# DROUGHTS IN THE BAČKA DISTRICT DURING THE VEGETATION PERIOD

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УДК: 551.577.38
**DOI:10.14415/konferencijaGFS 2015.073**

***Summary:*** *This study targets meteorological droughts during the vegetation period, lasting at least 25 days with eventual precipitations less than 5 mm/day. Time series corresponding to four meteorological stations in the Bačka district of province Vojvodina have been analysed. Probability of drought frequency during the vegetation period was established for each meteorological station. Following the empirical cumulative distribution function of drought duration is determined for each particular meteorological station. Based on the results, plot of isolines corresponding to droughts with recurrence interval of 5 years was produced by method of inverse distance interpolation.*

***Keywords:*** *Drought, vegetation period, Bačka*

## 1. INTRODUCTION

Meteorological drought occurs in case of prolonged period with less than average precipitation. Meteorological drought usually precedes agricultural and hydrological droughts. Identification of droughts in terms of duration and frequency facilitates the estimation of possible drought damages and proper design of irrigation systems.
Its definition is region-specific. Meteorological drought is defined on the basis of the degree of dryness, in comparison to a normal or average amount, and the duration of the dry period. Degree of dryness is defined sometimes by the height of the negligible intermittent precipitation [1, 2], another time further parameters are included in the analysis, like mean air temperature [3] or soil moisture, and others. In this study drought is considered to be a dry period lasting at least 25 days, with eventual precipitation less than 5 mm/day. The root system of fodder plants can not utilize precipitation having lower intensity than 5 mm/day, so they get damaged after about 25 days of drought.
Data from four meteorological stations (m.s. Palić, m.s. Sombor, m.s. Vrbas and m.s. Rimski Šančevi at Novi Sad) in the Bačka district, province Vojvodina, Serbia has been analyzed. The random character of data assembling each data set corresponding to a

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particular meteorological station was checked by the Wald–Wolfowitz *runs test* for confidence limits of ±2.5%. The results are as shown in Table 2. The runs test proved that the data in the analyzed data sets are independent and identically distributed.

*Table 1. The analyzed data sets*

| Meteorological station | Palić | Sombor | Vrbas | Rimski Šančevi |
|---|---|---|---|---|
| Period | 1960-2012 | 1960-2012 | 1965-1991 | 1960-2012 |
| Drop outs | 1 (1999) | - | 2 (1978, 1980) | - |
| Number of analized years | 52 | 53 | 25 | 53 |
| Number of vegetation periods without droughts | 7 | 11 | 6 | 13 |
| Number of realized droughts | 73 | 66 | 30 | 57 |
| Maximum duration, $D_{max}$ (days) | 63 | 64 | 48 | 83 |
| Maximum temperature, $y_{max}$ (°C) | 25.5 | 25.8 | 22.9 | 24.0 |
| Minimum temperature, $y_{min}$ (°C) | 12.4 | 12.2 | 11.0 | 11.5 |

*Table 2. Checking the random character of the analyzed data sets by the runs test*

| Met. st. | Palić | Sombor | Vrbas | Rimski Šančevi |
|---|---|---|---|---|
| Conclusion | 28.2<K=32<45.8 | 25.0<K=33<42.0 | 10.0<K=20<21.0 | 20.8<K=32<37.2 |
| | the data is random | the data is random | the data is random | the data is random |

## 2. THE NUMBER OF DROUGHT EVENTS DURING THE VEGETATION PERIOD

Following the distribution of the number of drought occurrence during the vegetation period has been analyzed. Poisson distribution defined by

$$P(k) = e^{-\lambda_1} \frac{\lambda_1^{\,k}}{k!} \tag{1}$$

was assumed. In equation (1) $k$ is the rate of occurrence of drought within the vegetation period of the year, $\lambda_1$ is the average rate of occurrence and $P(k)$ is its probability. The appropriateness of the Poisson distribution was tested and confirmed by Pearson's chi-squared test ($\chi^2$ ), and the calibrated Poisson distribution function for each m.s. is given in Table 3.

## 3. THE PROBABILITY DISTRIBUTION FUNCTION OF DROUGHTS

It is important to notice that due to the adopted definition of droughts the probability distribution function (PDF) has constant value $F(D)=F(0)$ for $0 \le D < 25$, where $D$ is drought durationa in days. This makes the use of standard statistical distribution functions (like the double exponential distribution function, which is monotoniously increasing) unsuitable. For that, based on the observed data, a smooth empirical distribution curve of droughts (drought durations) was produced for each m.s., accounting for the mentioned shelf of constant value corresponding to the lower range of drought durations, Figs. 1 and 2.

