SPACE-TIME EVOLUTION OF THE AVERAGE RIVER FLOW IN TRANSYLVANIA DEPRESSION

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ABSTRACT. Space-time evolution of the average river flow in Transylvania Depression. Transylvania's physico-geographic factors distinguish it as a well-structured depression unit. Climate and relief features give it an unitary systemic functioning, which can be said about river water runoff. The three main rivers are well monitored by hydrometric stations located at the limits of the region. The length of flow strings has allowed real river flow analysis. Correlations between flow and time demonstrate the land's systemic unity from a hydrological point of view. The variation of annual, seasonal and monthly averages indicates unitary variation laws. The values of the specific flow and the depth of surface runoff highlight the influence of the local factors, which incubate flow differentials.

Keywords: climate and relief, average flow, flow laws, spatial differentiation, correlations.

1. GENETIC FLOW FACTORS

The Transylvanian Depression exists and functions as an area of geographic convergence (Irimuș, 1998). It is clear from this finding that in Transylvania not only the relief has transitory characteristics between Western and Eastern Europe, but also the other geographic components, including the hydrological component. The spatial relations of the depression with the Carpathian Range and the systemic functioning as a well-structured entity are also reflected in the river flow characteristics. The climate, as the direct determinant of river flow, owes its characteristics to the general circulation of the atmosphere over which local influences are exerted.

The main climatic factor of the river flow is precipitation. Its spatio-temporal distribution is determined by three types of air circulation: zonal, polar and tropical. Other important factors of precipitation are the main (Azoric and Siberian anticyclones, Icelandic and Mediterranean cyclones) and secondary pressure centers (Scandinavian, Greenland, North African, Arabic Cyclone, Carpathian orographic cyclone genesis) (Croitoru, 2006).

Along with precipitation, temperature is a determinant factor for river flow distribution. The position of the Transylvanian Depression towards the orientation

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of the dominant air currents and the characteristics of the surrounding mountain relief influence the temporal and spatial variation of the air temperature.

The relief, through elevation, slope exposure, gradient and shape configuration, is defined as an important climatogenetic factor, which also determines important differences in precipitation distribution. The relief's role in the genesis and distribution of precipitation it is not so much determined by the relative relief of the depression, relatively homogeneous, but by the presence of the mountain range, which closes it almost completely. The Carpathians constitute a climate barrier, at the same time generating ascending phenomena of air masses. An important local factor is the direction of the main valleys (Someş, Mureş, Târnava Mare, Târnava Mică, Olt), which facilitate the crossing of the region by western air masses.

The role of vegetation in influencing the precipitation distribution is manifested by the large extent of the forests in the adjacent Carpathian area, and less through the variety of vegetal associations in the depression.

2. DATA BASE AND METHOD

The river flow evaluation was performed using data from the Ulmeni hydrometric station on the Someş River, Brănişca on the Mureş River and Sebes Olt on the Olt River. They represent the closure stations of the largest rivers before leaving the Transylvanian Depression and express flow laws in the depression. The period taken into account was 63 years, between 1950-2012. For comparisons and evaluation of flow changes the period 1950-1967 was used. The 18 years have been used in the book *Water Geography of Romania (Geografia apelor României)*, as part of flow assessment throughout Romania (Ujvari, 1972).

Table 1. ***Morphometric station elements***

River	Hydrometric station	A (km^2)	H_{med} (m)
Someș	Ulmeni	11700	580
Mureș	Brănișca	24501	654
Olt	Sebeș Olt	10990	748

Multiannual values of monthly, seasonal and annual discharges were calculated for each period. The drawing of the type Q = f (T) graphs allowed conclusions on evolution and changes in river flow.

Table 2. ***Average flow values***

River	Hydrometric station	Q (m^3/s)	q (l/s.km^2)	V (mil.m^3)	R (mm)
Someș	Ulmeni	89.6	7.66	2826	242
Mureș	Brănișca	167.8	6.85	5292	216
Olt	Sebeș Olt	82.7	7.53	2608	237
		M=113	M=7.3	Σ=10726	M=232

The transformation of multiannual discharges into specific values, water layer and volume allowed correlations with the morphometric elements of the river basins (average altitude and hydrographic basin's area).

