ATMOSPHERIC CIRCULATION TYPES IN ROMANIA OVER THE PERIOD 1997-2001

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ABSTRACT. – Atmospheric circulation types in Romania over the period 1997-2001. Atmospheric circulation types represent a substantial issue in weather forecasting, and therefore in meteorological and climatological research. For this paper were considered two classification methods for the atmospheric circulation types: a subjective one (HBGWL/HBGWT) and an objective one (GWT). Both of them are available in COST733 online database, for five years (1997-2001), over Romania. Based on these materials, it also has been made a consideration for the weather types they generated on land. The main results consist in the differences identified between the two classification methods in terms of frequency and synoptic structure as well as the weather types generated at ground level by each circulation type.

Key words: atmospheric circulation types, HBGWL/HBGWT classification, GWT classification, COST733, weather types, Romania

1. INTRODUCTION

A good knowledge together with the correct identification of the main types of atmospheric circulation are of great importance for weather forecasting, as well as for meteorological and climatological research. Jan Kyselỳ *(2008)* states that the influence of atmospheric circulation has on the short and long-term variability of the most meteorological parameters at mid-latitudes is of great significance. The main objective of this paper is the identification of possible connections between different weather types and the circulation types that generates them in Romania.

Over the last decades, a large variety of classification methods had been created, therefore the challenge that now lays in front of us is to find and use the most efficient one for the area considered in this study. That is why, in the following lines will be presented and compared two of the main methods. One of them is subjective, *Hess and Brezowsky European Grosswetterlagen/-typen (HBGWL/HBGWT)*, and respectively an objective method, based on predefined threshold values, the classification *Grosswetter- types (GWT) (Philipp, 2009).*

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At European level, the number of scientific contributions that had been part of the development of this subject is much higher than those for Romania. Jan Kyselỳ, P. M. James and Radan Huth are just a few researchers who gave special attention to the atmospheric circulation types above Europe. There have been elaborated numerous classification methods for the atmospheric circulation. Lamb, Vagengeim or Girs are just a few of them, which had as a major application the synoptic-climatological analyses *(Huth, 2009).*

One of the most used classification methods for Europe is Hess-Brezowski Catalogue, elaborated in 1952. It represents a subjective classification method, containing 10 major circulation types (*Grosswettertypen* – GWT) and 29 subtypes (*Grosswetterlagen* - GWL) *(James, 2006)* which are determined by the distribution of the sea level pressure over Europe *(Kyselỳ, 2008).* Being a macroscale classification, mostly it is used for characterizing the synoptic situation above the north-eastern region of the Atlantic Ocean, as well as for the Central Europe *(Planchon, 2009, after Hess and Brezowski, 1952; Gerstengarbe and Werner, 2005; Kyselỳ and Huth, 2006).* The classification method had also been used and validated for other parts of the continent, for example Bretagne, France *(Planchon, 2009).* The method implies three major classes of atmospheric circulation: *zonal, mixed* and *meridianal*, which are then divided in five main types (GWT): types of *westerly, southerly, north and north-westerly, north-easterly and easterly circulation,* respectively a *low/high* over the Central Europe.

Subjective classifications are based on the knowledge level of the expert and they have their own deficiencies *(Philipp, 2009).* Therefore, in the last decades, there have been developed numerous objective classifications for the atmospheric circulation types, as well. One of them is part of COST (European Cooperation in Science and Technology), Action 733 *"Harmonisation and Applications of Weather Types Classifications for European Regions",* being a software whose goal is creating, comparing, visualizing, and evaluating the atmospheric circulation types classifications *(Philipp, 2014).*

One of the objective methods available on COST733 Software is *Objective-GWL* (GWT), this being the objective and computerized version for Hess-Brezowsky classification. They have the same name and synoptic conditions as in the original classification. Withal, they are filtered so that the minimum allowed event duration is of 3 days – another trait which is preserved from the original one. On the other hand, the major difference between the two classifications is that the objective one has a larger coherency than Central Europe, being homogenous and consistent throughout the years. The original Hess and Brezowsky Catalogue had been used in numerous studies that were evaluating frequencies, event duration changes and possible transitions between GWT types *(Planchon 2009, after Bárdossy and Casspary, 1990; Klaus, 1993).*

