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# TEMPORAL CHANGES IN PLUVIAL CONTINENTALITY OVER OLTENIA PLAIN

# MODIFICĂRI ALE CONTINENTALISMULUI PLUVIOMETRIC ÎN CÂMPIA OLTENIEI

Alina Ștefania VLĂDUȚ [1]

**Abstract**: There are analysed the variability and trends of pluvial continentality over the Oltenia Plain for the period 1961 to 2018. The datasets cover monthly precipitation amounts from seven meteorological stations, based on which there were calculated five specific continentality indices: Vemičs index of precipitation and seasonal precipitation quotients (RShy/RWhy, RWin/RSum, RWin/RSpr, RAut/RSpr). In terms of spatial distribution, continentality generally increases eastwards. The variability of the pluvial continentality was analysed by the mean of ten-year intervals, while linear regression and the non-parametric Mann-Kendall test were used to emphasize any trend present in the datasets. Linear regression did not highlight a significant upward or downward trend, while Mann-Kendall test illustrated a monotonic upward trend all over the analysed region for RAut/RSpr mainly induced by the increase of the precipitation amount during autumn. The results are statistically significant for the eastern and western extremities of the plain.

**Key-words**: *pluvial continentality, seasonal precipitation quotients, Vemičs index of precipitation, Oltenia Plain*
**Cuvinte cheie**: *continentalism pluviometric, indici sezonieri de continentalism pluviometric, indicele de precipitații Vemičs, Câmpia Olteniei*

## I. INTRODUCTION

Atmospheric precipitation is one of the key factors influencing the development of natural ecosystems, as well as numerous socio-economic activities including agriculture, forestry, energy production, water supply, etc. According to IPCC (2014), precipitation amount calculated as a global average increased during the period 1901–2008, the upward trend being also statistically significant for Northern Europe. However, if taking into consideration the period after 1950, the trends are not statistically significant.

At seasonal level, EEA (2012, 2016) highlights an increase in winter precipitation in Northern Europe and a decrease in Southern Europe. Romania, which is included in the continental region (except for the Carpathian Mountains that belong to a distinct category) experienced an increase in heat extremes and a decrease in summer precipitation. The projections also indicate an increasing risk

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of river floods in spring, on the background of higher winter precipitation, and of forest fires, due to increasing temperature in summer.

Continentality, as a climatic effect induced by the increasing distance to oceans, is mainly associated with temperature range. However, there are three main categories of continentality indices applied worldwide – thermal continentality indices, pluviothermal continentality indices and pluvial continentality indices. Most of the studies achieved so far focused on thermal continentality (Apostol&Sîrghea, 2015; Szabó-Takács et al., 2015; Vilček et al., 2016; Szymanowski et al., 2017; Vlăduț et al., 2018) or on pluviothermal continentality (Brázdil et al., 2009; Deniz et al., 2011; Ciaranek, 2014; Nistor, 2016; Andrade&Corte-Real, 2017). The studies taking into account pluvial continentality were mostly achieved for Poland (Szreffel, 1961; Starkel Obrębska, 1984; Szymanowski, 2018), but there are certain climatologists who considered pluvial continentality for larger areas (Mikolaskova, 2009) as well.

The purpose of the present study is to emphasize the type of pluviometric regime and possible territorial differences and the temporal changes of a series of indices meant to characterize the pluvial continentality within Oltenia Plain.

## II. DATA AND METHODS

For the present study, there were used monthly precipitation values for the seven meteorological stations located within Oltenia Plain or in its immediate proximity (Fig. 1, Table no. 1). At five of the stations, the data cover the interval 1961-2018, at Băilești the interval is 1964 -2018 and at Slatina, 1977-2018, as the last two stations started their activity later. The data were partly provided by the National Meteorological Administration (1961-2010), while those for the interval 2011-2018 were taken from the annual reports elaborated by the Environment Protection Agencies and the Inspectorates for Emergency Situations (for each county of the region).

