SNAMP Spatial Team Product Report: Sugar Pine and Last Chance

This report lists the products created from the lidar data for the SNAMP study sites: sugar pine and last chance. This includes the process for creating vegetation products, the analysis used for determining the input parameters, and the parameters used in creating the products.

Product List

Below are the products produced:

- Mean Height [meters]
- Max Height [meters]
- Diameter at Breast Height (DBH) [meters]
- Height to Live Canopy Base (HTLCB) [meters]
- Canopy Cover [percent]
- Leaf area index (LAI) [index]
- Individual Tree Segmentation

Products are created in conjuncture with ground truth plot level analysis that is about 20 m wide. Therefore, the resolution for these grid products is also 20 m. Figure 1 shows some of the products for the Sugar Pine site.

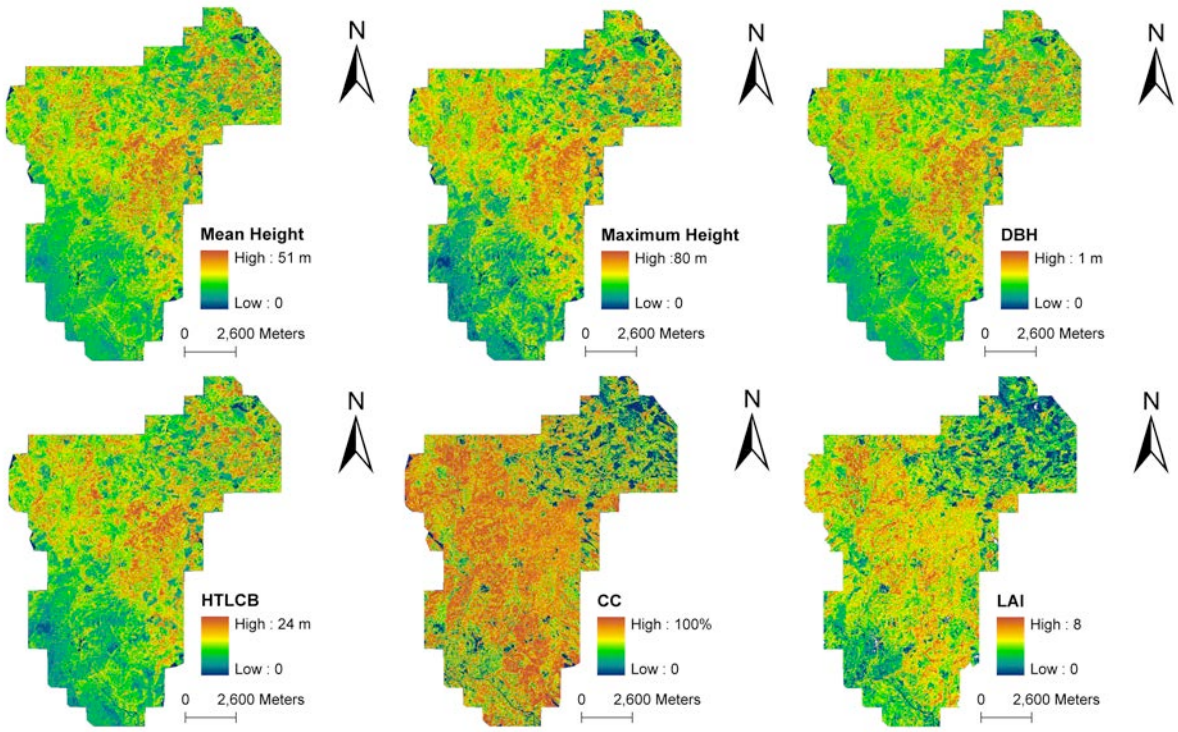

Figure 1. Vegetation products at Sugar Pine site.

Product Creation Process

Vegetation Products

Mean Height, Max Height, Height to Live Canopy Base (HTLCB) and Diameter at Breast Height (DBH) products are created using a regression-based approach. This approach starts by first extracting a subset of lidar points in the same location as each plot, matching the plot radius (12.62 m). A height profile is created on the extracted points using the following groups: z values for minimum, percentiles (1^{st}, 5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}, 95^{th}, 99^{th}), maximum, mean, standard deviations and the coefficient of variation. Coefficients are found for each product by a linear relation to each height group that all share the same intercept.

Product values can be predicted using each height profile. A stepwise regression analysis is conducted on each product to determine the combination of the coefficients that yields the best predicted values in correlation with measured values.

The coefficients are then applied to the entire study area. This is done by iterating through each pixel of the product grid, extracting lidar points that fall within that pixel and calculating the pixel value using the relation found in the previously mentioned analysis (Andersen et al., 2005).

Canopy Cover

Canopy Cover (CC) is determined by analyzing the canopy height model (CHM). CHMs typically have a resolution of 1 meter, and the canopy covers have a resolution of 20 meter. Each pixel in the canopy cover grid is iterated and CHM pixel values that fall within the canopy cover pixel are extracted. The value of the canopy cover pixel is calculated as the ratio of CHM pixels that have a value above a certain threshold to the total number of extracted pixels from the CHM (Lucas et al., 2006).

