Ground-based remote sensing of the atmospheric boundary layer in the East River Valley in the Colorado Mountains during SPLASH

Bianca Adler[1,2], Laura Bianco[1,2], James Wilczak[2], Joseph Sedlar[1,3], Irina Djalalova[1,2], Timothy Myers[1,2]

[1] CIRES, University of Colorado Boulder [2] NOAA Physical Science Laboratory (PSL) [3] NOAA Global Monitoring Laboratory (GML)

Cooperative Institute for Research in Environmental Sciences
UNIVERSITY OF COLORADO **BOULDER** and **NOAA**

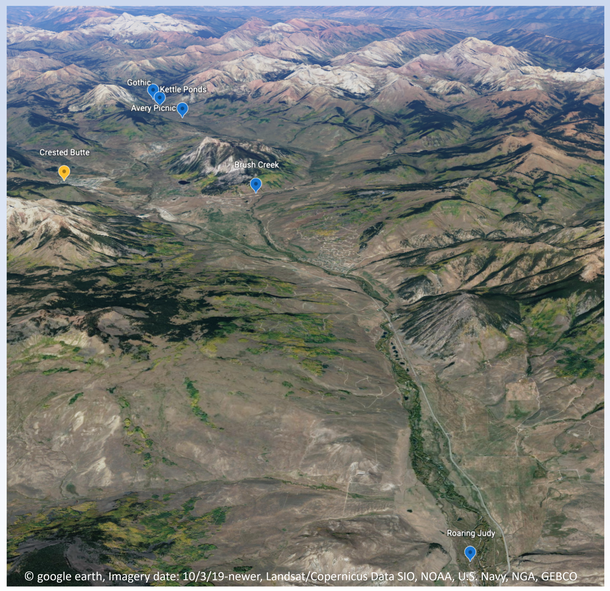
Introduction:

- The ongoing Surface Atmosphere Integrated Field Laboratory (SAIL) and Study of Precipitation, the Lower Atmosphere and Surface for Hydrometeorology (SPLASH) field studies in the East River watershed aim to investigate key physical processes in the watershed hydrology.
- Three months of data (10/21-1/28) are used to study the spatial variability and temporal evolution of the atmospheric boundary layer during the transition from fall to winter.

Used Data:

Several sites are deployed along the valley axis with similar instrumentation (including the ARM mobile facility):

- Surface meteorology, radiation fluxes, and heat fluxes
- Ceilometers for cloud base height
- Infrared spectrometers (AERI and ASSIST) and microwave radiometers are used to retrieve thermodynamic profiles with an optimal estimation physical retrieval (TROPoe, Turner and Löhnert 2014, Turner and Blumberg, 2019, Turner and Löhnert 2021)



References:

SAIL: https://sail.lbl.gov/,
SPLASH: https://psl.noaa.gov/splash/

Turner, D. D., and U. Löhnert. "Information content and uncertainties in thermodynamic profiles and liquid cloud properties retrieved from the ground-based Atmospheric Emitted Radiance Interferometer (AERI)." JAMC 53.3 (2014): 752-771.

Turner, David D., and W. Greg Blumberg. "Improvements to the AERIoe thermodynamic profile retrieval algorithm." *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* 12.5 (2018): 1339-1354.

Turner, David D., and Ulrich Löhnert. "Ground-based temperature and humidity profiling: combining active and passive remote sensors." *AMT* 14.4 (2021): 3033-3048.

Main points:

- Snow cover changes from intermittent to more homogeneous after first strong snowfall event of the season between 12/7-12/10
- Major changes in surface energy balance, valley wind, near-surface temperature, and stratification after this event
- Lower stations experience colder nighttime temperatures -> cold air pooling in the valley

2-m temperature, precipitation, radiation and heat fluxes:

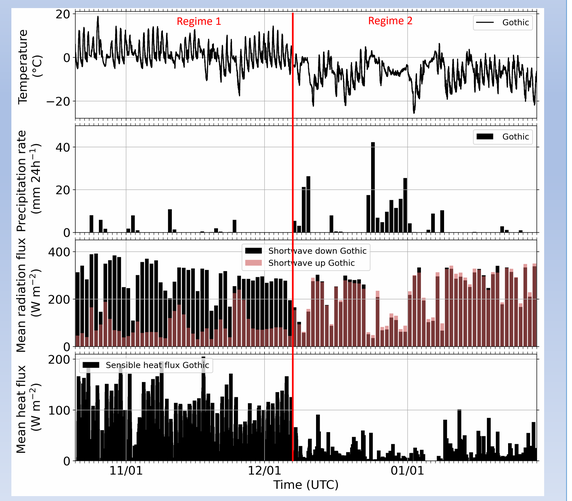
- 3-month period can be split in two main regimes separated by a major precipitation event on 12/7-12/10

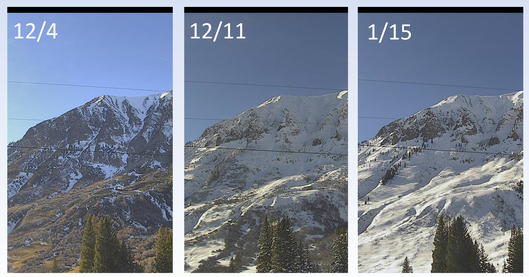
Regime 1:

- Relatively warm and dry
- Small albedo (shortwave down much larger than shortwave upward radiation)
- High sensible heat flux
- Intermittent now cover

