



## **An approach to physical rating curve development in remote rivers through UAV imagery**

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Unmanned Aerial Vehicles (UAV), close-to-ground camera, and satellite data have rapidly become a revelation for water resources management as a low-cost, accurate, safe and convenient data collection method. Although applications of UAVs, camera and satellite observations for monitoring rivers have been established, reconciling these to estimate river flows is an avenue not yet pursued. This paper sets forth research requirements that will lead to a framework for remote river flow observations, suitable for rivers that are difficult to access frequently, and difficult to equip with permanent water-borne instruments and applicable with small financial resources. We argue that remote river flow observations entail three major components: 1) Establishment of the river's geometric behaviour, i.e. rating curves between flows, and proxies for flow such as surface velocities, flow depth and width; 2) reconciliation of ground observations with what satellite proxies can see; and 3) comprehensive analysis of the social and legal implication of using UAVs. We demonstrate that the first component can be achieved through a combination of low-cost UAV geometry observations and hydraulic modelling and that recommendations on flight parameters and photogrammetric treatments are needed. The second can be achieved through comparison of snapshots of the surface velocity and width of the river and satellite observations during overpasses. The third requires a contextual understanding of legal and social requirements that have to be met to use remote platforms such as UAVs. Multiple missions can be considered including passive microwave remote sensing and optical remote sensing. We recommend what investigations are needed to establish a sound remote observation method in the forthcoming years.