Територіальне довгострокове прогнозування характеристик максимального стоку весняного водопілля в басейні р.Південний Буг

Шакірзанова Ж.Р., Казакова А.О.

Використаний метод територіальних довгострокових прогнозів характеристик стоку весняного водопілля (на прикладі р. Південний Буг та річок межиріччя Дністра і Південного Бугу) дозволяє передчасно визначати максимальні витрати води та шари стоку в весняний період для будь-яких річок території, включаючи і невивчені в гідрологічному відношенні.

Ключові слова: *територіальне довгострокове прогнозування, максимальний стік, весняне водопілля*

Территориальное долгосрочное прогнозирование характеристик максимального стока весеннего половодья в бассейне р.Южный Буг

Шакирзанова Ж.Р., Казакова А.А.

Использованный метод территориальных долгосрочных прогнозов характеристик стока весеннего половодья (на примере р. Южный Буг и рек междуречья Днестра и Южного Буга) позволяет преждевременно определять максимальные расходы воды и слои стока в весенний период для любых рек территории, включая и неизученные в гидрологическом отношении.

Ключевые слова: *территориальное долгосрочное прогнозирование, максимальный сток, весеннее половодье*

Territorial long-term forecasting characteristics maximum runoff spring flood in the basin of the Southern Bug

Shakirzanova Zh.R. , Kazakova A.O.

The method used for territorial long-term forecasts of spring flood runoff characteristics (for example, r. Southern Bug and rivers of territory between the Dniester and Southern Bug) allows premature to determine the maximum discharge of water and the layers runoff in the spring for any river area, including uninvestigated hydrologically.

Keywords: *spatial long-term forecasting, maximum flow, spring flood.*

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ASSESSMENT OF THE RETURN PERIOD OF THE RAINFALL INTENSITY THAT CAUSED THE MAY 2014 FLOOD IN SERBIA

Keywords: *May 2014 flood, heavy rainfall, rainfall intensity, rainfall duration, probability of occurrence, return period, statistical significance*

Introduction. The major floods in Serbia were caused by heavy rainfall events in most of western and central Serbia, which occurred between midnight (00:00) of 12 May and 3 am on 19 May 2014. This flood affected the Kolubara River basin, the lower Drina River basin, the Zapadna Morava River basin, the lower Južna Morava River basin, the catchment areas of the Velika Morava tributaries, and the Mlava River basin, as well as the lower Sava River basin, from the state frontier to the confluence of the Sava and the Danube at Belgrade. The heavy rainfall that led to the formation of a flood wave on the Sava and its tributaries also affected Croatia and Bosnia and Herzegovina, but these two countries are not included in the present assessment.

The main causer was a spatial cyclone which was formed and developed at all altitudes, as a result of a cold wave of Atlantic air coming via the Alps into the Mediterranean region. It shifted over the Adriatic to the Balkans. On 13 May, the cyclone moved from the Adriatic Sea to the western and central parts of the Balkans, and from 14 to 16 May it strengthened (deepened) at all altitudes and also became localized (moved very slowly). The focus at the lower end moved from the Gulf of Genoa via the Apennines and the South Adriatic to southern Serbia, Bulgaria and Romania, and then made an elliptical "loop" above southeastern parts of the Pannonian Plain (northern Serbia, eastern and southeastern Hungary and northwestern Romania). On that particular occasion the cyclone deviated from the usual path followed by Genoa cyclones, which is towards the Black Sea, where they generally dissipate. The main zone of clouds and rain was above most of Serbia, particularly western Serbia, then Republika Srpska and Slavonia. It moved very slowly, as did the cyclone itself, and from 14 to 18 May 2014, according to the data collected by the National Meteorological Service of Serbia (RHMZ), delivered extreme amounts of rain, in most places exceeding 200 l/m^2, and locally more than 300 l/m^2. This event was preceeded by heavy rainfall between 14 April and 5 May, when most of Serbia received between 120 l/m^2 and 170 l/m^2 of rain, and southwestern Serbia even 250 l/m^2 or more. All of this together caused disastrous floods, flash floods, erosion and landslides, first along small watercourses (creeks), than medium-size rivers and finally large rivers, particularly the Sava.

Assessment of statistical significance of heavy rainfall in May 2014 and its characteristics. The study of high-intensity rainfall requires hourly data expressed in mm/h. In principle, regular gauging of the amount of fallen rain (hereafter also precipitation) is conducted in Serbia by the National Hydrometeorological Service (RHMZ), which operates a network of weather stations, including main meteorological stations (MMSs), precipitation stations and automated stations. An MMS records and archives hourly precipitation totals. Precipitation stations measure 24-hour totals, from 7 am to 7 am on the following day. Rainfall information from automated stations is retrieved online, depending on current needs of the RHMZ Operations Division. For the purposes of the present research, only MMS hourly data were used. For the duration of a flood event, data from the precipitation stations are transmitted via telephone. However, when there is a flood, telephone lines tend to be disrupted and the data are therefore unreliable. The automated stations are also often affected and, almost as a rule, they are down in emergency situations.

Of all the data recorded for the duration of a flood, only MMS hourly precipitation totals are truly available. All such MMS data, recorded from 00:00 on 12 May to 03:00 hours on 19 May 2014 by 28 stations in Serbia, were compiled for the present research.

The spatial distribution of the MMSs that provided the data is shown on a map in Figure 1, along with precipitation depth isohyets for the duration of the heavy rainfall. The map clearly shows the part of Serbia that was exposed to the heaviest precipitation. It included the catchments of the Jadar and Kolubara Rivers. The highest precipitation depths during the major rainfall event were recorded by the MMSs at the City of Loznica (188.3 mm), the Belgrade Observatory (179.1 mm), the City of Valjevo (178.9 mm), the Rimski Šančevi suburb of the City of Novi Sad (133.8 mm), and the City of Smederevska Palanka (130.8 mm).

