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ANALYSIS OF PRECIPITATION QUANTITY IN VOJVODINA

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Abstract:
In view of the fact that the areas of arable soil in Vojvodina covered by irrigation systems are very small, and so are the possibilities to diminish the negative consequences of occasional droughts, our agricultural production is greatly dependent on the natural conditions. The natural meteorological processes, including also precipitation are of stochastic character, so that they can not be described by mathematical expressions in a simple way, and their future states can not be reliably predicted. On the example of precipitation data registered at the meteorological station R. Sancevi we demonstrated the application of several statistical methods to analyze the periodicity.

Keywords:
precipitation, changes, periodicity

1. INTRODUCTION

As a consequence of the insufficiently developed irrigation systems in Vojvodina, and relatively small areas of arable land where irrigation is possible, the atmospheric precipitation are still the major factor in providing water to the soil and crops. Lack of precipitation in one area in relation to average perennial value for specific period, leads to the occurrence of meteorological drought that can also cause substantial decrease of water quantities in aquatories and decline in ground water levels (hydrological drought), and thereafter it can also hinder proper growth and development of crops (agricultural drought). Hence, the phenomenon of droughts, as a time series of a stochastic character, deserves serious attention and thorough analyses.

The ever increasing water demands, and the simultaneously increasing danger of potential deterioration of water quality, have directed substantial research activities on the problems concerning the causes of drought occurrence. In view of the fact that in our present circumstances a decissive role in drought occurrence have the amount and time distriution of precipitation, i.e. their shortage, a need is evident for many-sided study and analyses of this complex phenomenon.

2. THE STUDY

The natural meteorological processes, including also precipitation, are of stochastic character, so that they can not be described by mathematical expressions in a simple way, and their future states can not be reliably predicted. Hence, for this purpose certain statistical methods are to be used. It is frequently the case, especially in the agricultural investigations and practice, that the description of precipitation is based only on the most elementary statistical indicators which, lacking the necessary application of all the preceding and accompanying analyses, may yield erroneous conclusions and predictions. Often, such analyses pay insufficient attention to the fact that the time series can have a certain cyclic component, so that it is of crucial importance to choose correctly the time period taken for the analysis. Depending on the nature of the variable, the duration of the period in which a process is developed and the effect of man and the environment, stochastic series can have, a more or less expressed deterministic component, which is manifested either through periodicity, abrupt changes, or trends.

It has been observed that the direct causes of hydrometeorological phenomena, solar activity, atmospheric processes, and the like, have marked elements of periodicity. Hence, it

can be expected that their consequences also exhibit a certain degree of periodicity, although it is very difficult to prove direct partial cause-consequence relations [1,2]. A certain stochastic series is to be analyzed on the basis of the results of long-term measurements and registering of all the relevant hydro meteorological quantities in the past. In order to carry out the analyses in a correct way, and thus provide a better description of the phenomenon itself, it is necessary to ensure that the analyzed sample encompasses at least two full hydrologic, or meteorological cycles, one series of dry and one series of wet years [3,4,5].

The cyclic nature of a certain phenomenon which can be represented by a stochastic time series can be analyzed using one or more of the existing numerous methods, such as autocorrelation, moving average, periodogram, integral curve of modular deviations, etc. On the example of a series of monthly and annual precipitation sums registered at the meteorological station Rimski Sancevi near Novi Sad, in the 1948-2008 period for the monthly and annual values, by the presented analysis we demonstrated the applicability of some of the above meteorological and statistical methods for the analysis of droughts.

3. ANALISES AND DISCUSIONS

After establishing that they are representative and consistent, and on proving their independence by Anderson's autocorrelation test, the series of data on monthly and annual precipitation sums registered at the Rimski Sancevi meteorological station were analyzed for their homogeneity. For this purpose use was made of Student's T-test and normalized Z-test. In this way it was established the significance of the differences of the mean values and standard deviations between the series of data for the 1948-1994 period and the second series for encompassing the 1995-2008 period.

