CYCLONIC ACTIVITY OVER ROMANIA IN CONNECTION WITH THE AIR CIRCULATION TYPES[*]

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Abstract. Generally, the severe weather phenomena are associated with cyclonic activity over Romania. The aim of this paper is to assess a correlation between the cyclone frequency into a representative area for Romania and the circulation types conform to "COST733 Catalogue". The selected domain was between 10° and 35° E longitude and 35° and 55° N latitude. The selected area is similar to Domain 10 from COST733 Catalogue. The Mediterranean cyclones, reaching this domain from the south-west can be accounted for. The cyclones of Icelandic origin with north-west to south-east trajectories sometimes are reactivated in Central Europe through cold air penetrating the upper troposphere and reach over Romanian territory. A peculiar category is that of cyclones moving along retrograde tracks. Using daily NCEP/NCAR reanalysis data for the sea level pressure, a subjective analysis of cyclone frequency has been performed for the cold period (the 1st of November-the 31st of March) between 1996-2002 years. All closed cyclonic nuclei with a pressure equal to or lower than 1,015 hPa in the sea-level pressure field were accounted for using LWT2 Cost 733 catalogue, the frequency of circulation types for the analyzed interval has been established. The anticyclonic circulation types seem to be the more frequent and, by the other hand, the graphical correlations show that the cyclonic activity in the domain is important especially during the periods with eastern or south-eastern dominant air circulation.

Key words: cyclonic activity, Cost733 Catalogue, circulation types.

1. INTRODUCTION

The study of the circulation types is a topic of permanent interest for European meteorologists and climatologists, with an already existing huge number of papers dedicated to it. Circulation types were often studied in connection with the weather types, so as the two notions come to superpose.

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The earliest studies dedicated to classifications by types followed the evolution in time of parameters such as: temperature, precipitation or wind speed, aiming the division by homogeneous classes, in accordance with spatial and temporal criteria [1]. Obtained results are classifications of the weather types. In today's understanding, these classifications are (discrete) characterizations of the current atmospheric conditions.

On the other hand, in order to describe the atmospheric circulations, the sea-level pressure distribution or the geopotential height were used the most often. Studies regarding the backward air trajectories [2, 3, 4] or the cyclone tracks [5, 6, 7, 8] may also be introduced in the same category.

The indestructible connection between the circulation types and the weather types is very well synthesized in the classical work of N. Topor and C. Stoica, *Circulation types and atmospheric action centres above Europe* [9], written in 1965. According to the mentioned work, weather type "means an atmospheric process evolving somewhat homogeneously within the geographic region in question and is determined by a certain position of the high planetary frontal zone". In order to classify the atmospheric processes in the Romanian area, the notion *main circulation form* was used, "characteristic for the average evolution of the weather above Central and South-Eastern Europe, with peculiar stress on the weather conditions in our country".

The present study is addressed to researches that combine subjective and objective approaches; it pay more attention to the physical interpretations, in comparison with researches only carried out through objective methods, thus becoming applicable in the fields of meteorology and synoptic climatology. Noteworthy is that a subjective approach uses the meteorologist's knowledge and experience. The best known and still used subjective classifications developed for various regions, at various scales are those of Hess and Brezowsky [10] and that of Lamb [11, 12, 13]. The studies of Maheras [6, 7] and those of Maheras et al. [8] are also noticeable, combining subjective and objective methods to make up a catalogue of the weather types, associating this notion to the cyclonic trajectories over Europe. The results are used to analyse the precipitation trend in connection to the cyclonic circulation types in the area of Greece. Lamb's subjective classification was used by Jenkinson and Collison [14] so as to obtain an objective classification scheme that uses daily grid-point mean sea level pressure data. The objective and the original subjective Lamb scheme were compared by Jones et al. [15].

Classifications of circulations that are based solely on automated algorithms operating on selective data sets are mainly developed to be used in achieving climate change scenarios [16].

In the last years, studies concerning the circulation type classifications were developed within COST Action 733 "Harmonisation and Applications of Weather Types Classifications for European Regions" whose main objective is to: "achieve a general numerical method for assessing, comparing and classifying weather

situations in Europe, scalable to any European (sub) region with time scales between 12 h and 3 days and spatial scales from 200 to 2,000 km, applicable for a number of situations". A synthesis regarding the history of the circulation type and weather classifications, as well as the present-day stage of this study, within COST Action 733 inclusively is presented by Huth et al. [1].

The aim of this paper is to establish o correlation between the cyclone frequency into a domain considered to be representative for Romania and the circulation types, in conformity with "COST733 Catalogue of Circulation Types".