*Table 3. The distribution function of the number of drought events*

| Met. st. | Palić | Sombor | Vrbas | Rimski Šančevi |
|---|---|---|---|---|
| $\chi^2$ | 8.77 | 4.11 | 2.45 | 5.72 |
| $\chi^2_{\alpha=\pm 2.5\%}$ | 9.49 | 7.81 | 7.81 | 7.81 |
| Result | $\chi^2 < \chi^2_\alpha$ | $\chi^2 < \chi^2_\alpha$ | $\chi^2 < \chi^2_\alpha$ | $\chi^2 < \chi^2_\alpha$ |
| Conclu-sion | hypothesis confirmed | hypothesis confirmed | hypothesis confirmed | hypothesis confirmed |
| The calibrated equation of the Poisson distribution | $P(k)=e^{-1.404}\frac{1.404^k}{k!}$ | $P(k)=e^{-1.245}\frac{1.245^k}{k!}$ | $P(k)=e^{-1.200}\frac{1.200^k}{k!}$ | $P(k)=e^{-1.076}\frac{1.076^k}{k!}$ |

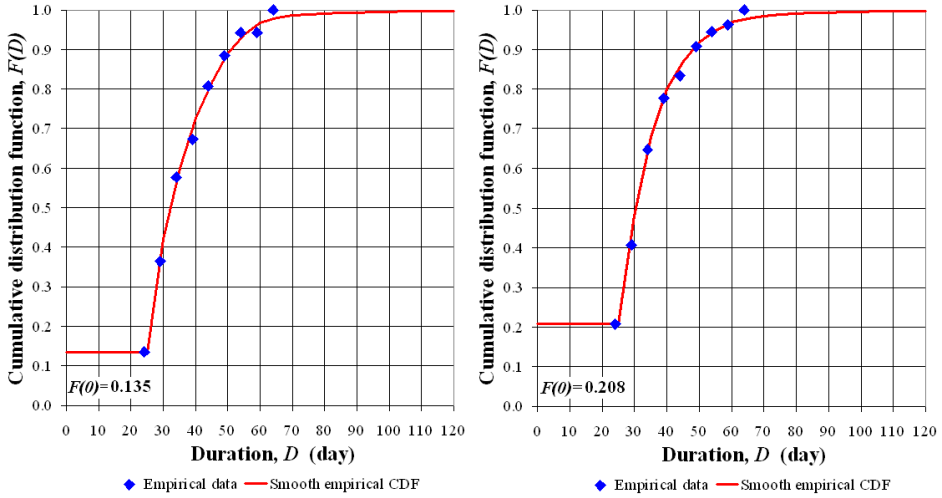


*Figure 1. The CDF of drought duration, m.s. Palić left, m.s. Sombor right*

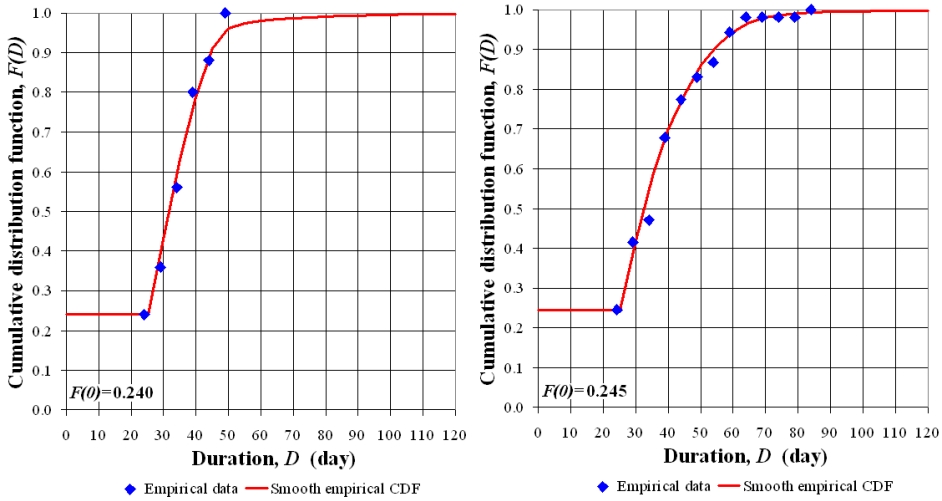


*Figure 2. The CDF of drought duration, m.s. Vrbas left, m.s. Rimski Šančevi – Novi Sad right*

Based on the smoothed curves of CDFs the following table of drought duration vs. recurrence interval was produced.

*Table 4. Drought duration vs. recurrence interval*

| Recurrence interval, $T_r$ (year) | Duration of drought, $D$ (day) | | | |
|---|---|---|---|---|
| | Palic | Sombor | Vrbas | Rimski Šančevi |
| 2 | 31.78 | 30.32 | 31.17 | 32.10 |
| 3 | 37.20 | 34.48 | 35.72 | 38.25 |
| 5 | 43.55 | 40.00 | 40.19 | 45.50 |
| 10 | 50.65 | 47.40 | 44.13 | 53.60 |
| 20 | 56.37 | 55.00 | 48.20 | 60.75 |
| 30 | 59.89 | 59.44 | 51.67 | 64.92 |
| 40 | 62.31 | 62.67 | 55.00 | 67.46 |
| 50 | 64.69 | 65.80 | 60.00 | 70.00 |
| 60 | 67.16 | 69.16 | 64.00 | 71.86 |
| 70 | 69.65 | 71.80 | 67.60 | 73.50 |
| 80 | 73.60 | 74.20 | 71.10 | 75.67 |
| 90 | 77.00 | 77.00 | 74.68 | 77.83 |
| 100 | 80.00 | 80.00 | 78.17 | 80.00 |
| 500 | 115.00 | 115.00 | 115.00 | 115.00 |

