EGU2020-4229
https://doi.org/10.5194/egusphere-egu2020-4229
EGU General Assembly 2020

A drone-borne contactless method to jointly estimate discharge and Manning's roughness in rivers

Filippo Bandini[1], Beat Lüthi[2], Salvador Peña-Haro[2], and Peter Bauer-Gottwein[1]
[1]DTU Environment, Technical University of Denmark, Lyngby, Denmark (fban@env.dtu.dk)
[2]Photrack AG: Flow Measurements, Zürich, Switzerland

Unmanned Aerial Systems (UASs) can monitor streams and rivers also in remote, inaccessible locations during extreme hydrological events. Image cross-correlation analysis techniques, such as Particle Image Velocimetry (PIV), applied to videos acquired using UASs can provide estimates of water surface velocity (WSV) in rivers. However, estimation of discharge from WSV is not trivial: it requires water depth and the mean vertical velocity (U_m). Scientific studies show that U_m is generally between 70% and 90% of WSV; however, an accurate estimation of U_m from WSV requires assumptions on the full vertical velocity profile. We developed a new method for estimating WSV applying PIV techniques on UAS-borne videos. This method does not require any Ground Control Point (GCP), because the conversion of the velocity field from pixels into meters is performed by using a camera pinhole model where the distance from the pin-hole to the water surface is measured by an on-board radar altimeter. For approximately uniform flow conditions, U_m becomes a function of Gauckler–Manning–Strickler roughness coefficient (Ks) and WSV. Our method can be used to jointly estimate Ks and discharge by informing a non-linear system of 2 equations and 2 unknowns (Ks and discharge): i) Manning equation ii) mid-section method equation for computing discharge from U_m, which is a function of WSV and ks. This approach merely relies on bathymetry knowledge, on UAV-borne measurements of WSV and water surface slope. Our approach was extensively validated in 27 case studies, in multiple Danish streams with different hydraulic conditions. Compared to discharge measured with a multi-depth electromagnetic velocity probe, PIV-estimates of discharge showed a mean absolute error of 18% and a mean bias error of -9%. The underestimation of discharge is caused by inaccuracies in WSV, by deviations from the uniform flow assumption and by the assumption of constant Ks coefficient for the entire cross section.