On the basis of the results presented in Table 1 it is evident that at the level of annual values, a inconsiderable precipitation increases occurred (the average value is higher by 31.7 mm), whereas for the monthly sums of precipitations the situation differs from one month to another. A largest increase of monthly precipitation in the analyzed period was registered in September and October (15.1 and 15.8 mm), as well as in some the other months (5-11.4 mm), whereas in February, June, August and December insignificant decreases in precipitation (0.2-9.4 mm) were observed. In all cases, the noticed differences for the significance level of α=0.05 and the corresponding number of degrees of freedom, there were no statistically significant differences, i.e. the series can be considered as the homogeneous ones.

Table 1. Test of the homogeneity of monthly and annual precipitation. Criterion for the hypothesis acceptance at the significance level of a=0.05 and the corresponding number of degrees of freedom for T-test t=0±2.00, and for Z-test z=0±1.96.

Statist. indicat.	Monthly values												Years
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Subseries 1: Period 1948 - 1994; N=47													
Min. 1	5	3	3	15	15	20	2	8	2	0	9	3	384
Max. 1	102	113	117	90	134	204	169	148	89	113	156	150	888
Avg. 1	36	38	36	48	55	87	63	55	37	39	51	54	599
Std. 1	23	29	24	17	31	41	41	34	22	33	29	32	113
Subseries 2: Period 1995 - 2008; N=14													
Min. 2	8	1	3	9	17	28	11	0	4	1	7	16	289
Max. 2	75	64	95	156	176	237	209	125	160	143	143	138	999
Avg. 2	41	29	36	54	67	79	68	50	53	55	57	45	631
Std. 2	18	17	24	34	37	45	55	33	39	43	33	31	184
Δ Avg.	-5.0	9.2	0.2	-6.4	-11.4	8.1	-5.9	5.3	-15.1	-15.8	-6.2	9.4	-31.7
t	-0.73	1.10	0.02	-0.94	-1.13	0.62	-0.43	0.51	-1.81	-1.43	-0.68	0.97	-0.77
Z	-0.85	1.45	0.02	-0.68	-1.04	0.61	-0.37	0.53	-1.38	-1.26	-0.63	1.00	-0.61

The time variations of annual precipitation sums are presented in Fig. 1.a. However, only after carrying out the periodogram analysis (Fig. 1.b) it appeared that the most probable

durations of the identified cycles are about 14 years (maximum values of the periodogram peaks - halves of amplitude squares). The hydrological duration and the periodic sequence of dry and wet periods can be best observed on the integral curve of modular deviations. I this, the increasing values of this function denote precipitation surplus (the series of wet years) and decreases determine precipitation deficits (Fig. 1.c). On the integral curve of modular deviations is clearly evident the termination of an extremely dry and the beginning of another wetter period.

The periodicity of precipitation occurrence can also be followed on the basis of the moving average. It can be noticed that in respect of annual precipitation registered at the Rimski Sancevi meteorological station the period since 1982 to 1994 can be characterized as extremely dry. After that, started a extremely wet period (in 2001 annual precipitation sum where absolutely maximal - 999 mm)

