Remote Sensing of Forest and Snow Using Lidar

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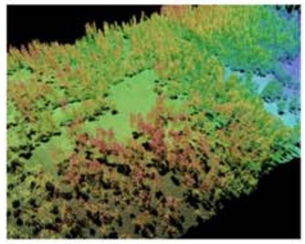
ABSTRACT

LiDAR (Light detection and Ranging) is an optical remote sensing technology that measures properties of scattered light to find range and/or other information of a distant object. Lidar gives us the ability to generate 3-dimensional data with high spatial resolution and accuracy (See Right). From lidar, useful information such as topological mapping including surface and bare earth modeling are more practicable then satellite imagery in that elevation and slope can be accurately analyzed and utilized. Other notable uses of lidar include vegetation height, biomass measurement and snow depth. Lidar has had applications in agriculture, archaeology, biology, geology, hydrology, meteorology, law enforcement and many more.

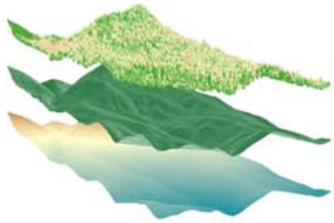


INTRODUCTION

Existing spatial data cannot meet the research needs of the Critical Zone Observatories (CZO) due to lack of completeness, being outdated and the insufficient spatial resolution and temporal scale. Therefore, two lidar flights (snow on/off, leaf on/off) have been conducted across 6 CZO sites to provide updated, accurate spatial data. The lidar acquisition initiative strives to collect this new spatial data to a central location where data can be analyzed for quality improvement, standardized and processed to produce products such as the surface, elevation, canopy cover, vegetation heights, leaf area index and diameter at breast height models. The data will be made available in a centralized location for easier downloading.

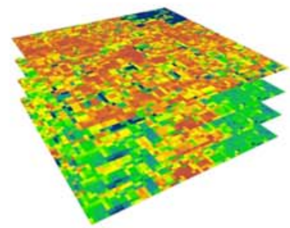
LIDAR PRODUCTS

Standard Products derived from the Lidar data include the Digital Surface Model (DSM) and the Digital Elevation Model (DEM) (See Right). DSM represents earth surface topography including vegetation whereas DEM represents a bare earth surface topography in which vegetation has been removed. Raw Lidar points are filtered to separate ground and non-ground points and are interpolated into the DEM and DSM. Classification methods for ground point determination are compared to obtain the greatest number of ground points from raw lidar to produce the highest quality DEM. Subtracting DEM from DSM yields another product called the Canopy Height Model (CHM) that represents true vegetation height. Forest feature products that include canopy cover models, mean height models, diameter at breast height models, and leaf area index models are also being produced for each CZO site. These products can be integrated into Geographic Information Systems as model input layers for analysis.



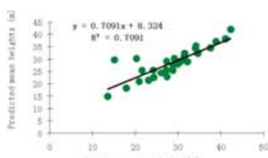
FOREST FEATURES FROM LIDAR

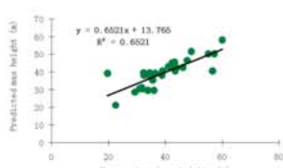
Forest features products obtained from Lidar include canopy cover, mean hieght, max height, diameter at breast height and leaf area index models (See Right). Other features include individual tree locations, individual tree heights and individual tree DBH and are obtained using tree segmentation. Featured data is verified with ground truthing - information collected on location.

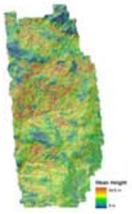


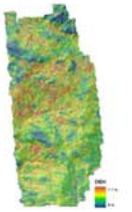
REGRESSION ANALYSIS AND LIDAR PRODUCTS (PROVIDENCE, CA)

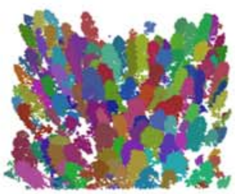
Ground truth collected on site represent the actual measurements for vegetation height, diameter at breast height and leaf area index. To the right is a subset of regression analysis curves used to create the forest feature vegetation products from below. Plot locations are identified using ground truth sites, and cut from the raw lidar. Height profiles are created for each plot and are used to estimate a given feature across the study area. To the right are forest feature products created for the Southern Sierra sub-area CZO site, Providence, Ca. They include: Canopy cover, mean height, max height, diameter at breast height (DBH) and leaf area index (LAI). The CANOPY COVER MODEL represents the vegetation coverage over the area where each pixel is valued between 0% canopy cover to 100% canopy cover. The MEAN HEIGHT MODEL and the MAX HEIGHT MODEL represent the average vegetation height and maximum vegetation height, respectively, over the area where each pixel value presents vegetation height. The DBH model represents the diameter at breast height for vegetation over the area where each pixel value presents diameter. The LAI model represents the effective leaf area index over the area.











TREE SEGMENTATION

Points from a lidar point cloud can be segmented into groups to identify individual trees (Left). This is done using an object based segmentation method in point cloud analysis. From these tree segments, attributes about a single tree can be extracted including its location, height, crown size and leaf area index. Diameter at breast height could be derived from the above attributes and tree species could be derived from the shape formed by point cloud clusters.

FOREST VISUALIZATION

Individual tree attributes are used to create tree models to specified sizes and species and placed in corresponding locations on a digital elevation model for forest visualization. Right is a real photo taken from Panther Peak as compared to a simulated scene derived from lidar.

SNOW

Snow Depth is calculated from lidar by using the digital elevation model produced from the snow on and snow off lidar flights. This is useful in snow related research such as calculating the snow water equivalent or analyzing snow spread. With tree segmentation, snow melt behavior could be predicted using the snow depth model, individual tree information and energy distribution analysis.

CONCLUTION

For the CZO project, lidar provides important information about the surface of the earth. Raw lidar is a cluster of points that are great for point cloud visualization, yet is useless in Geographic Information System analysis and interpolation or as an input parameter for research models. However, the products discussed in this poster that are produced from raw lidar have many applications such as terrain slope analysis, calculating biomass, vegetation analysis, individual tree identification, three dimensional forest simulation, snow depth analysis and much more. The CZO project has given us the rare opportunity to study remote sensing in different areas using lidar as well as collaboration amongst different disciplines across different Universities. Storing and processing data in a central location simplifies product creation, maintains the product quality level across CZO sites and makes obtaining it intuitive.

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