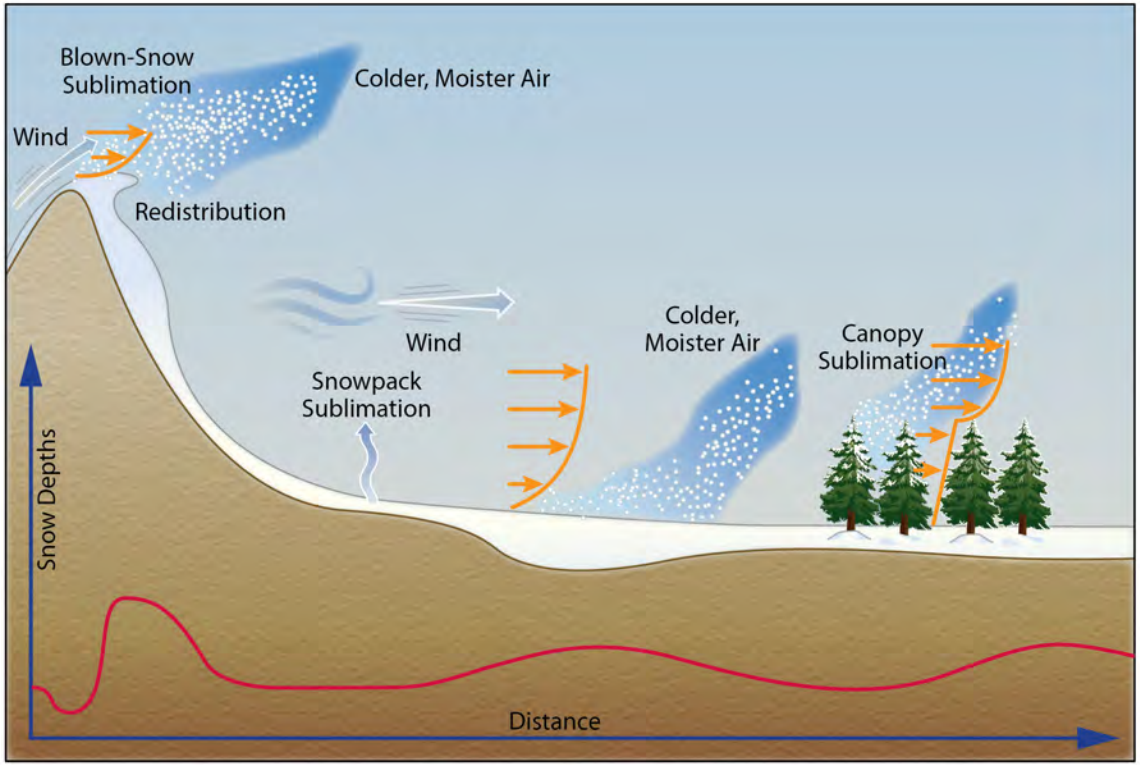
SAIL will measure the spatiotemporal variability in precipitation, determine the processes that contribute to that variability, and use this info to determine where atmospheric process models need improvement.

Sublimation and Wind-Redistribution Process Studies

Snow can be redistributed during and after precipitation events, and snowpack can be lost mostly due to sublimation on blowing particles.

There is large spatiotemporal variability in these processes.

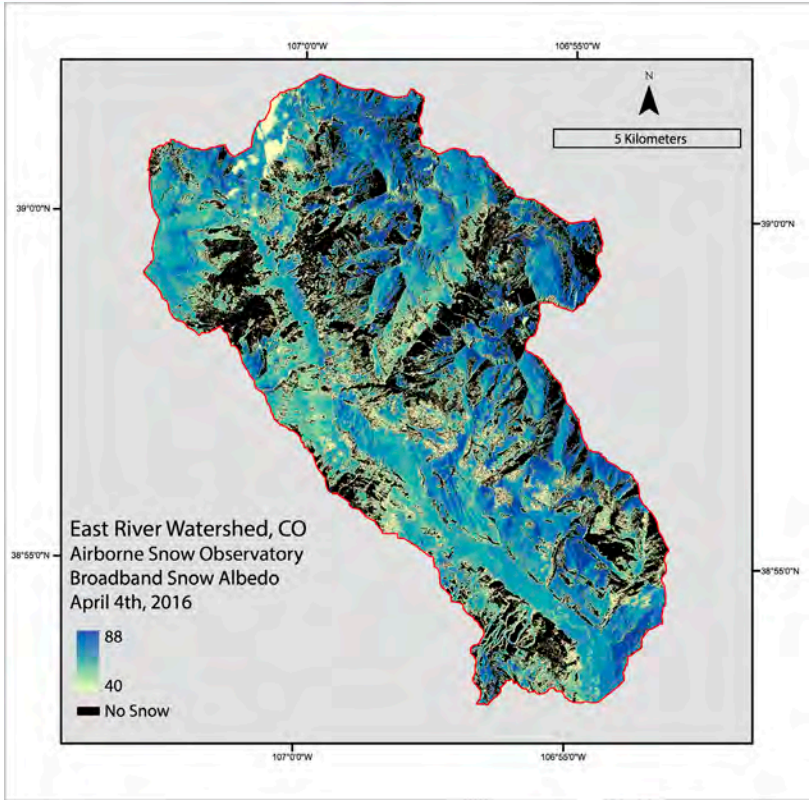
SAIL will measure winds, snow entrainment, thermodynamics and fluxes to test representation of these processes in atmospheric models.



