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PRECIPITATION-RELATED HAZARDS IN VIDIN-NIKOPOL DANUBE FLOODPLAIN SECTOR – CURRENT STATE AND TENDENCIES

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INTRODUCTION

Heavy precipitation in Bulgaria is subject to increased research over the last decade in relation to climate change. Global and regional climate models in most of the cases project an increase of these phenomena over the territory of Bulgaria. Recent studies (B o c h e v a et al. 2007; B o c h e v a et al., 2008a, B o c h e v a et al., 2008b, B o c h e v a et al., 2009, N o j a r o v, 2013a, 2013b; S i m e o n o v et al., 2009) have confirmed the increase of heavy precipitation events in Bulgaria. This has been particularly evident in the period 1991–2005 when compared to the base period 1961–1990. It is valid for both heavy precipitation over 30 mm/day and for heavy precipitation over 100 mm/day. Also there is an increase of cases of thunderstorms and hail in the warm half of the year from April to September. These studies usually cover the entire Bulgaria or a large part of it, and hence the spatial resolution is relatively coarse. Also, there are almost no studies of heavy snowfalls and blizzards, which are connected with both precipitation and average wind speed. The aim of the article is to reveal spatial and, partially, temporal characteristics of precipitation-related hazards in Vidin-Nikopol sector of the Danube floodplain. Several tasks were completed in order to achieve this aim. Annual course of studied meteorological hazards was revealed. Trends in heavy precipitation events were calculated. Maps of the spatial distribution of meteorological hazards for both the current period and the older period were drawn.

DATA AND METHOD

The borders of the studied area are defined by the borders of the Danube municipalities from Vidin to Nikopol. Data from 7 meteorological stations, 5 of which are located along the Danube – Novo selo, Vidin, Lom, Oryahovo, Svishtov and 2 in the southern part of the valley – Vratsa and Pleven were used in this research. Only several meteorological hazards in Vidin-Nikopol Danube floodplain sector were investigated in this article. They were defined as follows. Heavy precipitation over 30 mm/day is dangerous for agriculture. This type of precipitation causes intense erosion. A few consecutive rainfalls may also lead to floods. Heavy precipitation over 50 mm/day is dangerous for transport, agriculture and in most cases cause floods. Blizzards occur at average wind speed exceeding 10 m/s and snowfall over 15 mm. They are dangerous for the transport system. Heavy snowfall is defined when new snow cover of at least 20 cm is formed. It is also dangerous for the transport system. The period of study is from October 2001 to December 2012 and aims to describe the current status in terms of meteorological hazards. Heavy precipitation was investigated also in the period from 1953 to 1965 in order to determine whether there are any trends in its frequency. Only at station Pleven this period spans from 1953 to 1979. Cases of certain event have been counted using synoptic data, which are collected every 3 hours. Thus average frequencies of a given phenomenon were obtained on a monthly or annual basis. The study employs statistical methods such as trend analysis. Also mapping method was used for the analysis of the spatial distribution of meteorological hazards.

Hazard classes have been determined on the base of the results for the average frequencies of studied meteorological hazards. Hazard classes are as follows:

1 class (very low): 0–0.19 cases/month
2 class (low): 0.2–0.39 cases/month
3 class (medium): 0.4–0.59 cases/month
4 class (high): 0.6–0.79 cases/month
5 class (very high): >0.8 cases/month

RESULTS AND DISCUSSION

HEAVY PRECIPITATION OVER 30 MM/DAY

Figure 1 shows the annual course of the number of cases of precipitation over 30 mm/day for the current period at the seven studied meteorological stations. It could be seen that the number of cases increase in the period from May to October, which is due to the nature of precipitation during the warm half of the year, which originate from convective clouds or along fast moving cold front. In such cases, the intensity of precipitation is big, which results in large amounts in short periods of time. Also, it could be seen that higher number of cases of this hazard throughout the entire year is observed at the two stations located in the southern part of the valley – Vratsa and Pleven. This is due to their position, which is closer to the mountains (especially Vratsa) that have orographic influence on precipitation strengthening both frontal precipitation and convective precipitation. The figure shows that even in winter there is precipitation that is above the accepted limit. But, generally, the most serious hazard of heavy precipitation is during the warm half of the year.

Trends in the number of cases of heavy precipitation over 30 mm/day for the period 1953–2012 are shown in Fig. 2. It could be seen that, at nearly all stations, the frequency of this hazard has increased in recent years. The only exception, having negative trend, is station Svishtov. Obviously, the picture is different moving in eastern direction. But, given the extent of the area, it could be concluded that cases with heavy precipitation will increase against the background of higher air

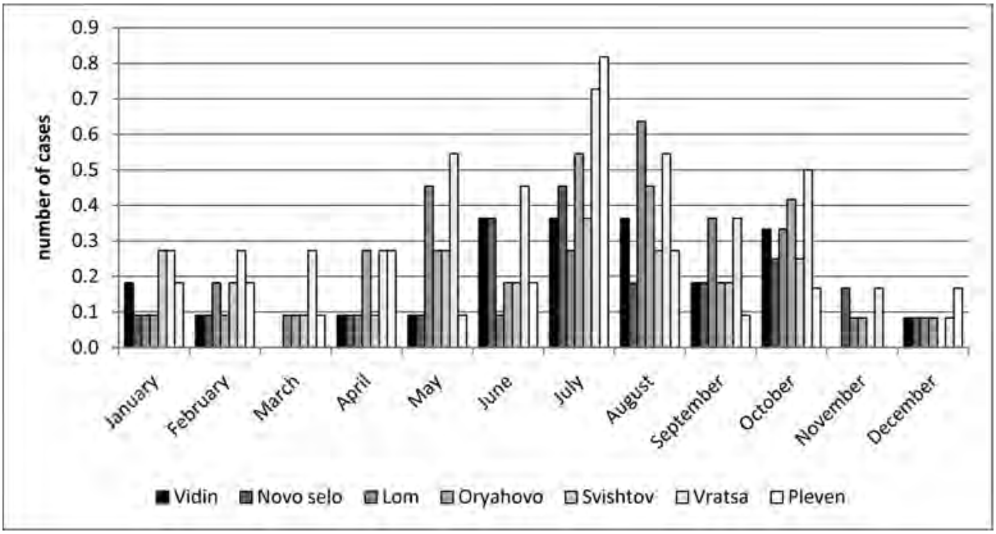

Fig. 1. Annual course of cases of heavy precipitation over 30 mm/day for the period 10.2001–12.2012

temperatures and lower annual precipitation. This will require adaptation measures and additional protection of the population and infrastructure against possible future floodings.

