Water resources and wetlands, *Editors: Petre Gâştescu, William Lewis Jr., Petre Breţcan*
Conference Proceedings, 14-16 September 2012, Tulcea - Romania
ISBN: 978-606-605-038-8

THE REASONS OF THE INSTATIONARITY OF THE SEASONAL RUNOFF OF RIVERS AND STREAMS IN THE RIKA RIVER BASIN

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Abstract

In this paper are the results of the research of the stationarity of the seasonal (spring, summer, autumn, winter) hydrological and meteorological observations data and changes at time their average values in the Rika River Basin for all period of observation. The stationarity of the hydrometeorological characteristics was researched by estimation of the significance of the trends at 5% level of the significance. The total and diference-integral curves were analyzed.

Keywords: climate change, small mountain catchments, stationarity, seasonal runoff, integral curves, cyclical fluctuations

1 INTRODUCTION

One of aspects of the research of long-term fluctuations of the river runoff is the seasonal runoff. Establishing of the regularities of distribution of river runoff for calendar period, seasons and within seasons for the year has important scientific and practical importance. On the basis of these data is planning the using of water resources for the various water economic purposes and determination of the main parameters of the hydraulic engineering constructions. However, before beginning of the statistical analysis of the basic data it is necessary to check this data on the stationarity because in view of the climatic changes in the runoff time series of the rivers and also in the series of the meteorological characteristics very often there are trends of the different directions.

The main goal of this paper is the research of the stationarity seasonal hydrological and meteorological data and the research of the changes at time their average values in the Rika River Basin. It will allow to define the possible changes of their seasonal distribution and to analyze the reasons for such changes.

The 16 points of observations were chosen for research which is located on the 4 small and 2 medium rivers and 5 streams. These mountain watercourses have very different physical and geographical conditions of the runoff formation. The period of observation on these water bodies is from 46 to 49 years. The characteristics of the study area are enough described in details in the work (Bauzha&Gorbachova, 2012).

2 METHODS

The determination of the stationary of the long-term fluctuations of the seasonal runoff (spring, summer, autumn and winter) of the rivers and streams of the Zacarpatska station is carried out by the assessment of the statistical significance of the linear trends (MRAH, 2010). In turn, the statistical significance of the trends is defined by the statistical significance of the correlation coefficient (R). The correlation coefficient of this dependence is estimating on the relation to the standard deviation (σ_R):

$$R / \sigma_R \geq \beta \tag{1}$$

For 5 % of the significance level or for the 95 % confidential limit $\beta = 2$. If as a result of the calculations it will appear that $2\sigma_R < R$, it indicates no stationarity of the long-term fluctuations of the runoff, and on the contrary, if $2\sigma_R > R$ – the homogeneity of the runoff in the time. The standard deviation of the correlation coefficient for $n > 25$ is defining by the formula:

$$\sigma_R = \left(1 - R^2\right) / \sqrt{n-1} \tag{2}$$

where n – the total number of the members of the row.

The change at time the average of the seasonal runoff, air temperature and precipitation in the basins of the researched rivers and streams was carried out according to

$$\overline{A}_k = \frac{\sum_{i=1}^{N+k} A_i}{N+k}, \tag{3}$$

where A – the value of the hydrological and meteorological characteristics; i – the ordinal number of the hydrological and meteorological characteristics; N – the initial number of members of the observation series; $k = 1, 2, 3...n$.

For analysis of the regularities of the cyclical fluctuations of the runoff, air temperature and precipitation on the mountain watersheds were used the difference integral curves. For comparison of the results the plots of the long-term dynamics, of the difference integral curves, of the change at time of the average of the hydrometeorological characteristics were created in the modulus coefficients (K) according to

$$K_A = A_i / \overline{A} \tag{4}$$

The estimation of the homogeneity of the series of observations is carried out by the total integral curves.

3 RESULTS

For analyses of the relationship of the seasonal discharge, air temperature and precipitation was created the matrix of their pair correlation coefficients (Table 1).

