THE EFFECTS OF EXCESS PRECIPITATION FALLEN IN THE CURVATURE SUBCARPATHIANS (ROMANIA) DURING THE WARM PERIOD OF THE YEAR. CASE-STUDY: SĂRĂȚEL AND BĂLĂNEASA DRAINAGE BASINS

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Key-words: pluvial regime, annual precipitation quantities, seasonal average quantities, monthly precipitation quantities, Buzău drainage basin.

Abstract. The present work aims at presenting the main characteristics of the pluviometric regime in the Bălăneasa and Sărățel basins, represented by the quantitative parameters of the warm season (spring-autumn). The climatic data provided by the Pătârlagele Weather Station are representative for the geographical area we are interested in. The period analysed (1961–2007) is statistically relevant in terms of climatology, covering the standard climatological period (1961–1990), the last decade of the twentieth century and the early years of the current decade which are characterized by major extreme pluvial events on a global, regional and local scale. The distribution of precipitation quantities presents value differences on various time-scales. In the annual rain regime specific to the temperate-continental climate of Romania, the quantities of the warm semester have the greatest share. For adequate decisions to be made and implemented in order to diminish the negative environmental effects of excess/deficient precipitation, the present article has been aimed at establishing the multi-annual water values in the warm semester of the year. The analysis and conclusions are based on the annual, seasonal and monthly precipitation values, highlighting the value differences, imposed mainly by the complexity of the Subcarpathian Curvature sector.

1. INTRODUCTION

The Subcarpathian sector studied is one of the most complex physical-geographical units in Romania in terms of geology, morpho-structure and intense sedimentation processes, e.g. folding, overfolding and overthrust, visible in the general landform features.

The present paper has been aimed at establishing the multi-annual water values in the warm semestre of the year, for adequate decisions to be made and implemented in order to diminish the negative environmental effects of excess/deficient precipitation.

The ISU (Inspectorate for Emergency Situations) database of 2005 (May and August), 2006 (May), 2009 (July) and 2010 (July) has been used to identify and quantify the damage produced by the exceptional pluvial events of those years.

2. MATERIAL AND METHODS

The paper uses available data from weather stations representative from a climatic point of view located in the Curvature Subcarpathian region (Pătârlagele), covering the 1961–2007 period, which also encompasses the standard climatic interval recommended by the WMO (1961–1990) for all statistical processings used in international and national climatology; the aim is to compare the results obtained. This period also includes the most intense frequency and intensity of the extreme weather events associated to the current trend of climate change. The climatic variability discussed in the present study addresses different time episodes: annual, quarterly, monthly and multi-seasonal.

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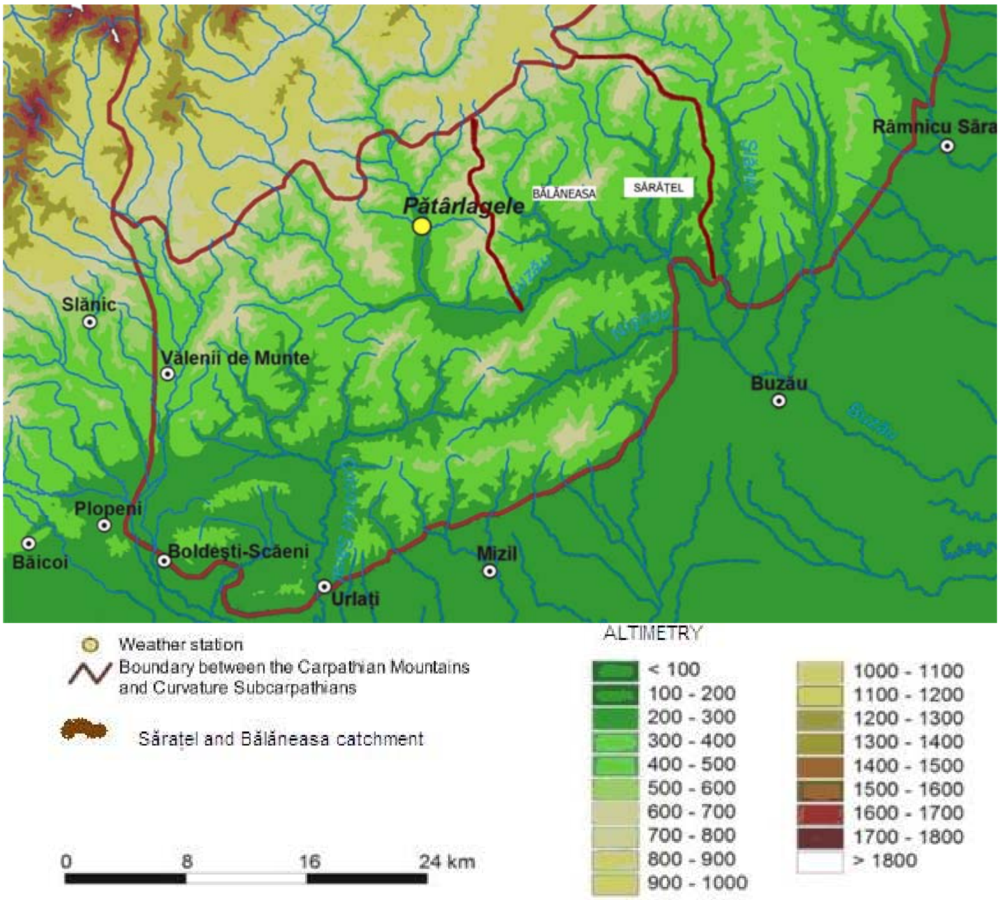
The database used was provided by the Information and Public Relations Departament of ISU Buzău.

