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Multi-temporal UAV-borne LiDAR point clouds for vegetation analysis – a case study

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In the recent past the introduction of compact and lightweight LiDAR (Light Detection And Ranging) sensors together with progress in UAV (Unmanned Aerial Vehicle) technology allowed the integration of laser scanners on remotely piloted multicopter, helicopter-type and even fixed-wing platforms. The multi-target capabilities of state-of-the-art time-of-flight full-waveform laser sensors operated from low flying UAV-platforms has enabled capturing of the entire 3D structure of semi-transparent objects like deciduous forests under leaf-off conditions in unprecedented density and completeness. For such environments it has already been demonstrated that UAV-borne laser scanning combines the advantages of terrestrial laser scanning (high point density, short range) and airborne laser scanning (bird's eye perspective, homogeneous point distribution). Especially the oblique looking capabilities of scanners with a large field of view (>180°) enable capturing of vegetation from different sides resulting in a constantly high point density also in the sub canopy domain.

Whereas the findings stated above were drawn based on a case study carried out in February 2015 with the Riegl VUX-1UAV laser scanner system mounted on a Riegl RiCopter octocopter UAV-platform over an alluvial forest at the Pielach River (Lower Austria), the site was captured a second time with the same sensor system and mission parameters at the end of the vegetation period on October 28^{th}, 2015. The main goal of this experiment was to assess the impact of the late autumn foliage on the achievable 3D point density. Especially the entire understory vegetation and certain tree species (e.g. willow) were still in full leaf whereas the bigger trees (poplar) where already partly defoliated.

The comparison revealed that, although both campaigns featured virtually the same laser shot count, the ground point density dropped from 517 points/m^2 in February (leaf-off) to 267 points/m^2 end of October (leaf-on). The decrease of ca. 50% is compensated by an increase in the upper canopy area (>20 m a.g.l.; Feb: 348 points/m^2, Oct: 757 points/m^2, increase rate: 118%). The greater leaf area in October results in more laser echoes from the canopy but the density decrease on the ground is not entirely attributed to shadowing from the upper canopy as the point distribution is nearly constant in the medium (10-20 m) and lower (0-10 m) sub-canopy area. The lower density on the ground is rather caused by a densely foliated shrub layer (0.15-3 m; Feb: 178 points/m^2, Oct: 259 points/m^2, increase rate: 46%). A sharp ground point density drop could be observed in areas covered by an invasive weed species (*Fallopia japonica*) which keeps its extremely dense foliage till late in the year.

In summary, the preliminary point density study has shown the potential of UAV-borne, multi-temporal LiDAR for characterization of seasonal vegetation changes in deciduous environments. It is remarkable that even under leaf-on conditions a very high terrain point density is achievable. Except for the dense shrub layer, the case study has shown a similar 3D point distribution in the sub-canopy area for leaf-off and leaf-on data acquisition.