TYPES OF HYDRIC REGIME IN THE SMALL RIVER BASINS FROM ROMANIA IN TERMS OF ANNUAL AVERAGE FLOW VARIATION

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Types de régime hydrique à l'échelle des petits bassins hydrographiques en Roumanie. Les auteurs examinent les types de régime hydrique à l'échelle des petits bassins hydrographiques sous 100 km^2, selon les données des bassins représentatifs situés dans différentes parties de la Roumanie, différenciés en fonction du régime des pluies et des facteurs naturels (géologie, relief, sol, végétation). Ces facteurs, mais surtout le régime des précipitations ont déterminé, dans le cas de ces rivières, l'existence d'un type particulier de variation de débit au cours de l'année. Dans chaque type de régime, on a déterminé l'apport qu'ils ont sur l'écoulement, chacun des facteurs qui le déterminent: précipitations liquides, précipitations solides, l'écoulement souterrain.

INTRODUCTION

Knowing the type of hydric regime (flow variation / year) is a problem of major interest not only for water management, but also for other areas, e.g. social–economic, energy, irrigations, etc. In view of it, the type of flow variation/year in small basins (under 100 km^2), was established at the hydrometric stations of representative basins.

Representative basins are situated in different zones of the country with distinctive rainfall regime and natural factors (geology, relief, soil, vegetation) (Miţă 1996). The rainfall regime of rivers has a certain type of flow varation over the year (TFV). Calculations for this study covered the 1975–2002 interval at the majority of hydrometric stations.

1. THE CHARACTERISTIC AVERAGE YEAR

Establishing a river TFV at a certain hydrometric station, involved analysing the average monthly values of the 28 years (1975–2002) take into calculation.

The hydrograph of a real year (conventionally called *characteristic average year*) is the year in which the annual average and the monthly average discharge values come closest to the annual and multi-annual averages registered at the respective station. Therefore, it is closest to the multi-annual average / year, both in terms of quantitaty and time-distribution, registered at the respective station, and can be considered typical of the respective river. Thus, the months intervals in which highest or smallest discharges constant flow periods and discharge phases characteristic of the respective river occur are highlight.

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For each characteristic average year established for a certain hydrometric station and therefore for each type of flow variation / year, corresponding to the respective station, quantitative determinations were made of supply sources: liquid rainfalls (1), snowmelt (z), and groundwater input (base). It was decided that the characteristic average year should be the hydrologic year (X–IX) and not the calenndar year (I–XII) for the cause–effect analysis to have continuity (the contribution of runoff from snowmelt water).

The analysis of flow distribution / year made in this paper, had in view monthly and is not daily average values, because the longer the time intervals, the more accurate the cause-effect analysis. In what concerns snowmelt runoff (for example) before showing up in discharge after a certain time; the same in the case of precipitation falling on the snow layer. The longer time-intervals blur this time-gap between cause and effect, making the analysis between the two factors more reliable.

2. SUPPLY SOURCES

River water sources in Romania are rain, snow, phreatic and deep waters. Supply inputs come from superficial sources and groundwater sources. Establishing groundwater supply sources meant dividing the daily average hydrograph corresponding to the characteristic average year.

Separating groundwater supply from superficial supply is graphically represented by a curve which runs through summer and winter minima and through the final points of flood decrease curves (Fig. 1). In this way, the average monthly groundwater-produced drained layer was calculated.

