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A methodology for hydrological post-flash flood field investigations

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Abstract :

Post event survey and investigation is one way to gain experience on natural hazards. The importance of the systematisation and standardisation of such investigations and re-analysis is progressively recognised in all the geophysical sciences as shown by the growing number of scientific papers and programs on the subject. Large research efforts have been made on the analysis and modelling of the meteorological aspects of the flash-flood triggering storms (c.f. the proceedings of Plinius conferences on Mediterranean storms) or on landslides and concentrated flows. In comparison, the analysis of the dynamics of the runoff processes during flash-floods is still at its infancy.

Most of the existing reports on flash-floods are restricted to measured point rainfall intensities and some peak discharge estimates, generally for gauged river cross-sections. But recent works have demonstrated that additional valuable data can be gathered after major flood events even on ungauged watersheds. These data, mainly peak discharge estimates based on flood marks and sometimes on films and partial time sequences of floods based on witnesses' interviews, can be used in combination with rainfall estimates to analyse the dynamics of the rainfall-runoff processes on the affected watersheds. This opens new perspectives: with the help of the Radar rainfall estimations it is possible to analyse the flash-floods wherever they occur and not only on well gauged watersheds at the appropriate time and space scales.

A first attempt to formalize a post-flood field investigation procedure will be presented. The proposed approach has been developed within the European FLOODSITE research project. The method has been tested at the national scale for the purpose of the Gard 2002 post flood investigation: 18 hydrologists from 8 different institutions were involved. The European research project HYDRATE (2006-2008) will give the opportunity to test it on further case studies with international teams.

I. Methodological aspects:

1) Cross-section surveys and peak discharge estimates

Large floods leave many marks (vegetation debris, silt or fuel marks on walls) indicating the maximum level reached by the water. These flood marks and the corresponding river cross sections can be surveyed after a flood as illustrated in figure 1. Peak discharges can be estimated on the basis of these surveyed cross-sections using hydraulic models or simplified hydraulic relations like the Manning Strickler formula. This help to evaluate the magnitude of the flood on ungauged watersheds or sub-areas of a watershed. It is also a necessity to map the discharges on a watershed and to identify the major contributing areas to the considered flood.

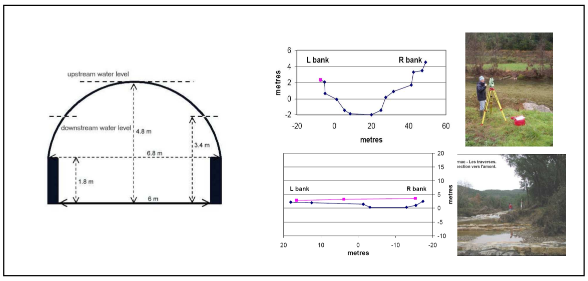


Figure 1: Example of surveyed river cross-sections (blue) and high-water marks (purple) after the 2002 Gard floods

2) Valuation of other clues

Not only flood marks but also other types of clues can be used, especially to evaluate the power of the flow and the water velocities as for instance pictures and films taken by eye-witnesses or erosion clues (see figure 2)

Super-elevation in front of an obstacle
application of the Bernoulli formula
2.5 m/s < V < 3 m/s

River bed particle size
application of a bed load formula
3 m/s < V < 4 m/s

Figure 2: Illustration of clues used to evaluate flow velocities

3) Information on the timing of the floods

Elements concerning the timing of the flood can be delivered by eyewitnesses on ungauged watersheds (see table 1).

