THERMAL CONTINENTALISM IN EUROPE

APOSTOL L. [1]*, SÎRGHEA L.*[2]

ABSTRACT. **Thermal continentalism in Europe**. In the context of current climate changes, this article aims to highlight the continental characteristics of Europe's climate (including a temporal evolution), regarding the multiannual thermal averages. For this purpose, 78 meteorological stations have been selected, placed approximately on two pairs of transects on West-East and South-North directions. The data were extracted from www.giss.nasa.gov (NASA Goddard Institute for Space Studies), statistically processed (Open Office) and mapped (www.saga-gis.org). For the lapse of time 1961-2010, the analysis of multiannual temperature averages has shown the following: if the multiannual average temperature is strongly influenced by latitude, its deviations are more dependent on longitude; the multiannual average thermal amplitude, as well as the Gorczynski continentality index, are strongly related to longitude; their temporal evolution has shown a significant decrease in the Eastern half of the continent and an increase (although less significant) in Western Europe.

Keywords: average thermal amplitude, Gorczynski continentality index, thermal continentalism, temporal evolution, Europe.

1. INTRODUCTION

Climate changes - "climate changes directly or indirectly assigned to an anthropic activity, which alters the atmosphere's composition on a global scale and which is added to the natural variability of the climate analyzed during some comparable periods" (Rio de Janeiro, 1992) - represents one of the biggest current threats. The accelerated transition towards a world with a warmer climate triggered an increase of the frequency of extreme phenomena, a fast alternation between rapid precipitations and floods, severe heat and accentuated drought, determining severe major effects on socio-economic life.

Climatic continentalism is influenced by: latitude, distance from seas and oceans (which can be expressed especially through longitude, in Europe's case), altitude and atmospheric circulation (Western circulation which is predominant in the temperate area, having a decisive role at the level of the European climate).

Throughout time, there were attempts to define thermal continentalism and the continentality index (Wypach, 2010) in order to characterize an area from a climatic point of view, but because to the difficulties in quantifying the factors which influence continentality, some simplifications were necessary. Depending on

[1] "Alexandru Ioan Cuza" University, Faculty of Geography and Geology, 700506 Iasi, Romania
E-mail: apostolliv@yahoo.com
[2] "Alexandru Ioan Cuza" University, Faculty of Geography and Geology, 700506 Iasi, Romania
E-mail: lilas_70@yahoo.com

thermal energy flows, the most important effect of continentalism is the considerable annual thermal difference between the mainland and the sea (Pettersen, 1969). Conrad and Pollak (1950) have determined a first correlation between the annual temperature variation and latitude. The first formula of the continentality index was suggested by Gorczynski[3] (1920, quote from Grieser and et al., 2006):

$$k = 1{,}7\frac{A}{\sin\varphi} - 20{,}4$$

where: k - continentality index (%);

A - annual thermal amplitude;

φ - latitude (°).

Gorczynski suggests three geographical areas, to which three intervals of the continentality index correspond:

- the maritime area: K from 0 to 33%;
- the continental area: K from 34 to 66%;
- the extreme continental area: K from 67 to 100%.

Gorczynski's equation was later improved by Conrad and Pollak (1950), Driscoll and Yee Fong (1992), Marsz (1995).

2. SPATIAL AND TEMPORAL ANALYSIS

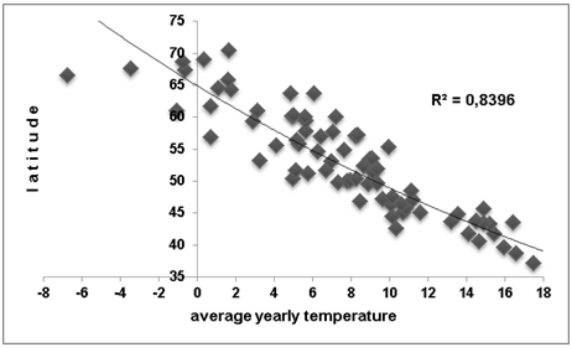

Fig. 1. ***Average annual temperature in Europe (1961-2010)***

For the 78 points which were analyzed, the thermal averages present a strong correlation with latitude, the negative values being present beyond the Northern Arctic Circle (even though the points situated at the highest latitude, from Northern Scandinavia, have positive values, as a result of the North-Atlantic Current.

