# Flash-flood monitoring by image analysis in the Ardèche river catchment, France: validation tests and set-up of a distributed observation network

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Jérôme Le Coz[1], Guillaume Dramais[1], Alexandre Hauet[2], Isabelle Braud[1]
[1]Cemagref, Hydrology – Hydraulics Research Unit, Lyon, [2]EDF-DTG, Toulouse. Contact :jerome.lecoz@cemagref.fr

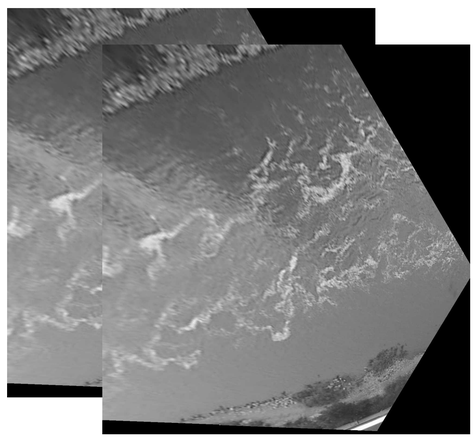
## Motivations

**Flash-floods** result in significant casualties and economic impacts. The understanding of flood generation and propagation processes requires reliable streamflow estimates throughout the river network, in real time. Due to the lack of discharge measurements during extreme floods, the rating curves empirically established at existing gauging stations often must be extrapolated to high flow rates, resulting in large uncertainty levels.

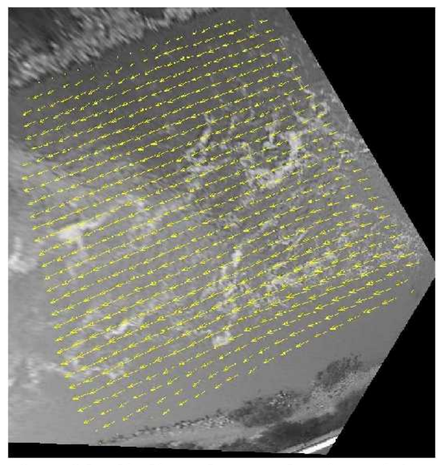
**Emerging remote flow monitoring systems**, e.g. based on image analysis offer promising potential for improving the quality of flash-flood discharge measurements. As part of the set-up of a distributed observation network throughout the Ardèche catchment, validation tests were conducted during recent floods with both mobile and fixed Large-Scale Particle Image Velocimetry (LSPIV) systems.

## Large-Scale Particle Image Velocimetry (LSPIV)

1 – Recording of images of a flow showing **tracers**



2 – **Ortho-rectification** from Ground Reference Points



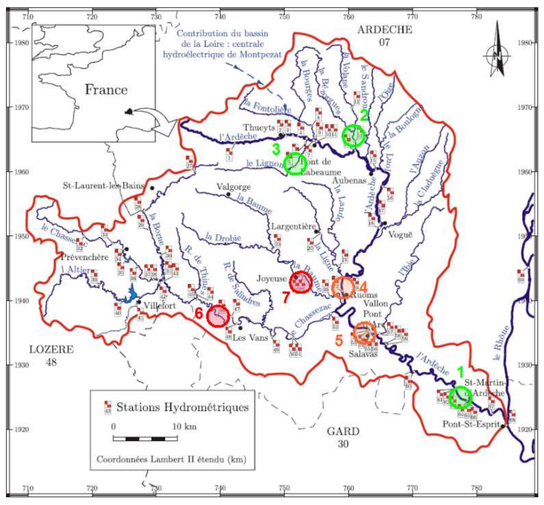
3 – **Statistical analysis** of the tracer displacement field

4 - The free surface velocity associated with river bathymetry and hydraulic assumptions leads to the **discharge estimation**.

## The Ardèche Project

**Distributed observation network:**

**Installation in 2008-2009**
**Planned (2010)**
**Tentative**




Some LSPIV stations are installed at gauging stations operated by the Compagnie Nationale du Rhône (CNR, sites 1 and 5), and the Grand-Delta Flood Forecast Service (SPC-GD, sites 2 and 5).

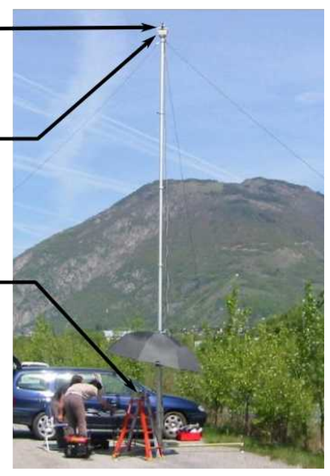
**Hydrological data** at station 1: catchment area 2240 km², mean annual discharge 63 m³/s
Q2=1830 m³/s, Q5=2770 m³/s, Q10=3390 m³/s

## Experimental methods

**Fixed LSPIV station**

(Sauze, site 1, CNR)

