BLOCKING CIRCULATION AND ITS IMPACT ON AGRICULTURE

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Abstract *The physical state of the atmosphere finds itself in continuous change. As such, it can be characterized as generating complex physical processes and out of these physical processes, a significant impact upon agriculture is imposed by severe weather events. All the heights that characterize the state of the atmosphere and of the oceans do possess a significant spatial but also temporal variability. At synoptic level, the atmospheric blocking circulation is determined by the persistence of very strong anticyclonic circulation, which extends on the entire tropospheric column. As such, the reorientation of the jet stream from its normal quasi-zonal circulation towards a polar direction is, as such, due to the jet stream's barotropic structure. The main aim of this paper is to analyse and present a short climatology of the blocking circulation events in the time scale 2000-2005 and their influence on agriculture. Throughout this paper the main meteorological parameter which will be analysed is the geopotential surface at non divergent level (500 hPa). The atmospheric blocking circulation is at best detected in the upper surface of the atmosphere. As such the presence of a blocking circulation above a region is equivalent to the existence of a large area of high pressure, which is characterized as being slow compared to a low-pressure area. The mean latitude region is characterized as having westerly winds at the surface as well as in altitude. The study concludes that the appearance and the persistence of the atmospheric blocking circulation events may, in some extent explain, the persistent drought especially in Câmpia Română. Besides this, another important blocking circulation event, which occurred in March 2005, led to severe flooding in the western part of Romania.*

Keywords: *blocking circulation, agriculture, geopotential height, drought, flooding*.

INTRODUCTION

Atmospheric blocking is a factor with a significant contribution to low frequency climate variability. A special attention on this phenomenon has been manifested in recent years by specialists in the field of climatology precisely because of the fact that the severe weather events associated with this type of weather increase in both frequency and intensity.

Studies in the field of operational meteorology (AUSTIN, 1980) support the idea that these blocking episodes, whether prolonged or less prolonged, can be felt during an entire season or during several seasons following this event. The seasonal changes imposed in a certain region by the anticyclonic block circulation cause changes in the thermal and precipitation regime, as well as the appearance of climatological extremes, whose effects directly influence the life of the people from an affected area.

The study of the block circulation is particularly important, because this type of circulation leads to the stagnation of the weather aspects in the blocked region. Thus, in case of block, the same situation can be maintained for a long period time, fluctuating from a few days to a few weeks. The stagnation of air masses can cause extreme weather with an impact on agriculture, such as drought, temperatures well above the climatic average or well below the climatic average, depending on the season and significant amounts of rainfall. In the Romanian operational research (TOPOR & STOICA, 1965) a classification based on the isohypse of the advection temperature at the 500hPa level was proposed, fact which presented a specific orientation towards the atmospheric process. In the western part of Romania, the block

circulation occurs in 10% (ŞERBAN, 2010) of cases, taking into account the fact that the European continent is crossed by a high-pressure axis, this axis being located between the Black Sea and the English Channel. Thus, the path of the North Atlantic or the Mediterranean cyclones is blocked towards Romania. Therefore, in winter the weather is characterized by a high degree of nebulosity and with little rainfall, and the summer denotes a low degree of nebulosity, with advections of both warm and dry air.

Within the study of the types of circulation, the block circulation has an important role in the evolution of the synoptic systems at a regional scale, but also at a mesoscale (local) or a global scale. Block circulations, generally associated with anomalies in the fields of pressure, temperature, geopotential and wind, result in anomalies in all-weather aspects. The types of synoptic configurations (BLUESTEIN, 1993) associated with atmospheric blocks are Omega type block, Rex type block and the Ring of Fire configuration.

The study of the variability of the geopotential field shows that, at mid-latitudes, the variation is much higher for the low frequency component. A significant criterion for the identification of the longitudinal distribution of the blocking ridges can be expressed by the difference between the geopotential height of 500 hPa between the latitudes of 60° N and 40° N. The difference between the two levels, also known as the blocking index must be a negative value to be characterized as a block circulation (LEJENAS & OKLAND, 1983). Another condition for imposing a blocking feature is the temporal persistence. Thus, the duration is arbitrary, being chosen in accordance to the synoptic conditions, but usually it is set at a range of five days (REX, 1950).

