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

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Key-words: Curvature Carpathians and Subcarpathians, deficitary precipitation, precipitation anomalies, Standardized Precipitation Index.

Mapping dryness time-scales in the Curvature Carpathians and Subcarpathians (Romania) by the Standardized Precipitation Index. In order to identify and describe deficitary precipitation hazards in the Curvature Carpathians and Subcarpathians, as well as excess of precipitation anomalies versus mean values, Standardized Precipitation Index (SPI) values were analysed over a period of 12 consecutive months during the 1961 … 2000 interval. Homogeneous data were recorded at the Bisoca, Lăcăuți, Întorsura Buzăului, Pătârlagele, Penteleu and Ploieşti stations. SPI values are a good indicator for determining and characterising deficitary precipitation. The results obtained were synthetised on maps of SPI territorial distribution values (%) of the extreme dry class, namely, the two sub-classes: moderately dry (-2 ... -2.5) and extremely dry (<-2.5). The share of each analysed SPI value set is illustrated on graphs.

1. INTRODUCTION

The aim of this paper is to outline the dry component (cumulated precipitation deficiency) 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 1990s (McKee *et al*. 1993).

The index is used to quantify precipitation anomalies versus mean values at particular time-scale. 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 and on the atmosphere-soil interface, etc. However, these short comings 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).

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2. TEMPORAL AND SPATIAL ANALYSIS

The SPI elaboration procedure is detailed out by the Colorado State University <http://ccc.atmosf. colostate.edu/spi.pdf>. The procedure consists in comparing a gamma distribution probability function with the distribution of 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.

Distributing SPI values for the geographical area studied was based on the maps of territorial distribution of SPI values for 12 months frequency and the dry category sub-classes (Păltineanu *et al.* 2007) obtained by interpolating the values calculated for 10 basic met stations of the study-area (Lăcăuţi, Întorsura Buzăului, Pătârlagele 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-kriging 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).

Table 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 interval, low SPI value variations were obtained for the *extremely dry sub-classes*. Extremely dry periods have a fairly low incidence, at 1.9–2% years on average and as low spatial variations both throughout the country and in the study-area. Referred to maximum values, such situations represent up to 3% in three consecutive months, 3.6% in six and 9 months and 5% in 12 months (Table 2).

Table 2

Magnitude and variation range of SPI (%) values for sub-classes in the extremely dry class ≤ -2, for 3, 6 ,9 and 12 consecutive months in România over the 1961–2000 period

SPI variation range	SPI interval	Class ≤ -2 (%)			Class total ≤ -2 (%)	SPI interval	Class ≤ -2 (%)			Class total ≤ -2 (%)
		-2.5…-2.0	-2.5…-3	< -3.0			-2.5…-2.0	-2.5…-3	< -3.0	
Maximum	3 months	3.1	1.2	1.1		9 months	3.6	1.4	2.6	
Minimum		0.0	0.0	0.0			0.0	0.0	0.0	
Mean		1.5	0.4	0.1	2.0		1.6	0.2	0.1	1.9
Standard deviation		0.6	0.3	0.2			0.8	0.4	0.3	
CV (%)		38.3	78.6	167.7			48.1	117.7	301.2	
Maximum	6 months	3.5	1.4	1.8		12 months	5.0	1.9	3.0	
Minimum		0.0	0.0	0.0			0.0	0.0	0.0	
Mean		1.5	0.3	0.1	1.9		1.5	0.3	0.1	1.9
Standard deviation		0.7	0.3	0.2			0.9	0.5	0.3	
CV (%)		49.8	103.5	259.1			59.3	140.7	356.9	

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

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 but particularly local conditions (altitude, slope aspect and slope declivity). The respective maps can be seen on figures 2 and 3. The shades of gray found in the Arc Gis 9.2. Programme were used to elaborate a value hierarchy of SPI magnitudes and range for the extremely dry 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).

