CONSIDERATIONS REGARDING THE FORECASTING OF AGRICULTURE RELATED SEVERE WEATHER EVENTS IN THE WESTERN PART OF ROMANIA

V. MĂRĂZAN[1,3], Karina Bianca Ioana HAUER[2], V. D. MIRCOV[1], A. OKROS[1], Antoanela COZMA[1]
[1]Banat's University of Agricultural Sciences and Veterinary Medicine "King Mihai I of Romania", 300645, Timisoara, Romania
[2] Doctoral School, West University of Timişoara, 300223, Timişoara, Romania.
[3]Department of Ground Communications, Foundations and Cadastre (CCTFC), Politehnica University of Timişoara, 300006, Timişoara, Romania
Corresponding author: vladmarazan@gmail.com

Abstract. *The aim of this paper is to analyze and highlight the most important meteorological parameters which are in strong bound with severe weather events and their impact on agriculture in the Western part of Romania. Forecasting severe weather events is one of the most challenging tasks in operational meteorology. The complexity of the forecasting process comes from the large amount of data which is to be analyzed in order to issue a severe weather alert. Nowcasting is used as a short-term three hour forecast in which severe weather events might appear. It is usually issued with the help of the Weather Surveillance Radar either by a forecaster or by a computer software. Severe weather events such as squalls, supercells and flashfloods tend to become normal under the current climate change situation. One of the most important areas in which climate change and its associated severe weather events produce important damage is agriculture. The climate of a region is determined by factors such as physical, dynamic and radiative geography. They directly affect spatial and temporal variations of climatic elements in a given territory. The Western part of Romania is characterized as having a warm temperate continental climate with moderate humidity originating from the South and South Western part of Europe. By analyzing the synoptic situation, the convection indices (KI, CAPE, CTI, TTI) together with RADAR and satellite images, weather related hazards are identified and hazard maps are compelled. Due to the humid air, which originates from the South Western part of Europe, convection is initiated and severe thunderstorms may develop. Risks associated with Cumulonimbus clouds (hail, squalls, flashfloods) account for the majority of the agriculture-related severe weather events. This study points out the importance of agriculture related severe weather forecasts as well as mitigation strategies and adaptation measures for climate change.*

Keywords: *severe weather events, agriculture, sustainable development, Western Romania*

INTRODUCTION

Severe weather has affected human society since the beginning of recorded history and certainly long before then. Humans, along with every other living being on Earth have adapted to a certain range of variabilities in the weather. But not only humans have been affected by severe weather events. One of the most by severe weather events affected areas is agriculture. Though agriculture in Romania continues to achieve enhanced productivity due to scientific research and development, hazards such as severe weather events affect the crops and as such reduce the quality and quantity of the harvest. Every year, droughts, floods, heat waves, storms cause destruction and significant agricultural losses in various regions across Romania. During the last several decades there has been an increase in both frequency and severity of severe weather events (BUSUIOC, 2010).

Due to the local but also regional air circulation, the Western part of Romania experiences a warm temperate continental climate with moderate humidity throughout the entire year, without excessive dry season and relatively moderate summers. There is a well-defined thermal difference between the warm and the cold season. The Western part of Romania has a large opening in all directions of the wind, so that advections of different air masses occur. Rain is usually determined by cyclonic formations (MIRCOV, 2017). Due to the Carpathian dam, weather fronts tend to have a higher frequency in the Western and South – Western part of Romania and frontal rainfall occurs.

Severe convective storms are those that produce strong winds, hail, extensive lightning, heavy precipitation and tornadoes. The term severe is typically used in operational meteorology when some variables exceed some specified thresholds, as wind speed exceeding 25 m/s or hailstones larger than 2 cm (DOSWELL, 2001). Usually, severe convective storms form under the influence of atmospheric instability, where more air masses meet together. The ingredients for creating severe storms are the presence of a lifting mechanism, low level deep moisture, instability and wind shear.

MATERIAL AND METHODS

For this study, the Western part of Romania has been selected because of the atmospheric circulation, which allows the mixing of both hot and humid air masses as well as cold and dry air masses. Weather data from three weather stations has been analyzed and processed. The analyzed meteorological parameters include monthly average temperature, monthly maximum temperature, monthly minimum temperature, precipitation quantity, number of days with squalls, number of days with hail and solar radiation. Data regarding the following stations has been used: Caransebeş, Vărădia de Mureş and Arad. These stations all represent a different landform. Data from 1979 to 2009 has been processed.