Despite its vast importance, the subject is very little discussed in Romania, so far. The first classification of the atmospheric circulation types is made by Nicolae Topor and it was mentioned in *Clima României, vol. I,* (1962). There were established seven circulation types which determine seven weather types based on analyzing the period 1899-1951. A more detailed analysis was made three years later, in a book titled *Circulation Types and Atmospheric Action Centers Above Europ*e written by the same author and his collaborator C. Stoica. They establish a clear set of criteria by which each circulation type is defined, and they also classified the atmospheric processes that took place between 1938 and 1961. The way they named the circulation types is based both on the geographical origin of air masses and their thermal character*:* Westerly circulation, Polar Circulation, Tropical Circulation and Blocking Circulation (Fig. 1). Polar and Tropical Circulations have 3, respectively 4 subtypes. It worth mentioning that after the description of each circulation type, the feature of the weather associated was presented *(Topor, 1965).*

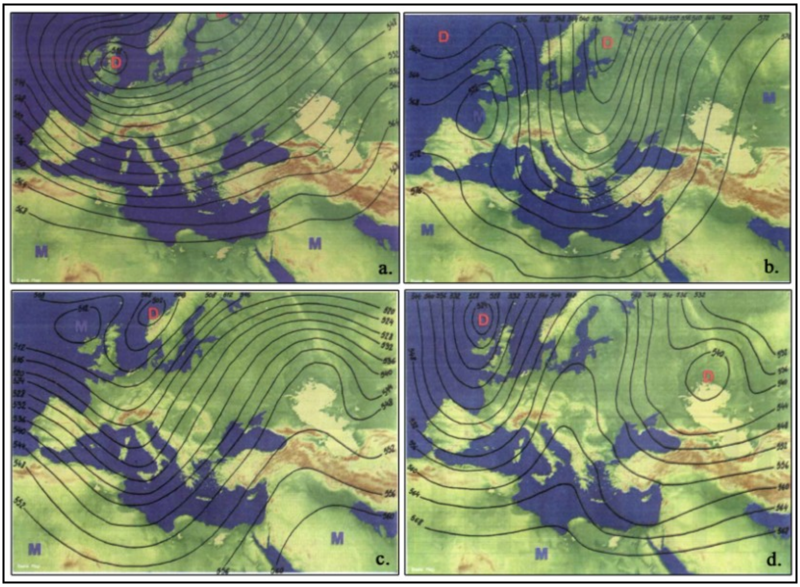

Fig. 1 Circulation types defined by N. Topor and C. Stoica a. Westerly Circulation; b. Polar Circulation; c. Tropical Circulation; d. Blocking Circulation (after Sandu et all, 2008)

Another study regarding the atmospheric types of circulation had been recently established by Lucian Sfîcă (2015). This study is based on the analysis of the daily meteorological bulletins issued by Romanian National Meteorological Administration (NMA) over the period 1980-2001, as well as on the synoptic maps available in the Global Forecast System archive over the period 1948-2001.

However, his study is focused on a relatively small part of Romania, Siret's Valley and the regions nearby. The author proposed first a general classification of the circulation types considering two categories: *radiative* and *advective* synoptic situations. The first ones were integrated in what is called *anticyclonic circulation type (Fig. 2a)*, because the air masses do not present any movement above Romania. The second category of synoptic conditions, the *advective* ones, are those in which the high pressure gradient over Romania determines the air masses advection. In this category four circulation types were included, each one named after the direction of the air masses origins which had been driven toward the South-East Europe: westerly, northerly, easterly and southerly circulation *(Fig. 2 c,d,e,f)*. It is remarkable that there were identified some cases when, for example, during days marked by northerly circulation type it were noticed rising air temperatures, or some cases when on days with southerly circulation a cooler weather was recorded. In addition to these four anticyclone types, the *cyclonic type* also was identified *(Fig. 2b) (Sfîcă, 2015)*.

