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A new GNSS-enabled floating device as a means for retrieving river bathymetry by assimilation into a hydrodynamic model

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Hydrodynamic models form an important component in flood forecasting systems. Model predictions with reduced uncertainty critically depend on the availability of detailed information about floodplain topography and riverbed bathymetry. While digital elevation models with varying spatial resolutions and accuracy levels are readily available at a global scale and can be used to infer floodplain geometry, bathymetric data is often not available and ground surveys are time and resource intensive. In this general context, our study aims at evaluating the hydrometric value of the Global Navigation Satellite System (GNSS) for bathymetry retrieval. Integrated with satellite telecommunication systems, drifting or anchored floaters equipped with navigation systems such as GPS and Galileo, enable the quasi-continuous measurement and near real-time transmission of water levels and flow velocities, virtually from any point in the world. The presented study investigates the potential of assimilating GNSS-derived water level measurements into a hydraulic model in order to estimate river bathymetry.

First, an ensemble of possible bathymetries and roughness parameters was randomly generated using a Monte-Carlo sampling approach. Next, water level measurements provided by a drifting GNSS-equipped buoy were assimilated into a hydrodynamic model using as input a recorded discharge hydrograph and as geometry the generated bathymetry ensemble. Synthetic experiments were carried out with a one-dimensional hydraulic model implemented over a 19 km reach of the Alzette River. A Particle Filter was used as an assimilation algorithm for integrating observation data into the hydraulic model. The synthetic observation, simulating the data obtained from GNSS measurements, was generated using a perturbed forward run of the hydrodynamic model using the true bathymetry (ground survey). The scenario adopted in the data assimilation experiment assumed that during a flood event, a buoy was launched into the water every ten hours. This frequency was considered plausible as the time needed for the buoy to drift from the upstream to the downstream end of the study area is estimated to be less than 6 h. Consequently, a time window of 10 h would allow an operator to launch the buoy at the upstream end, recover it at the downstream end and finally drive back to the upstream end and launch it again into the river channel.This synthetic observation was then assimilated into the hydraulic model. The first results were promising as sequentially assimilating the water level values provided by the synthetic GNSS-equipped buoy allowed gradually rejecting wrong bathymetries and converging toward bathymetries that are consistent with the ground surveyed one.