MAPPING WET TIME-SCALES IN THE CURVATURE CARPATHIANS AND SUBCARPATHIANS (ROMANIA) BY THE STANDARDIZED PRECIPITATION INDEX

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ABSTRACT. – Mapping wet time-scales in the Curvature Carpathians and Subcarpathians (Romania) by the Standardized Precipitation Index. Identifying and describing excess precipitation hazards in the Curvature Carpathians and Subcarpathians, as well as excess precipitation anomalies to the mean Standardized Precipitation Index (SPI) values were analysed over a period of 3, 6, 9 and 12 consecutive months within the 1961 … 2000 interval. Homogeneous data were recorded at the Lăcăuţi, Întorsura Buzăului, Pătârlagele, Penteleu, Tulnici, Râmnicu Sărat, Buzău, Ploieşti, Câmpina and Predeal stations. SPI values are a good indicator for determining and characterising excess precipitation. The results obtained were synthetised on maps of SPI territorial distribution values (%) of the extreme precipitation class of the sub-classes: moderately wet (2 – 2.5) and extremely wet (>2.5). The share of each SPI value set analysed is illustrated on graphs.

Key-words: Curvature Carpathians and Subcarpathians, excess precipitation, precipitation anomalies, SPI.

1. INTRODUCTION

The aim of this paper is to outline the wet component of the Curvature Carpathian and Subcarpathian rain regime by means of the Standardized Precipitation Index (SPI) developed by McKee, Doesken and Kleist (Colorado State University) in the early 1990's (McKee *et al*., 1993).

The index is used to quantify precipitation anomalies to the mean at particular time-scales. Noteworthy, the results are comparable for large geographical areas situated in distinctively different physical-geographical conditions based on the occurrence probability of some reference quantities irrespective of time of the year, place, or climate.

The SPI was created with a view to defining and monitoring drought occurrence and evolution by taking into account only atmospheric precipitation and not the other elements definitory of drought and precipitation in excess: soil water resources, soil moisture, underground flow, air and soil temperature, frequency of characteristic days in the warm season (summer days, tropical nights and cannicular or tropical days), the presence of hydrometeors in the atmospheric air

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and on the atmosphere-soil interface, etc. However, these shortages in using the SPI are included in the various time-scales these additional elements act on.

Basically, SPI is applicable to any landform in order to quantify the excess and deficit of precipitation for different time-scales, first for 3, 6, 12, 24 and 48 months (Hayes, 2003), and for shorter time-spans (month, weak). So, one of the main SPI advanteges is temporal flexibility (NDMC, 1996).

2. TEMPORAL AND SPATIAL ANALYSIS

The SPI elaboration procedure is detailed out by Colorado State University <http://ccc.atmosf.colostate.edu/spi.pdf>. The procedure consists in comparing a gamma distribution probability function with the distribution of the frequencies of precipitation amounts. The soft required by this SPI variant can be obtained via ftp (ulysses.atmos.colostate.edu/pub/spi-0.2.tar.z), that works under Fortran language.

Regionalising SPI values for the geographical area studied relied on the maps of territorial distribution of SPI values for each of the months covered (3, 6, 9, 12) and the sub-classes of the wet category (Păltineanu et al., 2007) obtained by interpolating the values calculated for 10 basic met stations of the study-area (Lăcăuţi, Întorsura Buzăului, Pătărlagele and Penteleu) and its neighbourhood (Tulnici, Râmnicu Sărat, Buzău, Ploieşti, Câmpina and Predeal). The programme used was Surfer 8 (Surface Mapping System, Golden Software Inc 2002) with kriging method, point-friging type, no-drift, ordinary kriging option. Assigning SPI-based precipitation values to the time-scales studied follows a scale of different value grades. McKee et al. (1993) uses seven such value grades (Table 1).

