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Numerical experiments for defining criteria for the use of LS-PIV based techniques in river monitoring

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The developing of new image-based techniques for environmental monitoring is opening new frontiers for remote streamflow measurements in natural environments, since they allow for non-intrusive measurements even in adverse circumstances, such as high flow conditions that often hinder the use of traditional approaches and instruments. Methods based on the acquisition, analysis and elaboration of images for streamflow observation, such as the large scale particle image velocimetry (LSPIV) and the particle tracking velocimetry (PTV) techniques, are rapidly evolving also in consideration of the growing availability of a new generation of optical sensors, digital cameras and methodologies. A number of free and easy software based on LSPIV and PTV allows for a complete characterization of the instantaneous surface velocity field of a river and the assessment of the discharge at specific cross-sections, when the cross-section geometry is known.
This kind of software usually requires a sequence of images that can be captured by digital cameras, which can be permanent gauge-cams installed close to the river, mobile-devices with operators standing on the banks or on bridges, or even cams installed on unmanned aerial vehicle (UAV). Despite the great accessibility of cost-effective devices and the simplicity of the free availability of software for image processing, LSPIV and PTV techniques are rarely systematically implemented in practical applications, probably due to the lack of consistent image processing protocols.
In this work the performance and the sensitivity of free software based on LSPIV to some factors, such as the seeding density, the frame to frame displacement of tracer, the number of elaborated frames, tracers geometry, are analyzed. In particular, difference sequences of images with known tracers (in size and density) moving at know velocity are created under different configurations (i.e. considering different combinations of the above mentioned factors) and the error in the evaluation of the instantaneous surface velocity field is assessed for each configuration. The different configurations are created considering three possible schemes: ideal (tracers constituted by white disks of equal size and uniformly distributed on a black background), semi-real (tracers constituted by disks of equal size, colored by a white color disturbed by a white noise, and uniformly distributed on a real background), real (real tracers on a real background). Real images, captured by a cam installed on UAV flying on a real river, have been used for the generation of the image-sequences generation under the schemes semi-real and real. Results can be considered extremely useful in defining criteria for guidelines for practical real applications.