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UAS mounted LiDAR for Estimating LAI Type Metrics for Winter Wheat

Jordan Bates[1], Carsten Montzka[1], Marius Schmidt[1], and François Jonard[1,2]
[1]Institute of Bio- and Geosciences: Agrosphere (IBG-3), Forschungszentrum Jülich GmbH, 52428 Jülich, Germany (j.bates@fz-juelich.de)
[2]Earth and Life Institute, Université catholique de Louvain, 1348 Louvain-la-Neuve, Belgium

Metrics such as Leaf Area Index (LAI) are key factors in agricultural monitoring to understand the health and predictive yield of crops. Knowing the spatial distribution and variability in more detail increases the precision of fertilizer and irrigation practices. Unmanned Aircraft Systems (UAS) provide a means to carry sensors at a low altitude below the clouds providing a much higher spatial and temporal resolution than previously seen with satellite remote sensing while also providing more spatially complete data as compared to ground methods. Being that LiDAR is an active sensor and does not depend on solar reflectance and its corresponding zenith angle like commonly used passive optical sensors, it can further improve upon these UAS characteristics. It can also sense further into the canopy as the laser signals can pass through small gaps and are not affected by the shadowing of plant features created by the canopy itself. Evaluating the penetration of these signals and investigating the gap fraction (GF) that relates to canopy density, we are able to retrieve LAI. However, as LiDAR is sensing all above-ground plant elements it may present the ability to estimate Plant Area Index (PAI) rather than LAI when monitoring an entire growing season for a cereal crop like winter wheat that begins browning during senescence. This study investigates the feasibility of using LiDAR to estimate LAI or similar crop canopy density metrics. As LiDAR sensors for UAS are just becoming more accessible, studies related to this topic are scarcely seen.

In this study, a winter wheat field in Selhausen, Germany (~10 ha in size) was monitored throughout the growing season using the following methods: [1] air campaigns with a DJI Matrice 600 UAS with a YellowScan Surveyor LiDAR system, [2] a DJI Matrice 600 UAS with a Micasense RedEdge-M (five band) multispectral sensor, and [3] ground measurements using a SS1 SunScan ceptometer. The resulting LAI type metrics of the UAS LiDAR methods used were compared to methods commonly used with multispectral (MS) and ground instruments to assess the proposed method's potential. Additionally, because both products are spatially complete unlike the ground measurements, the LiDAR and multispectral methods were compared for similarities in spatial patterns.

The results showed promise in using UAS LiDAR to estimate metrics that relate to LAI. Pearson

correlation coefficient between the LiDAR and multispectral methods were moderate to high (R= 0.39 – 0.66) over the growing season. The comparison of UAS LiDAR towards the ground reference was within a 3% difference at times before senescence. Later in the growing season, the discrepancy increased between LiDAR and MS sensor retrievals mainly because of plant browning related to changes in plant chlorophyll content. This study covers the benefits of using UAS mounted LiDAR for LAI related measurements and its potential for improving crop health monitoring for precision farming.