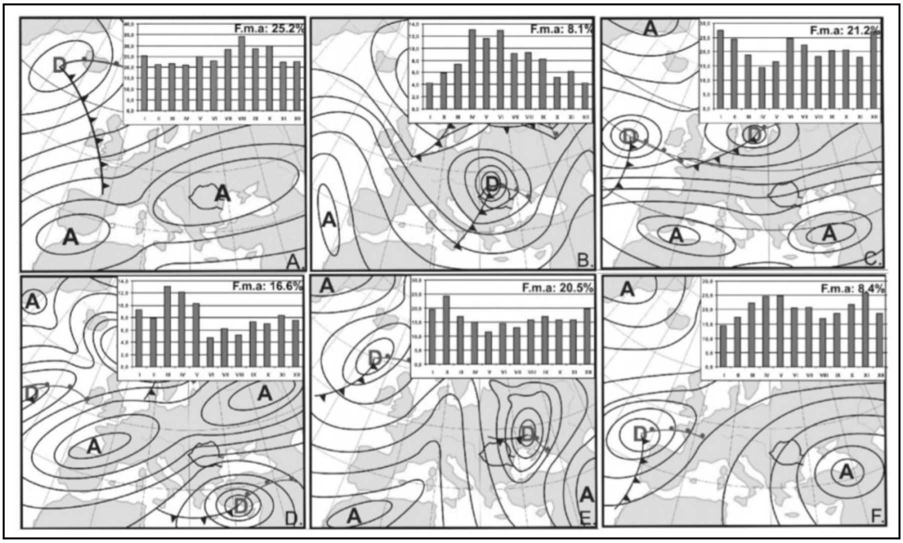

Fig. 2 Circulation types and their annual mean frequency (Fma) a. Anticyclonic circulation; b. Cyclonic circulation; c. Westerly circulation; d. Easterly circulation; e. Northerly circulation; f. Southerly circulation (after Sfîcă, 2007).

2. DATA AND METHODS

For this paper, the analysis was performed over a 5-yr period (1997-2001). Each day was characterized by a certain type of circulation based on two criteria: first according to the original subjective HBGWL/HBGWT classification and second, based on the objective classification GWT. In each case, after the types were established, an analysis of some meteorological parameters (maximum, mean and minimum air temperature, respectively the amount of precipitation) at 4 meteorological stations from Romania was conducted: Cluj-Napoca (410 m), Iași (102 m), București-Băneasa (90 m) and Vârful Omu (2 504 m).

The up-mentioned classification data were extracted from COST733-CAT Database, for the subdomain D10, which is situated on North latitude between 34° and 49° and on East longitude between 7° and 30°. They are freely available on *http://cost733.geo.uni-augsburg.de/cost733wiki/Cost733Cat2.0. (Philipp, 2009).* Furthermore, we employed the *plots* (maps) describing the pressure field distribution for each circulation type for D00 (for more details) and D10 domains from the same database *(http://cost733.geo.uni-augsburg.de/cgi/cost733plot.cgi)*. They were designed to represent the mean sea level pressure (MSLP), by taking into account 9 types of classification, and YR_S01 mode of pre-processing.

The data sets for the main meteorological variables used for analysing the weather types have been downloaded from several databases. Most of them are from the European Climate Assessment & Database *(ECA&D: http://eca.knmi.nl, Klein Tank et al., 2002)*.The data processing was performed by using the Microsoft Excel 2013 15.0.