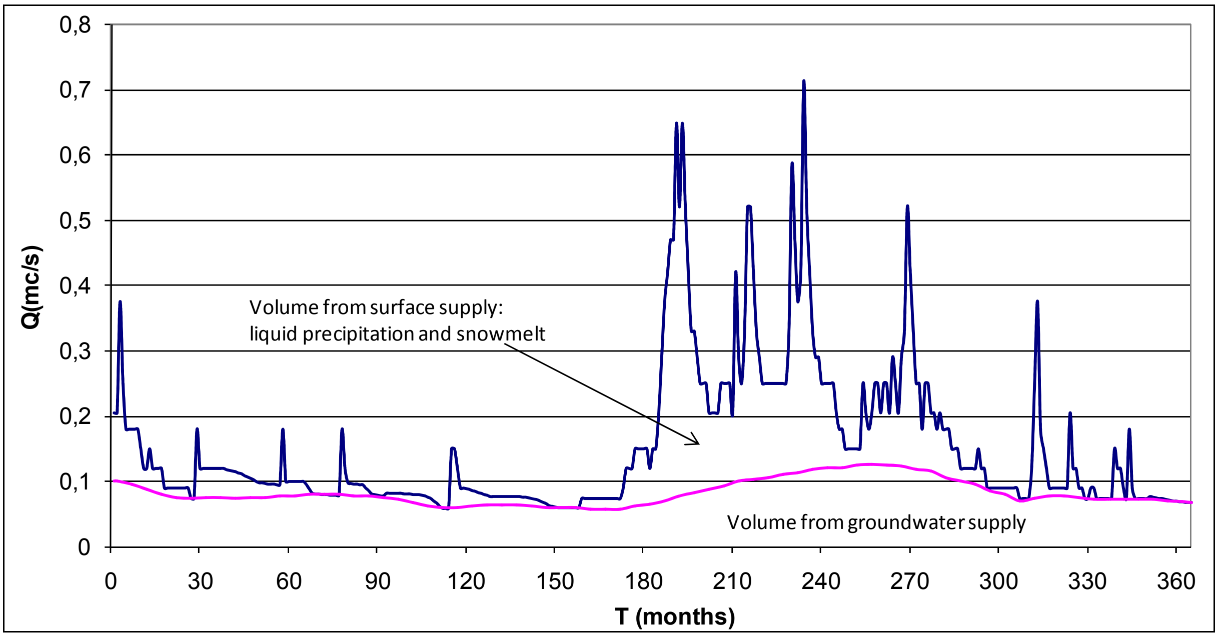


Fig. 1 – Hydrograph separation of groundwater supply.

Separating groundwater supply from the superficial supply allowed for the calculation of the layer drained by the monthly average groundwater (Fig. 2).

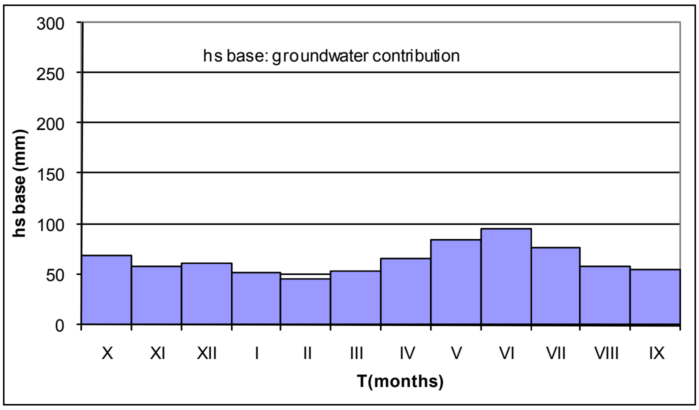


Fig. 2 – Monthly runoff variation of groundwater supply.

Extracting the layer drained by groundwater supply from the total drained layer (Fig. 3a) the layer drained by superficial supply could be obtained (liquid rainfall and snowmelt) (Fig. 3b).

