THE CONNECTION BETWEEN SUMMER PRECIPITATION ANOMALIES IN ROMANIA AND LARGE-SCALE ATMOSPHERIC CIRCULATION

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ABSTRACT

The relationship between summer precipitation anomalies in Romania and large-scale atmospheric circulation anomalies is empirically examined by canonical correlation analysis (CCA). The canonical correlation analysis yields pairs of patterns describing the simultaneous variability of the two analysed fields. From the analysis of the time series variation associated to the first CCA patterns explaining most of the total variance, an attempt is made to explain some characteristics of the summer precipitation anomalies variation in Romania through the variation characteristics of the atmospheric circulation anomalies.

It is concluded that above normal precipitation in Romania is connected with a cyclonic structure with the center over the Black Sea. The time coefficients associated to this patterns have a decreasing trend with a change point at about 1941 that means a weakening of the Black Sea cyclogenesis since 1941 and consequently less precipitation. This fact could explain the "downward shift" at about the same year for the central stations which are best controlled by this pattern.

1. INTRODUCTION

It is well known that atmospheric circulation and climate are linked. But the regional climate is generated by the simultaneous action of various processes on local, regional and global scales. The knowledge on the relative contribution of these processes is important for explaining the regional climate variability.

In this paper the relationship between summer precipitation in Romania and large-scale atmospheric circulation simultaneous variability is empirically examined by the canonical correlation analysis (CCA). As a parameter to represent the large-scale circulation the sea level pressure (SLP) field have been used. The result of CCA is a set of pairs of patterns the coefficient time series of which are correlated optimally. To explain the changes in the summer precipitation anomalies in Romania, the time series associated to the most significant CCA pairs of the two considered parameters have been analysed by using the Pettitt's statistic (Pettitt, 1979). The change-point in the local scale is shown to be considerably related to a change of the large-scale circulation regime.

2. DATA AND METHODS

The data used in this paper are the time series of the seasonal precipitation amount at 14 Romanian stations and the seasonal mean sea level pressure (SLP) during the summer (Jun.-Aug.) 1901-1987. For both parameters the anomalies have been computed by subtracting the long term seasonal mean from the original values. For the SLP the area between 30^0 N-55^0 N and 5^0 E-50^0 E has been selected.The monthly SLP data have been taken from the National Center for Atmospheric Research (USA) with a resolution of $5^0 \times 5^0$.

The CCA is a tool to find out a linear relationship between two space-time dependent variables (e.g., Barnett and Preisendorfer, 1987; Zorita et all., 1993; von Storch, 1995). The CCA selects a pair of spatial patterns of two space-time dependent variables so that their time coefficients are optimally correlated. Since the coefficients are normalized to unity, the canonical correlation patterns represent the typical strength of the signal. Thus the coefficients may be seen as time series of weights which describe the strength and the sign of the patterns for each realization in time. Prior to the CCA, the original data are projecting onto their empirical orthogonal function (EOFs) and only a limited number of them are retained, explaining most of the total variance. This also serves as a data-filtering procedure to eliminate noise (although it can exclude potentialy useful information).

The change-points in the summer precipitation in Romania and SLP fields have been detected by using non-parametric Pettitt's test (Pettitt, 1979). Mainly, this test is sensitive to change in the time series mean and its results are affected by the serial correlation and the linear trend of the analysed series. We have used therefore Pettitt's statistic only as an exploratory tool to identify possible change-points without attempting to make any probability statement (such as the risk of rejecting the null hypothesis of no change point). More details about this problem is presented by Busuioc and von Storch (1995).

3. RESULTS

The CCA analysis have been used to select the pairs of the spatial patterns of the SLP and precipitation in Romania so that their time components are optimally correlated. The first 5 EOFs for the SLP and 5 EOFs for the precipitation have been retained for the CCA.

