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An innovative experimental setup for Large Scale Particle Image Velocimetry measurements in riverine environments

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Large Scale Particle Image Velocimetry (LSPIV) is a powerful methodology to nonintrusively monitor surface flows. Its use has been beneficial to the development of rating curves in riverine environments and to map geomorphic features in natural waterways. Typical LSPIV experimental setups rely on the use of mast-mounted cameras for the acquisition of natural stream reaches. Such cameras are installed on stream banks and are angled with respect to the water surface to capture large scale fields of view. Despite its promise and the simplicity of the setup, the practical implementation of LSPIV is affected by several challenges, including the acquisition of ground reference points for image calibration and time-consuming and highly user-assisted procedures to orthorectify images. In this work, we perform LSPIV studies on stream sections in the Aniene and Tiber basins, Italy. To alleviate the limitations of traditional LSPIV implementations, we propose an improved video acquisition setup comprising a telescopic, an inexpensive GoPro Hero 3 video camera, and a system of two lasers. The setup allows for maintaining the camera axis perpendicular to the water surface, thus mitigating uncertainties related to image orthorectification. Further, the mast encases a laser system for remote image calibration, thus allowing for nonintrusively calibrating videos without acquiring ground reference points. We conduct measurements on two different water bodies to outline the performance of the methodology in case of varying flow regimes, illumination conditions, and distribution of surface tracers. Specifically, the Aniene river is characterized by high surface flow velocity, the presence of abundant, homogeneously distributed ripples and water reflections, and a meagre number of buoyant tracers. On the other hand, the Tiber river presents lower surface flows, isolated reflections, and several floating objects. Videos are processed through image-based analyses to correct for lens distortions and analyzed with a commercially available PIV software. Surface flow velocity estimates are compared to supervised measurements performed by visually tracking objects floating on the stream surface and to rating curves developed by the Ufficio Idrografico e Mareografico (UIM) at Regione Lazio, Italy.
Experimental findings demonstrate that the presence of tracers is crucial for surface flow velocity estimates. Further, considering surface ripples and patterns may lead to underestimations in LSPIV analyses.