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Integrating UAV Imagery and LiDAR Data for Tree Structural Properties

Forests cover approximately 31% of the global land area and are essential for biodiversity, supporting 80% of terrestrial species. However, these ecosystems are vulnerable to human-driven climate change, necessitating automated systems to monitor structural changes at the individual tree level and assess forest responses to climate anomalies. UAV-based tree canopy detection is valuable for estimating essential ecosystem variables (EEVs) and biodiversity variables (EBVs). However, applying UAVs to specific projects can be complex due to the range of data and processing requirements. To address this, we developed Drone4Tree, a user-friendly platform built on Streamlit and Flask that provides an end-to-end solution for processing UAV imagery. The platform processes UAV-acquired data to generate orthomosaics, delineate tree crowns, and derive tree attributes, with user-friendly options for standard and advanced processing modes. It uses structure-from-motion (SfM) through OpenDroneMap to generate orthomosaics and digital surface models (DSM), from which individual tree heights are calculated. Drone4Tree employs U-Net-based segmentation for tree canopy delineation. This workflow facilitates an analysis-ready time series of individual tree canopies, enabling detailed phenological and ecological assessments. Canopy boundaries generated by the platform will help build spectral libraries for species detection and mapping, contributing to studies of forest structure, ecosystem function, and species diversity.

In addition to UAV data, we used LiDAR data to analyze tree height and diameter at breast height (DBH) and validate UAV-derived measurements. Comparative analysis shows strong agreement between field DBH and LiDAR-derived DBH, indicating reliable DBH estimation from LiDAR data. For tree height, the LiDAR-based measurements correlated well with heights derived from the UAV-based canopy height models (CHM), though comparisons with field-measured heights revealed a lower correlation. These results indicate that LiDAR and UAV data complement each other, with UAVs offering efficient monitoring capabilities while LiDAR provides additional precision. This platform enables accurate, scalable individual tree monitoring, supporting ecological research and forest management.

Primary authors: Dr GUPTA, Sharad (Helmholtz Centre for Environmental Research - UFZ); Mr SCHULZE, Franz (Helmholtz Centre for Environmental Research - UFZ); MALLAST, Ulf (Helmholtz Centre for Environmental Research - UFZ); BREDE, Benjamin (GFZ German Research Centre for Geosciences)

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