Carpathian Journal of Earth and Environmental Sciences, February 2012, Vol. 7, No. 1, p. 161 - 170

LONG-TERM CHANGES IN AVERAGE ANNUAL LIQUID FLOW RIVER MILETIN (MOLDAVIAN PLAIN)

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Abstract: Miletin basin is located in a temperate continental climate with excessive variations. In this case rainfall causes an increased dispersion of values around the average multiannual flow. Between the stations Sipote and Nicolae Balcescu, where the natural drainage system is affected by human activity, there is a good correlation of the average annual flow fluctuations. The Pearson correlation coefficients of the artificial flow regime from Halceni-downstream flows and changes in the upstream gauging stations (natural regime) have low values. Equally there is a weak correlation between rainfall and the Halceni downstream flow. Analyzing the Moldavian Plain area is an innovation in Romanian literature. For this reason the data obtained cannot be compared with other regions of the country or similar basins. As a result of the relief of the basin in the area drained being relatively flat and low, there is a good correlation between the amount of precipitation and surface runoff. The liquid debit is strongly influenced by human activity, particularly by water harvesting for agriculture of by water collecting in fish farms.

Keywords: amplitude of variation, average flow, coefficient model, Pearson correlation coefficient, standard deviation

1. INTRODUCTION

The native rivers of the Moldavian Plateau have average annual low flow and can often run dry. The main reason is the existence of a climate where rainfall is less evapotranspiration, the sum of evaporation and plant transpiration from the Earth's land surface to atmosphere (the averages range between 550-570 mm of rainfall and evapotranspiration values over 700 mm) (Erhan & Precupanu-Larion, 1994). As a result of water shortages, the local population was forced to build a series of ponds to compensate for the lack of water in summer (Romanescu et al., 2005). For this reason, Botosani and Iasi counties are located between the second and third positions as to the extent of surface water in Romania, although they are among the driest regions in terms of precipitation (Romanescu, 2009).

This study aims to highlight the characteristics of the change of liquid in the annual average flow of a river located in a hilly lowland region, subject to influences of continental temperate climate with excessive variations.

Miletin falls within an anthropogenically heavily modified watershed, with Baseu and Bahlui, located throughout the Moldavian Plain (Romanescu et al., 2005). Miletin, as a tributary of Jijia, is situated in a leading position in terms of changes in surface drainage system and even underground. Precisely for this reason, difficulties have been encountered in linking data across the river course. In most cases water sampling, control or water-consuming units or the local population are not registered, and hence not is the exact value of the volume used (Romanescu, 2006a, b, 2009, Romanescu & Nistor, 2010). Summer water consumption in private households is extremely high because 80-90% of the population is employed in agriculture (Romanescu & Lasserre, 2006).

For analysis of average annual flows and water resources in river basins located in eastern Romania, material of a general nature has been published: Amariucai et al., 2004, Gavrilescu, 2002, Hobai, 2009, 2010, Jora & Romanescu, 2010a, b, Kettrup, 2003, Mares et al., 2009, Muresan, 2009, Napreadan & Chira, 2006, Plesoianu & Olariu, 2010, Romanescu et al., 2010, 2011a,b, Seer et al., 2010, Sica et al., 2002, Teodor & Matreata, 2011, Zavoianu, 1993 etc..

Information on methodology and the processes of similar events in other places worldwide was retrieved from the international literature: Burn & Elnur, 2002, D'Agostino et al., 2010, Festa et al., 2009, Gallerano & Camnata, 2009, Khalig et al., 2009, Schulz & Fleischer, 2002, Solantie, 2003, Tafangenyasha & Dube, 2008, Vos et al., 2010, etc..

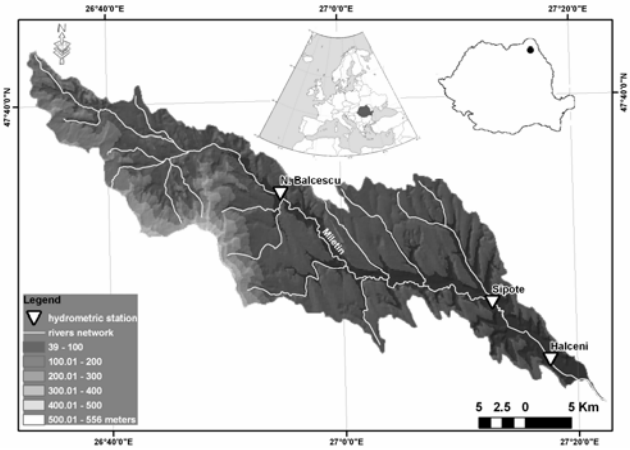

Figure 1. Geographical location of the Miletin basin

2. REGIONAL SETTING

The Miletin Basin is located in the Moldavian Plain and the Suceava Plateau, parts of the Moldavian Plateau. It is framed by the parallels of $47^0$20'25"and $47^0$43'11"N and meridians $27^0$34'26"and $26^0$21'35"E longitude (Fig. 1).

The Miletin River tributary on the right is Jijia. The catchments basins are adjacent to N Sitna, Jijioara and Bahlui S, Siret W and the present Jijia E.

The Miletin basin surface area is 11.72% of the Jijia river basin and 2.45% of the Prut basin area (Fig. 2). As a percentage, 30.24% of the basin area falls within the county of Iasi and 69.76% in Botosani County (Cadastral Survey Water Atlas of Romania, 1992).

The Miletin river basin has a general NW-SE direction. It presents maximum development in the central area and greatly narrows the mouth of the estuary.

3. MATERIALS AND METHODS

Statistical data were obtained from the Department of Water from the River Prut, Iasi, the Moldavian Meteorological Centre, Iasi and the Romanian Waters National Administration, Bucharest. These were processed in the Laboratory of Geo-Archeology of the Faculty of Geography and Geology, Iasi.