Like many other synoptic structures, it is not easy to rigorously define such a configuration, with all elements of subjectivity appearing in all definitions. From a synoptic point of view, the atmospheric block is determined by the persistence of strong anticyclones, on the entire tropospheric column. A factor that must be taken into consideration, in the analysis of such synoptic situations, is the analysed location. The mid-latitudes, those located between 30° and 60° north and south latitude, provide different meteorological conditions compared to tropical conditions due to the uneven distribution of kinetic energy through transient disturbances (ELLIOT & SMITH, 1948).

MATERIALS AND METHODS

This analysis uses materials from 2000 to 2005 archive. Among the parameters analysed are the height of the geopotential at 500 hPa level, the average pressure at sea level, the temperature at a height of two meters and the amount of precipitation recorded at stations in the western of Romania (MĂRĂZAN et al., 2020). The chosen period was from January 1st 2000 to December 31st 2005. Also, for the on the ground identification of some block circulations, data from the air quality monitoring stations were used. Among the types of block circulations, which are significant to mentioned and described in order to understand the research methodology are: Omega type block, Rex type block, Ring of Fire (Blocking High) and Cut-off low (Blocking Low) (LACKMANN et al., 2017).

1. Omega block

This type of block has the isobars similar to the Greek letter Omega. The meteorological characteristics of this circulation differ depending on the area. In the region under the influence of a Rex block, the wind is weak, the weather is generally calm and without precipitation for a long period of time. In the areas corresponding to the troughs associated on either side of the Omega type block, the nebulosity degree is high and there will be significant precipitation. The Omega type block is characterized by a high-pressure area

located between two low pressure areas. The area above which such a synoptic configuration stagnates will be characterized over a period of ten to fourteen days by lack of moisture. At the extremity of the Omega block there will be troughs that are characterised by a high degree of nebulosity and intense precipitation.

2. Rex block

The Rex block has a dipole structure, in which the anticyclonic circulation is superimposed over a cyclonic circulation. In this case, a high-pressure area is observed, delimited by a strong ridge having associated a low pressure are, delimited to the south by a wide trough. The atmospheric current flows along the ridge, the western current then suffering a bifurcation. The southern arm of the jet stream associated with this blockage deviates to the south and then returns to the general flow. The flow rate of this arm is slower, and the lifespan of such a structure is about six to eight days.

3. Ring of Fire (Blocking High)

The Ring of Fire, also known under the name of Blocking High refers to an area of high pressure installed at high latitudes, which blocks the western tropospheric flow, without the input of other areas of low pressure. This high-pressure area can stagnate over a region for several days, especially if the jet stream is weak. High pressure systems can persist for a long time over the same region, given the fact that the polar circulation and jet stream are weaker. In the centre of the high-pressure region the air is more stable, but at its edge convective activity may occur. Thus, it is possible that around the high-pressure region an unstable convective ring may appear, which will lead to the production of anticyclonic rotating thunderstorms around the high-pressure area. It is noteworthy that the atmospheric air is characterized by a high stability in the centre of the anticyclone. When such a block stagnates over an area for a long time, the lack of moisture creates the ideal conditions for both drought and forest fires. The stability of the air in the anticyclone decreases from the centre to the periphery, so that, at its extremities, the conditions necessary to trigger the afternoon convections can be met. These convections practically delimit the high-pressure cell, moving clockwise. The visual effect observed in satellite images is similar to that of a fire belt.

4. The Cut-off low (Blocking Low)

The low geopotential nucleus is a cyclonic configuration, unaccompanied by a high-pressure zone that interrupts normal tropospheric circulation. This configuration does not represent a real block situation, but only contributes to the southward movement of the basic flow and not to an interruption of it. Cyclonic cut-off usually occurs when high-altitude winds change direction, toward higher-latitude regions and by that leaving low-pressure circulation behind. Isohypses delimit the minimums at higher altitude. This type of block is stronger than the Rex block. The clustering trend of these systems is noticeable. The prediction of the precipitation areas in the case of cut-off nuclei is easy to perform at the synoptic scale, but quite difficult to locate at smaller scales, as for example at mesoscale. This type of block can stagnate, and both high nebulosity and rainfall may persist. These nuclei tend to stagnate for days in the blocked area at ground level or aloft of the area, until they are consumed or move very slowly. Rainfall in the affected areas is usually significant in quantity, the manifestations accompanying such a structure can take much more severe forms than in the case of Rex blockage. In the south-eastern part of Europe, but also in Romania, the block circulation is characterized by diverting the cyclonic disturbances generated in the Atlantic Ocean towards the north and northeast of the European continent.