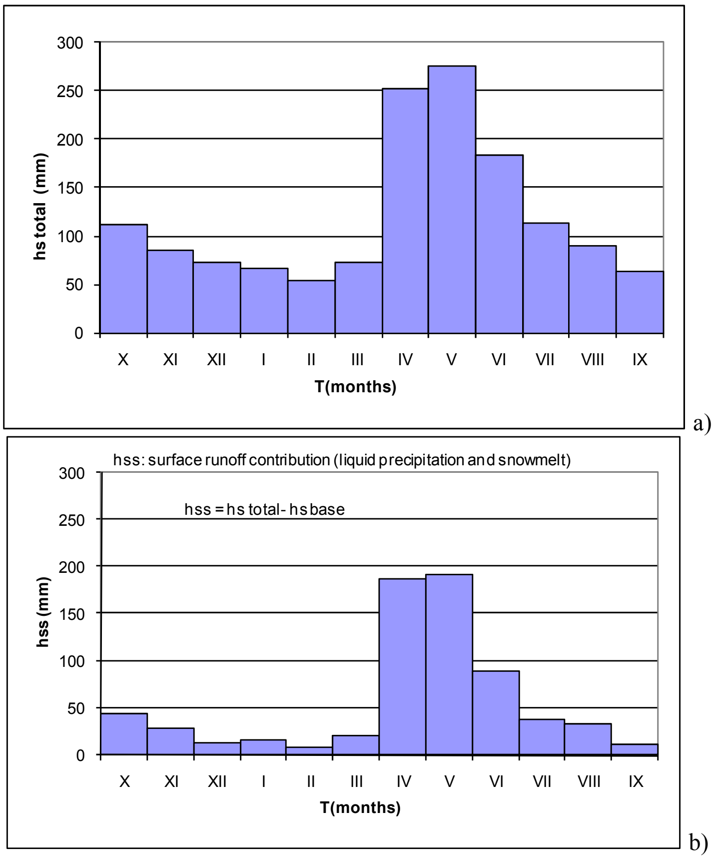
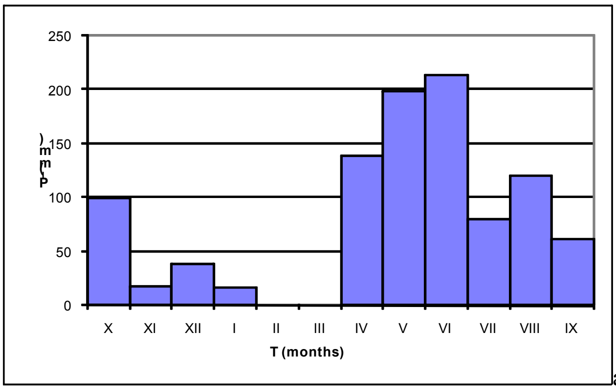


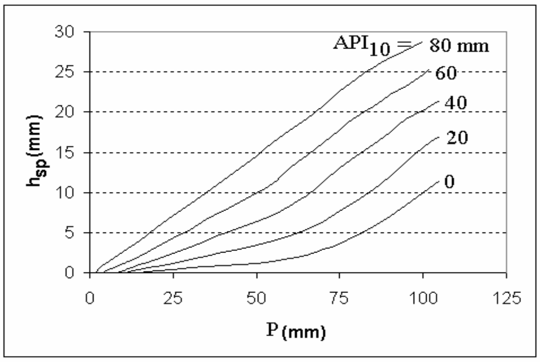
Fig. 3 – Monthly variation of total runoff (*a*) and surface runoff (*b*).

In order to separate the snow-related superficial supply from rain-triggered supply, the meteorological factors found at the representative meteorological stations of the basin, as well as snowmelt dynamics in the conditions of liquid precipitation fallen over the existing snow layer were taken into consideration.

Establishing the layer drained by liquid precipitation (Fig. 4c) was made by using the liquid precipitation layer (Fig. 4a) and the relations between the runoff coefficient and liquid precipitation at each hydrometric station in terms of the index value of the precipitation fallen for 10 days previously, API_{10} (Fig. 4b).



a)