Spatial distribution of the number of cases of precipitation over 30 mm/day for the current period is shown in Fig. 3. It could be seen that the number of cases of this hazard increases in southern direction. The lowest number of cases is observed

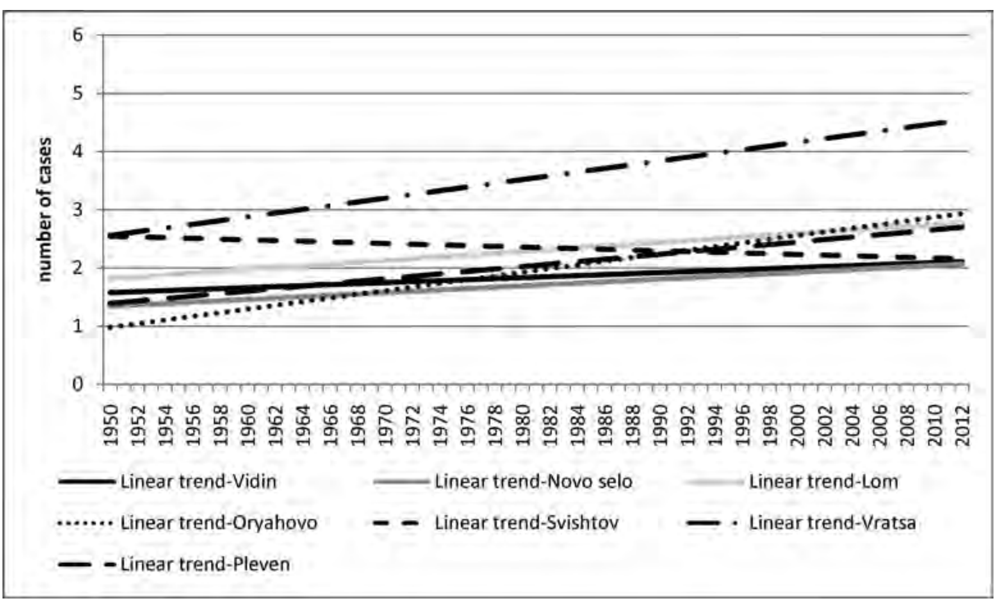

Fig. 2. Trends in cases of heavy precipitation over 30 mm/day for the period 1953–2012

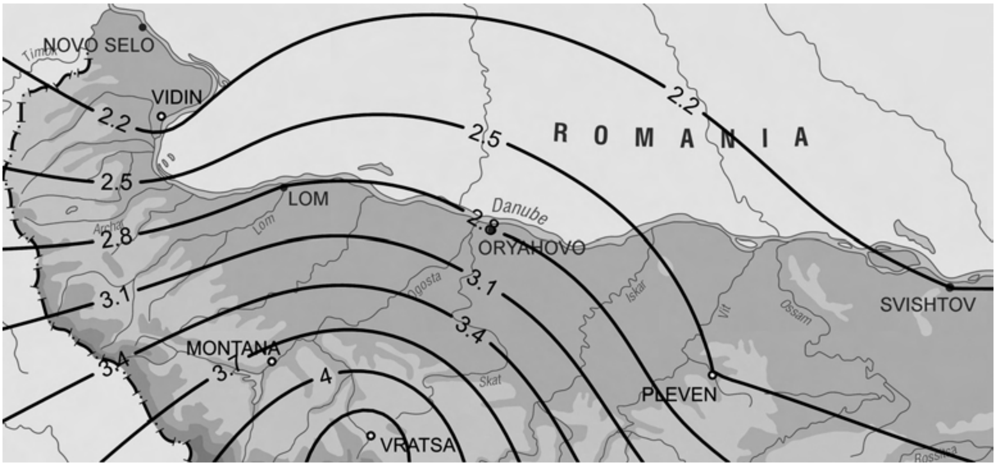

Fig. 3. Spatial distribution of cases of heavy precipitation over 30 mm/day for the period 10.2001–12.2012

at stations Novo selo, Vidin and Svishtov, and the highest – at Vratsa. The causes for such a spatial distribution were explained in the comments on Fig. 1. Average annual number of cases with this hazard is from 2 to over 3 in the Danube municipalities.

Spatial distribution of the number of cases of heavy precipitation over 30 mm/day for the period 1953–1965 is shown in Fig. 4. It could be seen that the lowest frequency of this phenomenon has been observed in the region Oryahovo–Pleven – less than 1.6 cases per year. The greatest was the frequency in the region of Vratsa – more than 2.4 cases per year. This spatial distribution reveals some peculiarities. In the western half of the studied area the number of cases of this phenomenon increases from north to south, while in the eastern half this number increases from west to east. Comparison with the current period shows some pronounced trends that are

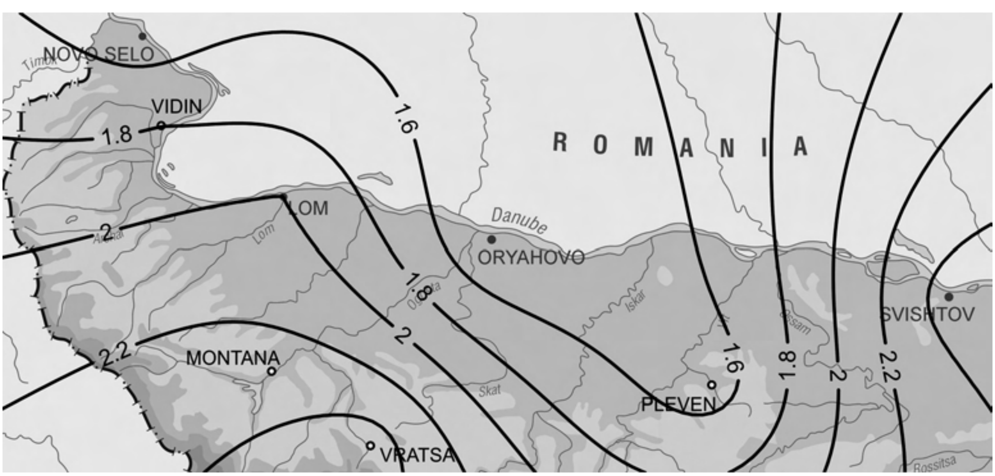

Fig. 4. Spatial distribution of cases of heavy precipitation over 30 mm/day for the period 1953–1965