3. RESULTS AND DISSCUSIONS

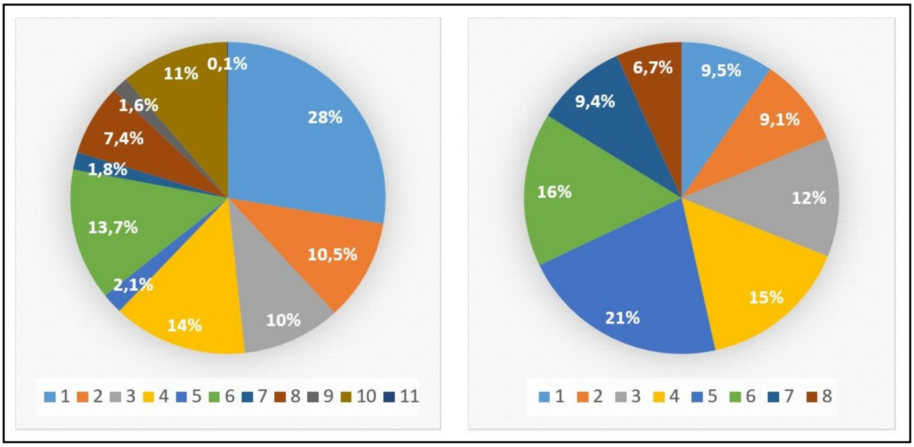

Fig. 3. Frequency of the atmospheric circulation types over the period 1997 – 2001 for GWL classification (left); for GWT classification (right)

For the GWL classification the type I had the highest frequency, of 28 % in all five years considered for this paper, its percentage being twice as much as compared to that of type IV, which is the second most frequent over the analysed period. Type XI had the minimum frequency among all, being present only two days over the entire period. On the other side, in the case of GWT classification, types V, VI and IV were found as the most frequent, whereas, type VIII is the least frequent one (Fig. 3). In terms of synoptic structure, there had been noticed several differences and similarities. Therefore, there are some similarities among the first three types from every classification in D00, due to the presence of a low pressure field over the northern part of the European continent, respectively a high pressure field over the continent's southern region. Their centres are situated over the Atlantic Ocean.

Types II are usually defined by a low pressure centre positioned over the northern basin of the Atlantic Ocean, respectively by a high pressure centre over the southern half of the North Atlantic, located west of the Northern Africa. A small difference was found and it consisted in their spatial extensions. Finally, in the case of types III, a cyclone is located over the Scandinavian Peninsula, with a trough extended southward until the Mediterranean northern coastlines in some cases. The difference between the two classifications consists in the extension of trough: the GWL classification is characterized by its extension over the entire Black Sea region and covering almost the entire Romania, whereas, in GWT classification, our region of interest is under the influence of a ridge extended from Azores High *(Fig. 4)*.

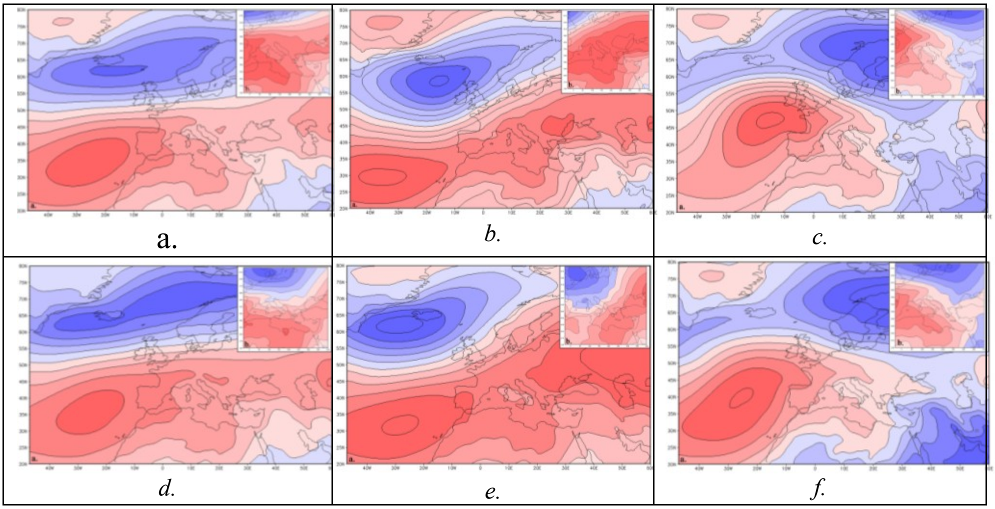

Fig.4. The synoptic structure of the Types I, II, III in GWL (a-c) and GWT (d-f) classifications: Upper right corner: plots for D10.

The impact of these circulation types on weather conditions is described shortly in the following two sub-chapters.

