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DOI: 10.2478/pesd-2019-0039 PESD, VOL. 13, no. 2, 2019

DISTRIBUTION OF CLOUDINESS ON THE CENTRAL PLATEAU OF MOLDAVIA

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Key words: cloudiness, Central Plateau of Moldavia, total and low cloudiness.

Abstract. The distribution of cloudiness on the Central Plateau of Moldavia is almost similar with that of other hilly areas of Romania, although the mentioned area are located in the east of Romania, where continental influences are present. In the Central Moldovan Plateau. The values of the cloudiness are higher than in the south-eastern areas of Romania, due to specific conditions. In winter the values are raised by the lower temperatures, sometimes generated by the presence of the Euro-Asian Anticyclone and by the high frequency of the thermal inversions. In addition, there is an intensification of the passages of Mediterranean cyclones, often above the anticyclonic cold air. At the end of spring and in the first half of summer, the western circulation intensifies, to the north of the Carpathians, as it enters the studied area. The Central Plateau of Moldavia is a relatively high area, located in the front of the predominant north-western local circulation, a fact that produces slight orographic convection in the case of north component circulations. The annual average of cloudiness is heavily influenced by the genesis of stratiform clouds. The multiannual regime shows decreases of the values. The annual regime is similar for entire Central Plateau of Moldova. In the Central Plateau of Moldavia, both the total and low cloudiness recorded has the highest average in December and the lowest average in August. Total hourly cloudiness recorded two main classes of values between 4-6, with presence in the months of warm semester and 6-8 tenths, characteristic of the cold semester. The low cloudiness presents, in the territory, small differencies for the annual averages and higher differencies than the total cloudiness regime. Diurnal, the low cloudiness exceeds 6 tenths only in the mornings of December, in Vaslui and values below 2 tenths occur only on the nights of June, July, August and September in whole area. The values in the territory are similar, only in the high areas we can see a slight increase in the number of clear sky days, with a corresponding decrease in the number of cloudy and covered days.

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Introduction

The Central Moldavian Plateau is located in the central-eastern part of the Moldavian Plateau. It is distinguished from the neighboring subdivisions belonging to the Plateau of Moldova, by the higher altitude and massiveness (Băcăuanu et al, 1980). The distribution of cloudiness on the Central Plateau of Moldavia is similar with that of other hilly areas of Romania, although the mentioned area are located in the east of Romania, where continental influences areas of Romania, although the mentioned area are located in the east of Romania, where continental influences are present (Geografia României, 1983, Clima României, 2008). In the Central Moldavian Plateau, the values of the cloudiness are higher than in the south-eastern areas of Romania, due to specific conditions. In winter the values are raised by the lower temperatures, sometimes generated by the presence of the Euro-Asian Anticyclone and by the high frequency of the thermal inversions and at their top, stratiform clouds are often formed. In addition, there is an intensification of the passages of Mediterranean cyclones, often above the anticyclonic cold air masses. At the end of spring and in the first half of summer, the western circulation intensifies, to the north of the Carpathians, as it enters the studied area. The Central Plateau of Moldavia is a relatively high area, located in the front of the predominant north-western local circulation, a fact that produces slight orographic convection in the case of north-west, north and north-east circulations.

The values of the annual average of the cloudiness are heavily influenced by the genesis conditions of stratiform clouds. The importance of the cloudiness from a climatic point of view is given by the fact that it produces important changes to other climatic elements (solar radiation, the duration of sunshine, temperature, air humidity, atmospheric precipitation etc) through the physic-chemical properties of the cloud formations. Principally, direct sunlight and the duration of sunshine are in the highest measure affected by water vapor that constitutes atmospheric cloudiness, by modifying the radiative flux, depending on the type and extension of the cloud formations.

1. Methodology

There are few studies on the cloudiness in the Moldovan Plateau, and on its division, the Central Moldavian Plateau, are missing. We can mention analyzes at country level, in Atlas - R. S. Romania (1972-1979), Geography of Romania vol. I (1983), Climate of Romania (2008), as well as a local analysis in *Climate of Vaslui municipality* (Larion, 2004), for the east of Romaia (Bostan et al, 2015), or parts of different others geographical monographies (Patrichi).

The periods prior to 1961 are only partially representative, due to the fact that they are based only on three daily climatic observations. The data base used, for the period 1961-2016, was produced by the National Meteorological Administration.