For the assessment of the return periods of extreme rainfall, which is one of the main causes of floods in a river basin, high-intensity rainfall monitoring data are required. Hourly values expressed in mm/h are needed for a thorough analysis of such events.

As only hourly values from the MMSs were truly available, it was possible to study the maximum rainfall intensities over the entire area and compare them to the most recent statistical and probabilistic assessments [1]

The outcomes of the study revealed an indisputable fact – that the heavy rainfall at and between the MMSs lasted for a very long time. This is generally a rare occurrence, which results in disastrous floods.

The total duration of rainfall across Serbia at that time exceeded a return period of 1000 years.

In this study the hourly rainfall data made it possible to determine the maximum rainfall intensities (depths) for different rainfall durations at all the MMSs. Specifically, maximum precipitation depths were extracted for the following characteristic rainfall durations: 1, 3, 6, 12, 24, 48 and 72 hours.

The isohyet maps produced using these data are presented in Figs. 2–8. They clearly show the directions of maximum rainfall centers in Serbia for different rainfall durations

During the studied heavy rainfall events, maximum hourly intensities (Fig. 2) concentrated at Smederevska Palanka, Niš and two smaller localities near the cities of Vranje and Loznica..

The focus of the three-hour maximum rainfall intensity (Fig. 3) was registered near Smederevska Palanka, while foci of lower intensity were noted near Niš, Loznica and Vranje. The focus of maximum six-hour rainfall intensity (Fig. 4) was recorded in the area between Belgrade and Smederevska Palanka and near Niš. The focus of six-hour maximum rainfall near Loznica was of a lower intensity. These foci merged over the region of Šumadija and a part of the Province of Vojvodina. The 50 mm isohyet for six-hour rainfall thus encompassed the area circumscribed by the MMSs at Belgrade, Smederevska Palanka, Valjevo, Loznica and Novi Sad.

The areas of maximum 12-hour intensity (Fig. 5) expanded: the highest intensities were registered between Belgrade and Smederevska Palanka, and somewhat lower intensities near Niš, Novi Sad and Loznica.

