Regionalization procedure to assess the maximum discharge quantiles for Romania

VALENTINA UNGUREANU

National Institute of Meteorology and Hydrology – Sos Bucuresti-Ploiesti 97, 71552 Bucharest, Romania

ungureanu@meteo.inmh.ro

Abstract An example of regionalization of the maximum specific discharge quantiles all around the Romanian territory is presented. A total of 164 Romanian gauging stations were selected, taking into account some criteria and a database containing information on the location and on the recording periods, the morphologic characteristics of the catchments, the series of the annual maximum discharges, and information on the estimates of the annual maximum discharges of certain probability of exceedence. Applying the proposed procedure, five regions resulted and the regression coefficients for each region for all standard quantiles (0.1%, 0.5%, 1%, 2%, 5%, 10%) were calculated.

Key words maximum discharge; quantiles; Romania

INTRODUCTION

At present, and for the foreseeable future, due to the move to a sustainable development of industry, agriculture, energy and water supply, the demands for synthetic hydrological characteristics of the flow regime are continuously increasing. These characteristic "hydrological parameters" (mean and time variation of the flow, flood characteristics, low flow sediment transport, etc.) are traditionally determined on the basis of the statistical methods applied to the series of data recorded over long periods at the gauging station.

The master plan for an integrated and complex water management implies good knowledge of the hydrological parameters in the basins lying above more points than those where the data are recorded. Consequently, there is a need for developing new procedures in order to estimate the hydrological parameters at ungauged or poorly gauged sites.

An approach towards the knowledge of the laws that govern the manner of existence of the hydrological parameters over a territory is regional analysis. This analysis results in a regionalization that may be defined as integration of location-specific data across a spatially contiguous area.

For certain characteristics, elements that vary smoothly across a given space (rainfall events), this interpolation is controlled by the position of the gauged points. Floods, characterized by their maximum discharge are conditioned not only by their triggering causes (i.e. rainfalls and snowmelt), but also by a variety of climatic and morphologic characteristics including relief, soil type, land cover and land use and basin geometry, all of which vary discontinuously in space.

DATA COLLECTION AND DATABASE

For the present work, 146 hydrometrical stations were selected, taking into account the following criteria:

– their morphological representativness;
– to cover an as large as possible range of variation of the basin areas;
– to have an as long as possible length of data series;
– to consider the data of the best reliability.

The database concerning the information on the annual maximum discharges at the selected stations consists in:

– Information on the location of the selected hydrological stations and on their recording periods.
– The morphologic characteristics of the catchments considered in the study corresponding to the selected stations.
– The series of the annual maximum discharges recorded at the selected stations.
– Information on probability of exceedence of certain outliers.

PROCEDURE FOR REGIONALIZATION

This procedure consists in the determination (by regression analysis) of the relationships between each standard quantile of the maximum specific discharge ($q_p = Q_p / AREA$) and a set of basin morphologic characteristics. This approach leads to an analytical model which reveals the manner in which each set of characteristics has a different influence on each quantile.

Denote $y = \log q_p$ and $x_i = \log X_i$, X_i being the value of a basin characteristic. Then, the linear regression relation is assumed:

$$y = \log a_0 + \sum_{i=1}^{n} a_i x_i \qquad (1)$$

where n is the number of the characteristics considered in the set, a_i are the corresponding coefficients and a_0 is a constant.

From equation (1) one can write the equation:

$$q_p = a_0 X_1^{a_1} X_2^{a_2} \ldots X_n^{a_n} \qquad (2)$$

Each relationship of type (2) is then assigned to a region across which there is a quasi-homogeneity of the morphologic and climatic characteristics.

The regions (zones) are chosen on the basis of a good knowledge of the topography, geometry and climate characteristics of the basins encompassed in the area.

DESCRIPTION OF THE WORK AND RESULTS

The procedure described was applied to 146 hydrological stations from Romania where reliable estimates of maximum discharge quantiles are assessed.

