APPLICATION OF THE GRADEX METHOD TO ARID AREA "OUED SEGGUEUR WATERSHED", ALGERIA

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ABSTRACT

The GRADEX method shows, in a simple way, the statistical relation between runoff and rainfall. This method procedure has been applied to Oued Seggueur watershed in El Bayadh (ALGERIA). The gradex method is a rainfall-runoff probability approach to computing extreme flood discharges in a river. It is used on catchments area in size from a few tents to several thousand square kilometer which relatively uniform areal rainfall patterns. The most important factor in flood generation on such catchments is the way rainfall becomes direct overland runoff. The principle of this method is based on historical weather records is to find the asymptotic behaviour of the probability model for rare flood volumes from a probability model for cumulative extreme rainfalls.

Keywords: Gradex method; Gumbel distribution; Oued Seggueur watershed.

1. INTRODUCTION

The surface hydrology in the Sahara has remained little studied in the early 20th century, it was not until 1953, with "Essai sur l'hydrologie superficielle au Sahara" of Dubief J. (Dubief, 1953). This region of Algeria is a country on the edge of life. It is therefore unnecessary and dangerous to create centers of life if you can not keep. In addition, floods recorded in this, referred to as micro tsunami, are devastating and they often have dramatic socio-economic consequences such as those recorded in EL BAYADH in 2011. It is therefore essential to study this essential factor of life in the Sahara which is the runoff, and these different modes of action.

The model is a simplified representation of a system process, in order to describe it, to explain it or to envisage it. Hydrological modelling is a representation of the water cycle. In this work, the study presents the models rain- flow, which represents the transformation of the rain into flow on continental surfaces. The applications of these models are multiple, and make it possible to simulate the impact of installations anthropic on the hydrology of a catchments area (construction of a stopping, proofing of a zone by construction), to manage alarms of raw on the basins slopes or to reconstitute chronicles of flows on basins on which one has only chronicles of rains (Lavabre et al., 2002). Therefore, it is important to define management tools and planning which presuppose a non-biased scientific understanding of natural phenomena. Generally defined the concept of flood risk by crossing two components: the random phenomenon flood related to hydrology of the river, and vulnerability to floods, linked in turn to land. Among these tools, we propose in this paper to exploit this information and by using the method developed by Gradex Electricité de France (EDF) for the design of spillways of dams (Guillot, 1980) which is defined as a climatological seasonal and local invariant depending on the location (Meddi &Bouchaib, 2010).

2. STUDY AREA

The study area located in the El Bayadh city at the interface Saharan Atlas (southern side) / Western Sahara in Algeria, it is between three natural regions:

- -The High Plains steppe.
- -The Saharan Atlas.
- -The pre-Saharan region.

For a total area of 7.169.670 hectares, 1272 223 ha are classified as desert and 5703 534 ha as steppic. The bioclimate is the semi arid to arid, cool to cold variant with an average annual rainfall ranging from 250 to less than 100 mm / year (South) (Mederbal et al., 2009). Therefore, the study area as part of this work is shown in Fig. 1.

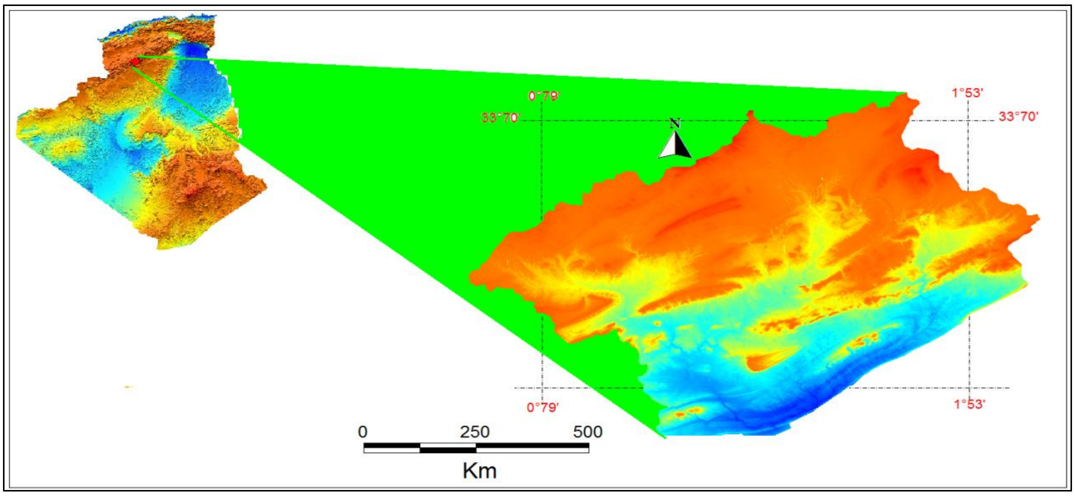

Figure 1. Presentation of the Oued Seggueur watershed

3. DATA

This study is based on the use of liquid flow rates, the length of data record is 11 years (2001-2011). We also used the extreme daily rainfall data at Brezina station (1970-2011).

