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# Change detection of riverbed movements using river cross-sections and LiDAR data

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Today, Airborne LiDAR derived digital terrain models (DTMs) are used for several aspects in different scientific disciplines, such as hydrology, geomorphology or archaeology. In the field of river geomorphology, LiDAR data sets can provide information on the riverine vegetation, the level and boundary of the water body, the elevation of the riparian foreland and their roughness. The LiDAR systems in use for topographic data acquisition mainly operate with wavelengths of at least 1064nm and, thus, are not able to penetrate water. LiDAR sensors with two wavelengths are available (bathymetric LiDAR), but they can only provide elevation information of riverbeds or lakes, if the water is clear and the minimum water depth exceeds 1.5m. In small and shallow rivers it is impossible to collect information of the riverbed, regardless of the used LiDAR sensor. In this article, we present a method to derive a high-resolution DTM of the riverbed and to combine it with the LiDAR DTM resulting in a watercourse DTM (DTM-W) as a basis for calculating the changes in the riverbed during several years. To obtain such a DTM-W we use river cross-sections acquired by terrestrial survey or echo-sounding. First, a differentiation between water and land has to be done. A highly accurate water surface can be derived by using a water surface delineation algorithm, which incorporates the amplitude information of the LiDAR point cloud and additional geometrical features (e.g. local surface roughness). The second step is to calculate a thalweg line, which is the lowest flow path in the riverbed. This is achieved by extracting the lowest point of each river cross section and by fitting a B-spline curve through those points. In the next step, the centerline of the river is calculated by applying a shrinking algorithm of the water boundary polygon. By averaging the thalweg line and the centerline, a main flow path line can be computed. Subsequently, a dense array of 2D-profiles perpendicular to the flow path line is defined and the heights are computed by linear interpolation of the original cross sections. Thus, a very dense 3D point cloud of the riverbed is obtained from which a grid model of the river bed can be calculated applying any suitable interpolation technique like triangulation, linear prediction or inverse distance mapping. In a final step, the river bed model and the LiDAR DTM are combined resulting in a watercourse DTM. By computing different DTM-Ws from multiple cross section data sets, the volume and the magnitude of changes in the riverbed can be estimated. Hence, the erosion or accumulation areas and their volume changes during several years can be quantified.

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