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A geomorphologist's dream come true: synoptic high resolution river bathymetry with the latest generation of airborne dual wavelength lidar

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Airborne, terrestrial lidar and Structure From Motion have dramatically changed our approach of geomorphology, from low density/precision data, to a wealth of data with a precision adequate to actually measure topographic change across multiple scales, and its relation to vegetation. Yet, an important limitation in the context of fluvial geomorphology has been the inability of these techniques to penetrate water due to the use of NIR laser wavelengths or to the complexity of accounting for water refraction in SFM. Coastal bathymetric systems using a green lidar can penetrate clear water up to 50 m but have a resolution too coarse and deployment costs that are prohibitive for fluvial research and management. After early prototypes of narrow aperture green lidar (e.g., EEARL NASA), major lidar manufacturer are now releasing dual wavelength laser system that offer water penetration consistent with shallow fluvial bathymetry at very high resolution (> 10 pts/m^2) and deployment costs that makes the technology, finally accessible. This offers unique opportunities to obtain synoptic high resolution, high precision data for academic research as well as for fluvial environment management (flood risk mapping, navigability,...).
In this presentation, we report on the deployment of the latest generation Teledyne-Optech Titan dual-wavelength lidar (1064 nm + 532 nm) owned by the University of Nantes and Rennes. The instrument has been deployed over several fluvial and lacustrine environments in France. We present results and recommendation on how to optimize the bathymetric cover as a function of aerial and aquatic vegetation cover and the hydrology regime of the river. In the surveyed rivers, the penetration depth varies from 0.5 to 4 m with discrete echoes (i.e. onboard detection), heavily impacted by water clarity and bottom reflectance. Simple post-processing of the full waveform record allows to recover an additional 20 % depth.
As for other lidar techniques, the main challenge lies in the post-processing of the massive amount of data generated by the instrument (typically 10 billions points for 60 km of rivers). Yet the very high density of the raw point cloud data (40 pts/m^2 on topography, 20 pts/m^2 on bathymetry) and the full waveform nature of the signal offers new opportunities to develop classification and change detection algorithms. In this context, we present a new automated workflow to extract automatically the water surface (a critical aspect for refraction correction) and submerged data in highly complex fluvial environments based on a combined analysis of the 1064 nm and 532 nm channels. We conclude that topo-bathymetric lidar is getting close to being an operational technique for fluvial bathymetry offering a vast range of applications in hydrology, ecohydrology, geomorphology and river management.