3. RESULTS AND DISCUSSION

The moderate temperate-continental climate (Fig. 1) of the study-area corresponds to the low and high hilly regions (380–800 m). The major influence exerted by the Curvature Carpathian orographic barrier and the great incidence of foehn winds are largely involved in the distribution of the main meteorological elements and climatic phenomena, their frequency, duration and intensity being particularly relevant in the Curvature Subcarpathians.



Source: *CLAVIER – Impact of extreme events on soil erosion and the agri-environmental potential in the Curvature Carpathians and Subcarpathians, 2009.*

Fig. 1 – Study-area: geographical position and altitude.

Among the factors initiating, unleashing and/or maintaining the present-day modelling processes which control and affect land-use in this very active geomorphological region, atmospheric precipitation play a major part.

The mechanical action, exerted by precipitation alone or in conjunction with other weather phenomena, does contribute to gullying and slope modelling, producing flash- floods and overflows.

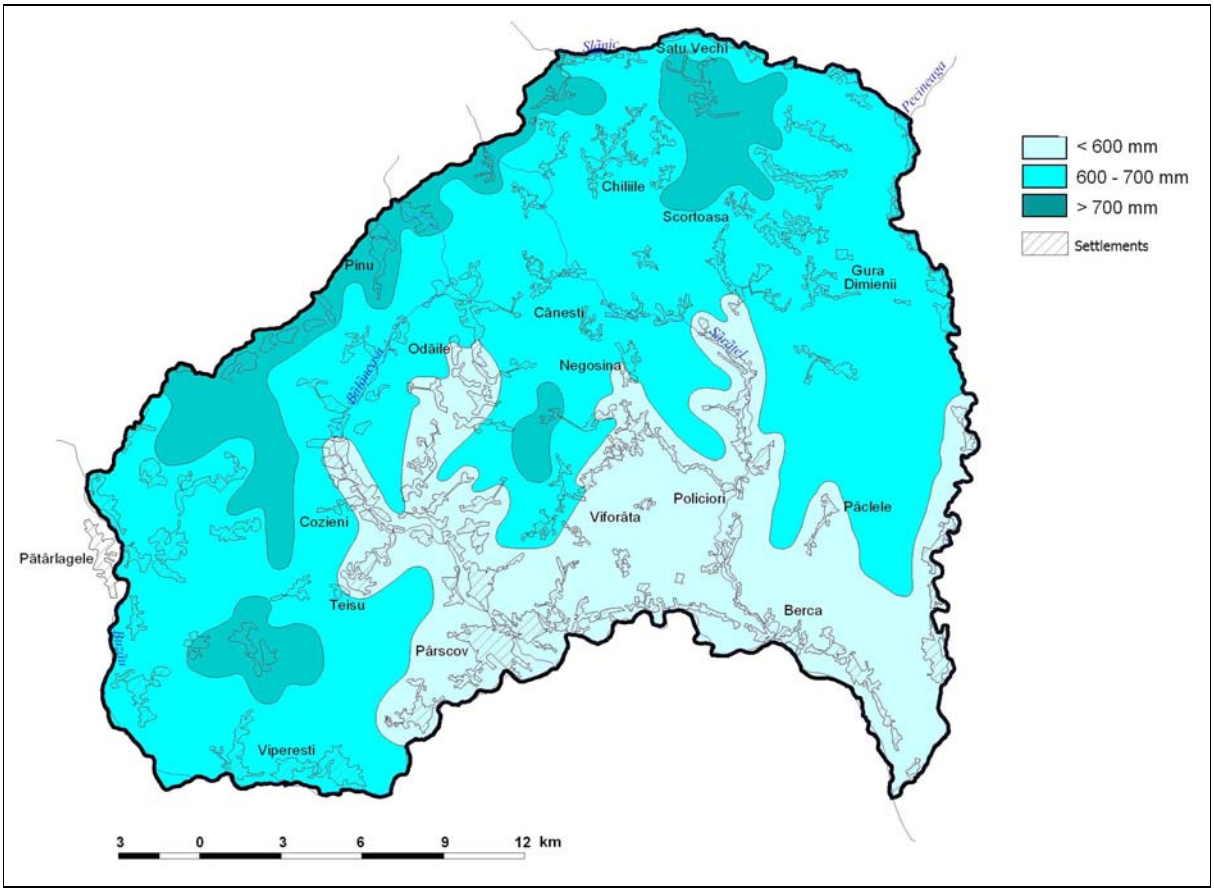
The characteristic features of the general atmospheric circulation, coupled with a specifically local subjacent surface, basically landform morphology and morphography, account for variations in the quantity of precipitation on all temporal scales.