Under the SPI class < -2 (very dry, the moderate component (-2.0…-2.5%) in the territory follows largely altitudinal distribution, in that drier areas (highest SPI values, > 2%) occur especially in the Subcarpathian space, covering all of the Buzău Subcarpathian space, basically all of the Buzău Subcarpathians, the south-east Vrancea Subcarpahians the Siriu and Clăbucetele Întorsurii Buzăului Mountains, that is 46.5% of the entire study-area (Figs 1, 2).

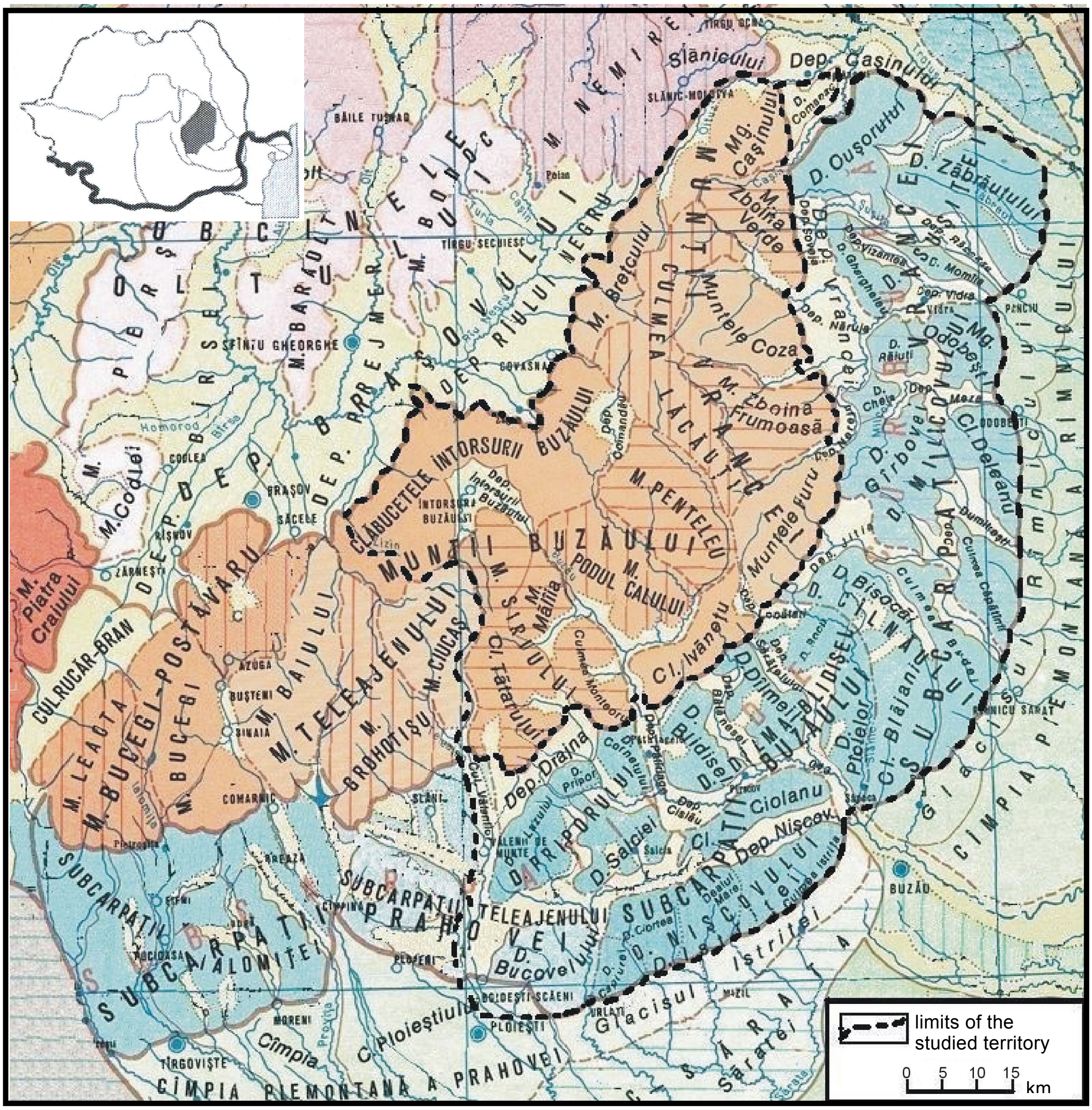

Fig. 1 – Relief units in the Curvature Carpathians and Subcarpathians between the Trotuş (N) and the Teleajen (W) valleys (modified after Posea and Badea, *România. Relief Units – Geomorphological regionalisation, scale 1: 750 000*, 1984).

The SPI value threshold of 1.0 – 1.5%, representing 29.4% of the overall area, occurs as follows: the Curvature Carpathians: The Breţcu Mts, Calu Mts, Ivăneţu Summit and Mount Furu; in the Subcarpathians: the north-west extremity of the Buzău Subcarpathians, the inner rim of the Vrancea Subcarpathians closing in the Jitia and Vrancea Subcarpathians, as well as the Zăbrăuţ Hills and Măgura Odobeşti uplift (Figs 1, 2).

Lowest SPI values (<1.0%), representing 23.0% of the study-area, are registered at top altitudes in the Vrancea Mts, (Lăcăuţi, Mount Zboina Frumoasă, Mount Coza, Mount Zboina Verde and Măgura Caşinului uplift), as well as in the Penteleu Massif – a subunit of the Buzău Mts. In the Curvature Subcarpathians such values are found only in the north-west extremity of the Vrancea Subcarpathians (Figs 1, 2).