Section 2 displayed the used data and methods and Section 3 contains the results, as well as their physical interpretation. The few concluding remarks end the paper.

2. DATA AND METHODS

In this study the selected domain ranges within 35°– 55° N latitude and 10°–35° E longitude (Fig. 1) appropriate to Domain 10 from COST733 Catalogue [1, 19].

The selected area allows the comparison and correlation between the appearance cyclones frequency and circulation types. For this domain the cyclones with Mediterranean origin can be accounted for, together with the cyclones of Icelandic origin taking North-West to South-East tracks towards the domain; these last cyclones sometimes are reactivated in Central Europe through cold air penetrations in the upper troposphere. A peculiar category is that of cyclones moving along retrograde tracks.
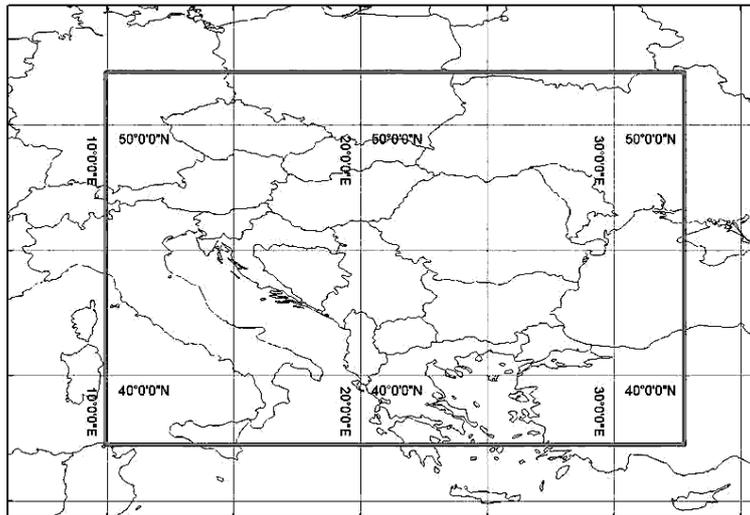

Fig. 1 – The representative domain for the cyclonic activity over Romania.

Using daily NCEP/NCAR reanalysis data for the sea level pressure [17, 18] a subjective analysis of cyclone frequency has been performed for the cold season (1 November–March), between 1996 and 2002. Daily, all closed nuclei with mean sea level pressure (MSLP) equal to or lower than 1,015 hPa were counted for the present statistics. The 1,015 hPa threshold value was chosen following the authors' expertise in synoptic meteorology field. Thus, 389 cyclones were retrieved, the majority of them being of the mesoscale type. The monthly occurrence frequency was computed by dividing the number of cyclones counted in one month of one year by the total cyclones number from the analysed interval (Fig. 2).

In the second part of the study it was attempted to establish a correlation between the number (and the occurrence frequency) of cyclones and the circulation types. The study was focused on the LWT2 catalogue for weather types developed by Paul James and used in the COST 733 Action [19]. The catalogue was built up using a method representing an improved and modified version of the Jenkinson-Collison (JC) objective system comprising a daily classification of the mean pressure field into 26 categories of the flow, indicating the direction and the vorticity (Table 1). According to JC, vorticity and flow thresholds are modified dynamically, so that exactly 33% of the number of days (in ERA 40) frames in each of the three vorticity classes: Ax, Ux and Cx (Table 1).

The appearance of each type of circulation from the LWT2 COST 733 catalogue throughout the interval was computed and afterwards the monthly frequency (total number of occurrences of one certain type divided by total number of days) was computed (Fig. 3).

Table 1

The 26 flow categories, indicating flow direction and vorticity [18]

1 - AA Anticyclonic (Centred)	10 - UNE - Unbiased North-Easterly	18 - CC - Cyclonic (Centred)
2 - ANE - Anticyclonic North-Easterly	11 - UE - Unbiased Easterly	19 - CNE - Cyclonic North-Easterly
3 - AE - Anticyclonic Easterly	12 - USE - Unbiased South-Easterly	20 - CE - Cyclonic Easterly
4 - ASE - Anticyclonic South-Easterly	13 - US - Unbiased Southerly	21 - CSE - Cyclonic South-Easterly
5 - AS - Anticyclonic Southerly	14 - USW - Unbiased South-Westerly	22 - CS - Cyclonic Southerly
6 - ASW - Anticyclonic South-Westerly	15 - UW - Unbiased Westerly	23 - CSW - Cyclonic South-Westerly
7 - AW - Anticyclonic Westerly	16 - UNW - Unbiased North-Westerly	24 - CW - Cyclonic Westerly
8 - ANW - Anticyclonic North-Westerly	17 - UN - Unbiased Northerly	25 - CNW - Cyclonic North-Westerly
9 - AN - Anticyclonic Northerly		26 - CN - Cyclonic Northerly

3. RESULTS AND DISCUSSIONS

In the cold period of the year (November-March) the highest values of the frequency of cyclone appearance are for November 1997–December 1998 time interval and especially for the November and December months (Fig. 2). Also, one can notice that for 2000–2002 cold period (winters) the cyclonic activity was reduced in respect with the interval of 1997-1999.

