THE MAXIMUM AMOUNTS OF RAINFALL FALLEN IN SHORT PERIODS OF TIME IN THE HILLY AREA OF CLUJ COUNTY - GENESIS, DISTRIBUTION AND PROBABILITY OF OCCURRENCE

BLAGA IRINA[1], DRAGOTĂ CARMEN-SOFIA[2], IRIMUŞ I., A.[3]

ABSTRACT. The maximum amounts of rainfall fallen in short periods of time in the hilly area of Cluj County - genesis, distribution and probability of occurrence. The maximum amounts of rainfall are usually characterized by high intensity, and their effects on the substrate are revealed, at slope level, by the deepening of the existing forms of torrential erosion and also by the formation of new ones, and by landslide processes. For the 1971-2000 period, for the weather stations in the hilly area of Cluj County: Cluj- Napoca, Dej, Huedin and Turda the highest values of rainfall amounts fallen in 24, 48 and 72 hours were analyzed and extracted, based on which the variation and the spatial and temporal distribution of the precipitation were analyzed. The annual probability of exceedance of maximum rainfall amounts fallen in short time intervals (24, 48 and 72 hours), based on thresholds and class values was determined, using climatological practices and the Hyfran program facilities.

Keywords: precipitation, short periods of time, geomorphological effects, probability of occurrence

1. INTRODUCTION

Cluj county, with an area of 6674 km², is located in the northwestern part of Romania between the parallels 47º28'44" North and 46º24'47" South, and meridians 23º39'22" West and 24º13'46" East. To the North, it borders Sălaj and Maramureş counties, Bistriţa-Năsăud and Mureş counties in the East, Alba county in the South and Bihor county in the West (Fig. 1).

The study area overlaps the hilly subunits of the Someş Plateau, having its limits in the southeast at the contact of the depression corridor of Arieşul Inferior with the Viişoara-Aiton Hills (Turda weather station), in the west at Săvădisla - Luna de Sus Corridor and the Iara - Hăşdate Depression, in the northwest at the Huedin Depression (Huedin weather station). The Cluj-Napoca weather station is located approximately in the center of the county, on the Somes Mic Corridor, and

[1] National Weather Administration, SRPV Cluj, Cluj-Napoca, Romania
e-mail: blaga_irina@yahoo.com
[2] Geography Institute, Bucharest, Romania
e-mail: dragotacarmen@yahoo.co.uk
[3] Babeş-Bolyai University, Faculty of Geography, Cluj-Napoca, Romania
e-mail: irimus@geografie.ubbcluj.ro

the Dej meteorological station is located at the confluence of the two Someş rivers, Someşul Mic and Someşul Mare (Fig. 1).

Fig. 1. Cluj County

Cluj county has numerous hydrological resources, such as rivers, lakes and groundwater. The river network belongs mostly to the Somes, Crişul Repede and Arieş basins. Daytime maximum quantities fallen in the hydrographic basins determine the accumulation of significant amounts of precipitation that can result in significant flooding (Blaga et al., 2011).

According to the general characteristic of temperate latitudes, a pattern of succession of extratropical cyclones at ground level was observed, while at an altitude of 5-10 km western circulation predominates. During these successions of great diversity, some configurations (the Icelandic cyclone and the Mediterranean cyclones) can be individualized, whose development is associated with large amounts of precipitation being recorded.

The root cause of the appearance, activation and development of geomorphological processes is represented by rain water; it has an impact on the edaphic substrate developed over the Neogene sediments in which the detrital formations, gravel and conglomerates, sands and poorly cemented sandstones, clays of various types, gypsum, tuffs, and salt are predominant (Irimuş, 1998).

Characteristic soils are represented by black soils (mainly chernozems of different types and subtypes), Luvisols (prelucosoluri reddish brown, brown clay), cambisols etc. The canopy, natural or grown, which has a protective role against erosion, is not present in large areas, often favoring the onset or reactivation of these erosion processes. The forest vegetation (beech, sessile oak in combination with hornbeam, linden, ash, etc.), the bushes and the grass have a high degree of floristic composition, mostly changed anthropogenically, while cultivated vegetation expands every year at the expense of natural grasslands and the forests.

The main genesis term used in this paper is the rainfall. The daily precipitation database covers the period 1971-2000, gathering data from four meteorological stations in the hilly region of Cluj County, located at altitudes between 232 m (Dej) and 560 m (Huedin).