3. RESULTS

3.1. Variation of annual flow

The most important finding is that at all three stations the linear trends of flow evolution are increasing. This means that in Transylvania the heating of 0.41 - 0.93°C, calculated based on data from ten meteorological stations (Tudose, Moldovan, 2006), is not accompanied by the flow decrease. The rivers flow trend is contrary.

The variation of grade 5 polynomial trends is very similar. There can be observed a pronounced increase in the early 1950s, followed by relative stability and then slight increase to a peak in the 1970-1980 decade. Then follows a reflux with a minimum between 1990 and 2000, followed by a sharp increase, reaching the peak between 2000-2005. In the last years of the analyzed period, there can be witnessed a decrease of the polynomial variation.

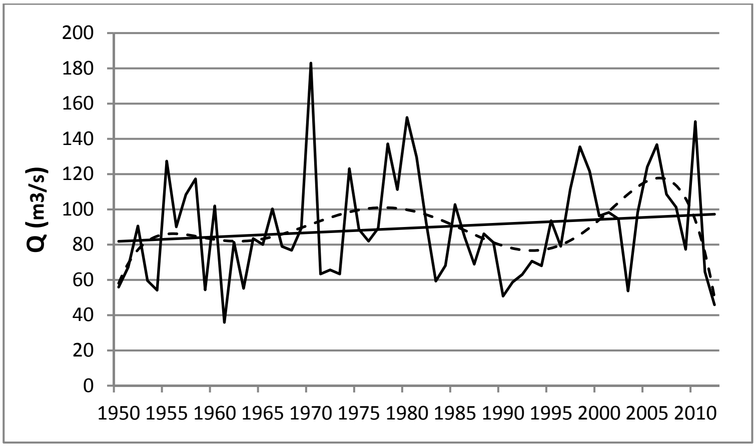

Fig. 1. ***Annual average discharges at Ulmeni station***

Of course, this average variation of river flow tends to have important maximum and minimum peaks. A first peak was recorded in 1955, more pronounced on the Olt River and less significant on the other rivers. An important year is 1970, with historical peaks on Someș (183 m^3/s) and Mureș (308 m^3/s). In 1980-1981, on all rivers, there was a particularly high flow, an historical maximum being observed on Olt River (131 m^3/s). Next, there are three short, one-year or two-year periods with remarkable peaks on all rivers: 1997-1998, 2005-2006 and 2010.

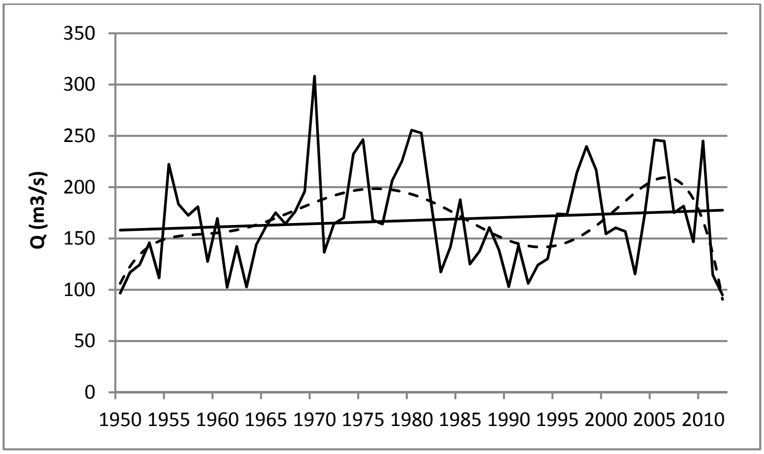

Fig. 2. ***Annual average discharges at Brănișca station***

The river flow was weak in the first and last year of the analyzed period. The lowest annual average flows were recorded in 1961 at Ulmeni (35.9 m^3/s), 2012 at Brănişca (95.0 m^3/s) and 1950, 1963 at Sebeş Olt (41.3 m^3/s). Longer periods with flow were between 1959-1969 on all rivers and between 1983-1996 on Someş and Mureş. In this last interval on the Olt River there were significant flow variations.

