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Utilization of UAV-Lidar to infer surface roughness and leaf area index of a heterogeneous wooded area

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The newly developed unmanned aerial vehicle (UAV)-based Light Detection and Ranging (Lidar) scanners may provide a research tool to yield a fine-grained analysis of surface processes and patterns for hydrological modeling by generating the 3-d structure of a surface in both high spatial and temporal resolution. To describe interactions between water and vegetation dynamics the aerodynamic roughness length (zo) and zero-plane displacement (d) are usually estimated based on micrometeorological observations which are confined to a specific footprint, or on morphometric surface roughness models which rely on the demarcation of surface objects. By linking the Lidar-derived geometry with surface roughness models, zo and d may be extracted without requiring any other data sources, such as aerial imagery or GIS databases. Compared to traditional remote sensing, Lidar may also more accurately measure vegetation structure with no apparent sign of saturation in estimating leaf area index (LAI).

This conceptual approach aims to evaluate the potential for UAV borne Lidar in estimation of surface roughness and LAI in a challenging heterogeneous field (3.5 x 5 km) in rural Switzerland, populated by deciduous trees of a range of species and heights and some unwooded grassy areas. To accomplish that, the study is focused on:

i) evaluating the performance of different filtering algorithms (e.g., maximum local slope, adaptive triangular irregular network, progressive morphology and object based classification) to separate Lidar data into terrain and off-terrain datasets, thus generating high-resolution digital terrain model and the necessary geometry for a morphometric model;

ii) investigating whether UAV-Lidar derived geometry of a surface (e.g., total plan area, percentage of area covered with vegetation, average height of features, number of trees) can be integrated effectively to a morphometric model in order to estimate the areal zo and d for subsequent use in resistance equations;

iii) exploring the effectiveness of various canopy Lidar metrics including canopy density, mean, maximum, and percentile height to estimate LAI over the heterogeneous field by incorporating them into a stepwise regression procedure to predict field-based measurements of LAI.

This technique may advance the establishment of more precise spatial representation of potentially nonlinear relationships between canopy structural characteristics and surface water dynamics across heterogeneous land cover types.