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Unmanned Aerial Vehicle observations of water surface elevation, depth and surface velocity

Unmanned Aerial Vehicles and hydraulics

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Unmanned Aerial Vehicles (UAVs) can provide accurate hydraulic observations with high spatial resolution and timely delivery. UAV-borne observations are a new dataset in hydrology that will be essential in areas not covered by the existing in-situ gauging network, especially for monitoring of remote and hard-to-access inland water bodies. UAV can obtain observations of: i) water surface elevation (WSE), ii) water depth and bathymetry, and iii) surface water speed of inland water bodies.

WSE can be measured from UAVs with a radar system and a GNSS (Global Navigation Satellite System) receiver, without need for Ground Control Points (GCPs) [1]. The GNSS receiver measures the altitude above mean sea level, while the radar measures the range to the water surface. The WSE is then computed subtracting the range measured by the radar from the GNSS-derived altitude. Compared to satellites, UAVs have several advantages: high accuracy and spatial resolution, mission repeatability, flexible flight routes, and accuracy better than 7-10 cm.

Water depths (and bathymetry) can be measured with a tethered sonar dragged by the UAV. We achieved an accuracy of ca. 2.1% of the actual depth with this system, with a maximum depth capability potentially up to 80 m [2]. Since other remote sensing techniques (e.g. LIDARs, through-water photogrammetry, spectral-depth signature of multispectral imagery) can survey water depths only up to a few decimeters (maximum 1-1.5 m), our technology has a maximum depth capability and an applicability range superior to other remote sensing techniques.

Surface water speed can be measured from UAVs using LSPIV (Large Scale Particle Image Velocimetry) [3] [4] [5] [6]. New LSPIV methods [7] [8] have been developed to estimate water flow by focusing only on natural tracers, such as foam, ripples generated by turbulence and differences in water color created by sediments or suspended solids. These new methods overcome the requirement for artificially seeding the water surface.

Combining UAV-borne water depth and surface velocity observations will enable the estimation of river discharge. UAV-borne hydraulic observations of discharge and WSE, retrieved in different hydrological conditions and at different time points, can be used to construct rating curves and, in combination with satellite radar altimetry data, can complement in-situ river gauging stations.

References

[1] Bandini, F., Jakobsen, J., Olesen, D., Reyna-Gutierrez, J. A. and Bauer-Gottwein, P.: Measuring water level in rivers and lakes from lightweight Unmanned Aerial Vehicles, J. Hydrol., 548, 237–250, doi:10.1016/j.jhydrol.2017.02.038, 2017.

[2] Bandini, F., Olesen, D., Jakobsen, J., Kittel, C.M.M., Wang, S., Garcia, M., and Bauer-Gottwein, P.. Bathymetry observations of inland water bodies using a tethered single-beam sonar controlled by an Unmanned Aerial Vehicle, Hess, https://doi.org/10.5194/hess-2017-625, 2017.

[3] Bolognesi, M., Farina, G., Alvisi, S., Franchini, M., Pellegrinelli, A. and Russo, P.: Measurement of surface velocity in open channels using a lightweight remotely piloted aircraft system, Geomatics, Nat. Hazards risk, 5705(October), doi:10.1080/19475705.2016.1184717, 2016.

[4] Detert, M. and Weitbrecht, V.: A low-cost airborne velocimetry system: proof of concept, J. Hydraul. Res., 53(4), 532–539, doi:10.1080/00221686.2015.1054322, 2015.

[5] Tauro, F., Petroselli, A. and Arcangeletti, E.: Assessment of drone-based surface flow observations, Hydrol. Process., 30(7), 1114–1130, doi:10.1002/hyp.10698, 2015.

[6] Tauro, F., Porfiri, M. and Grimaldi, S.: Surface flow measurements from drones, J. Hydrol., 540, 240–245, doi:10.1016/j.jhydrol.2016.06.012, 2016.

[7] Lüthi, B., Philippe, T. and Peña-Haro, S.: Mobile device app for small open-channel flow measurement, in 7th Intl. Congress on Env. Modelling and Software, vol. 1, pp. 283–287, 2014.

[8] Philippe, T., Luethi, B. and Peña-Haro, S.: Mesure optique, et non-intrusive du débit des cours d'eau: quand le smartphone se transforme en débitmètre, in Hydrométrie 2017, Lyon, SHF., 2017.