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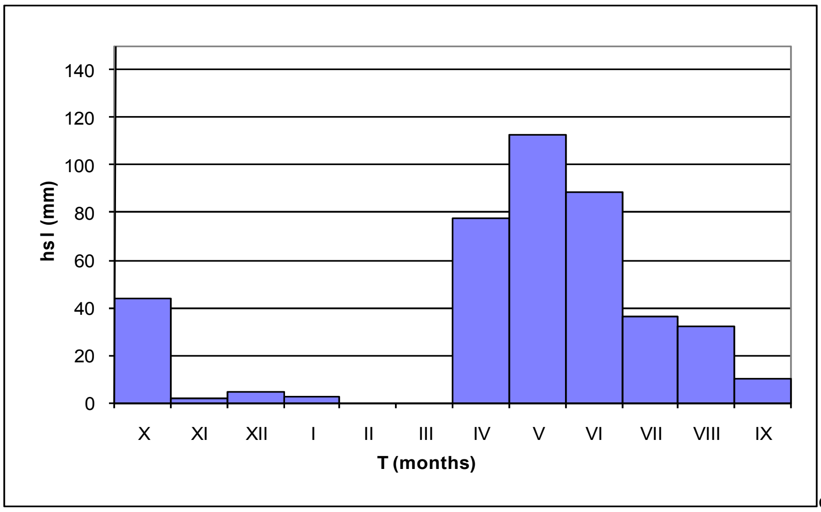

c)

Fig. 4 – Monthly variation of rainfall (*a*), total rainfall-triggered runoff (*c*), and the relation between the runoff coefficient and rainfall for different API_{10} (*b*).

Establishment the snowmelt drained layer was made in two distinct stages.

The first stage looked at the snowmelt water layer, hz (mm) (Fig. 5d) starting from the layer of solid precipitation fallen (Fig. 5a), hzc (mm), daily air temperature variation (Fig. 5b) and relations between the water quantity yielded by snowmelt, hz (mm) and the daily average air temperature in terms of sunshine duration, D_i (Fig. 5c) (Miță, Drăgan, 1986).