As well, the results showed the highest frequency for anticyclonic circulation types 1, 3 and 4 (i.e. AA, AE and ASE), followed by the unbiased types 11 and 12 (i.e. UE and USE).
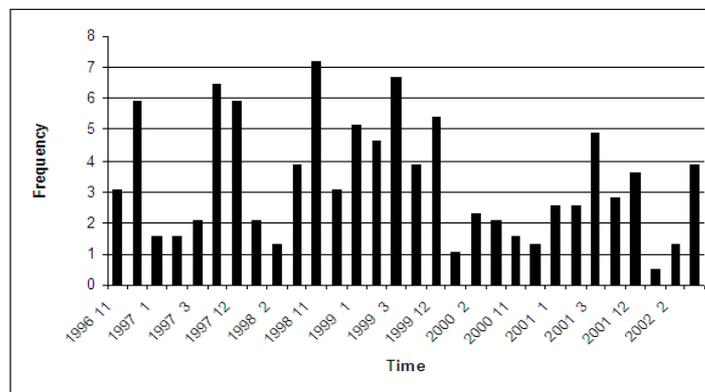

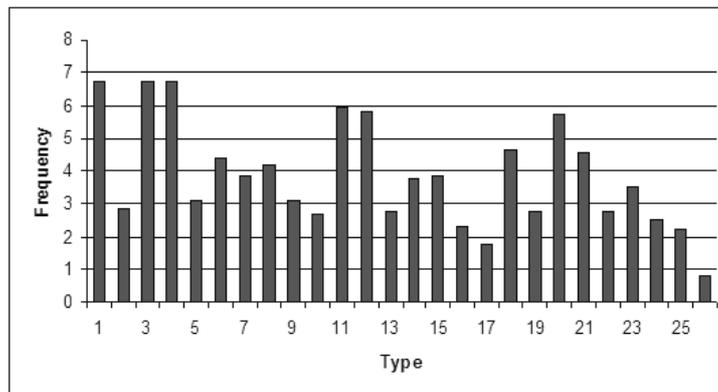Fig. 2 – The cyclones monthly occurrence frequency (percentages).

Fig. 3 – The occurrence frequency for each type of circulation (percentages).

The correlations between the cyclones appearance monthly frequency and circulation types were made for each month of year. As expected, the correlation between cyclones frequency and cyclonic and unbiased circulation types was better than for anticyclonic one.

Consequently, the circulation types 11 (UE), 18 (CC), 20 (CE) and 21 (CSE) were selected to be in detail analysed. The both correlation graphs and MSLP maps from LWT2 Catalogue are presented in Fig. 4 for 11 and 18, and in Fig. 5 for 20 and 21 circulation types, respectively.

The graphical correlation shows a time variability due to the mesoscale nature of the cyclones and their short life cycle compared to the persistency of large scale circulation types. Additionally, for periods with many circulation types it is difficult to establish a connection to the cyclonic activity. Thus for analyzing the connection between cyclonic activity and air circulation types, a simple statistics (a correlation coefficient) is not appropriate. For this reason 3D graphs "time – cyclonic activity – circulation type" were build for every chosen circulation types. One can observe in the lower panel of Figs. 4 and 5 the highest cyclonic activity within 1997–1999 period (blue dark color) for the 11, 18, 20 and 21 circulation types. Thus this representation can emphasize the dominant type of air circulation at synoptic scale that determines the larger cyclone frequency of occurrence.

In this idea the present study shows, for the chosen domain, the intense cyclonic activity when the air circulation types having an eastern component are dominant. This important result can be related to the both, influence of Black Sea by its forcing induced in cold months of the year and large frequency of blocking air circulation over Northern Europe. The blocking determines cyclones occurrence at lower latitudes of the selected domain and generates eastern or south-eastern air circulations toward Romania. The eastern component of air circulation types is also present in case of the circulations which have the largest frequency in the cold period of year, AE and ASE (Table 1).

