

**ANALYSIS OF 24-HOUR MAXIMUM PRECIPITATION IN
NORTH-EASTERN BULGARIA
THROUGH RELATIVE PERCENTAGE CRITERION**

**ANALIZA PRECIPITAȚIILOR MAXIME ÎN 24 ORE ÎN NORD -
ESTUL BULGARIEI CU AJUTORUL CRITERIULUI
PROCENTAJULUI RELATIV**

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Abstract: The paper presents the results of investigation of the 24-hour maximum precipitation in the region of North-Eastern Bulgaria by applying the relative criterion of Fukui. According to this criterion, 24-hour precipitation equal to or exceeding 10% of the yearly rainfall amount is “extraordinarily heavy rainfall” and this rainfall has significant effects on river flow, soil, natural and agriculture vegetation.

The criterion was applied to 24 stations from the National meteorological network during the period 1992-2008. The territorial and temporal distribution of 24-hour maximum precipitation and their impact on the natural complex and the society are analyzed.

Key-words: North-Eastern Bulgaria, 24-hour maximum precipitation, relative percentage criterion, floods

Cuvinte cheie: Nord-Estul Bulgariei, maximul precipitațiilor în 24 ore, criteriul procentajului relativ, inundații

Introduction

It is important to determine the regularities, both in theoretical and practical aspects, in terms of regime and territorial distribution of pouring and intensive (heavy) precipitations. We are witnessing the negative effects of heavy rainfalls during the recent years - floods, soil erosion, landslide activation, problems with the hydro-technical, transport and drainage infrastructure, which is tightly connected with considerable property damage and financial losses.

There are different quantitative criteria that are used for defining torrential (heavy) precipitations. When measuring the maximum precipitation of a 24-hour period, those considered potentially hazardous for Bulgaria are: quantities equal or

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above 50 mm/24 hours (Tishkov, Vladev, 1999) or 20-25 mm/24 hours (Velev, 1990). Those are not the only opinions expressed upon hazardous daily precipitation maximums (Sueva, 1960; Golub, 1973 etc.)

Fukui (1970) introduced the relative percentage criterion that would define, the measuring of 24-hour maximum precipitation that is to be included in the category of “hazardous rainfalls”. In his view, each measured daily precipitation quantity, exceeding 10% of the annual precipitation amount (for the respective year) is defined as extraordinary heavy rainfall that causes considerable negative effects on the river flows, soil surface and vegetation (natural and cultivated). The author suggested the relative percentage index is to be used instead of absolute values as it would be of bigger practical importance, because the hazardous precipitation depends on the rain conditions during the respective year.

The Fukui criterion is applied by Penkov (2002) for his research of spatial distribution of maximum precipitation quantities for 24 hour duration in Bulgaria.

The objective of this research is to determine the regularities in territorial distribution and the temporal variability of 24-hour maximum precipitations in North-Eastern Bulgaria, by applying the relative percentage criterion.

By using both absolute and relative percentage criteria for the research of a certain region, we have the chance to compare the obtained results.

Object, data and methods

Special scientific interest is expressed in heavy precipitation of North-Eastern Bulgaria, because this region is one of the driest in the country, regarding the non-precipitation periods that last more than 10 days (Kyuchukova, 1991). The annual rainfall amounts in the eastern part of the country are the smallest in Bulgaria (below 500 mm). In Krasen weather station (in the region of Dobrich) and Vetrino (in the region of Varna), annual absolute rainfall minimums (146 mm and 168 mm, respectively) are reported (Geography of Bulgaria, 2002). That is the reason why the recorded cases of heavy precipitation, compared to the drought periods, during the warm six months of the year, has turned out to be natural disaster.

The geographic area of North-Eastern Bulgaria, from a natural-geographic point of view, is outlined by the following borders: the river Danube to the North; the land border with Romania to the North-East. The western border is the watershed between the Yantra River and the Rusenski Lom River. To the south, the area stretches as far as the Fore-Balkans. It is bordered by the Black Sea to the East.

The relief is predominantly occupied by lowlands, plateaus and hills.

The catchment of the Rusenski Lom River (with its tributaries: the Beli, the Cherni, the Malki Lom), the Provadiyska and the Botova Rivers run only on the territory of North-Eastern Bulgaria. The Golyama Kamchiya River appears to be a transitional river. Its northern tributary – the Vrana River flows through utterly plain relief. The widely-spread karst limestone in Ludogorie-Dobrudzha plateau, is the reason for the insignificant surface flow here, but still there are many dry valleys with episodic flow (the Voina, the Krapinets, the Senkovets etc).

