CONSIDERATIONS ON THE EXCESSIVE RAINY SPELLS IN THE WESTERN PLAIN OF ROMANIA, NORTH OF THE MUREŞ RIVER: SPELLS LASTING 2 DAYS AND HAVING DIFFERENT PRECIPITATION THRESHOLDS

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Abstract

For the present work, we used daily precipitation data for the period 1961-2002, from 5 weather stations with common observation period. The working method consisted in choosing rainy spells, which lasted 2 consecutive days, in which precipitation reached and exceeded certain quantitative thresholds (20, 30, 35, 40, 45, 50, 55, 60, 70, 80 and 100 mm). The number of spells was established corresponding to each year and month, for each chosen threshold. The linear tendency was defined for the annual number of rainy spells. The result was that the highest total number of rainy spells was recorded at Oradea and Săcueni stations. The exceptional rainfalls with higher thresholds (between ≥70 and ≥100 mm) depend on the high temperature values. The hazards generated by heavy rainfalls have intensified in the west of the country, during the last years. The interval that is most favourable to excessive rainfalls is May-September. The month of the maximum risk is June or July.

Keywords: rainy spell, precipitation amount, threshold, length, tendency.

INTRODUCTION

The Western Plain of Romania is a narrow strip of land with an approximate north-south orientation, limited by the parallels of 45° and 48° northern latitude.

Studies on exceptional precipitation amounts have interested along time, specialists from different fields, because of the great threat they represent, given their effects upon the environment and human society: rise of river levels and flow causing floods, sometimes catastrophic; breaking dams; damaging the communication lines; flooding settlements; loss of human lives; compromising crops; intense erosion of riverbeds and slopes; soil quality deterioration by washing away the organic component etc. Exceptional rainfalls, especially those occurred within short time intervals, adversely affects the quality and quantity of crops. Moreover, by their genesis (usually thermo-convective), they are showery rains, they are accompanied by intensifying wind that doubles or triples the adverse effect upon the environment. In a word, exceptional rainfalls cause great material and human damage to society (Dragotă, 2006).

MATERIALS AND METHODS

To highlight the exceptional precipitation amounts fallen on the Western Plain of Romania, North of the Mureş River, daily precipitation data have been used for the period 1961-2002 (42 years). The data came from the archives of the National Administration of Meteorology (N.M.A.). To be more reliable, the analysis was performed only for the stations with common observation period: Satu Mare, Săcueni, Oradea, Arad and Sânnicolau Mare.

The working method consisted in choosing rainy spells, which lasted *2, 3, 4 or 5 consecutive days* in which certain amounts of precipitation were totalled. The spells were chosen so that *the total precipitation amount of each spell was greater or equal to a certain threshold.* Thus, for spells, which lasted 2 days, were chosen thresholds of 20, 30, 35, 40, 45, 50, 55, 60, 70, 80 and 100 mm. For the 3, 4 and 5 days long spells we chose thresholds of 10 to 10 mm or of 20 to 20 mm. The spells were selecting using the Excel 2002 automatic filtering program.

The number of spells was established corresponding to each year and month, for each chosen threshold. Maximum values to which precipitation grew within short time intervals were determined. The linear tendency was defined for the annual number of rainy spells.

The rainy spells that stretched over two consecutive months (the end of one month and the beginning of the next) were defined, for the monthly analysis, *to the month that contains the first day of the spell.* This method is consistent with Douguédroit's definition (1987, cited by Anagnostopoulou et al., 2003) for the drought spells.

In this research, we are presenting only the results of the climatologic analysis corresponding to the rainy spells that lasted 2 days.

RESULTS AND DISCUSSION

On the territory of the Western Plain of Romania, North of the Mureş River, the total number of spells which lasted 2 days and totalled amounts of precipitation ≥20 mm, within the interval 1961-2002, came to 263-315 spells. The number grows from south to north, once with latitude and also from west to east, once with the increase of altitude. Thus, most of the spells occurred at the Oradea station – because of its position, at the contact between Western Plain of Romania and Western Hills – and at the northernmost station of Satu Mare. The fewest spells were recorded at the southernmost station of Sânnicolau Mare (Table 1).

The cause of this distribution stands in the various climatic influences of this plain sector. Thus, oceanic, moderating climate influences are prevalent in its northern and central parts, where higher air moisture gives

richer precipitation. As a result, the number of rainy spells increases. The south-western part has Mediterranean influences, which generate dryness phenomena. As a result, rainfalls are poorer here. In another train of ideas, the location of weather stations at the contact between plains and hills brings them richer rainfalls. Here, air masses coming from the west, north-west or south-west of Europe are forced to ascend, thus generating precipitation (Măhăra, 1977).