The highest values of rainfall amounts for 24, 48, and 72 hours were extracted, the variation, spatial and temporal distribution were analyzed based on them. The annual probability of exceedance of maximum rainfall amounts fallen in short time intervals (24, 48 and 72 hours), based on thresholds and class values was determined, using climatological practices and the Hyfran program facilities.

2. DISTRIBUTION OF MAXIMUM RAINFALL

The amounts of precipitation that fall in the hilly area of Cluj county are strongly influenced by the position of Romania in relation to the existence and evolution of dominant baric formations present in Europe. Cases in which excess amounts of rainfall are registered are associated with the evolution over the European continent of the Icelandic cyclones which generally affect the northern and north-western parts of Europe, of the Mediterranean cyclones which have a stronger influence in the southern and southeastern Europe, and of the and double cyclones formed by the merger of the depression area from northern Europe and the depression area from the Mediterranean basin (Dragotă, 2006).

The maximum amounts of precipitation registered in 24 hours, and especially the maximum amounts registered in 48 or 72 hours, when reported to the average of the months in which there were registered, highlight an exceedance characteristic, this characteristic being emphasized by the fact that these amounts have exceeded the monthly average quantities or at least equaled them. The situations where such quantities remain below the average are rare.

Pronounced seasonal variability can be observed both monthly, and yearly. Thus, in the cold season, the predominance of the evolution of continental anticyclones in the country (in which the air masses in advection have low moisture content and the thermal convection is very weak) conditions the maximum quantities of low rainfall, especially between December and March. In the warm season, when the intense frontal and thermoconvective processes overlap the predominant Azores circulation, the maximum quantities reach the highest values, especially between May and July, followed by autumn and spring. Rains in this season are predominantly torrential (resulting in significant quantities of rainfall) and have detrimental mechanical effects on the environment, causing floods especially in the basins of small rivers.

The maximum amounts of rainfall in 24 hours. For the entire hilly area of the administrative unit of Cluj County, the annual daytime maximums of precipitation between 1971-2000 are in the range between the largest amount of

68.1mm (June 1973, Huedin) and the lowest of 17.1mm (August 2000, Turda), oscillating around the average of 35.6mm. Monthly (Fig. 2), the highest daytime maximum amounts approach or exceed 50mm from May to September, while the smallest decrease below 7.4mm (June 1975, Dej) and even down to 0.0mm in months without precipitation (February 1976 and December 1972, Huedin).

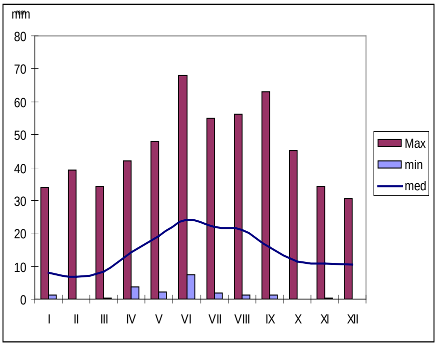

Fig. 2. Monthly average and extreme amounts of rainfall in 24 hours in the hilly region of Cluj County (1971-2000)

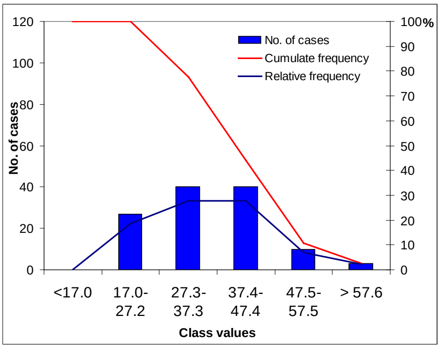

Fig. 3. Distribution of the maximum daytime quantities, based on class values (1971-2000)

The distribution of the climatic parameter on value classes (Fig. 3) shows the dominance of the maximum daytime quantities between 27.3 and 47.4mm in 66.7 % of the 120 cases (representing the total number of cases registered during the analyzed period of 30 years for the 4 meteorological stations), the underrepresented frequency of the over 57.6 mm (2.5 % of cases), and the absence of rain for which in 24 hours maximum amounts of less than 17mm were totaled.