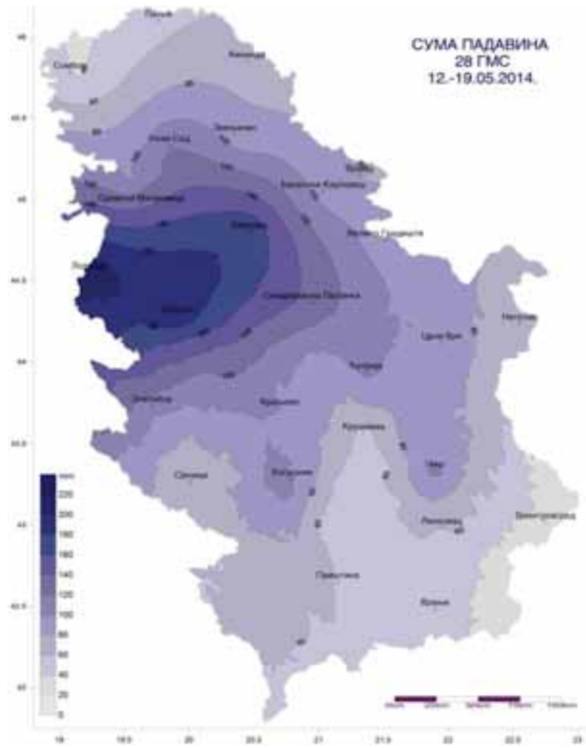

Figure 1. **Precipitation totals, 28 MMSs, 12–19 May 2014.**

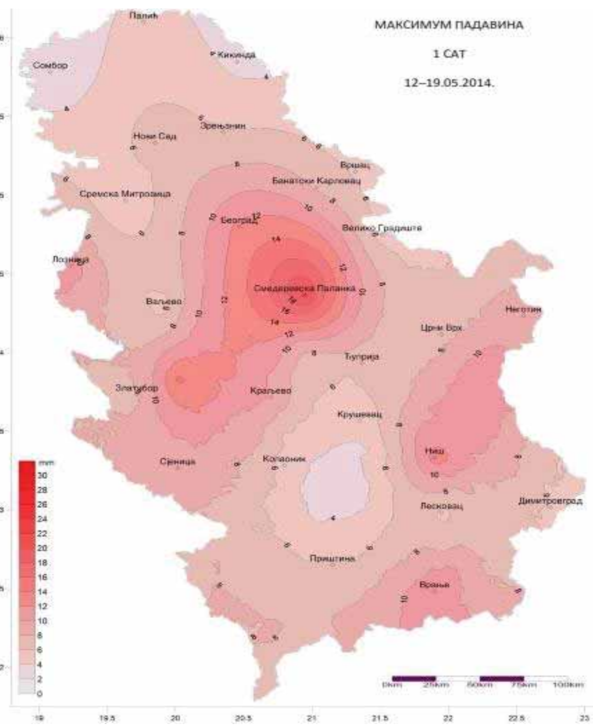

Figure 2. **Maximum hourly precipitation, 12–19 May 2014.**

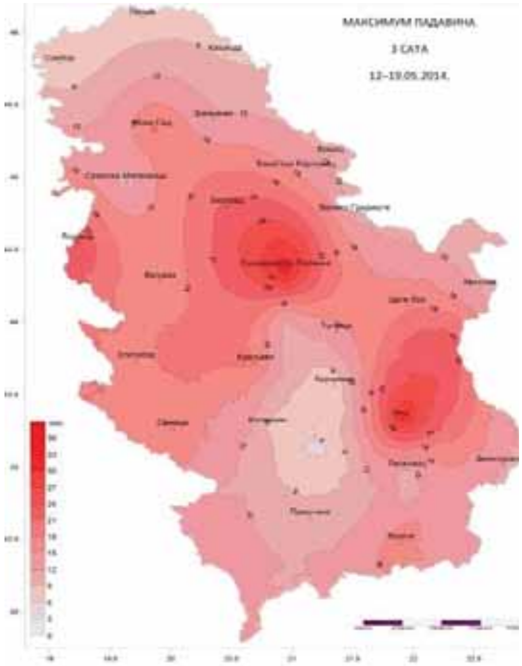

Figure 3. **Maximum three-hour precipitation,12–19 May 2014**

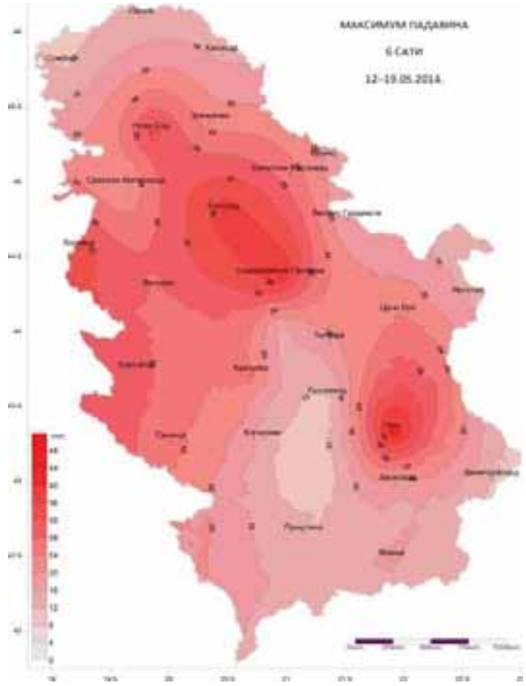

Figure 4. **Maximum six-hour precipitation,12–19 May 2014.**

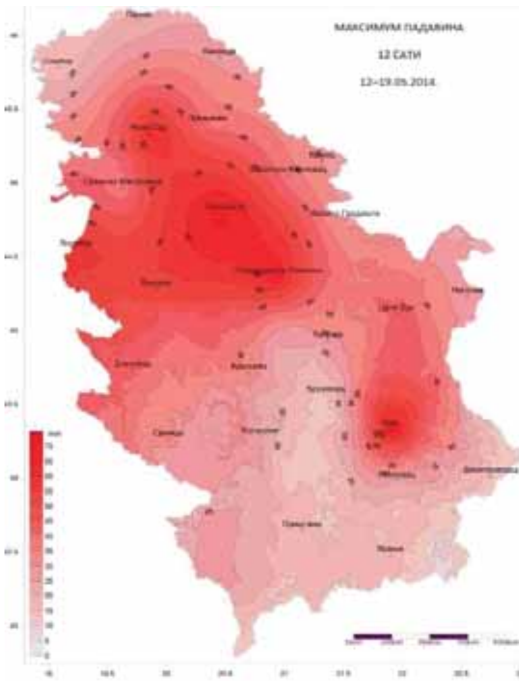

Figure 5. **Maximum 12-hour precipitation,12–19 May 2014.**

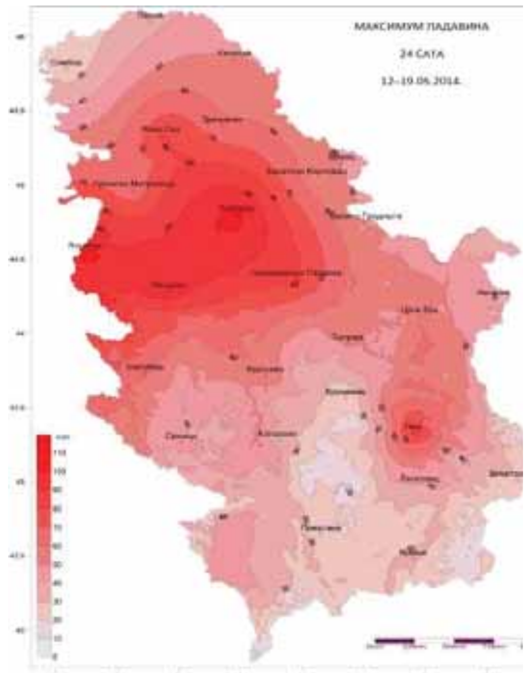

Figure 6. **Maximum 24-hour precipitation,12–19 May 2014.**

As shown in Fig. 6, the area that received the most intense precipitation over 24 hours was identical to that of the 12-hour rainfall, but there were two additional, smaller areas of concentrated rainfall near Belgrade and Loznica. The area of maximum 48-hour intensity (Fig. 7) remained virtually the same, but it was slightly elongated, generally in the Belgrade-to-Loznica direction. The highest rainfall intensity was recorded in downtown Loznica. The pattern of the maximum 72-hour rainfall (Fig. 8) was similar, but two high-intensity belts were divided into two focal areas of heavy rainfall: one between Belgrade and Valjevo and the other near Loznica.

