# THE INFLUENCE OF CHANGES IN TELECONNECTION PATTERN TRENDS ON TEMPERATURE AND PRECIPITATION TRENDS IN NORTHEASTERN ROMANIA

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**ABSTRACT. – The influence of changes in teleconnection pattern trends on temperature and precipitation trends in northeastern Romania.** Influence of changes in teleconnection patterns on temperature and precipitation have been identified in many studies performed at local, regional, or global scales. The research on this issue was poorly approached in Romania. In this paper, the northeastern Romania area was considered. This work is focused on analyzing trends in the time series of air temperature and precipitation at ten stations located in northeastern Romania across 50 years (1961-2010). Using the conditional Mann-Kendall test, these trends are compared with trends in Northern Hemisphere teleconnection indices. The main goal was to estimate the influence of trends in five teleconnection indices on changes in temperature and precipitation in northeastern Romania. The main results suggest that the highest increase in air temperature is typical for summer, followed by an increase in winter time series. The trends in precipitation are both positive and negative in the area, but most of them are statistically insignificant. However a significant increase has been observed in October at the most locations, and a significant decrease in time series of a high altitude station (Ceahlău). Significant changes have occurred in Northern Hemisphere teleconnection indices during 1961-2010. The results of the conditional Mann-Kendall test indicate that the changes in the teleconnection patterns are significantly related to changes in temperature and precipitation in northeastern Romania.

**Key words**: teleconnection patterns, conditional Mann-Kendall test, trend, northeastern Romania.

## 1. Introduction

Climate change over the last century is a subject of great topical interest worldwide. The surface-air temperature and precipitation are of vital social and economic importance (Krokhin and Luxemburg, 2006). Rising air temperature and changes in precipitation are undeniable facts which may have different effects on

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different aspects of human life, especially on human settlements, agricultural products, energy consumption, etc. The Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC, 2007) concluded that global mean surface temperatures have risen by 0.74 ± 0.18°C as estimated by a linear trend over the recent 100 years (1906–2005). The warming rate over the last 50 years of this period is almost twice that of the 100 years period as a whole (IPCC, 2007). Lots of studies have been conducted about the trend of climate changes indicating that in Romania and in most regions of the globe there has been a significant warming process over the last century, particularly during the past few decades (Vinnikov and Grody, 2003; del Rio et al., 2005; Moberg et al., 2006; IPCC, 2007; Busuioc et al., 2010; Dragota and Kucsicsa, 2011; Croitoru et al., 2012a; Fan et al., 2012; del Rio et al., 2012), and significant changes in precipitation, like increasing or decreasing of seasonal precipitation, increasing trend of extreme precipitation events, etc. (Qian et al., 2007; Lupikasza, 2010; Jung et al., 2011). Across all time and space scales, precipitation is characterized by higher variability. In Northern Hemisphere there were found different seasonal trends in precipitation; negative trends during summer and autumn, and positive trends in winter and spring (Diaz et al., 1989; Tomozeiu et al., 2005). Moberg and Jones (2005) found significant increasing trends in summer and winter temperature data and significant increasing of winter precipitation over the Europe.

The temporal variability of temperature and precipitation all over Europe is known to be largely influenced by variability in the atmospheric circulation. The relationships are particularly strong in the winter season, where numerous studies have linked changes in the North Atlantic Oscillation (NAO) and other circulation patterns to changes in temperature and precipitation in Europe (Hurrell, 1995; Marshall et al., 2001; Hurrell et al., 2003).

Attempts have been made to explain climate change in Romania with changes in large-scale circulation patterns, for example, in the time series of North Atlantic Oscillation (NAO), East-Atlantic Jet (EAJ) and Scandinavia pattern (SC) (Tomozeiu et al., 2002), in the time series of NAO and Atlantic-European blocking index (Tomozeiu et al., 2005), in the time series of East Atlantic Pattern (EA), NAO, East Atlantic/Western Russia (EW), SC, and Polar Oscillation (PO) teleconnection indices (Croitoru et al., 2012b).

