How does Snowpack Evolution Affect Climate?

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Research Objectives

- Measure fluctuations in surface albedo over time and across New Hampshire using a network of citizen-scientists.
- Evaluate the physical properties that drive changes to albedo and develop predictive albedo relationships with the interest of modelling regional climate effects.

What is Albedo?

- Albedo is the ratio of reflected energy to total incoming solar energy expressed as a unitless number between 0 and 1.

- Light colored surfaces such as new snow have a high albedo (0.8-0.9) while darker surfaces such as forest canopies and pavement have low albedo (0.05-0.15).

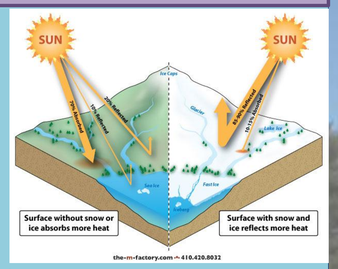


Figure 1: Albedo values differ depending on land surface type.

Data Collection

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

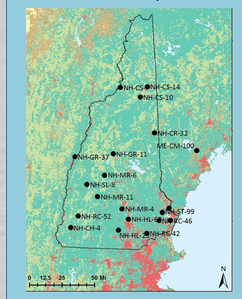


Figure 2 (left): Map showing CoCoRaHS-Albedo sites for past two winters.

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

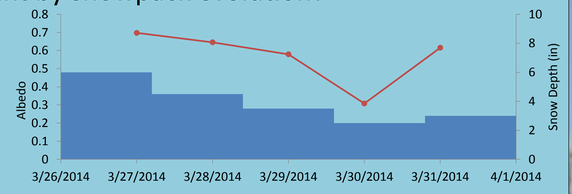
Project Rationale

1. Surface albedo plays an important role in local radiative forcing: *Small changes in albedo are significant for local climates.*
2. During winter, the albedo of snow can range from around 0.3 to above 0.9. This variation has important implications for the timing and pace of snowmelt events.
3. Although physical relationships between snow albedo and snowpack properties are well established, abundant field observations supporting these conclusions are lacking.

Results

What is meant by snowpack evolution?

Figure 6 (right): Following a snowfall event, there is decreasing snow depth (blue) and albedo (red) until subsequent snowfall event.



Snow Albedo vs Age

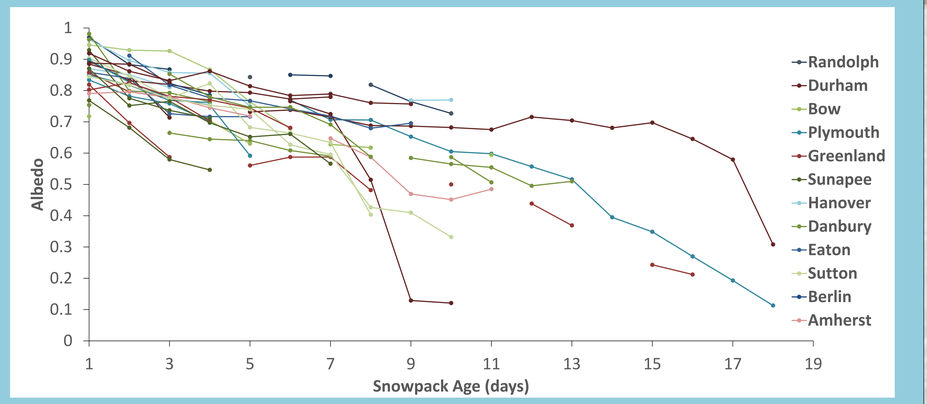


Figure 7: Twelve observer stations with data from past two years display a general decrease in albedo as snow ages. Note the extreme variability between different stations as well as albedo decay rate variability between data from the same stations just at different times (Ex. Durham).

What causes the albedo decay?

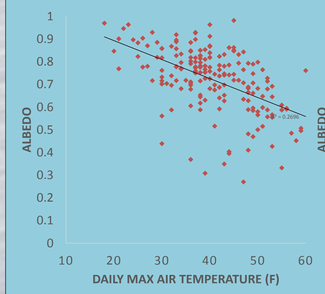


Figure 8: Albedo decreases linearly with increasing daily maximum air temperature. $r^2 = 0.27$

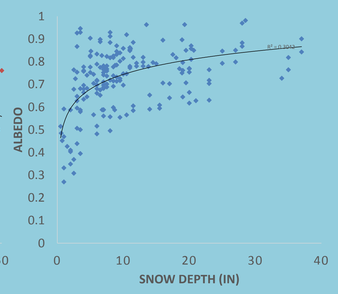


Figure 9: Albedo decreases logarithmically with decreasing snow depth. $r^2 = 0.30$

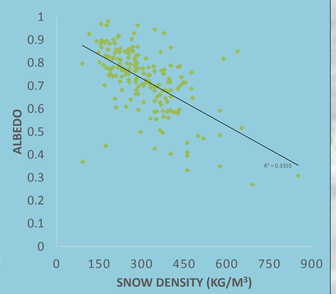


Figure 10: Albedo decreases linearly with increasing snow density. $r^2 = 0.34$

Summary

- Aging snowpacks have a warming effect on the Earth's surface due to a decrease in albedo over time [Figure 7].
- The decrease in albedo with snowpack age is highly variable across the state and over time, indicating complex influences on snow albedo.
- Some variability in decaying albedo may be attributed to snow depth, snow density and air temperature however the scatter within the data is too large to give any single parameter predictive power. [Figures 8-10].

Future Work

- Develop an empirical model that relies on snow age, depth, density and air temperature to predict surface albedo in a regional climate model.
- As noted, albedo ranges widely for a given snow age, depth, density or air temperature and also for given time and location. *See Figure 7 at left: four different snowpacks at the same sample site in Durham exhibit four distinct albedo decay rates.*
- In a multi-parameter approach, quantify the relative roles of snow age, depth, density and air temperature in driving changes to surface albedo over time and across New Hampshire.

References

Burakowski, E., C. P. Wake, J. E. Dibb and M. Stampone, 2013. *Putting the Capital 'A' in CoCoRAHS: An experimental programme to measure albedo using the Community Collaborative Rain, Snow & Hail (CoCoRaHS) Network*. Hydrologic Processes. 27 (21). 3024-3034.

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