3.1. Weather determined by GWL

GWL classification had different impact from one season to another. Thus, in spring, the highest mean air temperature (14.9 °C) was recorded during type IX *(Fig. 5a)* and the lowest value during types VI (5.4 °C), IV (5.5 °C) and III (5.5 °C). In summer, the highest mean air temperature was around 21.0 °C and they were recorded during the days marked by types I, VII and X, whereas the lowest (17.3 °C) was registered during type III *(Fig. 5b).* In autumn, the highest value (13.8 °C) of the mean air temperature was recorded under type VI, and the lowest (-1.1 °C) during type VII *(Fig. 5c)*. During the winter months, positive air temperature was recorded only under the influence of types I (0.5 °C), II and V (0.1 °C), respectively temperatures below -4.3 °C were recorded when the types VII, VIII and IX were dominant *(Fig. 5d)*. In the case of type XI, the highest value of air temperature was recorded (5.6 °C), but it should not be omitted the fact that this average is calculated for just 2 days (there were only two days when type XI occurred).

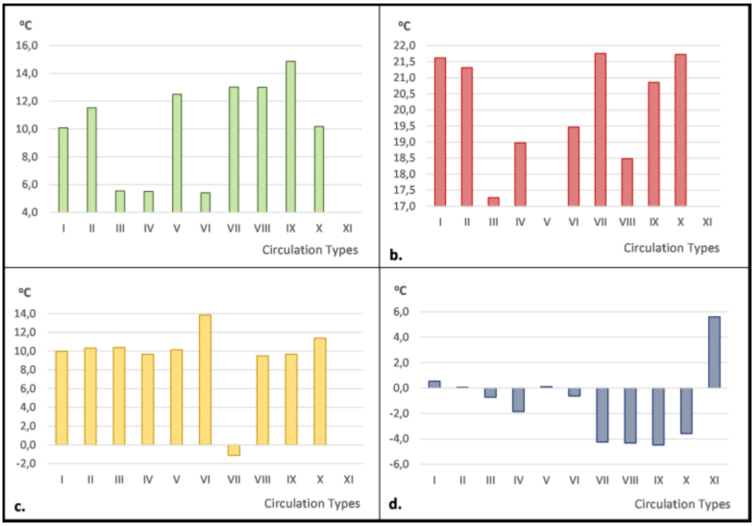

Fig. 5. Mean air temperature recorded under the influence of GWL classification types
a. spring; b. summer; c. autumn; d. winter

Regarding the amount of precipitation recorded, it is outstanding the fact that types I and VI determined the largest amounts, regardless the season over the five years analysed. Nevertheless, it is easily to notice that the maximum amounts in spring and summer registered under the influence of type VI, respectively in autumn and winter under the influence of type I. The minimum amounts were recorded during types II, VII, IX and X *(Fig. 5)*.

3.2. Weather determined by GWT

Based on the GWT classification analysis, we found that there is only for the type I that was associated to high mean air temperatures all over the year. However, it generated the maximum values in the transition seasons: spring (13.5 °C) and autumn (12.1 °C) *(Fig. 6 a, c)*. During summer, when at high altitudes the type VII was dominant, at ground level the maximum mean air temperature (22.6 °C) as well as the minimum one (17.8 °C) was registered during type VIII *(Fig. 7b)*. In winter, the same type VIII determined the minimum mean air temperature, of -3.8 °C, but it was type III, which was associated with the maximum one (1.3 °C) *(Fig. 6d)*.