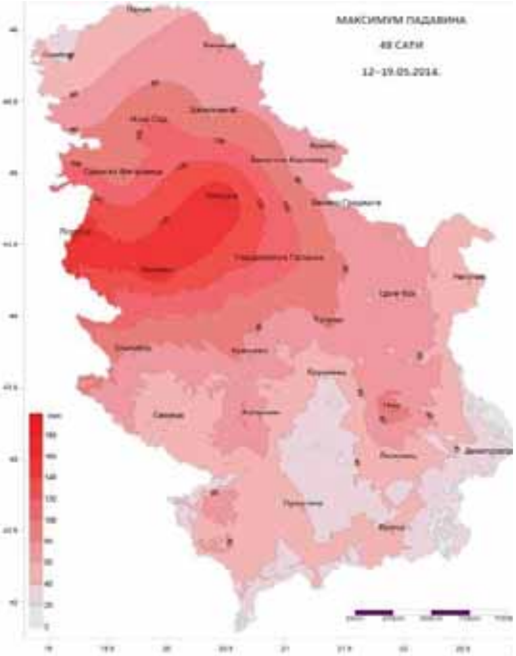

Figure 7. **Maximum 48-hour precipitation, 12–19 May 2014.**

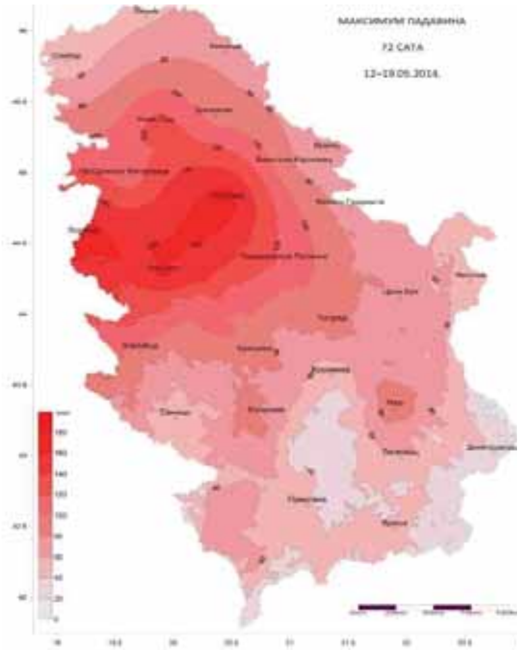

Figure 8. **Maximum 72-hour precipitation, 12–19 May 2014.**

It is evident that during this particular extreme rainfall event, the most statistically significant were the three-day amounts of precipitation recorded from 14 to 16 May 2014. To provide insight into the statistical significance, Fig. 9 shows the isolines of actual three-day rainfall depths and the corresponding theoretical depths for a 1000-year return period. To produce this map, both the MMS data and data from other weather stations, which do not record hourly values, were used. The assessment was based on Gumbel's model of the theory of extremes and 1961-2011 precipitation depth data from 59 weather stations in Serbia

As it is shown in the Fig. 9, this map indicates that the rainfall intensity was the highest from 14 to 16 May 2014 in the Drina and Kolubara regions, then in Mačva and Tamnava, where the actual amounts of precipitation exceeded three-day theoretical values for a return period of 1000 years.

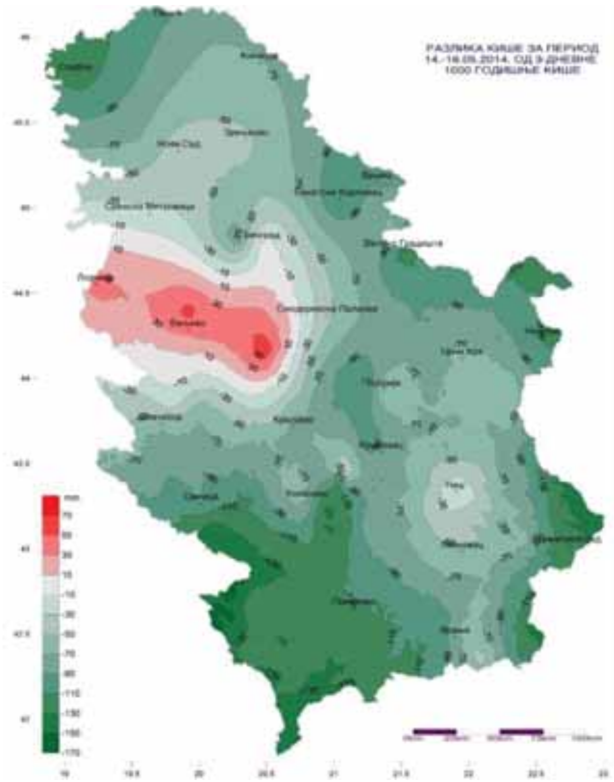

Figure 9. **Map of precipitation depths (mm), 14–16 May 2014.**

For the assessment, the return periods all recorded maximum intensities during the May's flood in Serbia a more subtle analysis of rainfall depths, or rainfall intensities, as a function of rainfall duration and probability of occurrence was conducted for all MMSs. The results are shown in Figs. 10–12, which contain a parallel representation of precipitation as a function of these two parameters, or the so-called depth-time-probability (DTP) curves, as well as the maximum rainfall intensities (depths) recorded during the May 2014 flood event by the MMSs at Belgrade and Loznica. The DTP curves were taken from the Monograph *Heavy Rainfall Intensities in Serbia* by S. Prohaska, V. Bartoš Divac et al., Belgrade, 2014, which contains the outcomes of the most recent statistical and probabilistic assessments of rainfall intensities at 30 pluviographic stations in Serbia. The results are shown in the Monograph in the form of, *inter alia*, DTP curves and GIS maps of rainfall depths for different rainfall durations and probabilities of occurrence.

The DTP curves shown here are indicative of the statistical significance of the studied rainfall event in Serbia. For example, it is evident in Fig. 10, which shows the DTP curve for Belgrade, that the maximum intensities for rainfall durations of up to four hours (240 minutes) were below the long-term average. Then the maximum intensities began to rise rapidly with increasing rainfall duration, and after 24 hours (1440 minutes) reached a level that corresponded to a 100-year return period. As the rainfall duration increased further, so did the maximum intensities, and after 48 hours (2880 minutes) the rainfall depth reached the level of a 400-year return period. For rainfall duration of 72 hours (4320 minutes), the return period was 700 years.