As in the case of precipitation amounts that exceed 20 mm, cumulated within 2 days and in the case of amounts over 30, 35, 40, 45, 50, 55 and 60 mm we can observe that the highest total number of rainy spells was recorded at the station Oradea (Table 1). In opposition, the lowest number occurred at the southernmost station Sânnicolau Mare, for lower thresholds (of ≥30, ≥35 mm) and the northernmost station Satu Mare, for higher thresholds (between ≥40 and ≥60 mm). The cause for the lower total number of rainy spells once with growth in their cumulated precipitation amounts, in Satu Mare, is attributed to the air moisture that has a moderating role, which diminishes the intensity of processes that generate exceptional rainfalls, and also to the lower air temperature, which does not favour either the thermic air convection in summer, nor the great vertical development of Cumulonimbus clouds.

In some of the situations – the case of ≥30, ≥35 and ≥40 mm thresholds – the station Arad presents a slightly higher total number of spells, compared to other stations in the plain. The cause could stand in its location along the wide Mureşului valley, which amplifies processes generating rich rainfalls in the warm season. The fact is due both to moisture surplus, which water surfaces concede to the air above and also to the thermic convection, more pronounced to the south than to the north of the plain, attributed to the higher air temperature recorded in Arad.

For the threshold of ≥70 mm, the highest total number of rainy spells is not recorded in Oradea anymore, but in Săcueni (4 spells), followed by the stations Arad and Satu Mare.

Quantities of more than 80 mm, accumulated within 2 days, were reported only in the Someşului Plain (that means Satu Mare and Săcueni stations) and Aranca's Plain (Sânnicolau Mare station), the last one representing the plain territory to the south of Mureş River. They were absent on Crişurilor Plain (Oradea station) and Aradului Plain (Arad station). Their occurrence in the Someşului Plain was favoured by the easy penetration of the atmospheric fronts in the north-west of the country. Their appearance to the south of Mureş was due to the highest air and soil temperature – recorded here because of low latitude – which favoured thermic convection. The fewest spells were recorded at the station Satu

Mare, because of the oceanic influences that have a moderating climatic role, felt more strongly here.

Table 1

Number of rainy spells lasting 2 days and having precipitation amounts over certain thresholds, in the Western Plain of Romania, North of the Mureş River (1961-2002).

THRESHOLD	VALUE/STATION	SÂNNIC. MARE	ARAD	ORADEA	SĂCUENI	SATU MARE
≥20 mm	Sum (1961-2002)	263	295	315	299	302
	Annual average	6,3	7,0	7,5	7,1	7,2
	Annual maximum	15	15	17	16	15
≥30 mm	Sum (1961-2002)	100	107	130	103	103
	Annual average	2,4	2,5	3,1	2,5	2,5
	Annual maximum	8	6	8	8	7
≥35 mm	Sum (1961-2002)	51	71	94	61	61
	Annual average	1,2	1,7	2,2	1,5	1,5
	Annual maximum	5	4	6	4	5
≥40 mm	Sum (1961-2002)	36	40	53	42	35
	Annual average	0,9	1,0	1,3	1,0	0,8
	Annual maximum	4	3	4	4	4
≥45 mm	Sum (1961-2002)	29	26	36	32	19
	Annual average	0,7	0,6	0,9	0,8	0,5
	Annual maximum	4	3	3	4	2
≥50 mm	Sum (1961-2002)	21	15	29	20	13
	Annual average	0,5	0,4	0,7	0,5	0,3
	Annual maximum	3	2	3	2	2
≥55 mm	Sum (1961-2002)	14	10	23	13	9
	Annual average	0,3	0,2	0,5	0,3	0,2
	Annual maximum	3	2	3	2	2
≥60 mm	Sum (1961-2002)	7	9	14	11	6
	Annual average	0,2	0,2	0,3	0,3	0,1
	Annual maximum	2	1	2	2	1
≥70 mm	Sum (1961-2002)	2	3	2	4	3
	Annual average	0,05	0,07	0,05	0,1	0,07
	Annual maximum	1	1	1	1	1
≥80 mm	Sum (1961-2002)	2	-	-	2	1
	Annual average	0,05	-	-	0,05	0,02
	Annual maximum	1	-	-	1	1
≥100 mm	Sum (1961-2002)	1	-	-	-	-
	Annual average	0,02	-	-	-	-
	Annual maximum	1	-	-	-	-

On the territory of the Western Plain of Romania, North of the Mureş River, were never recorded spells with ≥100 mm threshold, in the interval 1961-2002. In the plain area south of Mureş, where there are the highest

thermic values throughout the whole analyzed territory, only one spell was recorded.

