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On the use of airborne LiDAR for braided river monitoring and water surface delineation

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Airborne LiDAR is an established technology for Earth surface surveying. With LiDAR data sets it is possible to derive maps with different land use classes, which are important for hydraulic simulations. We present a 3D point cloud based method for automatic water surface delineation using single as well as multitemporal LiDAR data sets. With the developed method it is possible to detect the location of the water surface with high planimetric accuracy. The multitemporal analysis of different LiDAR data sets makes it possible to visualize, monitor and quantify the changes of the flow path of braided rivers as well as derived water surface land use classes.

The reflection properties from laser beams (1064 nm wavelength) on water surfaces are characterized by strong absorption or specular reflection resulting in a dominance of low signal amplitude values and a high number of laser shot dropouts (i.e. non-recorded laser echoes). The occurrence of dropouts is driven by (i) the incidence angle, (ii) the surface reflectance and (iii) the roughness of the water body. The input data of the presented delineation method are the modeled dropouts and the point cloud attributes of geometry and signal amplitude. A terrestrial orthophoto is used to explore the point cloud in order to find proper information about the geometry and amplitude attributes that are characteristic for water surfaces. The delineation method is divided into five major steps. (a) We compute calibrated amplitude values by reducing the atmospheric, topographic influences and the scan geometry for each laser echo. (b) Then, the dropouts are modeled by using the information from the time stamps, the pulse repetition frequency, the inertial measurement unit and the GPS information of the laser shots and the airplane. The next step is to calculate the standard deviation of the heights for all reflections and all modeled dropouts (c) in a specific radius around the points. (d) We compute the amplitude ratio density for all shots. The amplitude density ratio is the relation between the number of laser echoes having an amplitude within a specific interval (i.e. very low amplitudes) plus the dropouts (i.e. with amplitude of zero) divided by the number of all laser shots in a fixed search distance of a point. (e) We classify each point in water or a non-water by using the attributes of (i) the standard deviation of the height and (ii) the amplitude density ratio. For validation, a terrestrial orthophoto is used, which was taken at the same time as the laser campaign.

A major advantage of this new approach is the ability of a point cloud based delineation of water and non-water areas. We demonstrate the results at the glacier forefield of the Hintereisferner (Ötztal, Tyrol, Austria) with multitemporal data sets. The multitemporal analysis demonstrates the strength of the delineation method for mapping the watercourse and monitoring the changes in the flow path of the braided river between the different epochs.