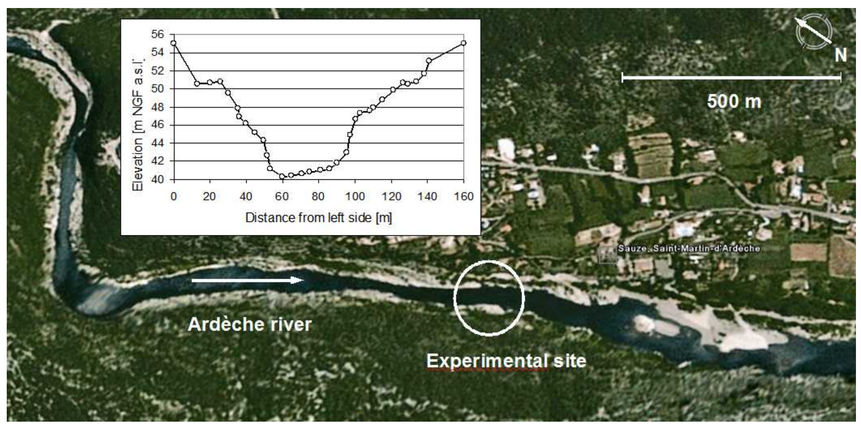
**Mobile LSPIV system**





- 10-m high mast
- ~10 Ground Reference Points

## Results



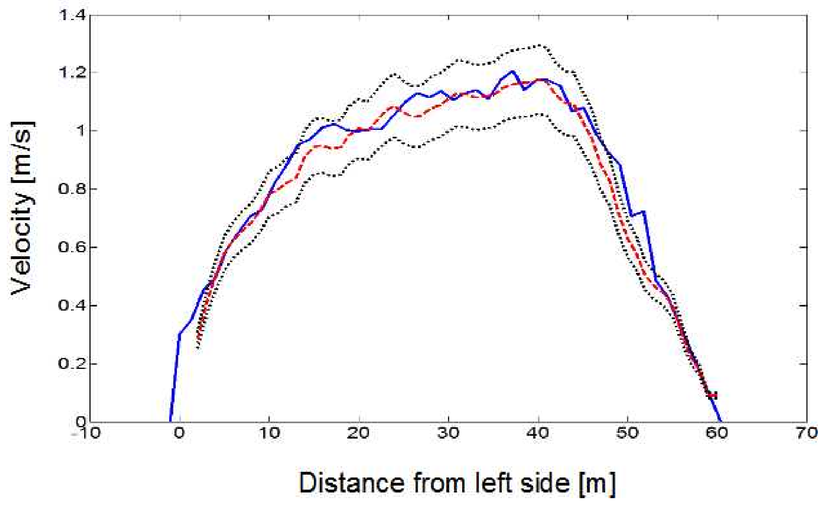

*Aerial view (Google Earth) of the Ardèche river at Sauze-St Martin, and cross-sectional profile used for LSPIV discharge computation.*

**Validation tests** using both mobile and fixed LSPIV systems were conducted at the Sauze-Saint-Martin gauging station (site 1), for discharges ranging from 300 m³/s to 2500 m³/s, i.e. for mean velocities ranging from 1.0 m/s to 2.9m/s.

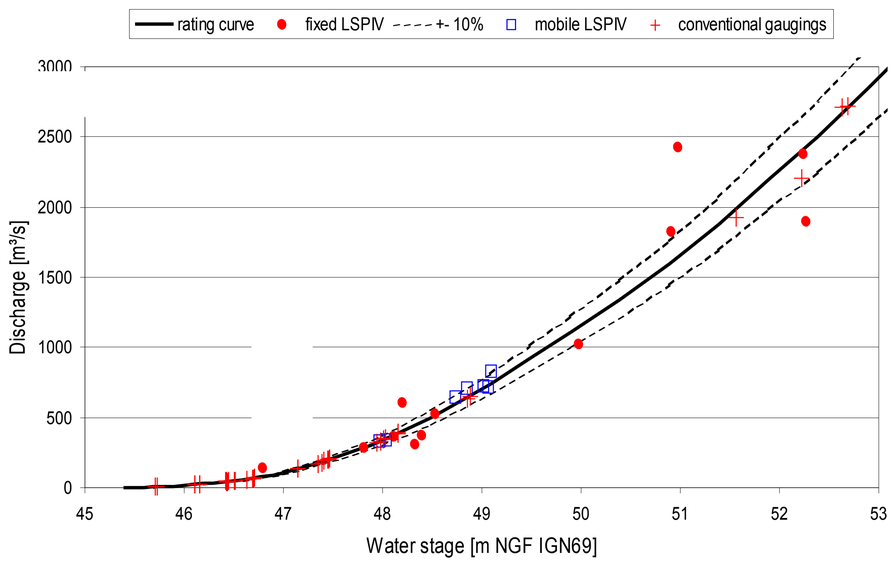
**Hydraulic assumptions:** A mean float coefficient value of 0.90 ±0.10 was derived from available measurements by conventional methods. Missing velocities were computed based on a constant-Froude extrapolation.

**Velocities:** For 300 m³/s, LSPIV velocities throughout the river cross-section were found to be in good agreement (±10%) with concurrent measurements by Doppler profiler (ADCP).

**Discharges:** Mobile and fixed LSPIV discharges usually were in acceptable agreement (<20%) with the rating curve, though some isolated poorer results appeared with the fixed LSPIV tests, potentially due to: some image sequences with poor quality, external conditions or instrumental limitations; insufficient number of averaged image pairs, significant discharge variations, float coefficient variability or inaccuracy of the constant-Froude extrapolation.




*Comparison of depth-averaged velocities obtained with aDcp and LSPIV*




*Comparison of mobile/fixed LSPIV discharge measurements with the rating curve and conventional gaugings (ADCP/current meter)*

## Conclusions

The LSPIV technique is well suited for monitoring flash-flood continuously and in real-time. Tested mobile and fixed LSPIV discharges usually were in acceptable agreement (<20%) with the rating curve, though some problems still have to be solved for validating continuous measurements with the fixed LSPIV system. Improvement perspectives should aim at reducing the errors, and defining criteria for discarding improper image pairs.
The non-intrusive aspect of LSPIV allows measurements during extreme floods, and so reduce the extrapolated range of the existing rating curves. The distributed LSPIV network will be expanded and exploited throughout the Ardèche catchment over 2009-2010 and later.