Predicting Snow Albedo Decay in NH Using Three Winters of Seasonal Snow and Weather Observations

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Background

- Albedo is the ratio of reflected energy to total incoming solar energy expressed as a unitless number between 0 and 1.
- Surface albedo exerts a major influence on local, regional and global climate.
- Incorporating fine-scale determinants of snow albedo into climate models is difficult due to sparse observation data to compare with and high computation demands (Flanner and Zender, 2007.
- Measurements of simple snowpack and weather variables can help test and improve empirical albedo parameterizations (Chen et al, 2014).

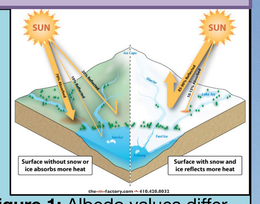

Figure 1: Albedo values differ depending on land surface type.

Research Objectives

1. Measure fluctuations in surface albedo over time and across New Hampshire using a network of citizen-scientists.
2. Evaluate the physical properties that drive changes to albedo and develop predictive albedo relationships to provide reference for climate model parameterizations.

Data Collection

Community Collaborative of Rain, Hail & Snow (CoCoRaHS) Network

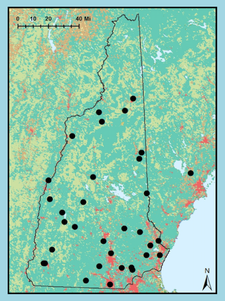

Figure 2 (left): Map showing CoCoRaHS-Albedo sites for past three winters.

Figure 3 (right): "Albedo kit" includes temperature gun, pyranometer, snow tubes, hanging scale, log book and spatula.

Figure 4

Figure 5

Figures 4 & 5: Measurements are taken of:
1. Albedo
2. Snow depth
3. Snow weight
4. Surface Temperature
5. Cloud cover/weather observations

Results: I. Albedo Decay

Analysis: Episodes of consistent albedo decline are selected from all data to investigate processes of albedo decay.

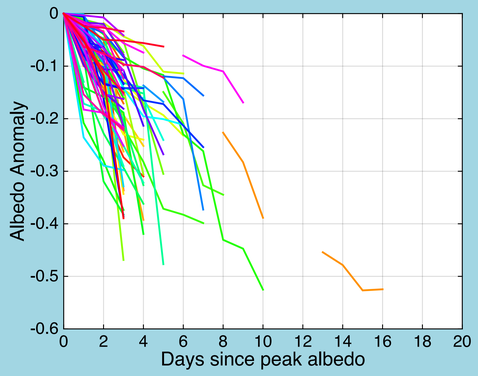

Figure 6: 72 separate intervals (389 measurements) of albedo decay lasting four or more days in duration from past three winters. Anomaly calculated as daily difference from albedo maximum (day 0) for each interval.

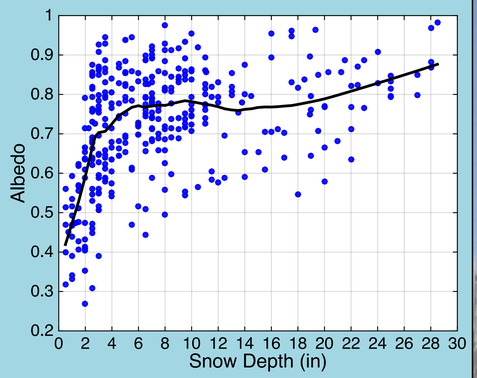

Figure 7: Relationship between albedo and snow depth with only data from decay intervals (see figure 6). Black line is LOWESS statistical smoothing.

II. What Causes the Albedo Decay?

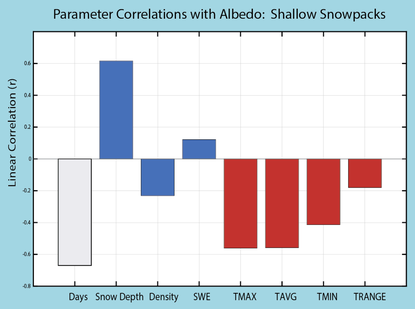

Figure 7: Linear correlations (r) between observed albedo and snowpack and weather variables for snowpacks <5.5 inches. Note strong correlation of albedo with days (since max albedo), snow depth and air temperature.

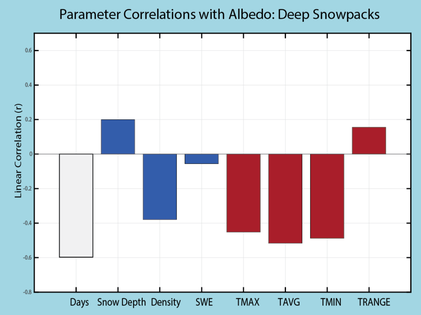

Figure 8: Linear correlations (r) between observed albedo and snowpack and weather variables for snowpacks >=5.5 inches. Note strong correlation of albedo with days (since max albedo), snow density and air temperature.

III. Predictive Models

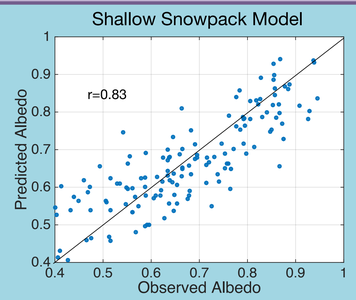

Figure 8: Predicted albedo values by multiple linear regression of Days (since max albedo), snow depth and average daily air temperature. Model explains ~70% variability in observed albedo.

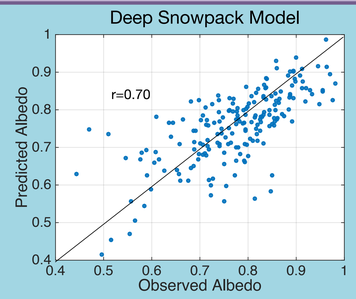

Figure 9: Predicted albedo values by multiple linear regression of Days (since max albedo), snow density and average daily air temperature. Model explains ~50% variability in observed albedo.

Discussion

- We establish two different optical snowpack regimes based upon a snow depth threshold of about 5.5 inches.
- Below this threshold, sunlight can penetrate through the snowpack and is absorbed by the underlying ground surface, impacting measured surface albedo. Above the depth threshold the snowpack is deemed "optically thick" and albedo is determined solely by snow surface properties.

Summary

- Using observations from the CoCoRAHS-Albedo network we have quantified the relative influence of snow age, depth, density and air temperature for surface albedo changes over time and across New Hampshire:
  1. For snowpacks shallower than 5.5 inches, albedo decay is most strongly influenced by snow depth, snow age and air temperature.
  2. For snowpacks 5.5 inches and deeper, albedo decay is influenced by snow age, air temperature and snow density.
- Our spatially-distributed observations capture fundamental relationships which may be broadly representative of snow albedo behavior across Northeast U.S. and other similar regions of seasonal snow.

Future Work

- Expand analysis to include winter 2014-2015 data once weather station data becomes available in May 2015.
- Submit journal article manuscript to *Journal of Glaciology* during summer 2015.

Selected References

·Chen, A., Li, W., Li, W., and Liu, X., 2014. *An observational study of snow aging and the seasonal variation of snow albedo by using data from Col de Porte, France.* Chinese Science Bulletin. 59(34) 4881-4889.
·Flanner, Mark G and C. S. Zender, 2006. *Linking snowpack microphysics and albedo evolution.* J. Geophys. Res. 111 (D12). 2156-2202.

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