From all mentioned above, one can notice that starting with the higher precipitation thresholds (between ≥70 and ≥100 mm), exceptional rainfalls do not depend only on local relief conditions (case of station Oradea), but also on the high temperature values, which give an intense thermic convection. Thus, the great number of spells recorded in Săcueni is due to the low, elongated shape of Ierului flood plain, in which the station is located. The flood plain lies perpendicularly to the dominant direction of penetration of the atmospheric fronts, in the north-west of the country. Under these conditions, the air is not vented in the summer, thus stagnating and overheating. The fronts crossing over this territory are reactivated, generating large amounts of precipitation within short time intervals.

On the territory of the Western Plain of Romania, North of the Mureş River, annually produce, on the average, 6 to 8 excessive rainy spells that last 2 days and cumulate ≥20 mm precipitation (Table 1). As the precipitation threshold gets higher, the average annual number of rainy spells gets lower. Thus, it decreases from about 3 spells for the ≥30 mm threshold, to 2 spells a year for the ≥35 mm threshold, 1 spell a year for the ≥40 and 45 mm thresholds, 1 spell every two years for the ≥50 mm threshold and less for the other thresholds. So, the spells that total ≥55 mm precipitation produce once every 2-5 years, those ≥60 mm once every 3-7 years and those ≥70 mm once every 10-20 years. The spells with ≥80 mm precipitation amounts produce once every 20 years in Aranca's and Ierului Plains, and once every 42 years in the lowland of Someşului Plain (Satu Mare station). The spells with ≥100 mm precipitation only produce to the south of Mureş, in Aranca's Plain, once every 42 years.

Compared to the average annual number of excessive rainy spells, the maximum number was double or even more than that (Table 1). It rose to 15-17 spells for the ≥20 mm threshold. The highest values were recorded by the stations Oradea (17 spells in 1996) and Săcueni (16 spells in 1974). The high number of excessive rainy spells in Oradea was due both to the location of the station at the hills border and to the "heat island" generated by the town, which determines intense convective processes, especially in summer. The air pollution with particulate matter is added, from the thermoelectric power plant CET I, which works on burning coal (Linc et al., 2006; Şerban et al., 2011). These fine particles act as "condensation nuclei", making a contribution to the local increase of precipitation amounts.

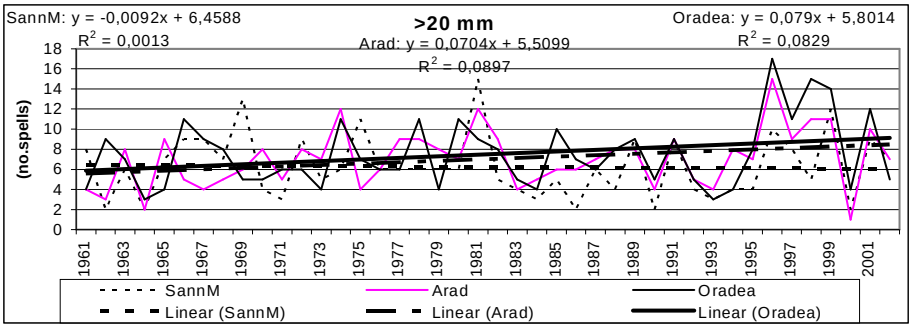

Fig. 1. Linear tendency of the annual number of rainy spells which lasted 2 days and had precipitation amounts ≥20 mm, at the Sânnicolau Mare, Arad and Oradea weather stations (1961-2002).

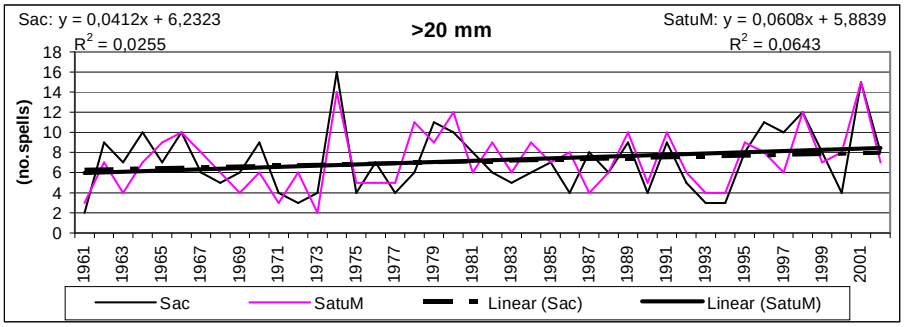

Fig. 2. Linear tendency of the annual number of rainy spells which lasted 2 days and had precipitation amounts ≥20 mm, at the Săcueni and Satu Mare weather stations (1961-2002).