Real satellite images were taken from the Remote Sensing and GIS Laboratory of the National Administration of Meteorology and Hydrology and partially processed or interpreted in the Remote Sensing and GIS Laboratory of the Faculty of Geography and Geology, "A.I.Cuza" University and the Geo-Archeology Laboratory.

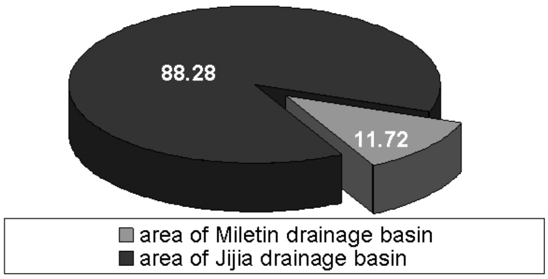

Figure 2. Share of river basin in the basin Miletin and the basin Jijia (main collector)

Most of the satellite images already processed was taken from the Romanian Space Agency (ROSA - Romanian Space Agency) or PNCD12 Project (http://sigur.rosa.ro) on the internet.

Land observations and measurements were taken between the years 2007, 2008, 2009 and 2010. The major route had flooded river beds Miletin and Jijia (main collector). Rates were monitored daily at three stations and topographical measurements were made upstream and downstream from it.

All data analyzed are taken from three meteorological stations (Nicolae Balcescu, Sipote and Halceni-downstream) and from two rainfall stations (Nicolae Balcescu and Halceni).

From a statistical viewpoint 59 and 47 terms respectively were processed. Data from Halceni took place over a period of only 18 years, compared with the other two stations where the period was about 60 years.

This study aims to analyze systematically the frequency of the mean-flow of rivers of Moldavia, in the Miletin River case study. The data obtained to help in assessing water reserves may be contributed by the local population.

4. RESULTS AND DISCUSSIONS

The average flow is the basic element of the hydrological regime of a river. The average flow expresses the amount of water drained by the river in a time unit (Sorocovschi & Buta, 1994).

Liquid medium flows in the river Miletin gauging stations measured the following: Nicolae

Balcescu in 1950, Sipote in 1950 and Halceni downstream in 1991.

Miletin River has an annual average flow from upstream to downstream which increases the discharge from 0.472m^3/s (Nicolae Balcescu station) to 1.258m^3/s (Sipote station). After leaving Lake Halceni the multiannual flow recorded a lower value (1.088 m^3/s), as part of the lake water is retained and used mainly in agriculture (Fig. 3).

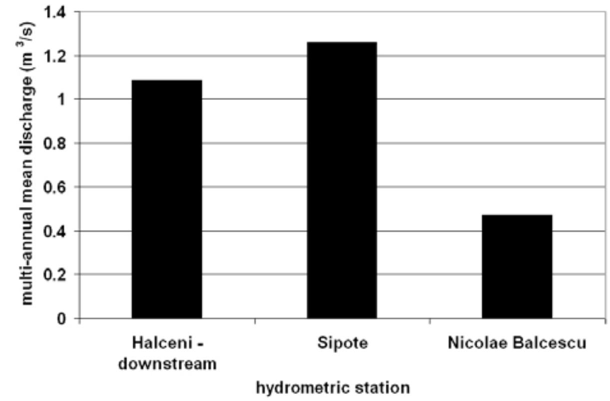

Figure 3. Variation of the multi-annual means discharge in Miletin basin

In the three years at groups of stations, the annual average flow over multi-annual average, and years when there were low flows largely overlap (Fig. 4, 5, 6). This also demonstrates the homogeneity of the morphological and hydrological river basin: the relatively low slopes, evenly distributed throughout the area, the predominance of agricultural use and forestry, etc.

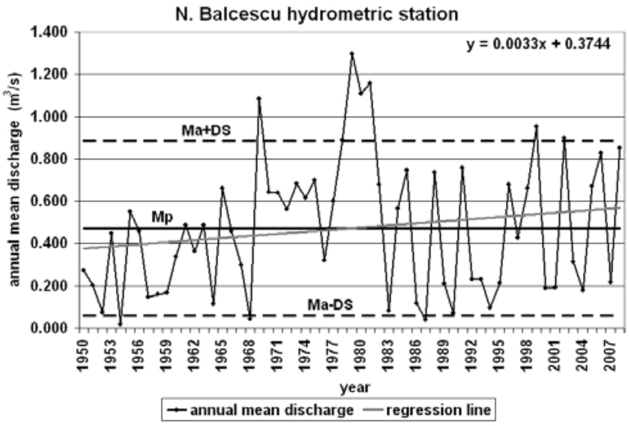

Figure 4. Changes in annual average flow gauging stations within the Miletin basin, at Nicolae Balcescu station

At Sipote and Nicolae Balcescu stations lower flows are highlighted over the 1950-1968 period. From 1969 to 1983, hydrological parameter values have greatly increased in parallel with increasing standard deviation values of the two variables. After 1984 the flow values were lower, remaining around the multiannual average. In the Halceni stream there was a period of four years with low flows (1992-1995) and a period of four years with a rich flow (1996-1999). After 2000 the values were low (1.088 m^3/s).