The first 3 EOFs for the Romanian precipitation are shown on Figure 1. The first EOF explains 41% of the total variance and shows the same sign over the entire country with the highest values in the center and Southwest and the lowest in Southeast. The second and third EOFs (13% and 12% explained variance) have a dipole structure, the two regions with opposite sign of variability being disposed on the east-west and north-south direction, respectively. That fact shows the influence of the Carpathians on the precipitation variability.

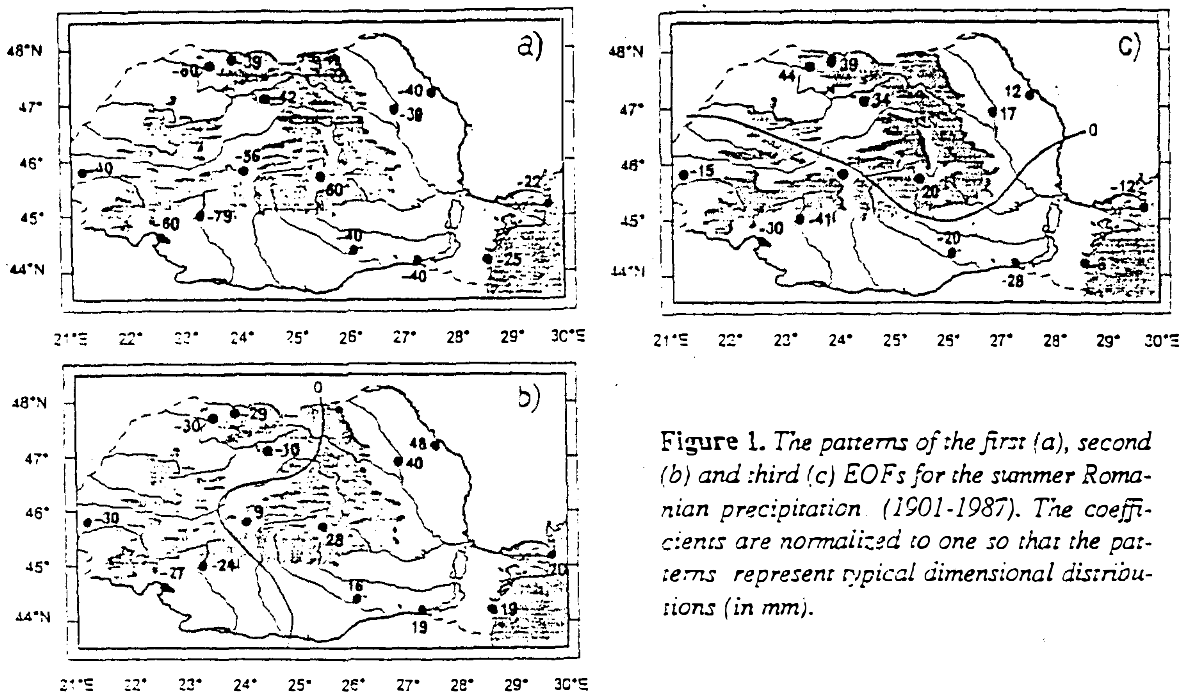

Figure 1. *The patterns of the first (a), second (b) and third (c) EOFs for the summer Romanian precipitation (1901-1987). The coefficients are normalized to one so that the patterns represent typical dimensional distributions (in mm).*

The first CCA pair (Figure 2a) has a maximum correlation between corresponding time coefficients of 0.70 and explains 39% of the total precipitation variance. The CCA pattern for the precipitation is similar to the first EOF (Figure 1a). The SLP CCA pattern shows a cyclonic structure with the center over the Black Sea. This phenomenon is very plausible from the physical point of view, the cyclonic structure leading to the above normal precipitation in Romania, the largest values being in the center and in the southwestern part of the country.

