SYNTHESIS AND ANALYSIS OF FLOOD DATA FROM MOUNTAIN TORRENTIAL WATERSHEDS IN THE FRENCH ALPS

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INTRODUCTION

For non-specialist practitioners, torrent hydrology appears difficult to understand because of its singularities: strong reactivity associated with the small size of the basins, increased sensitivity to localised thunderstorms, heterogeneous geology and vegetation cover, various hydrological situations able to cause floods, multiple factors which may interact to explain rainfall and runoff intensity.
Though involved in many operational applications that impact a variety of stakeholders, knowledge of rainfall and runoff in torrential watersheds suffers from scarcity of hydrological data. This is particularly due to the harsh climatic conditions at high altitude, the difficult access to some high mountain areas, the uncertainty in gauging streams with mobile beds or to the frequent destruction of hydrometric equipment during floods. These difficulties explain the slow development of hydrologic methods dedicated to the specific mountain context. As a consequence, the approaches used to evaluate floods in ungauged mountain basins do not really differ from those proposed for plain watersheds, even if the geographical situations are radically different.
The approaches currently used in France for flood frequency estimation include multivariate statistical models and pre-parameterized hydrological models. The principle of multivariate statistical models is based on the evaluation of statistical relationships between a variable that one needs to estimate (e.g. discharge) and some more easily identified variables on a map or in the field (e.g. the basin area or the rainfall depth). Inherently, the multivariate statistical models are not more accurate than pre-parameterized hydrologic models. However, their quite simple implementation makes them less uncertain when used, especially by non-specialist practitioners.

STUDY AREA AND METHODS

This paper aims to present the results of a regional study conducted in the French Alps as part of the following three step methodology: (i) synthesis of available hydrologic data on floods in torrential watersheds of the region (ii) delineation of hydrologically homogeneous areas according to similarities identified between geographic features of the different units; (iii) proposition of a representative model for the study area which takes into account its characteristics and can be implemented by non-specialist practitioners in hydrology.
Initially, a hydrological database on 159 torrential watersheds in the French Alps had been documented. These watersheds were selected after the hydrologic data collection, processing and control phase as part of the synthesis. This database contains the flood characteristics evaluated for each basin (peak flows for different return periods and durations) and variables related to watershed morphometry, climatological environment, drainage network, land use and geology. An original criterion was put in place to distinguish the orientation of the basin with respect to the dominant perturbations causing heavy floods in the area.
By merging criteria related to the spatial distribution of relief and rainfall, the geology and the dominant weather prevailing for the major flood events, we empirically define five homogeneous regions (Figure 1).

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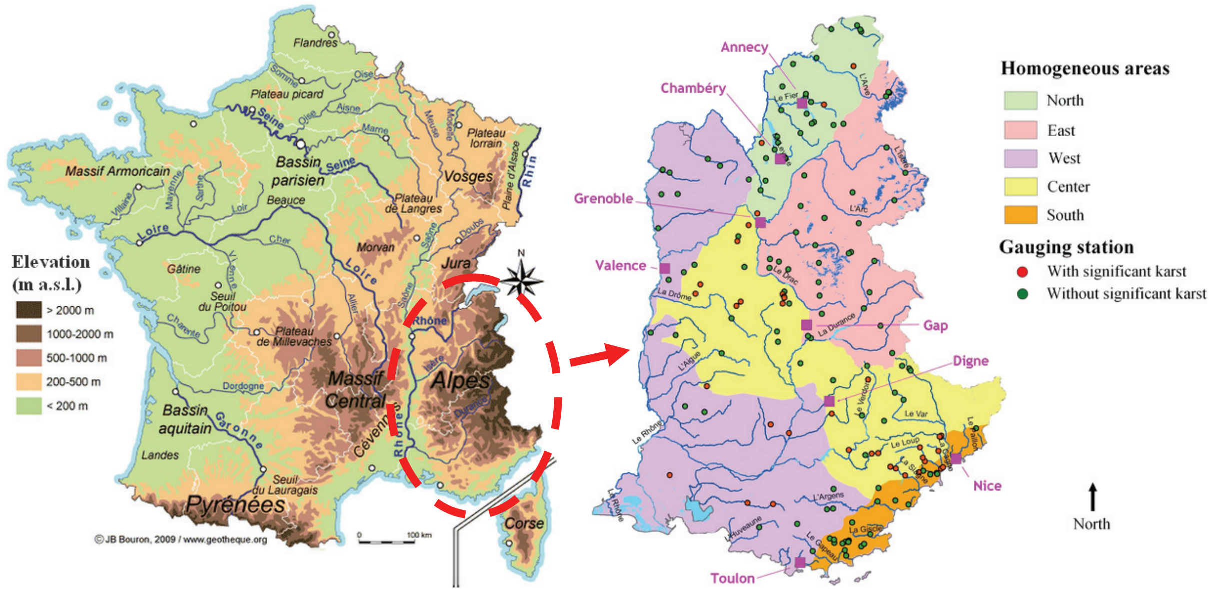

Fig. 1 Location of the study area and delineation of the proposed homogeneous areas.

RESULTS AND DISCUSSION

As the knowledge of the flow volumes yielded by torrential rivers is crucial for estimating sediment yield, a detailed analysis of the characteristic flood duration of each basin was conducted. This analysis focused particularly on the relationship between the characteristic flood duration, the drainage area and the peak discharge. A seasonal study was also undertaken but no clear relationship could be demonstrated across the study area.

Nevertheless, we were able to calibrate several regionalized multivariate statistical models to predict flood peak discharge (for 5, 10, 20 and 50 years return periods) depending on variables such as drainage area and daily rainfall depth (Table 1). The model performance is satisfactory compared to other similar approaches. The advantage of these models is their capability to propose peak flow estimations for a large range of return periods (from frequent to rare).. However, we could not investigate the estimation of the 100-year return floods given the relatively short observation period for most of the data. Other extrapolation methods for this frequency (e.g. the Gradex method) appear more suitable for this estimation.

Tab. 1 Established formulas to estimate Peak Flow for Return Period T (Qi_T in m3/s) depending on the Area (S in km ²), Daily Rainfall Depth of the same Return Period (P_{JT} mm) and a regional coefficient valid for the Return Period T (Cr_T)

Formula
$Qi_5 = S^{0.85} \times \left(\frac{P_{j5}}{87.5}\right)^{0.87} \times Cr_5$
$Qi_{10} = S^{0.85} \times \left(\frac{P_{j10}}{87.5}\right)^{0.9} \times Cr_{10}$
$Qi_{20} = S^{0.86} \times \left(\frac{P_{j20}}{87.5}\right)^{0.84} \times Cr_{20}$
$Qi_{50} = S^{0.86} \times \left(\frac{P_{j50}}{86}\right)^{0.87} \times Cr_{50}$

Area	Cr_5	Cr_{10}	Cr_{20}	Cr_{50}
North	1.97	2.01	1.79	1.94
Center	1.06	1.10	1.03	1.08
East	0.86	0.86	0.87	0.95
West	0.63	0.67	0.63	0.67
South	1.96	2.00	1.94	2.01

Keywords: Torrent hydrology, Flood Peak Discharge Predetermination, regional synthesis