The area's rain regime falls into distribution type IV, which means a precipitation maximum in summer (June, 93 mm) and a winter minimum (February, 30 mm) (*Clima României*, 2008).

The multi-annual pluvial regime, extremely uneven in time and space, presents contrasting values (Fig. 2). Thus, in the Sărăţel and Bălăneasa basins, a multi-annual mean of 640 mm was registered in the series of observation years (1961–2007) studied. The driest years were 1972 and 2000 (386 mm and 389 mm, respectively) while 2005 was a record high rainy year (993 mm). The annual variability range does not exceed 600 mm.

Looking at the evolution of annual precipitation trends suggests that in terms of quantity (see regression line, Fig. 3) there are periods of decrease (1961–1963; 1972–1985) and of increase (1964–1974; 1988–1995; 2002–2007), delimited by a six-order polynomial regression line.

The distribution of precipitation quantities over the year shows significant value differences on various time-scales. Thus, the quantities of the warm semester have the greatest share in the annual rain regime specific to the temperate-continental climate of Romania. In the study-area, the annual averages of the warm semester are of 429 mm (67.5% semestrial ratio), with maximum variability of 525 mm between the rainiest six months in 2005 (717.4 mm) and the driest ones in 1987 (192.3 mm) (Dragotă, Grofu 2010).



Source: *Grofu, Ph.D. thesis, 2012*.

Fig. 2 – Annual average quantities of atmospheric precipitation, in the Sărăţel and Bălăneasa basins (1961–2007).

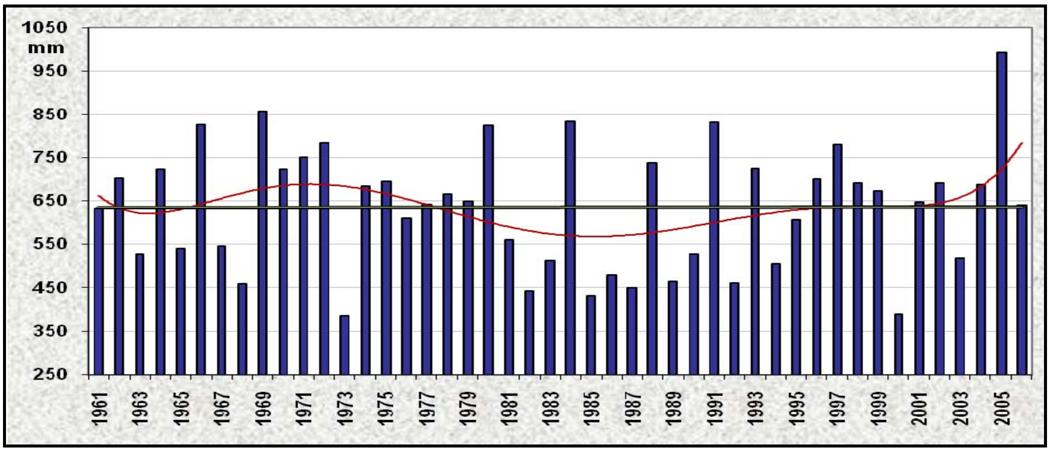


Fig. 3 – Variation in the annual quantities of precipitation (1961–2007) and variation trend, Pătârlagele Weather Station.

Viewed at country level, semestrial average quantities in the two catchments are relatively evenly distributed (400–500 mm) in terms of altitude, local modification deriving from landform configuration, position and orientation versus the local circulation, micro- and topoclimatic conditions, etc.