RESULTS AND DISCUSSIONS

1. The 2003 summer drought caused by the atmospheric block

It has been found out that the timescale 2001 – 2003 was characterized as being a period of severe drought for both the Romanian Plain, but also for the western part of Romania. The occurrence of block episodes at the end of winter (February - 20 days), during the spring (April - 12 days, May - 8 days) and during the summer (July - 12 days) largely explains the drought. Two phenomena associated with the block circulation have raised problems in the field of agriculture (SANDU ET ALL, 2010). The severe drought was also observed by the fact that the Danube waters reached an extreme minimum, the second one after that of 1947. Being located at the periphery of a high-pressure block system, the summer of 2003 was the second warmest summer in the history of meteorological measurements from Romania until that date after 1946.

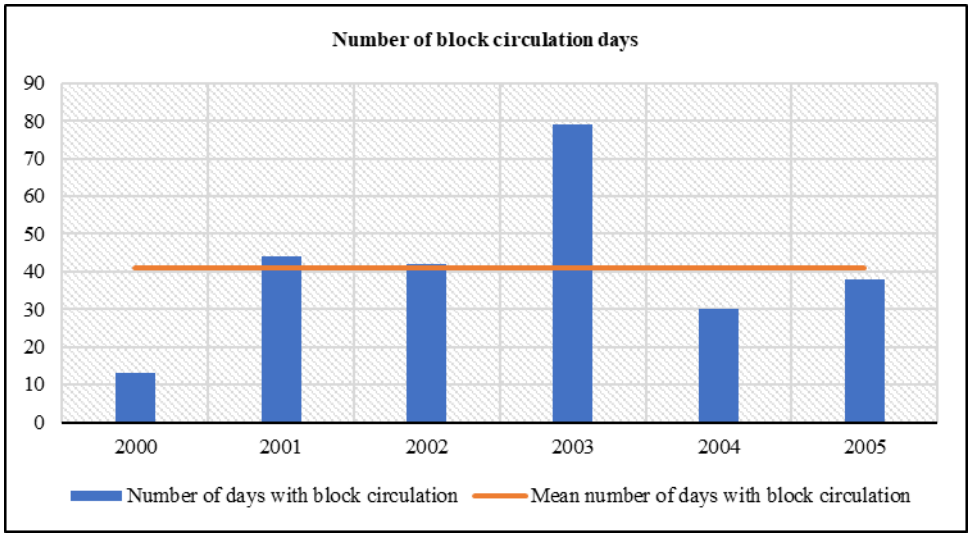

Fig. 1. Number of block circulation days in the timecale 2000 - 2005

The sudden increase in the number of days with block circulations in 2003 is related to those blocks in the eastern Atlantic Ocean, which blocks have caused significant damage in Western Europe. At the beginning of the summer of 2003, a block caused by an anticyclone stationed in the western part of Europe caused a prolonged drought at first in the southern part of Europe, and later through the advection of hot air of African origin, it entered the Europe of west and then in central Europe.

Drought is a complex phenomenon, characterized by insufficient moisture in the atmosphere and soil, especially in the area of the root system and increased evapotranspiration potential (BERBECEL & STANCU, 1970). Winter droughts cause a decrease in the soil water supply required in the spring, at the beginning of the vegetative cycle of plants. In the case of spring droughts, the vegetative cycle is delayed, and summer drought causes damage to agricultural crops depending on the type of crop and their phenophase (CHEVAL, 2003).

It has been observed that since 2001 there has been a tendency to increase the number of days with atmospheric blocks. The trend was maintained in 2002, and a maximum was reached in 2003, when, according to the analysis of geopotential fields, a number of 79 days characterized by atmospheric blocks were recorded (Figure 1).