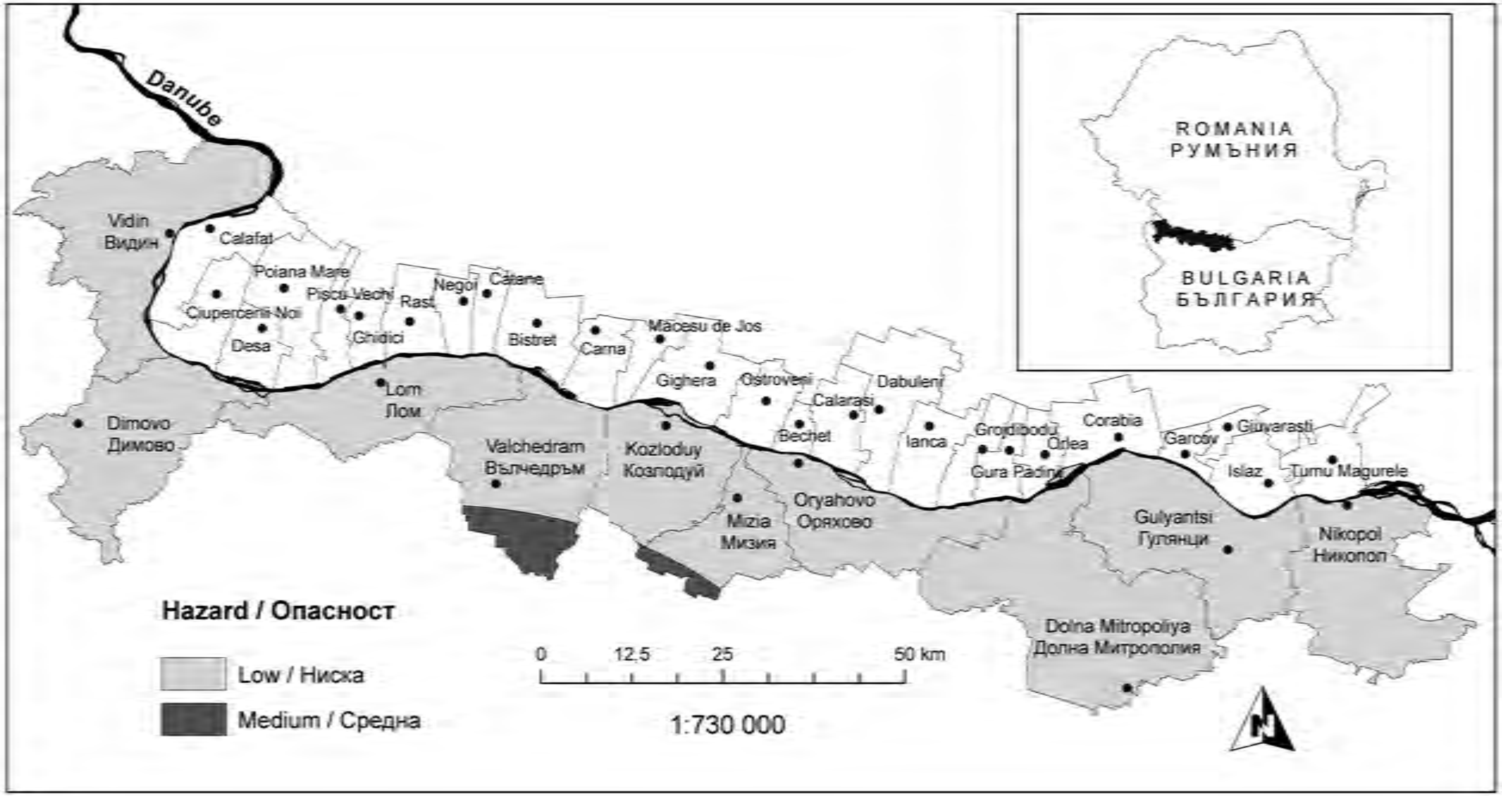

Fig. 5. Spatial distribution of hazard classes of precipitation over 30 mm/day (April-September) for the period 10.2001–12.2012 in Vidin-Nikopol Danube floodplain sector

visible also in Fig. 2. All in all, the frequency of heavy precipitation over 30 mm/day increases everywhere except in the eastern part of the studied area. This leads to a more homogeneous spatial distribution and a clear increase of the frequency only in south direction.

The annual course of the number of cases of precipitation over 30 mm/day shows that their maximum is in the period from April to September, which is due to the nature of precipitation during the warm half of the year, which originates from convective clouds or along fast moving cold front. That is why Fig. 5 shows hazards, connected with this phenomenon, only in the warm half of the year (April-September). It could be seen that the most of the studied area is characterized by low hazard (class 2). This means that there are about 2 rainfalls of this type per year. Only the southern parts of municipalities Valchedram and Misia are characterized by medium hazard (class 3), which means that there are about 3 such rainfalls in the warm half of the year.

HEAVY PRECIPITATION OVER 50 MM/DAY

Figure 6 shows the annual course of the number of cases of precipitation over 50 mm/day for the current period in the research area. As should be expected this hazard is quite rare and occur mainly in July and August and not at all stations. This type of precipitation, however, almost certainly leads to a flooding. Again, stations with higher frequencies are Vratsa and Pleven, but some stations along the Danube River also show high values in summer months. The figure reveals that such heavy precipitation is possible even in winter months. But the main danger of flooding remains in the warm half of the year and especially in summer.

Figure 7 shows trends in the number of cases of heavy precipitation over 50 mm/day for the period 1953–2012. The picture here is more diversified. The most stations maintain their positive trends of the number of cases of this phenomenon. Svishtov,

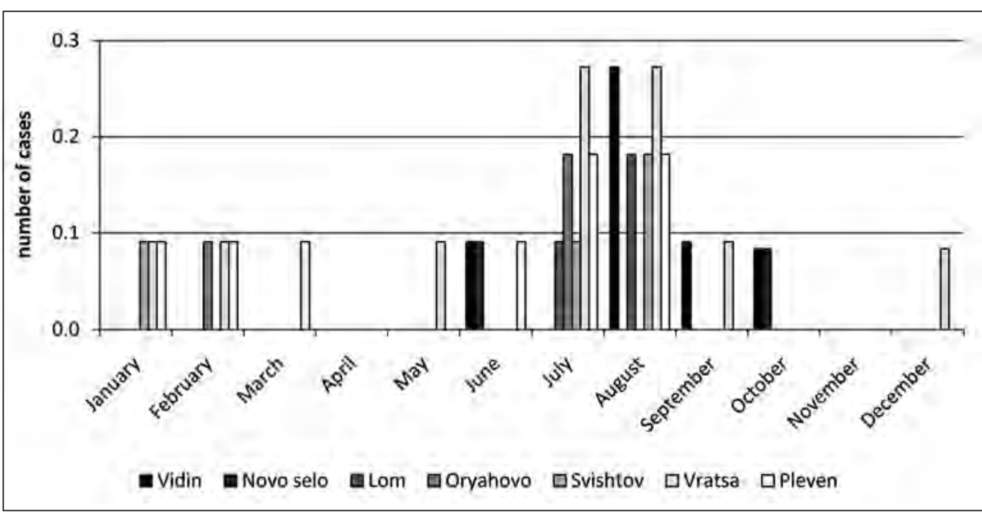

Fig. 6. Annual course of cases of heavy precipitation over 50 mm/day for the period 10.2001–12.2012