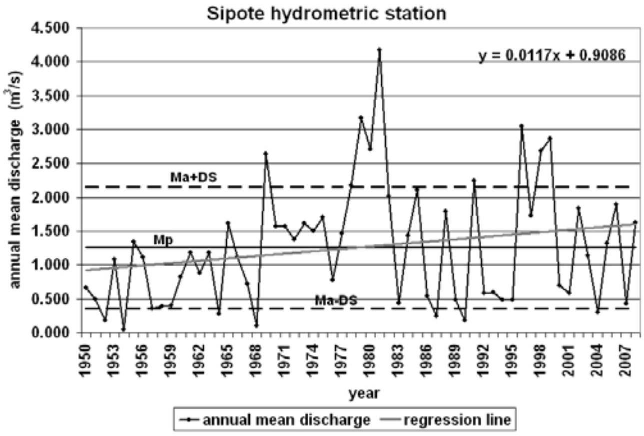

Figure 5. Variation of long-term average annual river flow rates Miletin, Sipote station

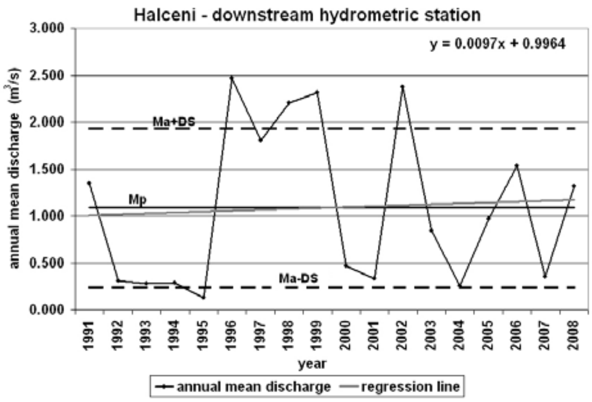

Figure 6. Variation of long-term average annual river flow rates Miletin, Halceni-downstream station

The moving averages calculated from 10 to 10 years, offset by a year, shows a period of rising in the river flow of the Miletin for the years 1973-1982 to 1950-1959 at stations where the river has a natural flow (Sipote and Nicolae Balcescu). After this period there were very much lower values until the period 1986-1995. On Halceni and Sipote downstream, since 1986, and ending with 2005, there is an increasing trend of leakage, after which values decrease again. At Nicolae Balcescu the growth trend has been maintained until today (Fig. 7).

Gliding though the 1950-1959 period, until 1973-1982, the Nicolae Balcescu and Sipote may represent a variation of a section of a centuries-old rhythm. This coincides with a period of 37-40 years. If we follow it now, it will be fully confirmed by the next period, which shows the same features, but with lower values.

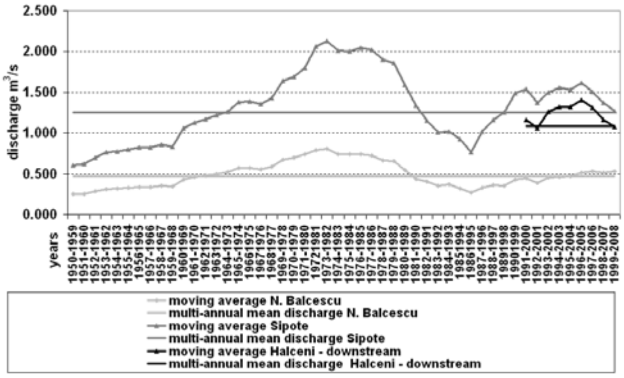

Figure 7. Development of the annual water-flow average calculated using sliding averages of 10 to 10 years, delayed by one year in the river Miletin (1950-2008)

The amplitude of variation increases the upstream flow (1.278m^3/s at Nicolae Balcescu) to downstream (4.125 m^3/s at Sipote) and recorded a much lower in-stream Halceni, 2.41m^3/s (Table 1).

Table 1. Average values of maximum and minimum average flows recorded at the three gauging stations.

Hydrometric station	Average maximum debit	Year	Average minimum debit	Year	Size of variation
Nicolae Balcescu	1.297	1979	0.019	1954	1.278
Sipote	4.172	1982	0.047	1954	4.125
Halceni-downstream	2.469	1996	0.127	1995	2.410

The average annual flow has large oscillations in rainfall characteristics. The standard deviation values in the hydrometric stations Sipote and Nicolae Balcescu (0.411 and 0.679) are very high, indicating a high degree of dispersion around the mean values of multi-annual variables (and a high occurrence of risk events: floods, droughts). Increasing the dispersion around the mean multiannual values from upstream to downstream is determined by uniform precipitation regime in the upper basin, at higher altitudes. The probability of risk events is lower in the upper basin of the river Miletin. Instead, over a shorter period of time (only 18 years), in the lower basin, downstream from Lake Halceni, the average flow shows significant variations from year to year (standard deviation has a value of 0.848 Halceni-downstream station).

The normal range of development of a variable is the arithmetic mean ± standard deviation (SD). Values that exceed this range are striking, if the ranges of the three gauging stations are ± 1D: 0.883 m^3/s - 0.061 m^3/s station Nicolae Balcescu, 1.837 m^3/s - -0.579 m^3/s station Sipote and 1.936 m^3/s - 0.240 m^3/s station Halceni downstream.

At Nicolae Balcescu there were seven years with very high average flow (1969, 1978-1981, 1999, 2002), Sipote 13 years (1969, 1978-1982, 1985, 1991, 1996, 1997, 1999, 2002 and 2006) and in Halceni stream four years (1996, 1998, 1999, 2002). Most years coincide in all three hydrometric stations.

At Nicolae Balcescu station very low flow rates were recorded during 1954 and 1987. Sipote station was 17 years outside the normal rotation interval variation, with very low average flow (1951, 1952, 1954, 1995, 1959, 1964, 1968, 1983, 1986, 1987, 1989, 1990, 1994, 1995, 2004, and 2007). Only in Halceni downstream was a value below 0.240 m^3/s (Fig. 4, 5, 6) recorded in 1995.

The area with the highest probability of hydrological risk phenomena occurring is Miletin middle basin, because Sipote standard deviation values are the largest for a longer period of time. This phenomenon is due to expansion in the central basin, hence the possibility of flood waves. In the upper catchment's area there is higher afforestation, and a more uniform precipitation regime results in a more stable flow. The general trend of increasing mean annual flow is very evident at the three gauging stations due to increased rainfall.

