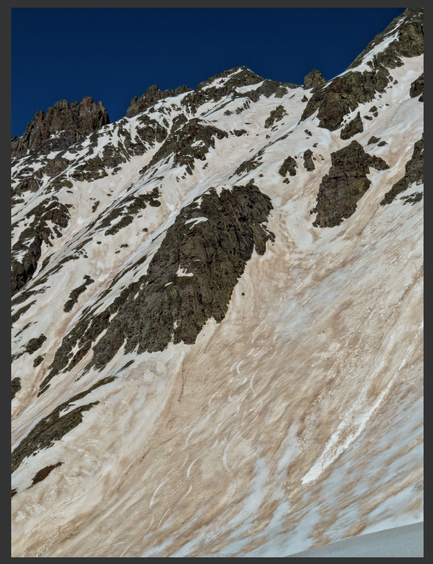

Advancing the use of the MODIS dust radiative forcing on snow dataset: Applications to Landsat fusion and snowmelt modeling

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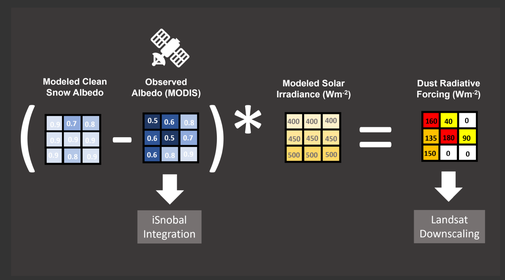
Importance

- Snow albedo is the dominant control on snowmelt in most regions of the Western United States.
- Dust and other light absorbing particles are deposited seasonally on snow surfaces, lowering snow albedo and accelerating snowmelt.
- Dust-accelerated melt has been correlated to shifting evapotranspiration patterns, streamflow forecasting errors, reduced water yield, and is not directly accounted for in water supply forecasting.
- Satellite remoting sensing techniques allow for daily measurement of snow albedo and dust radiative forcing, providing real time information on snowmelt controls over large spatial regions.

Dataset

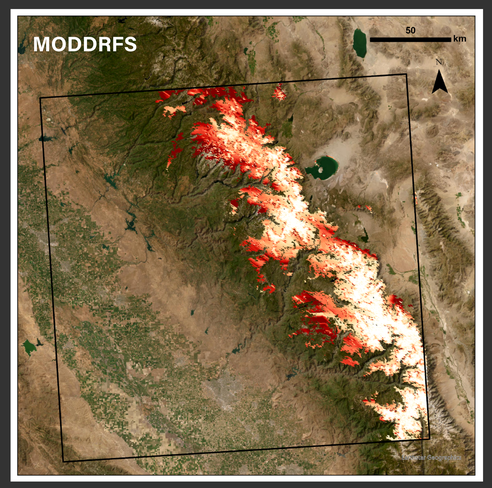
- The Spatially and Temporally Continuous MODIS Dust Radiative Forcing in Snow (STC-MODDRFS) dataset allows us to quantify the additional energy absorbed by the snowpack due to dust exposure (Painter et al., 2012; Rittger et al., 2020).
- MODDRFS is calculated daily from observed albedo at ~500x500 m spatial resolution.

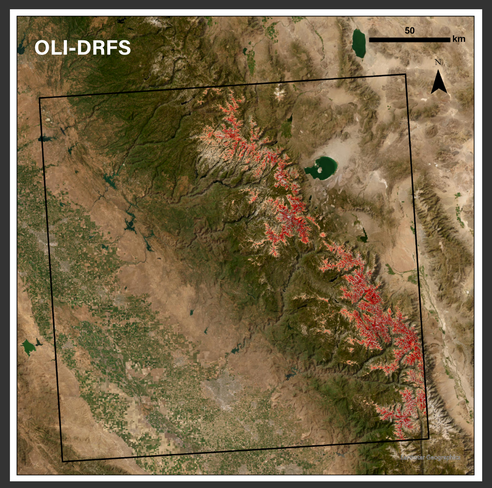


MODIS-Landsat Fusion

MODDRFS assumes a pixel is totally snow covered which can artificially inflate RF values from bare soil/rock and vegetation. This can be problematic in heterogenous terrain where there are few totally snow covered pixels. To address this, we apply the DRFS algorithm to Landsat 8 & 9 imagery (OLI-DRFS). OLI-DRFS has a spatial resolution of 30m, which is much better for heterogenous terrain, but a revisit length of 8 days which is too long for monitoring dust accelerated snowmelt.

To address this a data fusion is performed using a random forest regression model to predict 30m MODDRFS using 500m MODDRFS, 30m OLI-DRFS, pixel center lat and lon, and terrain data (e.g. elevation, aspect, slope).