The climate in North-Eastern Bulgaria is moderate-continental, as the continental influence is more severe here in comparison to the rest of North Bulgaria. In the context of the prevailing northwestern winds during the year, one of the climate features is the importance of northeastern cold winds for the climate formation during winter. Strong, dry winds, blowing from northwest, are usually recorded. They are formed in the South Russian and Ukraine steppes every summer. They cause prolonged dry periods (over 10 days - Kyuchukova, 1991). Due to the expressed continental climate from west to east, the Black Sea coast is characterized by small annual precipitation amounts (Varna, Shabla). As a whole, the hilly and uneven relief in North-Eastern Bulgaria is the ground for the scattered precipitations distribution, as the windy north and northwestern slopes of mountains, plateaus and hills are characterized by heavier rainfall amounts. The precipitations in the region have a continental regime, with a summer (June) maximum and winter (February) minimum.

The study is carried out on the basis of daily data regarding the precipitation amounts, measured in 24 weather stations (rain-gauge) of the National Meteorology Network (towns and villages), located in North-Eastern Bulgaria during the period 1992-2008 (17 years). Most of the analyzed stations are located in river valleys and dry valleys. In 2005 and 2007, some of these stations recorded heavy (even record) precipitation amounts, which caused floods and significant damage of properties.

In every station, the cases of 24-hour rainfall which either equal or range above 10% of the precipitation amount for the respective year are highlighted. The frequency rate is calculated for the need of comparison (the number of cases is divided by the number of the observed years). It is presented as relative values – 0.1; 0.2 etc.

Research results

According to Fukui criterion, the territory of Bulgaria can be divided into two districts with roughly the same territorial scope - one with cases in which the frequency rate is below 0.1 and the other with rate of above 0.1 (i.e. below and over 1 case for 10 years) (Penkov, 2002). North-Eastern Bulgaria belongs to the district with precipitation frequency above 0.1. It should be mentioned that according to the present research, this is the district that encompasses most of the weather stations where the frequency rate is 0.2 and 0.3. The results are shown in Table 1.

From all the 24 researched stations, only three frequency rate of 24-hour maximum precipitation above 0.1 is recorded (Glavnitsa, Vetovo and Provadiya). Two stations have frequency rate of 0.1 (Kaynardzha and Novi Pazar). In the other 19 stations, the rate is 0.2 or more. It should be noted that in 5 of all stations, the recorded frequency rate is 0.3 (Samuil, Topchii, Tsar Kaloyan, Venets, Vladimirovo) and in 4 stations - the rate is 0.4 (Krushari, Harsovo, Karapelit, Vetrino). In the last case, rainfalls above 10% of the annual precipitation amount are registered every 2.5 years on average.

It is important to highlight that in the majority of cases, the analyzed 24-hour precipitation maximums (above 10% of the annual rainfall amount) are not notably heavy. Excluding the maximum absolute values, the predominant daily amounts vary between 50 and 80 mm.

There are particular cases with significantly lower precipitation quantities (30-40 mm), even 25 mm.

Table 1
24-hour precipitation maximums by percentage criterion in North-Eastern Bulgaria in the period between 1992 - 2008

- 1- frequency of 24-hour precipitation
- 2- maximum 24-hour precipitation, mm
- 3- date
- 4- % from the respective annual precipitation amount
- 5- other cases - rainfall above 100 mm; two cases above 10 % for a year

Station	1	2	3	4	5
Isperih	0.2	136	August 8, 2006	15	
Samuil	0.3	158	July 2, 2006	23	
Alfatar	0.2	62	September 12, 2003	10	
Glavinitsa	below 0.1	52.7	January 2, 2001	10	
Dobrich	0.2	75.2	September 3, 1999	11	
Krushari	0.4	66.5	April 28, 2008	16	
Vetovo	below 0.1	84.7	August 27, 2007	13	
Chereshovo	0.2	55.6	July 13, 1994	10	
Topchii	0.3	126	October, 2, 1992	25	
Yonkovo	0.2	67	August 8, 2007	11	
Harsovo	0.2	82.6	August 8, 2007	12	
Tsar Kaloyan	0.3	291	July 7, 2007	31	121 mm; 2 cases in 2007
Kubrat	0.2	77.5	September 5, 1999	12	
Sitovo	0.2	66.4	September 5, 1999	11	
Kaynardzha	0.1	75	September 4, 1999	12	
Dulovo	0.2	109	September 5, 1999	16	
Novi Pazar	0.1	192.2	July 3, 2005	18	
Harsovo, Shumen.	0.4	85	August 28, 2006	19	
Todor Ikonovovo	0.2	94.5	August 29, 2006	17	
Venets	0.3	112.2	August 29, 2006	16	102,5
Karapelit	0.4	103	May 23, 2008	19	2 cases in 1999 and 2 in 2008
Vladimirovo	0.3	108	September 4, 1999	20	2 cases in 1999 and 2 in 2008
Vetrino	0.4	75	September 4, 1999	16	2 cases in 2001
Provadiya	below 0.1	56.8	July 13, 1994	11	

It is clear that by applying the percentage criterion, it is possible to distinguish, not only the extreme maximum rainfalls, but also the frequency rate of smaller precipitation quantities, which would not be included the category “heavy” and “hazardous” if using the absolute value criterion.

When studying every case of those with 24-hour maximum precipitation above 10%, it can be noticed that in the majority of stations, at least one case of rainfall amount above 15% is recorded.