Table 1 The matrix of the pair correlation coefficients of the seasonal discharge, temperature and precipitation (Rika River – Mizhhirya village, 1961-2006)

	Q	*T*	*P*		*Q*	*T*	*P*
	spring				summer		
Q	1	0.0	0.64	*Q*	1	-0.51	0.86
T	0.0	1	0.0	*T*	-0.51	1	-0.42
P	0.64	0.0	1	*P*	0.86	-0.42	1
	autumn				winter		
Q	1	0.0	0.93	*Q*	1	0.56	0.83
T	0.0	1	0.1	*T*	0.56	1	0.27
P	0.93	0.1	1	*P*	0.83	0.27	1

It is established that the discharges have the closest relation to the precipitation for all seasons of the year. The largest such relation is in the autumn (R = 0.93) in the absence of the relation between discharges and temperature, as well as in the absence of the relation between the temperature and precipitation. The least relation is at the spring ($R = 0.64$) in the absence of the relation between discharges and air temperature, and air temperature and precipitation, too. The relation of the discharges and temperature in the winter is positive ($R = 0.56$), and in the summer – negative ($R = -0.51$). The increasing of the temperature in the winter period increases the discharge of the rivers and streams in the Rika River Basin (liquid precipitation, snowmelt, etc.) but in the summer, on the contrary – the decreases of the discharges (evaporation, etc.). In the summer the relationship of the precipitation with the temperature is negative ($R = -0.42$) but in the winter – positive ($R = 0.27$). Thus, the absolute value of their correlation coefficient less than 0.8. It is indicates on the absence of the multicollinearity, i.e. the analysis of the formation of the discharges in the summer and in the winter is necessary to carry out with considering the precipitation and temperature but in the spring and in the autumn – the precipitation only.

The synchronous fluctuations of the temperature and precipitation observed at all of the meteorological stations, although they are located in the different parts of the studing area (Fig. 1 *a, b*). The dynamics of the seasonal (summer) temperature and of the seasonal (spring, autumn) precipitation has the statistically significant trends (Table 1). It is indicates on the inhomogeneity of the observations data (changes at time of the average). In the research of the dynamics of the seasonal runoff of the rivers and

streams on the 16 of observation gauges on four seasons (spring, summer, autumn, winter), statistically significant trends were found only in the 7 cases from 64 researched series of observations (Table 2).

