Sublimation from Drifting Snow

Observations from the Sublimation of Snow (SOS) project in the East River Basin, 2022-2023

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Overview

- Importance of Detailed Snow Processes
 - Snow and wind, albedo, and runoff
- The Sublimation of Snow (SoS) project
 - Team, measurements, SAIL/SPLASH connections
 - 1 year of continuous terrestrial lidar scans
- Sublimation
 - Impact of blowing snow
 - Valley winds, clouds and basin water balance (ask me after)



Predator-prey relationships Habitat

Elk Mountains, Colorado 2023, Movie: Ethan Gutmann

Suspension over mountain ridges



The Sublimation of Snow (SoS) Project

 See great talk by Jessica Lundquist (PI) on DOE SAIL webinar series

https://sail.lbl.gov/events/regular-meeting

- What were we measuring and why?
- More instruments than should fit in a 50 x 50m plot of land!
- Snow, Sublimation, and more

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EOL Technicians

Measuring Sublimation of Snow is Hard

- Stable conditions are very common over snow (it's a cold surface)
- Mountains are not horizontally homogenous & valley scale circulations are strong
- Blowing snow leads to vertical discontinuities & maybe saturation
- The snow surface itself is changing with time

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- Sensible and Latent Heat fluxes may not scale together
- Mountain snow is where all assumptions in MOST go to die.



Slide from Jessica Lundquist: (from left) Wind shear from daytime valley wind and slope winds (Rotach et al., 2008); very stable boundary layer (Mahrt et al. 2014) blowing snow layers (Bintanja, 2000); photo by E. Gutmann; Flux distributions from SHEBA (from Lamone et al. 2019)

Science Questions and Essential Observations

1) What governs characteristics of the near-surface boundary layer over snow in complex terrain?

Link turbulence measured at multiple heights above the surface to valley-scale wind fields, changing snow surfaces, and blowing snow

2) How much snow sublimation occurs during different boundary layer regimes, and how does this affect the total seasonal mass and energy balance?

Maintain multiple measurements through the winter

3) What measurement and analysis strategies are most robust for quantifying snow sublimation in a mountain valley?

Compare eddy covariance with mass and energy balance observations



Collaboration with SAIL for valley-scale context

In 2022 and 2023, the Department of Energy Surface Atmosphere Integrated Field Laboratory (SAIL) is studying winds, snowfall, and runoff in the East River Basin, CO



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Colorado State University X-band Radar Twice-daily radiosonde Rocky Mountain Biological Laboratory (RMBL) DOE Doppler Lidar

Near Daily Snow Pits: January – mid-March



A (snow) year in the life of an alpine basin





Terrestrial Laser Scanners (TLS)

Lower point density with distance

Upwind West Tower

- 6 Mounted 2 on each 10m tower
- 200
- Poir bus





Lidar Measurements of Snow Depth

• Very different dynamics ~20m apart





Snow Depth Spatial Visualization

- Context for local changes in snow depth
- Quantification of
 - Snow dune propagation
 - Scouring
 - Sastrugi formation and multiscale surface roughness
 - blowing snow particles
 - Vegetation heights? _
- **Characteristics**

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- 10 cm spacing —
- 1-5 min interval
- ~1cm vertical accuracy(?)-40 —



- Dunes are evident on many days at Kettle Ponds
- 10-20 cm vertical amplitude
- 5-10 m horizontal spacing

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• Speed varies, ~5 m/hr

Ridge line flow separation and downwind dynamics

 How do downwind eddies influence snow distribution, transport, and sublimation?

Cross valley doppler lidar imagery of flow detachment and downwind eddies/rotors

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Horizontal Distance from Lidar [m]

Basin circulation controlled by thermally driven flow

- Cold valley floor cools air, which settles and drains down the valley.
- Warm slopes in summer warm air, which rises pulling air up the valley and leading to cloud formation (which shade and cool the surface)
 - Unless there is still snow on the slope...
- How much of a basin has to be covered in snow to decrease thermal cloud formation?
 ~up-down valley Lidar radial velocity [m/s]

Valley winds, snow cover, and clouds

April 7, 2022

100

80

60

40

20

0

6

8

10

12

hour

14

16

Opaque Cloud Percent

May

Aug

Diurnal cycle of mountain valley winds varies seasonally, maybe with snow/moisture?

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Cloud cover coupled to topography varies seasonally, maybe with winds?

Thank you!