In 2005, a historical record year in the hierarchy of rainy years in Romania, the country was affected by six flooding episodes in the warm season and one more in November. These months are representative flood years for the study-area:

May 7. The Buzău ISU Demage Report reads: 5.5 km of road on county road DJ 103 that links the settlements situated in the north of the study-area; 5 bridges, two of which completely destroyed, leaving 370 households with 1,700 inhabitants isolated, 80% unpaved village roads, 150 flooded households and7 households without electricity.

August: 20 flood-affected settlements between the towns of Buzău and Slănic, 4 schools at Pănătău and Chiojdu, two schools and a kindergarten at Cătina; 60 flooded households, 10 wells and 4 villages isolated, traffic on County Road (DJ) 102 L blocked by alluvia and mass movements in 5 points.

A second rain-induced flood event hit Pănătău once again. Falls lasted around 3 ½ hrs; flood waves destroyed part of the county rood linking Pănătău to Pătârlagele Town; 18 localities had no electricity that night.

In Buzău County, the floods of 2005 affected 53 localities. It is the case of : Beceni, Berca, Buzău, Bozioru, Buda, Bisoca, Breaza, Cătina, Căneşti, Calvini, Cernăteşti, Chiojdu, Colți, Cislău, Costeşti, Cozieni, Gherăseni, Lopătari, Luciu, Mărăcineni, Merei, Mânzăleşti, Murgeşti, Mărgăriteşti, Movila Banului, Nehoiu, Năieni, Odăile, Pănătău, Pătârlagele, Pâscov, Pardoşi, Puieşti, Poşta Câlnău, Racovițeni, Râmnicelu, Râmnicu Sărat, Siriu, Scorțoasa, Săhăteni, Săpoca, Stâlpu, Săruleşti, Topliceni, Țintești, Tisău, Ulmeni, Valea Salciei, Vintilă Vodă, Verneşti, Vipereşti and Zărneşti (ISU Buzău).

That same year, there were situations when the Sărățel and Bălăneasa basins were ready to overflow:

– February 22–25 (heavy precipitation and increased discharge on the Bălăneasa Stream);
– May 6–8 (heavy rains, run-off on slopes);
– May 30–31 (heavy rains and hail);
– July 6–22 (heavy rains and run-of on slopes).

Time sequences in the warm semester of the year and multi-annual average seasonal quantities were determined by the Musset-Gaussen Index (Summer-Spring-Autumn-Winter). The findings have revealed a main pluvial maximum in July–August and an annual minimum in December–February, emphasising the dominance of the powerful Summer–Spring sequence (Table 1).

Table 1

The Musset-Gaussen index values.

Musset-Gaussen Index (IM–G)		
Season	Multi-annual average quantity of precipitation (mm)	Index IM–G
Summer	**257.8**	**S.S.A.W.**
Spring	**151.2**	
Autumn	129.2	
Winter	97.4	

So, the multi-annual average summer quantities in the two catchments reached a seasonal maximum of 405.8 mm in summer 1991 and a minimum of 82 mm in summer 1965 fluctuating around a multi-annual average of 257.8 mm. These precipitations occur in the conditions of maximum thermodynamic convection over the year, destabilising the masses of air and intensifying cyclonic activity alongside the polar front, especially in June. The rate of evolution of summer precipitation amounts in the study-areas is positive (Fig. 4).

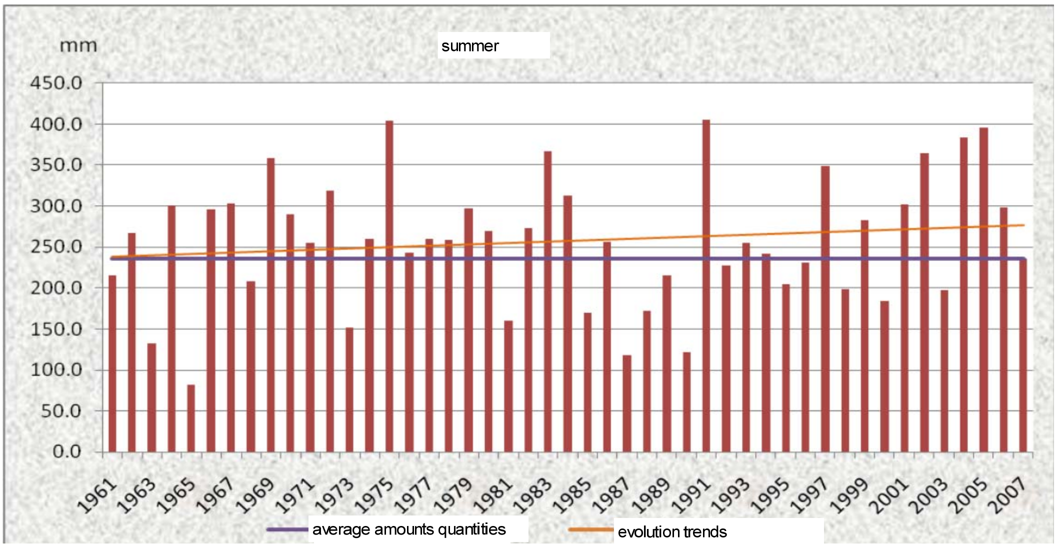


Fig. 4 – Multi-annual average seasonal precipitation amounts in summer, Pătârlagele Weather Station.