Since, today, in the area of the Central Moldavian Plateau, only 2 meteorological stations operate, Negreşti and Vaslui, and the third, Bârnova, does not have the complete mentioned period, it was also called on data from meteorological stations located in the neighboring areas of the Central Moldavian Plateau, Iasi, Roman, Bacău and Bârlad, as well as at some weather stations that were abolished (Plopana and Huşi). Data from the mentioned complementary stations were not used in all analyzes. Given some local features of the cloudiness, it was preferred that incomplete data strings should not be extended to a common period, but their use and presentation were relevant for the present analysis. The synthetic results are presented in tables and different types of graphs.

2. Total cloudiness

Romania's cloudiness is influenced by air masses transiting or stationed at country level, on the back of the barrel systems action. Usually, the total cloudiness records the maximum in December, between the intensification of the cyclones in the Mediterranean Sea basin and a minimum in August, which is determined by the characteristics of the anticyclonic formations, baric systems that prevailing in the warm season on the surface of Romania (Clima României, 2008).

The distribution of total cloudiness at the level of the Central Plateau of Moldavia is on the same register across the entire hilly region of Romania, with a maximum in December and a minimum in August. The values are close to those from previous studies, thus, Patriche (2005), mentions for Vaslui an average value of total cloudiness of 5.9 tenths for the period 1956-2000, and Machidon (2009), for the period 1961-2007, 6.1 tenths. At the Roman station, Budui (2009) for the period 1961-2006 and Sfîca (2015) for the period 1961-2005, obtained a total nebulosity value of 5.9 tenths.

At the multiannual level, the total cloudiness has a general tendency to slightly decrease, more towards the west, to the corridor of Siret river at Roman, and rise north of plateau, at the Iaşi station.

At the level of the Central Plateau of Moldavia, a maximum average annual value of 7.2 tenths was recorded throughout the period of 1968, in the north of the plateau at the Iasi meteorological station, and a minimum of 5.1 tenths in 1983 at the Vaslui station. The highest multiannual value of total cloudiness was registered in 1991, at the Negreşti and Vaslui stations, also in the north of the studied area, at Iaşi, in 1968. In the west side of the plateau, in the corridor of Siret at Roman, the highest average annual value occurred in the year of 1996. The year with the lowest average value of total cloudiness was 1963, across all stations (Fig.1).

The values of the annual total cloudiness are heavily influenced by the formation conditions of stratiform clouds, and during the summer season, due to low relative moisture, stratiform clouds have reduced conditions of forming, and in

winters due to the high humidity and a layer of persistent snow, high atmospheric stability, led to increased cloudiness.