Frequency and duration of the registration of charges on Miletin classes, Nicolae Balcescu station, showed values between 0 and 0.2 m^3/s (25.4% of cases). Years with high average debit of more than 1 m^3/s occur in only 6.7% of cases. At the station for 16 years after 1959 Sipote presented an average low flow from 0 to 0.5m^3/s and only in 1981 did the flow exceed the value of 3.5m^3/s. A similar situation is observed in Halceni downstream, where for almost half of the years analyzed, the sequence of low flows had values from 0 to 0.5m^3/s (Table 2, Fig. 8, 9, 10).

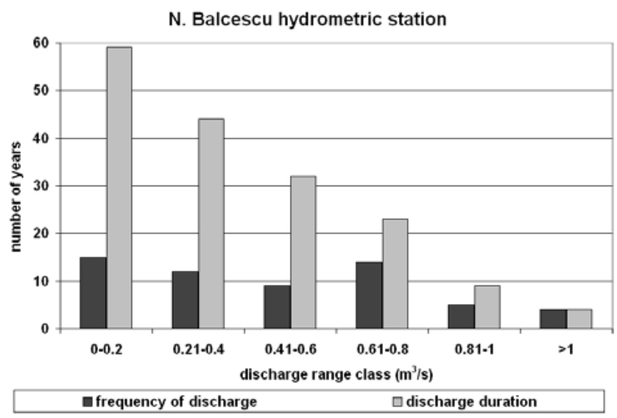

Figure 8. Graph of frequency and duration of discharge on Miletin River, at Nicolae Balcescu station (1950-2008)

The frequency of years with low average flow is the result of a higher frequency of dry years in the NE of the country. Correlation between the variation of the flow-Halceni and Sipote downstream is closer than the relationship of direct proportionality between the flow variation Sipote and Nicolae Balcescu.

Table 2. Frequency and duration of debits on Miletin River

Nicolae Balcescu					Sipote					Halceni-downstream				
Discharge range class (m^3/s)	Number of years	%	Cumulative period (years)	%	Discharge range class (m^3/s)	Number of years	%	Cumulative period (years)	%	Discharge range class (m^3/s)	Number of years	%	Cumulative period (years)	%
>1	4	6.7	4	6.7	>3.5	1	1.7	1	1.7	2.01-2.5	4	22.2	4	22.2
0.81-1	5	8.5	9	15.2	3.01-3.5	2	3.4	3	5.1	1.51-2	2	11.1	6	33.3
0.61-0.8	14	23.7	23	38.9	2.51-3	4	6.8	7	11.9	1.01-1.5	2	11.1	8	44.4
0.41-0.6	9	15.2	32	54.2	2.01-2.5	4	6.8	11	18.7	0.51-1	2	11.1	10	55.5
0.21-0.4	12	20.3	44	74.6	1.51-2	10	16.9	21	35.6	0-0.5	8	44.5	18	100
0-0.2	15	25.4	59	100	1.01-1.5	12	20.3	33	55.9	-	-	-	-	-
-	-	-	-	-	0.51-1	10	16.9	43	72.9	-	-	-	-	-
-	-	-	-	-	0-0.5	16	27.1	59	100	-	-	-	-	-

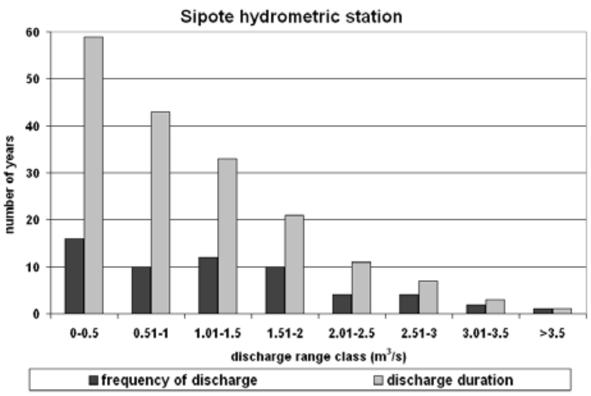

Figure 9. Graph of frequency and duration of discharge on Miletin River, at Sipote station (1950-2008)

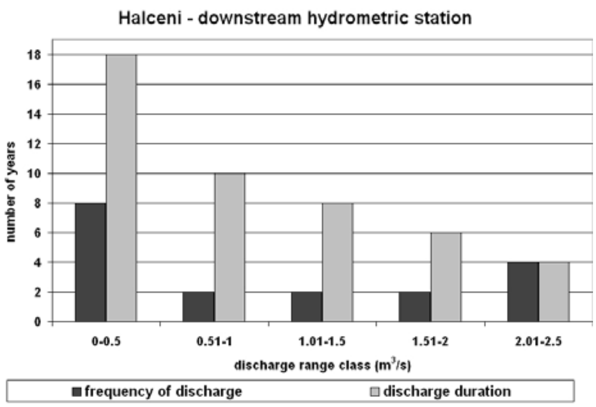

Figure 10. Graph of frequency and duration of discharge on Miletin River at Halceni-downstream station (1991-2008)

In the first case the Pearson correlation coefficient has a value of 0.946, and 0.932 in the second. Closer correlation between the variation of discharge at Sipote and Halceni-downstream stations can be explained by the geographical location of three rainfall stations. Between Nicolae Balcescu and Sipote the distance is 34 km and between Sipote and Halceni-downstream there are just 11 km. At the same time Nicolae Balcescu hydrological station measured parameters for the upper basin of the river. The other two stations are located at the East in the lower basin of the Miletin.

The correlation between changes in annual mean flow stations Nicolae Balcescu and Sipote was very close between 1950 and 1979. Since the1980s the Pearson correlation coefficient values have decreased. Case synchronization of an increasingly weaker annual flow from two vantage points can be attributed to the stronger impact of human activities on the environment, and climate change in recent decades (Fig. 11).