4. LEADING FEATURES OF GRADEX METHOD

The GRADEX method was conceived, developed, was tested and validated by the group of research of EDF (Guillot & Duband, 1967). Its purpose is to seek the maximum discharge of flows for rare appearance frequencies to very rare (time of return more than 100 years). It applies in particular when we have a long rainfall series and a short runoff series (10 years) on the basin, and especially in the areas of mountain. It is interesting to apply this method to the context of Brezina station.

The principle of the method is to consider that the distribution line of the flows is parallel starting from the threshold, corresponding to the return time of 10 years, with that of the rains.

This method is based on various assumptions:

1. The flows required maxima are caused only by maximum rains, uniformly distributed on the basin.

2. The maximum rains and the corresponding flows (maximum flows) follow the same statistical distribution law, known as of the “extremes”.

3. This expresses especially the fact that starting from a certain rain value, the asymptotic behaviour of the flow will be identical to the rains. According to the authors of this method, this threshold represents the rate of basin saturation which is reached after a pluviometric event which causes a decennial flow (T = 10 years).

The application of the GRADEX method implies several constraints:

1. The duration of the considered rains must strictly correspond to the flows (same Δt and in general 24h). It is conditioned by the concentration time of watershed.

2. If we use the Gumbel law, the units of the rains and the flows must be identical (in mm/24h).

3. The limits of application of this method are conditioned by concentration times Tc varying from 1 hour at 4 days. This method can be applied only to basins area of 5000 km2 to the maximum.

It is still advisable to announce that the obtained results by extrapolation are average maximum flows which result from mean maximum rains. It is thus a question of multiplying these values of flows by the average point coefficient (point coefficient =maximum /medium flow) to obtain the instantaneous maximum capacity.

5. CALCULATION OF THE GRADEX VALUE OF THE DAILY RAINS

The Gumbel law is often used to adjust the series of maximum rains and the flows corresponding. In this case, the exponential character of this distribution is described by the average line slope of the rains relationship observed. The slope of this line is the Gradient of this Exponential distribution, from where the name of GRADEX method.

5.1 GRADEX Calculation of the maximum daily rains

The adjustment parameters of the rains according to the Gumbel law (figure 2) are indexed in table 1.

Table 1. Adjustment parameters of the rains.

a	b	Average (mm)	Standard Deviation (mm)	variation coefficient
17.047	10.280	22.7	11.8	52%

From fig. 2, the estimate of the parameters a1 and b1 are a1 = 17.04 and b1 = 10.28. The slope b1 of this line is not other than the Gradient Exponential of the rains.