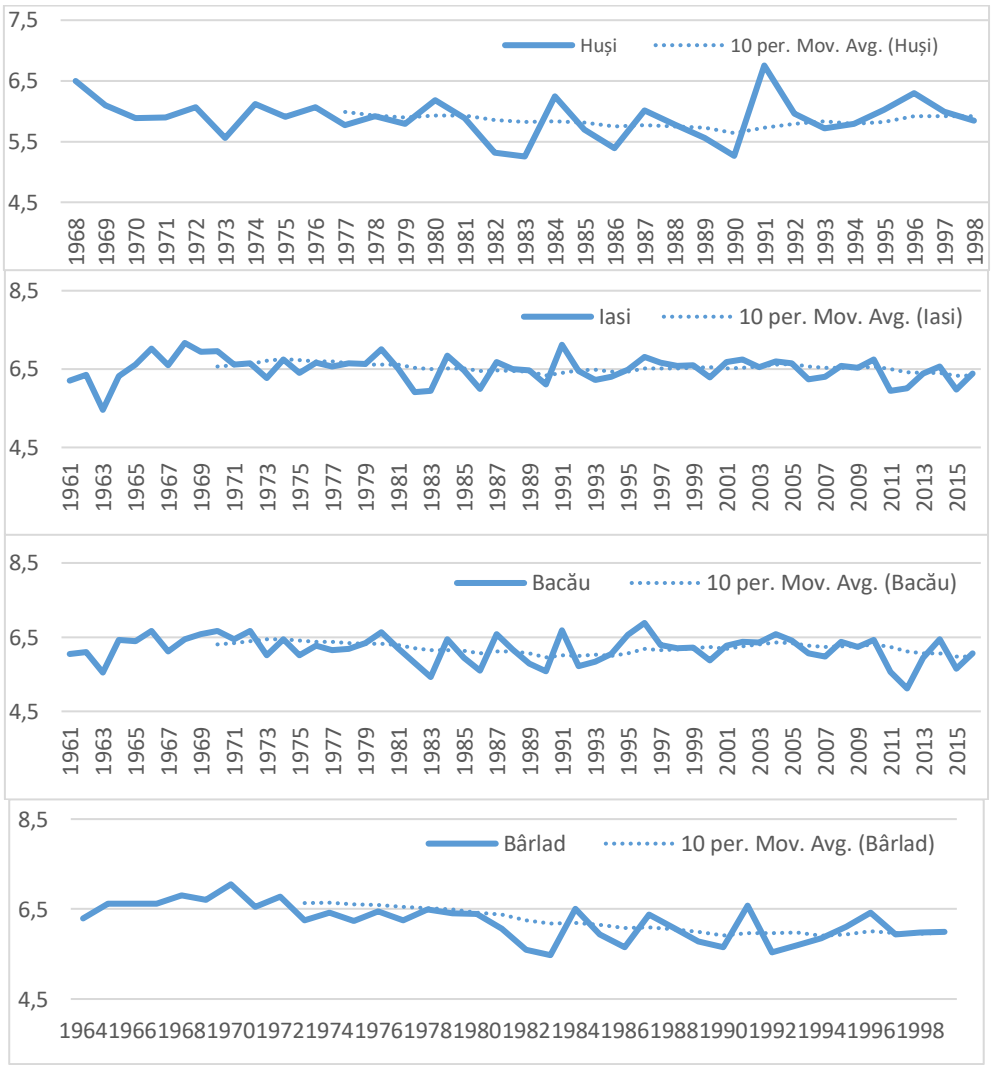

Fig. 1. Annual average total cloudiness (tenths) at stations in the Central Plateau of Moldavia (1961-2016)

The annual total cloudiness has a similar distribution across the plateau, with the maximum in December and the minimum in August, as can be seen in Figure 2.

The annual distribution shall have a greater amplitude than at the multiannual level, where it does not exceed 2 tenths. In this relatively small area, the influence of air masses transiting it causes reduced differences, but they arise between the western Central Moldavian Plateau, where the Carpathian massive, still has a noticeable influence and the eastern plateau as it is more exposed to the continental air masses. Also, topoclimatic conditions and altitude, bring differences in the development of the total cloudiness, but, especially of the low cloudiness.

The annual average of total cloudiness recorded the highest values at the north side of studied area, at Iaşi station (6.5 tenths) as a result of the presence of numerous condensing cores, also the influence of the high altitude of the Iași Coast which produces forced ascent of the air masses belonging to the prevailing north-western and northern circulations. Monthly, in the northern neighborhood, at Iaşi, the monthly averages present a maximum of 7.7 tenths in December and a minimum of 5.0 tenths in August. On the west of the studied area, in the Corridor of Siret, at Roman station, or southwest of the Central Plateau of Moldavia, at Plopana, the maximum values were 7.2 respectively 7.0 and the minima 4.2 respectively 4.4 tenths. It is noted that at Roman the total cloudiness is higher than at Plopana in December, yet in August the situation is the other way round. At the Negreşti station, August records an average of total cloudiness of 4.6 tenths and December of 7.5 tenths. Vaslui Station records a minimum average value, as at the Plopana station, of 4.4 tenths, and maxima had a value of 7.5 tenths (tab. 1). The annual regime is similar for entire Central Plateau of Moldova.

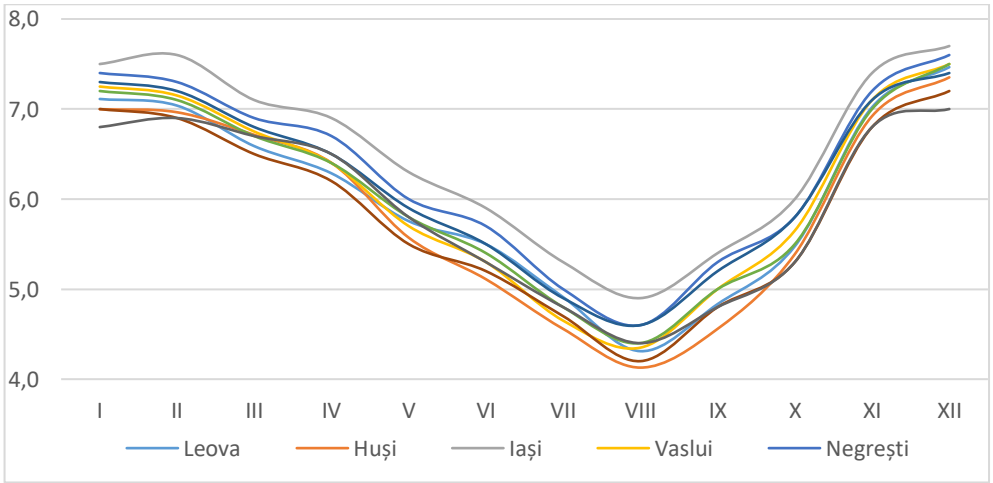

Fig. 2. Monthly average (tenths) of total cloudiness in the Central Plateau of Moldavia (1961-2016)

