Perspectives on surface albedo in the East River Basin from SPLASH observations

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SPLASH Team


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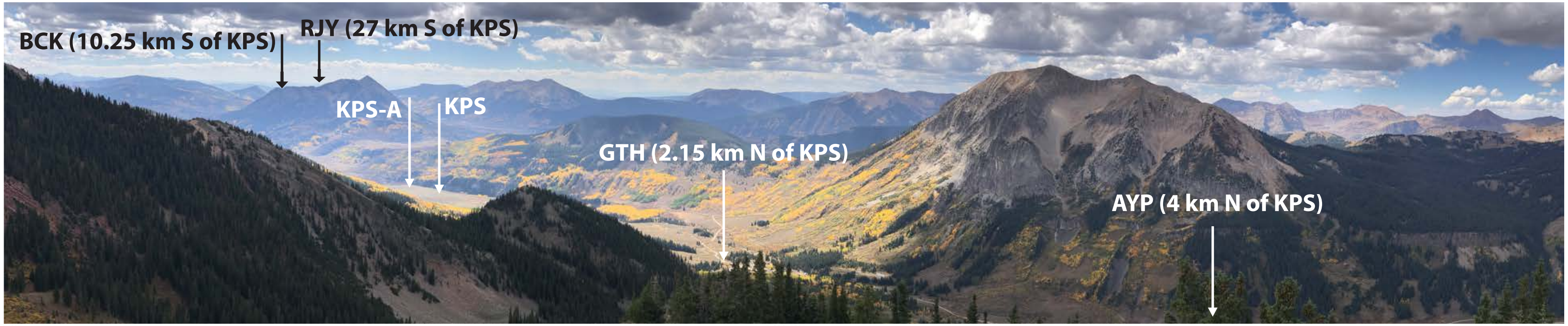
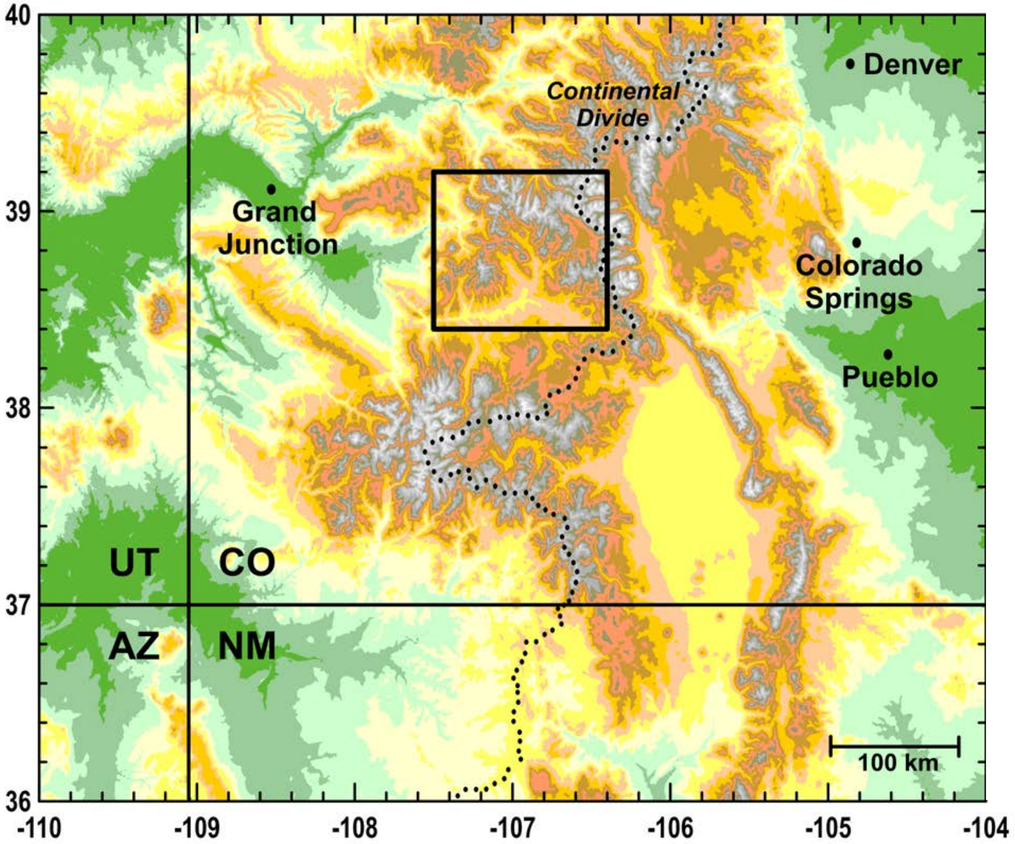
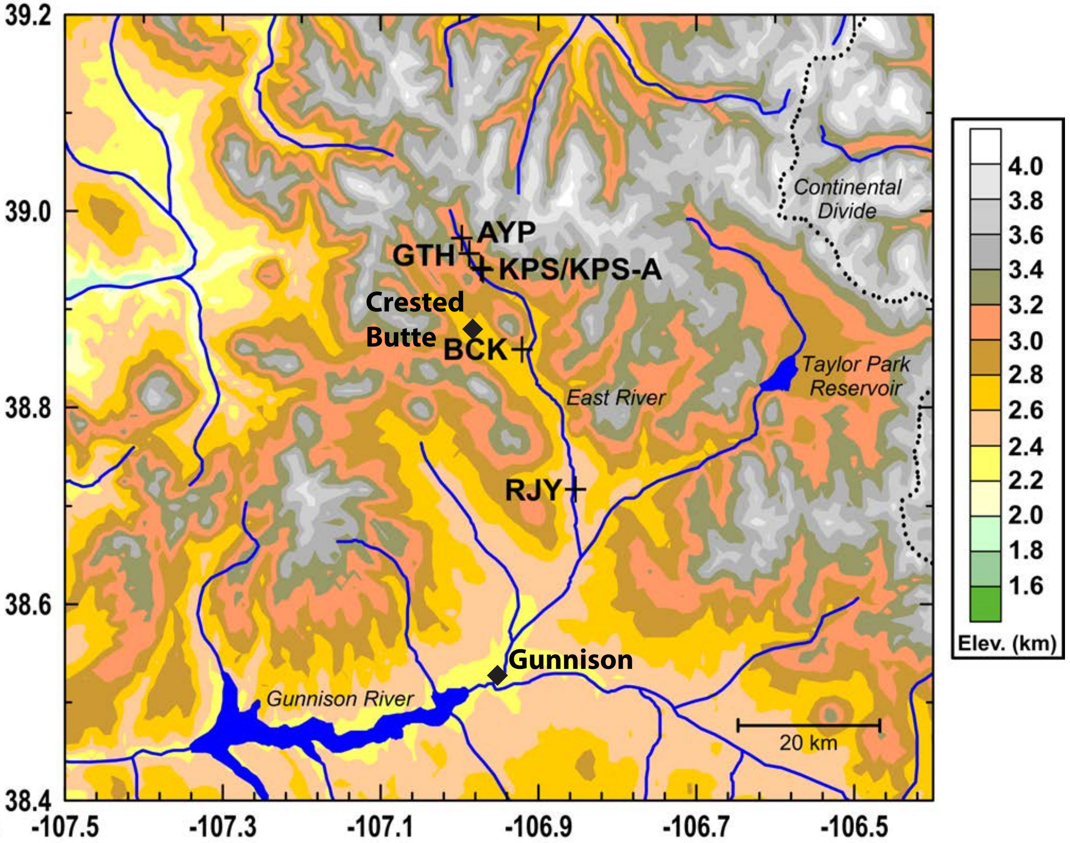
SPLASH Location