n°	Stream name and location	Watershed area (km²)	Peak discharge (m³s⁻¹)	Peak specific discharge (m³ s⁻¹ km⁻²)	Time of first Peak (UTC)	Time of second peak (UTC)
1	Aigalade, Pondre	42	250	6	1500, 08/09	1100, 09/09
2	Brestalou, Brouzet-les-Quissac	88	500	5.5	2100, 08/09	0800, 09/09
3	Courme, Montmirat	38	650	17	1700, 08/09	1000, 09/09
4	Crieulon, la Rouvière	95	1400	15	2300, 08/09	0800, 09/09
5	Vidourle, Conqueyrac	83	600	7	0000, 09/09	0600, 09/09
6	Rieumassel, Ceyrac	45	500	11	2100, 08/09	0900, 09/09
7	Galeizon	85	1200	14	0600, 09/09	
8	Gardon de Mialet, Saint Etienne	84	400	5	0400, 09/09	
9	Gardon de Saint Jean, Saumane	67	500	7.5	0600, 09/09	
10	Amous, Générargues	21	400	19	0400, 09/09	
11	Alzon, Saint Jean du Pin	15	450	30	0500, 09/09	
12	Ourne, Tornac	11	300	27	2300, 08/09	0600, 09/09
13	Avène, Saint Hilaire de Brethmas	57	600	10.5	0300, 09/09	0500, 09/09
14	Droude, Brignon	99	1200	12	2200, 08/09	0900, 09/09
15	Bourdic, Bourdic	39	500	13	2200, 08/09	1000, 09/09
16	Alzon, Uzès	76	250	3	2200, 08/09	1000, 09/09
17	Auzonnet, Les Mages	46	450	10	0600, 09/08	

Table 1: Occurrence time of peak discharge according to the eyewitnesses for the various tributaries of the Gard and Vidourle rivers (2002 flood). See figure 3 for the location of the tributaries.

II. Some results:

1) Peak discharge estimates and spatial repartition

The specific peak discharge of almost all the tributaries of the Gard and Vidourle rivers appear to have exceeded 5 m³/s/km². This spatial extension of the September 2002 floods explains the extraordinary peak discharge values of the Vidourle river at Sommières (about 3000 m³/s for 800 km²) and the Gard river at Remoulins (about 5500 m³/s for 2000 km²). The repartition of the specific discharges appears coherent with the spatial repartition of the total rainfall amounts. More detailed analysis of the data available on the tributaries, not shown here, revealed nevertheless a variety of rainfall-runoff dynamics apparently explained by the geology of the watersheds.

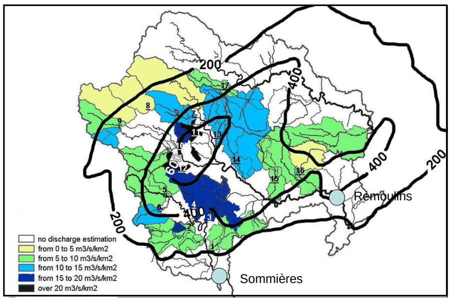


Figure 3: Peak discharge estimated for the various tributaries of the Gard and Vidourle rivers during the 2002 flood event.

2) Timing of the flood

The information on the timing of the Gard river tributaries reveals that the shape of the downstream hydrograph at Remoulins is mainly due to the transfer process in the main river channel. The flood expansion in the large floodplain (Gardonenque) located in the second third of this channel has slowed down the flood propagation: this explains the ten-hour duration of the flood in Remoulins. It has, as a consequence, also reduced significantly the downstream peak discharge.

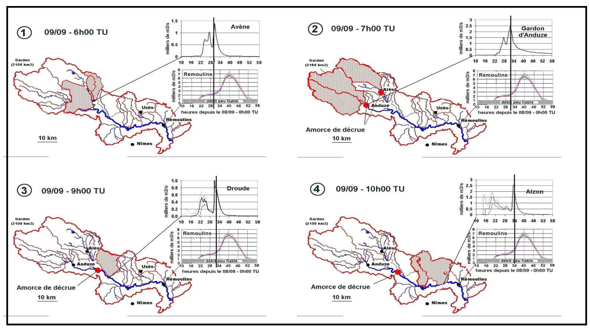
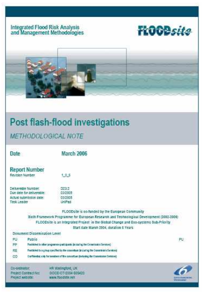


Figure 4: tReconstructiion of the time sequence of the 2002 Gard river flood, the tributaries where the peak discharge occurs appear in grey

III. Conclusion

The post-flash flood field investigation methodology as well as the results of previous post-flood studies are presented in more details in a report published within the European research project FLOODSITE. This report is available, on demand, from the first author of this poster. The proposed methodology will be further tested during the European research project HYDRATE.



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