July 2009

That year was rich in summer precipitation with overflows in several regions of Romania. Buzău County in July: 5 villages isolated, over 30 households flooded, scores of wells silted, two communal roads (Bădila–Palici and Ursoaia–Ruşavăţu) alluvia – covered and destroyed. Pănătău Commune: isolated villages (Râpele, Zahareşti, Măguricea, Tega and Mânăstirea; Nehoiu Town: four households flooded at km. 69 on National Road (DN), 10 km blocked by a landslide. Tisău: seven households flooded, and several wells silted; similar problems in Bădila Village, Pârscov Commune; traffic blocked by alluvia and boulders on DN 10 Buzău–Braşov, close to Siriu Water–Power Station.

July 2010

Short-term heavy rainfall and hazardous hydro-meteorological phenomena triggered landslides and floods in the administrative territory of Pătârlagele Town and adjacent villages:

– Natural Park DN 10, at Criveni outside Pătârlagele was completely blocked by alluvia over a distance of 1 km, traffic stopped in both directions;

– Communal Road (DC 91) between Pătârlagele and Valea Muscelului, was destroyed by a rain-triggered landslide over a distance of 40 m (at Toma point), people having to go on foot to the 200 households in the proximity;

– Communal Road DC 69 between Pătârlagele and Colți was covered by alluvia over a distance of 1 km;

– a concrete dam on the Muscel Brook (facing Fundăturile Village) was destroyed;

– a number of 44 households in Pătârlagele Town and a church in Sibiciu de Sus Village were affected.

(Source: *Information and Public Relations Department, ISU Buzău, July 13, 2010).*

In springtime, the multi-annual average rain regime cumulated more than 150 mm, that is about 24% of the total multi-annual average. This situation is the result of increased air and implicitly soil temperatures, reflected by thermal convection, overlapping a more active evolution generated by pressure differences between masses of interacting oceanic and continental air. The maximum seasonal variability range was 335.9 mm (spring 1988) and only 45.4 mm (spring 1968), the trends in the evolution of spring rain quantities indicating a decrease (Fig. 5).

22 May 2006, torrential rainfalls, scores of flooded houses and cellars, silted wells, hail-bitten vineyard in 4 communes: Cislău, Cătina, Vipereşti, and Siriu. In Cislău 13 houses and 11 cellars flooded, 15 silted wells; 30 homesteads overflown; Cătina: county road (DJ) 102B sank over a distance of 100 m at 500 m from Zeletin and 4 silted wells; Vipereşti: four houses flooded; DN 10 blocked by run-off from slopes. Disrupted telephone service in Buzău, Pătârlagele, Calvini, Pietroasa, Cătina, Nehoiu and Cislău; Merei: large cultivated terrains and vineyards bitten by hail (source: USI Buzău Report).

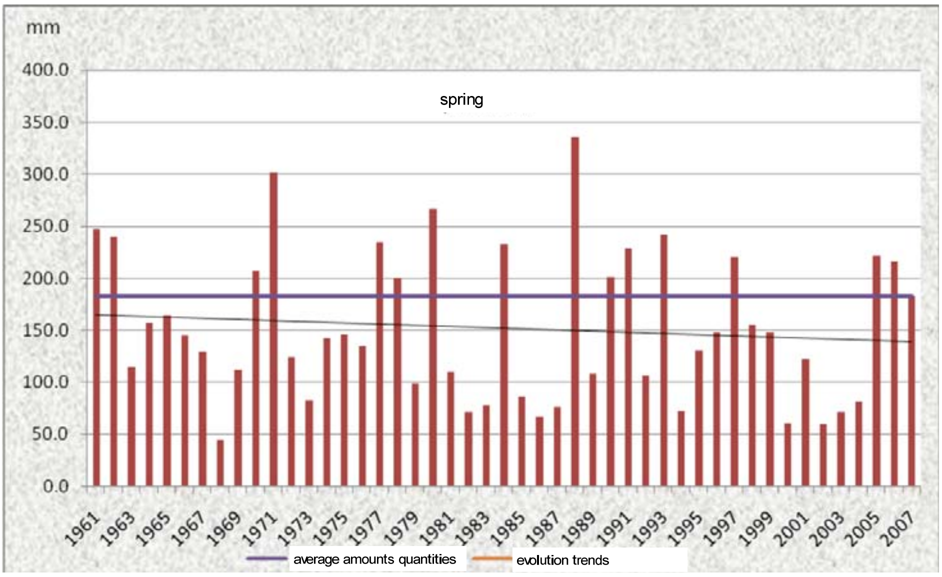


Fig. 5 – Multi-annual average seasonal (spring) amounts of precipitation, Pătârlagele Weather Station.