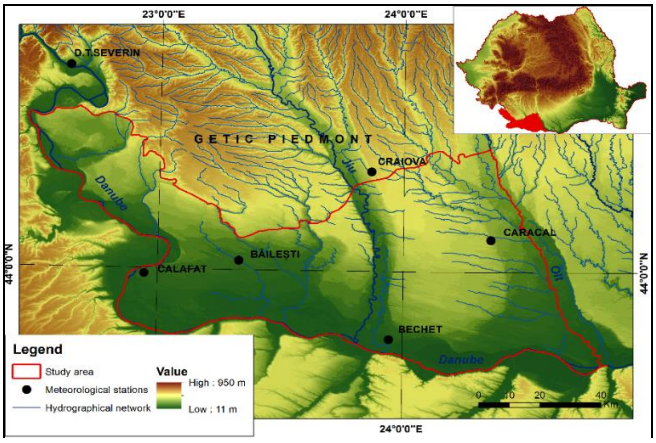



**Fig. 1. Study area and considered meteorological stations**
(Source: Vlăduţ&Onţel, 2013)

**Table no. 1. Location of the meteorological stations within Oltenia Plain**

| No. | Meteorological station | Altitude (m) | Latitude | Longitude |
|---|---|---|---|---|
| 1. | Dr. Turnu-Severin | 77 | 44°38` | 22°38` |
| 2. | Calafat | 61 | 43°59` | 22°57` |
| 3. | Băileşti | 57 | 44°01` | 23°20` |
| 4. | Craiova | 192 | 44°19` | 23°52` |
| 5. | Bechet | 36 | 43°47` | 23°57` |
| 6. | Caracal | 106 | 44°06` | 24°22` |
| 7. | Slatina | 172 | 44°43` | 24°37` |

In continental areas, the precipitation amounts are not uniformly distributed during the seasons. Thus, winter precipitation sum ($R_{Win}$) is usually smaller than summer amount ($R_{Sum}$), as well as winter and autumn ($R_{Aut}$) sums compared to spring ($R_{Spr}$). At the same time, the amount characteristic to the summer half year ($R_{Shy}$), which is the interval from the 1st of April to the 30th of September, is higher compared to the winter half year ($R_{Why}$), which is the interval from the 1st of October to the 31st of March. The precipitation occurrence depends on air circulation determined by pressure distribution during the year. The lower amounts registered in the area during winter are the result of high pressure systems, which are persistent above the mainland, while in summer, pressure reduces allowing maritime air masses penetrate inland and thermal convection intensifies and thus, the amounts increase.

*2.2.1 Pluvial continentality indices*. In order to assess pluvial continentality, there were selected five indices, which were calculated for each year of the period:

- Vemičs index of precipitation or coefficient of continentality, which represents the share of March to September sums in annual total precipitation and is calculated according to the following formula:

$$K = \frac{R_{III-IX}}{R_Y} 100 \quad (1),$$

where $R_{III-IX}$ is the total amount for the aforementioned interval and $R_Y$ is the annual precipitation amount;

- the quotient of the summer half year and winter half precipitation totals as $R_{Shy}/R_{Why}$ (2);
- the quotient of the winter and summer precipitation totals as $R_{Win}/R_{Sum}$ (3);
- the quotient of the winter and spring precipitation totals as $R_{Win}/R_{Spr}$ (4);
- the quotient of the autumn and spring precipitation totals as $R_{Aut}/R_{Spr}$ (5).

In case of the first index, the greater the value of the index, the stronger the continental signal (Szymanowski et al., 2018 apud. Szreffel, 1961). Continentality rendered by $R_{Shy}/R_{Why}$ is highlighted by values higher than 1, as this means $R_{Shy}$ amounts contribute more to the annual amount and vice-versa (Mikolaskova, 2009). For the following three indices, the lower the index value, the stronger the continental signal.

*2.2.2 Trend analysis*. In order to test the trends of the pluvial continentality it was used the Mann-Kendall test (Mann, 1945; Kendall, 1975). The data for all the

five analysed indices and annual and seasonal precipitation amounts (7 meteorological stations) were processed in the MAKESENS Excel template, developed by the researchers of the Finnish Meteorological Institute (Salmi et al., 2002). The statistical significance of the trends is evaluated using the *Z* value - positive Z values indicate an increasing/upward trend, while negative Z values indicate a decreasing/downward trend. The significance levels (α) are 0.001, 0.01, 0.05, and 0.1.

## III. RESULTS AND DISCUSSIONS

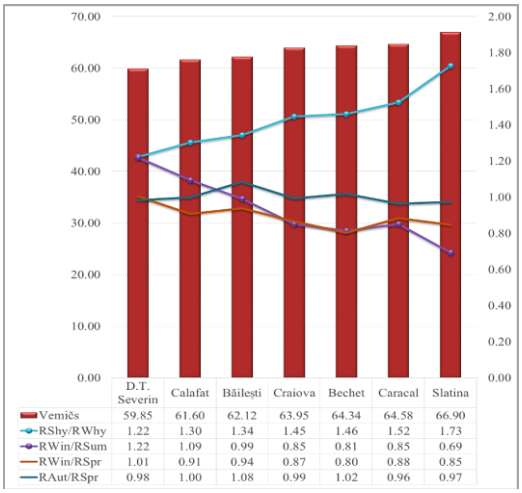
### 3.1 The territorial distribution of the pluvial continentality within Oltenia Plain

The annual precipitation amounts vary between a minimum of 530 mm at Bechet and a maximum of 682.9 mm at D. T. Severin, decreasing both eastwards and southwards. The continentality of the pluviometric regime does not result from the total amounts registered within an area, but mainly from the distribution pattern during the year at monthly, seasonal and half-year levels. In a purely continental climate a great share of the annual amounts is registered in the warmer part of the year, while in oceanic climates, the precipitation amounts are uniformly distributed during the year. Within Oltenia Plain the transitional character of the climate is highlighted by this distribution.