Table 1.

Weather stations used for the study

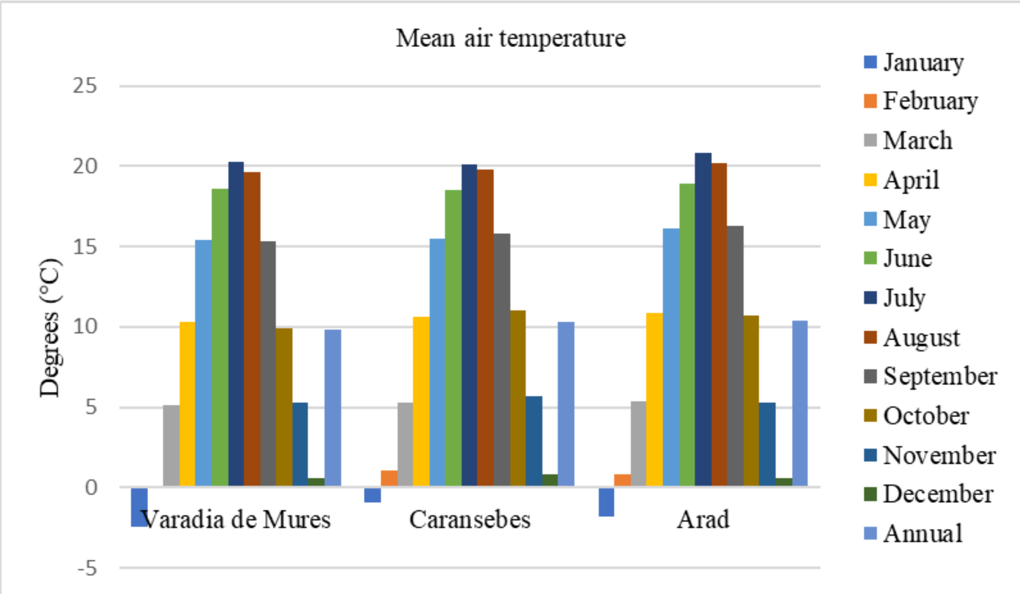
Weather station	Altitude (m)	Elevation level	Geographical coordinates		River basin	Year of establishment
			Latitude	Longitude		
Caransebeș	241	Hallow	45°25’	22°15’	Timiş	1896
Vărădia de Mureș	156	River valley	46°10’	22°09’	Mureș	1953
Arad	117	Plain	46°08’	21°21’	Mureș	1935

Besides data from weather stations, synoptic conditions together with instability indexes and associated weather events are discussed. Precipitation and air masses have always been closely related. ŞERBAN (2010) described to most important air masses which affect the Western Part of Romania. The Polar air masses have the highest frequency. The unstable, cold and wet air masses which originate from the West and North West have a higher frequency during the summer due to the general atmospheric circulation and to the Azores Anticyclone. This air masses are known as maritime polar air masses and usually are present also during the winter and cause significant amount of precipitation. Another air mass, which originates also from the Azores Anticyclone, is the old polar maritime air mass. This air mass travels the continent and tends to have the peak points during late spring (May – June) and during the winter months (December). The continental influence is felt during the winter because of the development of the Scandinavian Anticyclone. Cold, dry and stable air masses originate from the North and North-Eastern Europe. Because of the Carpathian orography, these air masses do not influence the entire year, but reach the peak in December (Ion-Bordei, 1983). Tropical air masses originate from the Northern part of Africa and are influenced by the Subtropical Ridge. After reaching the Mediterranean Sea, these air masses are influenced by the Mediterranean cyclones (Topor et Stoica, 1965). Due to the high degree of humidity, these air masses are able to produce important amount of precipitation. Peak months are usually between the beginning of summer (June – July) and in winter (December). There are also some continental tropical air masses, which are drier and they produce advection of high temperature together with snowmelt in winter.

1. Air temperature

Table 2.

Mean monthly and mean annual air temperature for the timescale 1980 – 2010



Mean monthly air temperature range between -2.4°C in January (Vărădia de Mureş), -1.8°C in January (Arad) and -0.9°C in January (Caransebeş) to 20.8°C in July (Arad), 20.3°C in July (Vărădia de Mureş) and 20.1°C in July (Caransebeş). The most winter days, with daily maximum temperature under 0°C were recorded in Arad (22 days) and the least in Vărădia de Mureş (12 days).

