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Estimating sediment features and hydraulic parameters on a sand bedded point bar using LiDAR height and intensity and high resolution UAV-based images

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The small scale sedimentation formations on a riverine environment are an important source of information about the fluvial processes behind them. Together with the grain size distribution, it is possible to estimate the predominated flow conditions and thus derive information of inaccessible flooded areas. The traditional survey methods, however, do often not allow for a detailed observation of such formations over an extensive area. Moreover, sampling the sediment in order to define the distribution of the grain sizes is time consuming and does not allow for a good spatial resolution. Thus, the usage of remote sensing for better accuracy and spatial resolution and more effective data gathering is reasoned.

LiDAR (Light Detection and Ranging) sensor emits laser light and receives the backscattered beam, which carries information about the sensor-target distance and the reflectivity of the target. As the usage of the detailed terrestrial LiDAR data has recently increased also in fluvial studies, the information is still not fully utilized. Especially the exploitation of the intensity of the backscattered beam is missing from the riverine studies. The LiDAR intensity is defined as the ratio of strength of reflected light to that of emitted light, and is influenced by the power of the emitted light, distance from the source to the target, surface reflectance, athmospheric transmission and the incidence angle of the bean. Thus, to make intensity represent only reflectance of the object it is necessary to calibrate the raw intensity data. Furthermore, the resolution of digital images has improved greatly recently and the interpretation of a LiDAR DTM (digital terrain model) may be enhanced with aerial photographs. Thus, it is possible to produce, combine and exploit detailed remotely sensed data for a detailed morphological analysis of a flood plain.

In this study, terrestrial laser scanning data and highly accurate UAV (Unmanned Aerial Vehicle) –photographs (taken from a remote controlled helicopter) are used to define the morphological features of a meander point bar after a flood event. A detailed DTM is created from the TLS point cloud and examined together with the aerial image in order to locate and identify the flood-based formations and their orientations. In addition, the received TLS intensities are calibrated to represent only the reflectance of the object and thereby, the distribution of grain sizes over the point bar is derived. The observed small scale formations and grain size distribution are then further used to estimate the hydraulic parameters (flow velocity and direction, shear forces) of the past flood event. Finally the findings are validated with in-situ observations of the flood event.

The methodology represented in this study may be further exploited for example in defining a roughness parameter for CFD (computational fluid dynamics), validating the simulation results or in examining how bed roughness varies in time and space, and how it evolves during floods of different magnitude.