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PROSPECTS OF PHOTON COUNTING LIDAR FOR SAVANNA ECOSYSTEM STRUCTURAL STUDIES

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ABSTRACT:

Discrete return and waveform lidar have demonstrated an undoubted capability to measure vegetation canopy height and the associated ecological functionality such as aboveground biomass and consequently carbon storage. Since discrete return lidar (DRL) is mainly suitable for small scale studies and the only so far available spaceborne lidar sensor (ICESat-GLAS) is now obsolete, the main question now is what the future holds in terms of large scale lidar remote sensing studies. The planned future spaceborne lidar mission is ICESat-2 that will use a photon counting technique. To pre-validate the capability of this mission for three dimensional vegetation structural studies we assessed the potential of the sensor's simulator to estimate canopy height in a savanna ecosystem. We used data from the Multiple Altimeter Beam Experimental Lidar (MABEL), an airborne photon counting lidar sensor developed by NASA Goddard. MABEL fires a laser pulse in the green and near infrared bands 5 000 times a second and records the millions of photons in each pulse that are reflected back to the sensor. The photons' time of arrival and the instrument's GPS positions are used to calculate the distance the light travelled and hence the elevation of the surface below. A few transects flown over the Tejon conservancy range in Kern county of California, USA were used for this work. We segmented each transect into sections of 50 m, 25 m and 10 m length and the photons in each subset were then aggregated and modeled into a histogram based on their elevation values. We then used a moving window algorithm to identify cut off points where the cumulative density of photons from the highest elevation resembles the canopy top and likewise where such cumulative density from the lowest elevation resembles the ground peak. These cut of points were compared to DRL derived canopy height and ground level elevations. Our results showed that the 50 m segments were heavily distorted by terrain relief and hence had a very low correlation between MABEL and DRL derived canopy height. Modeling the MABEL derived canopy height using terrain extent as an additional variable slightly improved this correlation. When the segment length was reduced to 25 m, the terrain extent variable was no longer significant and the correlation between MABEL and DRL derived canopy height improved to $r = 0.74$, RMSE = 6.2m. Reducing the aggregation segment to 10 m further improved this correlation to $r = 0.80$, RMSE = 5m. Our work has demonstrated a capability of photon counting lidar to estimate canopy height in savannas and it is our belief that with improvements, even better results can be obtained with the upcoming ICESat-2 mission.