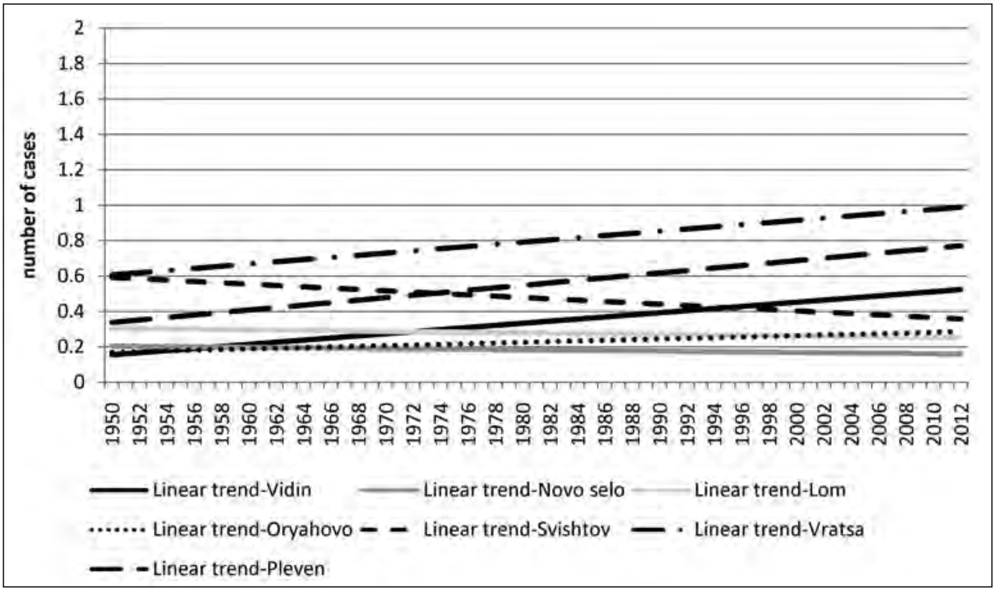

Fig. 7. Trends in cases of heavy precipitation over 50 mm/day for the period 1953–2012

again, has a decreasing trend together with stations Novo selo and Lom. This is probably due to the relatively lower frequency of this meteorological hazard and as a result – of the relative randomness of its distribution. I.e. it is difficult to make a solid projection of this hazardous climatic element.

Figure 8 shows spatial distribution of the number of cases of precipitation over 50 mm/day for the current period. It could be seen, compared to Fig. 3, that there is a serious reduction in the average annual number – it is between 0.2 and 0.6 for

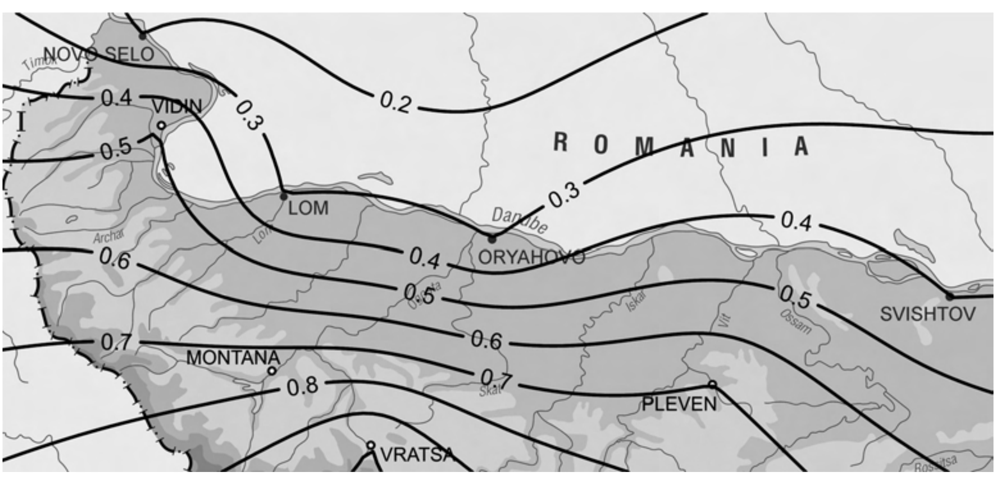

Fig. 8. Spatial distribution of cases of heavy precipitation over 50 mm/day for the period 10.2001–12.2012

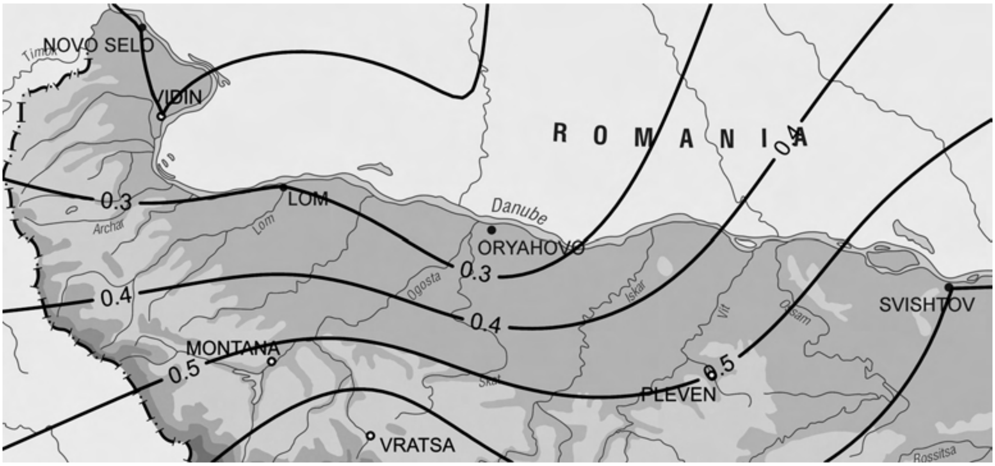

Fig. 9. Spatial distribution of cases of heavy precipitation over 50 mm/day for the period 1953–1965

this sector of the Danube floodplain. This means that there may be years without the occurrence of such dangerous meteorological phenomenon. The spatial distribution shows an increase of the number of cases in southern direction. This is due to the proximity of these areas to the mountain range.