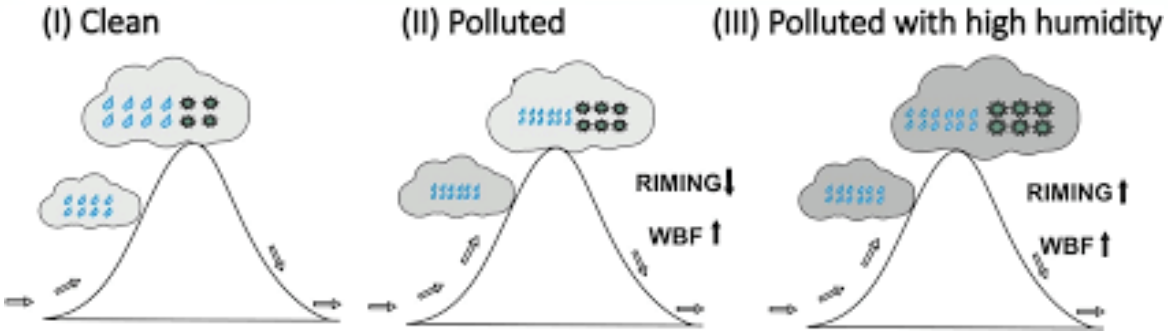
Aerosols: Regimes and Radiation (Allison Aiken)

Local and non-local aerosols impact atmospheric and surface radiation in the East River Watershed, sometimes in opposing ways.

SAIL will use the AMF2 AOS and collaborative resources to characterize aerosol regimes and radiative impacts.



Aerosols: Precipitation Interactions (Jiwen Fan)



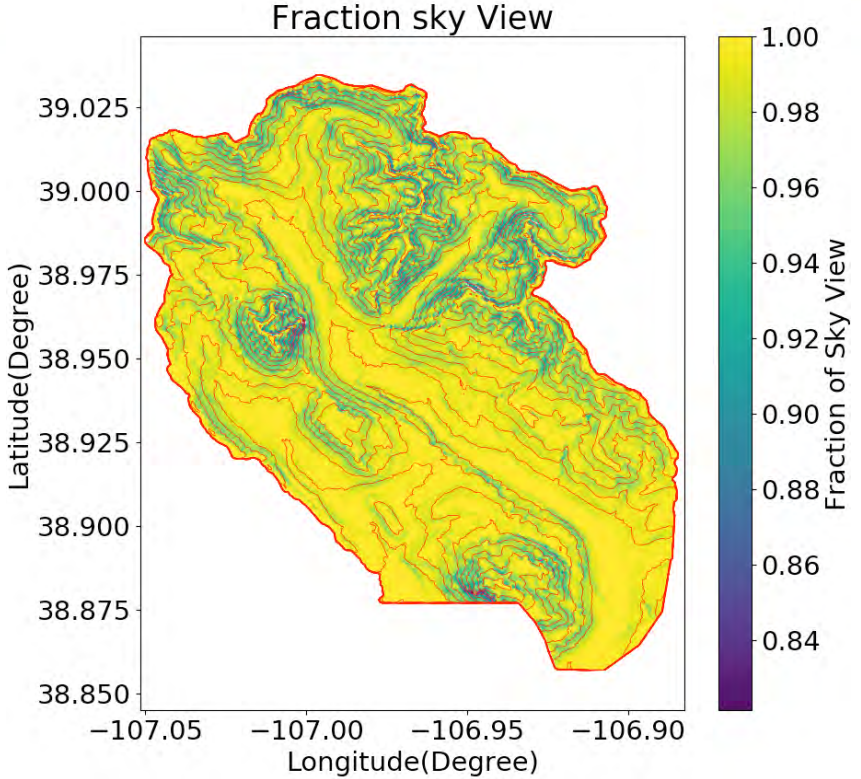
Choudhury et al, 2019, Atmos. Env.