Instead, the deviations from the multiannual average temperature and the average thermal amplitude (as well as the Gorczynski continentality index, directly influenced by amplitude) are strongly correlated with longitude, highlighting the major importance that Western circulation has on Europe's climate. The smallest deviations (around 0.5°) are characteristic to Southern Europe - including the Caspian Plain (approximately 1.0°C), having an arid continental climate.

[3] This formula was use in this study

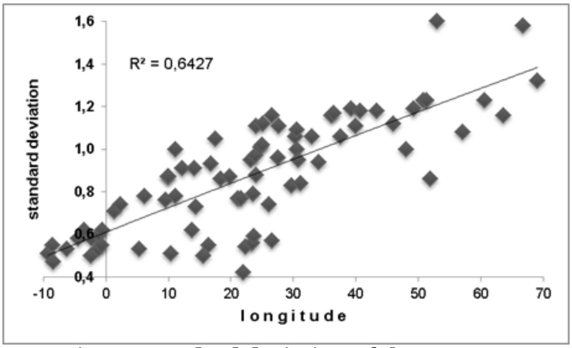

Fig. 2. ***Standard deviation of the average temperature in Europe (1961-2010)***

The maximum values (between 1.0 and 1.6 °C) are present in the extreme Eastern Europe, at the border with the Ural Mountains (maximum values being also present behind the Ural mountain chains).

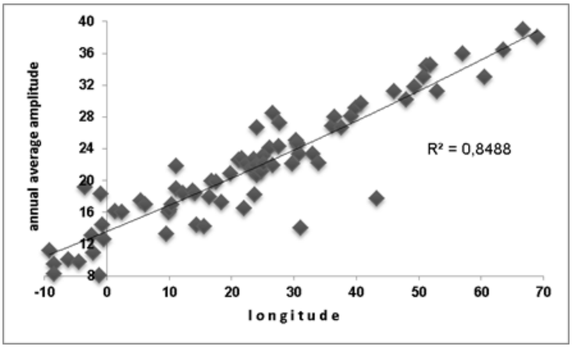

Fig. 3. ***Annual average temperature amplitude in Europe (1961-2010)***

The strong correlation between the average amplitude and longitude is disrupted within the Iberian Peninsula (proving the presence of a "continentalism nucleus", with high annual average amplitudes (18-19 °C) and on the Scandinavian Northern shores, where values are lower by over 10°.

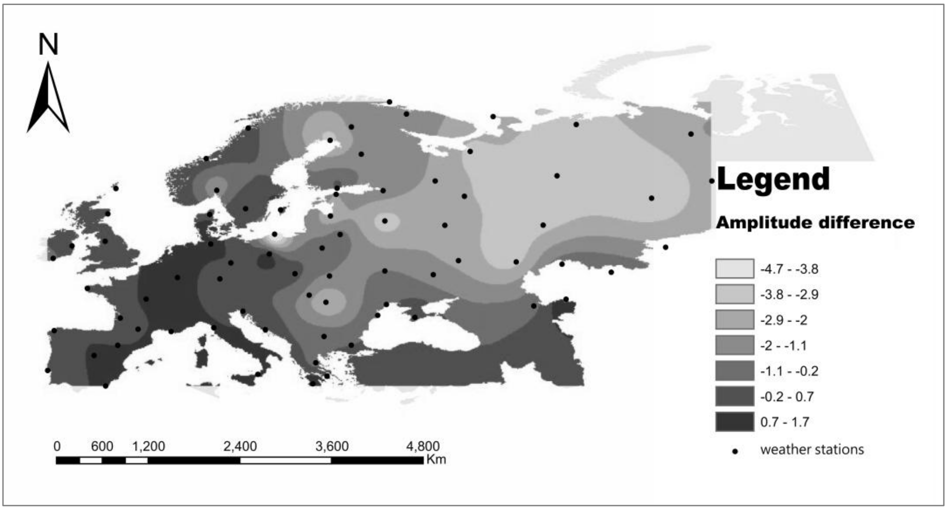

Fig. 4. ***The evolution of multiannual average thermal amplitude in Europe between 1961 - 1970 and 2001 - 2010.***

To highlight this evolution in time, the difference between the average amplitude of the first and the last decade of the analyzed period was calculated, the data obtained being afterwards mapped. On the one hand, an accentuated decrease in thermal amplitude occurred in the Eastern half of Europe (with approximately 2 °C near the Ural Mountains) and an increase (although less important - under 1°C) in Western Europe, and, on the other hand, an increase in thermal continentalism levels is noticed towards the west of the continent (Fig. 4).