Leaf Area Index

The leaf area index (LAI) product is created using the lidar vegetation points, normalized by the DEM. Each pixel in the LAI grid is iterated and lidar points that fall within the pixel are extracted. An average scan angle is calculated using the extracted lidar points and the following equation:

$$ang = \frac{\sum_{i=1}^{n} angle_i}{n}$$

where *ang* is the average scan angle, *n* is the number of extracted points and $angle_i$ is the scan angle for a single extracted point *i*. Next the gap fraction (*GF*) is calculated using the following equation:

$$GF = \frac{n_{ground}}{n}$$

Where n_{ground} is the number of extracted points that have a z value smaller than 1.5 m (equivalent to the height of a hemispherical camera) and *n* is the total number of extracted points. Finally, the LAI value is calculated using the following equation:

$$LAI = -\frac{\cos(ang) \times \ln(GF)}{k}$$

where *k* is the extinction coefficient and ln is the natural logarithm (Richardson et al., 2009).

Individual Tree Segmentation

We developed a new algorithm to segment individual trees from the lidar point cloud by taking advantage of the relative spacing between trees (Li et al., 2012). In general, there is horizontal spacing between trees and the spacing at the top of a tree is larger than the spacing at the bottom. Hence, starting from a tree top, we can identify and "grow" a target tree by including nearby points, and exclude points of other trees based on their relative spacing. By defining an adaptive spacing threshold, most of the points can be correctly assigned to their corresponding tree clusters. Figure 2 shows the segmented point cloud for a 50×50 m area.

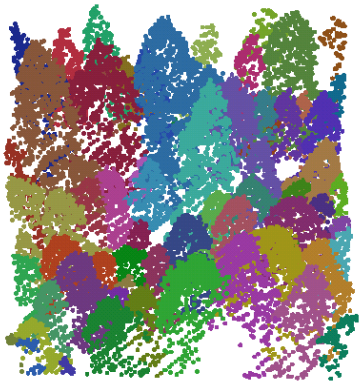

Figure 2. Segmented point cloud in a 50×50 m area

Product Parameters

Vegetation Products

Below is the table with parameters used in the generation of the grid products. The row "inmodel" indicates whether the corresponding variable is used (1) or not (0); "coefficients" indicates the coefficient for each entered variable; "intercept" is the constant variable for the regression equation.

Stepwise Regression Models (Sugar Pine)															
Product	Parameters	MIN	PCT_1	PCT_5	PCT_10	PCT_25	PCT_50	PCT_75	PCT_90	PCT_95	PCT_99	MAX	MEAN	STD	CV
DBH	inmodel	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	Coefficients	NA	NA	-1.402	NA	NA	1.398	NA	NA	NA	NA	NA	NA	NA	NA
	intercept	24.816													
	R2	0.614													
MeanH	inmodel	0	0	1	0	1	1	0	0	0	0	0	0	0	0
	Coefficients	NA	NA	-0.652	NA	0.301	0.49	NA	NA	NA	NA	NA	NA	NA	NA
	intercept	10.881													
	R2	0.674													
MaxH	inmodel	0	0	0	0	0	0	0	0	1	0	0	0	1	0
	Coefficients	NA	NA	NA	NA	NA	NA	NA	NA	1.265	NA	NA	NA	-1.045	NA
	intercept	5.366													

	R2	0.786													
HTLCB	inmodel	0	0	1	0	0	0	0	0	0	0	0	1	0	0
	Coefficients	NA	NA	0.178	NA	NA	NA	NA	NA	NA	NA	NA	0.332	NA	NA
	intercept	0.656													
	R2	0.617													

Stepwise Regression Models (Last Chance)															
Product	Parameters	MIN	PCT_1	PCT_5	PCT_10	PCT_25	PCT_50	PCT_75	PCT_90	PCT_95	PCT_99	MAX	MEAN	STD	CV
DBH	inmodel	0	0	0	1	0	1	1	0	0	0	1	0	0	0
	Coefficients	NA	NA	NA	-2.384	NA	1.315	0.708	NA	NA	NA	-0.237	NA	NA	NA
	intercept	27.904													
	R2	0.576													
MeanH	inmodel	0	1	0	0	0	0	0	0	0	1	0	1	0	0
	Coefficients	NA	-2.089	NA	NA	NA	NA	NA	NA	NA	-0.104	NA	1.057	NA	NA
	intercept	11.964													
	R2	0.723													
MaxH	inmodel	0	0	0	0	0	0	1	0	0	0	1	0	0	0
	Coefficients	NA	NA	NA	NA	NA	NA	0.989	NA	NA	NA	0.198	NA	NA	NA
	intercept	4.741													
	R2	0.814													
HTLCB	inmodel	0	0	0	1	0	0	0	0	0	0	0	1	0	0
	Coefficients	NA	NA	NA	0.341	NA	NA	NA	NA	NA	NA	NA	0.275	NA	NA
	intercept	-0.446													
	R2	0.524													

Canopy Cover

- Height threshold: 1.5m (typical height for a hemispherical camera)

LAI

- Extinction coefficient (*k*): 0.5 (Richardson et al., 2009).

Invidual Tree Segmentation

- Adaptive spacing threshold d_t: 2m if tree height is greater that 15m; 1.5m otherwise.

References

Andersen, H.E., McGaughey, R.J., and Reutebuch, S.E., 2005. Estimating forest canopy fuel parameters using LIDAR data. *Remote Sensing of Environment*, 94: 441–449.

Hopkinson, C., Sitar, M., Chasmer, L., and Treitz, P., 2004. Mapping Snowpack Depth beneath Forest Canopies Using Airborne Lidar. *Photogrammetric Engineering & Remote Sensing*, 70(3): 323-330.

Li, W., Guo, Q., Jakubowski, M.K., and Kelly, M., 2012. A New Method for Segmenting Individual Trees from the Lidar Point Cloud. *Photogrammetric Engineering & Remote Sensing*, 78(1): 75–84.

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