MONITORING PRIMARY HYDRO-CLIMATE INDICES IN THE TIMISOARA AREA, ROMANIA

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Abstract . *The most important hydro-climate risks in the Timisoara area, Romania, are hydric deficits and humidity excess periods. There have been, because of climate change, droughty periods in areas where the sum of annual or season precipitations is close to multiannual means: the problem is that the water came from high intensity (mm/min) precipitations, which prevented water from accumulating in the soil. The study aimed at presenting the hydric deficits (the existence of droughty periods and of hydric excess) in the Timisoara area over two years (2013-2014). The years have been analysed from the perspective of several hydroclimate indicators in literature. The following parameters of monitoring hydro-climate risks in the Timisoara area have been studied: average monthly temperatures, sum of monthly and annual precipitations, mean monthly and annual evapotranspiration, monthly and annual hydric deficits and their graphic representation, mean monthly temperatures and their evolution; we have calculated and analysed climate and hydro-thermal indicators of drought (Hellman, Topor, Lang), we have characterised depending on the precipitation deficit, the Thornthwaite indicator of precipitation efficiency. From the point of view of the rainfall regime, an important indicator in acknowledging drought and humidity excess depending on the sum of monthly precipitations in summer and even in spring (annual sum of precipitations), we can draw the conclusion that, during the period studied (2013-2014), and the year 2014 was humid, rainy. Depending on the precipitation deficit, compared to monthly, seasonal and annual multiannual means, we can say that June, August and September were droughty periods and months in the analysed years. The year 2013 was semi-arid according to most indicators analysed, with monthly and annual mean temperatures higher than multi-annual ones, with significant hydric deficits during the hot season. Results show that there were periods with hydric deficits, droughty periods in the year (2013) (April-August), this year was also defined as semi-arid in most indicators analysed and the year 2014 was humid and rainy.*

Keywords: *potential evapotranspiration, climate coefficient, annual hydric deficits, precipitation deficit*

INTRODUCTION

Drought and phenomena associated with it, i.e. hydric deficits and desertification, are huge issue humankind has had to deal with in the last fifty years.[7],[8]

Droughts are the result of decreasing precipitation levels in a certain area (below multiannual mean) on the background of high temperatures over a certain period, and whose size differs from one area to another.[3],[6]

The expansion of these unwanted phenomena at global level is emphasised by climate data that point to a progressive warming of the atmosphere and a diminution of the amount of precipitations, i.e. an uneven distribution that causes drought.[4],[5]

Observations and measurements all over the Globe and in Romania on certain climate parameters and on the effects of climate on water resources point to the hypothesis of climate change. [6],[7]

MATERIAL AND METHODS

In this paper, we analyse the following factors:

Mean monthly and annual temperatures and their evolution during the period analysed, with the differences compared to multi-annual means;

Annual precipitations and precipitations during vegetation recorded at the Meteorological Station in Timisoara and their evolution and deviations compared to multi-annual means;

Evapotranspiration monthly, annual and vegetation values calculated with the Thornthwaite formula;

Annual hydric indices Topor index, Hellman index

Potential evapotranspiration was calculated with the Thornthwaite formula (1948) based on the mean air temperature [6]:

$$ETP = 16\left(\frac{10 \cdot tn}{I}\right)^{a} \cdot K$$

where:

ETP – monthly potential evapotranspiration (mm);

tn – mean monthly temperature for which we calculate ETP in °C;

I – area thermal index (sum of monthly thermal indices);

a = an exponent depending on I;

$a = 0.0000006751 I^3 - 0.00007711 I^2 + 0.0179211 I + 0.49239$;

In = monthly thermal index.