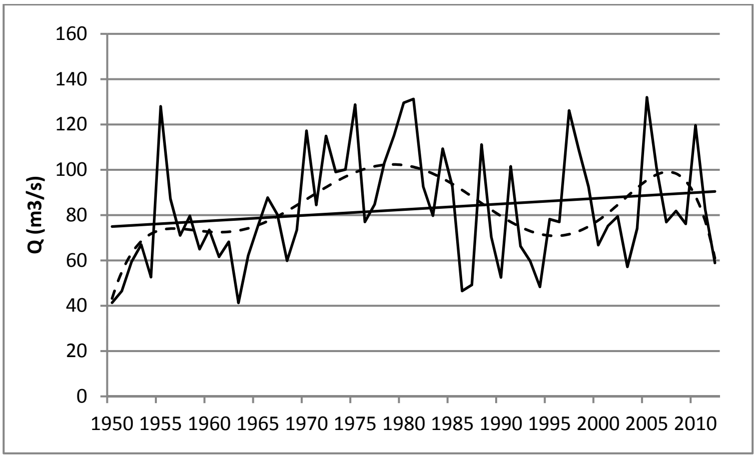

Fig. 3. ***Annual average discharges at Sebeș Olt station***

On all three rivers, the magnitude of annual average discharge variations was significant. The biggest difference was 213 m^3/s on the Mureș River (1970 and 2012). The lower maximum differences were 147 m^3/s (1970 and 1961) on Someș River and 90 m^3/s (1981 and 1963) on Olt River. The amplitude's magnitude is directly proportional to the multiannual average discharges.

3.2. Monthly flow variation

The monthly multiannual average discharge charts have classic aspects and are similar. The richest month in river water flow is April, followed by a continuous decrease until September-November.

However, there are some differences between the three rivers. The value of March is closer to April on Someş than in the case of the other two. March has higher discharges compared to May on Someş. The situation is inverse on Mureş and Olt. The lowest flows were recorded in September - October on Someș, September - November on Mureș and November on Olt. December shows a slight increase over the autumn months on all three rivers. In January, discharges are lower than in December. The discharges are higher than the multiannual average in the months February - June at Ulmeni, March - July at Brănişca and Sebeş Olt.

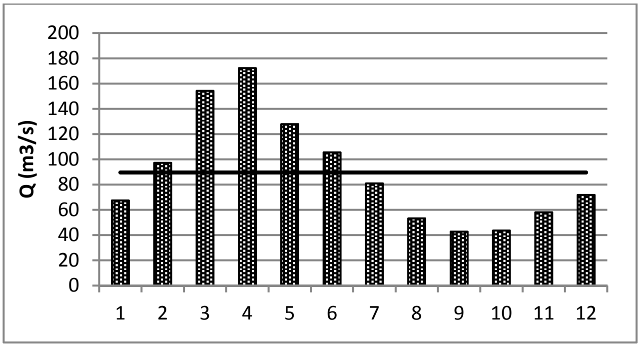

Fig. 4. ***Multiannual monthly average discharges at Ulmeni station***

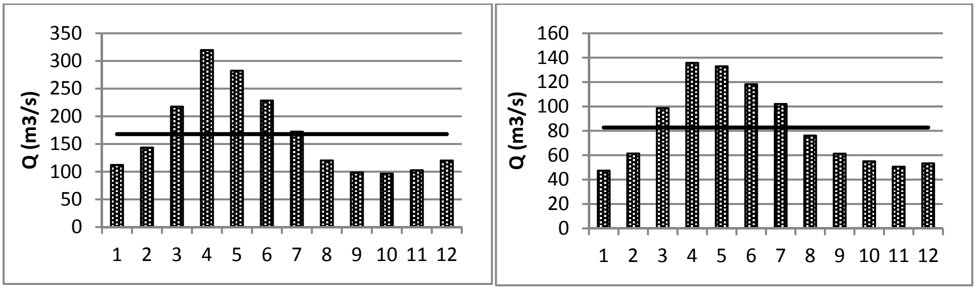

Fig. 5. ***Multiannual monthly average discharges at Brănișca and Sebeș Olt stations***

In order to compare the values obtained over long periods and the values with which I. Ujvari operated, the monthly percentages in the multiannual average discharge were calculated (Ujvari, 1972). There can be noticed a clear decrease of the high spring river discharge during spring months and an increase of September – November discharges. In April, the richest month in water flow, the differentiation has a constant rate from north to south: Someş 1.9 %, Mureş 1.6 %, Olt 1.3 %. In September, a month that has the characteristic the low discharges, the percentage increase of the flow has the following values: 1.2 % on Someş, 1.5 %

on Mureş and 1.0 % on Olt. In January and December, the percentage values of the two periods almost overlap.

