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Full waveform airborne laser scanning for mapping morphometric parameters in terrain with varying vegetation cover

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The application of full waveform analysis in the field of geomorphology is a relatively new field, especially in the case of small footprint laser scanners. Sensors providing larger footprints have been tested and positive results have shown that return waveform is correlated with geomorphology of the terrain. The relatively recent increase in the use of sensors which provide both classic discrete returns and full waveform leads to a natural increase interest in investigating the potential of full waveform analysis. The digitizer allows sampling of the whole return signal, usually at 1 ns intervals, thus with a theoretical discrimination value of 0.15 m. This technology can be used to enhance a classic discrete-return LiDAR survey with the metrics (usually from Gaussian decomposition) of the waveform segment corresponding to the point. In this study four areas with different vegetation cover characteristics were investigated to compare morphometric parameters derived using a sensor (Optech's ALTM) which provides both discrete-return data and full waveform raw data at 1 GHz sampling rate (1 ns). The survey was done in leaf-on conditions with a pulse density of $\sim$10 pulses per square meters. Ten sample plots were defined for each of the four areas and waveform metrics were extracted for each sample. The waveform data relative to the last significant peak of the return signal was considered (SdL = last significant peak data); by relative data in this case we mean all waveform data sample above the baseline around time tL of the detected peak. Peak detection was done with a local maximum filter with a 5 ns window which moves from last data sample backwards toward the first. SdL is therefore a vector, of varying magnitude, of amplitude samples. The metrics extracted regard shape information over the SdL data distribution (skewness and kurtosis) after it has been normalized considering several aspects which affect return amplitude such as range and objects which cause partial reflection. The results report the correlation between morphometric surface parameters - which are affected by the presence (or absence) of low vegetation, deadwood present on the ground or standing, as well as an actual forest stand with a mean tree height of 14 m - with the waveform metrics investigated. Future studies will focus on creating an automated workflow for mapping the metrics using 2D (pixel) and 3D (voxel) digital grid models to use for the classification of terrain as a function of terrain morphometry.