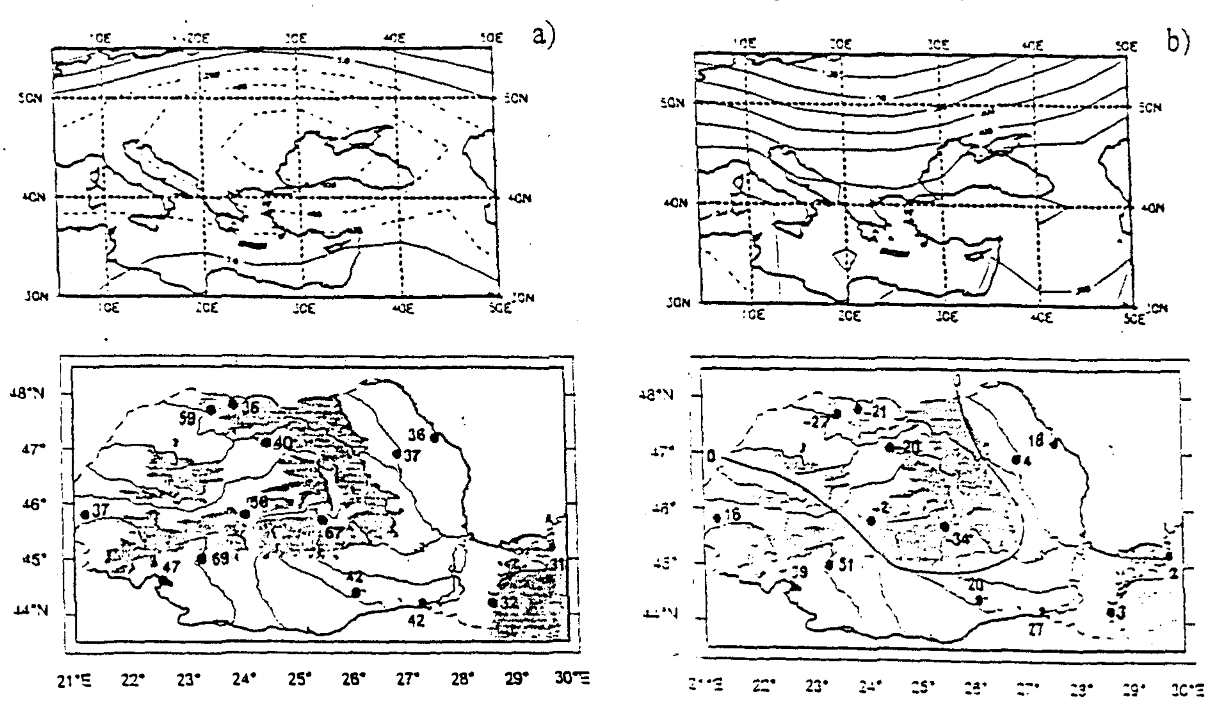

Figure 2. *The patterns of the first (a), second (b) canonical pair of the summer mean SLP (contour of 0.2 mb) and total summer Romanian precipitation. Continuous lines mark positive values and dashed lines, negative values.*

The second CCA (0.39 correlation) explains 11% of the total precipitation variance (Figure 2b). The SLP CCA pattern shows a positive anomaly field and it is associated with below normal precipitation in the intra-Carpathian region and above normal in the extra-Carpathian region (similar to the third EOF). From the physical point of view the positive anomalies are related to an eastern circulation which guides dry continental air into Romania. The southwestern and southern regions are less influenced by this circulation. Also, some short-lived convective weather systems or the Mediterranean cyclones could be responsible for the positive precipitation anomalies over these regions.
The time coefficients associated to the first two CCA patterns have been analysed to explain some characteristics of the summer precipitation variability in Romania through the characteristics of the atmospheric circulation variability. Table 1 shows the trend and change-point for the 14 stations considered. Some areas with the same change-point are delimited. So, the central and some southeastern stations have a downward shift around 1941, the southwestern / southern stations have an upward shift between 1938-1952 and northeastern ones, an upward shift around 1968.
Even if the first EOF of the precipitation in Romania has the same sign, there is not a common physical process dominating the summer precipitation variability. This fact is consistent with the results of the CCA analysis, the first EOF of the precipitation not having a maximum correlation with the first SLP EOF and with a cyclonic structure with the nucleous placed over the western Black Sea. Both time coefficients associated to this CCA pattern (Figure 3a) have a less marked downward shift around 1941. That means a weakening of the Black Sea cyclogenesis since 1941 that could explain the same change-point of the central stations which are best controlled by the first CCA.
The time coefficients associated to the second CCA (Figure 3b) exhibit an increase with a change-point around 1961 for SLP and 1938 for the precipitation. The year-to-year variation for both curves is not highly coherent. Some discrepancies which appear between the amplitudes over some intervals likely lead to the different change points. The increase of the summer precipitation at the various stations but with different change points could be expained by some intense short-living systems likely induced by the convective structure which are common during the summer in Romania.