The maximum quantities of rainfall in 48 hours are associated with daytime highs in 90% of cases, completing the distribution of consecutive intervals with rainfall. The maximum annual quantities totalized in 48 hours amount between 95mm (July 1975, Huedin) and 20.1mm (June 1983, Cluj), fluctuating around their 45.2mm average. The same maximums in monthly multiannual regime (Fig. 4), over the entire study area reached the highest values of over 70mm/interval between May and September, and the lowest, around 40mm in October and January. The lowest values accumulated in 48 hours range between 8.8mm in June 1977 in Cluj, and 0.0mm in February 1976 and December 1972 at Huedin.

The distribution of the maximum quantities of two consecutive days on value classes (Fig. 5) indicates dominant quantities between 33.4 and 48.7mm (in 56 cases out of the possible 120) with a probability of occurrence of 46.7% between 1971 and 2000, the under-representation of those of more than 79.6mm (2.5%) and the lack of those under 18.2mm.

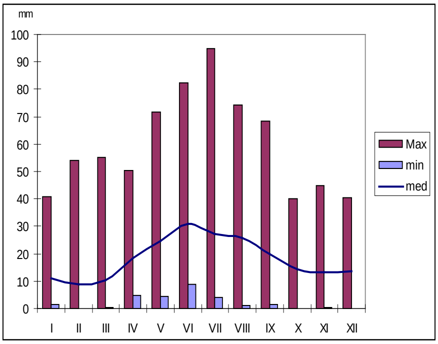

Fig. 4. Monthly average and extreme amounts of rainfall in 48 hours in the hilly region of Cluj County (1971-2000)

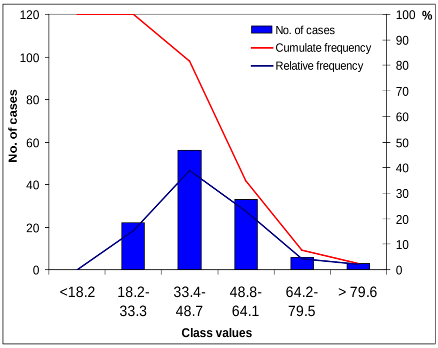

Fig. 5. Distribution of the maximum quantities in 48 hours, based on class values (1971-2000)

Maximum rainfall amounts in 72 hours. Clearly, with increasing the interval duration, from two to three consecutive days, the maximum amount of precipitation increases, sometimes remaining within the limits of the previous time frame. In 72 hours, over the entire hilly area of Cluj, the annual maximums range between 108.1mm (July in Huedin) and 20.5mm (in June, also at Huedin), fluctuating around the annual average (1971-2000) of 50.3mm (Fig . 6). The best represented months are from May to September, with maximums of over 70mm/three consecutive days, the antipode being October with only 40.7mm. In the case of these maximum quantities, the value class distribution (Fig. 7) indicates the highest probability of occurrence (47.6%) for amounts ranging between 38.1 and 55.6mm (57% of the range of values examined), followed by those between 55.7 and 73.2 mm (25.8%) the median positions. However, there are extremes with low probability of occurrence (smaller than 20.5mm or larger than 90.9mm).

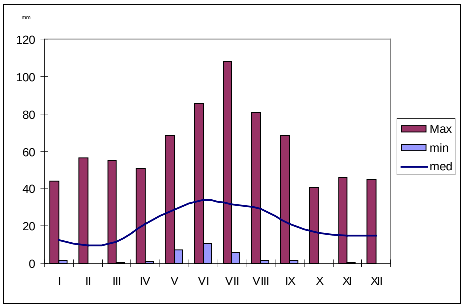

Fig. 6. Monthly average and extreme amounts of rainfall in 72 hours in the hilly region of Cluj County (1971-2000)

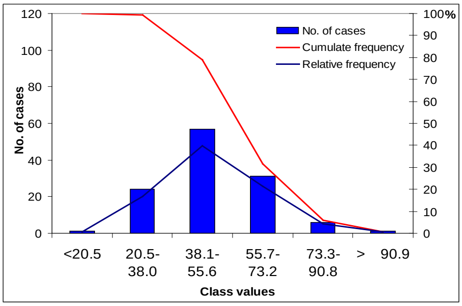

Fig. 7. Distribution of the maximum quantities in 72 hours, based on class values (1971-2000)

The analysis of the maximum rainfall values using the values method has the advantage of yielding a valid hierarchy of the existing extremes data samples, offering the projection of distribution and variation. The disadvantage is that the with the expansion of the data stream, the amplitude values change, requiring the resumption of the gap of variation/classes, establishing other growth rates/classes.