2. Wind pattern

Wind pattern is characterized by wind speed and frequency. Caransebeş had 50.5% of days with wind and 49.5% windless days. The wind blew mostly from South – Eastern (15%) and Southern part (14%). Wind speed was in mean 3m/s. Arad presents more than 70% of the days with wind patterns and has a fluctuant wind direction, the South – Eastern pattern accounts for 15%, the Northern pattern for 11.5% and the Southern pattern for 10.5%. Wind speed in Arad tends to be at an average for all directions, at around 2.6 m/s. Vărădia de Mureş is characterized by a more windless reign. North-Western pattern, which accounts for 15.9%, a Western pattern which accounts for 6% and wind speeds up to 3 m/s make up the wind pattern in Vărădia de Mureş.

3. Precipitation

Due to the humid air masses which come from the Southern part of Europe, the quantity of precipitation increases from the West towards the East. The mean quantity of precipitation for the plain area is 600 mm in the Western part and increases to 700 mm towards the Eastern part and reaching almost 900 mm in the mountain area. During the winter months, precipitation quantity is low, with values ranging from 30 mm (Western Plain) to 65 mm (Caransebeş area). During the summer, convective situations produce an important quantity of precipitation in a short time scale. The least precipitation occurs during the winter months. Spring and autumn each account for about 22% of the yearly precipitation.

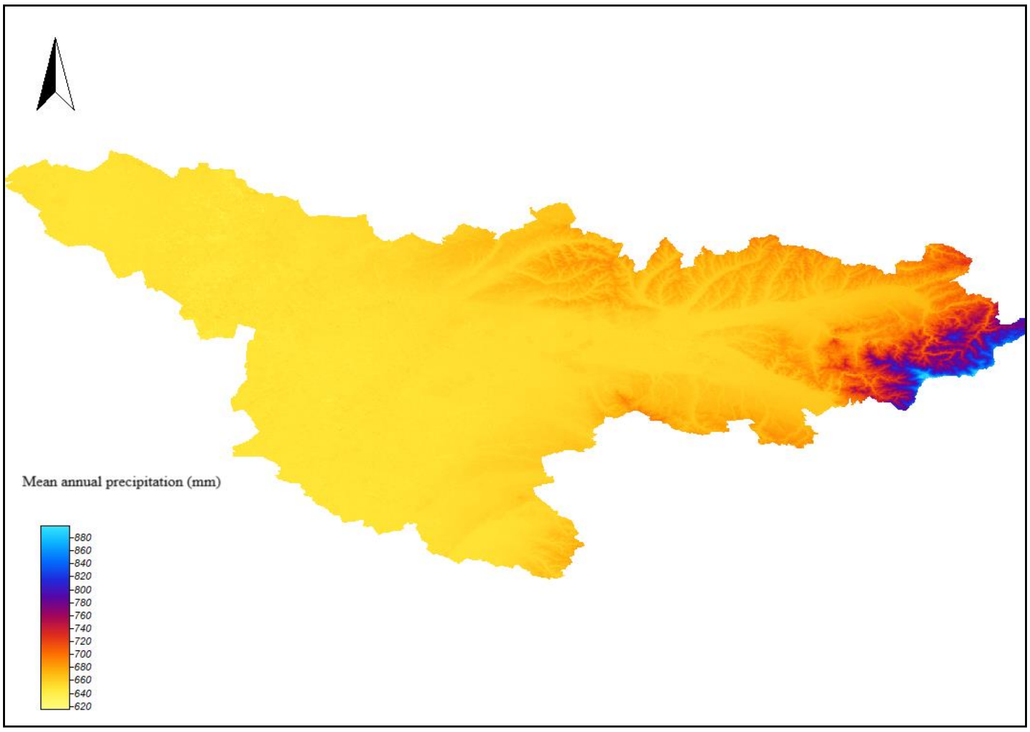


Figure 1. Mean annual precipitation (mm) for the timescale 1980-2010

The terrain is also a key factor in annual distribution of precipitation. For the plain area, the biggest amount of precitiation occurs during the summer, accounting for 34%, followed by 26% during spring, 22% during autumn and 18% during winter. In Vărădia de Mureș, in the river valley, changes only occur during summer and winter months. Summer accounts for 31% and winter accounts for 21% of the total amount of precipitation. A slight difference is observed in the Caransebeş hallow, where during the summer convective precipitation accounts for 36%, spring accounts for 25%, autumn accounts for 21% and winter accounts for 18% of the total amount of precipitation.