To characterise synthetically the climate, we used the following climate indices:

Hydro climate balance = Precipitations – Potential evapotranspiration; annual indices of aridity (de Martonne), Thornthwaite index

Results were interpreted according to the table suggested by Donciu (1986) that presents limitative values of the main climate types of wetness in Romania, table 1. [1]

Table 1

Limitative values of main climatic types of humidity in Romania (Donciu, 1986) [1]

Climatic Type	P –ETP (mm)	Donciu index	Thornthwaite index	De Martonne index
Excessively humid	600 to 1200	200 to 570	100 to 470	60 to 187
Very humid	300 to 600	160 to 200	60 to 100	50 to 60
Wet	100 to 300	120 to 160	20 to 60	40 to 50
Moderately wet I	0 to 100	100 to 200	10 to 20	35 to 40
Moderately wet II	-100 to 10	90 to 100	0 to 10	30 to 35
Moderately dry	-200 to -100	70 to 90	-20 to 0	24 to 30
Semiarid	-35- to -200	50 to 70	-30 to -20	15 to 24

The global index of wetness lm supplies an annual pluviometric characterisation [2]:

Im = Iu – 0.6*Ia or Im = [(s – 0,6*d)/ETP]*100

Table 2

Climate characterisation after Thornthwaite

Global index of wetness (Im)	Annual characterisation
Im>100	Over wet
100>Im>80	Wet
80>Im>20	Semi wet
20>Im>0	Sub wet
0>Im>-20	Sub dry
-20>Im>-40	Semiarid
-40>Im	Arid

- The de Martonne aridity index allows the delimitation of arid, semi-humid climates, while the monthly one differentiates the areas affected by drought. [1],[2]

$$A = \frac{P}{T + 10} \text{ annual}$$

$$A_1 = \frac{12Pi}{T_i} \text{ monthly}$$

P = annual or monthly precipitations (mm)

T = mean annual or monthly temperatures (^{0}C)

Interpretation of the de Martonne aridity index:

0 < A < 5 Arid climate

5 < A < 20 Semi-arid climate

20 < A < 30 Semi-humid climate

30 < A < 55 Humid climate

- **The Donciu humidity index** is calculated with the formula:

$$I_D = \frac{100 \cdot P}{ETP} \%$$

where:

P – sum of annual precipitations (mm);

ETP – potential evapotranspiration (mm).

- precipitation efficacy (P - ETP), where P is the sum of annual precipitations (mm) and ETP is potential evapotranspiration (mm); [1]

- The Lang index allows delimiting climate in plane areas (agricultural areas). It cannot be applied to monthly vales. It can be calculated with the formula:

$$L = \frac{P}{T} \text{ annual}$$

where:

P = annual precipitations (mm)

T = mean annual temperatures (^{0}C)

Interpretation:
0 < L < 20 Arid climate

20 < L < 40 Mediterranean climate

40 < L < 70 Semi-arid climate

70 < L < 1000 Humid climate [2]

- The Hellman Index

Pluviometric characterisation of a month is done by comparing the amounts of precipitations of the month with the multiannual mean. It is grouped into 9 categories. [2],[3]

The N. Topor Index is a hydrothermal index [2]

Table 3

Characterisation after the N. Topor index

Pluviometric index (Ia)	Characterisation
Ia<0,33	Exceptionally droughty
0,33<Ia<0,40	Excessively droughty
0,41<Ia<0,70	Very droughty
0,71<Ia<0,84	Droughty
0,85<Ia<1,00	Less droughty
1,01<Ia<1,17	Normal
Ia>1,18	More rainy

RESULTS AND DISCUSSIONS

Analysis of the evolution of mean monthly temperatures in Timisoara and of their differences compared to the multiannual means as shown in Figure 1 points to 2014 as the hottest year followed by 2013.