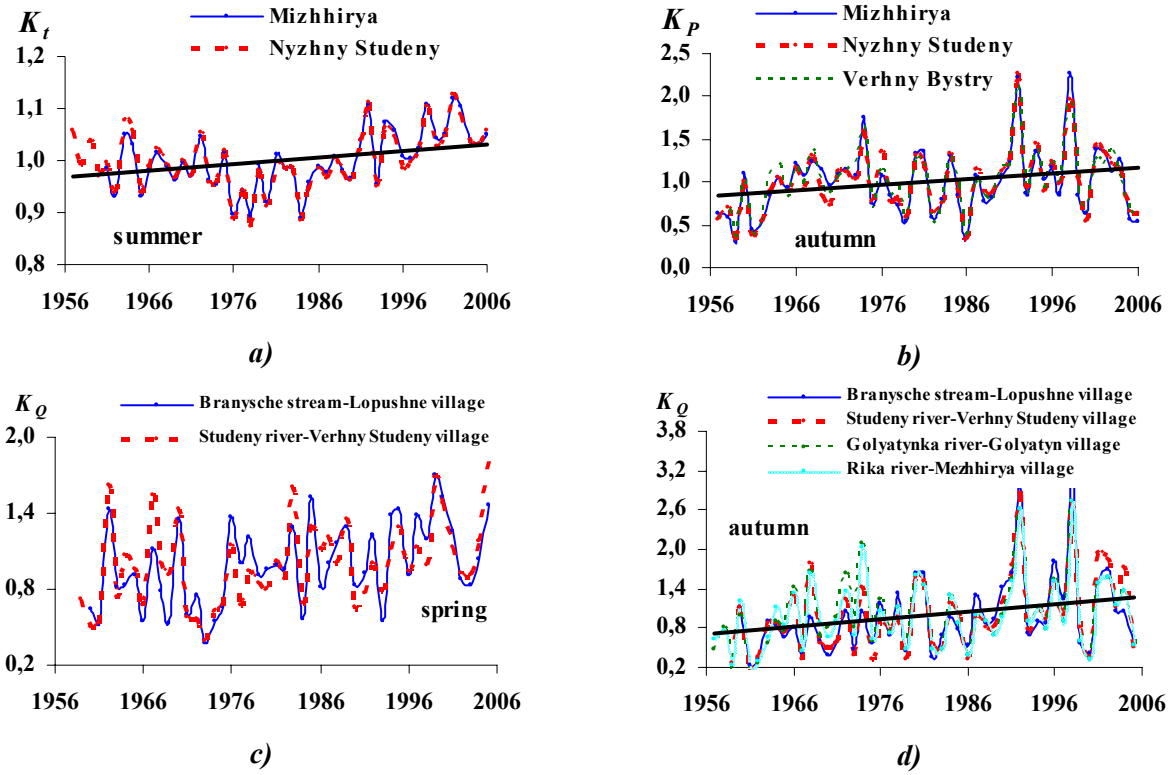

Fig. 1 The long-term dynamics and linear trends of the seasonal air temperature (*a*), precipitation (*b*) and discharges (*c, d*) of the rivers and streams in the Rika River Basin.

The view of the total curves of the seasonal temperature (Fig. 2 *a*), precipitation (Fig. 2 *b*) and discharges of the rivers and streams (Fig. 2 *c*, *d*) indicates on the homogeneity of the observations data, i.e. to absence of the influence of the anthropogenic factors and the climate change.