The following basic morphologic characteristics of the catchment and of the main course have been considered: *F*, area of the catchment; *H*, mean altitude of the catchment; I_b, mean slope of the catchment; *B*, width of the catchment; *L*, length of the main course of the catchment.

The sets of morphologic parameters that were considered are: (*H*, *F*), ($H/\sqrt{F}$), (*F*, *H*, I_b) and (*F*, *H*, *B*/*L*).

The quantiles of the specific maximum discharge were correlated with each set of the above-mentioned variables.

By means of the analysis of the deviations of the quantiles resulting from the regression (denoted $q_p^{'}$) and those that were directly assessed at stations (q_p), five zones (Fig. 1) were established, namely:

– Zone 1: River basins Somes, Barcau, Crisul Repede, Crisul Negru, Crisul Alb, and the basins from Banat area, 48 stations;
– Zone 2: River basins Mures and Upper Olt, 34 stations;
– Zone 3: River basins Jiu and Lower Olt, 27 stations;
– Zone 4: River basins Arges, Ialomita, and Buzau, 20 stations;
– Zone 5: River basin Siret (right side), 17 stations.

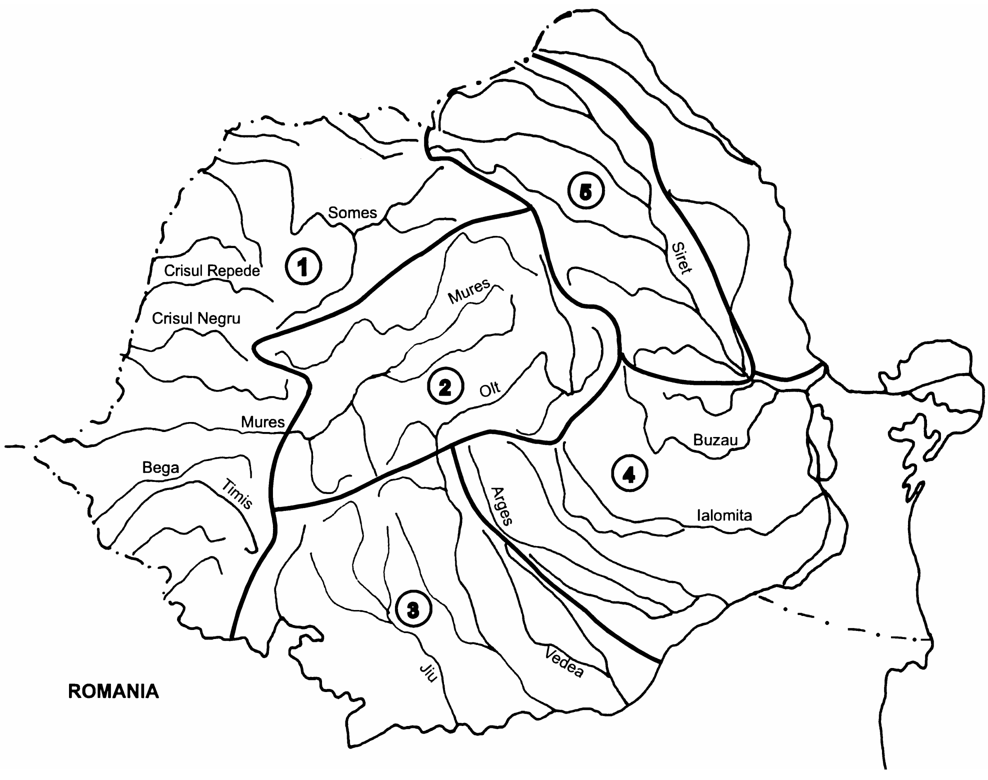

Fig. 1 Regionalization of the regression coefficients.

For each region, the combination of basin characteristics that resulted in the best estimation of 1% quantile has been chosen. The errors computed $E_r = \frac{q_p^{'} - q_p}{q_p}$ by use of the regression for different sets of basin characteristics are presented in Table 1 and Fig. 2 (the number of cases refers to all five regions). The best result is given by the correlation of the 1% quantile with the set (F, H, B/L). The correlation with the set (F, H, I_b) is also acceptable, but for three zones (1, 4 and 5) the coefficient of I_b is negative, which is not plausible.