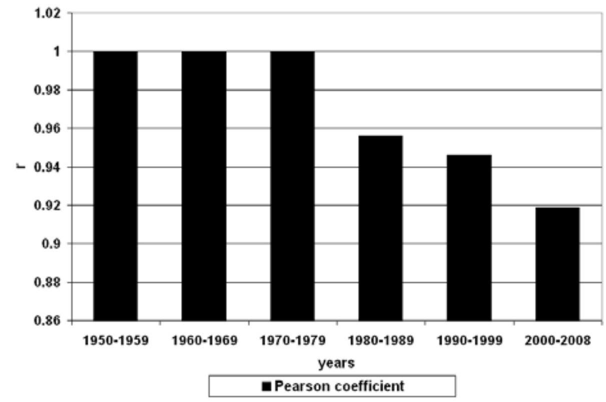

Figure 11. Variation of the Pearson correlation coefficient (r) between the values of flow gauging stations Sipote and Nicolae Balcescu (1950-2008)

Mode coefficient (K_i) is an index widely used in analyzing changes in average flow (Minea & Romanescu, 1997). This index expresses the average annual flow oscillation (Q_{an}) from the flow module (Q_0) and is calculated as the ratio of the two types of flows: $K_i = Q_{an}/Q_0$. When the values of this coefficient are above the unit, leakage is high. When the value becomes less than the unit, flow is reduced (the river is drained to 0).

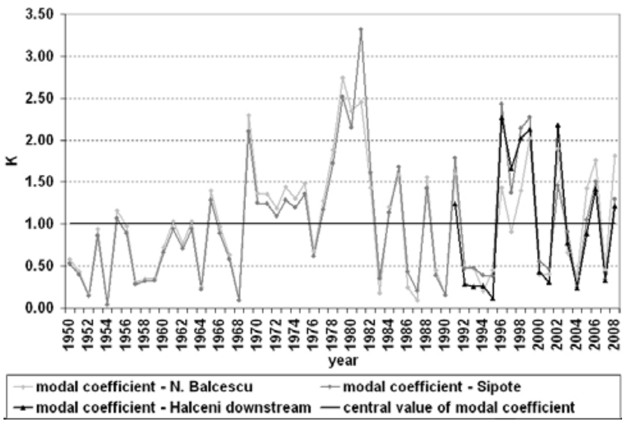

Figure 12 Variation of modules of coefficients (K) on the river gauging stations Miletin (1950-2008)

The values of these coefficients show that the hydrographic Miletin basin has leaked considerably in the years 1955, 1965, 1969-1975, 1977-1982, 1984, 1985, 1988, 1991, 1996-1999, 2002, 2005, 2006 and 2008. Smaller amounts of water were recorded in the years 1950-1954, 1956-1964, 1966-1968, 1976, 1983, 1986, 1987, 1989, 1990, 1992-1995, 2000, 2001, 2003, 2004 and 2007 (Fig.12). There is a period of 19 years with below par values of the coefficient modules (1950-1968) and an interval of 14 years in which there was a high frequency of years characterized by a rich flow (1969-1983). Amplitude coefficients of variation of modules recorded the highest value to Sipote (3.28) and a minimum value-stream at Halceni (2.02) due to the regularization of the Miletin river course (Table 3).

Monthly average flow at present significant fluctuations from month to month. These variations are a consequence of influence exerted by climatic factors acting on the food sources. Analysis of monthly average flow oscillations allows the peculiarities of flow regime to be determined.

Highest average flows, Nicolae Balcescu and Sipote stations were recorded in March-April and June (Table 4, Fig. 13). Maximum average flow during March-April is a result of melting snow. Precipitation values increased in the first half of the spring season. High frequency of air masses from the northwest and southeast generate peak annual rainfall, which causes the formation of the second maximum annual flow regime of the summer.

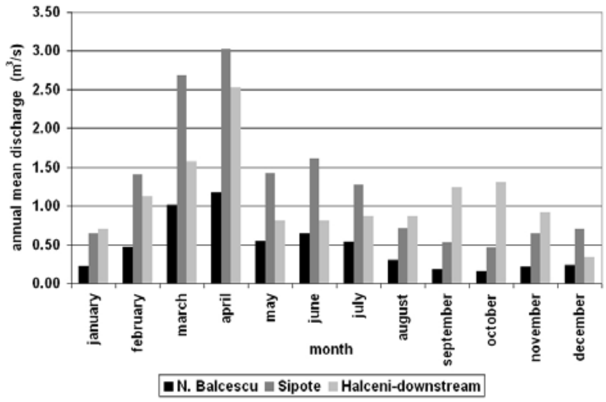

Figure 13 Variation of the annual mean discharge in the catchment's area of the Miletin basin

The smallest quantity of water recorded at the beginning of the autumn season (September-October) because of an intense anticyclonic activity in this period, an activity which results in a decrease in cloud and precipitation (Erhan & Precupanu-Larion, 1994, Pantazica, 1967, 1974).

At the hydrometric Halceni-downstream station, due to the width of the Miletin River, annual average flow regime is different. At the beginning of the autumn season, unlike the other two stations upstream and downstream from Halceni second maximum flow is recorded, reaching average values of 1.32m^3/s in October.

Table 3. Minimum and maximum module coefficients in the River Miletin catchment's characteristics at the gauging stations

Nr.	Hydrometric station	Maximum coefficient module (K_M)	Year	Minimum coefficient module (Km)
1	Nicolae Balcescu	2.75	1979	0.04
2	Sipote	3.32	1981	0.04
3	Halceni-downstream	2.13	1999	0.12

Table 4. Changes in monthly average river flows during 1950-2008 Miletin

Hydrometric Station	J	F	M	A	M	J	J	A	S	O	N	D
Nicolae Balcescu	0.222	0.466	1.010	1.167	0.540	0.649	0.529	0.300	0.175	0.162	0.214	0.235
Sipote	0.642	1.40	2.69	3.02	1.420	1.606	1.269	0.708	0.524	0.460	0.649	0.706
Halceni-downstream	0.699	1.121	1.574	2.528	0.805	0.800	0.873	0.872	1.23	1.302	0.916	0.336

J-January, F-February, M-March, A-April, M-May, J-June, J-July, A-August, S-September, O-October, N-November, D-December.