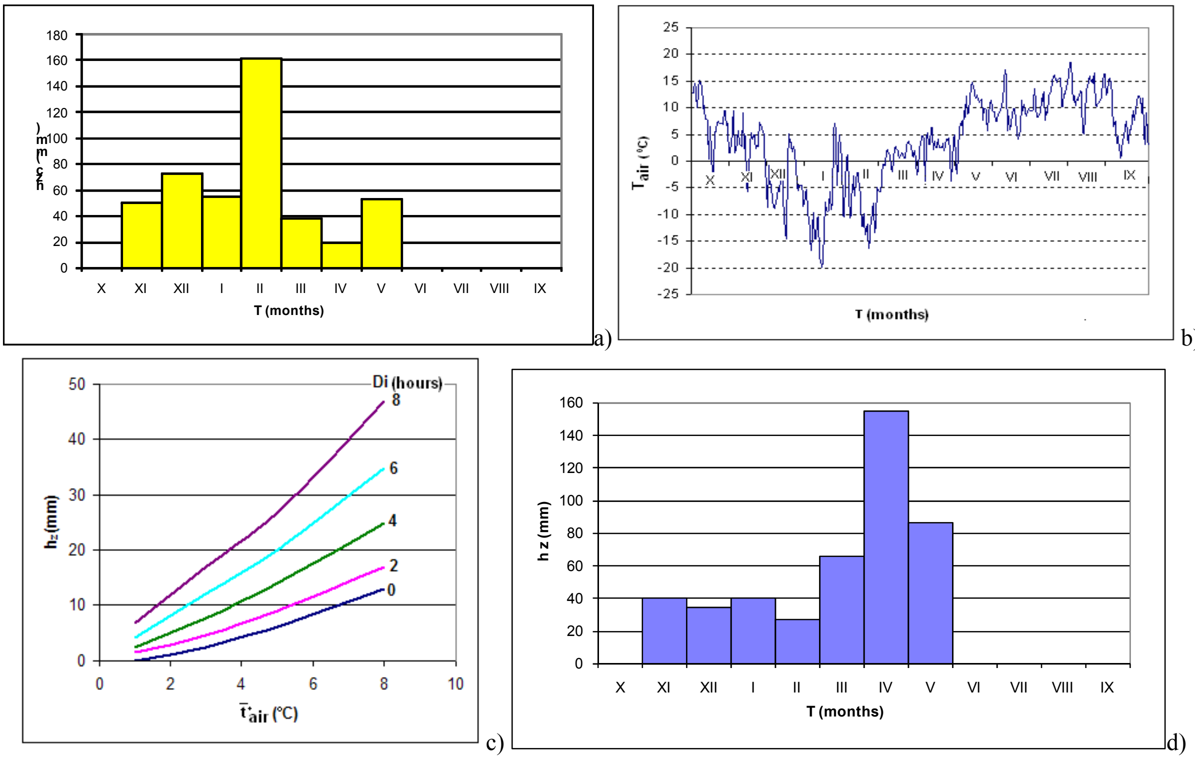

Fig. 5 – Monthly variation of snowfall (*a*), total snowmelt triggered-runoff (*d*), daily air temperature variation (*b*), and the relation between snowmelt and daily air temperature for different sunshine duration (*c*).

Starting from these values and using the relations between the snowmelt-drained layer and snowmelt-related water layer (Fig. 6a) enabled determining the snowmelt drained layer (Fig. 6b).

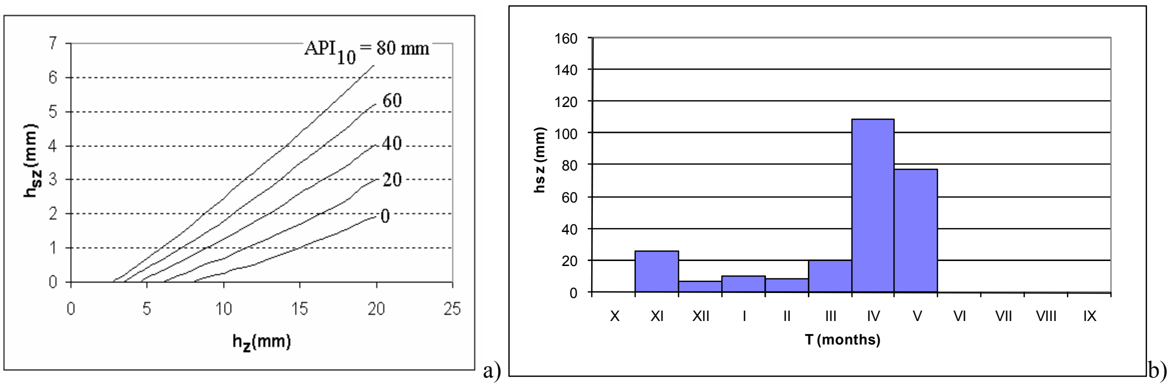

Fig. 6 – Relations between snowmelt-related runoff and snowpack water equivalent for different API_{10} (*a*) and the monthly variation of snowmelt-triggered runoff (*b*).

Finally, by combining these results and based on the monthly average values, the TFV was obtained, with highlight on the contribution of each constitutive factor to the flow: liquid precipitation (hs l), snowmelt water (hs z), and groundwater (hs base). For comparison's sake, the values of flow elements and of supply sources were expressed in terms of layer (mm and %). The results obtained for four representative basins are illustrated in Fig. 7.