In Fig. 3 the comparison between the 1% quantiles obtained by statistical calculus and those obtained using the correlation with the set (F, H, B/L) for Zone 1 is presented.

Table 1 Distribution of cumulative errors for 1% probability.

Set of basin characteristics	Errors $Er > 25$	$20 < Er < 25$	$10 < Er < 20$	$5 < Er < 10$	$Er < 5$
F, H	3	14	46	35	48
$H/\sqrt{F}$	31	13	46	28	28
F, H, B/L	2	11	50	33	50
F, H, Ib	3	11	51	31	50

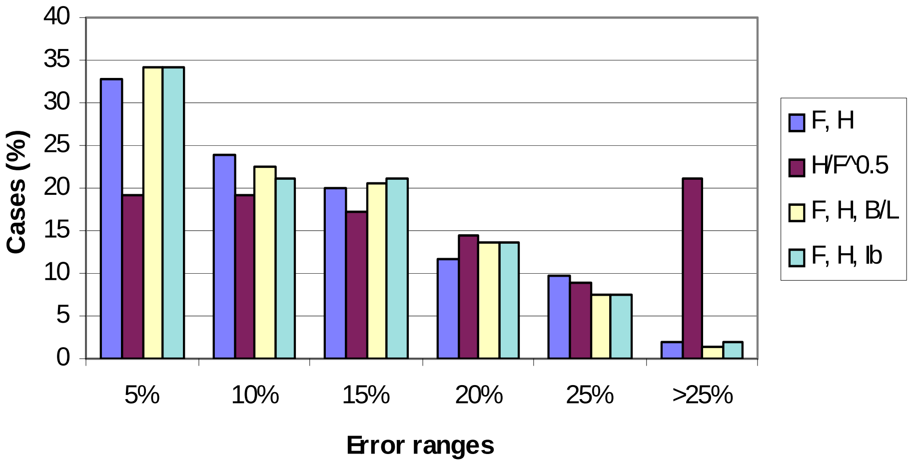

Fig. 2 Analysis of cumulative errors (between $q'_{1\%}$ and $q_{1\%}$) for all considered zones.

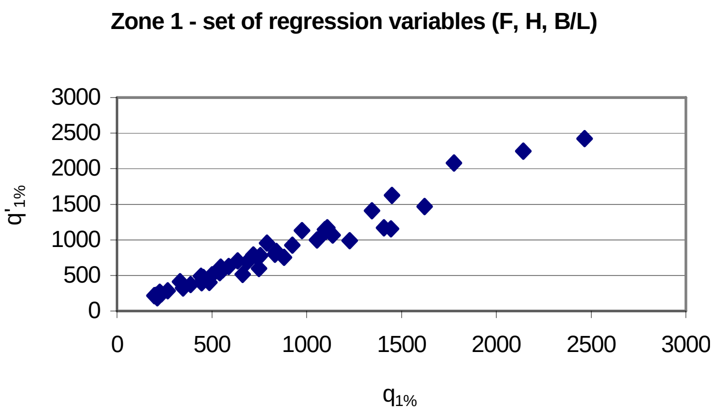

Fig. 3 Comparison between $q'_{1\%}$ and $q_{1\%}$.

Further, considering the set (*F*, *H*, *B*/*L*) the regression coefficients of all standard quantiles (0.1%, 0.5%, 1%, 2%, 5%, 10%) were determined (Table 2).

The distribution of errors between $q_p^{'}$ and q_p by ranges for all considered zones is presented in Table 3.

Table 2 Regression coefficients - variables: F, H, B/L.