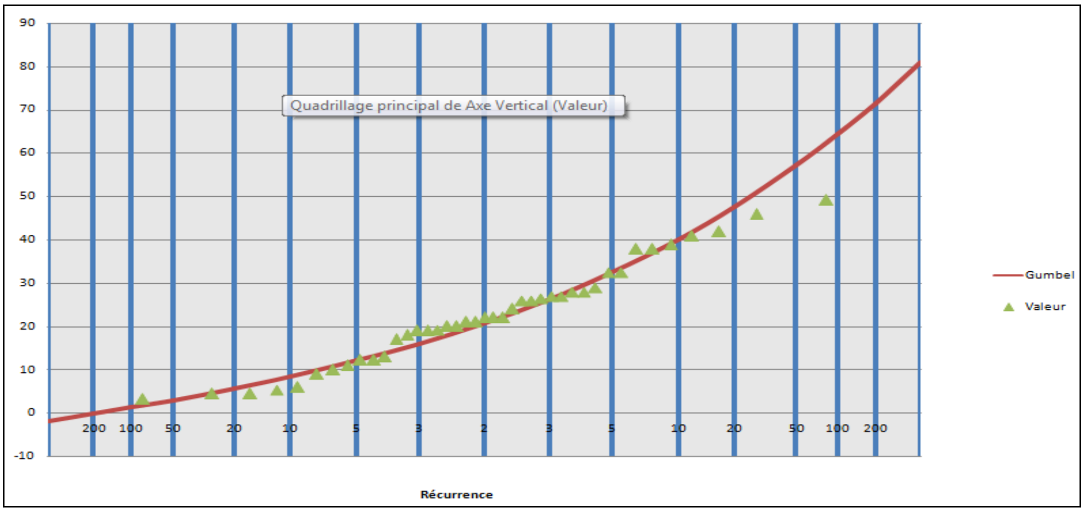

Figure 2. Graphic adjustment of the maximum rains annual day laborers according to a Gumbel law.

6. Gradex Calculation the daily maximum annual runoff

After the adjustment (fig. 3), we calculus the daily mean maximum annual flow for return time T=10 years in (mm/24h) (table 2).

Table 2. Daily medium maximum annual flow corresponding to the time return 10 years.

Return time T (year)	daily mean maximum annual flow (m^3/s)	daily mean maximum annual flow (mm/24h)
10	156	34

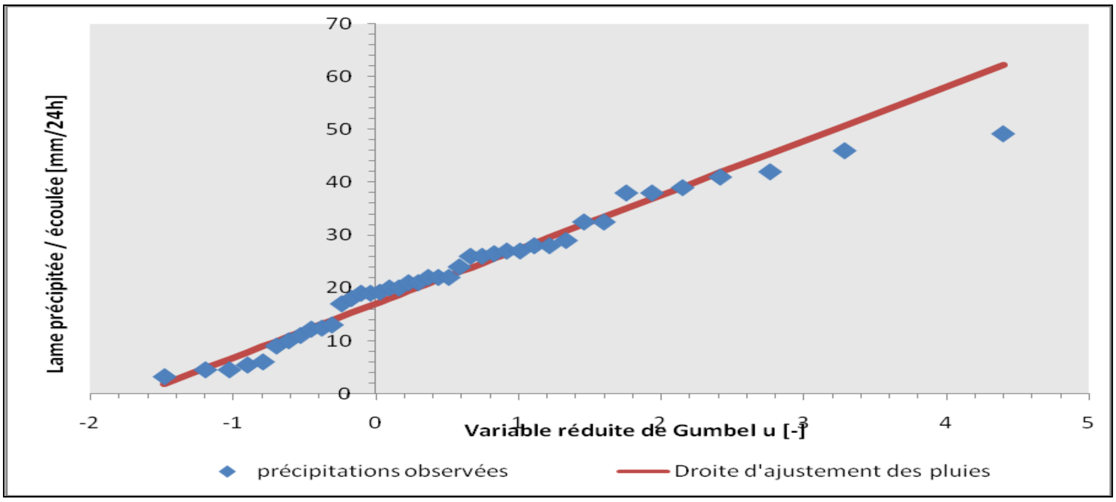

Figure 3. Parameters calculation "a" and "b" of the Gumbel average line relationship by the graphic method

7. CALCULATION OF THE FLOWS EXTRAPOLATED BY THE GRADEX METHOD

The precipitations adjustment according to Gumbel law is made, we can then trace the of distribution function of the medium flows daily maximum, like the parallel with the right-hand side of the rains (b2 = b1 = 10.28) and passing by the pivot point corresponding to the daily medium flow of return time of 10 years (fig. 4). The coefficients "a" and b of the flow line of extrapolation are presented in table 3.

We should not forget to convert the values of daily output (in m^3/s) into past blade (in mm) in order to be able to apply the GRADEX method (Qp (10) = 156 m^3/s = 43mm/24h).

Table 3. a, b coefficients of the extrapolation line of the flows.

a	b	Pivot point
10.89	10.28	10 ans

Volumes of rare risings are then obtained:

- Decennial rising 34 mm is 156 m^3/s.
- Centennial rising 58,2 mm is 267 m^3/s.

By applying the law of adjustment extrapolated of the flows for return times of 20, 50,100 and 500 and by making adequate conversion to have values in m3/s, values of daily medium flows are obtained.

From table 4, it is noticed that this extrapolation agrees well with the empirical distribution of the maximum annual runoff (established independently). The peak of the centennial rising corresponds to a specific flow of 674 $l/s/km^2$.