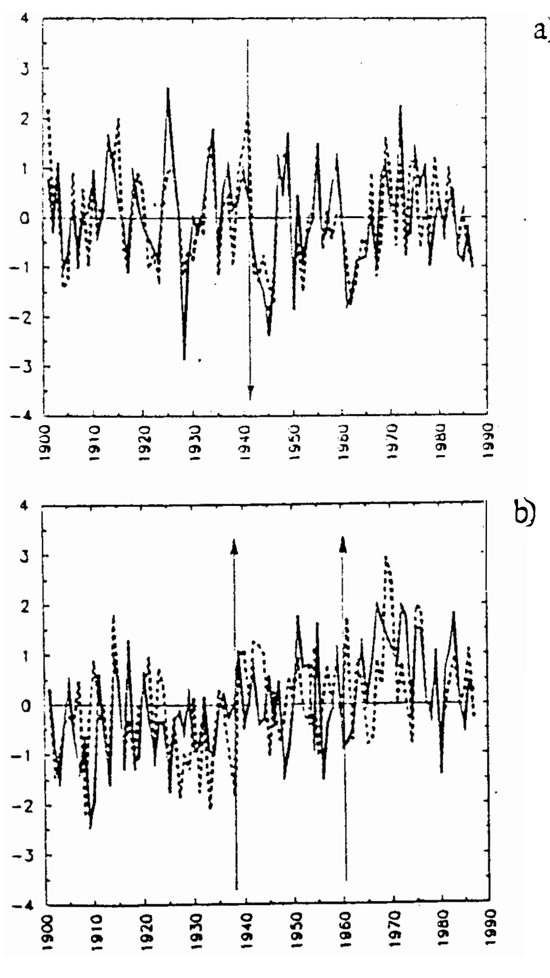

Figure 3. *Normalized time components of the first (a) and second (b) CCA patterns of SLP anomalies (continuous line) and Romanian precipitation anomalies (dashed line).*

Table 1. *Trend (mm/season/100/years), change-point (year) for the summer precipitation in Romania (1901-1987).*

Stations	Trend	Change point
Ocna Sugatag	20	1952
Baia Mare	-27	1917
Bistrita	4	1968
Brasov	-81	1941
Sibiu	-34	1942
Timisoara	5	1952
Tr. Severin	25	1938
Tg. Jiu	85	1952
Bucuresti	2	1967
Calarasi	11	1938
Sulina	-43	1941
Constanta	-6	1920
Roman	21	1968
Iasi	78	1968

4. CONCLUSIONS

The relationship between summer precipitation anomalies in Romania and SLP anomalies is strong. The above normal precipitation is connected to a cyclonic structure with the center over the Black Sea. The time series associated to this pattern have a decrease with a change-point about 1941 that could justify the same change-point of the central stations, controlled by this pattern.
The analysis of changes in the summer Romanian precipitation concluded that there is not a common large-scale physical process dominating the variability of this field. The significant changes found in the SLP patterns seem to overlap

to some intense short-living weather systems likely induced by the convective structure which are common during the summer in this region.

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