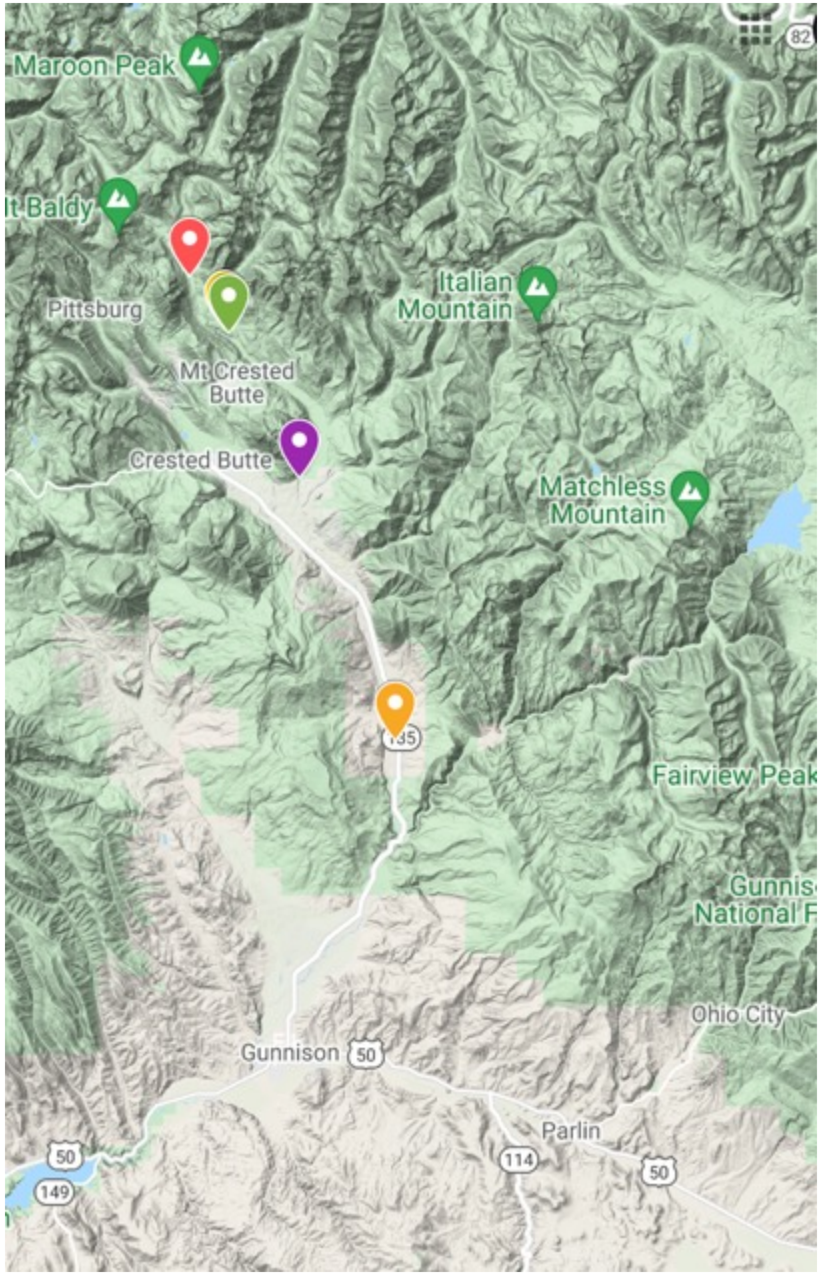
[de Boer et al., 2023]







Core SPLASH Measurements



Measured quantities	Avery Picnic	Kettle Ponds	Brush Creek	Roaring Judy
Surface Meteorology (2m T, p, q, winds)	X	X	X	X
Soil Moisture	X	X	X	
Snow depth	X	X	X	
Snow temperature and density		X		
Thermodynamic profiling			X*	X*
Wind profiling			X*	
Cloud base height		X	X	X*
Surface precipitation rate and droplet size distribution		X	X	
Snow/Rain level		X	X	
Precipitation profiling		X	X	X
Sky/Surface broadband surface radiation	X	X	X	
Surface Spectral radiation		X	X	
Surface turbulent fluxes	X	X	X	
Turbulence at 10 m		X		
Cloud optical depth			X	
Aerosol optical depth		X	X	
Cloud fraction		X	X	X
Surface albedo, snow cover and soil moisture surveys	X	X	X	
In-situ thermodynamic, wind and turbulence profiling	X	X		
Normalized Difference Vegetation Index	X	X	X	