Regime 2:

- Maximum temperature near freezing
- Significant snowfall at the end of December followed by a dry January
- Very high albedo (≈1)
- Very low sensible heat flux
- Continuous snow cover



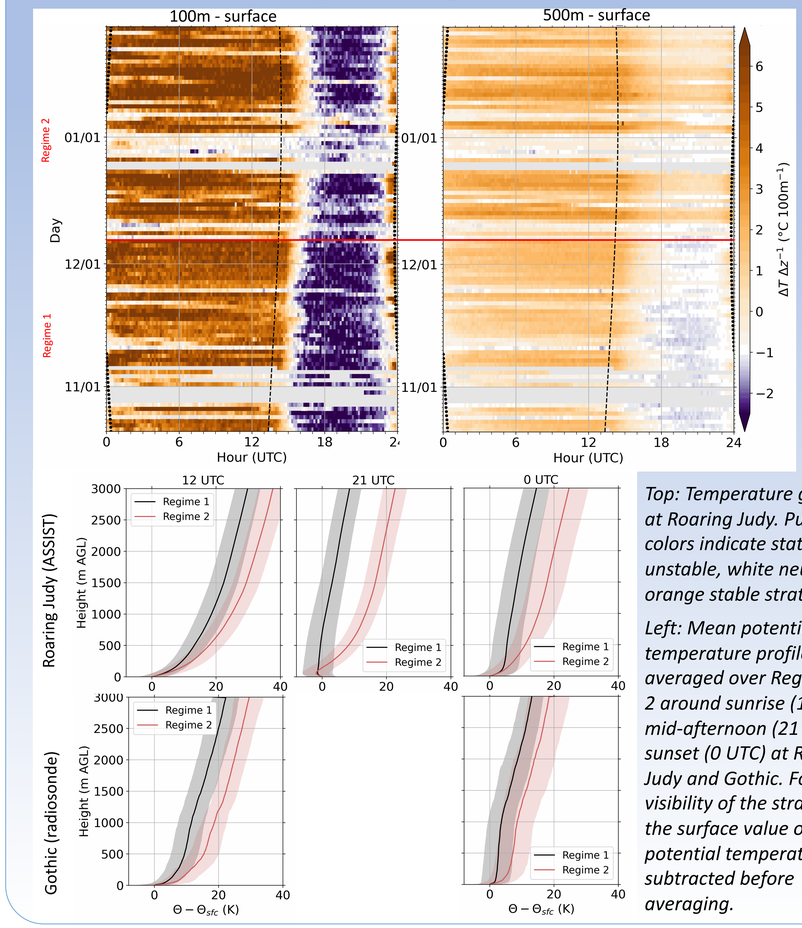


Top: 2-m temperature, 24-h precipitation rate, mean diurnal shortwave downward and upward radiation, and mean diurnal sensible heat flux at Gothic

Bottom: Camera images looking west from Gothic at 21 UTC on 3 days.

Stratification in the boundary layer

- Strong surface inversion during nighttime forms regularly during both regimes
- Surface inversion gets mixed out during daytime during Regime 1, while a stable layer of more than 500 m depth persists during daytime during Regime 2with a shallow CBL embedded
- Nocturnal inversion stronger at Roaring Judy than Gothic

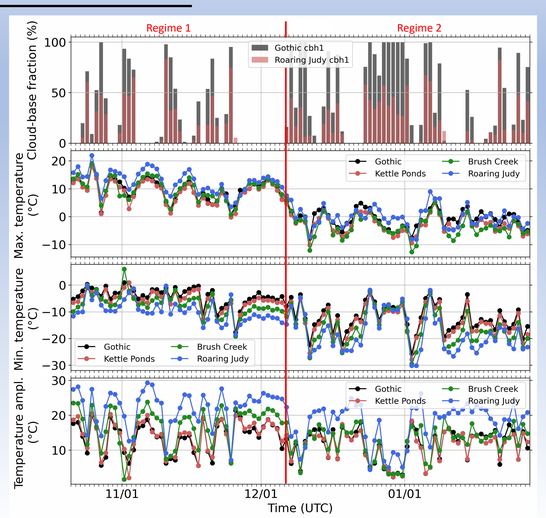


Top: Temperature gradients at Roaring Judy. Purple colors indicate statically unstable, white neutral, and orange stable stratification.

Left: Mean potential temperature profiles averaged over Regime 1 and 2 around sunrise (12 UTC), mid-afternoon (21 UTC), and sunset (0 UTC) at Roaring Judy and Gothic. For better visibility of the stratification, the surface value of potential temperature is subtracted before averaging.

Variability along the valley axis

- Cloud-base fraction higher further up the valley, but clear-sky days generally occur at both sites
- Maximum temperature similar at all sites, but minimum temperature lower further down the valley → cold air pooling and stronger diurnal cycle at lower stations
- Downvalley wind dominates at all sites during both regimes, even more frequent during Regime 2
- Downvalley wind direction most variable at Gothic, very clear at Kettle Ponds, Brush Creek and Roaring Judy
- Upvalley wind forms during Regime 1 only, mostly absent during Regime 2



Left: Daily cloud base fraction (cloud base < 3 km), daily maximum and daily minimum temperature, and diurnal temperature amplitude.

Bottom: Wind roses at 4 sites for days during Regime 1 (top) and Regime 2 (bottom) when the mean shortwave downward radiation flux exceeded 250 W m⁻²