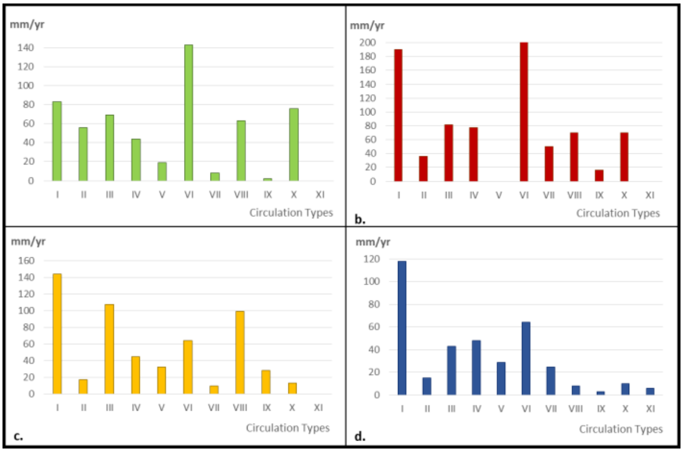

Fig. 6 The amount of precipitation accumulated under the influence of GWL circulation types:a - spring; b - summer; c - autumn; d – winter

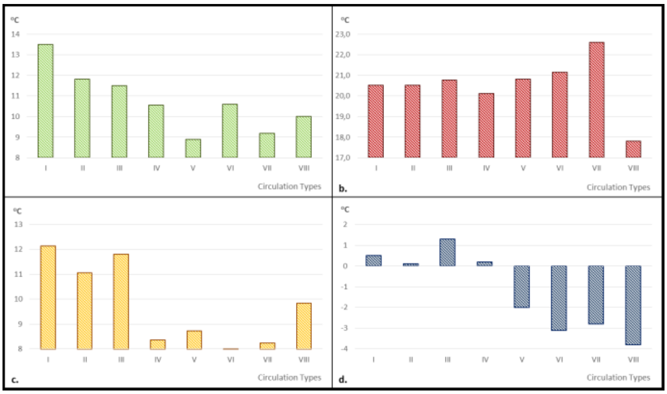

Fig. 7 Mean air temperature recorded under the influence of GWT classification types:a - spring; b - summer; c - autumn; d – winter.

On the other hand, types II, VII and VIII were associated with small amounts of precipitation, regardless the season. But is not the case of finding similarities among types and seasons in terms of maximum values. Therefore, under the influence of type III the maximum amount was registered in spring, of type IV in summer and autumn, respectively of type I in winter *(Fig. 8)*.

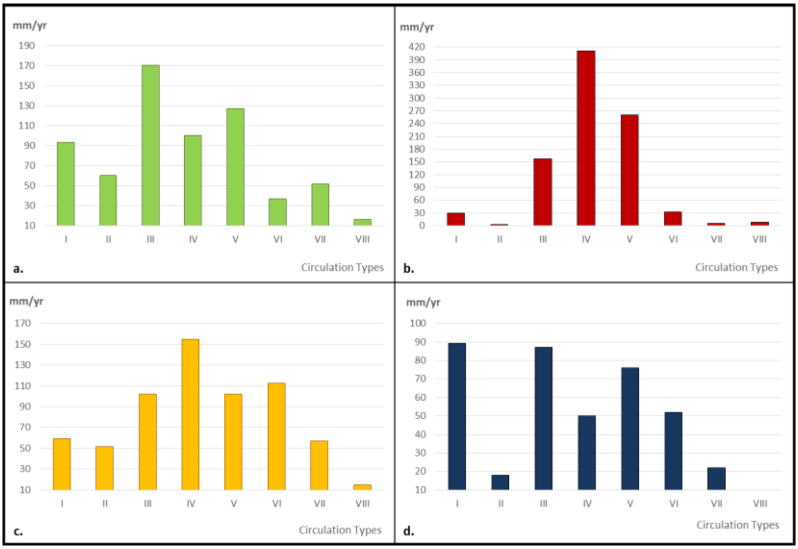

Fig. 8 The amount of precipitation accumulated under the influence of GWL circulation types:a - spring; b - summer; c - autumn; d – winter.

4. CONCLUSIONS

Comparing the two methods of atmospheric circulation classification, we can conclude that there are several differences regarding their frequency, synoptic structures and of course, the weather conditions they generate at ground level, but these distinctions are justified because the methods themselves are very different. However, as stated above, there are a few similarities, too. Also, it should be mentioned that connections between atmospheric circulation types and weather types are quite obvious. It remains the challenge to identify and use the most appropriate one for the Romanian territory. That is why, this paper represents just a small part of research on this subject and it should be developed in the future.

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