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Combining UAS LiDAR, sonar and radar altimetry for river hydraulic characterization

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Hydraulic characterization of river reaches is fundamental for flood risk assessment and flood forecasting. Hydraulic models can translate discharge into water levels, with measurements of river topography, water level and hydraulic roughness. Traditionally, these measurements are taken with in-situ surveys that are normally costly and time consuming when large or spatially distributed datasets are required, and difficult to retrieve in some locations. Remote sensing solutions have been widely used in the last years to measure inland water topography and water levels, reducing the time and cost of traditional surveys. Satellite earth observations can measure inland water bodies with high temporal and spatial frequency, but they only work in large rivers, can have limited accuracy and cannot measure the submerged portion of the river. UAS techniques offer high-resolution measurements of river topography, including river bathymetry and water level in medium-sized streams that are too big to wade through, offering a good opportunity to recover a full river hydraulic characterization.

UAS techniques have been widely used in hydrologic surveys, especially in smaller streams where satellite-based solutions are unfeasible due to the measurement sparsity. In addition, these techniques are very versatile, offering different types of measurements depending on the payload attached to the airborne system. River bathymetry can be retrieved using sonar or water penetrating radar (WPR), which provides depth measurements that, combined with water level measurements, can be used to calculate bathymetry. Moreover, land elevation can be measured with a LiDAR payload, providing topographic information on the river edges and adjacent floodplains. Radar altimeters can also provide water level measurements at a very high spatial resolution and accuracy. These data-sets can be used together to calibrate hydraulic roughness, which cannot be observed at the scale needed.

In this study, we propose a new UAS data acquisition technique for full hydraulic characterization of a river reach combining sonar bathymetry, LiDAR elevation of the land adjacent to the river and radar water level measurements to calibrate a hydraulic model. The method is demonstrated in a reach of Ryå stream in Jammerbugt, Denmark. This stream has a river width of around 10 meters and is characterized by dense vegetation in the surroundings, with deep areas where it is not

possible to wade through. The bathymetry is observed using a sonar payload that measures depth in contact with water and water level measurements from RTK. The sonar depth is acquired in 1 day with a quasi-continuous UAS flight that measured 54 cross-sections separated by 100 meters. The land elevation is measured using a LiDAR in scanning mode, which gives measurements for 8 km of the river reach in less than half a day. The water level measurements were taken with a radar altimeter payload for 8 km of the river reach. The topographic and water level measurements are used in a hydraulic model to calibrate hydraulic roughness by estimating water levels that are compared with observed water level from radar altimetry.