Thus, the mean precipitation amounts registered during *Shy* exceed 60% of the annual amount only at Slatina, which is the easternmost station. However, the time series is shorter in this case and the final results could be altered. The most uniform distribution on semesters is registered in the western extremity of the plain (D.T. Severin and Calafat), where the shares are quite close to 50%. With regard to the seasonal distribution, the two aforementioned stations also display uniform values, $R_{Spr}$ being higher compared to $R_{Sum}$ (about 27% compared to 25-26%). The situation changes eastwards, $R_{Sum}$ having a gradually greater share compared to $R_{Win}$: Băilești – 27.6%/21.7%, Caracal – 31.2%/20.6% and Slatina – 34.1%/18.8%, which highlights the increase of pluvial continentality to a higher extent in this direction compared to the north-south direction: Craiova – 30.1%/20.9% and Bechet – 29.3%/19.7%. The difference in case of $R_{Aut}$ and $R_{Spr}$ is about 2% between the eastern and western parts of the plain, the percentages being higher in spring (about 25-27%/22-24%).

At monthly level, the percentage difference increases but, except for the extreme months, the distribution is quite uniform. Ideally, each month should have 8.3% of the annual amount of precipitation and this pattern is characteristic to autumn months and April within the entire plain and August in the central part, while in the west, this month registers a deficit. The greater degree of continentality of the pluviometric regime in the eastern sector is emphasized by the shares of the summer months registered at Slatina: May – 10.3%, June – 12.6%, July – 12% and August 9.6%. In the western sector the differences between months are more reduced compared to the eastern sector.

This distribution pattern is generally highlighted by the indices of pluvial continentality. The mean values of Vemičs index of precipitation (K) and the quotient of the summer half year and winter half precipitation totals ($R_{Shy}/R_{Why}$) increase eastwards indicating an increase of continentality on the same direction (Fig. 2 – stations are arranged on a west-east direction). In case of $R_{Win}/R_{Sum}$ the distribution pattern of continentality is quite similar, but in the south-east, at Bechet, the value is smaller compared to Caracal and Craiova. At the same time, in the west, at D.T. Severin and Calafat, the averages exceeds 1 that means winter has quite a similar contribution with the other seasons to the total amount, which indicates the importance of cyclone activity over the Mediterranean Sea for this part of the country. The other two quotients ($R_{Win}/R_{Spr}$ and $R_{Aut}/R_{Spr}$) display a more diverse distribution but the difference between the minimum and maximum values is reduced compared to the previous indices (0.85-1.01 for $R_{Win}/R_{Spr}$ and 0.96-1.08 for $R_{Aut}/R_{Spr}$, respectively 0.60-1.22 for $R_{Win}/R_{Sum}$ and 1.22-1.73 for $R_{Shy}/R_{Why}$), which suggest a more uniform territorial distribution in spring and autumn.




| | D.T. Severin | Calafat | Băileşti | Craiova | Bechet | Caracal | Slatina |
|---|---|---|---|---|---|---|---|
| Vemičs | 59.85 | 61.60 | 62.12 | 63.95 | 64.34 | 64.58 | 66.90 |
| RShy/RWhy | 1.22 | 1.30 | 1.34 | 1.45 | 1.46 | 1.52 | 1.73 |
| RWin/RSum | 1.22 | 1.09 | 0.99 | 0.85 | 0.81 | 0.85 | 0.69 |
| RWin/RSpr | 1.01 | 0.91 | 0.94 | 0.87 | 0.80 | 0.88 | 0.85 |
| RAut/RSpr | 0.98 | 1.00 | 1.08 | 0.99 | 1.02 | 0.96 | 0.97 |

**Fig. 2. Mean values of the indices of pluvial continentality at the considered meteorological stations**

If comparing the values for Oltenia Plain with those obtained in Poland we conclude that continentality is less severe southwards, in spite of a more eastern location. Thus, in case of south-western Poland $R_{Win}/R_{Sum}$ is between 0.48 and 0.65, $R_{Win}/R_{Spr}$ is between 0.78 and 0.96 and $R_{Aut}/R_{Spr}$ is between 1.02 and 1.10 (Szymanowski et al., 2018), the last index being quite similar to the values from Oltenia Plain. $R_{Shy}/R_{Why}$ also displays a higher degree of continentality in Poland: 2.42 (Klodzko) and 1.99 (Wroclaw-Strachowice) (Mikolaskova, 2009). Vemičs index of precipitation also indicate a higher continentality in Poland (between 65 and 69) (Szymanowski et al., 2018).