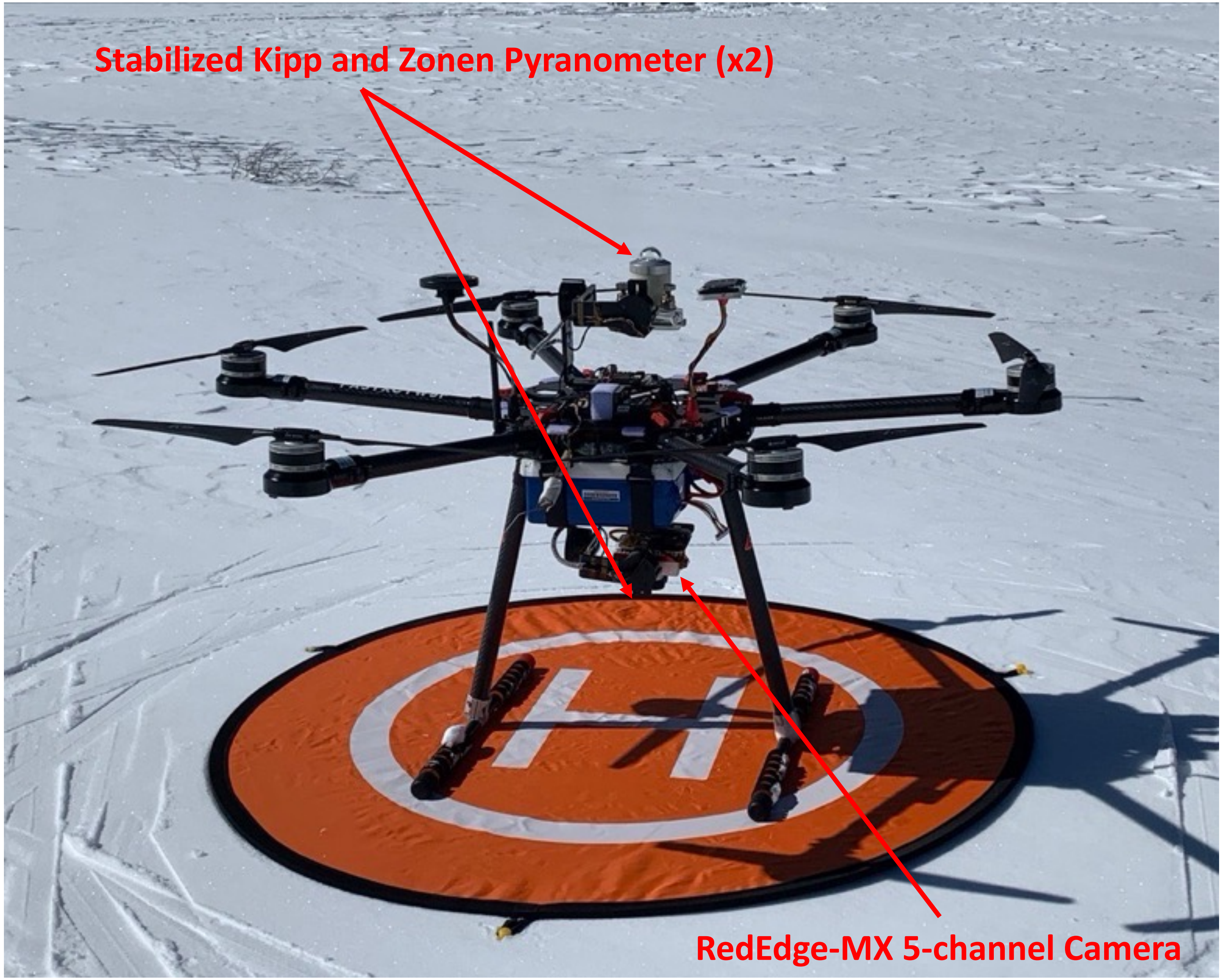
*Fall 2021 only

Surface Albedo: Capturing Spatial Variability

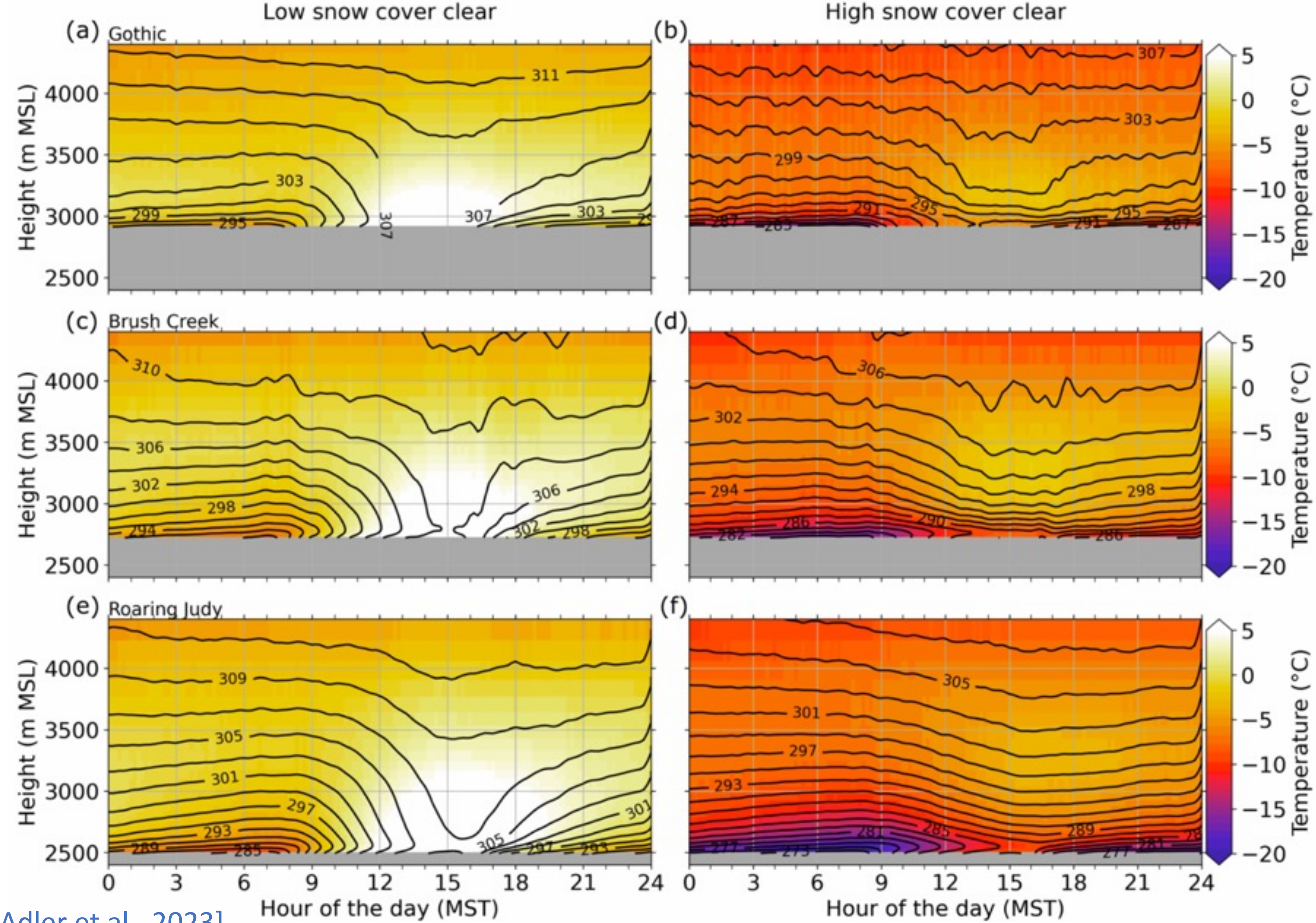
[de Boer et al., 2022]