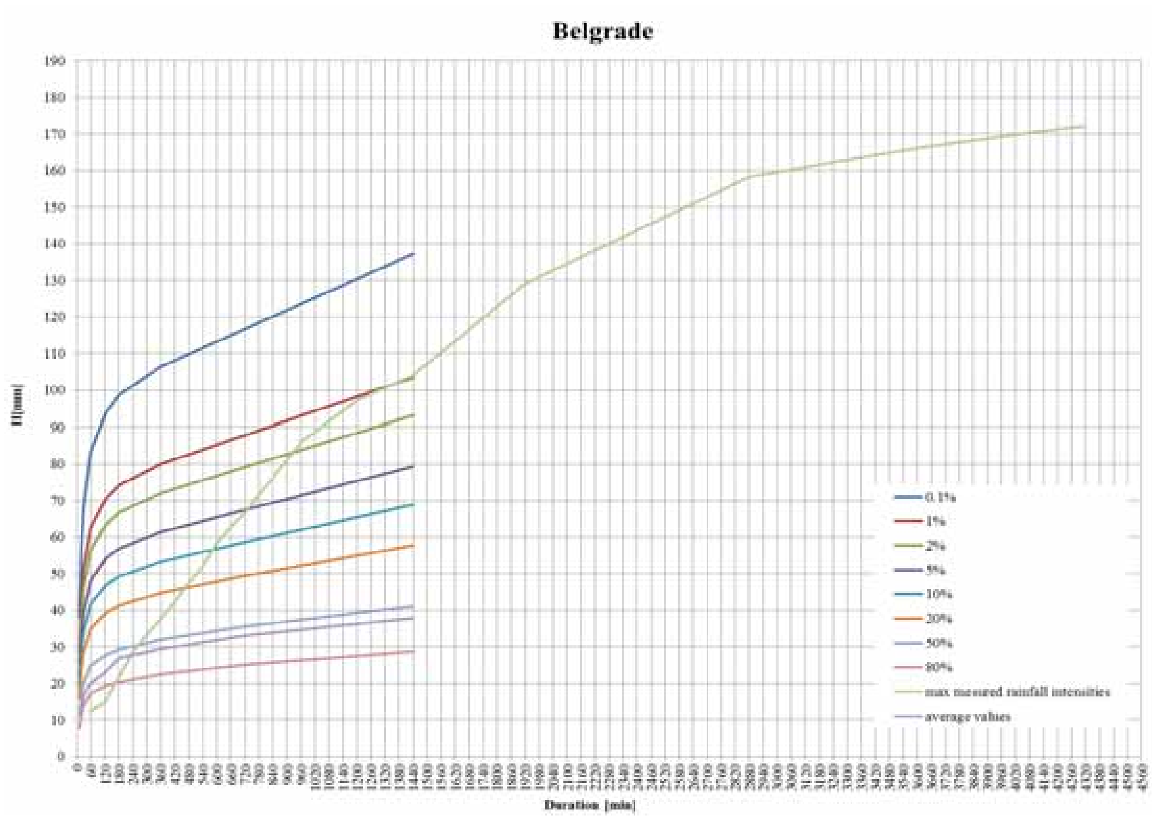

Figure 10. **DTP curve for Belgrade**

The second example is given for a nearly identical situation which was reported by the MMS at Loznica. The maximum recorded intensities of up to five hours (300 minutes) were below the long-term average. Then there was a sudden increase in the maximum intensities, up to 48 hours. The 24-hour maximum intensities (1440 minutes) exceeded a 100-return period, while in 48 hours (2880 minutes) they reached a level that corresponded to a 1000-year return period. Then, as rainfall duration increased, the intensities began to decline and after 72 hours (4320 minutes) they were commensurate with a 400-year return period.

