Estimating flood discharge using witness movies in post-flood hydrological surveys

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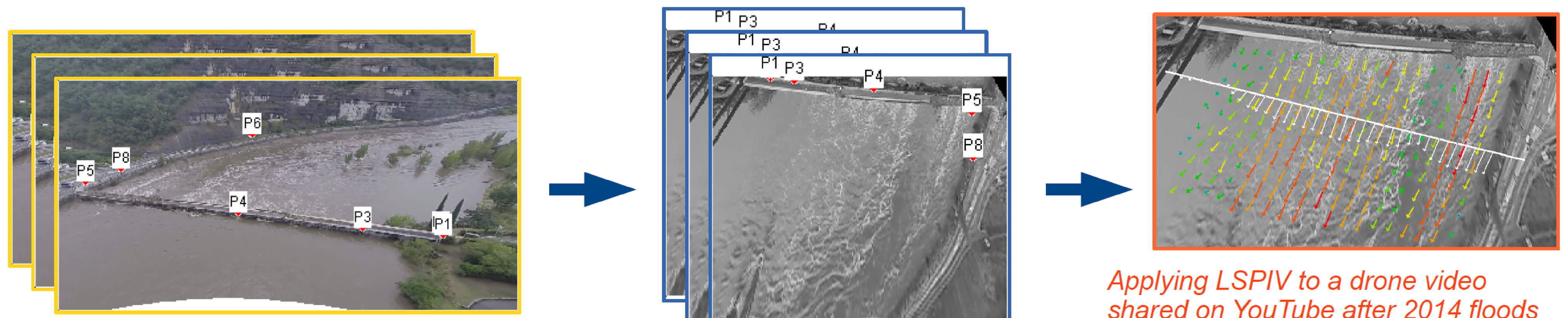
Measuring flood discharges: a challenge

The knowledge of river discharges during extreme hydrological events is of prime importance for applications such as structure design, risk management or hydrological modelling.
Unfortunately, measuring discharge using conventional methods, such as current-meters or acoustic profilers, is often impossible during floods because:

- High velocities and floating debris endanger the operators and the equipment;
- Flash-floods are highly unsteady and are difficult to capture;
- Floods are meso-scale events that generally affect several watersheds simultaneously, and gauging teams do not have the capabilities for covering the whole region of interest.

Large-Scale Particle Image Velocimetry

LSPIV, a non intrusive image based analysis, showed its efficiency for measuring surface velocity and discharge in streams, especially during extreme events [1]. LSPIV encompasses 4 steps: (i) **recording of a sequence of images**, knowing the time interval between image pairs; (ii) **orthorectification of the images**, to correct perspective distortion effects and to georeference pixels, based on the topography survey of ground reference points; (iii) **cross-correlation analysis** of image pairs to determine the displacement of visible flow tracers such as boils, ripples, vegetation debris, etc. and (iv) **discharge computation** based on a cross-sectional profile and a surface to depth-averaged velocity ratio.

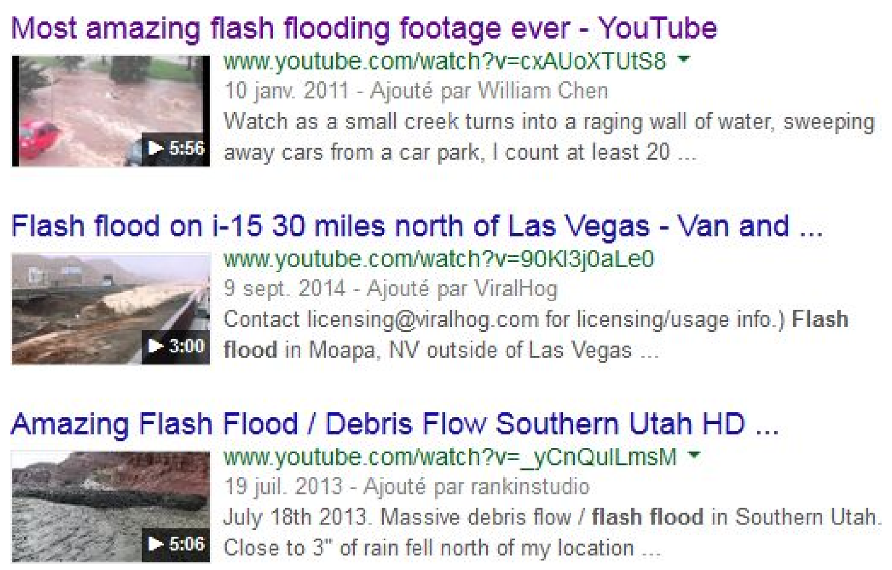


Applying LSPIV to a drone video shared on YouTube after 2014 floods in the Ardèche River, France

Nevertheless, LSPIV needs to be deployed by trained operators, and the aforementioned problems of time-scale and space-scale covering are not solved.

Flood videos galore in the Internet!

Floods are important events for people living in the vicinity of the impacted rivers. Witnesses often record high quality videos of those events and share their images through **video sharing platforms** in the Internet. Searching "Flood Boulder 2013" and "Flood Brisbane 2011" on YouTube yields 65 000 and 43 000 results, respectively. Interestingly, **air-borne and drone movies** are increasingly made available by flood observers.
Very recently, LSPIV [2] and an alternative image velocimetry technique [3] were applied to the estimation of discharges after flash flood events.



References and acknowledgements

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[3] I. Fujita, Y. Kunita, and R. Tsubaki. Image analysis and reconstruction of the 2008 Toga River Flash Flood in an urbanised area. *Australian Journal of Water Resources*, 16(2):12, 2013.

