Evaluating the accuracy of LiDAR in forested areas and understanding the variability of snow depth with respect the canopy – UW-SLF collaboration

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Introduction & Driving Questions
We plan to evaluate ASO LiDAR accuracy in forests using: 1.) TLS SnowEx data and 2.) SLF manual snow depth measurements. Furthermore, we are using already existing Airborne LiDAR observations from various climates to understand the spatial variability in forested and open areas. Particularly, we have focused on categorizing forest edges and looking at how snow depth distributions vary based on the forest architecture. Together, we’re specifically motivated to answer:

1. How do ground observations (TLS & manual snow depth measurements) compare to ASO snow depth in forests?
2. How is accuracy related to distance from canopy?
3. Do unique snow depth distributions appear along the forest edge when a hypothetical model grid cell (Figure 1) is broken into north facing edges and south facing edges?
4. Does the edge effect depend on climate?
5. How do snow depth distributions change based on:
   • How we categorize the forest edge?
   • Determine the forest edge based on: Distance from Canopy, SF, NF, and Tree Height
   • The size of the bounding box we’re evaluating?

Airborne LiDAR Accuracy in Forests

Questions

Airborne LiDAR Validation Data

Swiss Data:
- Two Snow On Flights (29 & 31 March 2017)
- Same Sensors as ASO
- Altitude: ~2000 m above forest (~10 pts/m2)
- At site 1: 1-m canopy height model with 30 pts/m2 LiDAR data
- 11,000 Manual Snow Depth (HIS) Measurements taken in 8 different cardinal directions around trees
- 20 x 20 m plots, 132 measurements/plot
- 20 snow depth measurements per transect

Preliminary Results

1. North Facing (NF) and South Facing (SF) edges (based on 15-m distance from canopy), along with Open areas shows unique snow depth distributions at Tuolumne (Figure 9) and Jemez, NM, shows more snow than Open, SF Edges, or Forested areas regardless of how we categorize the edge or spatial domain (Figure 10)

Spatial Variability of Forest Snow Depth

While SnowEx and SLF LiDAR data continue to be processed we’re exploring forest edge effects using already available LiDAR data from 4 different environments.

Preliminary Results Continued:

- Figure 10: Snow depth distributions for various bounding box sizes (x-axis) and various sub regions (Open, NF, and SF forested edges) of that domain based on different methods for classifying the forest edges
- Figure 9: Example calculation and result of calculating the SVF - the fraction of the sky that is visible - in SF and NF directions
- Figure 8: Spatially classified Forest Snow Depth longitude for 15-m search distance within various Bounding Box Sizes
- Figure 7: Example of obs. from Jemez TLS site A

Conclusions

1. 20-50% more snow in the open than under the canopy across all study sites
2. Snow depth distributions were generally consistent when scaling the domain from 150 m to 1.2 km and when categorizing the forest edge based on various metrics: Distance from the canopy, SVF, and tree height (Figure 10).
3. SF shows more snow than Open, SF Edges, or Forested areas at all locations except the Olympics (Figure 11) which has little incoming shortwave radiation (decrease in forest shading) and more longwave radiation compared to other locations (Figure 6).
4. We hope to soon begin answering how accurate snow depth is in forests from airborne LiDAR.
5. Determine how wind speed/direction lead to unique snow depth patterns. Characterize spatial snow depth distribution with model grid cells in terms of canopy structure.

Acknowledgements:

We would like to thank the entire Mountain Hydrology Research Group for feedback and support. W.R. Currier was supported by a NASA Earth and Space Sciences Fellowship.