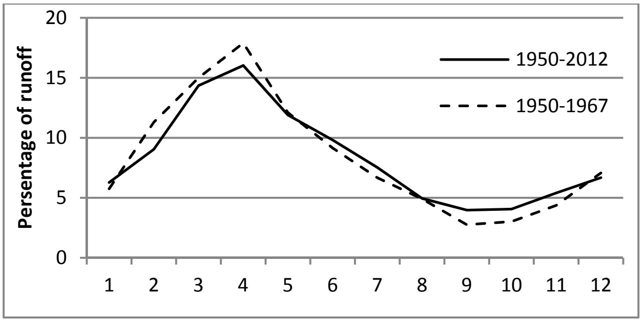

Fig. 6. ***Percentages of multiannual monthly average discharges at Ulmeni station***

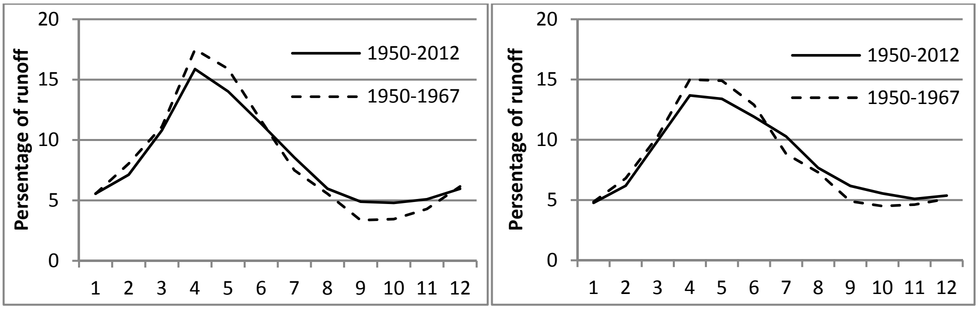

Fig. 7. ***Percentages of multiannual monthly average discharges at Brănișca and Sebeș Olt stations***

3.3. Seasonal flow variation

The differences between the percentages values of seasonal water flow have the same laws at the three hydrometric stations. The spring flow has become poorer and the autumn one richer. During summer and winter the values remained almost unchanged. The decrease in spring is much weaker on Someş (1.7 %) than on the other two rivers (3.8 % on Mureş, 3.2 % on Olt). Autumn increases are more uniform: Someş 3.2 %, Mureş 3.7%, Olt 2.8 %.

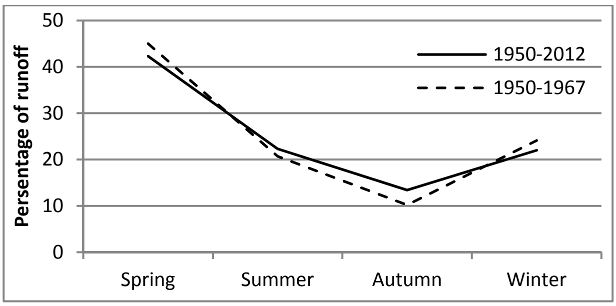

Fig. 8. ***Percentages of seasonal average discharges at Ulmeni station***

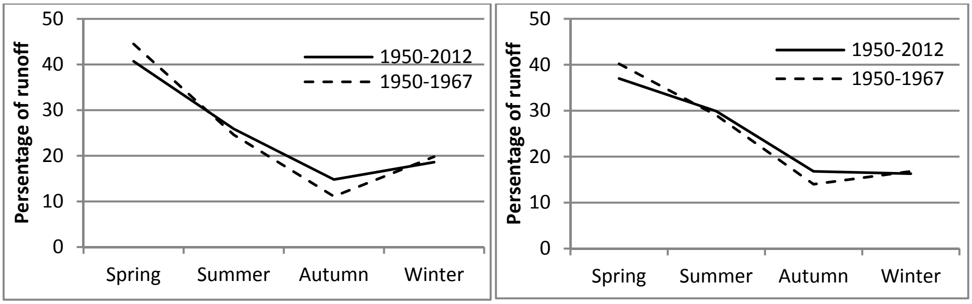

Fig. 9. ***Percentages of seasonal average discharges at Brănișca and Sebeș Olt stations***

