Using Airborne Hydromapping Data for Habitat Investigations in running waters

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1. Introduction

Ecohydraulic studies are an interpretation of the hydraulic situation in running waters with regard to living conditions for their flora and fauna. Bathymetric surveys are the essential basis for these investigations. With increasing computational performance and powerful models for describing the hydraulic situation and stream water habitats, the expectations for basic surveys are rising. Against this backdrop and further reinforced by the stipulations of the European Water Framework Directive, the technology of Airborne Hydromapping, a survey system with a water-penetrating laser system was developed (Steinbacher et al., 2010).

2. Airborne Hydromapping

2.1 Technology

Main part of the Airborne Hydromapping concept is a water penetrating laser system which is able to deliver high resolution information about the riverbed geometry (VQ-820G; Riegl LMS, Research project between University of Innsbruck and Riegl LMS). With this technology it is possible to survey water bodies and riparian strips comprehensively and in high resolution (10–40 points/m^2). Moreover, a penetration of the water body up to a depth of 10 m is achieved under clear water conditions, deeper depths are captured by echo sounding devices (Baran et al., 2013). Detailed and extensive data of riverbeds and riverbanks can be acquired within a couple of flight hours. Additionally, LiDAR points from the water surface are gained by this device and can be used to reconstruct the water table. For turbid water torrents it is also possible to measure the turbidity in the water stream.

This new technology has a great advantage in contrast to traditional survey concepts where multiple cross sections are measured by a survey team. The survey of cross sections is time consuming and may be dangerous or not feasible in places of interest (see Fig. 1).

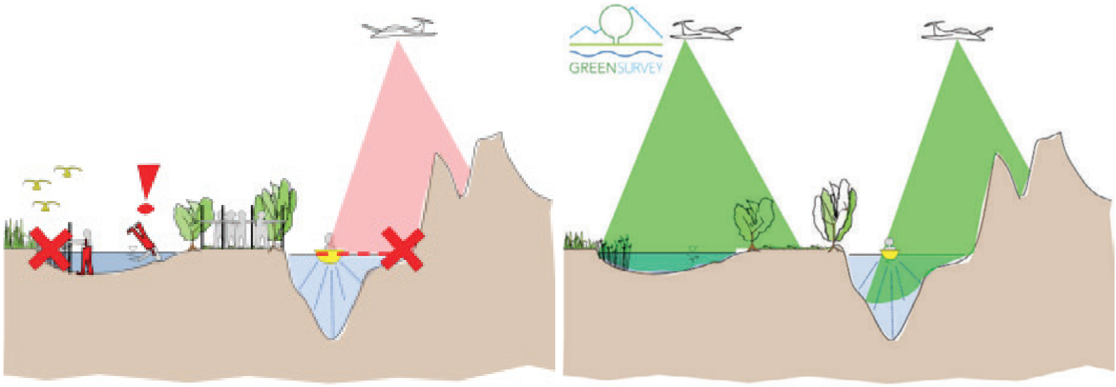

Figure 1: Concept of traditional bathymetric surveys (left) and high resolution bathymetric surveys with Airborne Hydromapping coupled with sonar technics (right).

Airborne Hydromapping survey campaigns result in a comprehensive database, which consists of the original point cloud, the classified point cloud, digital elevation models, numerical meshes and abundant additional information (areal images, thermal data, etc.). The data analysis and visualization is done with the software HydroVish (see Fig. 2), which is a highly efficient software package to handle very huge data sets (larger than a billion points, Benger et al., 2007).

Figure 2: example of a bathymetric terrain model generated on basis of Hydromapping data (visualization with HydroVISH)

2.2 Data quality

In order to calibrate Hydromapping scan data, an additional terrestrial survey of reference points is carried out in a project area. The reference points are defined for example by the outer corners of roofs, or crosswalks on streets and are selected subsequently to the survey flight from the data set. The position of the reference points are then determined using GPS.

Usually, a data set consists of several scan stripes with a large overlap of often more than 50% among the stripes. The stripes need to be aligned to each other due to a slight offset between the stripes. The accuracy of the strip adjustment is usually in the range of 10 cm (standard deviation). Furthermore, the entire point cloud is georeferenced with an accuracy in the order of 8 cm (standard deviation; e.g. Dobler et al. 2013) using the above mentioned reference points.