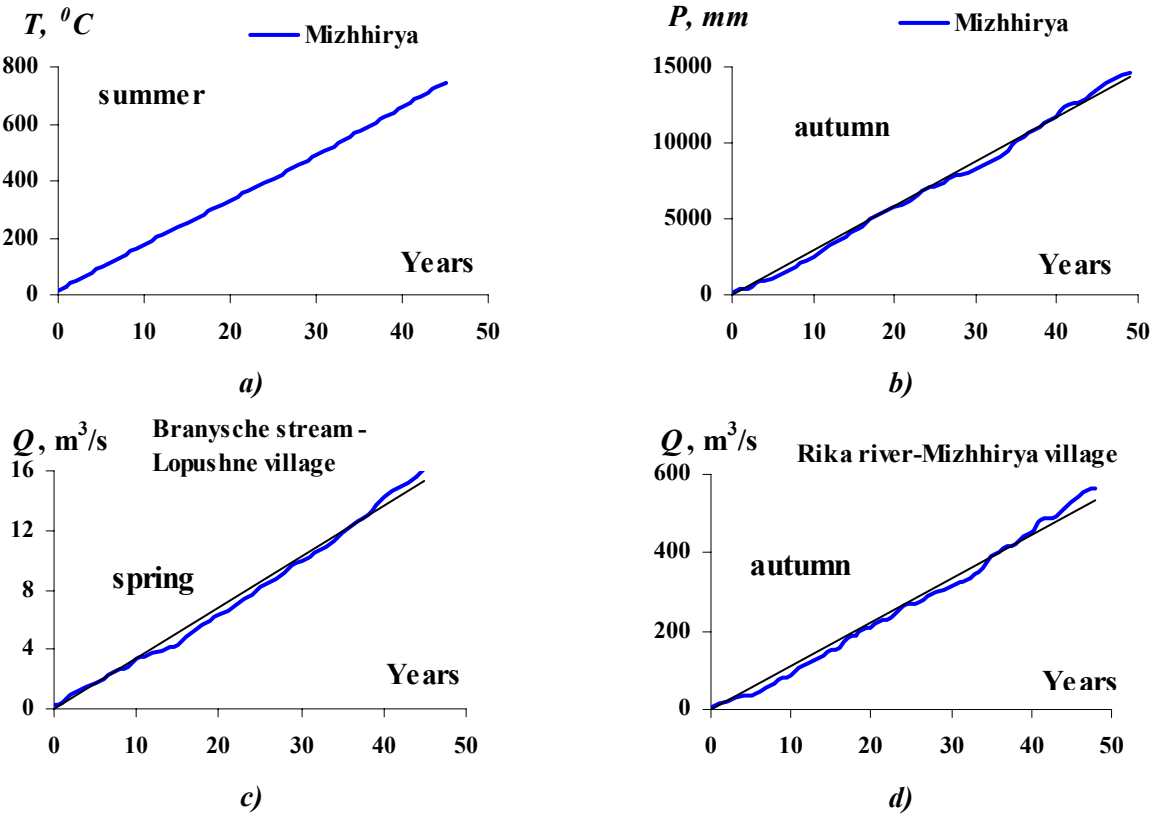

Fig. 2 The total integral curves of the seasonal air temperature (*a*), precipitation (*b*) and discharges (*c, d*) of the rivers and streams in the Rika River Basin.

Table 1 The statistically significant linear trends of the precipitation, air temperature and discharges in the Rika River Basin

The meteorological station / The name of gauge	The season	The observation period	The equation of the trend	R^2	R	σ_R	$2\sigma_R$	$3\sigma_R$
Precipitation								
Mizhhirya meteorological station	spring	1961-2006	y = 1.58x-2859	0.087	0.296	0.130	0.261	0.391
Verhny Bystry meteorological station		1957-2006	y = 1.69x-3086	0.103	0.320	0.128	0.256	0.385
Nyzhny Studeny meteorological station	autumn	1957-2006	y = 2.01x-3748	0.107	0.327	0.128	0.255	0.383
Air temperature								
Mizhhirya meteorological station	summer	1961-2006	y = 0.034x-51.6	0.255	0.505	0.111	0.222	0.333
Nyzhny Studeny meteorological station		1957-2006	y = 0.018x-20.2	0.094	0.306	0.129	0.259	0.388
Seasonal discharges								
Branysche Stream – Lopushne village	spring	1960-2006	y = 0.004x-7.49	0.209	0.457	0.118	0.236	0.354
	autumn		y = 0.004x-6.87	0.148	0.384	0.127	0.254	0.381
Studeny River – Verhny Studeny village	spring	1958-2006	y = 0.003x-5.40	0.145	0.381	0.126	0.252	0.378
	autumn		y = 0.003x-4.78	0.160	0.400	0.124	0.248	0.371
Pylypets River – Pylypets village	winter	1958-2006	y = -0.012x+25.7	0.111	0.333	0.130	0.259	0.389
Pylypets River – Podobovets village		1959-2006	y = -0.002x+3.49	0.084	0.290	0.135	0.270	0.405
Seredniy Zvir Stream – Lopushne village	summer	1960-2006	y = -0.001x+1.51	0.078	0.280	0.137	0.275	0.412
Golyatynka River – Golyatyn village	autumn	1957-2006	y = 0.016x-30.6	0.099	0.314	0.130	0.260	0.390
Rika River – Mizhhirya village			y = 0.129x-244.8	0.087	0.294	0.132	0.264	0.396

The analysis of the difference-integral curves showed that the statistically significant trends are in the series of observations which does not have of one full hydrological cycle (Fig. 3).