### 3.2 The temporal changes of the pluvial continentality within Oltenia Plain

If analysing the 58 years included in the studied series it does not result a clear and uniform pattern of evolution towards a more continental climate.

*3.2.1 Vemičs index of precipitation.* For the central and western part of the plain, the year displaying the most continental character was 2001, K > 80% at all the stations. In the eastern part (Bechet and Caracal), 1992 was such a year, while at Slatina, 2018 registered a record of 91.02%, which means most of the precipitation amount fall from March until September, during the vegetation period. The increase of continentality eastwards is also emphasized when analysing the top 20 values: 4 at Bechet, 5 at Caracal and 6 at Slatina (which also has a shorter data series), 11 of these values being registered after 1990. The other stations have only one year with K > 80% except for Craiova with two such cases. If analysing the decade mean values, it results that a greater continentality characterizes the decades 1971-1980 and especially 1991-2000 (Table 2), the values decreasing a little during the next decade. The continental features are thus preserved or enhanced in the north-eastern-eastern sector of the plain, as well as in its western extremity, as D.T. Severin is the only station where K values for the last eight-year period increased compared to the previous decade.

**Table no. 2. Vemičs index of precipitation – 10-year averages**

| Station | 1961-1970 | 1971-1980 | 1981-1990 | 1991-2000 | 2001-2010 | 2011-2018 | Average |
|---|---|---|---|---|---|---|---|
| **D.T. Severin** | 57.51 | 60.99 | 58.48 | 62.29 | 59.00 | 61.06 | **59.85** |
| **Calafat** | 56.79 | 65.88 | 60.53 | 64.90 | 61.57 | 59.53 | **61.60** |
| **Băileşti** | 59.11 | 64.41 | 59.57 | 64.74 | 62.27 | 60.53 | **62.12** |
| **Craiova** | 61.29 | 66.17 | 63.56 | 66.14 | 62.98 | 61.53 | **63.95** |
| **Bechet** | 63.15 | 64.30 | 61.55 | 64.78 | 66.81 | 62.53 | **64.34** |
| **Caracal** | 63.27 | 66.38 | 62.68 | 69.87 | 63.40 | 63.53 | **64.58** |
| **Slatina** | - | - | 62.33 | 71.48 | 66.51 | 64.53 | **66.90** |

*3.2.2 The quotient of the summer half year and winter half precipitation totals* emphasizes 1975, 1991, 1992, 2000, 2001 and 2005 as the years with the highest degree of pluvial continentality ($R_{Shy}/R_{Why}$>2.5). Even if 2005 is the year with the second greatest annual precipitation amount in the region (after 2014), it also has a high degree of continentality as most of the precipitation amount fell in the interval May-September. Generally, there is the same evolution pattern compared to the previous index, namely the most continental decades are 1971-1980 and 1991-2000, the last one with the highest values within the entire plain area (Table no. 3).

**Table no. 3. $R_{Shy}/R_{Why}$ – 10-year averages**

| Station | 1961-1970 | 1971-1980 | 1981-1990 | 1991-2000 | 2001-2010 | 2011-2018 | Average |
|---|---|---|---|---|---|---|---|
| **D.T. Severin** | 1.07 | 1.22 | 1.10 | 1.54 | 1.13 | 1.16 | **1.22** |
| **Calafat** | 1.06 | 1.41 | 1.31 | 1.66 | 1.24 | 1.07 | **1.33** |
| **Băileşti** | 1.28 | 1.39 | 1.18 | 1.66 | 1.40 | 1.05 | **1.34** |
| **Craiova** | 1.25 | 1.56 | 1.45 | 1.17 | 1.40 | 1.15 | **1.45** |
| **Bechet** | 1.49 | 1.44 | 1.34 | 1.49 | 1.61 | 1.32 | **1.46** |
| **Caracal** | 1.39 | 1.63 | 1.57 | 1.83 | 1.39 | 1.12 | **1.52** |
| **Slatina** | - | - | 1.26 | 2.03 | 1.75 | 1.98 | **1.73** |

This decade was also the driest in the last 60 years within Oltenia (Vlăduţ, 2004; Vlăduţ, 2007), precipitation amounts being registered especially during the warm season. After 2005, none of the stations had $R_{Shy}/R_{Why}>2.5$. In fact, continentality reduced, as there were only 3 situations with $R_{Shy}/R_{Why}>2.0$, all in the eastern sector of the plain. This means that the distribution of the precipitation amount on semesters got more balanced within most of the plain. However, the two aforementioned sectors (north-eastern and western) are marked by the increase of continentality in the last interval.