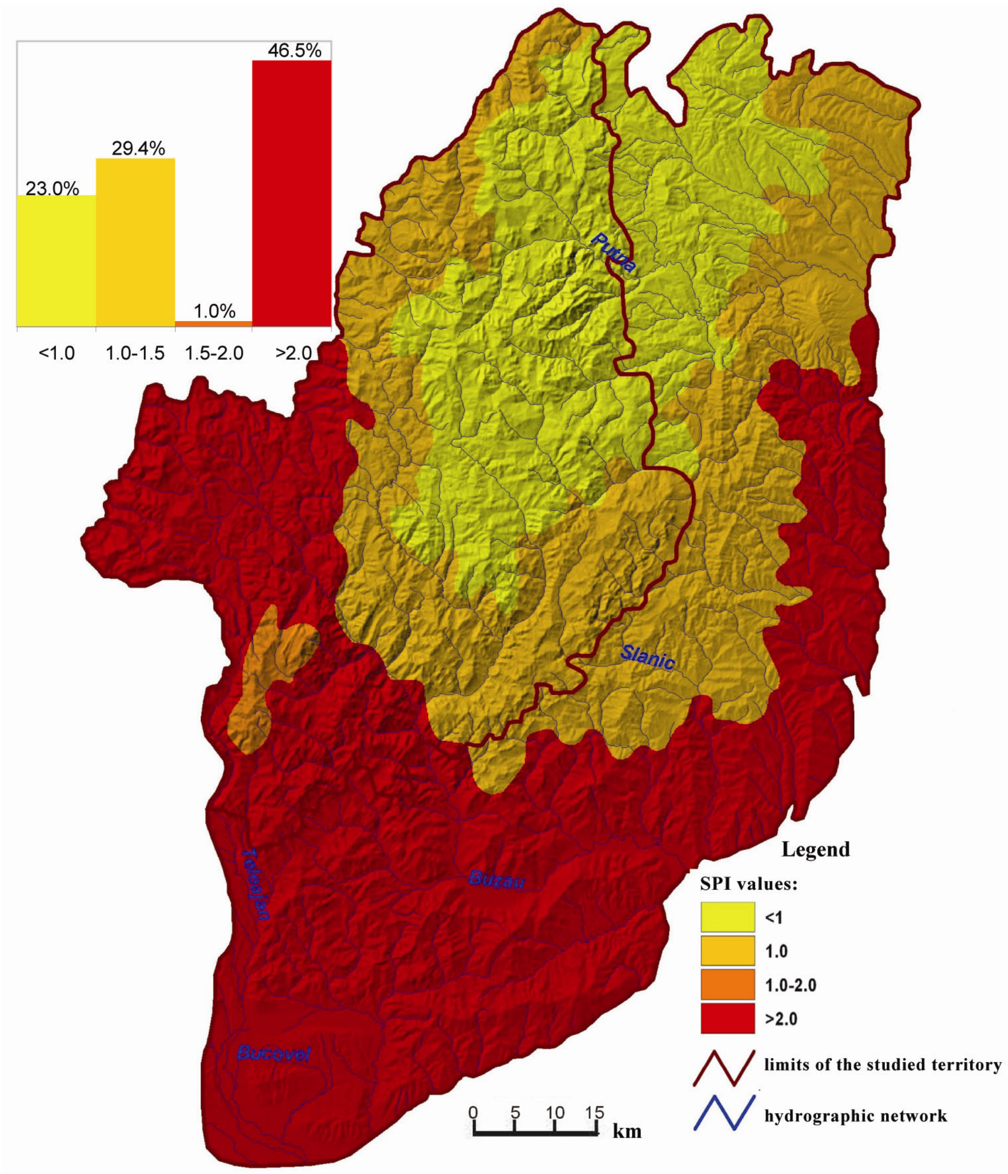

Fig. 2 – The territorial distribution of SPI values (-2…-2.5 %) for 12 consecutive months, representing the frequency of the extremely dry class moderate sub-class in the Curvature Carpathians and Subcarpathians (Source: processed after Păltineanu *et al.* 2007).

SPI values calculated for a 12-month period (< -2.5%), standing for the extreme component of the very dry period, are quite weakly represented, their incidence being sub-unity. Broadly speaking, characteristics are the same as the moderate component has, the Curvature Subcarpathian inner rim and the Subcarpathian mountain areas having the lowest values: 0.0–0.5%, but in this case they represent the majority – 69.3% – of the area total); 30.7% occur in the marginal areas: Clăbucetele Întorsurii Buzăului, the mountain space and outer rim of the Curvature Subcarpathians (Figs 1, 3).