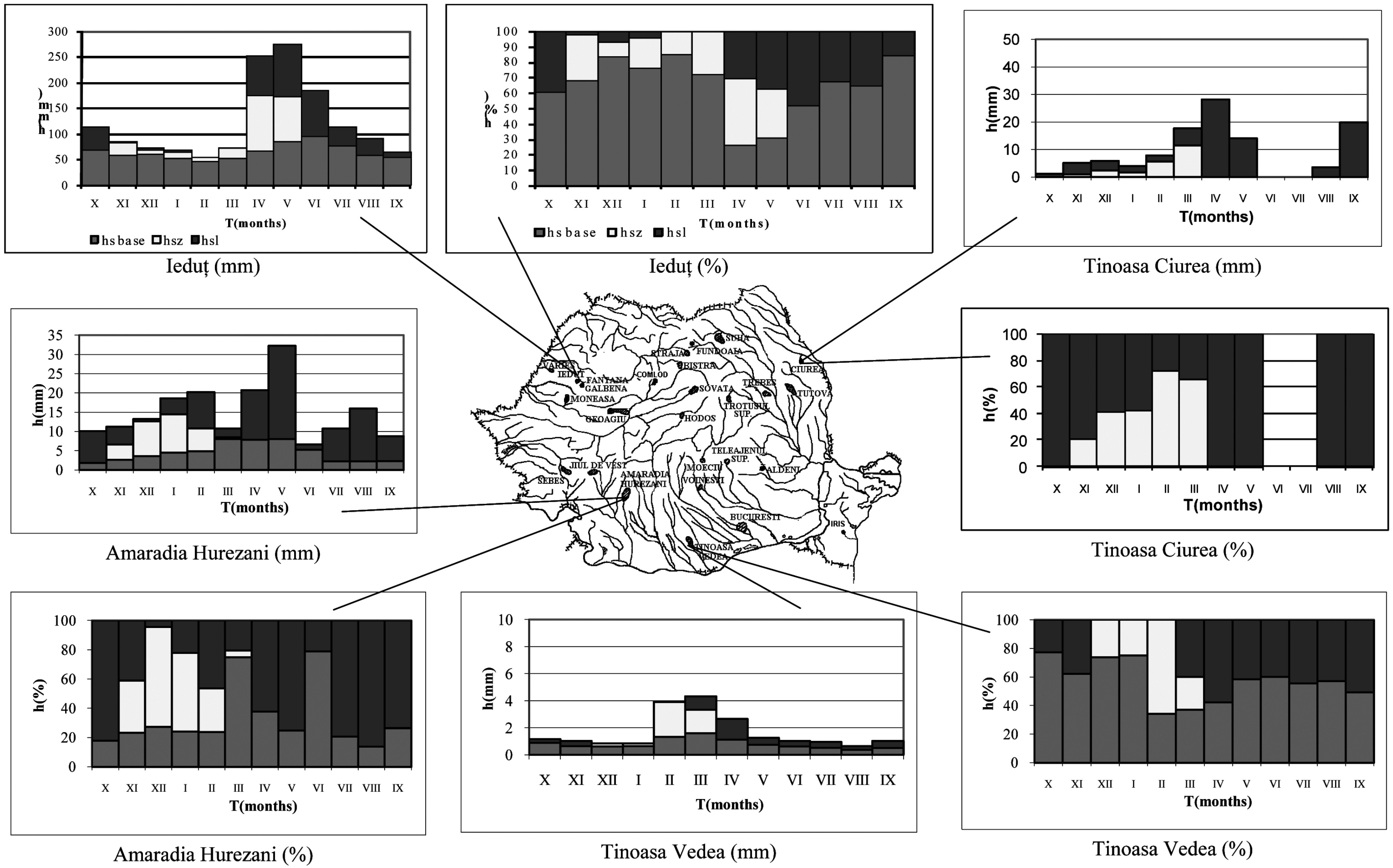

Fig. 7 – Annual cycle of monthly runoff variation (mm, %) – different variation types.

3. TYPES OF FLOW VARIATION IN THE SMALL RIVERS OF ROMANIA

Flow variation types were established by taking into account the following:
– the size of the drained layer hs (annual values);
– time intervals in which characteristic drained layer values occur (highest and lowest);
– supply sources.**A. TFV corresponding to mountain region**

I. In the high mountain region (over 1,000 m) from the West of the country (R.B. the Ieduț), annual hs > 1,000 mm

- Highest hs values: months IV–V, source: rains and snowmelt
- High values: months VI–VIII, source: rains
- Lowest hs values: months XI–II, source: groundwater supply

II. In the high mountain area (over 1,000 m) from the South – East of the country (R.B. the Jiul de Vest) annual hs > 1,000mm