Between April and May there is a threshold for decreasing total nebulosity on the account of rising atmospheric instability and reducing the frequency of stratiform clouds, also between October and November, the cloudiness rises sharply, on the back of anticyclonal circulation that reduces convective processes, and promotes the emergence and development of stratiform clouds.

Tab. 1. Monthly and annual average values (tenths) of total cloudiness in the Central Plateau of Moldavia (1961-2016).

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Huşi	7.0	7.0	6.7	6.4	5.6	5.1	4.6	4.1	4.6	5.4	6.9	7.4	5.9
Iaşi	7.5	7.6	7.1	6.9	6.3	5.9	5.3	4.9	5.4	6.0	7.4	7.7	6.5
Vaslui	7.3	7.2	6.8	6.4	5.7	5.3	4.7	4.4	5.0	5.7	7.1	7.5	6.1
Negreşti	7.4	7.3	6.9	6.7	6.0	5.7	5.0	4.6	5.3	5.8	7.2	7.6	6.3
Roman	7.0	6.9	6.5	6.2	5.5	5.2	4.7	4.2	4.8	5.3	6.8	7.2	5.9
Iași	7.5	7.6	7.1	6.9	6.3	5.9	5.3	4.9	5.4	6.0	7.4	7.7	6.5

Huși, 1961-1998; Plopana, 1961-1999), data source: A.N.M.

At the Vaslui station, the highest annual amplitude is 3.1 tenths, followed by Roman with 3.0 tenths and Negrești with 2.9 tenths. At Plopana and Husi stations, the difference between the monthly recorded maximum and minimum is 2,5, respectively 2.8 tenths (tab. 1).

The daily regime of total cloudiness has registered similar trend at all weather stations. Values recorded are between 3.2 and 8.0 tenths, measured at the climatologic terms, at 1, 7, 13, 19 hours (Fig. 3.). The values of the hourly total cloudiness can be considered as indices of the synoptic situation. Diurn, the values of the total cloudiness exceed at all hours of climate observations (1, 7, 13, 10), the value of 6 tenths and fall below 4 tenths in the first half of the night.

In August, at most of the stations, the total cloudiness records a minimum around 13, and has a growing trend until the second part of the day, when the maximum values are recorded. In December, the maximum is produced in the first part of the day around 7 a.m. and decreases to the second part of the day around 19, when the daily minimum is registered at all of the stations.

In fig. 3 is representing the daily values measured at the 4 terms for stations from the Central Plateau of Moldavia. They were grouped into 3 classes of values, between 2-4, 4-6 and 6-8. The class of values ranging from 2 to 4 tenths is representative of the summer season, from mid-June to the end of August, at Iaşi and being present in August only. The cloudiness of up to 4-tenths has a timeframe from 1 a.m. to around 4 a.m. registering in the June - August range only.

Except for the class of values 2-4 tenths, which is restricted as a temporal distribution, the total cloudiness is represented by two classes of main values between 4-6 and 6-8 tenths respectively. Class 4-6 is specific to the warm semester, at night, but is restricted to 13 o'clock only for June-October (July-September in Iaşi).