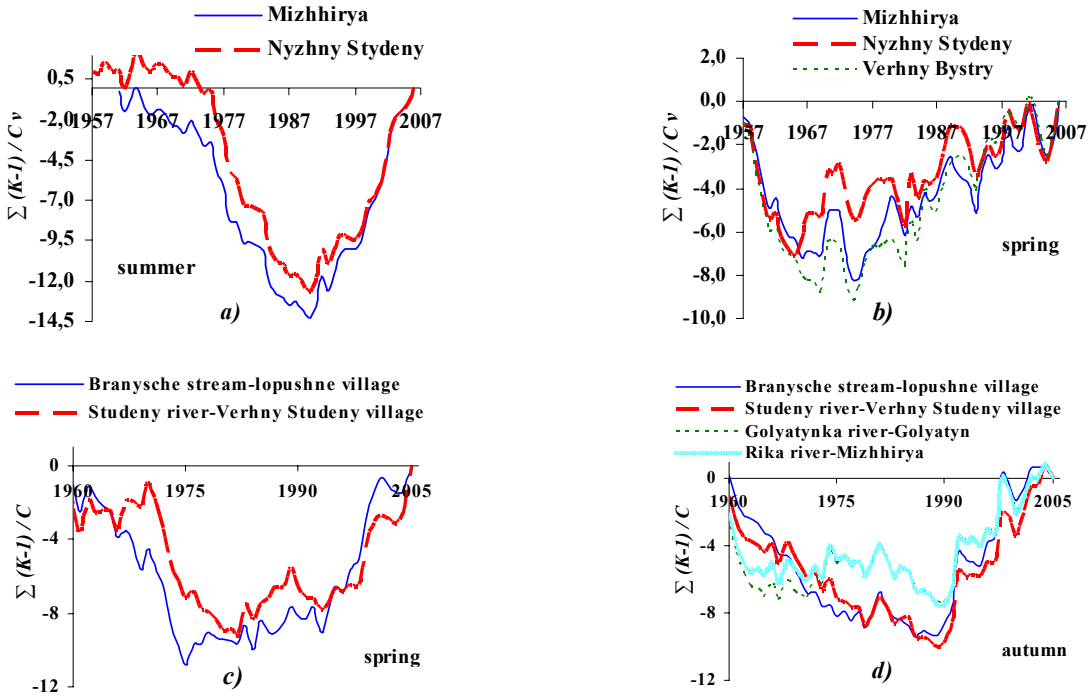

Fig. 3 The difference integral curves of the seasonal air temperature (*a*), precipitation (*b*) and discharges (*c, d*) of the rivers and streams in the Rika River Basin.

The presence of the statistically significant or statistically insignificant trends in the observations series have the periodic natures, which don't only depend from duration of the observations, but also depends from the length of the separate full hydrological cycles and of their phases.

The research of change at time of the average seasonal temperature, precipitation and discharges of the rivers and streams was carried out for all meteorological stations and the water gauges. In the formula (3) N is equal to 10 years. It showed that the changes of the average discharges on 16 observation gauges for all seasons of the year occurs synchronously or asynchronously to change the average precipitation and air temperature and have the cyclical fluctuations (Fig. 4). The cyclical fluctuations the average values of the hydrometeorological characteristics in the Rika River Basin are well expressed during of all seasons of the year.

4 CONCLUSION

In the Rika River Basin the correlations discharges, air temperature and precipitation shown that the analysis of the formation of the discharges in the summer and in the winter is necessary to carry out with considering the precipitation and air temperature, but in the spring and in the autumn – the precipitation only.

The appearance of inhomogeneity of the series at 5% level of the significance indicates about the disturbance of the stationarity of the runoff formation process. However, the view of the total curves of the hydrometeorological characteristics for all researched meteorological stations and the gauges indicates on the homogeneity of the observations data, so as they don't have any points of the fracture in the directions. The changes of the average seasonal runoff at time of the watercourses of the Rika River are due to the cyclical fluctuations. They synchronously or asynchronously change with the changing of the average precipitation and air temperature. The statistically significant trends were found only in 7 cases from 64 studied series of observations for discharges of the rivers and streams, in 2 cases from 8 – for temperature and in 3 cases from 12 – for precipitation. Thus, as the whole, the study area is characterized by the stationarity of the hydrometeorological processes of formation of the river runoff in Rika River Basin and that allows to use the apparatus of the mathematical statistics for processing of the observations series.

