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Application of drone borne LiDAR technology for monitoring agricultural biomass and plant growth.

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With rising demand for increasing the yield potential of agricultural products and for reducing greenhouse gas emissions during food production, strengthening our scientific and technological capacity to monitor crop growth and above ground biomass (AGB) is indispensable to move towards more sustainable management of our agricultural resources. Pivotal to meet this goal is the application of high-throughput field-phenotyping tools such as drone borne Light Detection and Ranging (Lidar) systems for accurate, fine-grained, rapid and labor-saving measurements of vegetation growth parameters. Our objective is to develop and assess a workflow to estimate AGB, leaf area index (LAI), plant height (PH) and volume of a homogeneous and highly dense agricultural field using the capabilities of UAV-Lidar technology. The experimental site is located in Denmark and populated by potato plants. Aerial campaigns and field experiments, including destructive biomass sampling and measurements of LAI and plants' geometrical characteristics at 1m^2 square plots, were performed once per month during the vegetation growth period (May–September 2019). The high resolution (3.6 cm) Canopy Height model (CHM) is generated by first evaluating the performance of different filtering algorithms that separate the ground points from the Lidar-derived point cloud datasets. To extract the geometrical parameters of individual crop plants, we delineate the CHM by applying segmentation directly to the Lidar point cloud rather than segmenting the CHM as an interpolated raster surface. The PH obtained by the Lidar scanner is highly correlated with the field-measured PH (R^2=0.89 and RMSE=0.028 m) implying that the point cloud data processing evaluated here is efficient and able to generate serviceably accurate CHMs for agricultural sites with similar vegetation structures. Throughout the observed vegetation growth period, the AGB can be quantified with high accuracy when it is considered to be a function of plant volume (R^2=0.81 and RMSE=31.65 %) rather than a function of PH, as the latter approximating an exponential relationship with AGB. Height and density Lidar metrics were more effective in predicting in situ LAI measurements in comparison with remotely sensed LAI calculated directly from Lidar vegetation points following the Beer Lambert law. The predictive frameworks emerging from this approach indicate the applicability of drone borne Lidar systems for obtaining agricultural crop growth parameters in both high spatial and temporal resolution.