4. CONCLUDING REMARKS

A subjective analysis of cyclone frequency has been performed for the cold period (November-March) between 1996–2002 years for a domain considered to be representative for Romania. The objective analysis was made to establish the connection with the frequencies of the air circulation types from LWT2 Cost 733 catalogue.

The dynamic characteristics of the cyclones press on physical analysis of the relation between the cyclone frequency and the circulation type. Therefore, this paper shows the results of combined analysis statistics and physics.

The statistics analysis shows the dominant type of air circulation at synoptic scale that determines the larger cyclone frequency of occurrence; the physical analysis explains the frequency of cyclones occurrence in different air circulation types. In the cold period of the 2000–2002 years, the cyclonic activity was reduced comparatively to the period, 1997–1999 (Figs. 2, 4 and 5) The correlation between cyclone frequency and circulation types from LWT2 Catalogue was variable in time because the cyclones are mesoscale ones and their life cycle is shorter than a circulation type at large scale. In addition, in the periods with a great number of circulation types it is difficult to establish a connection to cyclonic activity.

The anticyclonic circulation types seem to be the more frequent in this selected period over the chosen domain.

The correlation between cyclone frequency and cyclonic and unbiased circulation types was better than for anticyclonic types.

The connection between the cyclones occurrence and circulation type frequencies shows that the cyclonic activity in the domain is important especially during the periods with eastern or south-eastern dominant air circulation, confirming the important contribution of the Black Sea in intensifying cyclonic activity as revealed by other studies.
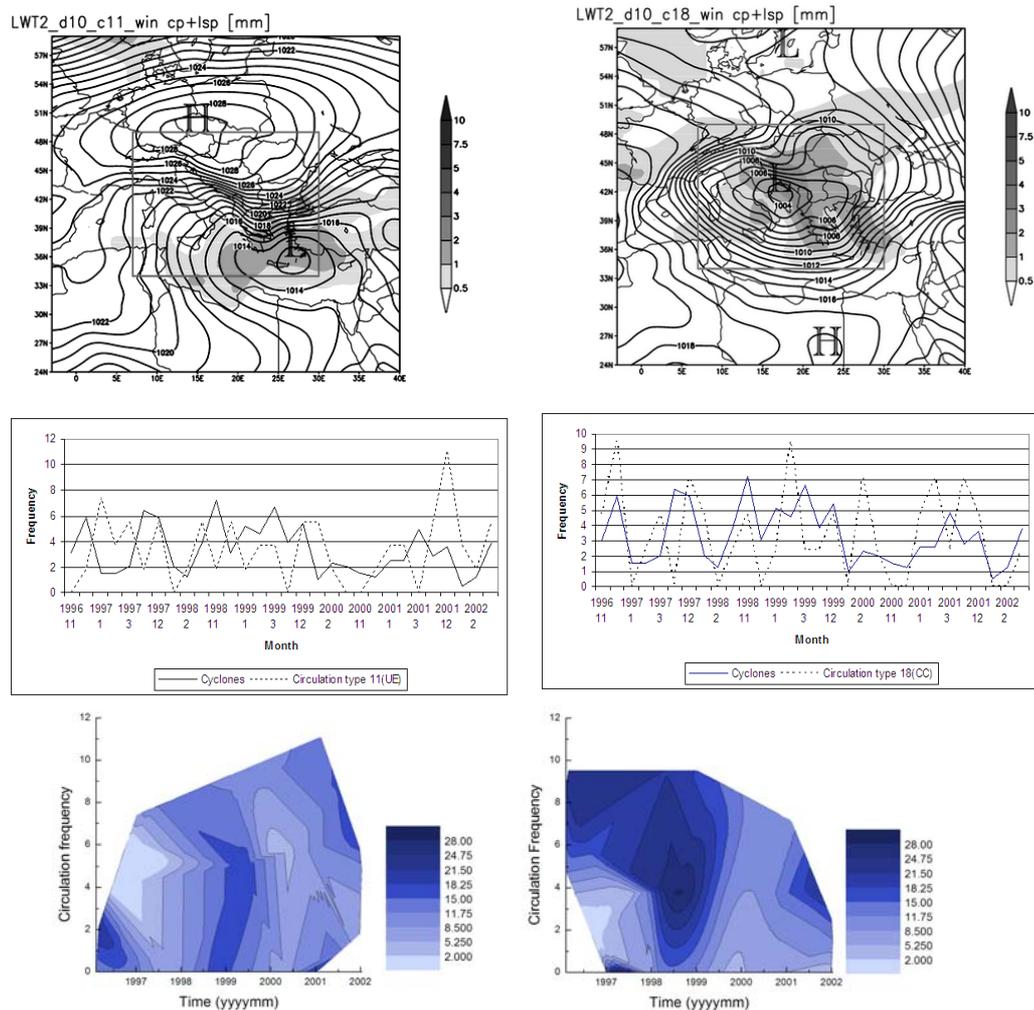

