Collection and valuation of information on past historical flash floods

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Abstract :

The results of an investigation on historical floods in four watersheds of the Aude region in France will be presented. Using both, archive documents and field investigations, the discharges of the main historical floods could be estimated for a period ranging from one to two centuries.

The use of this data, in addition to systematic discharge measurements (continuous series of about 30 years in each case) shows that the calibration of the standard Gumbel and EVII statistical distributions is highly modified by using historical data, despite of the poor accuracy of discharge estimations for historical floods. In other words, the historical perspective modifies completely the hydrological risk perception on these watersheds.

In some cases, it is also possible, with a simple test using historical data, to exclude a type of statistical distribution (Gumbel in the presented case) which is not adapted to represent both historical and systematic data samples. Lastly, the historical data gathered highlights important differences in flood intensities among the four studied watersheds, differences that seem not to be explained by variations of the meteorological hazard only.

I. Methodological aspects:

1) Position of the problem

Series of measured discharges generally do not exceed 20 to 30 years on small watersheds, if they exist. This is too short to estimate accurately the 100-year return period peak discharge (Q100) needed for dimensioning purposes or flood prevention plans. The peak discharge estimation appears to be highly sensitive to sampling fluctuation and to the choice of a statistical distribution type (see figure 1). Extending the duration of the discharge series used to calibrate this discharge distribution is one way to reduce this high uncertainty.

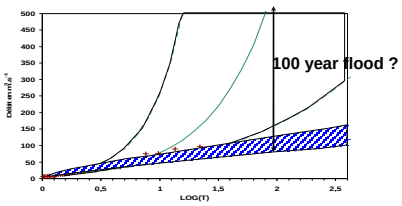


Figure 1: Calibrated Gumbel (EV I) and Frechet (EV II) distributions on a series of 25 years of maximum annual peak discharges and 90% credibility intervals : Clamoux river (Aude region, France).

2) Collation of data on historical floods

An inventory of the existing archive documents on the floods of 4 small tributaries of the Aude river (Clamoux, Orbiel, Salz, Lauquet) has been conducted. About 200 references mainly localized in the Aude departmental archives and in the Aude DDE archives could be retrieved. Peak discharges of the major flood events of the last 150 to 200 years could be estimated on the basis of these documents for the 4 tributaries (see figure 2 for one example).

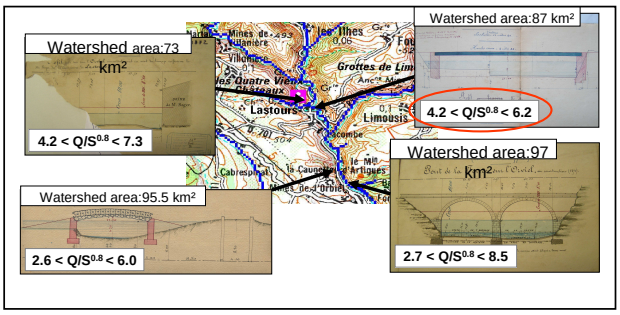
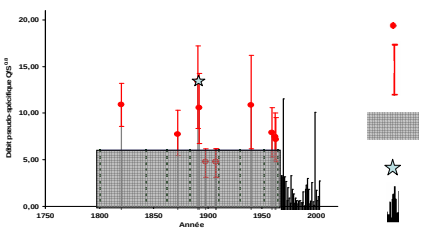


Figure 2: Peak discharge estimations for the 1874 flood on the Orbiel river.

3) Historical data and statistical inference

- The generalised Extreme Value distribution is tested (Jenkinson, 1955)
- Maximum Likelihood Estimator is used
- Bayesian Monte Carlo Markov Chain method (MCMC) is used for the calibration of the parameters
- 5 likelihoood expressions corresponding to various levels of quality of the historical information have been tested (Stedinger, 1986; Naulet, 2002):



- **MLE 1:** Historical discharges perfectly known
- **MLE 2:** Range of possible values for each historical discharge known
- **MLE 3:** The only known information is the exceedance of a threshold
- **MLE 4:** Only the maximum historical peak discharge is known
- **MLE 5:** Calibration with the measured data only

II. Results:

1) Impact of the historical data on the choice of a distribution

Taking into account the historical data modifies significantly the calibration and hence the Q100 estimate. For instance, for the Clamoux river, the estimated Q100 is equal to 43 m^3s^{-1} if the EVII distribution is calibrated with the MLE 5 (measured data only) and lies between 106 and 152 m^3s^{-1} if MLE 1 to MLE 4 are used. Moreover a distribution acceptance test can be build on the basis of the computed likelihood value of the peak discharge data sets (measured and/or historical estimated discharges) : is the computed value in accordance with the values of comparable data sets drawn using Monte Carlo simulations from the tested distribution (see figure 3) ? As can be seen in table 1, the distributions calibrated on the measured data sets only are almost always discarded through such a test when the historical data are considered. This result holds for any type of MLE model.

Test type:		Measured data set	Historic set
Gumbel	Clamoux		
	Orbiel		
	Lauquet		
	Salz		
Fréchet	Clamoux		
	Orbiel		
	Lauquet		
	Salz		

Distribution accepted — Distribution discarded

Table 1: Acceptance test results for the statistical distributions calibrated with the measured data set only.

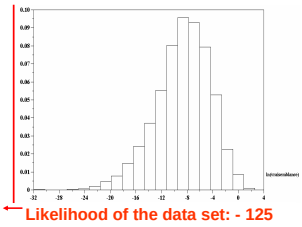
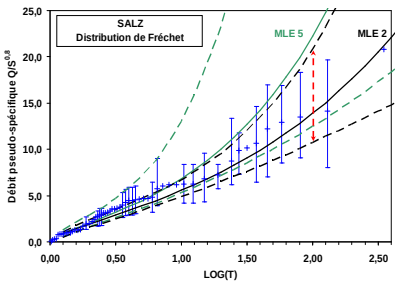


Figure 3: Comparison between the likelihood of a measured and historical set and the likelihood distribution of Monte Carlo simulated sets

2) Reduction of the size of the credibility intervals

The MCMC method enables the computation of credibility intervals. It appears, without surprise that the historical information leads to a significant reduction of this interval for the 4 rivers (see figure 4 for an example). This reduction does not highly depend on the MLE type used : i.e. historical information is determinant even if the historical peak discharge estimates are highly uncertain !



Calibration with measured data only (MLE 5)

618 $m^3.s^{-1}$ <Q_{100}< 4309 $m^3.s^{-1}$

Calibration with historical floods (MLE 2)

529 $m^3.s^{-1}$ <Q_{100}< 1028 $m^3.s^{-1}$

Figure 4: Calibrated distributions and 90% credibility intervals when MLE 2 and MLE 5 are used

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