Autumn precipitation amounts are significantly lower as anticyclonic pressure fields are prevailing. At Pătârlagele Station, the multi-annual seasonal average was of 129.2 mm (20.3%). In the studied Subcarpathian areas, highest quantities (270.2 mm) were registered in 1972, the lowest ones (44.9 mm) in 1967, seasonal evolution trends being positive (Fig. 6).

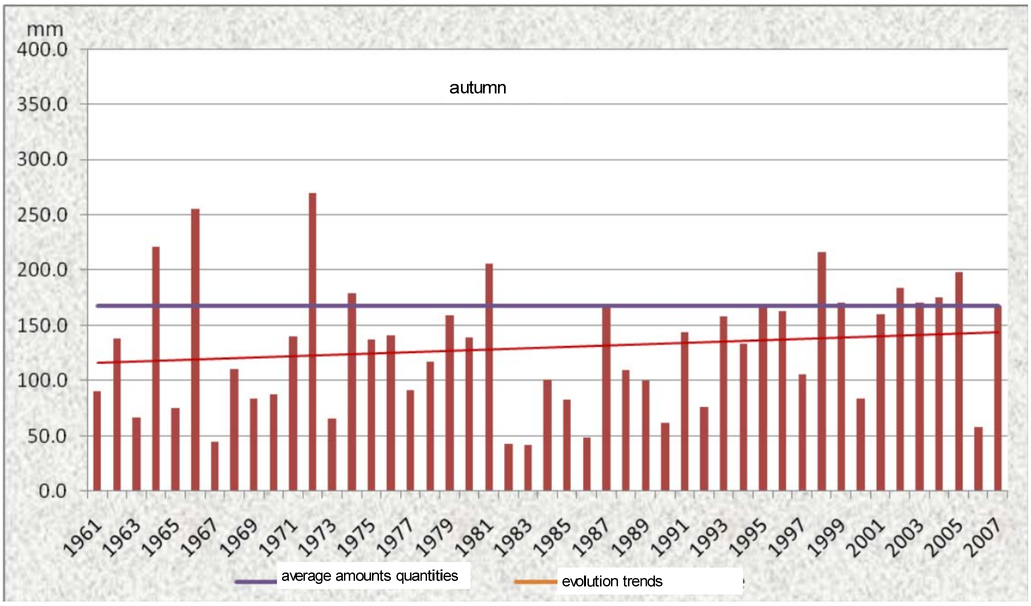


Fig. 6 – Multi-annual average autumn quantities of precipitation, Pătârlagele Weather Station.

In the warm semestre of the year (between April and September) the monthly variability of cumulated quantities was very high, as revealed by differences between maximum and minimum values (282.5 mm, July 1975 and 0.1 mm, August 1962, respectively). The row of observation years showed no year completely free of precipitation in the warm season.

June is the month of the main annual rain maximum, with multi-annual average amounts of 90.8 mm, that is 14.3% of the overall annual quantities (635.1 mm).

June rainfalls in the Subcarpathian study-area had a slightly deficitary evolution yet not statistically significant (Pătârlagele -3.5 mm/47 years) (Fig. 7) (Dragotă, 2010).