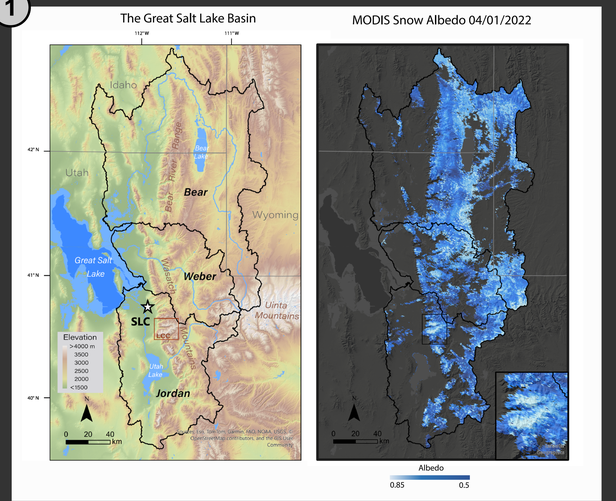




- 130 Landsat scenes in total - split between California and Colorado - with an 80/20 split for training and testing.
- An early version of the random forest model without terrain data included is promising with relatively good R^2(0.97) and MAE (2) but high MSE (290).
- The fused product will then be tested against in situ measurement at the two Senator Beck Basin snow energy balance sites and Grand Mesa study plot to evaluate the performance compared to MODDRFS.

MODIS Integration to Physically-Based Snowmelt Modeling

1



- The Bear, Weber, and Jordan Watershed supply critical water resources to 1.7 million Utahns and provide the primary surface inflows to the Great Salt Lake.
- Watershed hydrology is snowmelt dominated, and the seasonal snowpack is affected by dust emitted from playa regions in the eastern Great Basin.
- By analyzing 23 years of MODIS albedo, it is know that dust influences snowmelt annually in the GSLB with high interannual variability - but the resulting shift in snowmelt timing has never been quatified spatially over the basin.

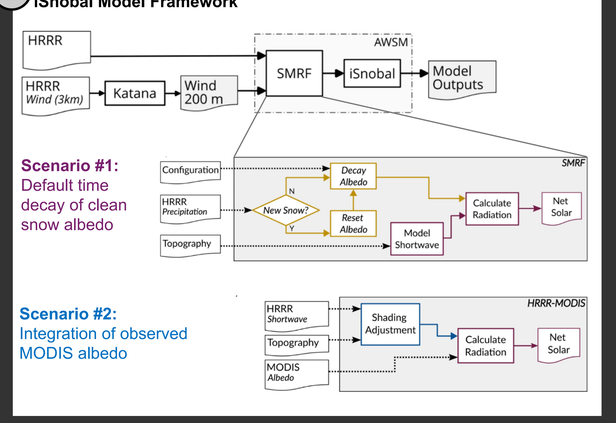
2

- To quantify the basin-wide snowmelt acceleration due to dust, we utilize the physically-based HRRR-MODIS-iSnobal snowmelt model developed in Meyer et al. (2023) and Meyer et al. (2024).
- We run this model under two different snow albedo representations: 1) A time decay method developed from clean snow after snowfall events, and 2) incorporating observed MODIS albedo, the same used within MODDRFS retrievals, to integrate real-time snow reflectance properties.

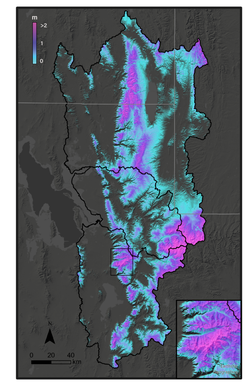
3

- Model results are spatially distrubuted at 100m over the entire GSLB.

2 **iSnobal Model Framework**

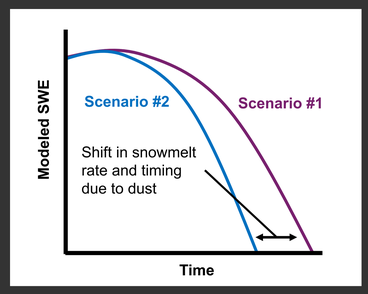


iSnobal Snow Depth 04/01/2022



4

- The difference in snow depletion trends between the two model scenarios will represent the impact of dust and other light absorbing particles on snowmelt rates and timing.



Take Aways

- The STC-MODDRFS dataset is highly versatile and can be applied to improve albedo representation in physically-based snowmelt modeling allowing for a better understanding of snowmelt controls in the Great Salt Lake Basin.
- STC-MODDRFS and OLI-DRFS can be fused using a random forest model to create a daily 30m dust radiative forcing product, better representing dust radiative forcing on applicable scales in heterogenous terrain.

Acknowledgements

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