4. Severe weather events

Thunderstorms with its associated phenomena like squalls and hail make up the most frequent agriculture – related severe weather events. Hail is defined as being precipitation in the form of spherical or irregular pellets of ice, which are larger than 5 mm in diameter and are associated with severe thunderstorms. In order to produce hail, the updraft of a thunderstorm needs to be strong in order to sustain the ice pellets. Besides a strong updraft current, supercooled water content is needed to enable it to grow fast enough before falling out. Temperatures at which hailstones grow in updraft are between -10° and -30°C (Marazan, 2018). Convective Available Potential Energy (CAPE) is a good indicator for updraft strength. Using CAPE value, the maximum updraft speed in a thunderstorm (W_{MAX}) can be determined by using the formula:

$$W_{MAX} = \sqrt{2CAPE}$$

Formula 1. Maximum updraft speed (Lohmann, et all., 2016)

The use of CAPE as a predictor for large hail has been discussed before (Groenemeijer & Delden, 2006), so that it can be maintained as a good hail indicator in non-tornadic environment.

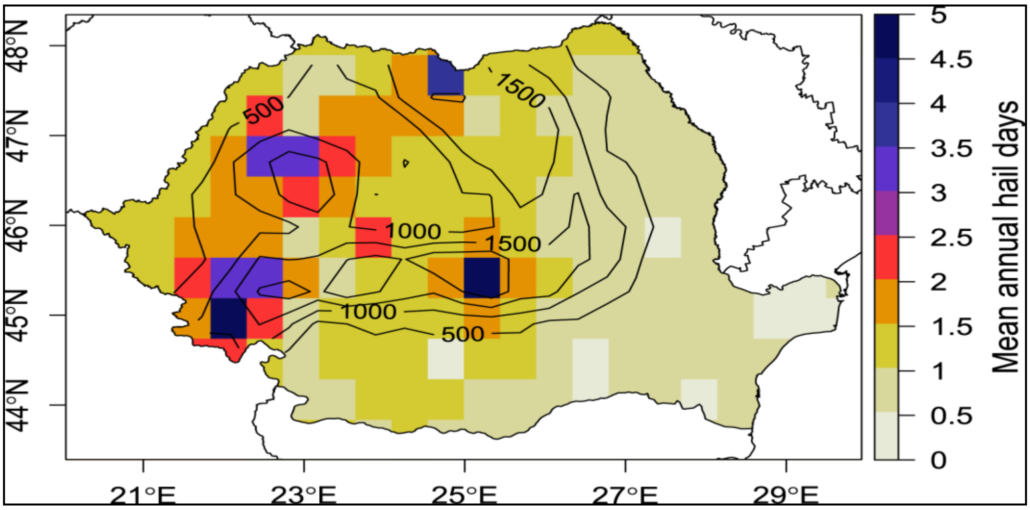


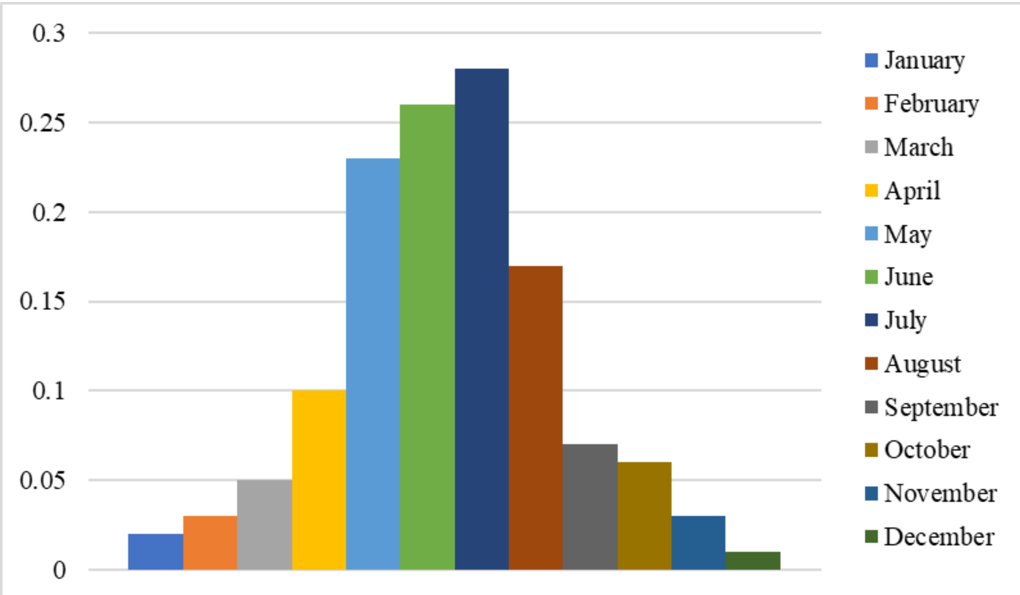
Figure 2. Mean annual hail days (Burcea et all., 2016)

The mean annual hail days for the research area is 1.5 in Arad area, 2 in Vărădia de Mureş, and reaches a maximum of three days per year in Caransebeş.