What follows is a calculation of the Gorczynski index for the first and last decade of the analyzed interval. In order to compare the two empirical distributions, the Kolmogorov - Smirnov statistical test was used (Groza et al, 2003). The initial null hypothesis supposed that there are significant differences between the two distributions.

Table 1. ***Calculation of cumulative proportions differences***

C l a s s		≤ - 0,8	– 0,7 – ≤ 7,8	7,9 – ≤ 16,4	16,5 – ≤ 25,0	25,1 – ≤ 33,6	33,7 – ≤ 42,2	≥ 42,3
Proportions	distrib.00-10	0,09	0,08	0,21	0,23	0,23	0,08	0,09
	distrib.61-70	0,09	0,09	0,18	0,18	0,23	0,09	0,14
Cumulative	distrib.01-10	0,09	0,17	0,37	0,60	0,83	0,91	1,00
proportions	distrib.61-70	0,09	0,18	0,36	0,54	0,77	0,86	1,00
Difference (δ)		0,00	-0,01	0,01	**0,06**	0,06	0,05	0,00

The theoretical test statistic was calculated using the formula:

$$Dt = K\sqrt{\frac{n1 + n2}{n1 * n2}}$$

where: n1 and n2 - sample volumes;

K - constant which depends on the desired significance threshold.

Table 2. ***Values of the K coefficient in order to calculate the significance threshold of the Kolmogorov - Smirnov test***

Limit of significance	Limit of p	The value of K	Dt
Significance (S)	0,95	1,36	0,22
High significance (HS)	0,99	1,63	0,26
Very high significance (VHS)	0,999	1,95	0,31

Because the maximum obtained difference of 0.06 is smaller than the theoretical test statistic (tab.1), for all the three significance thresholds, the null hypothesis is rejected and, thus, it be can stated (with a 0.1% risk) that there are no significant differences between the two statistical distributions (Table 2).

The graphic representation of the Gorczynski Continentality Index for the two decades emphasizes (as in the case of average amplitudes) a decrease in thermal continentalism in the Eastern half of the European mainland, simultaneously with its increase (but on a smaller scale) in the Western part of the continent (Fig. 5). In latitude, the most significant decreases in the second analyzed decade demonstrate the influence of Western air mass circulation for the European continent. The highest increases in the Gorczynski index values - between 2.5% and 3.2 % - were recorded in Southern Europe.

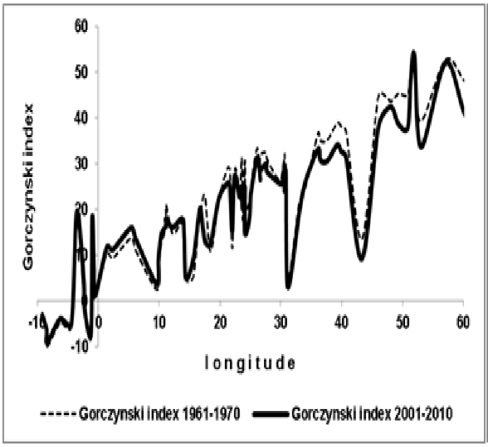

Fig. 5. ***Longitude variations in the Gorczynski Continentality Index in Europe (between 1961 - 1970 and 2001 - 2010)***

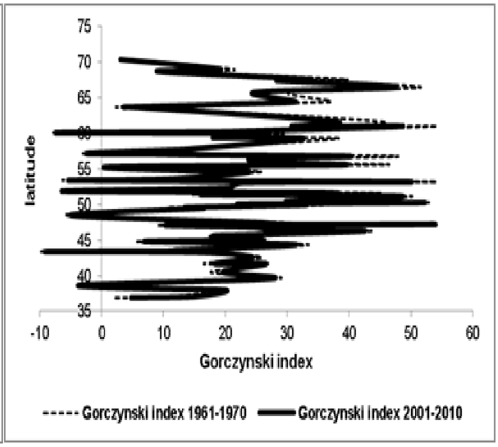

Fig. 6. ***Latitude variations in the Gorczynski Continentality Index in Europe (between 1961 - 1970 and 2001 - 2010)***