CU-HELiX:

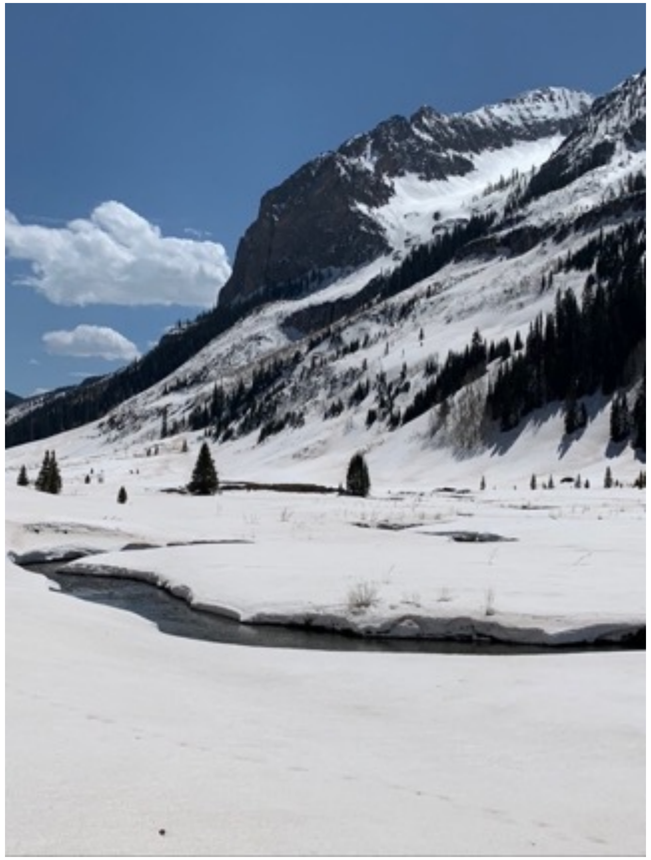
- 20-25 minutes of flight time
- Sensors include:
  - Custom Kipp and Zonen PR1 pyranometers for up- and downwelling broadband shortwave irradiance
  - Micasense RedEdge-MX camera to capture imagery across 5 channels (465, 560, 668 717 and 842 nm)
- 11 flights, 12-16 March
- 15 flights, 18-21 April
- 13 flights, 10-13 May
- 10 flights, 1-4 June
- Using a laser altimeter to maintain ~10 m AGL



Surface Albedo Impact on Overlying Atmosphere

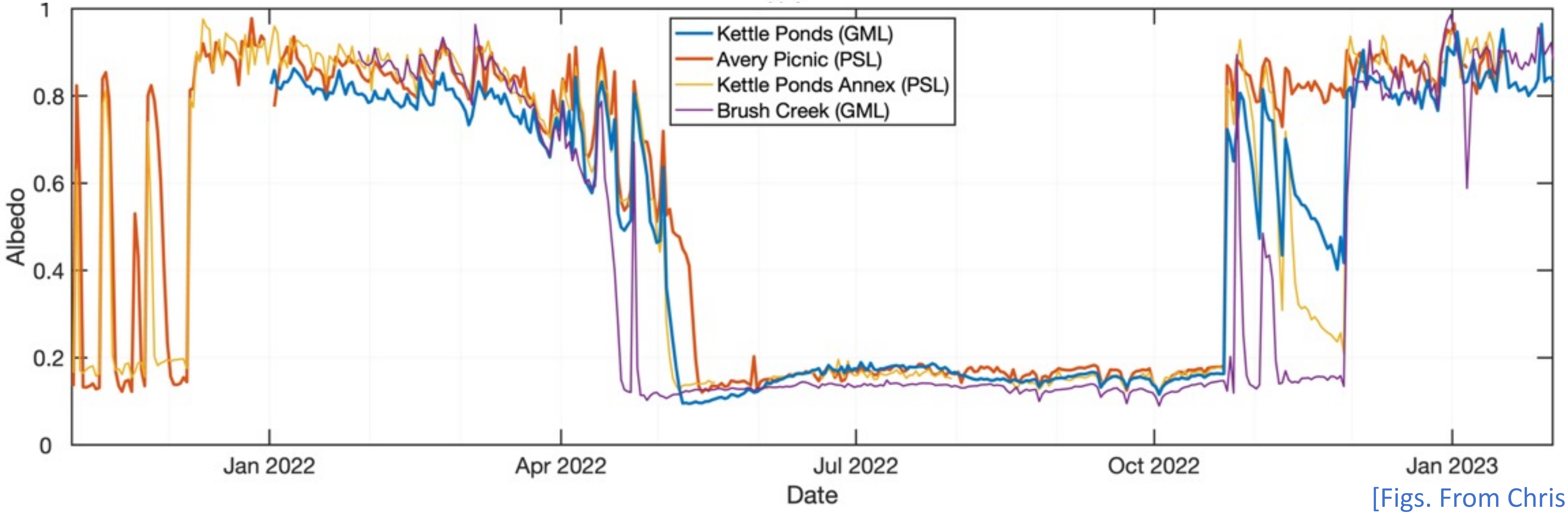


Surface snow cover has a profound effect on the diurnal cycle of the atmospheric thermodynamic and dynamic conditions.



