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BACKSCATTERING OF INDIVIDUAL LIDAR PULSES FROM FOREST CANOPIES EXPLAINED BY PHOTOGRAMMETRICALLY DERIVED VEGETATION STRUCTURE

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Abstract. In recent years, airborne LiDAR sensors have shown remarkable performance in the mapping of forest vegetation. This experimental study looks at LiDAR data at the scale of individual pulses to elucidate the sources behind interpulse variation in backscattering. Close-range photogrammetry was used for obtaining the canopy reference measurements at the ratio scale. The experiments illustrated different orientation techniques in the field, LiDAR acquisitions and photogrammetry in both leaf-on and leaf-off conditions, and two-waveform recording LiDAR sensors. The intrafootprint branch silhouettes in zenith-looking images, in which the camera, footprint, and LiDAR sensor were collinear, were extracted and contrasted with LiDAR backscattering. An enhanced planimetric match (refinement of strip matching) was achieved by shifting the pulses in a strip and searching for the maximal correlation between the silhouette and LiDAR intensity. The relative silhouette explained up to 80 – 90% of the interpulse variation. We tested whether accounting for the Gaussian spread of intrafootprint irradiance would improve the correlations, but the effect was blurred by small-scale geometric noise. Accounting for receiver gain variations in the Leica ALS60 sensor data strengthened the dependences. The size of the vegetation objects required for triggering a LiDAR observation was analyzed. We demonstrated the use of LiDAR pulses adjacent to canopy vegetation, which did not trigger a canopy echo, for canopy mapping. Pulses not triggering an echo constitute the complement to the actual canopy. We conclude that field photogrammetry is a useful tool for mapping forest canopies from below and that quantitative analysis is feasible even at the scale of single pulses for enhanced understanding of LiDAR observations from vegetation.

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