*3.2.3 The quotient of the winter and summer precipitation totals* is one of the indices that better highlights pluvial continentality. Values close to 1 indicate a similar distribution of precipitation during the two extreme seasons of the year, which is not characteristic to continental areas where summer registers a much greater amount compared to winter. During the analysed period, there were certain years with values much higher than 1 within the entire plain, such as 1965, 1984, 1987, 1990, 2003 and 2012 (Fig. 3). The highest $R_{Win}/R_{Sum}$ reached 7.38 at Calafat in 1965, when the summer was exceptionally dry, the total amount being of only 24.4 mm, while the winter exceeded with about 80 mm the multiannual average.

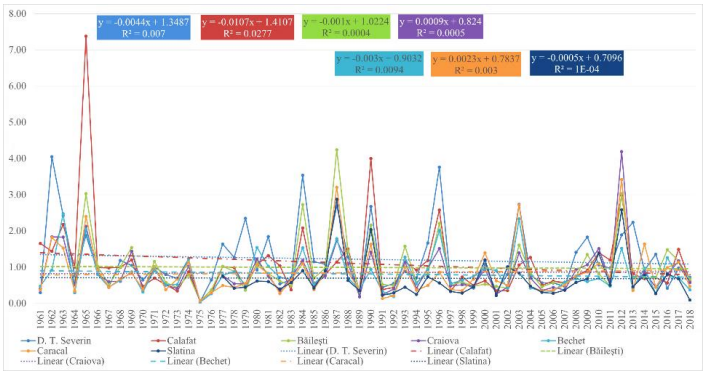



**Fig. 3. $R_{Win}/R_{Sum}$ variability and linear trends within Oltenia Plain**

The highest values are registered in the western sector of the plain, at D. T. Severin and Calafat, where we also have the greatest number of years when $R_{Win}/R_{Sum}$ exceeds 1 – 27, namely 22 out of a total of 58 years. However, there cannot be considered a drastic reduction of continentality as about 65% of these years were registered before 1990. Eastwards, this number decreased (Băileşti – 18, Craiova – 17, Bechet – 12, Slatina – 6, on a shorter period), but, concomitantly half or more than half of these years are were registered after 1990, which stands for a slight decrease in continentality as well. Even if the linear trends calculated for all the stations are positive, they are close to 0, which means they do not express a clear increase or decrease tendency.

In terms of 10-year averages, continentality was more severe between 1971 and 1980 (Table no. 4), except for the eastern sector of the plain, where 1991-2000 registered the smallest values of the $R_{Win}/R_{Sum}$ index. 2001-2010 also displays reduced values, below the average of the entire period, which means winters were drier. Even if in the last 8 years the average values are higher than 1 suggesting a decrease of continentality, the trend is not significant as these averages are the result of one or two years with extremely high values (such as 2012, when $R_{Win}/R_{Sum}$ index varied between a minimum of 1.89 at D.T. Severin and a maximum of 4.19 at Craiova), the other years being subunitary.

**Table no. 4. $R_{Win}/R_{Sum}$ – 10-year averages**

| Station | 1961-1970 | 1971-1980 | 1981-1990 | 1991-2000 | 2001-2010 | 2011-2018 | Average |
|---|---|---|---|---|---|---|---|
| **D.T. Severin** | 1.37 | 1.06 | 1.57 | 1.07 | 1.06 | 1.19 | **1.22** |
| **Calafat** | 1.83 | 0.63 | 1.32 | 0.89 | 0.78 | 1.13 | **1.06** |
| **Băileşti** | 1.16 | 0.68 | 1.45 | 0.83 | 0.78 | 1.12 | **0.99** |
| **Craiova** | 1.06 | 0.63 | 0.87 | 0.71 | 0.75 | 1.13 | **0.85** |
| **Bechet** | 0.93 | 0.72 | 0.92 | 0.82 | 0.73 | 0.75 | **0.81** |
| **Caracal** | 0.97 | 0.61 | 1.02 | 0.59 | 0.83 | 1.15 | **0.85** |
| **Slatina** | - | - | 0.97 | 0.48 | 0.61 | 0.77 | **0.69** |

*3.2.4 The quotient of the winter and spring precipitation totals* reveals a more homogeneous situation compared to the previous indices. There are certain years with values above 1 within the entire plain (1965, 1968, 1969, 1977, 1984, 1987, 1996, 2009), which generally results from higher precipitation amounts during winter not from extremely dry springs (Fig. 4).