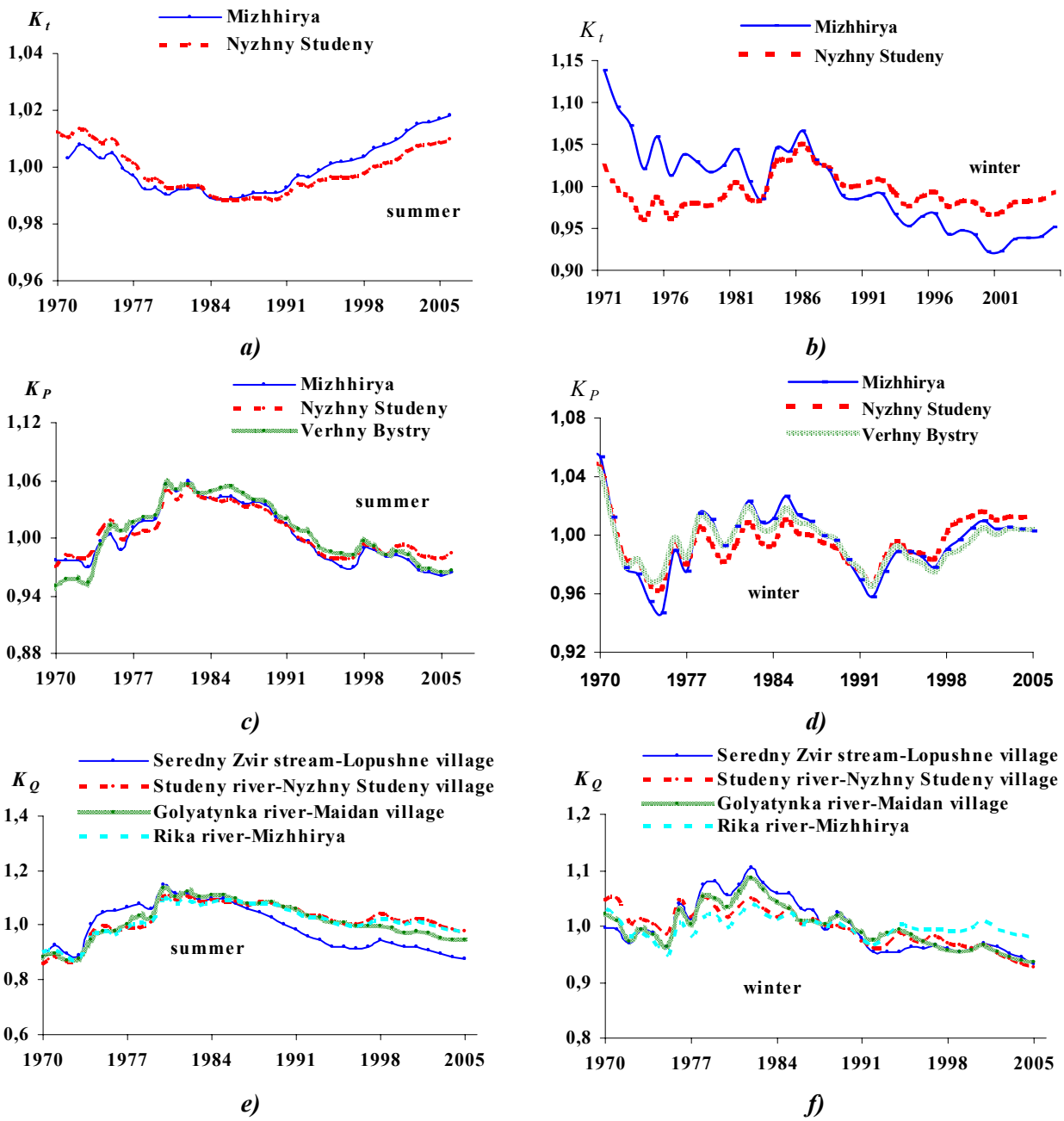

Fig. 4 The change with time of the mean of the seasonal air temperature (*a, b*), precipitation (*c, d*) and discharges (*e, f*) of the rivers and streams in the Rika River Basin.

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