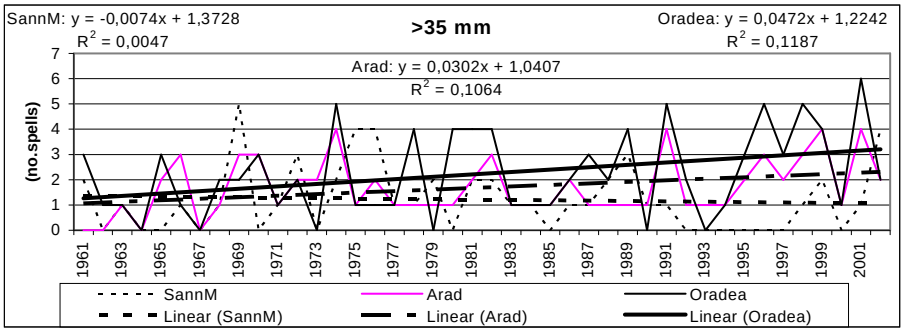

Fig. 3. Linear tendency of the annual number of rainy spells which lasted 2 days and had precipitation amounts ≥35 mm, at the Sânnicolau Mare, Arad and Oradea weather stations (1961-2002).

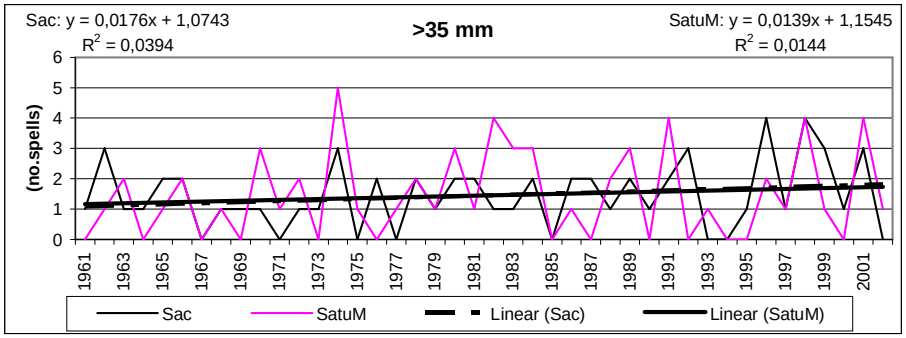

Fig. 4. Linear tendency of the annual number of rainy spells which lasted 2 days and had precipitation amounts ≥35 mm, at the Săcueni and Satu Mare weather stations (1961-2002).

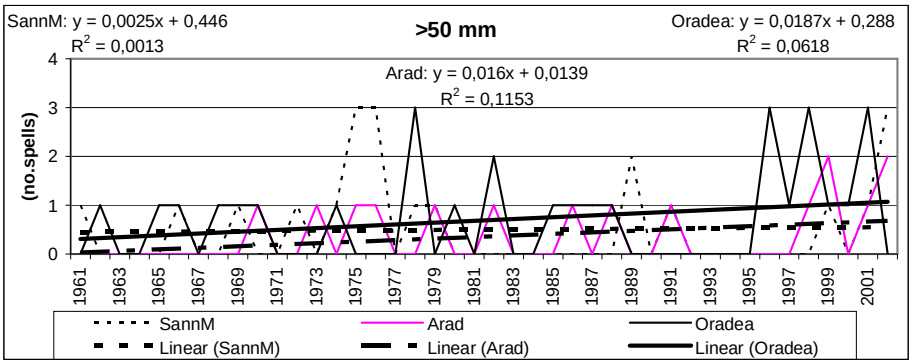

Fig. 5. Linear tendency of the annual number of rainy spells which lasted 2 days and had precipitation amounts ≥50 mm, at the Sânnicolau Mare, Arad and Oradea weather stations (1961-2002).