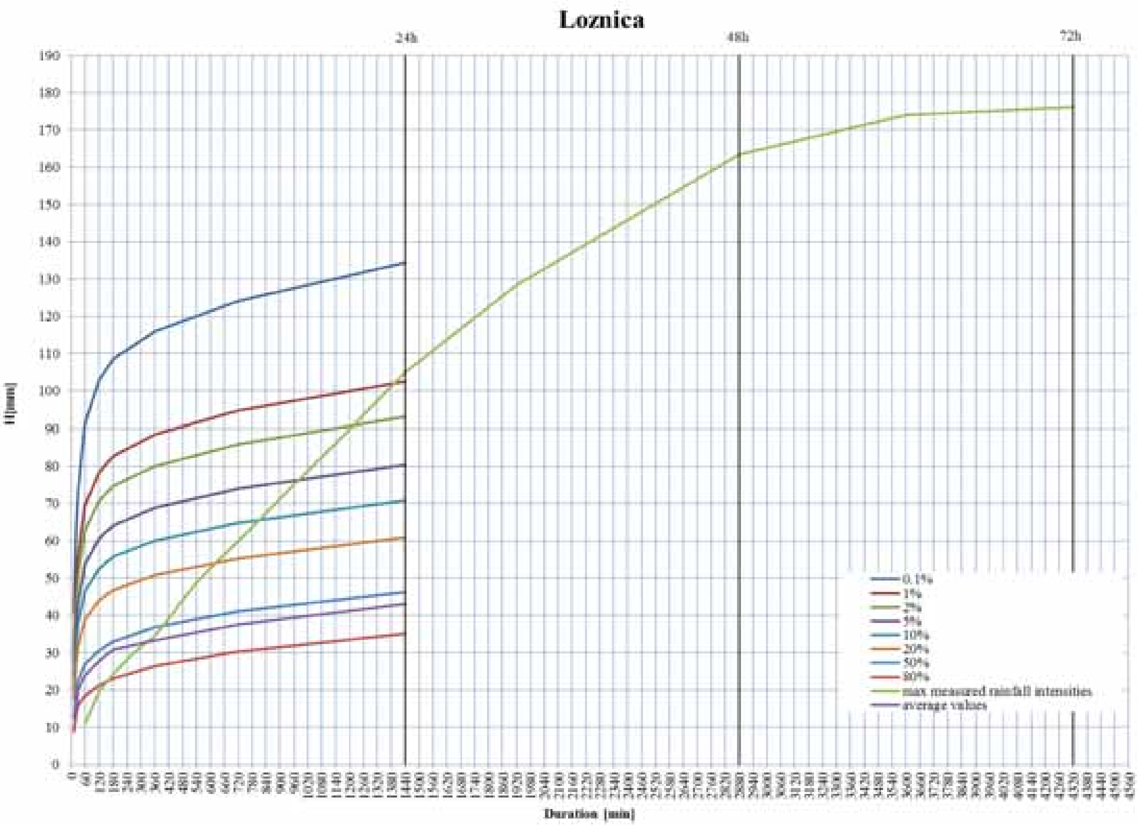

Figure 11. **DTP curve for Loznica**

To provide insight into the statistical significance of the rainfall in the extended flooded area of Serbia, Table 1 contains a summary of rainfall depths for different rainfall durations and the corresponding return periods for seven MMSs, with the highest registered precipitation levels from midnight on 12 May to 3 am on 19 May 2014. For rainfall durations shorter than six hours, long-term averages (Av.) are shown instead of return periods T(yr).

It is obvious that Table 1 shows that the recorded maximum hourly intensities were well below the long-term averages. The recorded maximum three-hour rainfall depths at nearly all the MMSs were below the long-term averages, except for the MMSs at Smederevska Palanka and Niš, where they were slightly higher. The maximum six-hour intensities were generally around the long-term averages, except at Niš, where the intensity was considerably higher, and at Sremska Mitrovica where it was lower. The recorded maximum 12-hour intensities were statistically significant solely at the MMS in Niš, of the order of a 100-year return period. Only the recorded maximum 24-hour intensities were statistically significant in the extended area: 100-year return period at the MMSs in Belgrade and Loznica, 70-year return period at Valjevo and 50-year return period at Niš. The highest statistical significance during the May flood event was registered at the Loznica MMS, where for a 48-hour duration (two-day maximum) the recorded maximum rainfall depth corresponded to a 1000-year return period. For the same duration, the other MMSs recorded statistically significant rainfalls of the order of a 400-year return period at Belgrade and Valjevo and an 80-year return period at Niš. Statistically very significant maximum rainfall depths over 72 hours (three-day maximum), exceeding a 700-year return period, were recorded at Belgrade and Valjevo. The MMS at Loznica recorded a maximum rainfall intensity (of the same duration) whose return period was about 400 years. The MMS at Rimski Šančevi reported 100-year rainfall intensity and that at Niš 80-year maximum intensity.

Assessment of the return period of monthly precipitation totals in May 2014. As already mentioned, such events preceeded the maximum rainfall episodes analyzed in the previous section of this paper and similar events were also recorded afterwards. In May, the total number of rainfall days at the MMSs in Serbia ranged from 14 days on Mt. Zlatibor to 21 days in Novi Sad, which was seven days more than the usual number of rainy days in May.

In order to insight into the statistical significance of recorded precipitation totals in Serbia in May 2014, Table 2 shows the characteristic May precipitation totals at selected weather stations, which reported the highest levels. Specifically, the table shows precipitation totals for the period from 1 to 31 May 2104, the highest May precipitation total on record and the year recorded, as well as typical statistical parameters, such as the long-term averages and theoretical precipitation totals for the month of May for different return periods.

As it can be seen in Table 2, the monthly precipitation totals recorded in May 2014 at selected MMSs in Serbia were considerably higher than the previously registered extremes. At Valjevo, for instance, the highest May precipitation total was previously recorded in 1957, but was exceeded in 2014 by nearly 50%. The MMSs at Belgrade and Smederevska Palanka previously recorded May extremes in 1990 and 1929, respectively, which were exceeded in 2014 by 45%. At Loznica, the extreme recorded in 1938 was exceeded by 44%. The MMSs at Novi Sad, Mt. Zlatibor and Požega, whose highest May precipitation totals were recorded in 1987, 1956 and 1980, respectively, exceeded those levels in 2014 by 12 to 14%. Only the MMS at Sremska Mitrovica reported a slightly higher May precipitation total in 2014 (by 2%) than the previous 1939 record. The long-term average May precipitation totals were exceeded by a factor of 2.0 (Mt. Zlatibor) to 4.1 (Belgrade). From a return period perspective, all MMSs reported that May 2014 precipitation exceeded previous return periods of maximum precipitation depths, of different durations (and consequently led to disastrous floods in Serbia). The MMS at Smederevska Palanka registered the longest return period of the May precipitation total, of the order of 5000 years. The MMS at Valjevo reported a return period of some 3333 years and that in Belgrade of 2500 year, followed by Loznica (667 years), Novi Sad (588 years), Kragujevac (333 years) and Sremska Mitrovica (286 years). The southern periphery of the study area recorded May precipitation totals that corresponded to return periods of 154 years on Mt. Zlatibor and 125 years at the City of Požega.

Conclusion. The conclusion of this paper is as following:

1. All main meteorological stations (MMSs) reported a very long duration of high-intensity rainfall, both at their locations and in-between, and this rainfall caused the May 2014 flood. Such an occurrence is very rare and generally results in disastrous floods. The total duration of this rainfall event across Serbia exceeded durations that have a 1000-year return period.