Spatial distribution of the number of cases of heavy precipitation over 50 mm/day for the period 1953–1965 is shown in Fig. 9. It could be seen that the lowest frequency of this phenomenon has been observed in the region of Vidin – about 0.2 cases per year. The greatest was the frequency in the regions of Vratsa and Svishtov – around and above 0.6 cases per year. This spatial distribution reveals an increase of the number of cases in south and east directions. Comparison with the current period shows an increase of the frequency of heavy precipitation over 50 mm/day in almost the entire region with the exception of its easternmost part. The increase is about 2 times in the western part. This leads to a more homogeneous spatial distribution and a clear increase of the frequency only in south direction.

The annual course of the number of cases of precipitation over 50 mm/day shows that their maximum is also in the period from April to September. That is why Figure 10 shows the hazards, connected with this phenomenon, only in the above mentioned period. The map reveals that all studied municipalities belong to class 1 – very low hazard. This means that such rainfall occurs once every one to two years.

BLIZZARDS

Figure 11 shows the annual course of the number of cases of blizzards for the current period in the research area. This hazard was examined only during the months from November to March as in the rest of the year there is no such phenomenon. Its frequency is highest in January and February, but it does not occur at every meteorological station. Overall, it could be concluded that this hazard, which is associated with strong winds, is not particularly typical for the studied sector of the Danube floodplain.

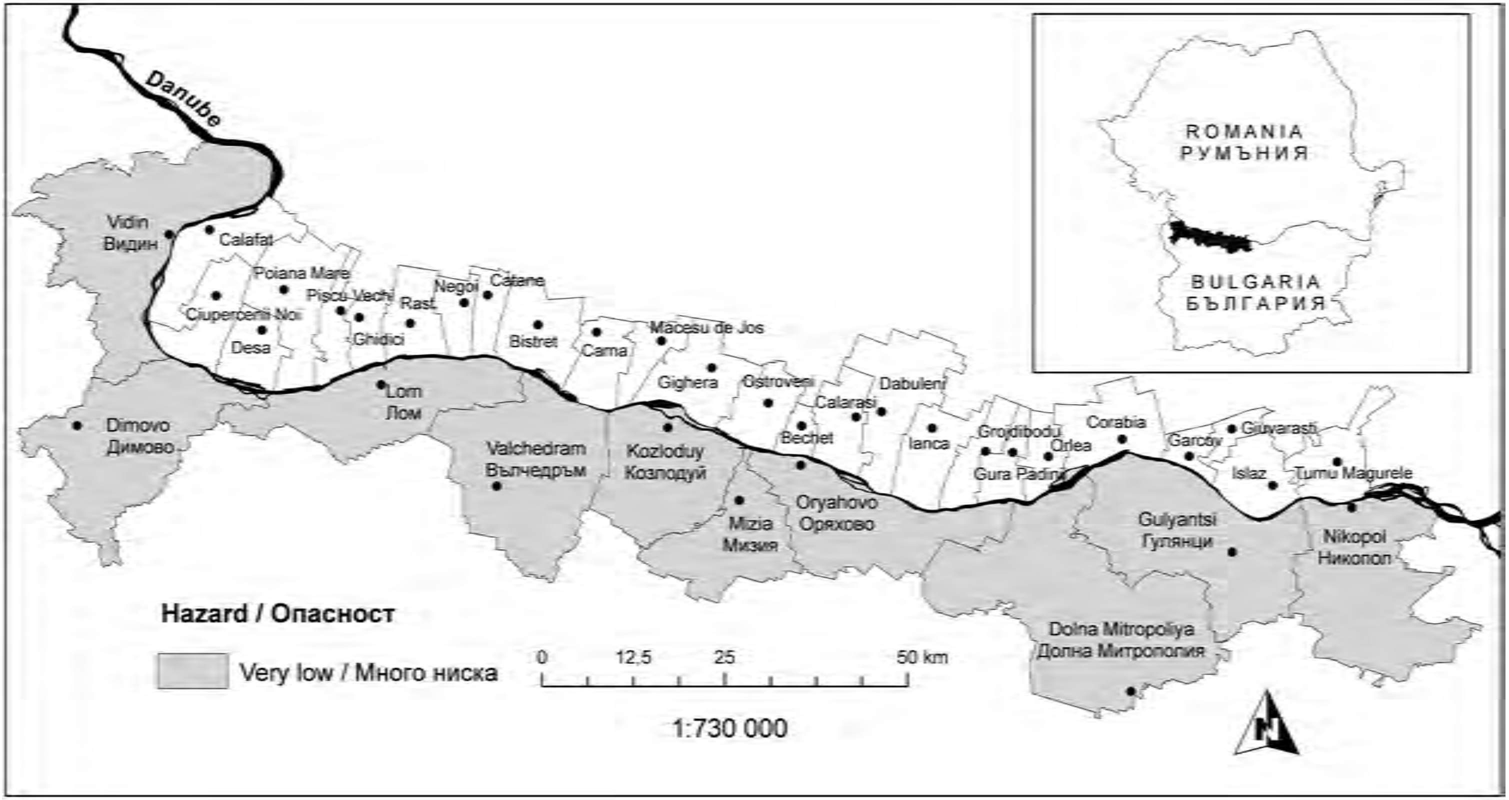

Fig. 10. Spatial distribution of hazard classes of precipitation over 50 mm/day (April-September) for the period 10.2001–12.2012 in Vidin-Nikopol Danube floodplain sector