In areas characterized by a temperate continental climate with excessive rainfall, a high degree of variation was recorded, a phenomenon clearly highlighted by the high values of statistical parameters of dispersion. Within the Miletin watershed the rainfall measurements have been at Nicolae Balcescu station since 1962 and in Halceni station since 1991. The graphic analysis of variation in annual precipitation offers the following conclusions for Nicolae Balcescu (Fig. 14):

- the period 1962-1980 has seen in surplus in terms of rainfall. Most of the years recorded values over multi-annual average of 560 mm. Average annual flow values recorded the highest values, especially in the second interval.

- after 1980 until 1995, precipitation decreased greatly, a phenomenon that led to a lowering of Miletin river flow values.

- after 1995 values of precipitation and liquid flow rates varied around the average multi-annual value.

- eighty per cent of surplus years in terms of rainfall were recorded over the average multi-annual flow.

- in years with rainfall amounts of less than 560 mm, 74% were characterized by lower flows of 0.522 m^3/s (multi-annual average of the leak).

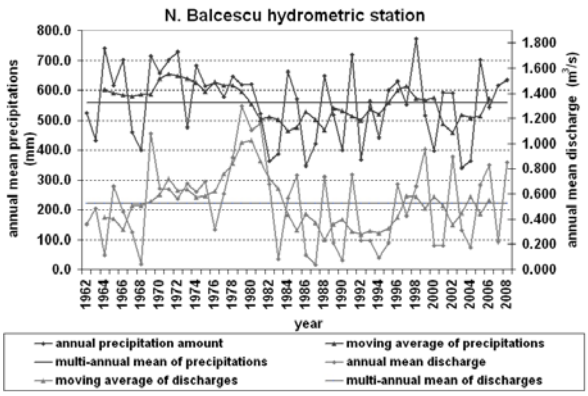

Figure 14. Variation over several years of the annual quantity of precipitation and the average annual discharges on Miletin river, at Nicolae Balcescu station (1962-2008)

Decisively influential changes in the precipitation regime in the average annual river flow of the Miletin watershed at Nicolae Balcescu hydrometric station.

Changes in rainfall precipitation Halceni-downstream station during the period 1991-2008, show an irregular (Fig. 15). Periods 1992-1994, 1997-2000 and 2003-2005 were characterized by low amounts of precipitation. Only 44% of these years give values of liquid flow of a multi-annual average.

In the years 1991, 1995, 1996, 2001, 2002, 2005-2008 rainfall values over multi-annual average were recorded, but in only 45% of cases was the flow rich. When comparing the Pearson correlation coefficients of atmospheric precipitation and liquid flow regime of the two gauging stations, there is a very considerable difference (r = 0.477 to r=0.237 - Nicolae Balcescu to Halceni-downstream). This phenomenon is a consequence of regularization of the Miletin river course in the lower basin, which has modified the natural flow of the watercourse.

Within a year, monthly rainfall modified evolution from one month to another, depending on the relations established between different cyclonic and anticyclonic seasons which required a certain dynamic of air masses crossing the NE part of the country.

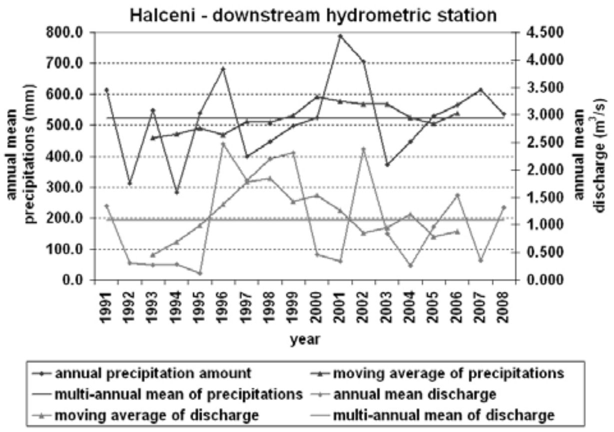

Figure 15. Variation of annual precipitation amounts and annual mean discharge at Halceni-downstream station (1991-2008)

Monthly amounts of precipitation increased gradually from February to June when the maximum rainfall occurs annually. From June to February, when the two stations recorded minimum annual rainfall, monthly rainfall amounts diminished.

February is dominated by the movement of continental Eastern circulation and the frequency of pulsed air masses of the Russian-Siberian anticyclone is very high. This contributed to the occurrence of the minimum annual rainfall.

June is dominated by the Azores anticyclone Ridge, which develops more depression than for N and E. The Icelandic depression collapses gradually, while the Arabian one, extinguished, occupies the south-eastern periphery of Europe, dominating the oceanic circulation in the area from NE to SW. It favors the appearance of intense sunshine. The cyclones cause the formation of local rainfall (Mihaila, 2006).