Zone	p (%)	Regression coefficients F (km^2)	H (m)	B/L	Const.
Zone 1	0.1	–0.4645	0.5578	0.0487	755.24
	0.5	–0.4483	0.5624	0.0507	500.62
	1.0	–0.4362	0.5641	0.0558	394.95
	2.0	–0.4231	0.5599	0.0613	315.51
	5.0	–0.3965	0.5596	0.0656	201.68
	10.0	–0.3710	0.5589	0.0791	133.19
Zone 2	0.1	–0.5065	0.6583	0.0098	326.53
	0.5	–0.4805	0.6658	0.0170	200.76
	1.0	–0.4622	0.6559	0.0243	171.63
	2.0	–0.4421	0.6754	0.0511	112.94
	5.0	–0.4026	0.7196	0.0967	50.16
	10.0	–0.3719	0.7613	0.1298	24.02
Zone 3	0.1	–0.4739	0.2842	0.0101	550.62
	0.5	–0.4560	0.2944	0.0151	364.32
	1.0	–0.4441	0.3019	0.0573	264.78
	2.0	–0.4282	0.3116	0.0823	155.62
	5.0	–0.4000	0.3202	0.0938	97.06
	10.0	–0.3774	0.3351	0.1030	54.50
Zone 4	0.1	–0.5419	0.6060	0.1887	1724.76
	0.5	–0.5320	0.6144	0.1423	1038.00
	1.0	–0.5274	0.6190	0.1347	816.00
	2.0	–0.5204	0.6155	0.1240	643.61
	5.0	–0.5171	0.6213	0.0995	428.53
	10.0	–0.5122	0.6208	0.0766	295.23
Zone 5	0.1	–0.5368	0.0302	0.1197	818.18
	0.5	–0.5151	0.0668	0.1279	599.11
	1.0	–0.5053	0.1402	0.1248	317.05
	2.0	–0.4819	0.2350	0.1127	294.82
	5.0	–0.4569	0.2627	0.1308	177.79
	10.0	–0.4231	0.2892	0.1364	76.48

Table 3 Cumulative errors (all considered zones) – variables: *F*, *H*, *B*/*L*.

p (%)	Errors $E_r > 25$	$20 < E_r < 25$	$10 < E_r < 20$	$5 < E_r < 10$	$E_r < 5$
0.1	1	15	53	24	53
0.5	3	13	50	32	48
1.0	2	11	50	33	50
2.0	3	12	46	37	48
5.0	6	16	44	35	45
10.0	10	15	44	35	42

CONCLUSIONS

This work is based on an important volume of data concerning the annual maximum discharges recorded at 146 stations in Romania.

The length of the records is considered sufficient to accurately estimate the statistical parameters of the series. An important number of series show records that exceed 50 years.

In order to determine the regression coefficients the following set of morphologic parameters were considered: (H, F); ($H/\sqrt{F}$); (F, H, I_b); (F, H, B/L) where H, F, I_b and B stand for the mean altitude, area, mean slope and width of the basin, respectively, and L is the length of the main course of the catchment.

The analysis of the deviations of the maximum specific discharge quantiles as resulting from the regression (q'_p) from those directly assessed at stations (q_p) shows a regional grouping of them. Thus, five specific zones valid for several relationships $q_p = a_0 X_1^{a_1} X_2^{a_2} \ldots X_n^{a_n}$ have been established.

For each region, the combination of basin characteristics that resulted in the best estimation of the 1% quantile has been chosen from the resulting relationships $q_p = a_0 F^{a_1} H^{a_2} \left(B/L\right)^{a_3}$ for all standard quantiles (0.1%, 0.5%, 1%, 2%, 5%, 10%).

REFERENCES

Diaconu, C. & Serban P. (1994) *Hydrological Synthesis and Regionalization*. Editura Tehnica, Bucharest, Romania (in Romanian).

Stanescu, V. Al. (1992) A spatial-temporal analysis for the assessment of the maximum discharges for project. Hidrotehnica 6–8, Bucharest, Romania (in Romanian).

Stanescu V. Al. & Oancea V. (1994) Procedures for hydrological regionalization applied in Romania. In: *FRIEND: Flow Regimes from International Experimental and Network Data* (ed. by P. Seuna, A. Gustard, N. W. Arnell & G. A. Cole). IAHS Publ. 221. IAHS Press, Wallingford, UK.