Tabel 1. ***Precipitation value grades assigned to the analysed time-scales or to other scales of interest in terms of the SPI value (source: McKee et al., 1993)***

SPI	**≥ 2**	**1.5 - 1.99**	**1.00 - 1.49**	**0.99…-0.99**	**-1.00…-1.49**	**-1.50…-1.99**	**≤ -2.00**
Precipitation value grades	extremely wet	very wet	moderately wet	near normal	moderately dry	severely dry	extremely dry

In Romania, based on the precipitation data registered over the years 1961-2000, low SPI value variations were obtained for the extremely wet sub-class. Low spatial variations occur at 1.8% years, on average, both throughout this country (from a minimum of 0.0% to a maximum of 7.5%) and in the study-area (Table 2).

A complete and much more accurate regionalisation (on a larger scale) for the Curvature Carpathians and Subcarpathians was eventually worked out having in view the initial SPI values and the local conditions (altitude, slope aspect and slope declivity). The respective maps can be seen on figures 1, 2, 3 and 4. The shades of gray found in the Arc Gis 9.2. Programme were used to work out a value hierarchy of SPI magnitudes and range for the extremely wet SPI category. The number of gray shades (from white to black) corresponds to the frequency classes mentioned in the legend to each map. The histogrammes indicate the spatial dimension of each sub-class expressed in percentages (with the same shade).

Table 2. ***Magnitude and variation range of SPI (%) values for sub-classes in the extremely wet class ≥2, for 3, 6 ,9 and 12 consecutive months in România over the 1961-2000 period***

ISP variation range	**SPI interval**	**Class >2 (%)**			**Class total >2 (%)**	**SPI interval**	**Class >2 (%)**			**Class total >2 (%)**
		> 3	**3.0 -2.5**	**2.0-2.5**			**> 3**	**3.0 -2.5**	**2.0-2.5**	
Maximum	3 month	0.7	1.3	3.1		9 month	0.8	1.9	4.3	
Minimum		0.0	0.0	0.0			0.0	0.0	0.0	
Mean		0.1	0.3	1.4	1.8		0.1	0.3	1.4	1.8
Standard deviation		0.2	0.3	0.6			0.1	0.4	0.8	
CV (%)		171.9	89.6	41.1			302.3	143.0	58.9	
Maximum	6 month	0.6	1.9	3.2		12 month	1.5	1.7	7.5	
Minimum		0.0	0.0	0.0			0.0	0.0	0.0	
Mean		0.1	0.3	1.4	1.8		0.0	0.3	1.4	1.7
Standard deviation		0.1	0.4	0.6			0.2	0.4	1.0	
CV (%)		231.4	110.7	48.2			460.1	170.7	74.8	

**Source: processed after Păltineanu et al.,2007.*

The geographical distribution of the **SPI >2 (extremely wet class)** in the Curvature Carpathians and Subcarpathians *over the three month interval (SPI 3M)* usually varies from 14% to 50%. Highest SPI values (>2%) cover 35.7% of the area in the Clăbucetele Întorsurii Buzăului, the Teleajen Subcarpatians, the northern sector of the Buzău Subcarpathians, and the outer rim of the Vrancea Subcarpathians. The SPI value threshold of <1.5% holds the greatest share (50.4%) occupying the highest summits of the Vrancea, Penteleu and Siriu mountains and the southern sector of the Buzău Subcarpathians (Fig. 1A). For *SPI 6M*, the highest value range (>2.5%) is seen in the Vrancea Mountains (28.5% of the overall area); the areas having a SPI value of 2% represent 31.7% and cover the Clăbucetele Întorsurii Buzăului, the Siriu Mts, the Întorsura Buzăului and the Comandău depressions, the Gârbova and Bisoca hills and the Subcarpathian depressions of Jitia and Lopătari. The lowest SPI values (<1%) cover 13.1% of the area in the value range of 1-1.5% (12.8% of the area) and 1.5-2% (13.9% of the area) in the Teleajen and Buzău Subcarpathians and in the south-east of the Vrancea Subcarpathians (Fig. 1B). The distribution of *SPI 9M and SPI 12M* is similar, in that the higher values (2-3% and >3%) occur mainly on the summits of the Curvature Carpathians in proportion of 10.4% and 24.6% (SPI 6M), 9.3% and 36.7% (SPI 12M) of the area of interest respectively. The lowest SPI 6M values (<1.5%) are found in the southern sectors of the Buzău and Teleajen Subcarpathians, while minimum thresholds (<1.0 and 1.0-2.0%) on the SPI 12M Map overlap most of the Curvature Subcarpathian area (Figs 2A and 2B).