The highest values were registered in 2009 in the western half of the plain (between 3.62 at D. T. Severin and 2.52 at Craiova) and in 1986 in the eastern part (between 3.67 at Slatina and 2.39 at Bechet). The more uniform distribution of precipitation is emphasized also by the total number of years with values above 1, which is lower compared to $R_{Win}/R_{Sum}$ – 21 years in the west and 8 years in the east. In most of the case there were equally distributed on the two intervals 1961-1990 and 1990-2018, except for the central and northern parts, where the share is

greater during the first interval (Băileşti and Craiova). None of the linear trends, either positive or negative, are statistically significant.

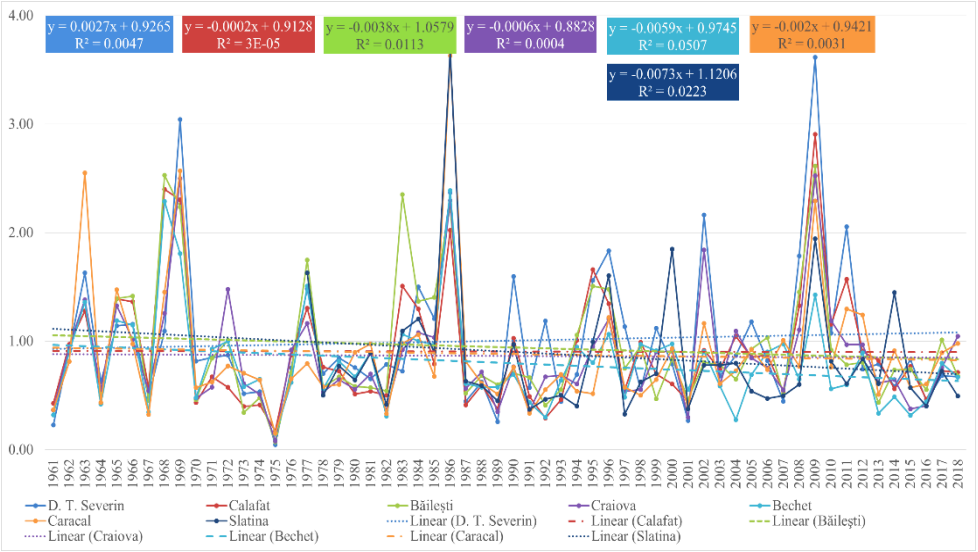



**Fig. 4. $R_{Win}/R_{Spr}$ variability and linear trends within Oltenia Plain**

The most continental decade was 1971-1980, as winter amounts were lower than usual. At Slatina, it is 2001-2010 as there are no data for the aforementioned decade, while at Bechet, it is a particular situation – three of the 10-year periods have the same average, 0.75 (Table no. 5). The average of the last 8 years is also much lower than the average of the period, but in this case, it is not about lower amounts in winter, but increased spring amounts.

**Table no. 5. $R_{Win}/R_{Spr}$ – 10-year averages**

| Station | 1961-1970 | 1971-1980 | 1981-1990 | 1991-2000 | 2001-2010 | 2011-2018 | Average |
|---|---|---|---|---|---|---|---|
| **D.T. Severin** | 1.11 | 0.74 | 1.02 | 0.99 | 1.29 | 0.85 | **1.01** |
| **Calafat** | 1.17 | 0.64 | 0.91 | 0.81 | 1.08 | 0.82 | **0.91** |
| **Băileşti** | 1.29 | 0.70 | 1.10 | 0.87 | 1.02 | 0.72 | **0.94** |
| **Craiova** | 1.04 | 0.71 | 0.88 | 0.74 | 1.08 | 0.72 | **0.87** |
| **Bechet** | 1.03 | 0.75 | 0.91 | 0.75 | 0.75 | 0.57 | **0.80** |
| **Caracal** | 1.15 | 0.64 | 1.04 | 0.65 | 0.94 | 0.88 | **0.88** |
| **Slatina** | | | 1.08 | 0.79 | 0.76 | 0.71 | **0.85** |

*3.2.5 The quotient of the autumn and spring precipitation totals* displays the most homogenous average values (just 0.12 difference between stations). There is also registered a great share of years with values above 1 at all the considered meteorological stations, 14, 7 of which after 2000. This suggests the increase of

autumn amounts in the last two decades not the reduction of precipitation during spring. 1972 is the year with the highest values of $R_{Aut}/R_{Spr}$ index (between a minimum of 3.38 at Băileşti and a maximum of 4.88 at Craiova) within most of the plain. In the western and eastern extremities the maximum values are lower and were registered in different years (D. T. Severin 3.04 in 2009, Calafat 2.96 in 1968 and Slatina 2.67 in 2000) (Fig. 5). The linear trends are upward indicating a slight decrease of pluvial continentality based on the increase of the precipitation amounts during autumn.