Squalls are characterized by sudden variation in both wind direction and wind speed on short timescales. They are usually joined by a sudden rise in atmospheric pressure and of relative humidity, but bring together a sudden fall in temperature and heavy rainfall. Squalls are defined as strong winds which increase by up to 50% to at least 30 km/h for at least two minutes (Allaby, 2013). Squalls originate from the mixing of two different air masses, one of them being a polar air mass and the other one usually tropical. Squalls have a higher frequency during the summer, due to convective activity and due to the instability between different air masses.

Table 3.

Mean annual days with squall events for the Western part of Romania (adapted from Sandu et all., 2008 & Şerban, 2010)



5. Droughts

Drought is to be considered in relation to some long-term average conditions of balance between precipitation and evapotranspiration in a well-defined area. It must be related also to some other factors like season of occurrence, growth stages and start of the raining season but also to factors like amount of precipitation, rainfall intensity and overall effectiveness of the rain. Temperature, high wind speeds and low relative humidity are also related to droughts. Synoptic circulations, which are often associated with droughts, especially in the Western part of Romania, are the hot and dry air masses, which originate from both Western Europe but also from Northern Africa (MIRCOV ET ALL., 2018). Mainly there are three types of droughts, commonly noted as meteorological drought, hydrological drought and agricultural drought. Drought period is defined as a period of at least 10 days during the hot season, between April and September, in which precipitation of less than 0.1 mm/day has been recorded. The mean drought intervals for the timescale 1961 – 1990 was around 12 – 14 days per year in the Western part of Romania (SANDU ET ALL., 2010). Records show that there were at least two drought intervals per year and also four drought intervals were recorded (SANDU ET ALL., 2010).

RESULTS AND DISCUSSION

Overall agriculture-related severe weather events tend to focus more on the hydro-atmospheric risks, but also on drought. The biggest problem which arises, is that of nowcasting phenomena. Drought can be forecasted and adaptation measures and mitigation strategies may be implemented. With regard to flashfloods, heavy rain and hail there are modern forecasting methods besides climatological charts.

Hail and heavy rainfall producing thunderstorm follow the classic thunderstorm pattern. As such, a thunderstorm is made up of two basic processes: an updraft and a downdraft. The updraft is fed by an inflow current and it usually manifests by the appearance of a Cumulonimbus cloud. The main constituents are cloud droplets, which are not detected by Weather Surveillance Radars (WSR). The downdraft, by the other hand, is produced by condensation and droplet growth originating from the updraft. This region is visible on the WSR.

A high reflectivity will always indicate heavy rain and hail. There are no thresholds that indicate severe weather, as even between two fairly identical storms reflectivities may be heavily influenced by rain density and ice processes rather than by in storm circulations and hailstones size. As stated before, the updraft region of a thunderstorm frequently develops an echo – free area surrounded by precipitation. In its weaker form this produces overhang of a strong echo over an area with weak echoes or none at all. If the signature is strong, the weak echo region may form a concavity that seems to punch into the bottom of the surrounding reflectivity. As such, the following products might be used in order to forecast severe weather events.

1. Standard Base Reflectivity is the energy reflected from water droplets and ice particles back to the WSR receiver. The stronger the reflectivity, the stronger the stronger the correlation to rainfall intensity and to the presence of hailstones.

Table 4.