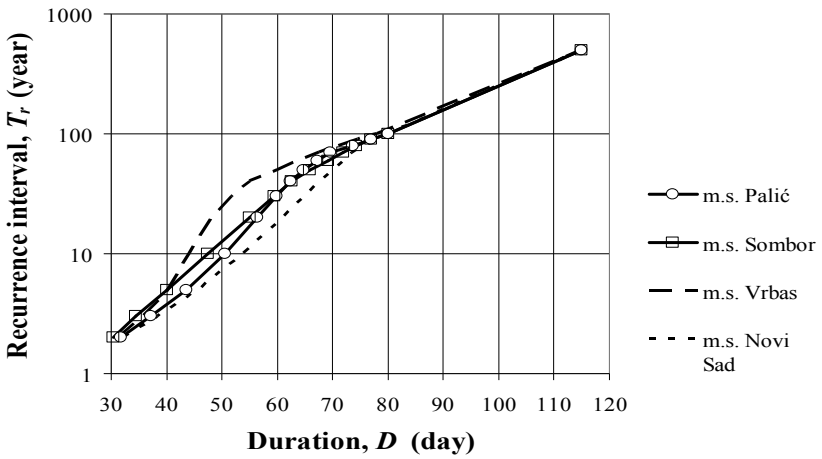


*Figure 3. Drought duration vs. recurrence interval for all meteorological stations*

## 4. DROUGHT MAP

Izolines of drought duration for district Bačka, Province Vojvodina, Serbia, corresponding to droughts occurring in the vegetation period, having recurrence interval of 5 years have been produced by method of inverse distance interpolation, Fig. 4. Drought map in Fig. 4 should be taken as a try, since for producing a practically applicable one, data of more meteorological stations covering much broader area than the considered district, would be preferable, like in [1, 2].

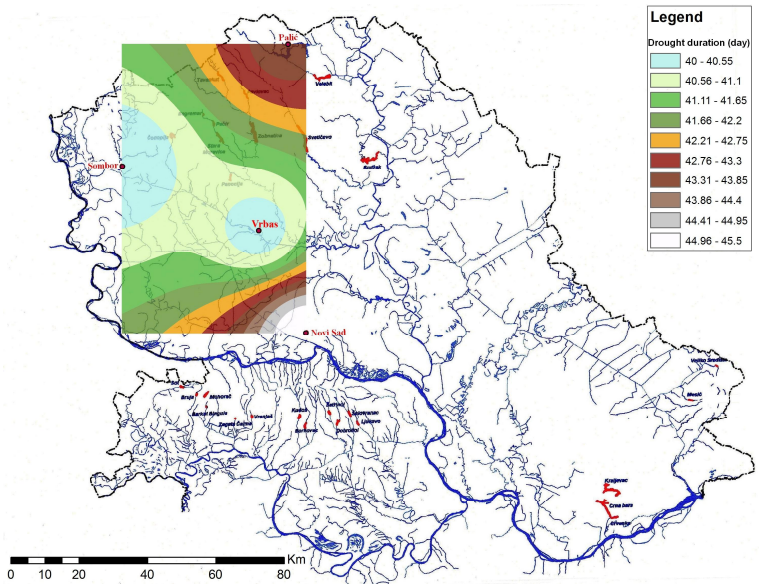


*Figure 4. The isolines of droughts having recurrence interval $T_r$=5years*

## 5. DISCUSSION AND CONCLUSIONS

The presented analysis produced longer drought durations for a chosen recurrence interval than the earlier studies. For example, according to the current analysis (Table 4, Figs. 3 and 4) for the location of the Palić Lake the value of drought duration with recurrence interval of 5 years is $D(T_r$=5 years)=43.6 days, while $D(T_r$=5 years)=38 days was estimated by [1]. This is probably due to the definition of droughts adopted; droughts of minimum duration $D_{min}$=25 days have been considered in this paper, while it was $D_{min}$=15 days in [1]. Furthermore, data set corresponding to period 1960 - 2012 has been analyzed in this paper, while period 1949 - 1988 was considered in [1].
Therefore, the differences observed do not indicate contradiction between the current and the earlier studies. The purpose of the analysis should define the basys and the methods of drought analysis. Besides, the continuously increasing data requires time to time recalculation of statistical parameters.

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# СУШЕ У БАЧКОЈ ТОКОМ ВЕГЕТАЦИОНОГ ПЕРИОДА

***Резиме:*** *Овим радом су изучаване метеоролошке суше у вегетационом периоду, трајања 25 и више дана са евентуалним падавинама висине мање од 5 мм/дан. Анализиране су временске серије података са четири метеоролошке станице у Бачкој, Војводини. За све њих утврђена је расподела броја појаве суша током вегетационог периода, као и емпиријска кумулативна функција расподеле трајања суша. Коначно, на основу добијених резултата приказане су изолиније трајања суша повратног периода од 5 година.*

***Кључне речи:*** *Суша, вегетациони период, Бачка*