Tableau 4. Medium daily maxima flows

				QT (m^3/s)	
T (ans)	F(x) [−]	U[−]	QT (mm/24h)	Using rainfall GRADEX	Estimation of distributions
10	0.900	2.25	34	156	142.2
20	0.950	2.97	41.4	190	189.4
50	0.980	3.90	51.0	234	250.4

100	0.990	4.60	58.2	267	296.2
500	0.998	6.21	74.8	343	402

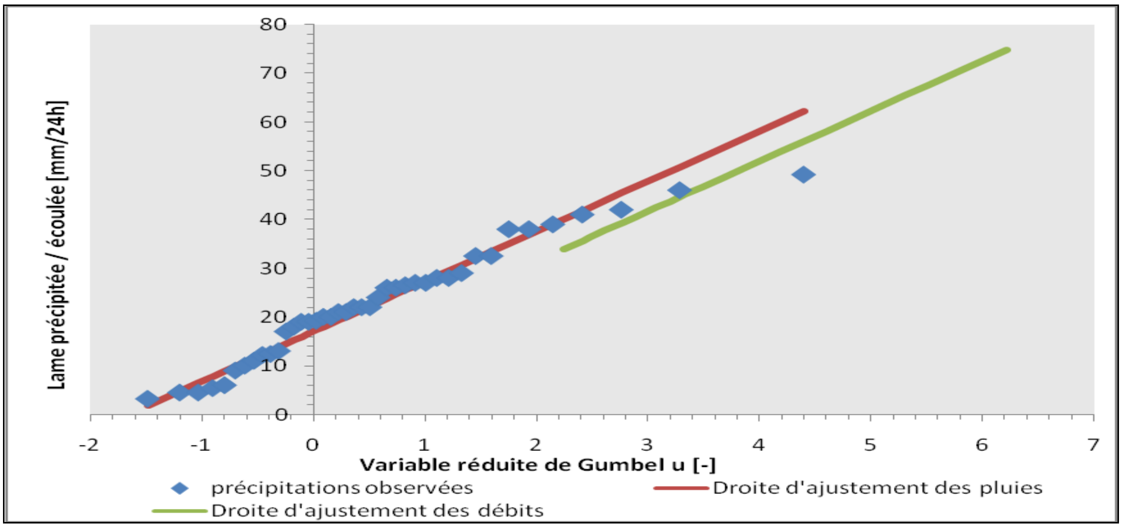

Figure 4. Graphic adjustment for the rains and extrapolation line of flows

8. CONCLUSION AND RECOMMENDATIONS

The main aim of this work was to develop a model able to give an account of the raw mode of u the Oued Seggueur watershed, this type of information is useful within the framework of the prevention of the risks related to the floods.

The examination of specific Gradex of the area of study, was applied first to the samples of the annual maxima of the daily rains which made it possible to calculate the parameter (a) of the distributions of Gumbel at the pluviometric stations (a= slope or Gradex), then one applied the Gradex method, with step of the daily time, at the station of gauging available with weak durations of observation. The point pivot was taken with T = 10 years.

It was concluded that this method gives reliable results and it is appropriate particularly very well when it is a question of evaluating the extreme risings (period of return 1000 to 10.000 years) generated on a catchments area of moderate size (lower than 15.000 km ²), and when information in rain and flow is available.

REFERENCES

Dubief J. (1953) *Essai sur l'hydrologie superficielle au Sahara*. Alger : Institut de météorologie et du globe physique de l'Algérie.

Guillot P. (1980) Débits et pluies extrêmes. *Météorol.* 1980; 5: 65 – 70.

Guillot P. and Duband D. (1967) The Gradex to compute extreme flood probability from the observation rainfall. Colorado State University, Fort Collins, Colorado, USA. *International hydrology symposium* ; Vol 1, pp. 506-515.

Lavabre, J. Andréassian V. Laroussinie O. (2002) Les eaux et les forêts. La forêt : un outil de gestion des eaux? *La Houille Blanche* 2002; 3: 72-77.

MeddiI M. Bouchaib F(20101) Etude des crues dans le bassin du Cheliff . Application de la méthode du Gradex. Revue *« Nature et Technologie »* 2010;3: 21 -28.

Mederbal K. Jose R. Boukhari Y.(2009) Ecosystème steppiques (cas de Brezina – El Bayadh) caractérisation et proposition d'une fiche de travail sur terrain. *Séminaire international (la présentation et la mise en valeur de l'écosystème steppique*-Msila 2009.