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Investigating the Relationships Between Canopy Characteristics and Snow Depth Distribution at Fine Scales: Preliminary Results from the SnowEX TLS Campaign

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Objective

Using terrestrial laser scans (TLS) from multiple sites across Grand Mesa, CO I will describe the relationship between both forest cover and topography on snow depth distribution. Specifically, I focus on canopy patch configuration and possible predictors of wind redistribution from digital elevation models (DEMs). Additionally, topography is examined for its effect on snow depth.

Background: Snow distribution is controlled by many biophysical and geographical attributes of the landscape such as vegetation cover and topography. In forested environments, forest and vegetation has been observed to strongly control snow depth distribution (Deems et al., 2006, Trujillo et al., 2007) by the mechanisms of canopy interception and wind redistribution from open areas to forest edges. The effect of forest canopy on snow depth is dependent upon the stand density (Anderson, 2014), species and stand configuration, as well as climate (Dickerson-Lange et al., 2017).

SnowEx – multiyear NASA campaign designed to:
1. Determine the effect of forest canopy on remote sensing retrievals and snow distribution

Data:
Point clouds from terrestrial lidar scanning (TLS) from the 2017 Colorado SnowEx Field Campaign in Grand Mesa, CO.

Approach:
1. Create rasters of snow depth (DEM's of differencing): snow on – snow off
2. Create canopy metrics (max ht, range, std deviation, etc.) from canopy classified points.
3. Create rasters of snow depth (DEM's of differencing): snow on – snow off
4. Identify correlation between metrics and snow depth distribution
5. Regression analysis to assess influential canopy and topography metrics on snow depth.

Calculating Snow Depth:
1. Georegister point clouds from fall and winter (snow off and snow on)
2. Create digital elevation model (DEM) of ground
3. Difference the two dates

Snow depth = Snow on (elevation) – Snow off (elevation)

Canopy Classification

Preliminary Results

1. Comparison of means (under canopy vs. outside canopy)
   T-test results:
   - Statistically different means – snow depth under canopy vs open.
   - p-value = 0
   Mean snow depth:
   - outside canopy: 168cm
   - inside canopy: 132cm

2. Effect of Forest Edge
   - For each line segment of forest cluster edge (Figure 3a; green border), calculated the direction normal to line.
   - Each snow depth cell located outside of cluster, was assigned direction of closest line segment.
   - Snow Depth Vs. Orientation Evaluated.

3. Distance from canopy edge.

4. Influence of bare earth concavity

Figures 1a, 1b, 1c. Site K. (a) Snow depth map overlain with canopy point cloud. (b) Interpolation method used to aggregate forest clusters: 7x7 pixel moving window with minima clipping. (c) Resulting forest edges traced overlain on snow depth.

Canopy classification from point cloud performed using Boise Center for Aerospace Laboratory (BCAL) Lidar Tools extension in Excel's Environment for Visualizing Images (ENVI).

Figures 2a, 2b. Snow depth deeper in the open. Snow depth values under canopy vs. outside of canopy. Histogram portrays values from ~16,000 1m2 grid cells over entirety of Site K.

Figures 3a, 3b. Staining from forest edge. (a) Mean and interquartile range (IQR) vary based on orientation of nearest forest edge. Deepest snow in N and W which is visible in Figure 1c, annotated with “Deep snow drifts...” (b) Representation of direction of closest forest edge to cell location.

Figures 4a, 4b. (a) At Site K, depth appears to be positively correlated to distance from canopy, out to 24m. Note* low snow depths at 0-3m may reflect that edge delineation needs to be more sensitive to low canopy height, rather than snow accumulation/ablation processes. (b) Illustration of distance scale at Site K.

Snow depth

Snow on and snow off images from Site K.

SnowEx

Snow distribution at fine scales: Preliminary results from the SnowEx TLS campaign

Snow on (elevation)

Snow off (elevation)

Next Steps

1. Compare concavity to snow depth: Preliminary results indicate no statistical correlation (Pearson’s Correlation Coefficient = +0.075) between concavity and snow depth. Perhaps optimizing the LoG filter and considering aspect, slope and other topographical attributes using a multilinear regression will yield better correlation.

2. Effect of forest edge
3. Distance from canopy edge.
4. Influence of bare earth concavity
5. Regression analysis to assess influential canopy and topography metrics on snow depth.

Citations


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Citations


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