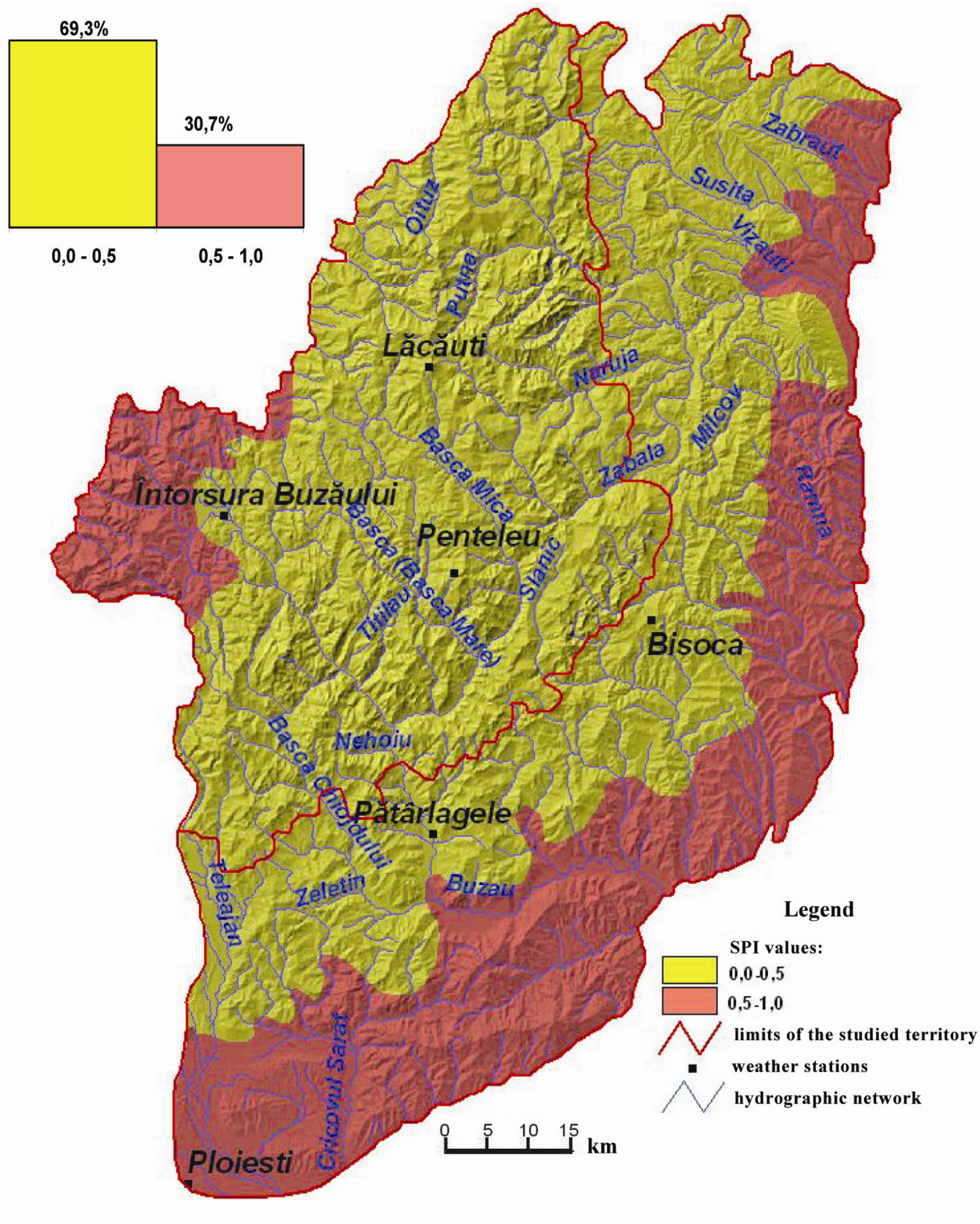

Fig. 3 – The territorial distribution of SPI values (-2…-2.5 %) for 12 consecutive months, representing the frequency of the extremely dry class extreme sub-class in the Curvature Carpathians and Subcarpathians (Source: processed after Păltineanu *et al.* 2007).

3. CONCLUSIONS

Summing up we would say that the SPI vallues that designate a shortage of precipitation in the Curvature Carpathians and Subcarpathians are unevenly distributed, their isolines crossing both the relatively severely dry Subcarpathian sector and the generally more humid Carpathian sector. What is really important is the value order of these magnitudes.

In the Curvature Carpathians and Subcarpathians there are no < -3.0% SPI values, which represents the maximum level of the very dry class. Also the extreme subclass (< -2.5%), including dry situations, is very weakly represented (sub-unity values), fact that sustains the conclusion that extreme climatic phenomena are not specific to the study area.

Dryness and drought are the result of foehn processes characteristic of this region. Pluviometrically speaking, the Curvature Region in Romania ranks first in terms of these types of processes. Next in line comes the Alba Iulia–Turda Depression, followed by the Carpatho-Balkan inner Curvature (*Romania. Space, society, environment,* 2006), where temperature increases simultaneously with lower nebulosity and implicitly fewer precipitation, depressed atmospheric humidity, etc.

An interesting climatological aspect is that arid regions do not necessarily overlap dry regions, nor are vertical levels, part of the geographical characterisation of the Romanian territory, distinguished either. This is the result of the specific SPI calculation modality as deviation of precipitation quantities from the multiannual monthly mean at any weather station, irrespective of its position on the Globe.

Acknowledgements: The paper was conducted under the Romanian Academy research project "*National, regional and local assessment of natural and technological hazards*" (Institute of Geography Research Plan).

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Received May 27, 2011