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Quantifying vertical distribution of the volume of leaves by using bi-temporal terrestrial LiDAR data taken in the leaf-off season and leaf-on season

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The vertical variations of canopy structures, especially, of photosynthetic parts, drive canopies to form stratified microclimate and ecosystems even within the canopy of a single tree. The volume occupied by leaves is an important parameter because leaves are engines of canopy functions and the volume can represent the spatial characteristics relative to solar energy absorption and gas exchange. Traditional methods to measure canopy structures are usually laborious and time consuming, and hard to quantify three dimensional characteristics. LiDAR remote sensing has emerged as a powerful technology to measure three dimensional information at fine scale.

We collected the LiDAR point cloud data of 32 *Zelkova serrata* trees planted at two plots in the Experimental Forest of Seoul National University, Suwon, Korea (37°15'58.7"N 126°56'22.7"E), on March 22^{nd}, 2017 (leaf-off season) and August 30^{th}, 2017 (leaf-on season) using terrestrial LiDAR. The point cloud data of the trees' canopy was normalized by the 5 cm^3 voxel, the volume was calculated by counting the total number of voxels. From the differences of the volume in the two seasons, we excluded the volume of non-photosynthetic tissues and estimated the volume occupied by leaves. The vertical distribution of volume occupied by leaves was calculated by counting the number of voxels at every 50cm crown layer.

Finally, the crown of every single tree was divided into 7 layers and the volume of each layer was calculated. The average volume occupied by leaves is 0.21 m^3 per layer in Plot A and 0.33 m^3 per layer in Plot B at single tree level. The ratio of the volume occupied by leaves to the total volume is 64% in Plot A and 48% in Plot B at single tree level. The area of the two plots are the same but there are 22 trees evenly planted in Plot A and 10 trees randomly planted in Plot B. The tree density of Plot A is higher than Plot B. We found that although the average total volume occupied by leaves in Plot A is smaller than Plot B, the average ratio in Plot A is much higher than Plot B. This result implicates that in order to become more competitive in a high-density environment, trees strategically improved the ratio of volume occupied by leaves.

The preliminary results highlighted the potential usefulness of multi-temporal LiDAR measurements to quantify the changes in canopy structure in more than centimeters accuracy at the single tree level. However, it has been challenged by the measurement errors based on the unstable field condition (e.g., wind) or the options on preprocessing methods for the LiDAR data.