Fig. 4 – Vertical: circulation type 11 (UE) on the left and 18 (CC) on the right. Horizontal: upper panel, MSLP distribution and mean precipitation amount, according to LWT2 catalogue; middle panel, circulation type and cyclone occurrence frequencies versus time and lower panel, 2D correlation maps between circulation type 11 (UE) and 18 (CC) and cyclone occurrence frequencies.
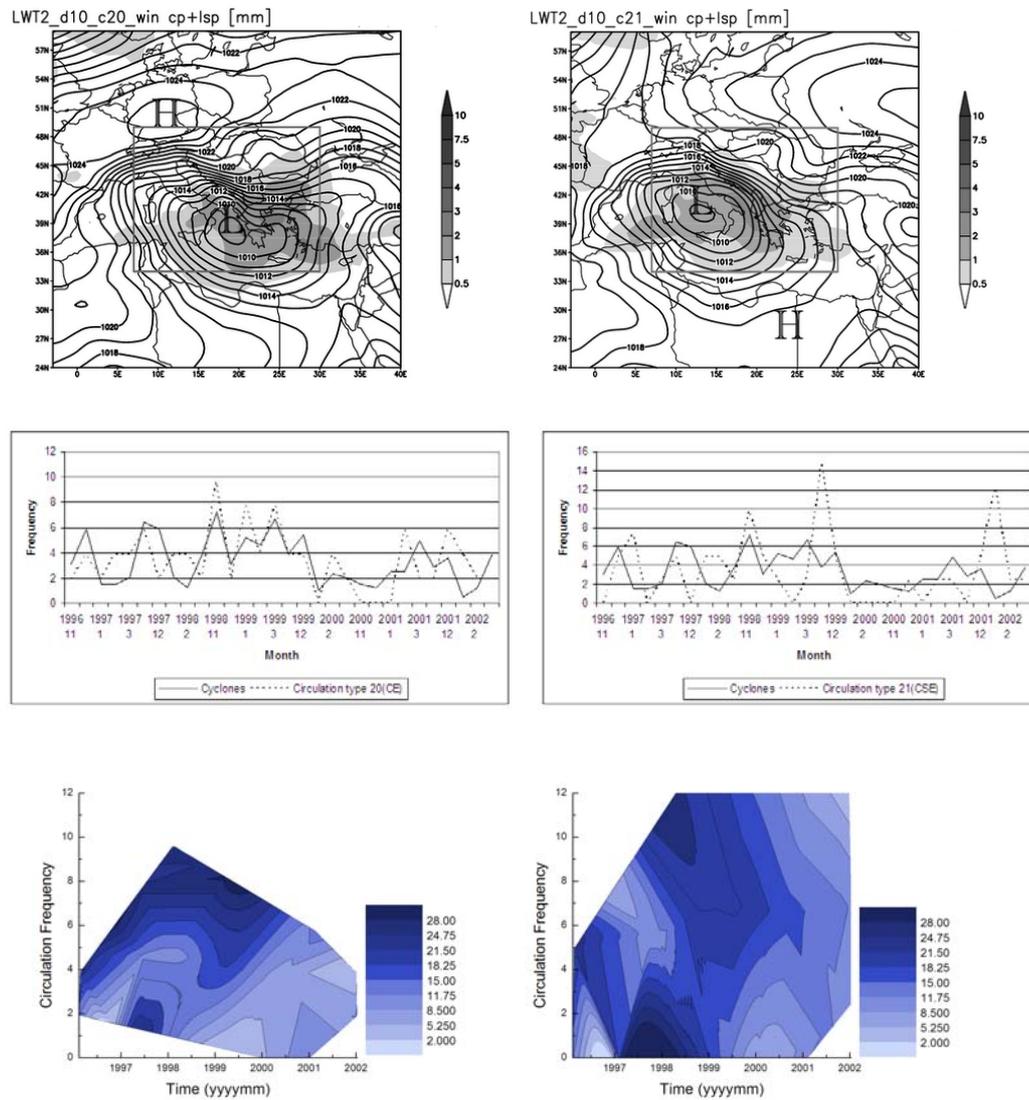
Fig. 5 – As in Fig. 4 but for the circulation type 20 (CE) on the left and 21 (CSE) on the right.

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