The frequency of the **extreme sub-class (SPI >2.5%)** of the extremely wet class in terms of SPI value thresholds calculated for 3, 6, 9 and 12 months, remains in the sub-unity range. The lowest value thresholds (0.2-0.4%) for *SPI 3M* occur in the eastern and western marginal areas, rising progressively with the altitude up to 0.6-0.8% in the mountain region and to 0.8-1.0% on the highest summits. The histogramme shows an overriding proportion (57.0%) of SPI 3M values between 0.4% and 0.6%, whereas the 0.8-1.0% threshold represents only 7.9% (Fig. 3A).

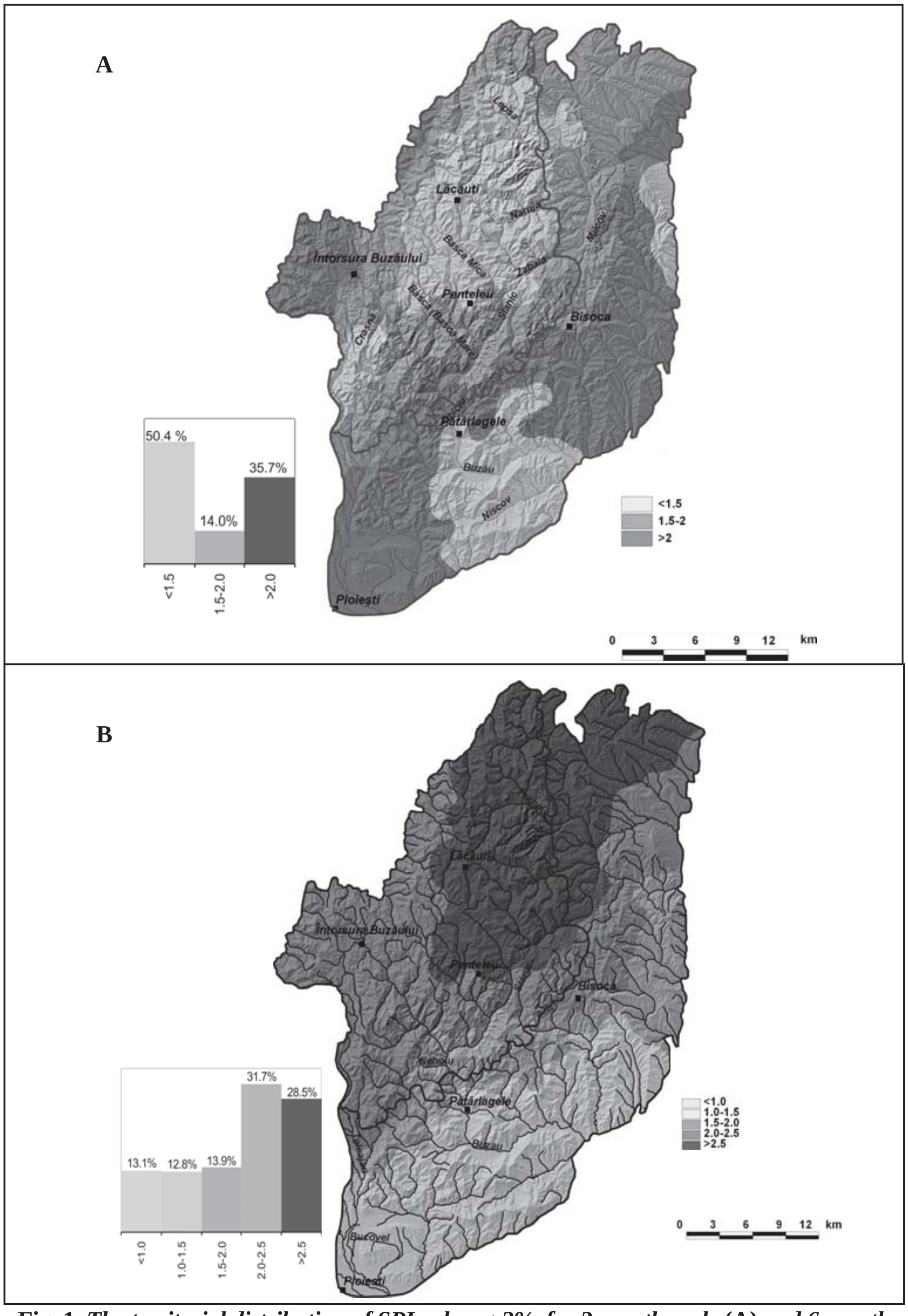

Fig. 1. ***The territorial distribution of SPI values >2%, for 3-month scale* (A) *and 6-month scale* (B), *representing the frequency of extremely wet periods in the Curvature Carpathians and Subcarpathians (Source: processed after Păltineanu et al., 2007)***

