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3D remote sensing of forest canopy structure and biomass

Kenji Omasa[1]; Fumiki Hosoi[2]

[1] Agr. Life Sci., Univ. Tokyo; [2] Agricultural and Life Sciences
The University of Tokyo

http://joho1.en.a.u-tokyo.ac.jp/

Accurate estimation of canopy structures and biomass in forests is crucial for studying the functioning of forests and in studies of the global carbon budget. Recently, scanning lidar with a small footprint and a high pulse frequency, mounted on a helicopter, has been developed with high spatial resolution. These systems were expected to more completely illuminate the ground surface and generate more accurate 3-D data. The system could offer accurate estimation of tree heights accompanied with FP-mode DEM (Digital Elevation Model), DTM (Digital Terrain Model), that were mesh images of target trees and terrain generated from first returned laser pulse and last ones respectively, and DCHM (Digital Canopy Height Model), that was produced by subtracting DTM from FP-mode DEM and represented net tree heights. Estimated tree heights then provided carbon stocks of each tree based on allometric relationship between the tree heights and carbon stocks.

On the other hand, portable ground scanning lidar has been available for estimation of carbon stocks in forest. The stems in a Japanese larch forest with dense undergrowth were scanned from only one point, then the stem diameters of each observable trees were estimated at a measurable height. The DBH of each tree was estimated accurately from the stem diameter at the measurable height using the relationship between stem diameter at specific height and DBH that was obtained from ground-truthing data. Lidar-derived DBH can be converted into the carbon stock of each tree using allometric relationships between DBH and the carbon stock. The use of ground-based scanning lidar thus permits accurate estimation of individual-tree carbon stock.

3-D composition of plants is very important to sustain its functional roles. The 3-D structure is often expressed as vertical profile of leaf area density (LAD). The voxel-based canopy profiling method (VCP method), in which the 3D space is divided into volume elements (voxels), has been developed for estimating the LAD profile using portable ground scanning lidar. Individual trees were scanned with inclined laser beams from several measuring points that surround the trees. The laser beams were able to fully illuminate the tree inside the canopy. The information about tree positions and laser traces were assigned into the attributes of the voxels. Based on the information, vertical LAD profiles could be estimated by calculating contact frequency of laser beams in each horizontal layer within the canopy. This method showed the applicability of portable scanning lidar for estimating 3-D plant structure.