Geophysical Research Abstracts
Vol. 20, EGU2018-1776, 2018
EGU General Assembly 2018

Assessing the performance of a topo-bathymetric lidar system for fluvial applications

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Over the last decade, a number of new techniques have emerged which enable capture of high resolution topography of fluvial environments. Developments in airborne and terrestrial laser scanning, and more recently, UAV structure-from-motion (SfM) photogrammetry, have enabled generation of high resolution digital elevation models (DEMs) from point clouds. However, while such approaches are effective for capturing topography, recording the submerged terrain of the river channel remains challenging, and most approaches rely on labour-intensive field surveys. The research presented here evaluates a novel topo-bathymetric lidar system, which is able to deliver seamless, high resolution point clouds of both dry and submerged topography.

While topographic lidar relies on a near-infrared laser to capture Earth surface features, bathymetric lidar also employs a green wavelength laser (λ = 532 nm) which propagates through the water column and provides returns from the seabed or channel bottom. However, while bathymetric lidar has been utilised for seabed mapping in near-shore coastal zones for a number of decades, it is only very recently that systems for shallow waters (rivers, in-shore environments), have become operationally viable. Technological advances now enable capture of submerged riverbed topography at spatial resolutions of $>$20 points/m^2, offering significant potential for applications including hydrodynamic modelling, flood risk assessment, and river restoration activities.

In this study, topo-bathymetric lidar data was acquired for reaches of 5 – 8 km at five rivers across Scotland, UK. The data was collected from a fixed wing aircraft, utilising a Riegl VQ880-G sensor. Post-processing was undertaken to separate dry terrain, water surface, and submerged water points. Identification of the water surface is fundamental for correcting submerged laser echoes to account for the refraction of the laser beam as it travels through the water column. In order to eliminate the large number of spurious points, an automated outlier filtering approach was developed. DEMs of the water surface and channel bottom were produced, allowing for determination of depth. As measurements are strongly affected by water clarity, analysis was undertaken to assess the limitations of depth retrieval, and correlation with point density. The results from the five contrasting sites are being compared to understand how the resultant point cloud is affected by differing physical conditions, such as substrate material, water clarity and turbidity, and overhanging vegetation. Quality assessment undertaken through comparison to GNSS-measured cross sections indicates that the accuracy (RMSE) of the submerged points is in the region of 0.05 – 0.10 m. This contribution will discuss the performance of the technique under varying conditions, and highlight potential for future applications and research focus.