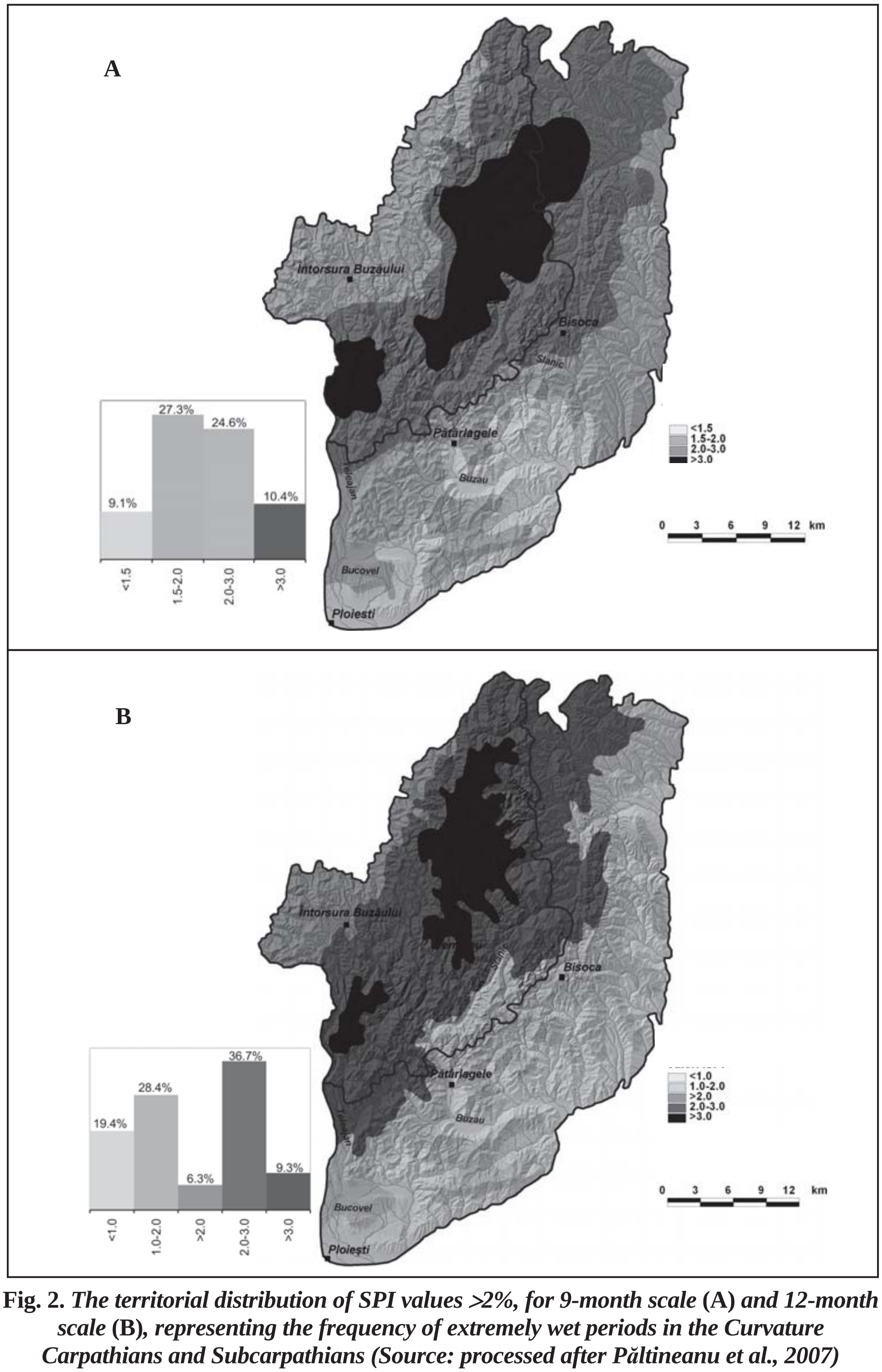

Fig. 2. ***The territorial distribution of SPI values >2%, for 9-month scale*** **(A)** ***and 12-month scale*** **(B)*, representing the frequency of extremely wet periods in the Curvature Carpathians and Subcarpathians (Source: processed after Păltineanu et al., 2007)***