In terms of decade averages, this is the only analysed index which unanimously displays the greatest continentality in the period 1981-1990, when autumn precipitation amounts were lower than the average (Table no. 6). The next decade registered a homogenous distribution of precipitations during the two seasons, while the decade 2001-2010 marks the increase of autumn precipitation, which leads to the lowest pluvial continentality during the analysed period if taking into consideration this index.

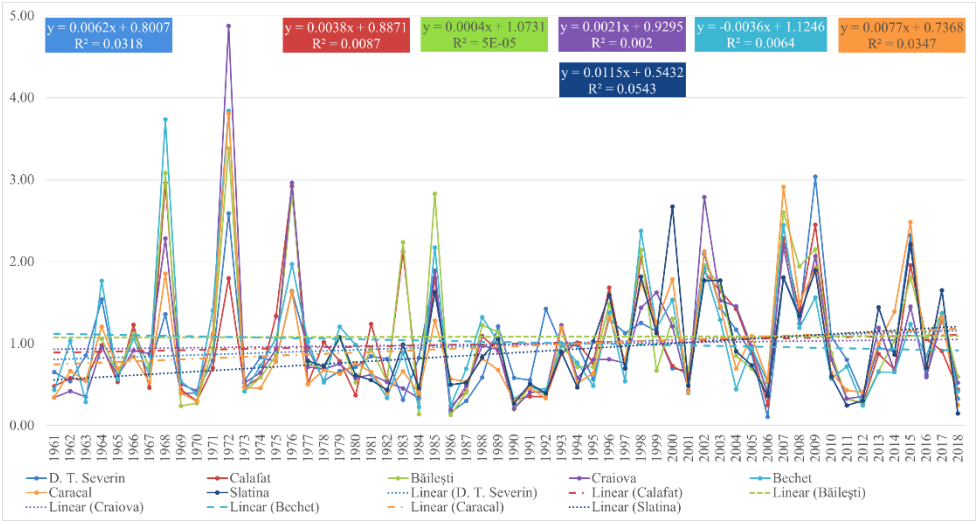



**Fig. 5. $R_{Aut}/R_{Spr}$ variability and linear trends within Oltenia Plain**

**Table no. 6. $R_{Aut}/R_{Spr}$ – 10-year averages**

| Station | 1961-1970 | 1971-1980 | 1981-1990 | 1991-2000 | 2001-2010 | 2011-2018 | Average |
|---|---|---|---|---|---|---|---|
| **D.T. Severin** | 1.01 | 0.90 | 0.86 | 1.38 | 0.91 | 0.83 | **0.98** |
| **Calafat** | 0.87 | 1.10 | 0.82 | 0.99 | 1.34 | 0.88 | **1.02** |
| **Băileşti** | 1.01 | 1.21 | 0.93 | 0.98 | 1.35 | 0.97 | **1.08** |
| **Craiova** | 0.84 | 1.33 | 0.64 | 0.93 | 1.38 | 0.87 | **0.99** |
| **Bechet** | 1.14 | 1.24 | 0.77 | 1.01 | 1.16 | 0.77 | **1.02** |
| **Caracal** | 0.82 | 1.04 | 0.61 | 1.00 | 1.33 | 1.08 | **0.96** |
| **Slatina** | - | - | 0.72 | 1.12 | 1.17 | 0.95 | **0.97** |

### 3.3 The trends of the pluvial continentality within Oltenia Plain

The statistical significance of the trends was tested with Mann-Kendall test. Even if it resulted that most of the trends are not significant from the statistical point of view, we emphasized certain characteristics of the pluvial continentality in the region (Table no. 7). Thus, in the western extremity (D. T. Severin), the trends of Vemičs index and $R_{Shy}/R_{Why}$ are positive, which means higher values of the indices, namely an increase of the pluvial continentality. In the eastern part of the plain (Slatina and partly Caracal) the trends are negative for the first two indices indicating a decrease of continentality during certain periods of the year. With regard to the annual and seasonal precipitation amounts we mention the downward trend at all level for the western and eastern extremities (except autumn) and the upward trends for the northern and north-eastern parts. At Craiova and Slatina, the annual and autumn precipitation amounts registered a statistically significant increase (0.05 in both cases at Craiova, respectively 0.1 and 0.05 at Slatina), while Caracal is the only station with a significant decrease trend during spring (0.1 significance). Autumn is the only season with upward precipitation trends all over the plain. Consequently, $R_{Aut}/R_{Spr}$ also displays an increase trend (0.1 statistical significance at D. T. Severin and Caracal), which stands for a decrease of the pluvial continentality during autumn.