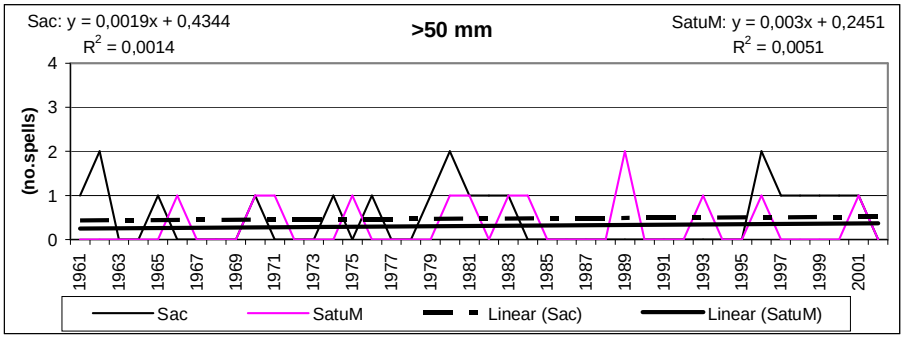

Fig. 6. Linear tendency of the annual number of rainy spells which lasted 2 days and had precipitation amounts ≥50 mm, at the Săcueni and Satu Mare weather stations (1961-2002).

The annual maximum number of excessive rainy spells decreases as the precipitation threshold increases. Thus, it decreases from 6-8 spells for

the ≥30 mm threshold, to 2-3 spells for the ≥50 and ≥55 mm thresholds and 1 spell for the ≥70, ≥80 and ≥100 mm thresholds. Generally, the annual maximum number of excessive rainy spells was higher at the stations of Oradea, Săcueni and Sânnicolau Mare. The years when those high values were recorded were: 1969-1970, 1974, 1981-1984, 1986, 1989, 1991, 1996-1999, 2001 etc. The interval of rainy years *1996-1999* and the year *2001* were best illustrated (Fig. 1-6). The increased number of rainy spells during these years is attributed to the air temperature growth in the last years of the analyzed period, 1961-2002 (Şerban, 2010), growth that led to the intensification of these climatic hazards.

Moreover, the linear tendency for all 5 stations reveals the same conclusion (Fig. 1-6). On almost entire territory of the Western Plain of Romania, North of the Mureş River, the annual number of rainy spells tends to *increase*, in the interval 1961-2002, for all thresholds (≥20, 30, 35, 40, 45, 50, 55, 60 and 70 mm) (we must point out that only a few of the charts were presented in the present paper). Growth rates are however insignificant, as there are low values for the coefficients of determination. The highest increase is recorded in Oradea and Arad. To the south of the Mureş (station Sânnicolau Mare) the tendency is slightly *declining*, but the decrease rate is insignificant (almost constant). In conclusion, *hazards generated by heavy rainfalls have intensified in the west of the country, during the last years*.

During the year, the interval that is most favourable to excessive rainfalls is *May-September* – for spells with cumulated amounts ≥20, 30, 35, 40 mm – *June-August* – for those with amounts ≥45, 50 mm – *June-July* – for those with cumulated amounts ≥55, 60, 70, 80 and 100 mm (Fig. 7-10). This interval generally corresponds to the warm summer months, when thermic convection overlaps dynamic convection. The risk of excessive rainfalls is the greatest now.

The month with the highest risk of occurrence of these phenomena is *June*. June is also, the month of the pluviometric maximum. Starting with great amounts of precipitation, over 45 mm, the month of the maximum risk becomes either *June* or *July* (the hottest month of the year). It seems that to produce high amounts of precipitation, high values of air temperature are need, as dynamic convection, specific to June is not sufficient. As a result, the month of the pluviometric maximum, as a maximum risk month, is replaced at some of the stations, with the month of the thermic maximum. In Ierului Plain, at the station Săcueni, the maximum risk month is generally, *July*, because of the local relief conditions described above.

Across the Western Plain of Romania, North of the Mureş River, there may be months with no rainy spells, so the risk of heavy rainfalls may be absent. This *no risk interval* correspond generally to cold semester months, when anticyclone regime with stable air masses is dominant, and the low air

temperatures do not favour thermic convection. So, for small precipitation amounts, of 35 mm, the risk-free interval includes *January*. As quantities increase, the interval free of heavy rainfalls risk extends. Thus, for quantities ≥45 and ≥50 mm the risk-free interval is *November-January*, for those of ≥55 mm is *November-March* and for those of ≥60 mm is *October-April* etc.