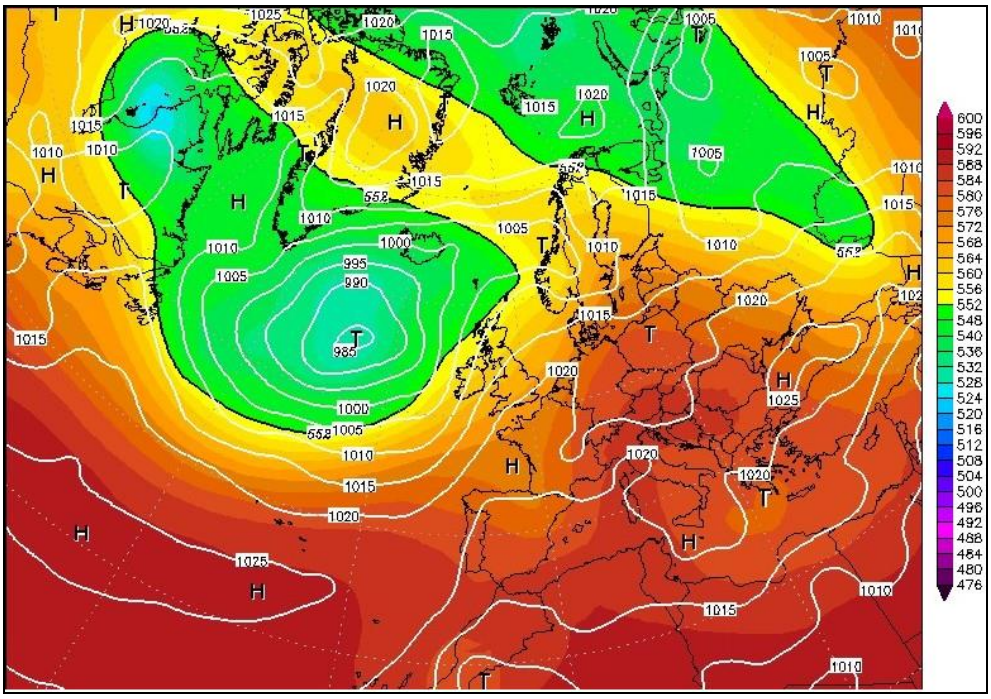

Fig. 2. Height of the geopotential field at mean sea level and at 500hPa on the 5th of June 2003, 12.00 UTC (post-processed according to www.wetterzentrale.de)

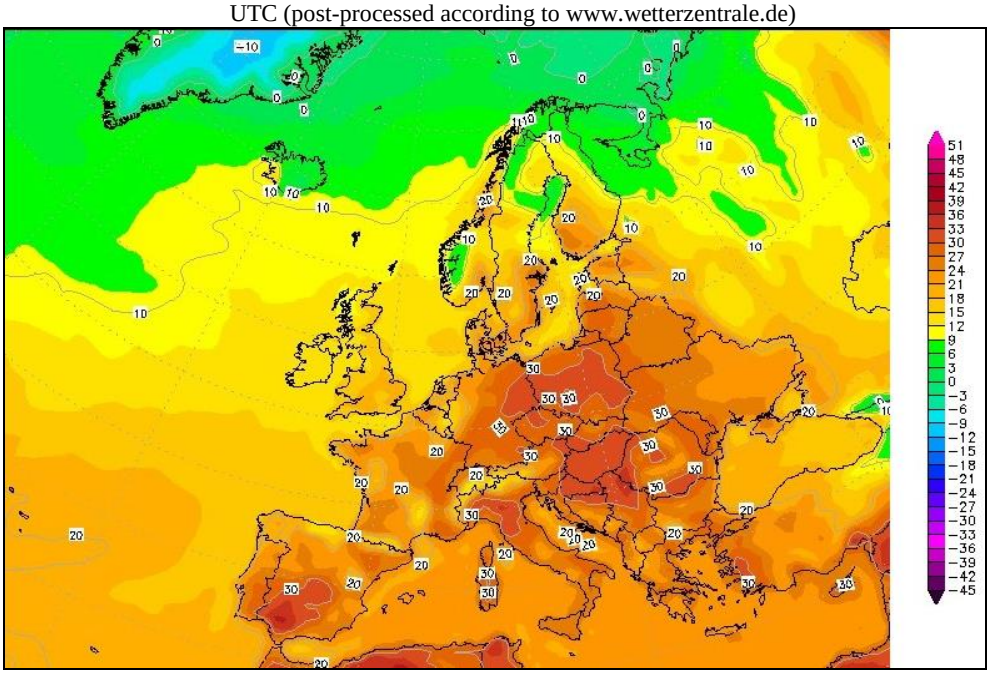

Fig. 3. Temperature at the height of 2 meters on the 5th of June 2003, 12.00 UTC (post-processed according to www.wetterzentrale.de)