3. Habitat investigations

Physical habitat models are used successfully as assessment tools of the ecological status of running waters. Structural and hydraulic characteristics are analysed and compared to reference values (e.g. water depths, flow velocities, substrate, Schneider, 2001). In discrete points the habitat suitability of target species is calculated with the help of expert knowledge (e.g. fuzzy rules or preference curves) and the overall habitat availability is calculated as integral value in form of the weighted usable area (WUA):

$$WUA = \sum_{i=1}^{n} HSI_i \cdot A_i \quad (1)$$

with

n = amount of calculation cells (–)

HSI_i = habitat suitability index (–)

A_i = area of the calculation cell (m^2).

The basis of physical habitat modelling is the detailed knowledge of the riverbed geometry and the associated hydraulic conditions in the river. Thereby the precision and resolution of the basic survey plays an important role in the habitat analysis (Hauer et al., 2009). For example, shallow water areas with low flow velocities are important habitats for juvenile fish. However, with interpolated cross section data it is difficult to depict these areas.

Additionally, dead wood structures and overhanging vegetation is important for fish serving as hiding and rest places. These structures can also be captured by Airborne Hydromapping data and analysed for habitat investigations.

The data generated by Airborne Hydromapping are used to create detailed, high-resolution calculation meshes and are therefore capable to accurately describe the hydraulic conditions in large river reaches. It can be used in both, small-scale and large-scale contexts and also opens new avenues for monitoring applications.

Based on a data set acquired in an alpine river in South Tyrol it was shown that 2D hydraulic models are capable to resolve complex and small scale flow patterns like horizontal eddys and backflows. In contrast to cross section based data these patterns can be depicted with high resolution bathymetric data and furthermore analysed in habitat investigations (see Fig. 3). These differences in results of hydraulic models have an effect on the calculation of the weighted usable areas and thereby influence on the results of habitat models.

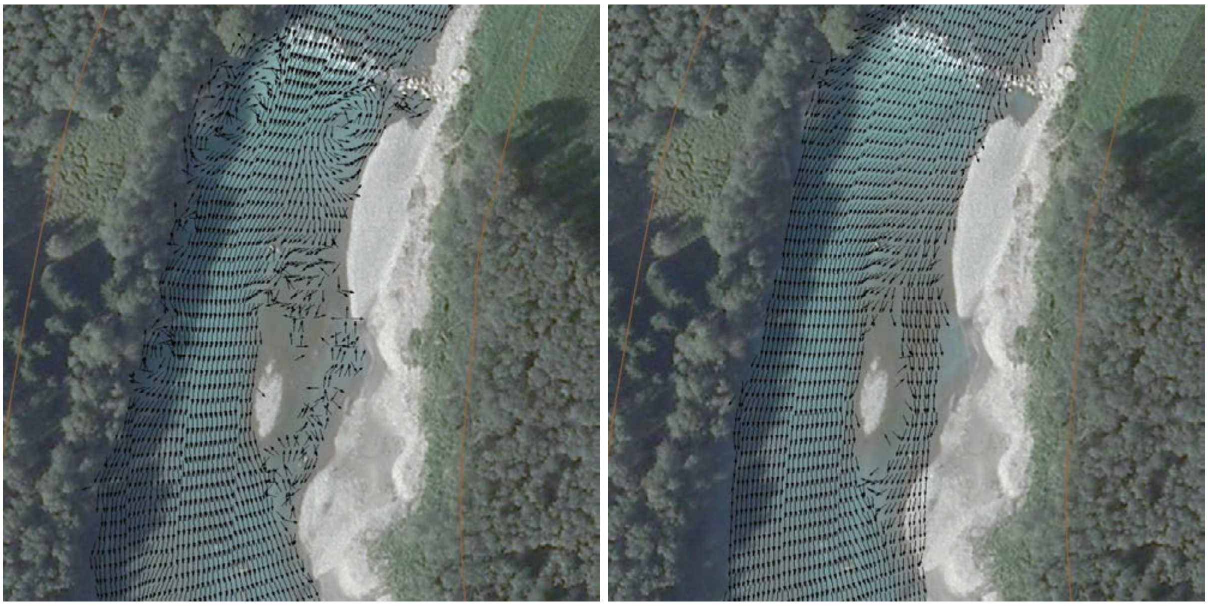

Figure 3: results of 2D hydraulic modelling; left, calculation mesh based on high resolution survey data showing horizontal eddys and backflow patterns; right, calculation mesh based on cross section data not showing eddys and backflow patterns

A further advantage of the airborne strategy is the possibility of large scale data acquisition of investigation areas. In contrast to rather short representative reaches, whole river sections up to several kilometers can be surveyed in high resolution. With a penetration depth of up to 10 m alpine and gravel bed rivers can be surveyed comprehensively that way.

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