Aerosols may impact orographic precipitation by serving as cloud-condensation nuclei (CCN) and ice-nucleating particles (INPs).

SAIL will characterize many aspects of how aerosols impact orographic precipitation by using numerous ARM datastreams to measure precipitation, aerosols, and boundary layer evolution.

SW and LW Radiation in Complex Terrain

The sky-view is limited by complex terrain, with implications for SW and LW radiation. These effects generally are not included in process and earth-system models.

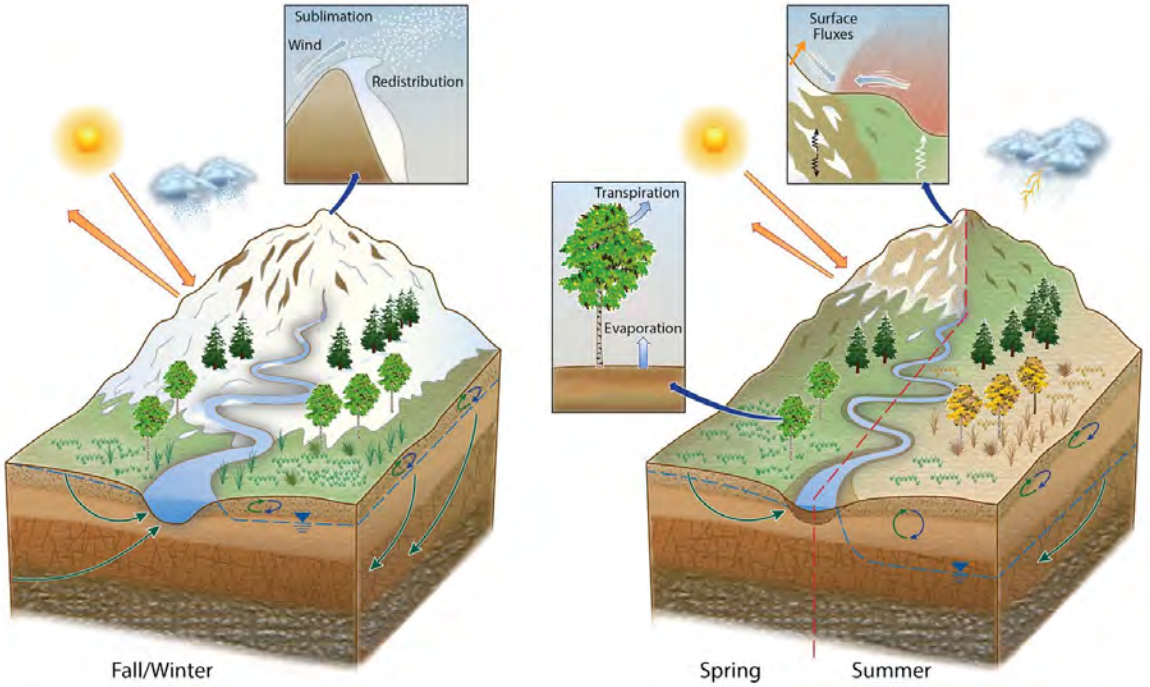


Surface Fluxes: Energy and Mass Budgets (Ryan Sullivan and Dave Gochis)

The factors impacting surface mass and energy balance vary strongly across seasons.

SAIL will measure radiative, sensible, and latent heat fluxes, characterize water fluxes, how they change across seasons, and connect those to hydrological observations.

These data will enable testing of integrated (atmospheric coupled to surface/subsurface) process models.



Follow-Up Information

- Visit https://sail.lbl.gov for the SAIL campaign.
- Visit https://watershed.lbl.gov for details on the Watershed Function SFA.
- Stay tuned for a virtual workshop to discuss SAIL science and opportunities.
- Consider joining the SAIL mailing list. Email Kim Stewart (kimberly.stewart@pnnl.gov) to join.

SAIL Discussion Topics

1. ARM data products and needs
2. Managing the different scales of surface and atmosphere process model.
3. Testing Earth System Models
4. Intensive Operations Periods
5. Other outreach opportunities
6. Second year hypothesis development