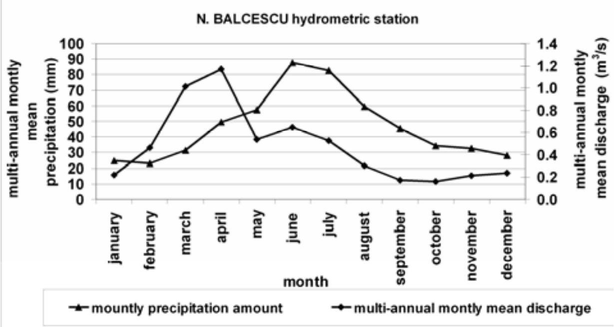

Figure 16. Annual variation of monthly quantities of precipitation and multi-annual monthly mean discharge at Nicolae Balcescu hydrometric station (1962-2008)

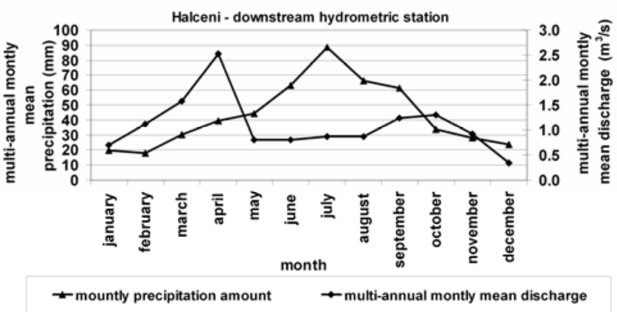

Figure 17. Annual variation of monthly quantities of precipitation and multi-annual monthly mean discharge at Halceni-downstream hydrometric station (1991-2008)

After maximum rain in June, the Nicolae Balcescu triggers the occurrence of the second maximum in the development of the average annual liquid flow. Decreased rainfall in July-December period is a negative trend in the average flow development. The invasion of warm air from the late winter and early spring, and increased rainfall in the February-April period, cause a sharp increase in average monthly liquid flow. On-stream Halceni correlation between the two hydro-climatic parameters is very poor due to regularization of the watercourse (Fig. 16, 17).

5. CONCLUSIONS

The variation of long-term average annual flow of liquid in the Miletin basin presents an irregular, with large variations from year to year. Many years of low river flow were recorded. This was due to the Miletin temperate continental climate with excessive variation, characterized by frequent droughts.

With the annual variation of monthly flows, Nicolae Balcescu and Sipote stations are predicting a peak in April, one in June and a minimum phase in February. At Halceni-stream, due to regularization of the watercourse, the second maximum flow was recorded in the first part of the autumn season (September-October), and a minimum during the summer, when high values of precipitation were registered.

The monthly liquid flow regime in the lower basin was an isolated incident in the Miletin Plain between the Moldavian's rivers. The main reason is anthropogenic interference: the riverbed hydraulic works of minor and major development, the construction of reservoirs, the removal of water by agriculture, etc.

Statistical parameters reveal a high degree of dispersion which spreads the values of hydro-climate around the multiannual average. The correlations between the rates and amounts of rainfall gauging stations and posts analyzing the natural flow of the river Miletin are very close. The regularization in the lower basin of water Miletin causes unusual characteristics of the flow compared to the normal.

Just gliding during the years 1950-1959, until 1973-1982 (Nicolae Balcescu and Sipote), perhaps represents a rhythmic segment of a centuries-old secular variation (at intervals of 37-40 years).

ACKNOWLEDGEMENTS

Our thanks go to the Laboratory of Geo-Archaeology within the Faculty of Geography and Geology, University Al. I. Cuza of Iasi, for providing all the instruments and facilitating the processing of the data.

REFERENCES

Amariucai, M., Romanescu, G. & Rusu, C., 2004. *Surface hydric potential and its capitalization in the eastern part of Romania (Moldavia).* Bulletin of the Romanian Geography Society, Special issue dedicated to the Congress of International Geographical Union „One Earth – Many Worlds", Glasgow, 15–20 august 2004, New series, CD PRESS, Bucharest, 10(80), 109-123.

Burn, D.H. & Elnur, M.A.H., 2002. *Detection of hydrologic trends and variability*, Journal of Hydrology, 255(1-14),107-122.

Cadastral Survey Water Atlas of Romania, 1992. *Part 1 – Morpho-hydrographic data on the surface hydrographic network (in Romanian)*, Ministry of Environment, Bucharest. p.694.

D'Agostino, D.R., Trisorio, L.G., Lamaddalena, N. & Ragab, R., 2010. *Assessing the results of scenarios of climate and land use changes on the hydrology of an italian catchment: modelling study*, Hydrological Processes, 24(19),2693-2704.

Erhan, E. & Precupanu-Larion, D., 1995. *The annual regime of the atmosferical precipitations in the Moldavian Plain*, Annals of the Alexandru Ioan Cuza University, Section Geography, 40-41, 113-122.

Festa, G., Verde, D. & Magini, R., 2009. *Rehabilitation of water distribution system with diffused water losses*, Water Resources Management, WITpress, 5, 259-268.

Gallerano, F. & Cannata, G., 2009. *Numerical integration of the contravariant from of the two phase flow motion equations*, Water Resources Management, WITpress, 5, 401-414.

Gavrilescu, M., 2002. *Risk management: land-use planning under european approach*, Environmental Engineering and Management Journal, 1(2), 231-241.

Hobai, R., 2009. *Analysis of air temperature tendency in the upper basin of Barlad river*, Carpathian Journal of Earth and Environmental Sciences, 4(2), 75-88.

Hobai, R., 2010. *Considerations regarding the impact of the global climatic changes on the mean discharges in the upper basin of Barlad river*, Present Environment and Sustainable Development, 4, 353-362.

Jora, I. & Romanescu, G., 2010. *Hydrograph of the flows of the most important high floods in Vaslui river basin,* Air and Water. Environmental Components, University Press Cluj-Napoca, 91-102.

Jora, I. & Romanescu, G., 2010. *Influence of human induced activities on Vaslui river hydrological regime (in Romanian)*, The Romanian Water Resources. Transversal Press, Târgovişte, 201-208.

Kettrup, A.A.F., 2003. *Environmental monitoring*, Environmental Engineering and Management Journal, 2(2), 119-130.