3. COMPUTING THE PROBABILITY OF OCCURRENCE AND EXCEEDING THE MAXIMUM ANNUAL AMOUNTS OF PRECIPITATION

An analysis to determine the probability of non-exceedance was performed (Haidu et al., 2002), using the Hyfran program. For Cluj-Napoca in the period 2006-2011, using the Hyfran program features the probability of exceeding certain thresholds of maximum annual quantities of rainfall in 24 hours was calculated (Blaga et al., 2012).

For the 1971-2000 period, the likelihood of exceeding certain thresholds of maximum annual quantities fallen in 24, 48 and 72 hours from meteorological stations in the hilly region of Cluj County was calculated.

For the maximum annual quantities of rainfall in 24, 48, and 72 hours, analyzing the data by using the independence test (Wald-Wolfowitz) and the stationary test (Kendal) provided by the Hyfran program it was observed that the null hypothesis H0 was accepted. The probability of recovery of certain values of the maximum annual amounts of rainfall in 24, 48, and 72 hours at certain time intervals was computed, having a confidence level of 95%.

For the maximum annual amounts fallen in 24 hours, for Cluj-Napoca a probability of 1% was computed that once every 100 years the values will exceed 67.7mm, a probability of 2% that twice every 50 years the values will top 62.9mm and a 10% probability that every 10 years the values will surpass 50.9mm. For Dej, the results show a 1% probability that once every 100 years the value of 70.8mm will be topped, a 2% probability that once every 50 years the values will reach 64.6mm and a 10% probability that every 10 years the values will exceed 49.5mm. For Huedin, the probability that once every century values will exceed of 67.2mm is 1%, the probability that twice every 50 years the values will top of 62.5mm is 2% and the probability that every 10 years values will exceed 50.1mm is 10%. For Turda, results indicate a 1% probability that once every 100 years values will exceed 68.6mm, a 2% probability that every 50 years values will exceed 62.7mm and a probability of 10% that every 10 years values will exceed 48.6mm.

For the maximum annual amounts fallen in 48 hours, for Cluj-Napoca a probability of 1% was computed that once every 100 years the values will exceed 97.2mm, a probability of 2% that twice every 50 years the values will exceed 88.7mm and a 10% probability that every 10 years the values will exceed 68.5mm. For Dej, the results show a 1% probability that once every 100 years the value of 81.6mm will be exceeded a 2% probability that once every 50 years the value of 75.6mm will be topped and a 10% probability that once every 10 years values will exceed the value of 60.9mm. For Huedin, results indicate a 1% probability that once every 100 years values will be exceeding 90.4mm, a 2% probability that once every 50 years values will exceed the value of 83.2mm and a 10% probability that once every 10 years the value of 65.7mm will be reached. For Turda there is a 1% probability that once every 100 years values will be exceeding 83.1mm, a 2% probability that once every 50 years values will top the value of 76.2mm and a 10% probability that once every 10 years the value of 59.9 mm will be reached.

The probability of recovery of certain values of the maximum annual amounts of rainfall in 72 hours was computed, thus for Cluj-Napoca computations showed a probability of 1% that once every 100 years values will exceed 88.9mm, a probability of 2% that once every 50 years values will reach 84.0mm and a 10% probability that once every 10 years the value of 71.1mm will be topped. For Dej the results revealed a 1% chance that once every 100 years values will top 88.5mm, a 2% probability that once every 50 years values will exceed the value of 81.4mm and a 10% probability that once every 10 years the value of 84.7mm will be reached. For Huedin results indicate a probability of 1% that once every 100 years values will exceed 86.2mm, a 2% probability that once every 50 years values will top 82.5mm and a 10% probability that once every 10 years the value of 71.5 mm will be exceeded. For Turda computations revealed a probability of 1% that once every 100 years values will exceed 88.7mm, a 2% probability that once every 50 years values will reach 81.5mm and a 10% probability that once every 10 years the value of 64.7 mm will be topped.

4. CONCLUSIONS

The annual daytime amount of precipitation peaks in the hilly area of Cluj county between 1971-2000, oscillating around the multiannual average of 35.6mm. The largest monthly daytime maximums tend towards 50mm, and the distribution of the climatic parameter on value classes show that the predominant maximum daytime quantities either vary between 27.3 and 47.4mm (66.7% of the cases), or top 57.6mm (2.5% of the cases) but no cases were registered with less than 17mm.