2. Maximum rainfalls of 5–6 hours, which tend to cause flash floods, were below long-term averages, except in the vicinity of Smederevska Palanka and Niš.

Table 1. ***Assessment of statistical significance of actual maximum rainfall intensities (depths) of different durations, which resulted in the May 2014 flood event in Serbia***

Main meteorological station (MMS)	Rainfall duration													
	1h		3h		6h		12h		24h		48h		72h	
	mm	Av.	mm	Av.	mm	Av.	mm	T(yr)	mm	T(yr)	mm	T(yr)	mm	T(yr)
Belgrade	12.5	23.1	21.8	29.5	37.3	33.2	66.8	20	103.9	100	158.2	400	172.3	700
Loznica	11.1	27.8	24.2	33.3	34.5	37.5	59.8	7	105.0	100	163.4	1000	176.1	400
Valjevo	5.5	25.3	15.0	32.1	27.7	36.1	53.8	3	97.4	70	149.4	400	164.2	700
R. Šančevi	7.5	17.2	18.4	26.6	33.5	33.1	60.9	20	81.1	30	107.5	50	131.3	100
S. Palanka	20.5	21.9	32.3	27.6	39.7	31.9	64.0	12	83.5	40	111.5	30	116.1	25
S. Mitrovica	4.0	18.1	10.8	26.1	19.1	31.2	35.9	2.5	62.8	20	88.6	50	106.5	70
Niš	13.1	20.0	30.3	24.1	43.3	27.9	67.3	100	84.0	50	96.8	80	100.1	80

Table 2. **Statistical significance of May 2014 precipitation totals recorded at select weather stations in Serbia**

Weather station	Precipitation total, 1 to 31 May 2014 (mm)	Highest precipitation total on record		Long-term average precipitation total for May	Theoretical May precipitation totals for different probabilities of occurrence p(%)					Statistical significance of recorded May 2014 precipitation totals	
		(mm)	Year		0.1%	1.0%	2.0%	5.0%	10%	P(%)	T(yr)
Novi Sad	201.9	175.7	1987	57.8	211.7	159.5	143.0	120.2	102.0	0.17	588
Loznica	314.6	218.6	1938	79.2	330.0	229.1	200.6	163.8	136.4	0.15	667
Sremska Mitrovica	189.0	184.9	1939	58.4	216.9	167.0	150.0	126.0	106.3	0.35	286
Valjevo	317.6	213.2	1957	80.7	280.5	211.7	190.0	160.3	136.7	0.03	3333
Belgrade	278.5	191.7	1900	67.7	252.2	189.3	169.2	141.5	119.4	0.04	2500
Kragujevac	227.0	169.7	1970	67.8	257.0	198.2	178.0	149.2	125.4	0.30	333
S. Palanka	238.2	164.7	1929	62.1	202.3	161.6	147.2	126.2	108.5	0.02	5000
Zlatibor	195.6	172.5	1956	99.5	217.4	187.8	176.8	160.2	145.6	0.65	154
Požega	199.4	177.9	1980	79.0	258.2	193.7	174.1	147.8	127.2	0.80	125

3. Statistically significant precipitation totals were recorded for rainfall durations of more than 24 hours. For example, the maximum 24-hour rainfalls in Belgrade and Loznica exceeded a 100-year return period, and the return periods reported by Valjevo, Niš and Rimski Šančevi exceeded 70, 50 and 30 years, respectively. The maximum 48-hour precipitation depth was measured at Loznica (exceeding a 1000-year return period), followed by Belgrade and Valjevo (400-years) and Niš (80 years). The return period of the three-day rainfall registered at Belgrade and Valjevo was estimated at 700 years, followed by Loznica (400 years) and Rimski Šančevi (100 years).

4. From a statistical significance perspective, the May 2014 precipitation totals exceeded the return periods identified for the maximum rainfall that caused the disastrous flood in Serbia. A return period of the May precipitation total was 5000 years at Smederevska Palanka, 3333 years at Valjevo and 2500 years at Belgrade. All the other considered MMSs reported monthly precipitation totals in excess of a 100-year return period (from 125 at Požega to 667 years at Loznica).

It can be said that the May 2014 extreme rainfall episodes were characterized by enormous amounts of precipitation, which lasted for a long time and affected a relatively large area. In Serbia, in the catchments of the Jadar and Kolubara rivers and in Mačva, from a statistical-probabilistic perspective, they exceeded a 100-year return period. In the absence of all relevant monitoring data, it was difficult at the time of writing to assess the statistical significance of this exceptional rainfall event in the entire area shared by three countries.

On the contrary to this extreme rainfall, more statistically significant were the monthly precipitation totals recorded at the considered MMSs in Serbia. They resulted in protracted floods in all the previously mentioned catchment areas.

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Оцінка повторюваності інтенсивності опадів, які викликали повінь у травні 2014 року в Сербії

Прохаска Стеван

Повінь в середині травня 2014 року, яке призвело до людських жертв і величезному матеріальному збитку, найбільше з спостережених. Очевидно, що таке повінь була результатом надзвичайно сильних дощів на більшу частину території Сербії, або конкретно на території, прилеглій до річок Дрина, Сава, Західна Морава і Млава. Природа повені показує, що це була комбінація потужних зливових паводків в гористих областях (характеризується дуже швидкодіючим і руйнівною дією), що збіглися в басейнах річок, і великомасштабного повені із затяжними затопленнями річкових долин, які є типовими рівнинними річками.

У статті наведено детальне уявлення про максимальні інтенсивності опадів різної тривалості, які передували катастрофічної повені у зазначеній частині Сербії. Аналіз події складено з використанням офіційних даних щогодинних опадів, записаними основними метеорологічними станціями Національної Гідрометеослужби Сербії. Просторовий розподіл максимальних інтенсивностей опадів у Сербії різних продолжительностей показано на картах ізогієт.