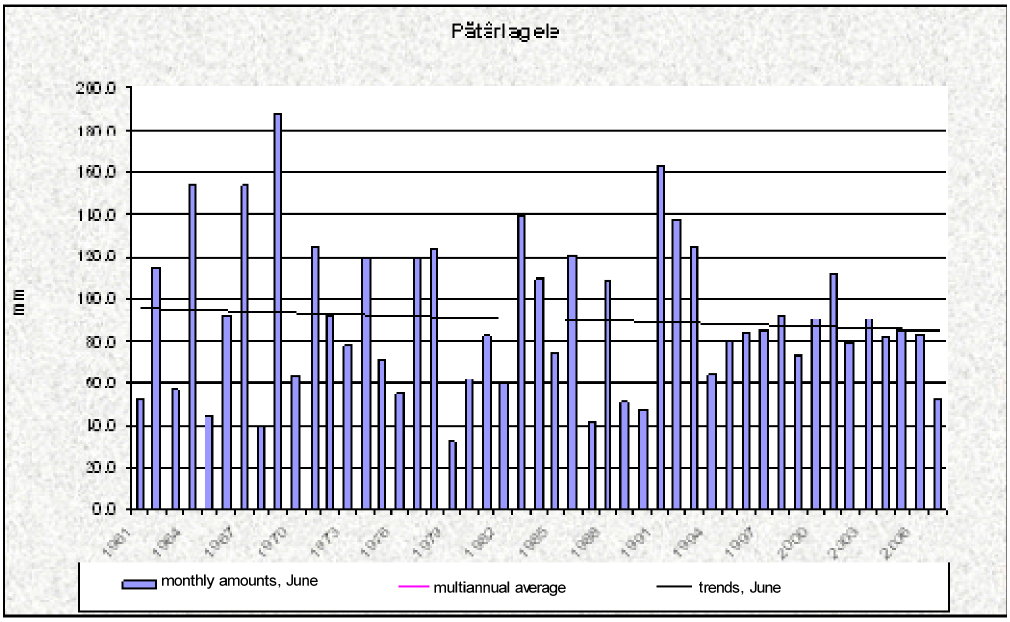


Fig.7 – Multi-annual monthly average amounts of June rainfalls, Pătârlagele Weather Station.

A representative pluvial semester in terms of cumulated quantities, duration and intensity of rain, the degree of continentalism in the region is also discussed. “The Köppen Index [KI=PP(year) /T (year)+7]” quantifies this element by associating the annual precipitation amounts with the annual air temperature regime in Romania. The findings have revealed the following values:

– KI values below 30 units in the plain and lower hilly regions of the south, east, extreme wet being designated by high continentalism;

– KI values of 30–50 units in hillsides and tablelands indicate moderate continentalism;

–KI values over 75 units stand for weak continentalism.

In the Sărățel and Bălăneasa catchments, KI values of 30–60 units indicated moderate-to-weak continentalism (Fig. 8).