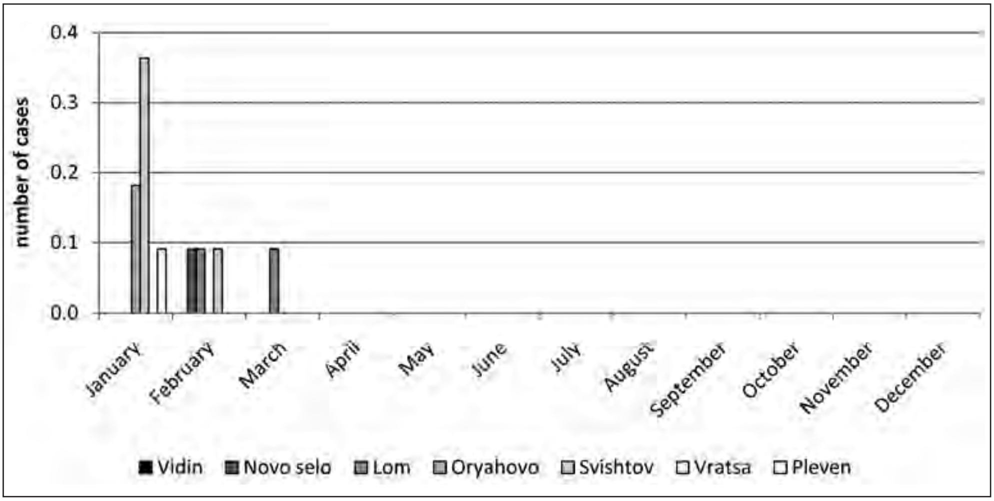

Fig. 11. Annual course of cases of blizzards for the period 10.2001–12.2012

Figure 12 shows spatial distribution of the number of cases of blizzards for the current period. It could be seen that the average number is extremely small – between 0 at station Vratsa and 0.5 at station Svishtov. This means that the phenomenon is rare in the research area and is rather unusual than a regular event. The frequency increases in eastern direction. The cause for such a spatial distribution is wind speed. Western part of the Danube floodplain is relatively protected from the strong winds by the two mountain ranges that surround it on the north and south – Carpathian and Balkan Mountains. This protection decreases in eastern direction and the frequency of strong winds in the cold half of the year increases.

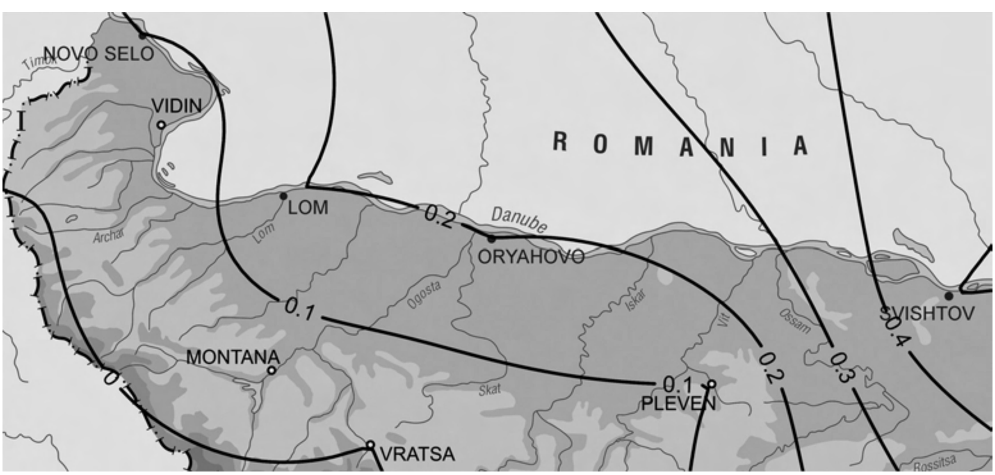

Fig. 12. Spatial distribution of cases of blizzards for the period 10.2001–12.2012

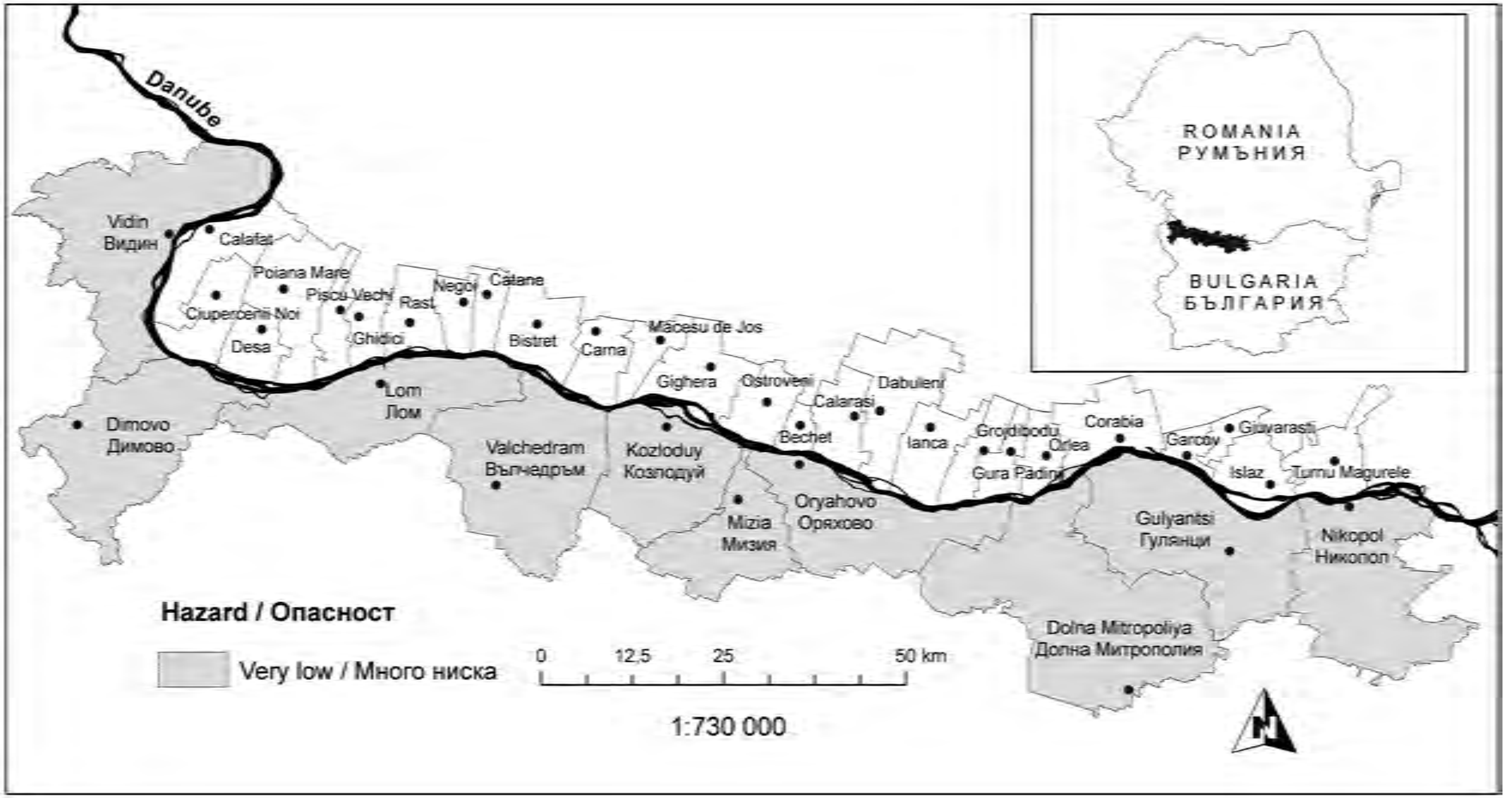

Fig. 13. Spatial distribution of hazard classes of blizzards (November-March) for the period 10.2001–12.2012 in Vidin-Nikopol Danube floodplain sector

Figure 13 shows spatial distribution of the hazard (in months from November to March), associated with this phenomenon, in the studied area. It could be seen that all municipalities are characterized by very low hazard (class 1), which means that blizzards happen every few years, particularly in eastern municipalities.