- Highest hs values: months IV–V, source: rains and snowmelt
- High values: months VI–VIII, source: rains
- Lowest hs values: months IX, XI–II, source: groundwater supply

III. In the high mountain area (over 900 m) from the South – West of the country (the Banat Mountains) (R.B. the Sebeş) annual hs > 900 mm

- Highest hs values: months III–IV, source: rains and snowmelt
- High values: months V–VI, source: rains
- Lowest hs values: months VIII–X, source: groundwater supply

IV. In the high mountain area (over 1,000 m) from the North – East of the country (R.B. the Straja, Suha, and Bistra) annual hs: 700–1,000 mm

- Highest hs values: months IV–V, source: rains and snowmelt
- High values: months VI–VIII, source: rains
- Lowest hs values: months XI–II, source: groundwater supply

V. In the high mountain area (over 1,000 m) from the East of the country (R.B. the Upper Trotuş) annual hs: 400–450 mm

- Highest hs values: month IV, source: rains and snowmelt
- High values: months VI–VIII, source: rains
- Lowest hs values: months XII–II, source: groundwater supply

VI. In the high area from the East of the country, the Western branch of the Eastern Carpathians (over 900 m) (R.B. the Sovata) annual hs 400–450 mm

- Highest hs values: month V, source: rains and snowmelt
- High values: months VI–VII, source: rains
- Lowest hs values: months XII–II, source: groundwater supply

VII. In the low area of the Apuseni Mountains, Codru-Moma, Zarand 700–800 m (R. B. the Moneasa) annual hs: 400–450 mm

- Highest hs values: months III–IV, source: rains and snowmelt
- High values: months I; VI, source: rains
- Lowest hs values: months VII; X–XI, source: groundwater supply
- Particularity: rain-and-snowmelt-triggered floods in January

VIII. In the high mountain area (over 1,000 m) from the South of the country (R.B. the Upper Teleajen) annual hs: 750–800 mm

- Highest hs values: month IV, source: rains and snowmelt
- Particularity: abundant flow throughout the year

B. TFV corresponding to hill and plateau regions

I. The hilly area from the South–West of the country, altitudes 400–450 m (R.B. Amaradia Hurezani) annual hs: 150–200 mm

- Highest hs values: month III, source: rains and snowmelt
- High values: months IV–VI, source: rains
- Lowest hs values: months VII–IX; XII–II, source: groundwater supply

II. Hilly area from Southern Transylvania, altidues 600–650 m (R.B. the Hodoş) annual hs: 200–250 mm

- Highest hs values: months III–IV, source: rains and snowmelt
- Lowest hs values: months VI–VIII, source: groundwater supply

III. Hilly area from the East of the country, the Central Moldavian Plateau and the Transylvanian Tableland – altitudes 250–350 m (R.B. the Trebeş, Tinoasa Ciurea, and Comlod) annual hs: 100–150 mm

- Highest hs values: months III–IV, source: rains and snowmelt
- Lowest hs values: months VII–VIII; XII–II
- Particularities: no groundwater contribution for F<30 km^2

C. TFV corresponding to plain regions

I. The West Plain and the Romanian Plain, 120–150 m altitudes (R.B. the Varieş, Tinoasa and Vedea) annual hs: 20–30 mm

- Highest hs values: month IV, source: rains and snowmelt
- High values: months I–II, source: rains and snowmelt
- Lowest hs values: months VI–VIII
- Particularity: no groundwater contribution at F<15–20 km^2 censed by drying up phenomena

4. CONCLUSIONS

On the basis of a very accurate hydro-meteorological data-base obtained from Romania's representative basins and the corresponding processing, the types of hydric regime in small basins have been established in terms of drained layer size (annual values), time-intervals in which highest and lowest drained layer values occur as well as the contribution of supply sources (liquid precipitation, solid precipitation and groundwater flow) in mm and also in percentages.

These basins are located in the main relief forms: mountains, hill-plateaus, and plains. Several sub-types have resulted as rainfall in the mountain region (for example) decreases from West to East.

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