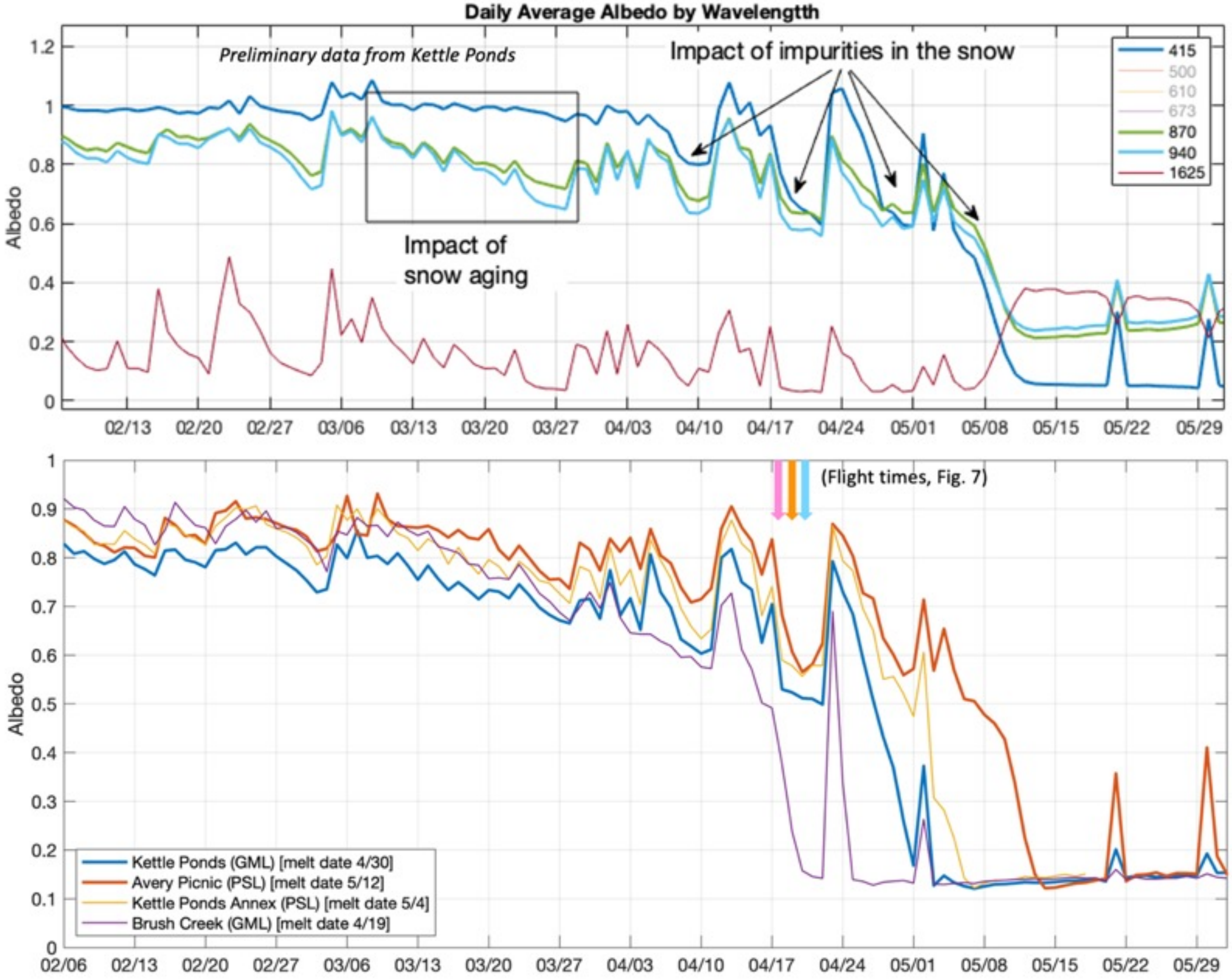
[Adler et al., 2023]

Surface Albedo: The Annual Cycle



[Figs. From Chris Cox]

Surface Albedo: Zooming in on Spring Melt



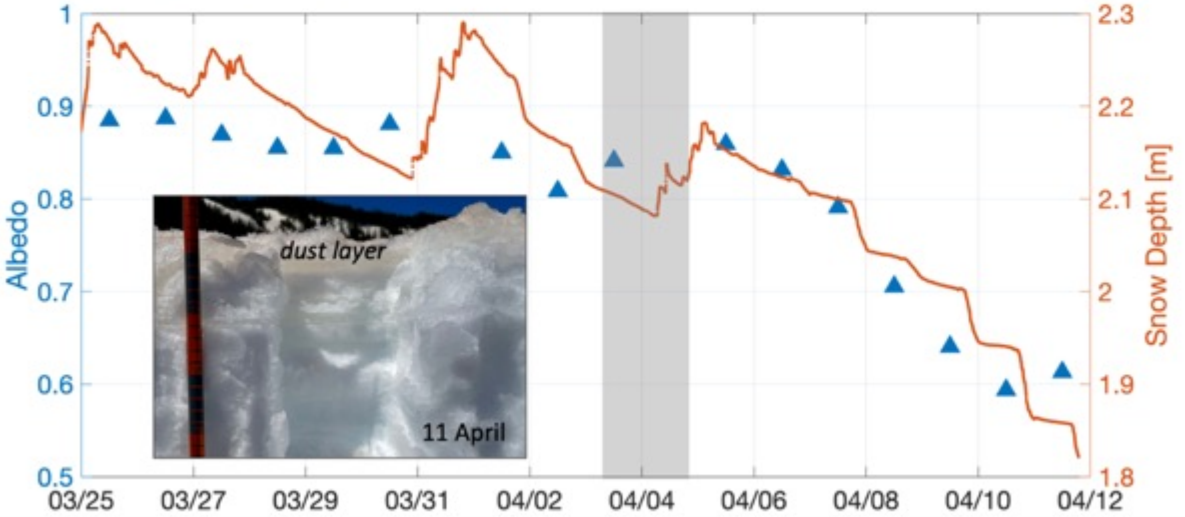
Spring melt impacts surface albedo significantly, reducing surface reflectivity from values representative of fresh clean snow (~0.85).