3.4. Correlations between specific discharge, water layer and water volume

The specific discharge expresses the richness of water flow from a river basin. The three rivers, although they collect the waters from a unitary physical-geographic unit, differ in their specific discharges. The rivers Someş and Olt, with average altitudes of the differentiated basin areas (580 km^2 and 748 km^2 respectively), have very close values of the multiannual specific flows (7.66 $l/s.km^2$ and 7.53 $l/s.km^2$ respectively). Mureş, with medium average altitude, has a significantly lower multiannual flow rate (6.85 $l/s.km^2$).

The values of the multiannual average water layers are positioned similar to the specific discharges. The maximum water layer appears in Someș River basin (242 mm), although the altitude is the smallest. The minimum value of the layer is in the Mureş basin (216 mm). Thus, for the two expressions of water flow, no correlations can be drawn with the average altitudes of the river basins.

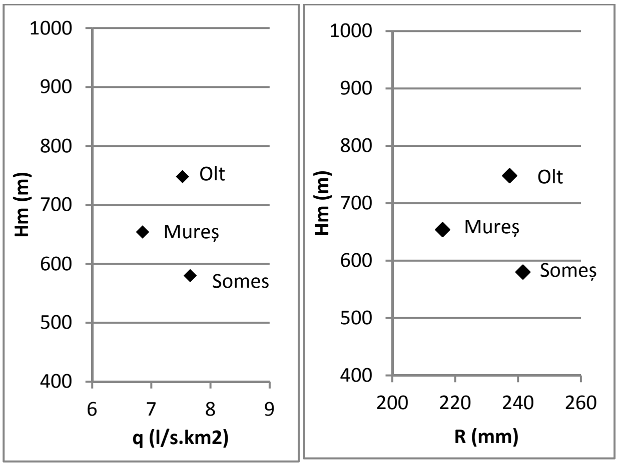

Fig. 10. ***Relation between specific discharge and water layer with altitude***

The volumes of water transported by the three rivers are directly proportional to the river basin sizes. The percentages of water volumes are almost identical to the percentages occupied by the respective basins. For Mureş, the situation is volume percentage is slightly below the surface, and for the other two rivers, the situation is opposite.

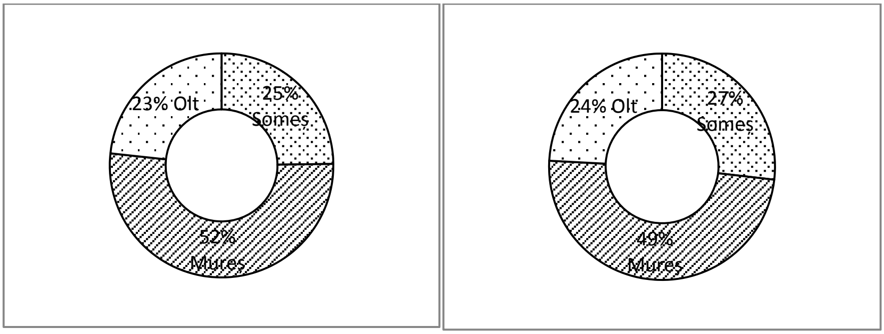

Fig. 11. ***Percentages of river basin surface and flown water volume***

4. CONCLUSIONS

The Transylvanian Depression is a well-personalized physical-geographic unit, including from a hydrological point of view. The three main rivers collecting the waters on this territory show common water flow characteristics, but also some obvious differences. The variation of the multiannual values for annual, seasonal and monthly average discharges present similar variation laws. Differences exist at the correlations of specific flows and water layers with the average altitude of the river basins.

The similarities are due to the relatively unitary systemic character of the Carpathian territory and mountain chain, which delimits and protects the depression in all parts. The differences are consequences of water flow conditions in different parts of the area: the depressions on Someş and upper Mureş rivers (Pandi etc., 2009), the supplying of Someş and Mureş rivers also from the Apuseni Mountains, the supplying of Olt River also from the Curburii and Făgăraş Mountains, the location in precipitation shade of a large part of the Mureş basin.

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