The aim of this study is to identify trends in monthly, seasonal, and annual temperature and precipitation across 50 years (1961-2010) and to estimate the influence of the trends in teleconnection patterns on these variables in northeastern part of Romania.

The study area is located in the northeastern Romania and covers the administrative territory of four counties: Suceava, Botoşani, Neamț and Iaşi and has an area of 24911 km$^2$ (Figure 1). The altitude decreases from west to east from mountainous area of Eastern Carpathians to Eastern part of the Moldavian

Tableland. The climate of this region is temperate-continental with a more pronounced continental character in the east (Moldavian Plane) and moderate character in the west.

## 2. Data and methods

### 2.1. Data

Monthly data of temperature and precipitation recorded at ten weather stations in northeastern Romania covering a period of 50 years (1961-2010) were used for the present study. Ceahlău station began recordings in 1964 therefore its data series is only 47 years long.

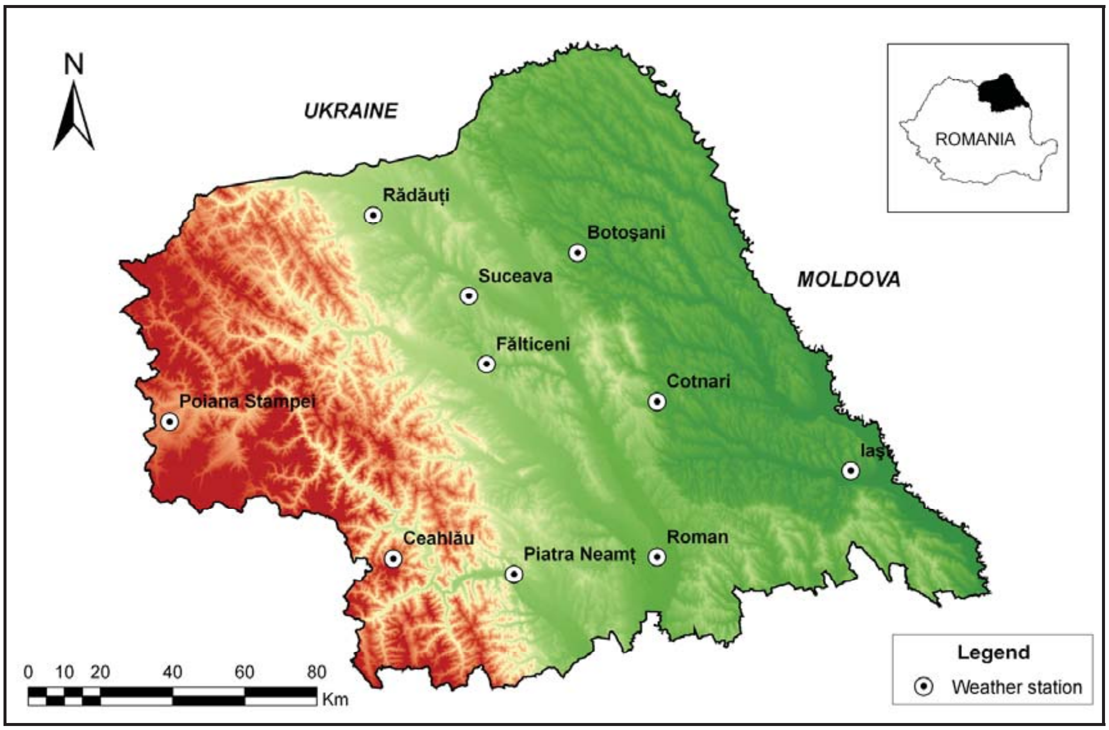


**Figure 1.** The analyzed area and the weather stations considered

Two of the weather stations are located in mountainous area, and eight are located in hilly area as shown in Figure 1 and Table 1. Data were provided by the National Meteorological Administration. The time series were selected according to the length and absence of gaps in the records, so as to provide a reasonable spatial coverage over northeastern Romania.

**Table 1.** Geographical coordinates of the weather stations considered

| Weather station[a] | Latitude (N) | Longitude (E) | Height (m) |
|---|---|---|---|
| Botoşani | 47°44’ | 26°39’ | 161 |
| Ceahlău | 46°59’ | 25°57’ | 1897 |
| Cotnari | 47°22’ | 26°56’ | 289 |
| Fălticeni | 47°28’ | 26°18’ | 348 |
| Iaşi | 47°10’ | 27°38’ | 102 |
| Piatra Neamț | 46°55’ | 26°24’ | 314 |
| Poiana Stampei | 47°20’ | 25°08’ | 923 |
| Rădăuți | 47°50’ | 25°54’ | 389 |
| Roman | 46°58’ | 26°55’ | 216 |
| Suceava | 47°38’ | 26°15’ | 350 |

[a]Weather stations are ranged in alphabetical order

In order to find connections between trends in mean air temperature and precipitation, and trends in the principal circulation patterns which influence the northeastern part of Romania, we used monthly indices of EA, NAO, EW, SC, and PO, provided by the National Oceanic and Atmospheric Administration Climate Prediction Center (http://www.cpc.ncep.noaa.gov/data/teledoc/telecontents.shtml). These were constructed from monthly mean standardized 500 mb heights anomalies using rotated principal component analysis (Barnston and Livezey, 1987; Croitoru et al., 2012b). This method extracts the main teleconnection pattern for all months, which results in time series of patterns. The seasonal values were calculated as the averages of the spring months (March, April, and May), summer months (June, July, and August), autumn months (September, October, and November), and winter months (December, January, and February) as defined by the World Meteorological Organization (WMO). The annual values were calculated as the averages of the 12 months of each year.

### 2.2. Methods

To detect and estimate trends in the time series of monthly, seasonal, and annual values of temperature, precipitation, and teleconnection indices, an Excel template MAKESENS (Mann-Kendall test for trend and Sen’s slope estimator), designed by researchers of the Finnish Meteorological Institute (Salmi et al., 2002), was used. The procedure is based on the non-parametric Mann-Kendall test for the trend (Mann, 1945; Kendall, 1975) and Sen’s non-parametric method for the magnitude of the trend (Gilbert, 1987). The Mann-Kendall test is applicable to the detection of a monotonic trend of a time series. Sen’s method uses a linear model to estimate the slope of the trend, and the variance of the residuals should be constant in time (Salmi et al., 2002).

These methods offer many advantages: missing values are allowed and data needed do not have to follow any particular distribution. In addition, single data errors of outliers do not significantly affect Sen's method. In this paper the trends are considered to be statistically significant on the $P<0.05$ level. These methods were previously largely used to detect trends in climatic data sets (Micu and Micu, 2006; Croitoru and Piticar, 2012; Croitoru et al., 2012c; del Rio et al., 2012; Fan et al., 2012)

The conditional (or partial) Mann-Kendall test is applied when a trend in one time series (dependent variable) is analyzed in relation with trends in one or several covariates (independent variables) (Libiseller and Grimvall, 2002; Jaagus, 2006). The purpose of the conditional Mann-Kendall test use is to check whether the trend in the time series of a dependent variable is statistically determined by the trend in the time series of the covariates.

In this paper, the conditional Mann-Kendall test is applied to climatic variables – air temperature and precipitation – in dependence on the teleconnection patterns for the Northern Hemisphere, which are used as covariates. A trend in time series of a dependent variable is considered to be determined by the trend in the time series of a covariate in the case when the significance of the conditional Mann-Kendall statistic is lower than $P<0.05$ level. In such case, the trend in the time series of the covariate describes the entire trend in the time series of the studied dependent variable (Jaagus, 2006).

A trend in the time series of a dependent variable (air temperature, precipitation, etc.) is assumed to be caused by the trend in a covariate also in the case when the conditional Mann-Kendall statistic is present on the lower significance level than the Mann-Kendall statistic for the time series of the dependent variable. Three significance levels are used: 0.05, 0.01, and 0.001. In that case the trend in the time series of covariate does not describe the entire trend in the time series of the dependent variable, but only a part of it. It means that also other factors may cause the trend.

The trends in climatic variables are analyzed in relation with those of the teleconnection patterns of the same time interval.

This method was employed with good results by other authors (Jaagus, 2006; Jaagus et al., 2008; Ramos et al., 2008; Jaagus and Kull, 2011).

## 3. Results and discussions

### 3.1. Temperature trend analysis

Annual mean air temperature has increased during the study period by 0.16…0.33°C/decade over the northeastern part of Romania (Table 2). According to the Mann-Kendall test, the trend is statistically significant at all stations on the $P<0.05$ level.

The warming has not been equal throughout the year. The highest increase in air temperature was typical for summer season (0.18…0.49°C/decade) indicating generalized positive slopes in the study area statistically significant at the level P<0.05 at all stations. A remarkable warming has been identified also in winter (0.01…0.66°C/decade), statistically significant at 7 weather stations.

**Table 2.** Trends in mean air temperature during 1961-2010 (°C/decade)

| Period | Botoşani | Ceahlău | Cotnari | Fălticeni | Iaşi | Piatra Neamț | Poiana Stampei | Rădăuți | Roman | Suceava |
|---|---|---|---|---|---|---|---|---|---|---|
| J | **0.932**[a] | 0.065 | **0.866** | **0.802** | 0.500 | **0.879** | **0.643** | **0.800** | **0.636** | **0.792** |
| F | 0.558 | -0.043 | **0.720** | **0.680** | 0.429 | 0.500 | 0.441 | 0.630 | 0.545 | 0.594 |
| M | 0.455 | -0.154 | **0.620** | **0.637** | 0.429 | **0.575** | **0.397** | **0.542** | **0.552** | 0.500 |
| A | 0.000 | 0.171 | 0.155 | 0.178 | 0.040 | -0.030 | 0.273 | 0.209 | 0.143 | 0.200 |
| M | 0.233 | 0.200 | 0.255 | 0.303 | 0.171 | 0.183 | **0.308** | 0.267 | 0.273 | 0.250 |
| J | 0.237 | **0.333** | **0.288** | **0.379** | 0.214 | 0.138 | **0.500** | **0.333** | **0.325** | **0.333** |
| J | **0.444** | **0.571** | **0.485** | **0.519** | **0.412** | **0.236** | **0.522** | **0.512** | **0.487** | **0.500** |
| A | 0.231 | **0.500** | **0.343** | **0.427** | **0.250** | 0.250 | **0.525** | **0.447** | **0.375** | **0.444** |
| S | -0.182 | 0.000 | -0.120 | -0.012 | -0.100 | -0.273 | 0.000 | -0.037 | -0.048 | -0.048 |
| O | 0.000 | 0.167 | 0.089 | 0.148 | 0.062 | -0.060 | 0.261 | 0.067 | 0.059 | 0.077 |
| N | -0.246 | 0.200 | -0.171 | -0.200 | -0.256 | -0.294 | -0.050 | -0.083 | -0.086 | -0.091 |
| D | 0.207 | 0.000 | 0.212 | 0.243 | 0.133 | 0.232 | 0.273 | 0.200 | 0.080 | 0.229 |
| Winter | 0.446 | 0.013 | **0.656** | **0.524** | 0.333 | **0.466** | **0.303** | **0.532** | **0.439** | **0.538** |
| Spring | 0.229 | 0.101 | **0.333** | **0.388** | 0.222 | 0.285 | **0.333** | **0.359** | **0.333** | **0.333** |
| Summer | **0.271** | **0.441** | **0.359** | **0.417** | **0.282** | **0.178** | **0.486** | **0.398** | **0.361** | **0.393** |
| Autumn | -0.085 | 0.091 | -0.044 | -0.022 | -0.071 | -0.179 | 0.067 | 0.000 | 0.000 | 0.030 |
| Annual | **0.230** | **0.157** | **0.273** | **0.297** | **0.250** | **0.199** | **0.328** | **0.286** | **0.232** | **0.270** |

[a]Values in bold are statistically significant on P<0.05

During the spring season the time series revealed a moderate warming with values of 0.10…0.39°C/decade. On the other hand, slight decreases were found for autumn season -0.02…-0.18°C/decade for 5 locations, but they were statistically insignificant.

On a monthly time-scale, it was observed that the most important increase of mean air temperatures was specific to summer months (June, July, August), especially to July where values are statistically significant for all stations. For January, February and March, the values also indicate an increasing trend statistically significant for the most of the time series. For May only one station (Poiana Stampei) have experienced a significant positive trend. No statistically significant trends were observed for the rest of the year. Few data series reveal negative trends, but they are all statistically insignificant.

A clear tendency towards a warmer climate in northeastern Romania during the study period may be stated, since positive trends (81%) prevailed over negative ones (15%) (Figure 2). Statistically significant positive trends occur for the 44% of the time series, while statistically significant negative trends are not present. Only 4% of the analyzed time series have no trend.

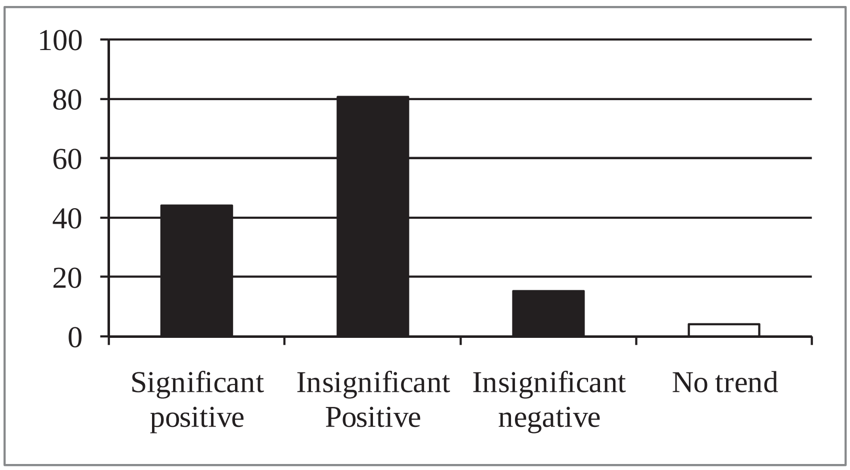


**Figure 2.** Total number of positive and negative trends and number of statistically significant positive and negative trends in mean air temperature (%)

These findings are similar to those presented in previous studies for this region (Piticar and Ristoiu, 2012), and for other regions of Romania and European Continent (del Rio et al., 2005; Micu and Micu, 2006; Hobai, 2009; Busuioc et al., 2010; Dragota & Kucsicsa, 2011; Sfică, 2011; Croitoru et al., 2012a).

### 3.2. Precipitation trend analysis

The results of the Mann-Kendall test applied on monthly, seasonal and annual precipitation data series are presented in Table 3. The trends in precipitation are both positive and negative for the study area, but most of them are statistically insignificant. The annual time series revealed an increasing trend in precipitation at 8 weather stations (5.40…18.21 mm/decade), but they were statistically insignificant. However the high altitude station (Ceahlău) recorded a pronounced significant decrease in precipitation (-27.23 mm/decade).

From seasonal point of view, the most important decrease in precipitation has taken place in winter and spring, but the decrease is statistically insignificant, except Ceahlău station. The decrease of precipitation in winter is in accordance with the results of other authors (del Rio, 2005; Lopez-Moreno, et al. 2010), showing a negative correlation in winter between the NAO and precipitation in some parts of Europe. In summer and autumn, the precipitation trend is positive for the majority of the considered stations, but statistically insignificant.

A high temporal and spatial variability of precipitation can be observed in trends of single months. There is not much evidence of clear temporal or regional patterns showing significant changes in precipitation except for a significant increase in October and a decrease in a high altitude station (Ceahlău), from November to February.

Micu (2009), Dragota and Kucsicsa (2011), also found significant decreasing trends in mountainous regions of Romania for almost the same period.

The high variability of precipitation trends can also be observed in Figure 3 where the percent of positive slopes was only slightly higher than negative slopes.

**Table 3.** Trends in precipitation during 1961-2010 (mm/decade)

| **Period** | **Botoşani** | **Ceahlău** | **Cotnari** | **Fălticeni** | **Iaşi** | **Piatra-Neamț** | **Poiana Stampei** | **Rădăuți** | **Roman** | **Suceava** |
|---|---|---|---|---|---|---|---|---|---|---|
| J | -1.073 | **-5.048**[a] | -0.431 | -1.666 | -0.500 | -0.194 | -0.679 | -0.941 | -0.733 | -0.429 |
| F | -0.667 | **-8.520** | -0.708 | -0.688 | -2.594 | 0.615 | -0.304 | 0.111 | 0.143 | -0.025 |
| M | -1.179 | -2.167 | -0.137 | 0.000 | -0.348 | 1.556 | 1.423 | -1.552 | -0.286 | -0.250 |
| A | -0.556 | -2.909 | 0.231 | 0.859 | -2.767 | 0.323 | -0.333 | -1.100 | 0.625 | 0.021 |
| M | -1.176 | -4.571 | -2.165 | -4.824 | -3.133 | -3.125 | -0.536 | -2.435 | 1.182 | -3.400 |
| J | -5.308 | 0.276 | 3.603 | 0.756 | -4.875 | -3.583 | -2.727 | -0.562 | -0.393 | -0.846 |
| J | 4.583 | 1.455 | 0.595 | 3.418 | -1.032 | 2.846 | -3.765 | 0.523 | 4.867 | 6.087 |
| A | 1.826 | 8.138 | 1.968 | 2.300 | 1.071 | 1.000 | 2.591 | 4.000 | 2.556 | 4.083 |
| S | 5.000 | 2.158 | 3.395 | 2.989 | 1.667 | 5.189 | 5.552 | 4.432 | 4.806 | 3.762 |
| O | **5.636** | 0.333 | **5.084** | 4.343 | **5.435** | **4.273** | 1.606 | 4.000 | **5.462** | **5.000** |
| N | -0.364 | **-4.185** | 0.464 | -1.930 | -0.200 | -1.385 | -1.081 | -0.808 | 0.625 | -1.083 |
| D | 0.000 | **-4.857** | 0.987 | 0.305 | 0.429 | 1.893 | -1.632 | 0.211 | 1.133 | 0.563 |
| Winter | -3.434 | **-20.715** | -2.530 | -3.081 | -5.419 | 2.558 | -4.452 | -1.268 | -1.056 | -1.261 |
| Spring | -3.920 | **-11.250** | -2.333 | -4.990 | -6.829 | -1.375 | 2.278 | -3.593 | 0.958 | -2.000 |
| Summer | 8.773 | 11.900 | 6.004 | 15.028 | -6.471 | 0.591 | -1.650 | 6.258 | 10.714 | 12.300 |
| Autumn | 10.684 | -1.129 | 9.556 | 5.932 | 7.947 | 6.870 | 4.512 | 8.152 | **10.400** | 6.419 |
| Annual | 12.315 | **-27.229** | 14.525 | 11.695 | -11.023 | 11.419 | 7.261 | 5.400 | 14.787 | 18.214 |

[a]Values in bold are statistically significant on P<0.05

### 3.3. Trends in the circulation patterns indices

Significant changes have been noticed in the characteristics of the large-scale atmospheric circulation patterns during the last decades. For a better understanding of the changes in teleconnection indices the absolute values are omitted and only the sign of the trend and statistical significance (P<0.05) are presented. The trends of atmospheric circulation patterns with upward or downward slope according to the Mann-Kendall test are listed in Table 4 with statistical significance highlighted.

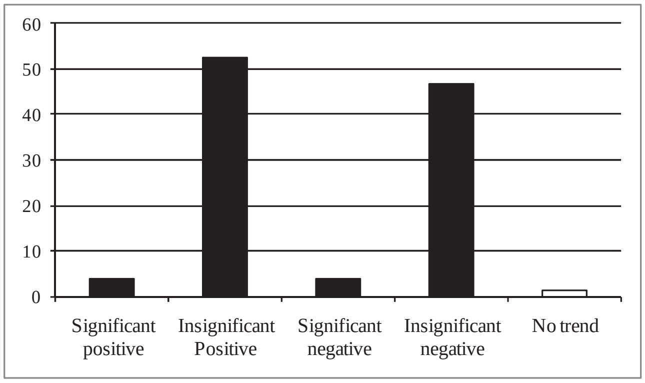


**Figure 3.** Total number of positive and negative trends and number of statistically significant positive and negative trends in precipitation (%).

The EA index has a positive trend in all time series, statistically significant for the great majority of them. It describes the intensity of the westerlies in Central and Southern Europe. The positive phase of the EA pattern is associated with above-average surface temperature in Europe in all months and with below-average precipitation across Southeastern Europe.

**Table 4**. Trends in circulation patterns having a downward”-” / upward trend during 19612010. The symbol in brackets is for trends atistically significant on P<0.05

| | EA | NAO | EW | SC | PO |
|---|---|---|---|---|---|
| J | (+) | (+) | - | - | - |
| F | + | + | + | - | (-) |
| M | + | + | + | - | (-) |
| A | + | + | - | - | - |
| M | + | - | - | - | (-) |
| J | + | (-) | (-) | (-) | - |
| J | (+) | - | - | + | + |
| A | (+) | - | (-) | - | (+) |
| S | + | - | (-) | + | + |
| O | + | (-) | (-) | - | - |
| N | (+) | + | + | - | - |
| D | (+) | + | + | - | - |
| Winter | (+) | (+) | + | - | (-) |
| Spring | (+) | + | - | - | (-) |
| Summer | (+) | - | (-) | - | + |
| Autumn | (+) | - | (-) | - | - |
| Annual | (+) | + | (-) | (-) | (-) |

The trends for NAO teleconnection index vary from positive to negative, but only few of them are statistically significant. However statistically significant trends for winter and January were positive, while for June and October they were negative. These findings are in accordance with some other studies referred to the Mediterranean region (Cohen & Barlow, 2005; Ulbrich et al., 2009; Nissen et al., 2010). The positive trends of NAO suggest an increase in the intensity of westerlies which carry warm air from the Atlantic far to the east, causing mild weather in winter. The intensification of westerlies is also confirmed by the high frequency of positive phase of the NAO pattern during recent decades (Tomozeiu et al., 2002). The negative trends of the NAO teleconnection pattern in the warm period result in weaker westerly winds and more frequent occurrence of easterly circulation.

For EW teleconnection index both negative and positive trends were found for the time series considered, but only in the negative ones statistically significant trends are found. These imply the weakening of the northerly circulation and the strengthening of the southerly airflow in the studied area.

Negative slopes prevail in the case of SC and PO patterns, but only few are statistically significant. A downward trend of SC teleconnection index is associated with above-average precipitation across central Europe in winter (Jaagus, 2006).

### 3.4. The influence of changes in circulation pattern trends on temperature and precipitation trends in northeastern Romania

The analysis of the dependence between the atmospheric circulation teleconnection patterns and temperature and precipitation variability in northeastern Romania was made based on conditional Mann-Kendall test (Table 5). The table lists the teleconnection patterns showing which trends are significantly related to the trends in air temperature or precipitation in the corresponding month or period. When taking into account the time series of those teleconnection indices within the conditional Mann-Kendall test, it shows when statistically significant trends in temperature or precipitation disappear.

The results of the conditional Mann-Kendall test indicate that the warming in January is connected with the trends in the EA and NAO indices. The correlation coefficient is the highest for NAO (0.58), while in the case of EA is only 0.39. The negative trends in the PO teleconnection index in February, March and May have shown a significant influence on changes in temperature. Warming in summer months can be explained by the negative trends in the EW and SC teleconnection indices in June and August, negative trends in the NAO in June, and positive trends in the EA in July and August. The highest correlation has been detected for EA teleconnection index – 0.52. This finding is in accordance with other studies made on Romania (Tomozeiu et al., 2002; Croitoru et al., 2012b).

The warming in winter is connected with positive trends in EA and NAO, and negative trend in PO. Temperature increase during spring is influenced by the positive trend in EA, and negative trend in PO teleconnection indices. The significant increase in air temperature in summer series is influenced by the positive trend in EA and negative trend in EW teleconnection indices, but the warming process may be only partly explained this way.

**Table 5.** Trends of circulation patterns which are significantly related to air temperature and precipitation trends in northeastern Romania. Bold abbreviation – the trend is significant in all stations; "-" – a negative relationship, * - the index describes a significant part of the trend, but not entirely

| Period | Temperature | Temperature |
|---|---|---|
| J | EA*, NAO | EA*, NAO |
| F | PO- | PO- |
| M | PO- | PO- |
| A | | |
| M | PO- | PO- |
| J | EW*-, SC*-, NAO- | EW*-, SC*-, NAO- |
| J | **EA*** | **EA*** |
| A | **EA*,** EW*-, SC*- | **EA*,** EW*-, SC*- |
| S | | |
| O | | |
| N | | |
| D | | |
| Winter | EA, NAO, PO*- | EA, NAO, PO*- |
| Spring | EA, PO*- | EA, PO*- |
| Summer | **EA*,** EW*-, | **EA*,** EW*-, |
| Autumn | | |
| | | |

Some teleconnection indices have a trend also in the annual data sets (EA, EW, PO, SC), that may have caused the annual increasing trend of air temperature.

The connection between precipitation and the circulation indices is remarkably low. This is caused by the strong influence of local factors (slope, altitude etc.) (Jaagus, 2006). Yet, some connections were found. The negative trend in precipitation recorded in January was found to be connected with positive trend in NAO index, which causes below-average precipitation over southern and central Europe. An increase in precipitation in October is significantly related with negative trends in the EW and NAO indices, but the increase can only partly be explained this way. The positive trend in EA teleconnection index in December causes a decrease in precipitation trend for western stations (Ceahlău, Poiana Stampei) located at higher elevations and more exposed to the direct influence of general air mass movements than the other stations. The influence of EA pattern was identified also in spring and annual time series.

## 4. Conclusions

The results of air temperature analysis recorded over a period of 50 years at 10 weather stations in northeastern Romania confirm the current general warming that characterizes many other regions of the world. It was found that during the last decades, annual mean air temperature has significantly increased with the highest increase recorded in summer.

The Mann-Kendall test applied on precipitation data shows that trends in precipitation are both positive and negative for the studied area, but most of them are statistically insignificant. However a significant increase in the area has been detected in October, while a significant decrease was found only at the high altitude station Ceahlău from November to February.

The results of the conditional Mann-Kendall test applied to circulation patterns indices and climatic data shows that the changes in temperature and precipitation time series in northeastern Romania were significantly influenced by the teleconnection indices. They are in accordance with other studies on relationships between teleconnection patterns and climate variability.

The results of the conditional Mann-Kendall indicate that the warming in winter is connected with positive trends in EA and NAO patterns - reflecting an increase in the intensity of westerlies which carry warm air from the Atlantic far to the east, causing mild weather - and a negative trend in PO pattern. Temperature rise during spring is significantly related with the positive trend in EA and the negative trend in PO teleconnection indices. Warming in summer is significantly influenced by positive trends in EA and negative trends in EW teleconnection indices. A decrease in EW and NAO patterns is significantly related with an increasing trend in precipitation in October. The decreasing trends in time series of Ceahlău station was found to be related with negative trends in EA pattern.

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