The maximum quantities of rainfall in 48 hours are associated 90% of cases with daytime maximums, wavering around their average of 45.2mm, with the highest values (>70 mm/interval) from May to September and the lowest (~ 40mm) in October and January. The lowest values range between 8.8mm and 0.0mm. The value class distribution of the maximum quantities indicate the dominance of values between 33.4 and 48.7mm (46.7% probability of occurrence), and the low occurrence of those over 79.6mm (2.5%) and the lack of values under 18.2mm.

The maximum annual quantities registered in 72 hours are between 108.1mm and 20.5mm, fluctuating around the annual average of 50.3mm. The best represented months are from May to September with peaks of over 70 mm/72h, the antipode being in October with only 40.7mm. The value class distribution indicates the highest probability of occurrence (47.6%) for amounts ranging between 38.1 and 55.6mm, followed by those between 55.7 and 73.2mm (25.8%). Extreme values (fewer than 20.5mm or over 90.9mm) have a low probability of occurrence.

For maximum annual quantities of rainfall in 24 hours, using the Hyfran program, the probability of recovery of certain values was computed- it was found that there is a probability of 1% that once every century values will exceed 67.2mm (Huedin) and 70.8mm (Dej), a probability of 2% that once every 50 years values will top 62.5mm (Huedin) and 64.6mm (Dej) and a probability of 10% that every 10 years values will surpass 48.6mm (Turda) and 51.1mm (Huedin).

For maximum annual amounts of rainfall in 48 hours, results indicate a probability of 1% that once every 100 years values will exceed 81.6mm (Dej) and 97.2mm (Cluj-Napoca), a probability of 2% that once every 50 years values will top 75.6mm (Dej) and 88.7mm (Cluj-Napoca) and a 10% probability that every 10 years values will surpass 59.9mm (Turda) and 68.5mm (Cluj-Napoca).

For the maximum annual quantities of rainfall in 72 hours computations revealed a probability of 1% that once per century values will exceed 86.2mm (Huedin) and 88.9mm (Cluj-Napoca), a probability of 2% that once every 50 years values will top 81.4mm (Dej) and 84.0mm (Cluj-Napoca) and a 10% probability that every 10 years values will surpass 64.6mm (Turda) and 71.5mm (Huedin).

REFERENCES

1. Blaga, Irina, Blaga, C. (2011), *Risk weather phenomena in Cluj County in June 2010,* Air and Water Components of the Environment Conference, Editura Presa Universitară Clujeană, 410-417.
2. Blaga, Irina, Blaga, C. (2012), *Atmospheric instability in urban area of Cluj-Napoca, Romania,* Air and Water Components of the Environment Conference, Editura Presa Universitară Clujeană, 305-312.
3. Dragotă, Carmen – Sofia (2006), *Precipitaţiile excedentare în Romania,* Editura Academiei Române, Bucureşti.
4. Haidu, I. (2002), *Analiza de frecvenţă şi analiza cantitativă a riscurilor*, Riscuri şi Catastrofe, Ed. Casa Cărţii de Ştiinţă, Cluj-Napoca, 180-207.
5. Irimuş, I.A. (1998), *Relieful pe domuri şi cute diapire din Depresiunea Transilvaniei*, Editura Presa Universitară Clujeană, ISBN 973-9354-55-6, Cluj-Napoca, p.299.
6. Irimuş, I.A. (2006), *Hazarde şi riscuri asociate proceselor geomorfologice în aria cutelor diapire din Depresiunea Transilvaniei*. Editura Casa Cărţii de Ştiinţă, Cluj-Napoca, ISBN 973-686-850-8, p. 287.
7. Irimuş, I.A., Petrea, D., Rus, I., Vescan, I. (2009), *Morfodinamica versanţilor în regiunile cu domuri şi cute diapire din Depresiunea Transilvaniei***.** Vol. „Mediul şi dezvoltarea durabilă”, Editura Labirint, Chişinău, R.Moldova, ISBN 978-9975-80-2, p.90-100.
8. Irimuş, I.A., Morărescu, G.R., Irimuş, N.G., (2010), *Climatic and Hydrographic Variations in the Dinamics of Geographic Landscapes in North-West Depression of Transylvanian Plain*, Philobiblon: Journal of the Lucian Blaga Central University Library, Cluj University Press, 2009, Vol. 14, p. 371-385, ISSN 1224-7448, http://www.bcucluj.ro/philo.
9. *** *Clima României*, (2008), Editura Academiei Române, Bucureşti