Ключові слова: *травень 2014 повінь, рясні опади, інтенсивність опадів, тривалість опадів, ймовірність появи, повторюваність, статистична значимість*

Оценка повторяемости интенсивности осадков, которые вызвали наводнение в мае 2014 года в Сербии

Прохаска Стеван

Наводнение в середине мая 2014 года, которое привело к человеческим жертвам и огромному материальному ущербу, самое большое из наблюденных. Очевидно, что такое наводнение было результатом чрезвычайно сильных дождей на большую часть территории Сербии, или конкретно на территории, прилегающей к рекам Дрина, Савва, Западная Морава и Млава. Природа наводнения показывает, что это была комбинация мощных ливневых паводков в гористых областях (характеризуется очень быстродействующим и разрушительным действием), что совпали в бассейнах рек, и крупномасштабного наводнения с затяжными затоплениями речных долин, которые являются типичными равнинными реками.

В статье приведено детальное представление о максимальных интенсивностях осадков различной продолжительности, которые предшествовали катастрофическому наводнению в указанной части Сербии. Анализ события составлен с использованием официальных данных ежечасных осадков, записанными основными метеорологическими станциями Национальной Гидрометеослужбы Сербии. Пространственное распределение максимальных интенсивностей осадков в Сербии различных продолжительностей показано на картах изогиет.

Ключевые слова: *май 2014 наводнение, обильные осадки, интенсивность осадков, продолжительность осадков, вероятность появления, повторяемость, статистическая значимость*

Assessment of the return period of the rainfall intensity that caused the may 2014 flood in Serbia

Prohaska Stevan

The flood in mid-May of 2014 caused human casualties and enormous material damage, the greatest on record. It is evident that such a flood was a result of extremely heavy rainfall across the most of Serbia, or specifically the area bordered by the Drina, Sava, Zapadna Morava and MlavaRivers. The nature of the flood shows that it was a combination of powerful flash floods in mountainous areas (characterized by a very rapid and destructive front), coinciding flash floods within river basins, and large-scale protracted floods that inundated river valleys, which are typical of lowland rivers. Rainfall events likely to cause such a flood pattern exhibit maximum intensities of different rainfall durations.

Detailed presentation of the maximum rainfall intensities of varying durations, which preceeded the disastrous flood in the designated part of Serbia is given in this paper. All analyses ware compiled using offical hourly rainfall data recorded by the main meteorological stations of the National Hydrometeorological Service of Serbia. The assessment of the return periods of the recorded maximum intensities that led to the flood was assessed using also the most recent analyses of heavy rainfall events recorded by all pluviographs at the main meteorological stations, from the time the pluviographs were placed online to the end of 2008. The spatial distribution of maximum rainfall intensities in Serbia, of different durations, is shown on an isohyet map.

The paper concludes with a statistical analysis of May 2014 precipitation totals at the same locations. These totals were analyzed in parallel with the extremes registered since each of the main meteorological stations was commissioned. The May 2014 precipitation totals were compared to the highest levels on record, then to long-term averages, and finally to the theoretical precipitation levels in May for different probabilities of occurrence. A return period was determined for each recorded May 2014 precipitation total.
Keywords: *May 2014 flood, heavy rainfall, rainfall intensity, rainfall duration, probability of occurrence, return period, statistical significance.*

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ГІДРОЛОГІЧНА ПОСУХА 2015 РОКУ В УКРАЇНІ: ЧИННИКИ ФОРМУВАННЯ, ПЕРЕБІГ ТА МОЖЛИВІ НАСЛІДКИ

Ключові слова*: посушливі явища,гідрологічна посуха,причини формування*

Вступ. Український Гідрометцентр та обласні гідрометеорологічні організації, виконуючи оцінку поточної водності річок країни, вже з кінця липня почали інформувати водогосподарські, гідроенергетичні організації та інших споживачів про складну гідрологічну ситуацію та загрозу формування низької водності у меженний період 2015 р. Починаючи з серпня поточного року у звітах про водогосподарську обстановку басейнових та обласних управлінь водних ресурсів Держводагентства України з'явилася інформація про ускладнення гідрометеорологічної обстановки та можливі негативні наслідки цього для роботи водогосподарського комплексу. Жарка, зі значним дефіцитом опадів погода в більшості областей України протягом літнього сезону сприяла суттєвому зменшенню водності річок та припливу до водосховищ. Особливо складна і небезпечна ситуація склалася й триває на Київському, Канівському і Дністровському водосховищах, до яких упродовж усього меженного періоду відмічається найменший за період їх експлуатації приплив води. Такі обставини зумовили необхідність зменшення скидів води до мінімальних санітарно-екологічних величин та значне спрацювання Дніпровського каскаду і Дністровського водосховища. Гідрологічна ситуація на більшості водних об'єктів України залишається вкрай несприятливою. Триває низька і дуже низька за рівнями і витратами води літньо-осіння межінь, яка по багатьох річках України може стати найнижчою за весь період регулярних спостережень. На значній території України ми спостерігаємо небезпечну гідрологічну ситуацію природного характеру – *маловоддя* або *гідрологічну посуху*.

Виклад основного матеріалу. Посушливі явища зумовлені складним комплексом геофізичних і біофізичних процесів, що виникають на деякій території протягом досить тривалого часу. *Атмосферною* посухою у місцевості з помірним кліматом є стан атмосфери з тривалим бездощів'ям, істотним зменшенням опадів, що супроводжується підвищеною інсоляцією та високою температурою повітря. Атмосферна посуха за певної тривалості зумовлює *ґрунтову*