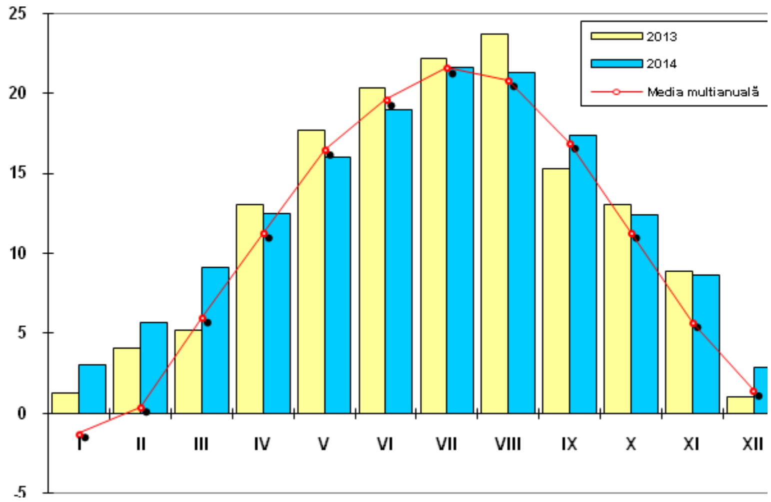

Figure 1. Monthly mean temperatures in the years 2013-2014

In the two studied years, mean annual temperatures were higher than the normal, with values ranging between 1.2 and 1.6°C, while in the hot season, the highest value of temperature was in 2013, i.e. 0.8°C more than the normal one, followed by 2014, when the mean during the hot period was sensibly equal to the normal one. The hottest months of 2014 were during the cold season: February and January with 3°C (4.2°C more than the normal one), as well as March and November.

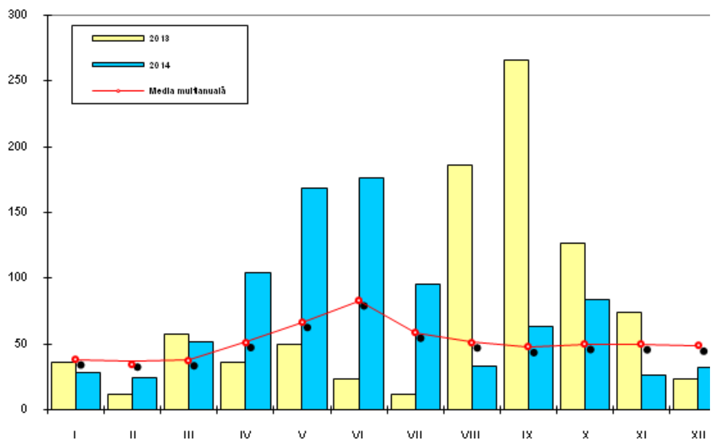

Figure 2. Monthly mean precipitations 2013-2014

The year 2013 was special from the point of view of the amount of precipitations: the total sum of annual precipitations was 902 mm, much higher than the annual mean (618.8 mm); in the hot season also the amount of precipitations was much higher than normal values in Timişoara (214.8 mm more than the normal). There were also months with precipitation deficits during the hot season: June with 23 mm (60 mm less than the normal), July (46.5 mm less than the multiannual mean), February (24.6 mm less) as well as April and May (Figure 3)

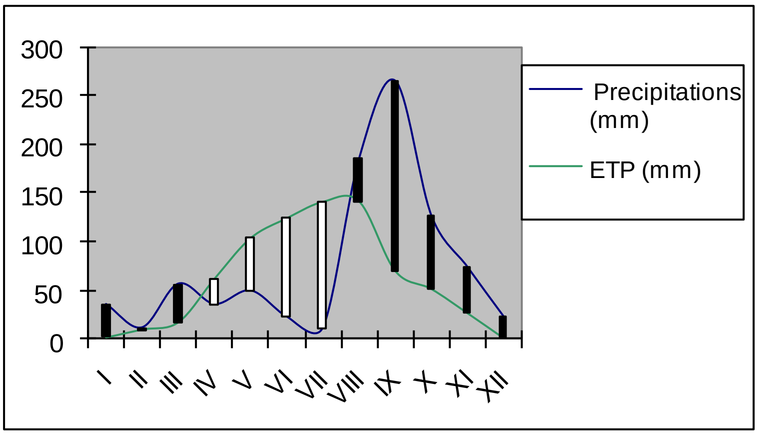

Figure 3. Hydroclimate balance in Timişoara (2013)

Figure 3 shows that in 2013 the total hydric deficit was higher but shorter from April to July only.