HEAVY SNOWFALLS

Figure 14 shows the annual course of the number of cases of heavy snowfalls for the current period in the research area. Here, as in blizzards, only months from November to March were considered. The highest frequency of this hazard is during the months of December, January and February. It is present at all meteorological stations and should be taken into serious consideration as there could be negative consequences for the transport.

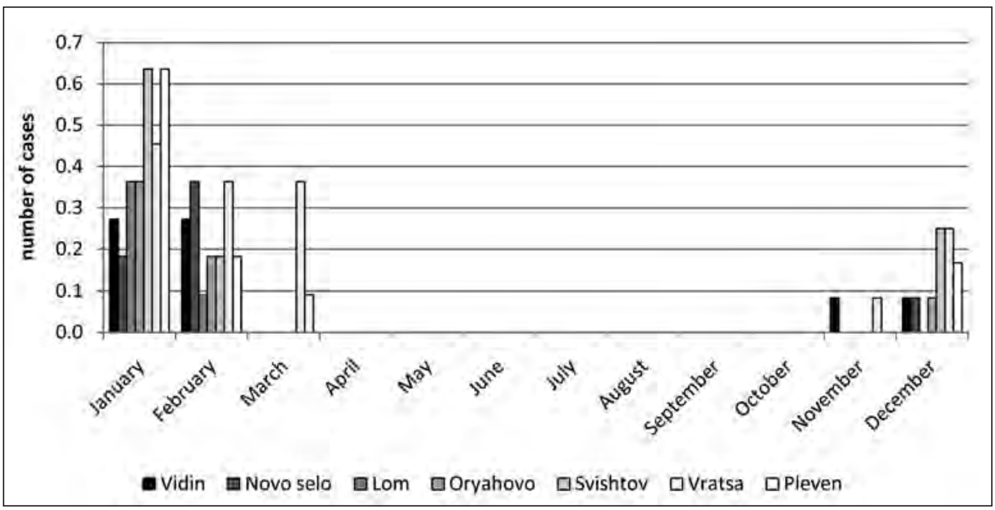

Fig. 14. Annual course of cases of heavy snowfalls for the period 10.2001–12.2012

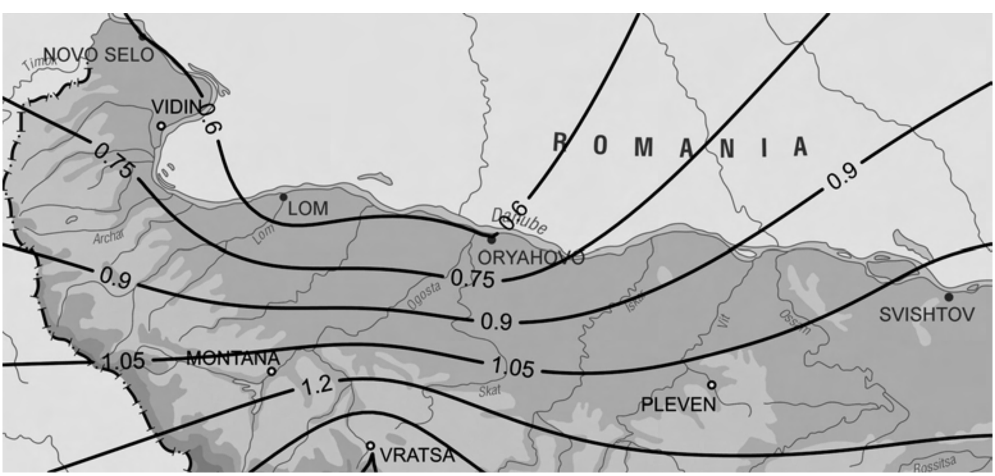

Fig. 15. Spatial distribution of cases of heavy snowfalls for the period 10.2001–12.2012