According to the 500hPa geopotential height map, (Figure 2) the footprint of the block shows high positive values in the southern part of Europe, and in the western part of the Balkans there are values of approximately 580 hPa. The western and southwestern area of Romania was under the influence of a high-altitude area of the geopotential field (HOFSTÄTTER et al., 2017).

The precipitation shortage is well highlighted by the negative nucleus that spatially corresponds to the centre of the block footprint, in the Atlantic Ocean, in the vicinity of the north of Great Britain. An area with positive anomalies is outlined near the Azores, to the west of the Iberian Peninsula.

In the area which was under the influence of the atmospheric block, high temperature values were registered at 12.00 UTC, values that reached 34° C at Sânnicolau Mare station, 37° C at Timişoara station and values of 32° C in the southwest area of Romania (Figure 3).

The year 2003 was divided into two periods. The period between January and June, this interval representing the winter and spring months and the second period between July and December, the last representing the summer season, autumn and beginning of winter. During the second half of 2003, most of the days characterized by atmospheric block circulation were registered. This explains the drought phenomenon that affected the western part of Europe, but also the Romanian territory (Figure 4).

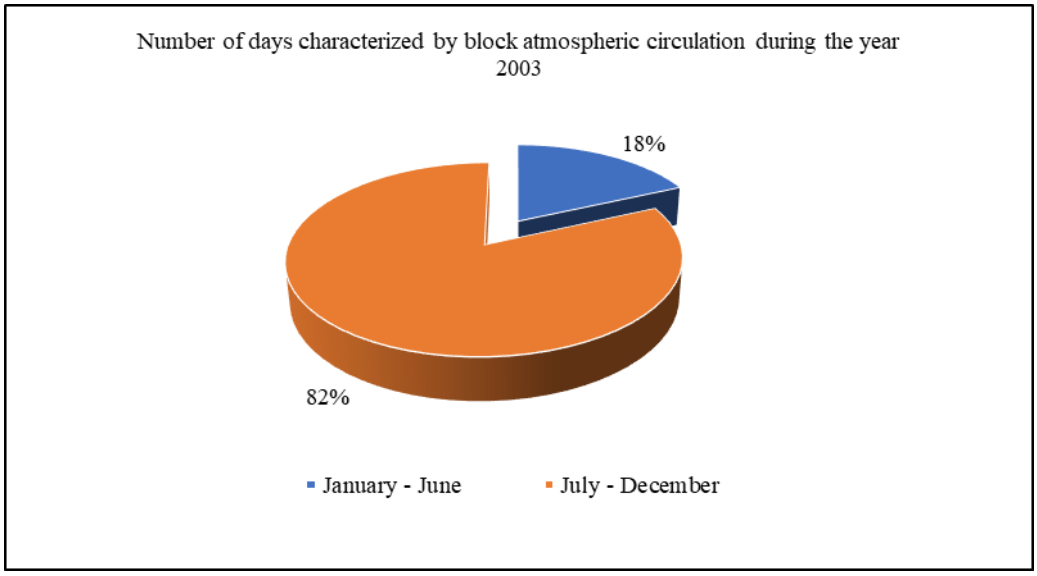

Fig. 4. Number of days characterized by block atmospheric circulation during the year 2003

2. The April 2005 flooding caused by the atmospheric block

From the point of view of extreme meteorological phenomena in our country, the year 2005 represented a landmark in terms of dangerous meteorological phenomena. The presence on the entire tropospheric column of two positive geopotential nuclei and pressure corresponding to the two blocking areas, in the Atlantic Ocean and in the area of the Russian Plain was noted (NIETO et al., 2005).