Weather Surveillance Radar (WSR) Reflectivity and phenomena description (EUMETSAT)

WSR Reflectivity (dBZ)	Description
10	Very light rain or light snow
20	Light rain or heavy snow
30	Moderate rain
40	Heavy rain with some thunder
50	Heavy rain with likely thunderstorm
60	Heavy thunderstorm, heavy rain and small to medium hail
70	Heavy thunderstorm, heavy rain and huge hail (> 2 cm)

2. Vertical Integrated Liquid (VIL) indicates the average mass of liquid water per cubic meter within a column above the earth's surface. VIL is an indirect estimate of the instantaneous liquid content above a given spot. Before the High Hail Treat (HHT) indicator, VIL was used for determining the possible presence of hail. VIL is closely correlated to updraft strength and can be used to quickly identify cells that require future monitoring.
3. Echo Tops product is a processed type of WSR image. The Echo Tops product indicates the highest altitude at which significant radar reflectivity exists. Although helpful, weak echo regions with values under 18.5 dBZ are not shown on the WSR screen, so that the Echo Tops might be wrong.
4. Hail Detection Algorithm (HDA) provides a good technique for measuring the hail potential of individual storm cells to produce hail that can reach the ground. The HDA produces three quantities for each location where hail is most probably to be detected. The Probability of Hail (POH) parameter determines the chance of any hail of any size to reach the surface of the Earth. The Probability of Severe Hail (POSH) determines if severe hail (diameter > 2 cm) will hit the Earth's surface. The Maximum Expected Hail Size uses data from the POSH and extrapolates it in order to determine the maximum dimensions of a piece of hail.

CONCLUSIONS

The aim of this study was to analyze and point out some of the severe weather events which can occur in the Western part of Romania. Since hail and squalls can affect the discussed area, a further analysis is required in order to better understand the need for nowcasting. By identifying some of the weather-related hazards, adaptation measures and mitigation strategies might be implemented in order to come with current severe weather events. As such, a review of current weather observation techniques is to be done in order to ensure that the latest technologies are implemented in order to achieve maximum forecasting efficiency. Some of the information presented in the Results and Discussion section were implemented in the National Weather Service of the United States of America and can be also implemented in the Romanian National Weather Service. The need for advanced technology and for powerful computing is crucial because climate change induced severe weather events tend to become more and more hazardous for both agriculture but also for human life.

BIBLIOGRAPHY

ALLABY, M. (2013). A Dictionary of Geology and Earth Sciences. Cambridge University Press, Cambridge.

BURCEA, S., CICĂ, R., BOJARIU, R. (2016). Hail Climatology and Trends in Romania: 1961-2014. Monthly Weather Review. Vol. 144, 4289-4299.

BUSUIOC, A., CAIAN, M., CHEVAL, S., BOJARIU, R., BORONEANT, C., BACIU, M., DUMITRESCU, A. (2010). Variabilitatea si schimbarea climei in Romania. Editura Pro Universitaria, București.

DOSWELL, C. (2001). Severe convective storms. American Meteorological Society, USA.

EUMETSAT (**). Distance Learning Operations Course.

GROENEMEIJER, P., H., DELDEN, A. VAN. (2007). Sounding-derived parameters associated with large hail and tornadoes in the Netherlands. Atmospheric Research. Vol. 83. Issue 2-4, 473-487

ION-BORDEI, E. (1983). Rolul lanțului alpino-carpatic in evoluția ciclonilor mediteraneeni. Editura Academiei Republicii Socialiste Romania, București.

LOHMANN, U., LUOND, F., MAHRT, F. (2016). An Introduction to Clouds – from Microscale to Climate. Cambridge University Press, Cambridge.

MARAZAN, V. (2018), The management of severe meteorological events, Eurostampa, Timisoara.

MIRCOV, V., NICHITA, C., OKROS, A., NICOLIN, A., BARLIBA, L. (2017), The relationship between climatic extremes from 2016 -2017 in the Western Romania, Proceedings of the 17th International Multidisciplinary Scientific GeoConference (SGEM 2017), 17, 561 -568.

MIRCOV, V., OKROS, A., COZMA, A., NICOLIN, A., MARAZAN, V. (2018), Consideration regarding instability indices of the Aladin model and radar structures associated under the framework of convective situations in Western Romania during the interval 2005 – 2009, Proceedings of the 18th International Multidisciplinary Scientific GeoConference (SGEM 2018), 18 (4.2), 395 -402.

SANDU, I., MATEESCU, E., VATAMANU, V. (2010). Schimbări climatice in Romania si efectele asupra agriculturii. Editura Sitech, Craiova.

SANDU, I., PESCARU, V., I., POIANA, I. (2008). Clima României. Editura Academiei Romane, București.

ȘERBAN, E. (2010). Hazarde climatice generate de precipitații in Câmpia de Vest situate la nord de Mureș. Editura Universității din Oradea, Oradea.

TOPOR, N., STOICA C. (1965), Tipuri de circulație si centri de acțiune atmosferica deasupra Europei, Editura CSA, București.