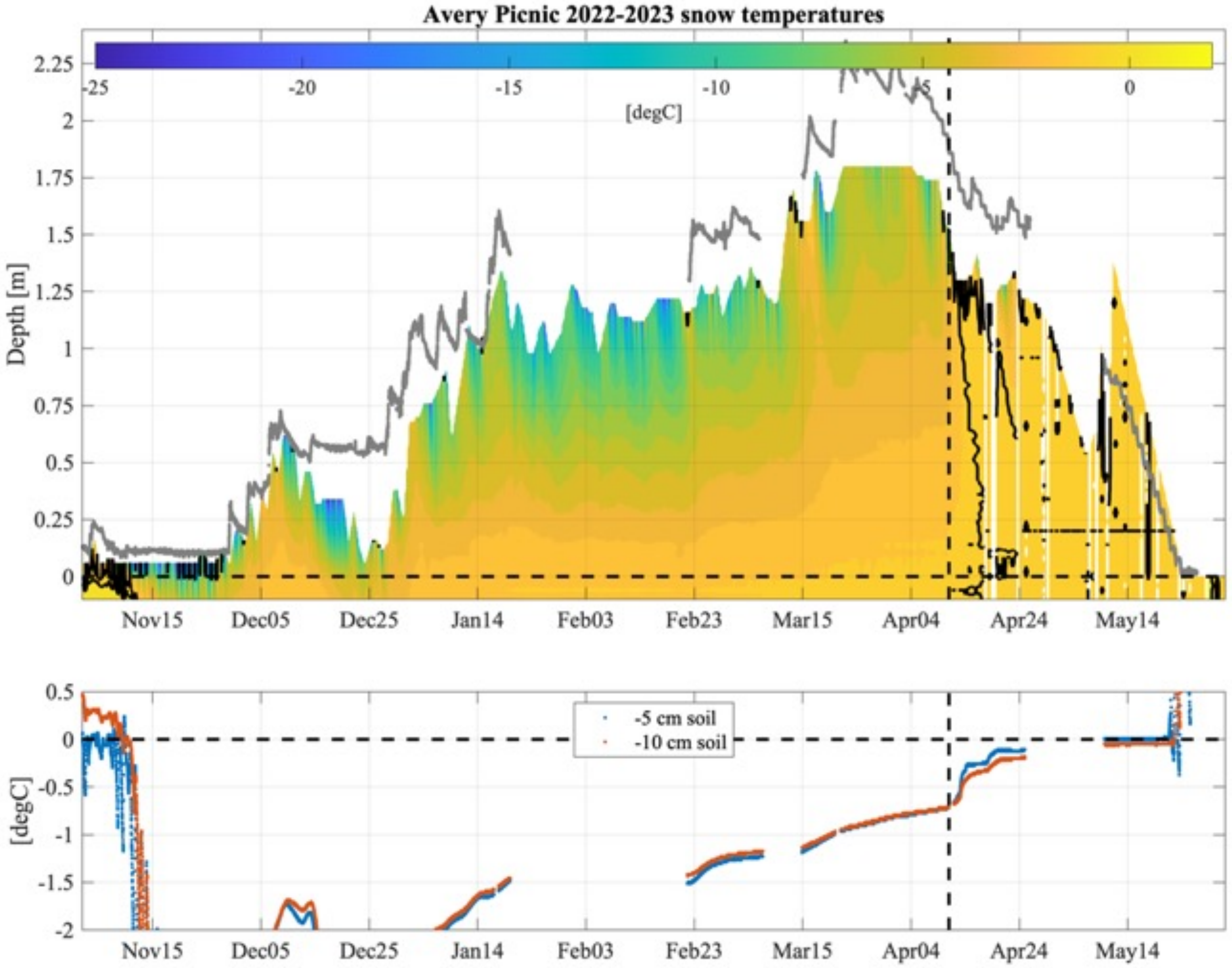
Albedo reductions result from both changes to snow grain size because of aging of the snowpack, and the deposition of impurities in/on the snowpack throughout the snow season.

Such reductions result in heating of the snowpack and acceleration of snow melt and transfer of melt water into the soil and river system.

[Figs. From Chris Cox]

Surface Albedo: Influence on Surface Temperatures

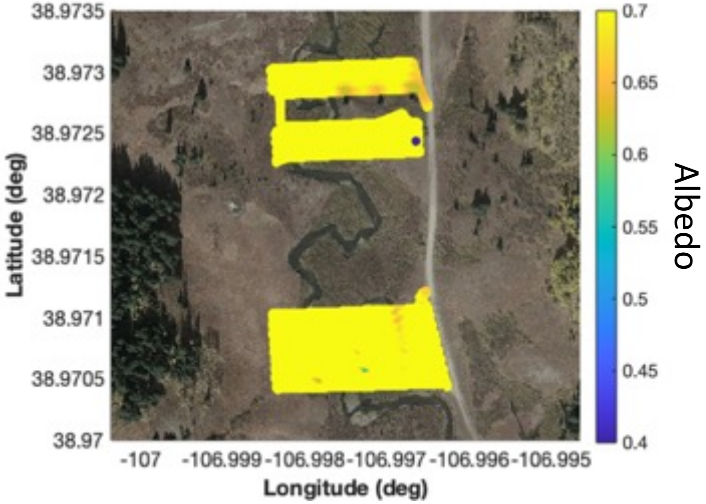




[Figs. From Chris Cox]

The Spatiotemporal Evolution of Albedo During Melt

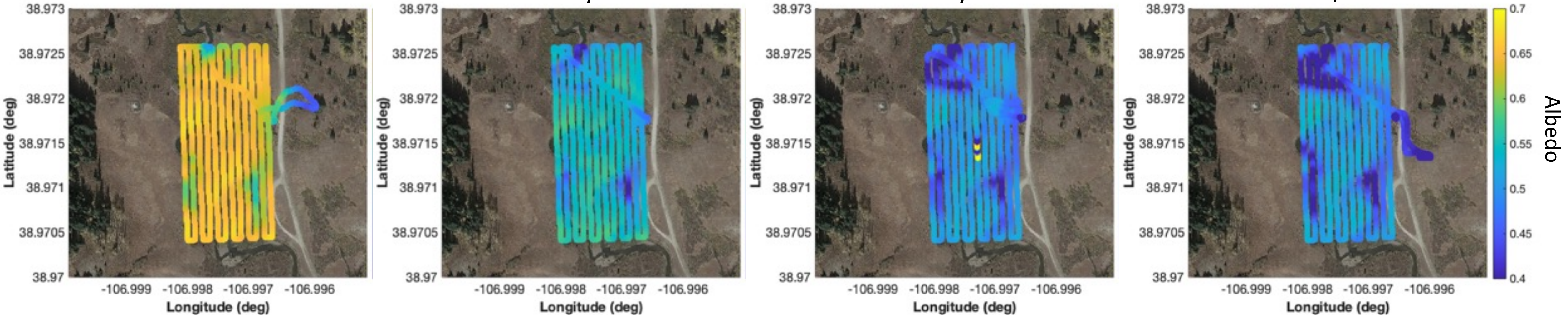
03/12-03/16



Significant snow melt was observed during the April deployment. During this time, dust that had previously been deposited in the snowpack emerged at the surface, and the snowpack became significantly wetter. Together, these events resulted in a substantial reduction of the snow surface albedo. March flights showed albedos in this area of around **0.8**, while the April albedos decreased from around **0.65** to **0.45** over the course of four days. Additionally, the river began to open up, resulting in even lower albedos values (**<0.4**). All flights in these figures were conducted around 10 am MDT.