**Table no. 7. The trends registered by the continentality indices and precipitation amounts within Oltenia Plain (1961-2018)**

| Station | D. T. Severin | | Calafat | | Băileşti | | Craiova | | Bechet | | Caracal | | Slatina | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Index** | **z** | **s** | **z** | **s** | **z** | **s** | **z** | **s** | **z** | **s** | **z** | **s** | **z** | **s** |
| **Vemičs** | 0.91 | | 0.00 | | 0.13 | | -0.05 | | 1.02 | | -0.36 | | -0.04 | |
| **$R_{Shy}/R_{Why}$** | 0.76 | | -0.07 | | -0.01 | | -0.67 | | 0.27 | | -1.01 | | -0.15 | |
| **$R_{Win}/R_{Sum}$** | -0.23 | | -0.66 | | 0.17 | | -0.25 | | -0.46 | | 0.43 | | -0.22 | |
| **$R_{Win}/R_{Spr}$** | 0.03 | | 0.51 | | 0.25 | | 0.24 | | -1.45 | | 0.64 | | -0.69 | |
| **$R_{Aut}/R_{Spr}$** | 1.67 | + | 0.90 | | 0.62 | | 1.29 | | 0.25 | | 1.68 | + | 1.01 | |
| **Y** | -0.50 | | 1.40 | | -0.15 | | 2.32 | * | 0.60 | | -1.25 | | 1.86 | + |
| **W** | -0.44 | | 0.64 | | 0.22 | | 0.93 | | -0.56 | | -0.56 | | 0.07 | |
| **Sp** | -1.19 | | -0.70 | | 0.07 | | 1.19 | | 1.02 | | -1.78 | + | 0.51 | |
| **Sm** | -0.27 | | 0.94 | | -0.12 | | 0.98 | | 0.19 | | -1.37 | | 0.43 | |
| **A** | 0.25 | | 1.40 | | 0.89 | | 2.03 | * | 1.01 | | 1.13 | | 2.17 | * |

*** if trend at α= 0.001 level of significance; ** if trend at α= 0.01 level of significance; * if trend at α= 0.05 level of significance, + if trend at α= 0.1 level of significance

## IV. CONCLUSIONS

Pluvial continentality acquired a great significance in the general context of climate change as precipitation trends and distribution on seasons widely varies compared to temperature, which generally increased at middle and high latitudes of the northern hemisphere. The analysis of the pluvial continentality in the last 58 years, within Oltenia Plain emphasized certain distribution patterns. Thus, three of the analysed indices, namely Vemičs index of precipitation, $R_{Shy}/R_{Why}$ and

$R_{Win}/R_{Sum}$ indicate an obvious increase of continentality eastwards. The other two indices, $R_{Win}/R_{Spr}$ and $R_{Aut}/R_{Spr}$ present much more homogenous mean values within the plain and consequently, not an evident spatial distribution pattern of the pluvial continentality. This is mainly the results of the general increase of the precipitation amounts registered in autumn and partially in winter altogether with the decrease of the amounts during spring. However, if strictly comparing the two westernmost and easternmost stations, continentality is greater in the east.

With regard to the trends, the analysis does not clearly confirm the increase of pluvial continentality. The Mann-Kendall test highlighted positive slopes for Vemičs index of precipitation along the Danube, meaning an increase of continentality, but they are not statistically significant. The eastern and northern parts of the plain have negative slopes – decrease of continentality, but also insignificant. The same evolution pattern is displayed by $R_{Shy}/R_{Why}$. $R_{Win}/R_{Sum}$ and $R_{Win}/R_{Spr}$ which revealed mostly negative slopes, while $R_{Aut}/R_{Spr}$ is the only index with positive slopes all over the plain (at Craiova and Slatina also statistically significant) indicating a decrease of pluvial continentality during autumn as a consequence of precipitation increase during this season and a slight decrease during spring. Consequently, we can assume that there occurs a series of changes in terms of precipitation distribution on seasons, which also modifies the continentality patterns.

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