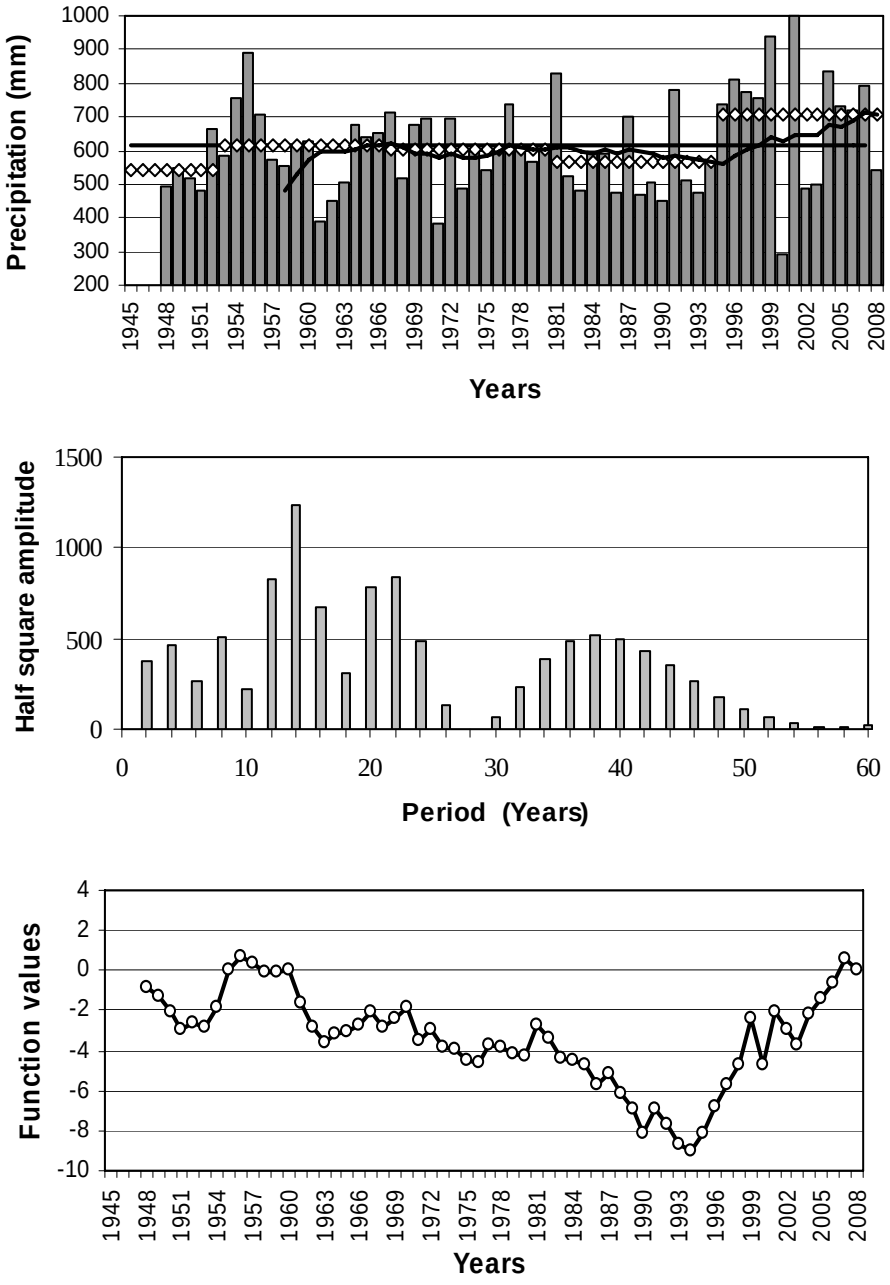

Fig. 1. a) Sum of annual precipitation, their average values and the 14-year moving average; b) Periodogram; c) Integral curve of modular deviations for the meteorological station Rimski Sancevi in the 1948-2008 period

4. CONCLUSIONS

The obtained results indicate that on the basis of data registered at the Rimski Sancevi meteorological station, a period 1982-1994 could be observed that is characterized by extreme deficiency of precipitation; in 1995 started a extremely wet period. This deficiency has been noticeably stronger than those registered in the past, but the differences are not so large to be statistically significant.

The precipitation distribution over a year has also undergone certain changes. A largest increase in precipitation has been observed for in September and October, and maximal decrease in February and June. This deficiency has been noticeably stronger than those registered in the past, but the differences are not so large to be statistically significant.

A certain regularity has been observed in the sequence of wet and dry years, so that appropriate longer or shorter cycles of changes could be noticed, as well as the termination of the one period with precipitation deficiency and the beginning of another considerable wetter period.

In view of the fact that in the previous time spans, droughts of similar character to the last one had been observed, it can be undoubtedly said that we do not deal with an unusual phenomenon. Only, the damages thus caused were this time very high because of the significant investments put into the intensification of agricultural production, and because of potentially higher yields, as well as in view of the unused possibilities to mitigate negative effects of such a drought.

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