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Retrieval of Savanna Vegetation Canopy Height from ICESat-GLAS Spaceborne LiDAR With Terrain Correction

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Abstract

Light detection and ranging (LiDAR) remote sensing enables accurate estimation and monitoring of vegetation structural properties. Airborne and spaceborne LiDAR is known to provide reliable information on terrain elevation and forest canopy height over closed forests. However, it has rarely been used to characterize savannas, which have a complex structure of trees coexisting with grasses. This letter presents the first validation of spaceborne Ice Cloud and land Elevation Satellite Geoscience Laser Altimeter System (GLAS) full-waveform data to retrieve savanna vegetation canopy height that uses field data specifically collected within the GLAS footprints. Two methods were explored in the Kruger National Park, South Africa: one based on the Level 2 Global Land Surface Altimetry Data product and the other using Level 1A Global Altimetry Data (GLA01) with terrain correction. Both methods use Gaussian decomposition of the full waveform. Airborne LiDAR (AL) was also used to quantify terrain variability (slope) and canopy height within the GLAS footprints. The canopy height retrievals were validated with field observations in 23 GLAS footprints and show that the direct method works well over flat areas (Pearson correlation coefficient r = 0.70, $p < 0.01$, and $n = 8$ for GLA01) and moderate slopes ($r = 0.68$, $p < 0.05$, and $n = 9$ for GLA01). Over steep slopes in the footprint, however, the retrievals showed no significant correlation and required a statistical correction method to remove the effect of terrain variability on the waveform extent. This method improved the estimation accuracy of maximum vegetation height with correlations ($R2 = 0.93$, $p < 0.05$, and $n = 6$ using the terrain index (g) generated from AL data and $R2 = 0.91$, $p < 0.05$, and $n = 6$ using the GLAS returned waveform width parameter). The results suggest that GLAS can provide savanna canopy height estimations in complex tree/grass plant communities.