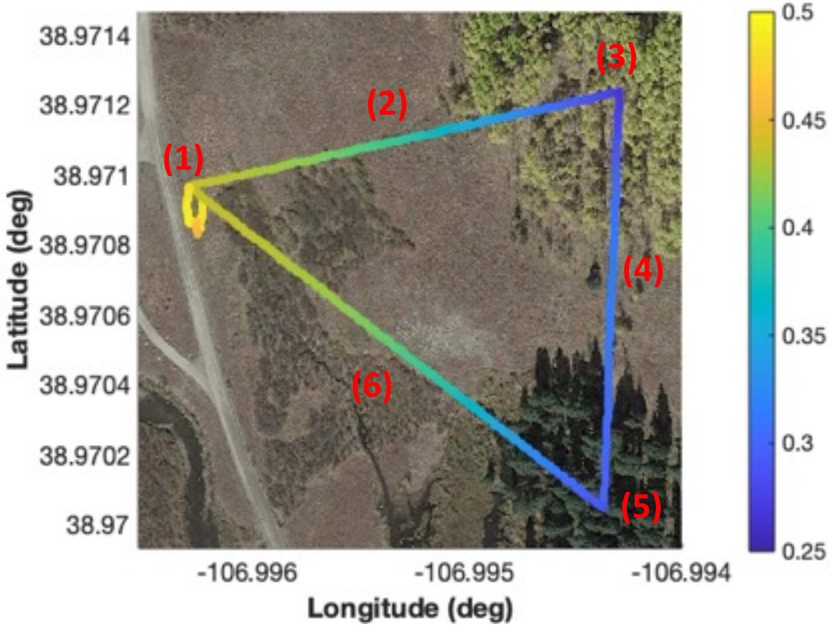
[de Boer et al., in prep]

04/18 04/19 04/20 04/21

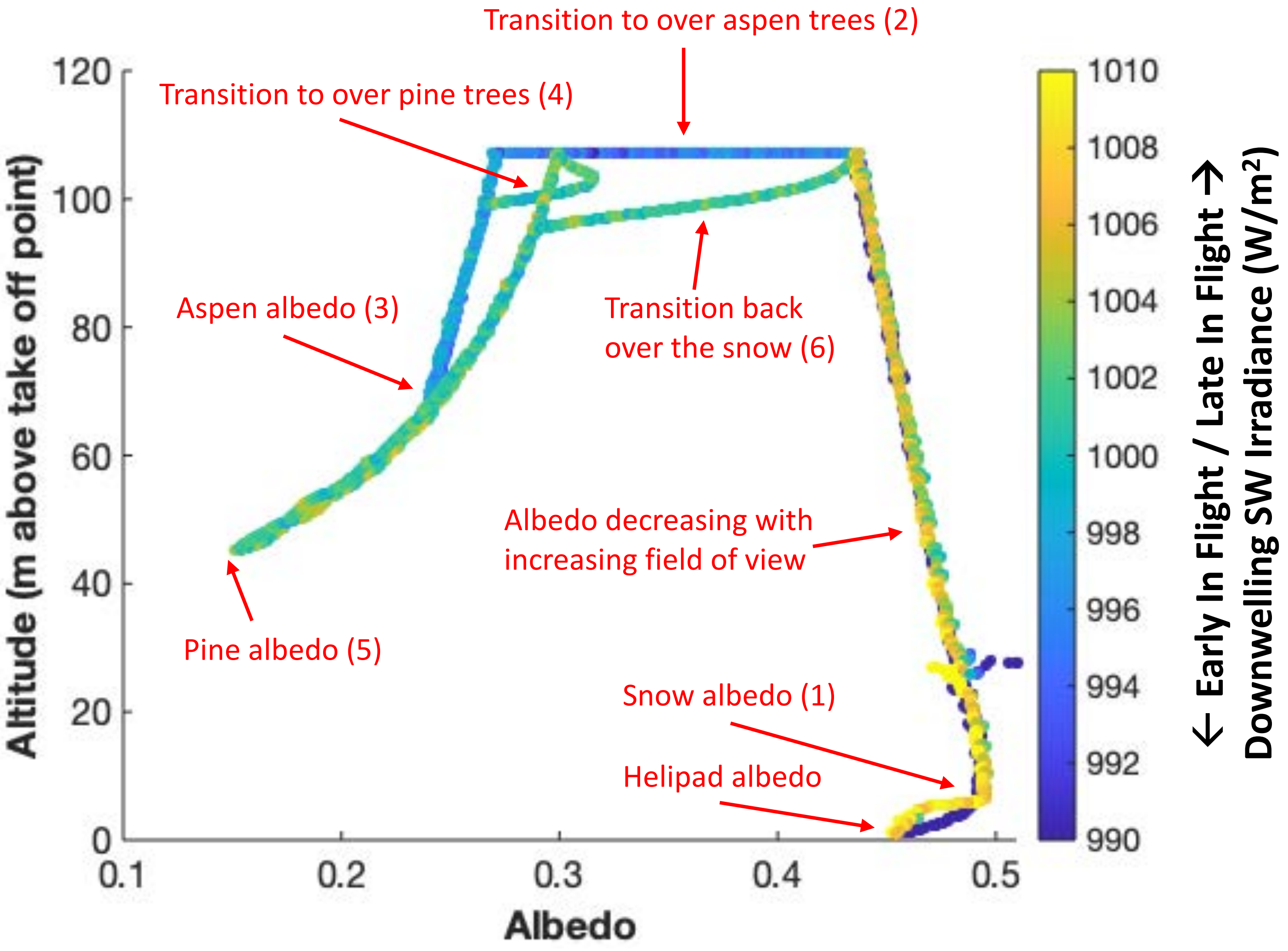


Albedo of Areas of Vegetation (Al"Tree"Do)

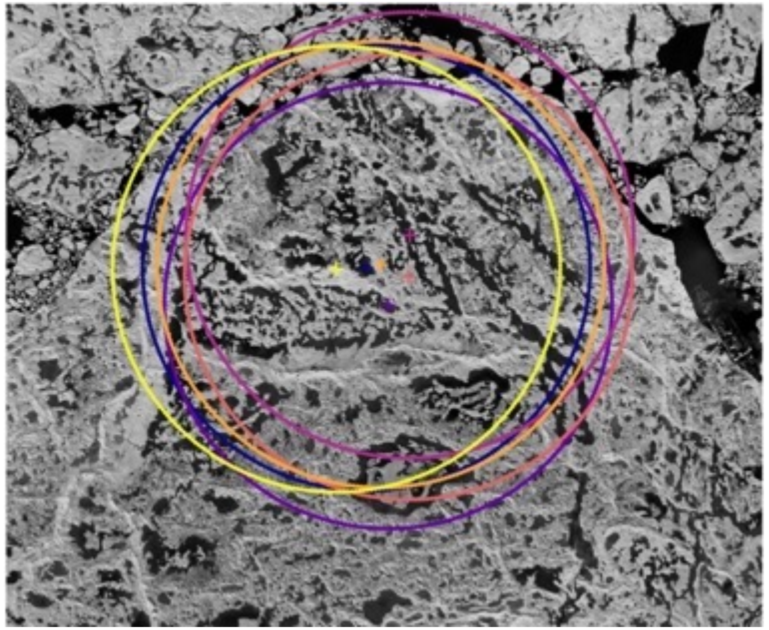
Initial evaluation of HRRR simulations appears to show that the HRRR surface albedo is significantly lower than observed. As a result, a question was posed about the influence of the mix of surface cover on grid-box-scale albedo. Using the HELiX, we flew over different surface types to understand the individual contributions of different types of surfaces and vegetations while the underlying is snow-covered.