The territory of Romania was under the influence of a low-pressure area, which originated from the Mediterranean Sea, and the ground low pressure area had a well-defined correspondent aloft, at the 500 hPa level. Most of the Romanian territory was in the ascending

front part of the low-pressure system. Also, in the south of the continent there was an area of high pressure, which related to the North African Anticyclone. In the eastern part of the European continent there was a warm sector due to the rear of the Southeast European Anticyclone. The presence of these types of baric fields forms a dam in the evolution of the cyclone located above Romania. Due to the baric blockage, a retrograde movement was reached in the low-pressure system, and the moisture supply of this cyclone was made mainly from the Black Sea area.

If the deep convection in the presented situation persists for a longer period of time, then it would have processed this accumulated moisture (ION-BORDEI, 1983). The initiation of convection in connection to a synoptic scale anticyclone or a ridge typically occurs on the edges of the suppressed area, where there are sudden thermal boundaries. This leads to the Ring of Fire effect, in which the active convection surrounds the area of the most intense suppression at the synoptic scale. Due to the two flooding situations from April 15th and from April 18th, large flows on most of the rivers in Banat were recorded. Thus, these flows did not manage to mitigate themselves, and the precipitations that fell further on had the rivers still at dangerously high levels. It is important to mention that the flooding in Banat were not caused by significant quantitative precipitation during a short time (Figure 5).

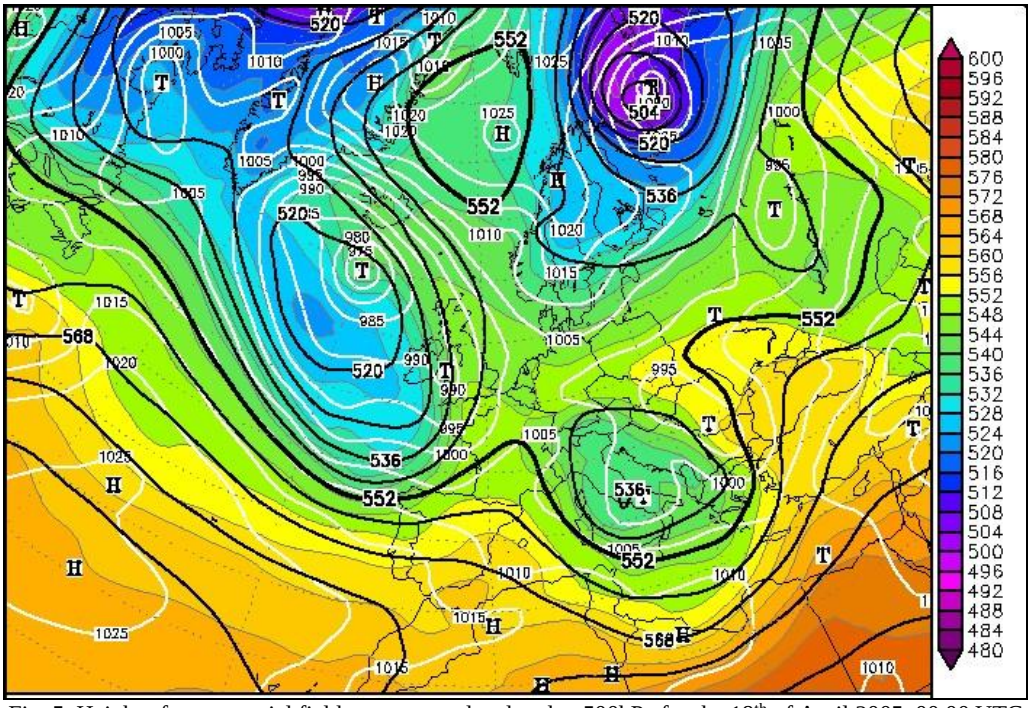

Fig. 5. Height of geopotential field at mean sea level and at 500hPa for the 18th of April 2005, 00.00 UTC (post-processed according to www.wetter3d.de)

The accumulation of precipitation during the two flooding events caused significant damage to both the goods of the population and agriculture in western part of Romania. Agriculture suffered because the soil was clogged with water and debris from floods. The withdrawal of the waters was not fast enough to allow the development of agricultural activities in 2005. At the Oravița meteorological station, an absolute record of 226 l/m^2 was

registered due to the failure of the Eastern European ridge. At the Timişoara meteorological station, over 70 l/m^2 were registered during the mentioned period, and at the stations from the hallow areas (Reșița and Caransebeș) values of over 100 l/m^2 were registered (Figure 6).