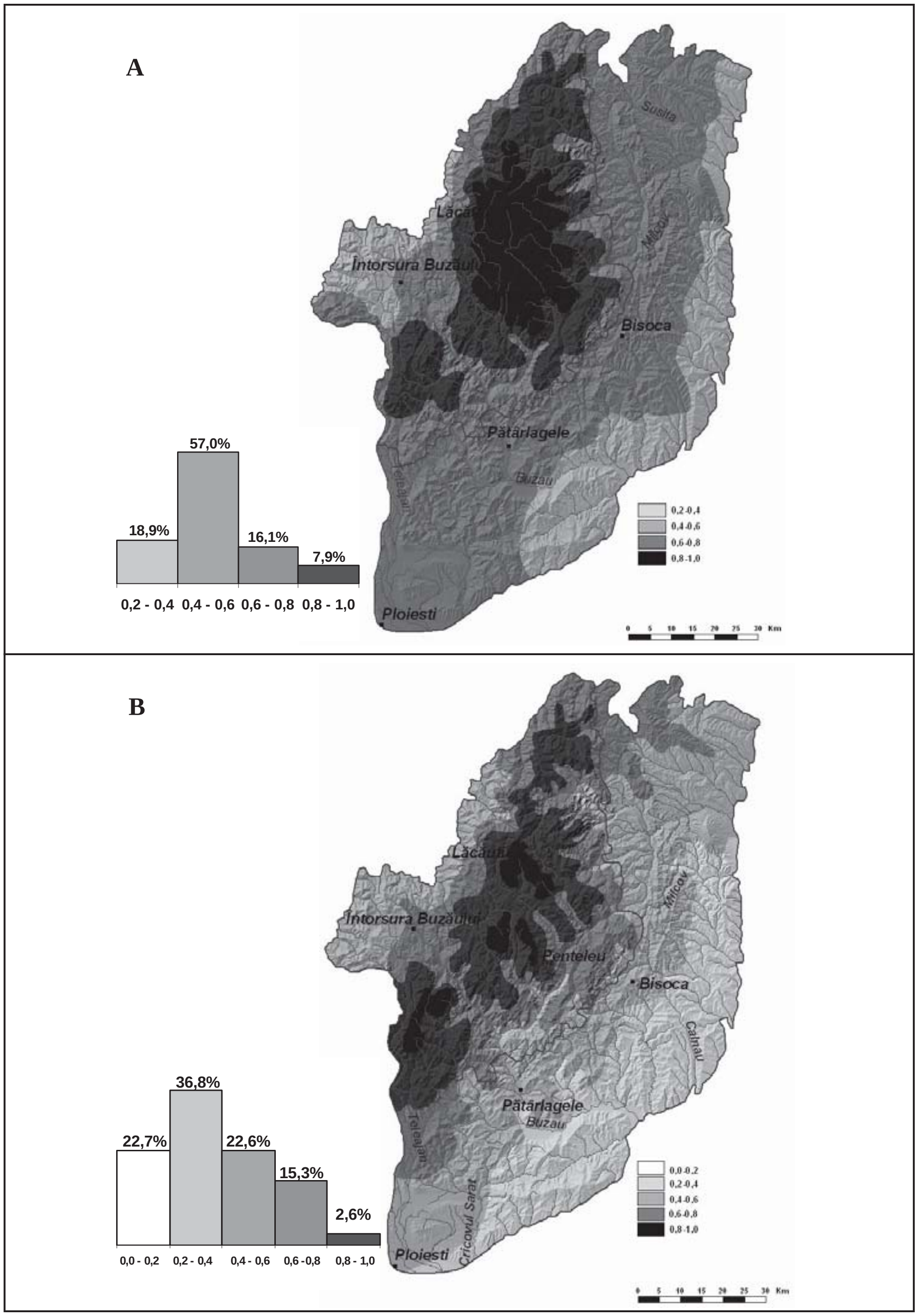

Fig. 3. ***The territorial distribution of SPI values >2,5%, for 3-month scale*** **(A)** ***and 6-month scale*** **(B)*****, representing the frequency of extreme sub-class of the extremely wet class in the Curvature Carpathians and Subcarpathians (Source: processed after Păltineanu et al., 2007)***