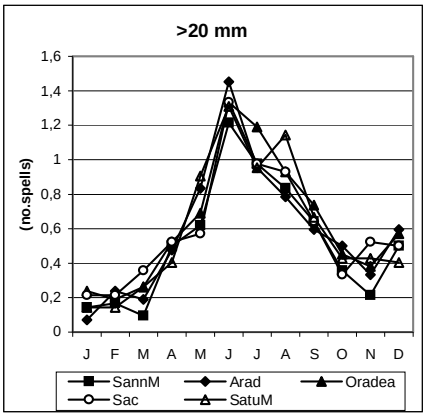

Fig. 7. Monthly average number of rainy spells which lasted 2 days and had precipitation amounts ≥20 mm, in the Western Plain of Romania, North of the Mureş River (1961-2002).

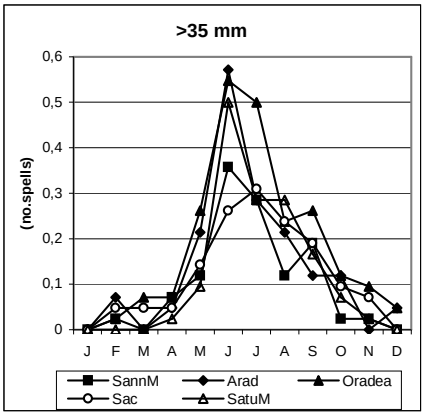

Fig. 8. Monthly average number of rainy spells which lasted 2 days and had precipitation amounts ≥35 mm, in the Western Plain of Romania, North of the Mureş River (1961-2002).

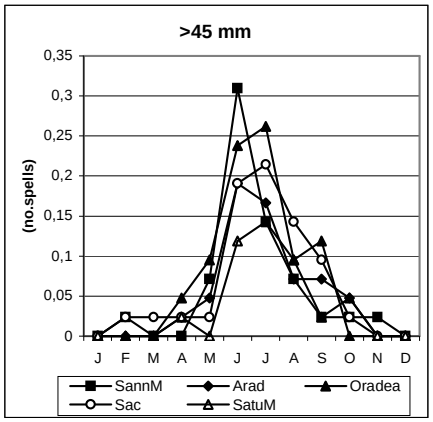

Fig. 9. Monthly average number of rainy spells which lasted 2 days and had precipitation amounts ≥45 mm, in the Western Plain of Romania, North of the Mureş River (1961-2002).

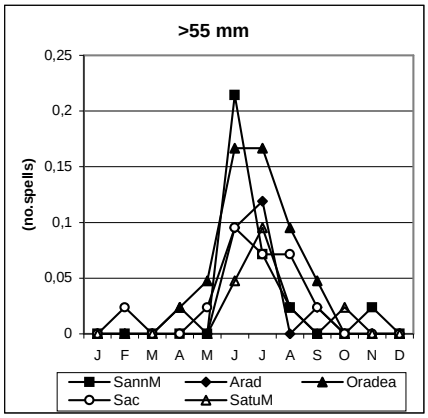

Fig. 10. Monthly average number of rainy spells which lasted 2 days and had precipitation amounts ≥55 mm, in the Western Plain of Romania, North of the Mureş River (1961-2002).

The monthly average number of rainy spells (Fig. 7-10) rises to 1 spell a month only in the maximum risk month, June, and only for the thresholds of ≥20, ≥30 and ≥35 mm. Starting with the higher thresholds, rainy spells may produce, in June, with an average repeatability of 1 spell every 3-4 years (for the threshold of ≥40 mm), 1 spell every 3-10 years (for the threshold of ≥45 mm) and less than that for higher thresholds.

CONCLUSIONS

On the territory of the Western Plain of Romania, North of the Mureş River, the highest total number of rainy spells, which lasted 2 days and had different quantitative thresholds of precipitation, was mostly recorded at Oradea station. The cause stands in the location of weather station at the limit between plains and hills, and also in the city pollution with particulate matter. Starting with the higher precipitation thresholds (between ≥70 and ≥100 mm), exceptional rainfalls do not depend only on local relief conditions, but also on the high temperature values, which give an intense thermic convection (case of station Săcueni).

On almost entire territory of the Plain, we can see an increase linear tendency of the annual number of rainy spells, in the interval 1961-2002, for all thresholds. Therefore, the hazards generated by heavy rainfalls have intensified in the west of the country, during the last years.

The interval that is most favourable to excessive rainfalls is May-September. The month of the maximum risk is June, which is also, the month of the pluviometric maximum. Starting with the higher amounts of precipitation, over 45 mm, the month of the maximum risk is either June or July (the hottest month of the year).

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