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Photogrammetric discharge monitoring of small tropical mountain rivers - A case study at Rivière des Pluies, Réunion island

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Reliable discharge measurements are indispensable for an effective management of natural water resources and floods. Limitations of classical current meter profiling and stage-discharge ratings have stimulated the development of more accurate and efficient gauging techniques. While new discharge measurements technologies such as acoustic doppler current profilers and large-scale image particle velocimetry (LSPIV) have been developed and tested in numerous studies, the continuous monitoring of small mountain rivers and discharge dynamics during strong meteorological events remains challenging. More specifically LSPIV studies are often focused on short-term measurements during flood events and there are still very few studies that address its use for long-term monitoring of small mountain rivers.

To fill this gap this study targets the development and testing of largely autonomous photogrammetric discharge measurement system with a special focus on the application to small mountain river with high discharge variability and a mobile riverbed in the tropics. It proposes several enhancements among previous LSPIV methods regarding camera calibration, more efficient processing in image geometry, the automatic detection of the water level as well as the statistical calibration and estimation of the discharge from multiple profiles. To account for changes in the bed topography the riverbed is surveyed repeatedly during the dry seasons using multi-view photogrammetry or terrestrial laser scanners.

The presented case study comprises the analysis of several thousand videos spanning over two and a half year (2013-2015) to test the robustness and accuracy of different processing steps. An analysis of the obtained results suggests that the quality of the camera calibration reaches a sub-pixel accuracy. The median accuracy of the watermask detections is F1=0.82, whereas the precision is systematically higher than the recall. The resulting underestimation of the water surface area and level leads to a systematic underestimation of the discharge and error rates of up to 25 %. However, the bias can be effectively removed using a least-square cross-calibration which reduces the error to a MAE of 6.39% and a maximum error of 16.18%. Those error rates are significantly lower than the uncertainties among multiple profiles (30%) and illustrate the importance of the spatial averaging from multiple measurements.

The study suggests that LSPIV can already be considered as a valuable tool for the monitoring of torrential flows, whereas further research is still needed to fully integrate night-time observation and stereo-photogrammetric capabilities.