Seeing the Snow through the Trees: Towards a Validated Canopy Adjustment for Fractional Snow Covered Area

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March 2013
Snow is an important water resource

Quantifying the spatial extent of snow is key for hydrologic models and monitoring climate change
Snow Remote Sensing

Snow is highly reflective compared to other land surfaces

Painter et al., 2009
Satellite sensors cannot penetrate tree canopy
85% of snow zone in the Oregon Cascades has greater than 20% canopy cover.
Current Canopy Adjustment

\[ f_{SCA}^{(adjusted)} = \frac{f_{SCA}^{(obs)}}{1 - f_{VEG}} \]

(Rittger et al., 2013)

Snow in open = Snow under canopy
Study Objectives

Test the current canopy adjustment for a range of forest types in the Oregon Cascades

Compare results to ground snow observations

Determine if the observable snow cover fraction can be used as a proxy for subcanopy snow
Study Area

Map showing the McKenzie River Watershed and Middle Fork Willamette Watershed with indicated sites of low and high density.
Snow Observations 2012

<table>
<thead>
<tr>
<th>Site ID</th>
<th>Site Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1100_LD</td>
<td>Open meadow</td>
</tr>
<tr>
<td>1100_HD</td>
<td>High density tree canopy</td>
</tr>
<tr>
<td>1200_LD</td>
<td>Burned forest, no canopy</td>
</tr>
<tr>
<td>1200_HD</td>
<td>High density tree canopy</td>
</tr>
<tr>
<td>1300_LD</td>
<td>Recent clear cut with some regeneration</td>
</tr>
<tr>
<td>1300_HD</td>
<td>High density tree canopy</td>
</tr>
<tr>
<td>1400_LD</td>
<td>Low density tree canopy</td>
</tr>
<tr>
<td>1400_HD</td>
<td>High density tree canopy</td>
</tr>
<tr>
<td>1500_LD</td>
<td>Burned forest, no canopy</td>
</tr>
<tr>
<td>1500_HD</td>
<td>High density tree canopy</td>
</tr>
<tr>
<td>1550_LD</td>
<td>Burned forest, no canopy</td>
</tr>
</tbody>
</table>

Number is site elevation  
LD = low relative canopy density  
HD = high relative canopy density
Hemispherical Photographs

Canopy Closure ~15%

Canopy Closure ~ 50%
Remote Sensing Data

MODIS Snow-Covered Area and Grain Size (MODSCAG) adapted for the Landsat Thematic Mapper (TMSCAG)

Cascades Fractional Snow-Covered Area (fSCA)
14 May TMSCAG\textsubscript{adj}
15 June TMSCAG$_{adj}$

![Graph showing fSCA and Fraction Canopy Closure for different conditions.](image)
Plot-scale ground snow Observations

<table>
<thead>
<tr>
<th></th>
<th>1400_HD</th>
<th>1400_LD</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 4</td>
<td><img src="chart1.png" alt="Chart" /></td>
<td><img src="chart2.png" alt="Chart" /></td>
</tr>
<tr>
<td>June 1</td>
<td><img src="chart3.png" alt="Chart" /></td>
<td><img src="chart4.png" alt="Chart" /></td>
</tr>
<tr>
<td>June 12</td>
<td><img src="chart5.png" alt="Chart" /></td>
<td><img src="chart6.png" alt="Chart" /></td>
</tr>
<tr>
<td>June 20</td>
<td><img src="chart7.png" alt="Chart" /></td>
<td><img src="chart8.png" alt="Chart" /></td>
</tr>
</tbody>
</table>

Legend:
- 20% Canopy Cover
- 10% Canopy Cover
- 5% Canopy Cover
- % Snow
- % No Snow
Validation of the Canopy Adjustment

Adjustment performs well during times of extensive snow cover, except when canopy closure is too high.

Not adequate for later in the year when snow cover is heterogeneous.

Snow cover distribution seems to be affected by a combination of vegetation structure characteristics.
Limitations

- Limited data availability
- Assumed ground snow observations at single locations along transects represent true snow-covered area
- Assumed vegetation is the only variable controlling snow spatial variability
- Only a case study, different factors need to be considered for other locations
Future Directions

• Characterize vegetation structure from the plot to landscape scale: ground based LiDAR, high resolution aerial images, multiangle reflectance data
• Investigate the inclusion of this data in canopy adjustments for other snow products
The observable snow fraction is not always an effective proxy for subcanopy snow. The canopy adjustment needs to be refined with considerations of vegetation structure and elevation. Study is a preliminary step in developing an operational canopy adjustment for snow products from Landsat, MODIS, and VIIRS. Challenge continues with the characterization of canopy structure at increasingly larger scales.
Questions?

This research is supported through the MISR Science Team subcontract with NASA/ Jet Propulsion Laboratory for NPP VIIRS and the NSF Water Sustainability and Climate Award, EAR-1039192

Thank you:
Mountain Hydroclimatology Research Group
Karl Rittger, Jet Propulsion Laboratory
Michael Olsen, Oregon State University
Nick Kules, Oregon State University

References: