THE INFLUENCE OF EUROPEAN CLIMATE VARIABILITY MECHANISM ON AIR TEMPERATURE IN ROMANIA

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ABSTRACT. - The influence of European climate variability mechanism on air temperature in Romania. The main objective of the present paper is to analyze the temporal and spatial variability of air-temperature in Romania, by using mean air-temperature values provided by the ECA&D project (http://eca.knmi.nl/). These data sets will be filtered by means of the EOF (Empirical Orthogonal Function) analysis, which describes various modes of space variability and time coefficient series (PC series). The EOF analysis will also be used to identify the main way of action of the European climate variability mechanism, by using multiple variables in grid points, provided by the National Centre of Atmospheric Research (NCAR, USA). The variables considered here are: sea level pressure (SLP), geopotential height at 500 mb (H500) and air temperature at 850 mb (T850), for the summer and winter seasons. The linear trends and shift points of considered variables are then assessed by means of the Mann-Kendall and Pettitt non-parametric tests. By interpreting the results, we can infer that there is causal relationship between the large-scale analyzed parameters and temperature variability in Romania. These results are consistent with those presented by Busuioc et al., 2010, where the main variation trends of the principal European variables are shown.

Keywords: EOF analysis, coefficient time series, non-parametric tests, Romania, Europe

1. INTRODUCTION

The atmospheric circulation exhibits a great variability which highlights different weather configurations appearing at various temporal scales. The tele-connection patterns, such as El Nino-Southern Oscillation, which occurs across the tropical Pacific Ocean, or North Atlantic Oscillation which develops in the Atlantic Ocean, are well known as persistent large scale configurations. These tele-connections partly reflect the climatic inter-annual variability and, at the same time, represent the atmosphere's internal dynamics. Because of this, their study is essential in order to find the connections between large scale atmospheric patterns and local or regional weather regimes. Moreover, for the Northern Hemisphere, the results presented in the 4th Assessment Report of Intergovernmental Panel on Climate Change (IPCC, 2007) reveal the climate change signal that can be detected. For this, the study of surface parameters, such as air-temperatures or precipitation amounts, represent an important concern for scientific community. The analysis of the observed climate variability is important for a

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better understanding of the local forcing that governs the main surface parameters. Air temperature is one of the most important parameters in weather and climate forecasting. Its study can provide evidence for changes in atmospheric warming processes, either if this is due to anthropogenic factors or to a natural climate variability or to a combination of both. Also should be noted that air temperature and its seasonal cycle "show the clearest signals of change in the observed climate" (IPCC, 2001b).

For the Romanian territory, various studies regarding the time evolution of climate parameters were conducted (Busuioc and von Storch, 1996, Busuioc and von Storch, 1995, Busuioc et al., 2010). These studies focused on analyzing the changes occurring in the temperature and precipitation parameters and their relationship with the larger scale circulation. Close relationships between Romanian temperature and precipitation parameters and European climatic variability were found. Also, must be pointed out that the results of the present study are in accordance with those presented by Busuioc et al., 2010, where the main variation trends of the principal European variables and their connection with temperature regime in Romania are shown.

2. DATA AND METHODS

The monthly air temperature data used in the present study are provided by the European Climate Assessment and Dataset project (ECA&D). The ECA&D started in 2003 and its main objective is to analyze the temperature and precipitation variation of more than 40 European countries, with special focus on trends in climatic extremes observed at meteorological stations. For this purpose, a dataset of daily surface air temperature and precipitation series has been compiled (Klein Tank et al. 2002a) and tested for homogeneity (Wijngaard et al. 2003). A number of 21 meteorological stations were selected, all with long time series available, both for summer (June, July, August - JJA) and winter (December, January, February - DJF) seasons. Knowing that the climatic research is based on analyzing long time series, for at least 30 years, and that the natural climate variability occurs on different time scales, the period considered is 1961-2010. The name and position of the meteorological stations used in the present study are shown in the Figure 1.

On the other hand, in order to explain the mechanism that controls the regional climate variability, three variables in grid points, provided by the National Centre of Atmospheric Research (NCAR, USA), (Kalnay et al., 1996), were used. The parameters that were considered are represented by the monthly means of the following variables: sea level pressure (SLP), geopotential height at 500 mb (H500) and air temperature at 850 mb (T850), with a resolution of 2.5º x 2.5º global grids. The area between -45W-50 and 30-60N was chosen to analyze the SLP and H500 parameters, while for T850, the area between 5-50E and 30-60N, respectively, was chosen.

The Empirical Orthogonal Functions (EOF), (Lorentz, 1956) method and the related Principal Components (PC) are being used for the spatial and temporal

Fig. 1. ***The meteorological stations used in the study***

investigation of observational and re-analysis data described below. EOF is a statistical method used for the spatial and temporal decomposition of large data sets. An important characteristic of the climatic data is the high dimension of the variables that represent the system at a given time period. Because of this, the method of separating the data in two phases is very often used, out of which only one represents the object of interest of the respective research theme. EOF is one of the most used techniques for subtracting the dominant spatial and temporal structures from a large data set. Usually, only the first few EOF configurations, which are represented by their large explained variance, are retained because they reveal the principal characteristics of temporal variability of the time series considered. It must also be pointed out that the EOF method is applied for the anomalies of the chosen variables, which are calculated from the multiannual average. On the other hand, the PC series reveals the temporal variability of the principal configurations that are detected. This represents the evolution in time of the main EOF configurations, expressed by their explained variance. More technical information about EOF analysis can be found in Barnett and Preisendorfer, 1987 and von Storch and Zwiers, 1999.

Another important aspect regarding the identification of the most important atmospheric circulation at large and regional scales is related to detecting the trend and change points in the resulting time series. For this, in order to analyze the statistical significance of PC series, Pettitt (Pettitt, 1979) and Mann-Kendall (Sneyers, 1975) tests are used. The Mann-Kendall test calculates the long terms linear trend and the Pettitt test detects the change points in the time series considered. So, the changes in the seasonality of the chosen variables are analyzed as a consequence of changes in their mean regime. The non-parametric tests were performed by using a significance level of 5%, this being considered as acceptable (Busuioc et al., 2010).

3. RESULTS

3.1. The main modes of European climate variability

In order to assess the large scale mechanism which can determine the variability of air temperature in Romania, we have analyzed the SLP, H5OO and T850 parameters. Therefore, Figure 2 presents the EOF analysis performed for SLP parameter. In summer, the first EOF configuration presents 35% of the explained variance, while the second only 17%. One can notice that EOF1 configuration presents a cyclonic/ anti-cyclonic structure on the whole area, with the center located in the northwestern part of Europe. This structure presents approximately 2 mb deviation from its normal. Also to be noted that over the Romanian territory, the pressure variability presents a low variability, with a deviation of about 0.9 mb. The EOF2 configuration reveals a dipole structure, with a first component that presents a pronounced lapse rate located in the northern part of the Atlantic Ocean and the second being less pronounced. In this case, sea level pressure over the Romanian territory is also less pronounced.

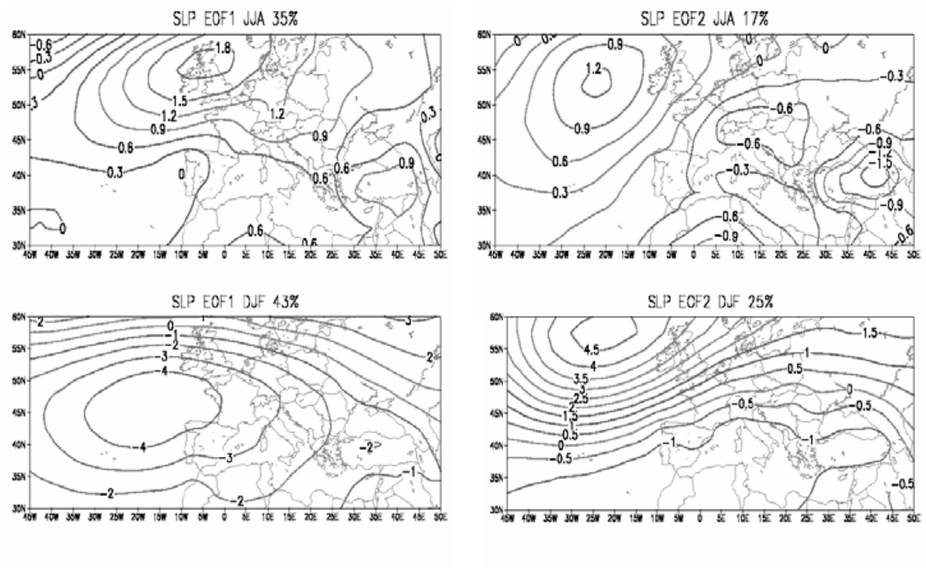

Fig. 2. ***The patterns of the first two SLP EOF configurations for the summer and winter seasons***

In winter, the first EOF, with 43% of the explained variance, presents a cyclonic/anti-cyclonic structure extended over Europe and the Atlantic Ocean. This circulation type is oriented to a southwest/ northwest direction, while for EOF2, it is oriented to a northwest/ southeast direction. The EOF2 configuration, having 25% of the explained variance, presents two structures, one centered in the northern part of the Atlantic Ocean and the second one centered in the Mediterranean Sea. This structure is quite similar with the NAO configuration in the winter season, which also affects the Romanian territory.

The first two H500 EOFs for the summer season, which explain together 50% of the variance and the corresponding EOFs for the winter season, which explain 63% of the variance, are presented in the Figure 3. EOF1 in the summer season presents a structure of positive anomalies centered in the northwestern part of Europe, while EOF2 presents two centers with positive/ negative anomalies located in the eastern and northwestern Europe. In the winter season, one may detect a structure with positive anomalies centering in the Atlantic Ocean for EOF1. The EOF2 presents a similar structure with those of the SLP, the bipolar structure being oriented to the same direction.

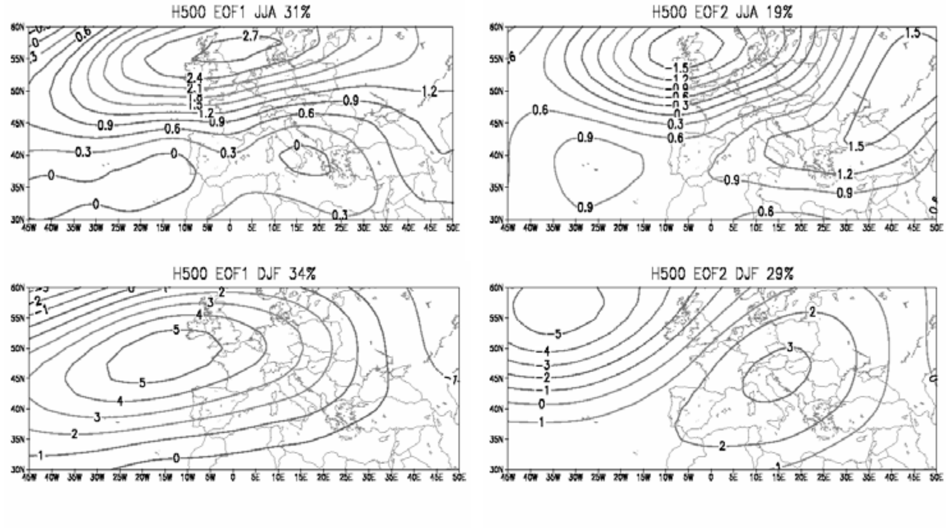

Fig. 3. ***The patterns of the first two H500 EOF configurations for the summer and winter seasons***

Figure 4 presents the EOF analysis performed for the T850 parameter, in the summer and winter seasons.

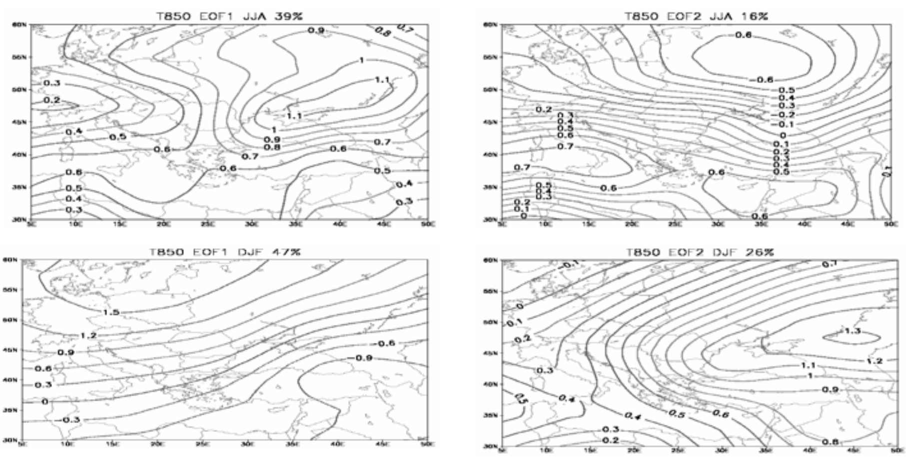

Fig. 4. ***The patterns of the first two T850 EOF configurations for the summer and winter seasons***

One may notice that in the summer season, the first two EOF configurations explain 55% of the variance. The EOF1 presents a monopolar structure with the centre located in the Black Sea and northeastern Europe. The second EOF reveals a bipolare structure, also evident over the Romanian territory. In winter, positive anomalies are detected in almost all area, in the case of EOF1, while the EOF2 shows positive anomalies.

3.2. Air-temperature variability in Romania

A similar EOF analysis was performed in case of mean air-temperatures in Romania. Figure 5 presents the configuration structure and the explained variance of each EOF. In both seasons, the first EOF's are explained by a large variance (77% in the summer and 88% in the winter). This can be explained by the fact that a larger scale mechanism could be responsible for the air temperature variability over the Romanian territory.

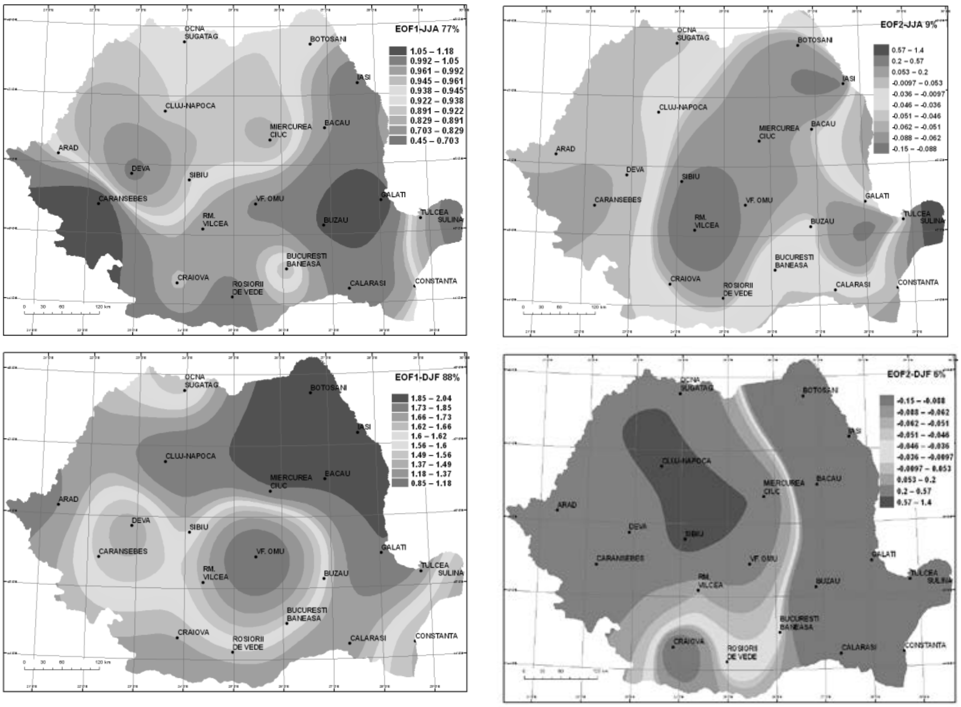

Fig. 5. ***The patterns of the first two mean air temperature configurations for the summer and winter seasons***

In case of EOF1, positive anomalies cover the area, with the center located in the southeastern parts of the country. This is in accordance with the results found for T850 in the summer season, where the largest positive anomalies were found in this part of the Romanian territory. As it is also shown in the table below, the year 1983 was identified as being the same change point for these two parameters. The

EOF2 reveals the influence of the Carpathian Mountains, but this explains a small variance of only 9%. In the winter season, for the first EOF, the center of action is located in the northeastern part of Romania, this also being in accordance with the results obtained for T850 parameter. As in the case of the EOF2 in summer, the second EOF in the winter season, which explains only 6% of the variance, reveals the opposite variability between extra- and intra-Carpathian regions.

Table 1 presents the linear trends and change points that were detected for the main resulting components. One can notice that upward trends are detected both for T850 and mean air temperature parameters. Regarding the SLP, the decreasing trend is in accordance with the increase or decrease of the cyclonic/ anti-cyclonic structures identified. Further studies must be undertaken in order to understand the large scale mechanism that governess the air temperature regime in Romania.

Table 1. ***The significant linear trends for the principal component series of the first two EOF's at the statistic level of 5 %***

Parameters	EOF 1		EOF 2	
	JJA	DJF	JJA	DJF
SLP		1981 ↓	1978 ↓	
H500	1982 ↑	1986 ↑	1985 ↑	
T850	1983 ↑	1984 ↑	1976 ↑	
Air temperature-Romania	1983 ↑	198		

4. CONCLUSIONS

Regarding the present analysis, the large explained variance of the first EOF configurations for the Romanian territory can be interpreted as a linkage of large scale increasing anomalies with local and regional scale. The Carpathian influence on modulating the air mass distribution over Romania, especially in the winter season, was detected by the second EOF's. Also, as many studies reveal (Bojariu and Giorgi, 2005, Tomozeiu et al., 2005), it seems that the North Atlantic Oscillation influence the weather regime in Europe, including Romania, especially in the winter season. By comparing the results of the air temperature at 850 mb with the air temperature anomalies in Romania, one may suspect that there may be a possible causal relationship. In other words, the increase of anomalies for T850 and H500 parameters can explain the increase trend of air temperature in Romania, detected by the first EOF configurations. Moreover, this affirmation can further be sustained by the change point detected as well.

In conclusion, we can say that there may be a possible relationship between the variability of large scale parameters and the thermal variability in Romania. But, we can't say for sure if the changes found are related to the natural variability of the climate system or are due to external forces, such as anthropogenic factors.

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