Khalig, M.N., Ouarda, T.B.M.J., Gachon, P., Sushama, L. & St-Hitaire, A., 2009. *Identification of hydrological trends in the presence of serial and cross correlations: A review of selected methods and their application to annual flow regimes of Canadian rivers,* Journal of Hydrology, 368(1-4), 117-130.

Mares, C., Mares I. & Stanciu, A., 2009. *Extreme value analysis in the Danube lower basin discharge time series in the twentieth century*, Theoretical and Applied Climatology, 95(3-4), 223-233.

Mihaila, D., 2006. *The Moldavian Plain. Climatic Study (in Romanian)*, University Press, Suceava. p.465.

Minea, I. & Romanescu, G., 1997. *Hydrology of continental environments. Practical applications (in Romanian)*, Demiurg Press, Iasi. p.221.

Muresan, A., 2009. *Relationship between the bed material size and the amount of metamorphic and volcanic rocks in hydrographic basins regarding two rivers from Maramures mountains (Eastern Carpathians – Romania)*, Carpathian Journal of Earth and Environmental Sciences, 4(1), 19-29.

Napradean, I. & Chira, R., 2006. *The hydrological modeling of the Usturoi valley – using two modeling programs – WetSpa and HecRas*, Carpathian Journal of Earth and Environmental Sciences, 1(1), 53-62.

Pantazica, M., 1967. *Phénomènes d'hiver sur les cours d'eau du nord-est de la Moldavie*, Annals of the Alexandru Ioan Cuza University, Section Geography-Geology, 13, 155-159.

Pantazica, M., 1974. *The Hydrography of Moldavian Plain*, Junimea Press, Iasi. p.246.

Plesoianu, D. & Olariu, P., 2010. *Monitoring data proving hydroclimatic trends in Siret hydrographic area*, Present Environment and Sustainable Development, 4,183-188.

Romanescu, G., Romanescu, Gabriela, Minea, I., Ursu, A., Margarint, M.C. & Stoleriu, C., 2005. *Inventory and typology of wetlands in the Moldavian Tableland. Case study for Iasi and Botosani counties (in Romanian),* Didactic and Pedagogic Press, Bucuresti. p.165.

Romanescu, G., 2006a. *The effect of the carastropgic inundations from Siret River's lower basin (Romania) from july 2005 in the context of the global climatic change*, Risks and Catastrophes, 5(3), 203-216.

Romanescu, G., 2006b. *Floods as risk factor. Case study for the floods ob Siret in July 2005 (in Romanian)*, TERRA NOSTRA Press, Iasi. p.88.

Romanescu, G. & Lasserre, F., 2006. *Le potentiel hydraulique et sa mise en valeur en Moldavie Roumaine. In: Politiques de l'eau. Grands principes et réalités locales*, Presses de l'Université du Québec, 325-346.

Romanescu, G., 2009. *Siret river basin planning (Romania) and the role of wetlands in diminishing the floods,* Water Resources Management, WIT Press, 5, 439-454.

Romanescu, G. & Nistor, I., 2010. *The effect of the July 2005 catastrophic inundations in the Siret River's Lower Watershed, Romania*, Natural Hazards, 57(2): 345-368. DOI: 10.1007/s11069-010-9617-3.

Romanescu, G., Dinu, C., Stoleriu, C. & Romanescu, A.M., 2010. *Present state of trophic parameters of the main wetlands and deep waters from Romania*, Present Environment and Sustainable Development, 4, 159-174.

Romanescu G., Jora I. & Stoleriu C., 2011a. *The most important high floods in Vaslui river bassin – causes and consequences*, Carpathian Journal of Earth and Environmental Sciences, 6(1), 119-132.

Romanescu G., Stoleriu C., Romanescu A.M., 2011b, *Water reservoirs and the risk of accidental flood occurrence. Case study: Stanca–Costesti reservoir and the historical floods of the Prut river in the period July–August 2008, Romania*, Hydrological Processes, 25, 2056-2070. Doi: 10.1002/hyp.7957.

Schulz, E. & Fleischer, K., 2002. *Risk and landscape changes*, Risks and Catastrophes, 1, 24-36.

Seer, M., Magyari-Saska, Z. & Dombay, S., 2010. *Some considerations on average, maximum and minimum flows in the catchment area of upper Mures*, Air and Water. Environmental Components, University Press Cluj-Napoca, 1, 240-247.

Sica, M., Toader, R., Draghici, C., Tica, R. & Drăgan, D., 2002. *Barsa river monitoring*, Environmental Engineering and Management Journal, 1(3), 347-354.

Solantie, R., 2003. *Land use in relation to climate and hydrology in Finland*, Risks and Catastrophes, 2, 151-159.

Sorocovschi, V. & Buta, I., 1994. *Hydrometry (hydrologic measurements and calculations)*, "Babes-Bolyai" University Press, Cluj-Napoca. p.290.

Tafangenyasha, C. & Dube, L.T., 2008. *An Investigation of the Impacts of Agricultural Runoff on the Water Quality and Aquatic Organisms in a Lowveld Sand River System in Southeast Zimbabwe*, Water Resources Management, 22(1), 119-130.

Teodor, S. & Matreata, S., 2011. *A way of determining how small river basins of somes rivers are susceptible to flash-floods*, Carpathian Journal of Earth and Environmental Sciences, 6(1), 89-98.

Vos, N.J., Rientjes, T.H.M. & Gupta, H.V., 2010. *Diagnostic evolution of conceptual rainfall-runoff models using temporal clustering*, Hydrological Processes, 24(20), 2840-2850.

Zavoianu, I., 1993. *Romanian's Water Resources and their Use*, Geojournal, 29(1), 19-30.

Receievd at: 01. 05. 2011
Revised at: 19. 10. 2011
Acepted for publication at: 28. 10. 2011
Published online at: 01. 11. 2011