The year 2014 had a lower hydric deficit (Figure 4) as both value and duration (July-September) – only 153.4 mm. The sum of hydric extra amounts was much lower than` in 2013 – 285 mm.

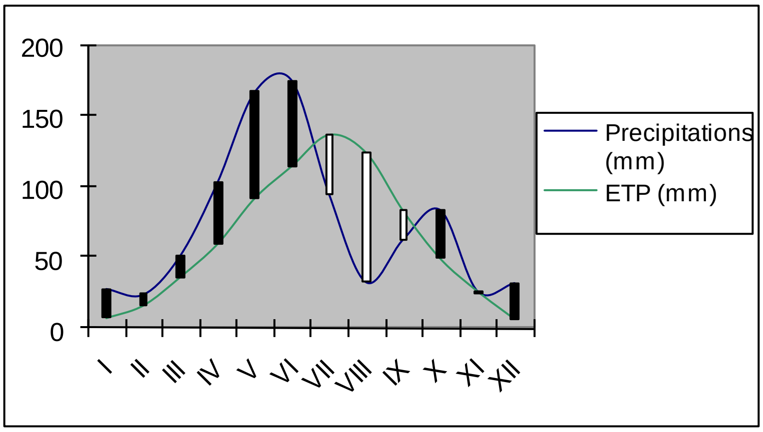

Figure 4. Hydroclimate balance in Timişoara (2014)

Table 4

Characterisation of the years 2013, 2014 in Timisoara depending on the main climate indices

Climatic type depending on indices	P – ETP (mm)	Donciu Index	Thornthwaite Index	De Martonne Index	Thornthwaite global index of Wetness	Lang Index
2013	141,8	118,6	18,6	40,8	35,1	74,5
Interpretation	Wet	*Moderate wet I*	*Moderate Wet I*	*Wet*	Semi wet climate	Wet climate
2014	132,8	117,6	17,6	39,3	25,7	70,9
Interpretation	Wet	*moderate Wet I*	*Moderate Wet I*	*Moderate Wet I*	Semi wet climate	Wet climate

Table 4 shows that the two studied years in Timisoara were humid, moderately humid or semi-humid according to the Donciu, Thornthwaite, de Martonne, or Lang indices.

Table 5

Characterisation after the Hellman criterion of the period 2013-2014 in Timişoara

Year	**Month**	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
2013		LN	LES	LEP	LFS	LS	LES	LES	LEP	LEP	LEP	LFP	LES
2014		LS	LFS	LFP	LEP	LEP	LEP	LEP	LFS	LFP	LEP	LFS	LFS

Depending on the Hellman criterion, Table 5 shows that the year 2013 had six droughty months (April-October and December and February), while in 2014, most months were rainy, except for August, when it was droughty.

Table 6

Pluviometric characterisation after the Topor index during 2013-2014 in Timişoara

Year	**Normal month**	**Rainy months**	**Droughty months**	**Value of pluviometric index**	**Characterisation**
2013	1	5	6	0,84	Droughty year
2014	0	7	5	1,4	Less rainy year

CONCLUSIONS

- The analysis of the years 2013-2014 in Timisoara shows that the year 2014 was the hottest one, that the mean annual temperature was 12.5°C, followed by the year 2013 with a mean annual temperature of 12.1°C, compared to the normal area temperature of 10.9°C;
- Pluviometrically, the year 2014 exceeded in precipitations, as did the year 2013: in both years, the annual sum of the precipitations was considerably higher than the normal one;
- The highest hydric deficits were in the year 2013, from April to July (313.3 mm), while in 2014 the hydric deficit was very low (153.4 mm) with a short period in July-September;
- Depending on the main climate indices – Donciu, Thornthwaite, de Martonne,

Thornthwaite global humidity, and Lang – the years 2013 and 2014 were moderately humid, semi-humid or humid;

- The Topor index shows that the year 2013 was droughty and the year 2014 was less rainy.

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