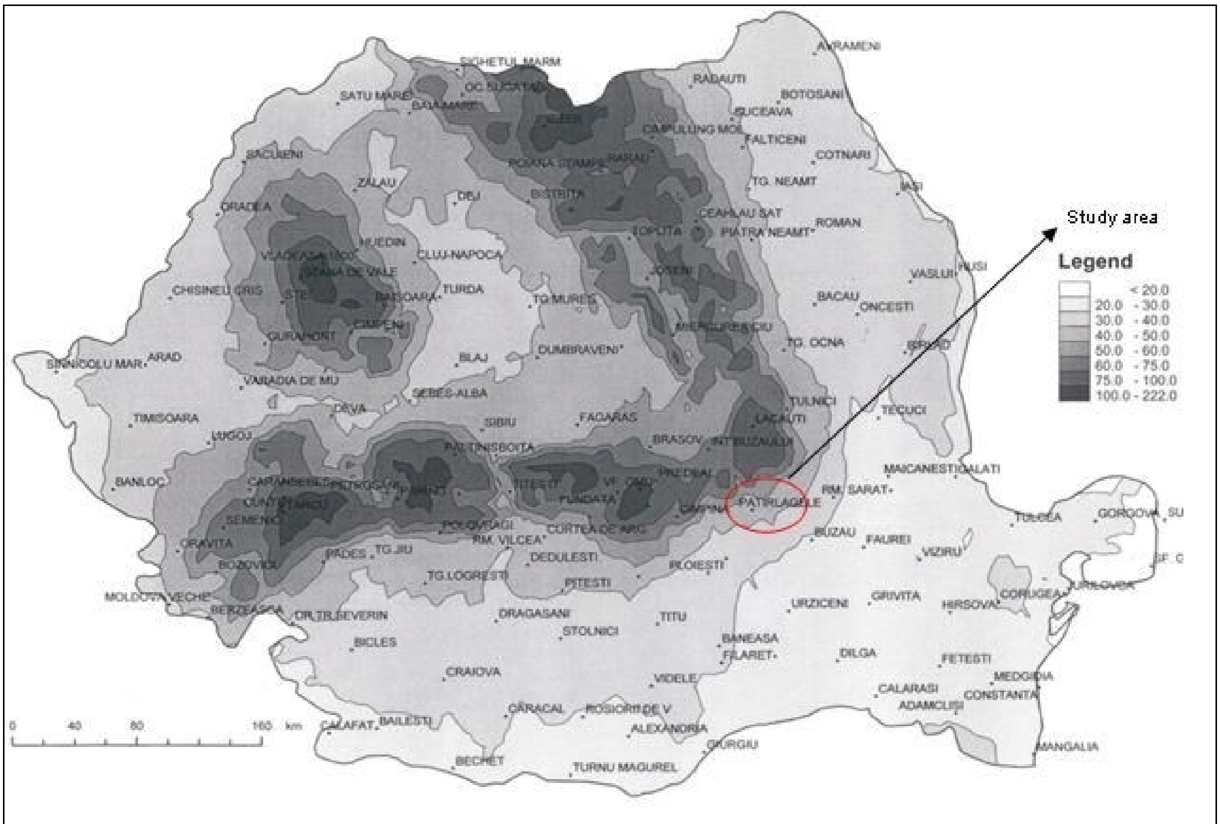


Fig. 8 – Köppen Index values in Romania (A. Dumitrescu *et al.*, 2005).

Summing up we would say that analysing the total quantities of precipitation fallen in the warm semester and their variability trends in the Sărățel and Bălăneasa basins over 1961–2007 has revealed important value aspects. These precipitation have a major impact on present-day slope dynamics and land-use, which are extremely sensitive to any climatic variation, primarily having in view the pluvial regime, and the effects of general climate warming in Romania.

As a result, the following aspects are worth outlining:

– continentalism in the Sărățel and Bălăneasa catchments is moderate-to-weak, also decreasing with altitude (KI values);

– the main climate-related hazards in the warm semester are flash-floods in small catchments, triggering flood events (especially due to the June-July annual pluvial maximum), frontal and convective rains associated with high winds and storms; here and there, moderate droughts and aridisation phenomena also occur, mostly between August and September, an aspect not tackled in this paper;

– the high precipitation rates in the warm semester call for the correct management of rain sources in order to reveal the negative effects of excess/deficient precipitation amounts;

– the case-studies chosen are significant for recent years, indicating some segments of the pluvial regime in the warm semester in which highest quantities, that have an essential impact on the environment, are recorded. The damage caused by excess precipitation affected both slopes and stream channels, producing important material losses.

BIBLIOGRAPHY

Bălteanu, D. (coordinator), Micu, M., Micu, Dana, Dragotă, Carmen, Dumitraşcu, Monica (2009), CLAVIER – *Impact of extreme events on soil erosion and the agri-environmental potential in the Curvature Carpathians and Subcarpathians*, Institute of Geography.

Bălteanu, D. (1992), *Natural hazards in Romania*, RRGGG, – Géographie, t. **36**.

Bălteanu, D., Badea, L., Dinu, Mihaela, Cioacă, A., Sandu, Maria, Constantin, Mihaela (1994), *Geomorphological hazards in the Romanian Subcarpathians,* Inst. Geogr., Bucureşti.

Bălteanu, D. (2000), *Present-day geomorphological processes and environmental change in the Romanian Carpathians,* in *Geomorphology of the Carpatho-Balcan Region*, Edit. Corint, Bucureşti.

Bălteanu, D. (2004), *Hazardele naturale şi dezvoltarea durabilă*, Revista Geografică, t. **X**.

Dragotă, Carmen-Sofia, Grofu, Anduța (2010), *Resursele pluviometrice ale semestrului cald al anului în sectorul subcarpatic cuprins între Buzău şi Slănicul Buzăului,* Comunicări Stiințifice **IX**, Mediaş.

Dragotă, Carmen-Sofia, Grofu, Anduța (2011), *Caracteristici cantitative ale regimului pluviometric în Subcarpații şi Carpații de Curbură*, Analele Univ. Spiru Haret, Seria Geografie, nr. **14**.

Dragotă, Carmen-Sofia, Micu, Dana, Micu, M. (2008), *Relevanța regimului pluviometric asupra genezei şi evoluției alunecărilor de teren. Studiu de caz: Bazinul Muscel (Subcarpații Buzăului), Romania*, Present Environment and sustainable development, nr. **2**, Iaşi.

Dumitrescu, A., Dragotă Carmen, Urban, J. (2005), *Management of water resources in the warm semester of the year, as resulted from the precipitation amounts fallen over the Romanian territory in the 1961–2000 interval,* Analele Universității Ovidius, Seria Geografie, vol. **2**, Constanța.

Grofu, Anduța (2012), *Studiul geografic al utilizării terenurilor în sectorul subcarpatic dintre Buzău şi Slănicul Buzăului,* teză de doctorat (manuscris).

*** *Clima României* (2008), Administrația Națională de Meteorologie, Edit. Academiei Române, Bucureşti.

Report of Information and Public Relations Department, ISU Buzău, July 13, 2010.

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