[4] J. Le Coz, M. Jodeau, A. Hauet, B. Marchand, and R. Le Boursicaud. Image-based velocity and discharge measurements in field and laboratory river engineering studies using the free FUDAA-LSPIV software. In *RIVER FLOW 2014*, 1961–1967, 2014.

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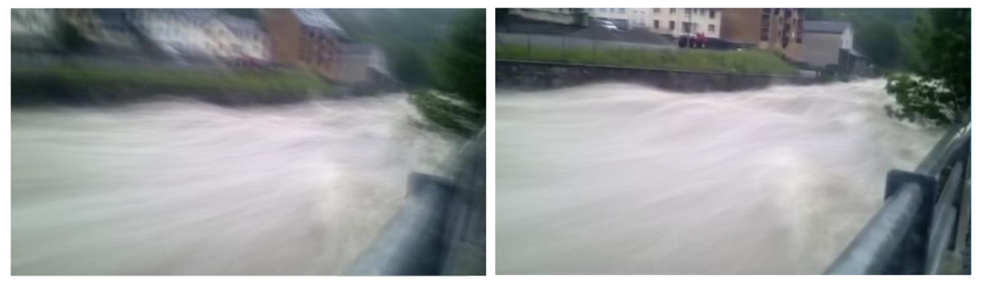
Methods

Flood movies recorded by witnesses do not match the requirements of the traditional LSPIV technique. Using such videos raises several issues:

- **Fixed points** that can be located in the images and in the real world are needed to calibrate the orthorectification;
- **Both river banks** should be visible in the image so that a complete cross-section is monitored;
- The video should be recorded **from a fixed point of view**: a shake movement with limited amplitude is acceptable;
- The **precise location and timing** of the video are necessary;
- Authors of the videos must be contacted in order to get their **personal agreement** for the use of their movie materials and **additional information**.

Using flood home movies therefore requires some **image pre-processing** to be applied before the LSPIV analysis, such as:



Correction of hand-held camera movement: image alignment

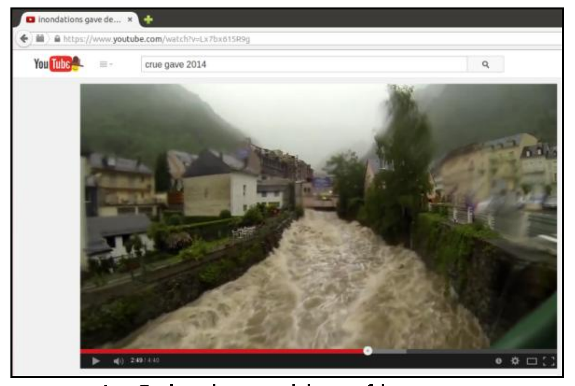
Correction of distortion due to non rectilinear camera lenses

Relative positioning of the free-surface

We used a fully reproducible approach, based on free software only. LSPIV analysis was conducted using **Fudaa-LSPIV** [4], a free software available online (https://forge.irstea.fr/projects/fudaa-lspiv/files). Image pre-processing was conducted using **Hugin**.

Case study: Catastrophic flood of June 18th 2013 in the French Pyrenees

On June 18th 2013, catastrophic floods occurred in the French Pyrenees. The floods resulted from the combination of an exceptionally thick snow cover, saturated soils due to a very rainy Spring, and heavy rainfall events. The floods claimed 3 casualties and the economic damage was about 25 million €.
A valuable video of the event, recorded on the Gave de Cauterets at Cauterets was selected on YouTube. The following steps were achieved:



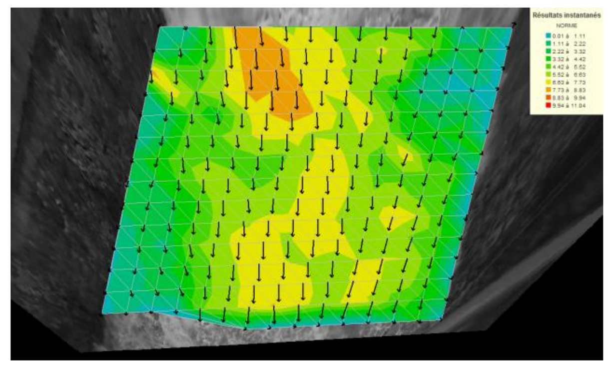
1 : Selecting a video of interest

2 : Contact the author to get agreement
Position of the viewpoint using GoogleMaps

3 : Achieve field topography survey : reference points and bathymetry

4 : Images processing : alignment and correction of lens distortion

5 : Images orthorectification



6 : LSPIV time-averaged surface velocities computed with Fudaa-LSPIV

Discharge estimates computed across 3 different transects show close agreement :

Transect	Discharge	Uncertainty	Difference
1	103 m^3/s	25 %	+5 %
2	94 m^3/s	25 %	-4 %
3	96 m^3/s	25 %	-2 %
Average	98 m^3/s		

The **main uncertainty sources** in the discharge computation are:

- Water stage estimate from the images (about ±20 cm);
- The possible bathymetry changes during the event.

Towards participative research in flood hydrology

This poster illustrates the typical issues and advantages of **applying LSPIV to flood home movies** shared by witnesses for improving post-flood discharge estimation. Locating precisely the video viewpoint is often easy whereas precise timing may be not, especially when the author cannot be contacted. The determination of the water level is the main source of uncertainty in the discharge estimates.

This kind of application opens interesting avenues for participative research in flood hydrology, as well as the study of other extreme geophysical events. Typically, as part of the **FloodScale ANR research project** (2012-2015), specific communication actions have been focused on the determination of flood discharges within the Ardèche river catchment (France) using home movies shared by observers and volunteers. Safety instructions and **a simplified field procedure** were shared through local media and were made available in French and English on the project website (http://floodscale.irstea.fr/). This way, simple flood observers or even some enthusiastic flood chasers can contribute to participative hydrological science.