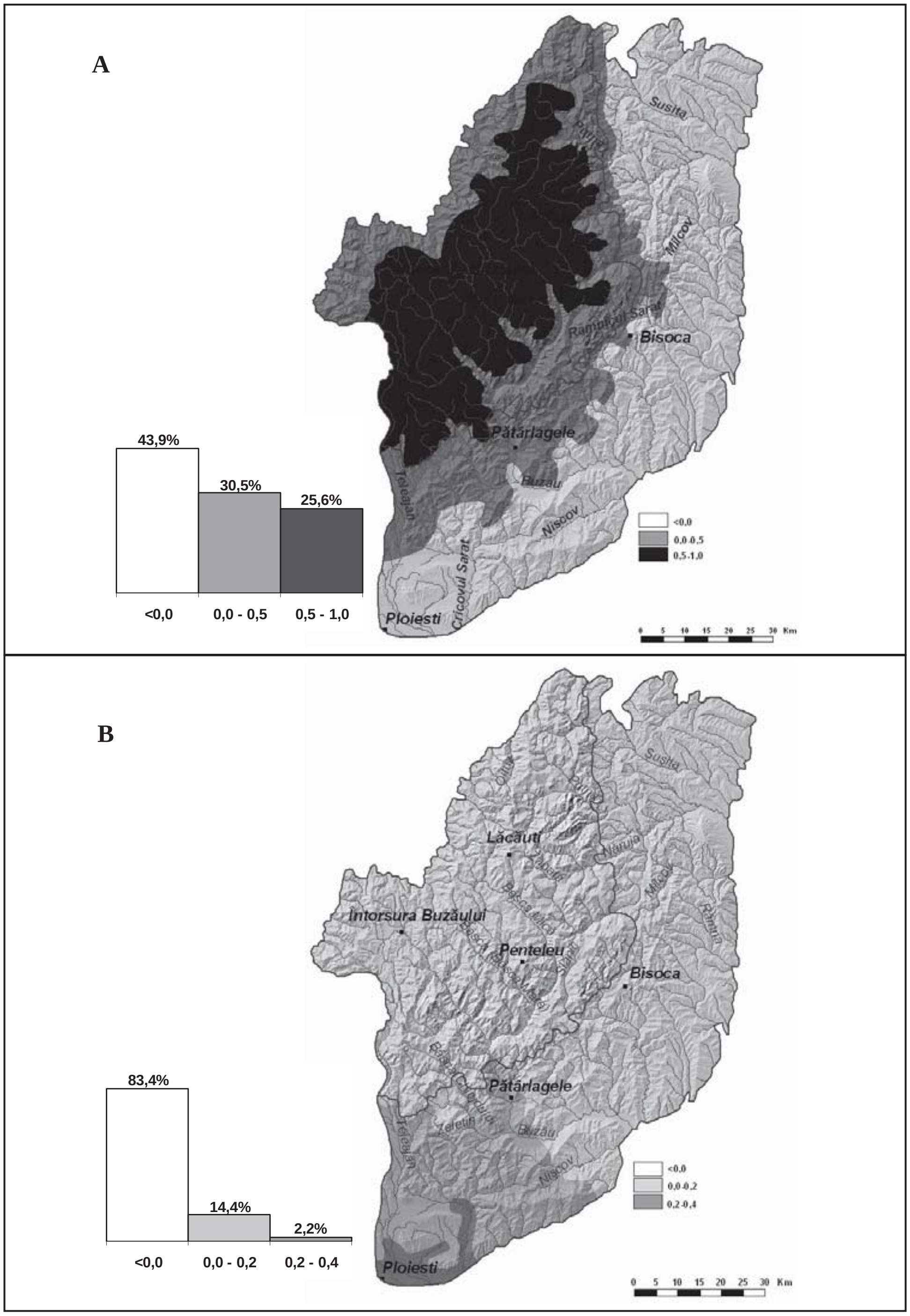

Fig. 4. ***The territorial distribution of SPI values >2,5%, for 9-month scale*** **(A)** ***and 12-month scale*** **(B)*****, representing the frequency of extreme sub-class of the extremely wet class in the Curvature Carpathians and Subcarpathians (Source: processed after Păltineanu et al., 2007)***

Very low values (0.0-0.2% and 0.2-0.4%) are notable for *SPI 6M* in hills and depressions, the highest summits having a 0.8-1.0% record. As shown in the graph, one-third of the study-area (36.8%) has values of 0.2-0.4%, and only 2.6% of it reaches the 0.8-1.0% threshold (Fig. 3B). Also in regard of the entire space of the Curvature Subcarpathians and of the outer rim of the Curvature Carpathians, *SPI 9M* indicates that the proportion of low values (<0.0% and 0.0-0.5%) is of 43.9% and 30.5%, respectively. It is only in the higher mountainous side of the study-area (which amounts to 25.6% of the overall area) that values stay in the range of 0.5-1.0% (Fig. 4A). When looking at *SPI 12M* it emerges that only 2.2% of the area of interest falls into the extreme sub-class of precipitation in excess, with values of 0.2-0.4%, while 83.4% of the area registers values of 0.0% (Fig. 4B).

3. CONCLUSIONS

SPI values >3.0 %, correspounding to the maximum international level set for the extremely wet class, are absent in the Curvature Carpathians and Subcarpathians. As a matter of fact, even the extreme sub-class (>2.5%) of the extremely wet class is very poorly represented. In