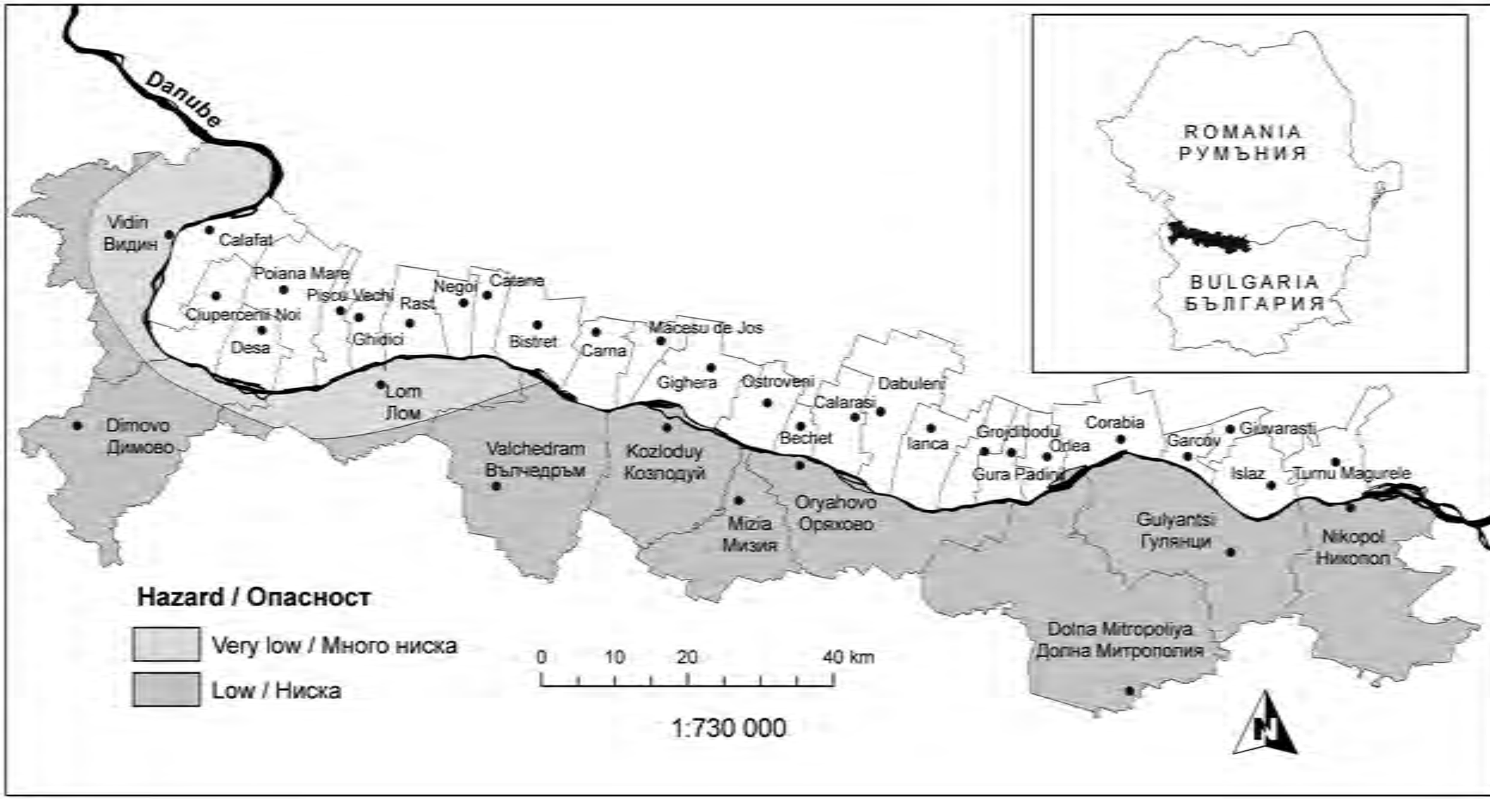

Fig. 16. Spatial distribution of hazard classes of heavy snowfalls (November-March) for the period 10.2001–12.2012 in Vidin-Nikopol Danube floodplain sector.

Figure 15 shows spatial distribution of the number of cases of heavy snowfalls for the current period. It could be seen again that the frequency increases in southern direction. The average annual number varies from 0.6 in the northernmost regions to more than 1 in the southern regions. This means that in the south, there is at least one case annually of such meteorological hazard, while the frequency in the north is one case per every two years. The orographic effect of the mountains is an essential factor.

Figure 16 shows the spatial distribution of the hazard (in months from November to March), associated with this phenomenon, in the studied area. It could be seen that almost the entire area of municipalities Vidin and Lom, and the northern part of the municipality Dimovo have very low hazard of occurrence of heavy snowfalls (class 1). This means that such snowfalls happen every year or two. The most western part of municipality Vidin, the southern parts of municipalities Dimovo and Lom as well as all other municipalities belong to class 2 (low hazard). This means that there are one or two cases of heavy snowfall per year.

CONCLUSIONS

The most of heavy precipitation occur in late spring, summer and early autumn. Its spatial distribution in this century shows increasing frequency from north to south. Trends, compared to the middle of the 20th century, reveal an increase of the frequency of these events in almost the entire studied area except the eastern part. This leads to a certain spatial redistribution. In the period 1953-1965, the frequency of heavy precipitation increases not only in south direction, but also in east direction. The hazard of heavy rainfall over 30 mm/day is low and the hazard of heavy rainfall over 50 mm/day is very low in almost the entire area during the warm half of the year. Only southern parts of municipalities Valchedram and Misia are characterized by medium hazard. Blizzards in the studied area are very rare and respectively the hazard is very low. Their frequency increases eastwards. Frequency of heavy snowfalls is greater with a maximum in January and February. Their spatial distribution shows an increase from north to south. The most of the area has low hazard of occurrence of this phenomenon. Exceptions are the eastern part of municipality Vidin and northern parts of municipalities Dimovo and Lom, which have very low hazard of occurrence of the phenomenon. All in all, the studied area has a relatively low level of hazard in terms of weather phenomena associated with precipitation. However, revealed tendencies, which suggest that the frequency and respectively the hazard of such events are increasing, raise some concerns.

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ОПАСНОСТИ СВЪРЗАНИ С ВАЛЕЖИ В ДУНАВСКАТА РАВНИНА В РЕГИОНА ОТ ВИДИН ДО НИКОПОЛ – СЕГАШНО СЪСТОЯНИЕ И ТЕНДЕНЦИИ

П. Ножаров

(Р е з ю м е)

Изследваният район обхваща дунавските общини от Видин до Никопол. Използвани са данни от 7 метеорологични станции – 5 по течението на р. Дунав и 2 във вътрешността на равнината. Опасностите, разгледани в статията, са от интензивни валежи над 30 mm/ден и над 50 mm/ден, снегонавявания и интензивни снеговалежи. Основният период на изследване е от м. октомври 2001 г. до м. декември 2012 г. За разкриване на тенденциите при интензивните валежи е изследван и периодът от 1953 до 1965 г. В разработката са използвани основно статистически и картографски методи. Класовете опасност са определени на базата на средните честоти на явленията.

Повечето интензивни валежи от дъжд над възприетите граници се случват през късната пролет, лятото и ранната есен. Пространственото им разпределение през настоящия век е с увеличение на честотата в посока юг. Трендовете в сравнение със средата на миналия век показват увеличение на броя на тези явления в почти целия изследван район, с изключение на най-източната

му част. Това води и до съответното териториално преразпределение. След средата на XX в. честотата на интензивните валежи се увеличава освен от север на юг, също така и от запад на изток. Почти в цялата територия през топлото полугодие опасността от интензивни валежи над 30 mm/ден е ниска, а за валежи над 50 mm/ден – много ниска. Единствено най-южните части на общините Вълчедръм и Мизия се характеризират със средна опасност. Снегонавяванията в изследвания район са много редки. Тяхната честота се увеличава в източна посока. Опасността от това явление е много ниска. Честотата на интензивните снеговалежи е по-голяма с максимум през януари и февруари. Пространственото им разпределение показва увеличение от север на юг. По-голямата част от територията е с ниска опасност от случване на това явление. Изключение правят източната част на община Видин и северните части на общините Димово и Лом, които са с много ниска опасност от случването на такова явление. Като цяло изследваната територия има сравнително ниско ниво на опасност по отношение на метеорологичните явления, свързани с валежите. Притеснение, обаче, будят разкритите тенденции, които показват, че честотата на такива явления се увеличава и съответно ще се увеличава и опасността.