Larger rate (over 20%) of annual precipitation amounts is registered in the following cases - Samuil in 2006 (158 mm - 23%), Topchii in 1992 (126 mm - 25%) and Tsar Kaloyan in 2007 (291 mm - 30 %). The last one is ranked in the list of absolute maximum 24-hour precipitation quantities in North-Eastern Bulgaria - above 250 mm. Those are cases of record elemental rainfalls, as the consequences were natural disasters. They are stated as absolute maximum quantities for Bulgaria in scientific literature, namely - in the town of Varna in August 1951 (258 mm) and the resort of St. Konstantine (342 mm) (Geography of Bulgaria, Sofia, 2002).

The risky natural phenomena in North-Eastern Bulgaria are also facilitated by the considerable number of registered cases of precipitation quantities above 100 mm and by the cases with two rainfalls above 10% in one year.

From a genetic point of view, the 24-hour precipitation maximums are determined by the moist and unstable air masses pushing in/penetrating through cold fronts of the Atlantic cyclones and colder and occlusion fronts of the Mediterranean cyclones. Considerable precipitation amounts are recorded in the presence of well-developed cyclones or occlusion, as a cold front of cyclones, when the effect of the cold front in the precipitation field is intensified by strong thermal convection. It is also essentially affected by the processes, provoking intramass precipitations.

The concentration of extreme heavy rainfalls in the region is due mainly to the relief, namely the plateaus and heights there. Those places, with the highest precipitation frequency rate by applying the Fukui criterion, are defined by the orography. This regularity is also determined by other authors, who analyzed the precipitation within the region (Tishkov, Vladev, 1999).

According to Koleva and Peneva (1990), in the regions with moderate continental climate, such as the analyzed region, the 24-hour precipitation maximums are recorded in May and June (20-30% of all cases). The frequency rate remains high in July and August: 10-15%. It decreases in autumn, and reaches its minimum in winter - around 0-5%.

The application of the percentage criterion when studying the period between 1992 and 2008 shows different trends in the interannual variability of precipitation maximums distribution. The greatest number of registered cases is in September (27% of all cases of rainfalls above 10% of the annual precipitation amount); then comes August (24%) and July (15%). The frequency rate is low during spring (3-5%), as its value is higher in January (9%). In none of the

analyzed stations in North-Eastern Bulgaria during February 24-hour rainfall fitting the Fukui criterion has been registered.

Consequences

The high frequency rate in August and September coincides with the frequent dry periods that are typical for the climate in North-Eastern Bulgaria. During those months, the dry periods last for 16-19 days, on average; and the periods over 20 days - 21-24 days and nights (Tetovski, 2004). The combination of these conditions serves as a ground for the formation of catastrophic high waters and with significant consequences - destruction of the surface soil layer, intensified erosion processes, mud streams, landslides activation (Penkov, 2002).

The concentration of a large number of stations with considerable precipitation maximums frequency rate above 10% in North-Eastern Bulgaria (one of the driest regions in the country, as previously mentioned), indicates the vulnerability of this territory to extreme rainfalls (past and future) and the subsequent consequences.

The high waters are typical features of the effluent variability of the rivers, flowing through the territory of North-Eastern Bulgaria. In most cases, it causes floods with significant damages. Erosion and accumulation processes appear because the dried soil (especially during summer and at the beginning of autumn) lay down the conditions for the formation of mud and stone streams when raining heavily. The heavy day and night precipitations determine the activation of landslides (not only along the Black Sea coast, but also inland).

Some of the biggest floods, which caused significant property damages to people and nature, are recorded in North-Eastern Bulgaria. For example, as a result of the heavy rainfalls during July 2005, the Provadiyska River and the Golyama Kamchiya River swept over buildings, roads and farm lands. In August 2007, Tsar Kaloyan municipality declared emergency to pouring rainfalls which caused a small dam to overflow and the Hlebarovska River, tributary of the Beli Lom River burst its banks. The consequences were: flooded buildings and roads and 8 casualties. In September, Rusenski Lom River overflowed buildings and farm lands. It resulted from torrential rainfalls. More examples can further be given.

Conclusion

The main conclusions to be drawn about the 24-hour precipitation maximums in North-Eastern Bulgaria by applying the 10% percentage criterion are the following:

In the period between 1992 and 2008 at least one case of 24-hour precipitation above the limit of 10% has been recorded in 21 out of 24 researched weather stations. This is a very significant phenomenon regarding the considerable short duration of the studied period (17 years).

Five of all stations registered frequency rate 0.3 and four stations - even 0.4 (i.e. at every 2.5-3 years have been recorded rainfall quantities of 10% above the

annual precipitation amount). This frequency rate is high regarding the weather conditions in Bulgaria.

The repetition of 24-hour precipitation maximums, above the 10% limit, in North-Eastern Bulgaria is the greatest in August and September, when dry periods are the most frequent. The combination of these weather conditions lay down the foundations for elemental natural phenomena in the region, causing considerable negative consequences for nature and community.

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