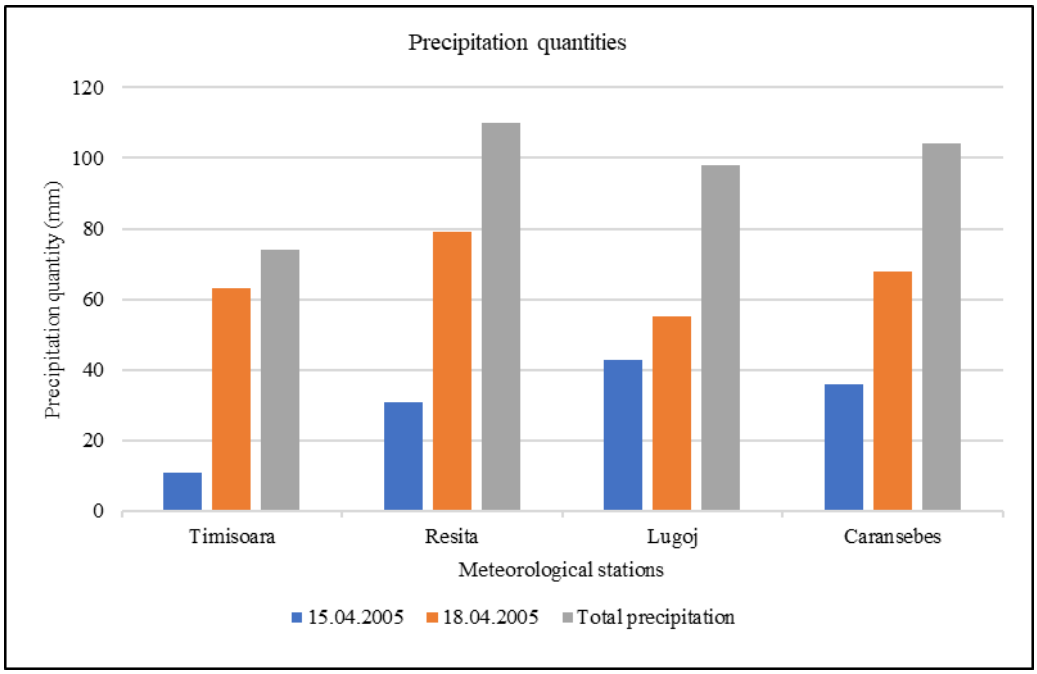

Fig. 6. Precipitation quantities

CONCLUSIONS

The purpose of this study was to highlight the way in which atmospheric block events in the Euro-Atlantic region influence the meteorological phenomena and especially those phenomena closely related to agriculture in the area of Romania.

The analysis presented throughout this paper reveal two diametrically opposed cases of severe weather as results for agriculture. The drought of 2003 is the direct effect of the block circulation in the western Euro-Atlantic area, an area where the air masses of oceanic origin were blocked and could not enter the continent. The advection of hot and dry air of African origin took place on the classic trajectory of the advections of hot air on the southern circulation.

The opposite of the 2003 drought, namely the 2005 floods, was a turning point in the organization of the national flood alert system. The detachment and the isolation of the cut-off cyclonic core from the extension of the Icelandic cyclone basin produced impressive amounts of precipitation. The statistics of the block circulations associated with the territory of Romania in the timescale 2000-2005, showed an appearance and a persistence of the blocking episodes from the first months of 2003, in which usually such circulations do not appear, and as such the persistent drought in the area of the Romanian Plain but also the Western Plain can be explained. The year 2005 was characterized by frequent and long-lasting block circulations, especially in February and March when in the Atlantic Ocean but also in the continental Europe there were extreme weather events, and in Romania the strongest flooding situation in series of climatological analyses occurred.

The results of this paper are a starting point for future studies, especially in the field of operational meteorology and agrometeorology. The North Atlantic oscillation is one of the most important ways of variability of air masses in the Northern Hemisphere and has a special influence during the winter. The integration of the North Atlantic Oscillation in the research of the block circulations and in the research of the extreme meteorological phenomena associated with them represents topical research in the conditions of climate changes.

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