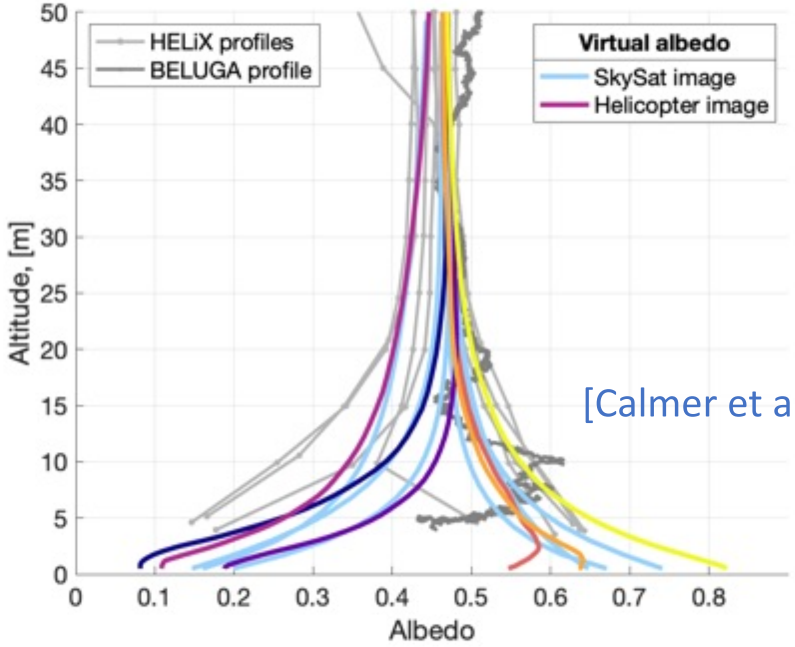


[de Boer et al., in prep]



The Altitude of Aggregation





[Calmer et al., in prep]

[de Boer et al., in prep]

Summary and Acknowledgments

- Spatiotemporal changes in surface albedo were documented over the East River Watershed in Colorado as part of SPLASH.
- There were multiple drivers of changes to surface albedo during the spring melt period.
- This region has seen significant deposition of dust which darkens the snowpack, resulting in accelerated seasonal snow melt.
- Drone data were used to provide insight into the spatial heterogeneity and vertical structure of albedo, including over vegetation and other difficult to sample environments (e.g., over a melting riverbed).
- SPLASH datasets provide new insight into the evolution of surface albedo in regions of complex terrain

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SPLASH research is supported by NOAA and the DOE ASR Program

References

Adler, B., J. Wilczak, L. Bianco, L. Bariteau, C.J. Cox, G. de Boer, I. Djalalova, J.M. Intrieri, T. Meyers, J.B. Olson, S. Pezoa, J. Sedlar, E. Smith, D.D. Turner and A. White, 2023: **Passive remote sensing of the atmospheric boundary layer in Colorado's East River Valley during the seasonal change from snow-free to snow-covered ground**, *Journal of Geophysical Research - Atmospheres*, accepted for publication.

Calmer, R., G. de Boer, J. Hamilton, D. Lawrence, M. Webster, N. Wright, M. Shupe, C. Cox, J. Cassano, 2022: **Relationships between summertime surface albedo and melt pond fraction in the central Arctic Ocean: The aggregate scale of albedo obtained on the MOSAiC floe**, *Elementa*, 11 (1), https://doi.org/10.1525/elementa.2023.00001.

de Boer, G., R. Calmer, G. Jozef, J. Cassano, J. Hamilton, D. Lawrence, S. Borenstein, A. Doddi, C. Cox, J. Schmale, A. Preußer, and B. Argrow, 2022: **Observing the Central Arctic Atmosphere and Surface with University of Colorado Uncrewed Aircraft Systems**, *Nature Sci. Data.*, 9, 439,https://doi.org/10.1038/s41597-022-01526-9.

de Boer, G., A. White, R. Cifelli, J. Intrieri, M. Hughes, K. Mahoney, T. Meyers, K. Lantz, J. Hamilton, W.R. Currier, J. Sedlar, C. Cox, E. Hulm, L.D. Riihimaki, B. Adler, L. Bianco, A. Morales, J. Wilczak, J. Elston, M. Stachura D. Jackson, S. Morris, V Chandrasekar, S. Biswas, B. Schmatz, F. Junyent, J. Reithel, E. Smith, K. Schloesser, J. Kochendorfer, M. Meyers, M. Gallagher, J. Longenecker, C. Olheiser, J. Bytheway, B. Moore, R. Calmer, M.D. Shupe, B. Butterworth, S. Heflin, R. Palladino, D. Feldman, K. Williams, J. Pinto, J. Osborn, D. Costa, E. Hall, C. Herrerab, G. Hodges, L. Soldo, S. Stierle, and R.S. Webb, 2023: **Supporting Advancement in Weather and Water Prediction in the Upper Colorado River Basin: The SPLASH Campaign**, *Bull. Amer. Meteor. Soc.*, submitted.

de Boer, G., J. Hamilton, C.J. Cox and J. Intrieri: Observational perspectives on the spatial and temporal evolution of broadband surface albedo in an upper Colorado River watershed during spring snowmelt, *Env. Res. Lett.*, in prep.

Feldman, D.R., A.C. Aiken, W. R. Boos, R. Carroll, V. Chandrasekar, S. Collis, J. Creamean, G. de Boer, J. Deems, P. J. DeMott, J. Fan, A. N. Flores, D. Gochis, M. Grover, T. Hill, A. Hodshire, E. Hulm1, C. Hume, R. Jackson, F. Junyent, A. Kennedy, M. Kumjian, E. Levin, J. D. Lundquist, J. O'Brien, M. S. Raleigh, J. Reithel, A. Rhoades, K. Rittger, W. Rudisill1, Z. Sherman, E. Siirila-Woodburn, S. M. Skiles, J. N. Smith, R. C. Sullivan, A. Theisen, M. Tuftedal, A. C. Varble, A. Wiedlea, S. Wielandt, K. Williams, Z. Xu, 2023: **The Surface Atmosphere Integrated Field Laboratory (SAIL) Campaign**, *Bull. Amer. Meteor. Soc.*, accepted for publication.