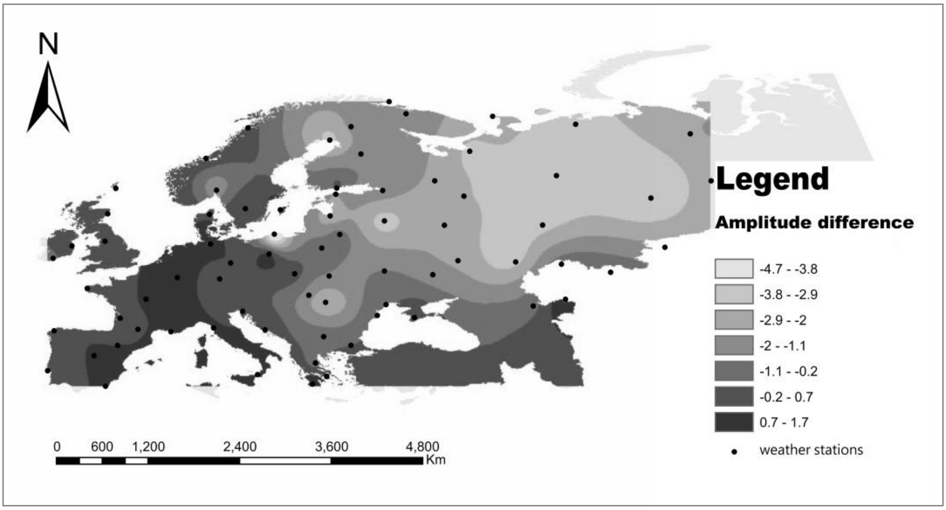

Fig. 7. ***Gorczynski Continentality Index evolution in Europe between 1961 - 1970 and 2001 – 2010***

From the cartographic representation of the continentality index, the same significant decrease in thermal continentalism in the Eastern half of Europe is noticed (the minimum values being recorded in the Baltic Sea region: - 9.8% on the Southern shore; significant decreases were also calculated on the territory of Romania: between - 2 and - 6.5%), its “advancement” towards Western regions, and higher values in comparison to the first decade of the analyzed period (with the highest values being recorded in Southern Europe: 3.3 - 3.8 %).

Table 3. ***Annual average temperature amplitude and Gorczynski continentality index***

period	annual average amplitude (°C)	Gorczynski index (%)
1960-2010	**21,8**	**21,0**
1960-1970	22,6	22,7
2000-2010	21,9	21,3

On a continental scale, both thermal amplitude and the Gorczynski Continentality Index have decreased in value in the last decade of the analyzed period, in comparison to the first decade (Table 3). Specifically, thermal amplitude has decreased with 0.7°C (reaching a value very close to the average of the entire analyzed period), while the Gorczynski index decreased by 1.4% (again, close to its average value throughout the last 50 years). As a result, on a continental scale, within 1961 - 2010, we can observe a decrease in thermal continentalism.

3. CONCLUSIONS

The Spatial and Temporal Analysis of multiannual average temperatures on the European continent, for the period 1961 - 2010, revealed the following conclusions: a strong correlation between thermal averages and latitude (in longitude, the correlation is "disrupted", especially by Western air circulation); deviations from the average and especially thermal amplitude are strongly influenced by longitude (with the exception of "continentalism nuclei", generated by the Spanish Meseta mountain chain, Eastern Scandinavia or the Hungarian Puszta); the difference between the average of the first and of the last decade of the analyzed period of the average thermal amplitude and, afterwards, of the Gorczynski Continentality Index (difference statistically validated with the Kolmogorov - Smirnov test) emphasizes their significant decrease in the Eastern half of the European mainland (where, thus, thermal continentalism diminishes) and an increase in the West (although less significant). This final conclusion will have to be further substantiated, through a comparative analysis of cyclonic passages, for to the two sample intervals analyzed (1961 - 1970 and 2001 - 2010). Simultaneously, there a "movement" of thermal continentalism towards Western Europe can be seen.

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