view of the above, it follows that these values are not specific to our study-area in which Föehn processes make the intensity of precipitation in terms of SPI values come second after other areas in Romania. Characteristic of Föehn processes is higher temperature simultaneously with lower nebulosity and implicitly fewer precipitation, depressed air moisture, etc. In the Curvature Carpathians and Subcarpathians SPI values are unevenly distributed, the isolines crossing both the wetter Carpathian sector and the drier Subcarpathian one, but what essentially counts is the order of magnitude of these values within the extremely wet class (SPI >2%).

REFERENCES

1. Hayes, M.J. (2003), Drought Indices, U.S. National Drought Mitigation Center-NDMC, <http://enso.unl.edu/ndmc/enigma/indices.htm#spi>
2. Holobâcă, I. H (2010), *Studiul secetelor din Transilvania*, Edit. Presa Universitară Clujeană, 242 p., ISBN: 978-973-610-981-2.
3. McKee, T.B., Doesken, N.J., Kleist (1993), *The relationship of drought frequency and duration to time scales.* Preprints, 8th Conference on Applied Climatology, pp. 179-184, January, 17-22, Anaheim, California.
4. NDMC (1996), *North American Drought: A Paleo Perspective.* http://www.drought.unl.edu/monitor/spi.htm.
5. Păltineanu, Cr., Mihăilescu, Fl. I, Seceleanu, I., Dragotă, Carmen, Vasenciuc, Felicia, *Ariditatea, seceta, evapotranspiraţia şi cerinţele de apă ale culturilor agricole în România*, Ovidius University Press, Constanţa, 2007, 319 p., ISBN: 978-973-614-412-7.