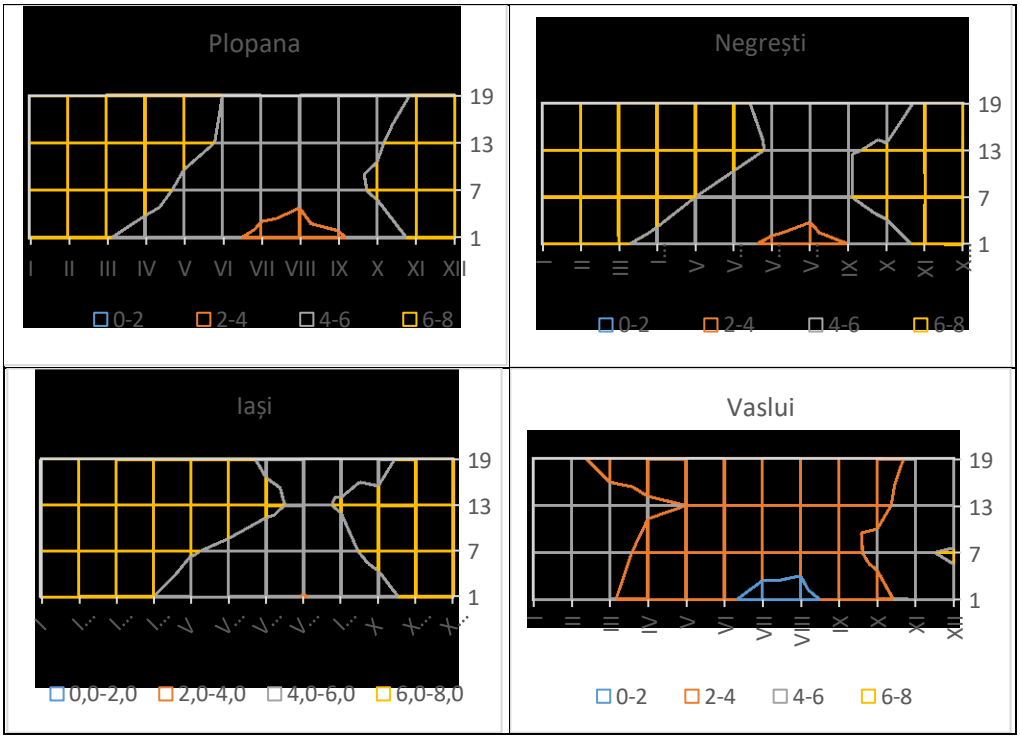

Fig. 3. Daily total cloudiness in the Central Plateau of Moldavia (1961-2007)

The cold season is representative of the 6-8 value class, but they extend to June, around 19 o'clock.

3. Low cloudiness

Low cloudiness is the degree of coverage of the celestial vault only with clouds whith the base located on the lower floor (below 2.000 m altitude), respectively Nimbostratus (Ns), Stratus (St), Stratocumulus (Sc), Cumulus (Cu) and Cumulonimbus (Cb), (Clima României, 2008). The low cloudiness is, from the meteorological perspective, a more relevant parameter than the total cloudiness, as when measuring the parameter, it only takes into account the clouds that are

generating precipitation (Sfîcă, 2015). Since the low cloudiness does not consider all of the cloud formations, its values are much lower than the total cloudiness, and, in the Central Plateau of Moldavia the registered values are between 1.6 and 6.2 tenths.

The annual averages variation of low cloudiness has the same course as the total cloudiness, being a component of it, as can be seen in Fig. 4. As a result, the maximum and minimum is produced in December, respectively, in August.

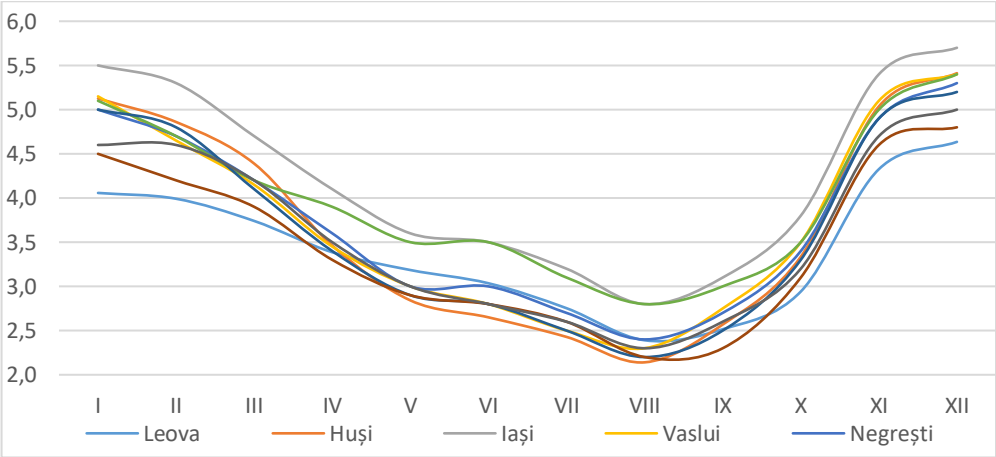

Fig. 4. Monthly average values (tenths) of lowcloudiness on the Central Plateau of Moldavia (1961-2016)

On an annual level, the highest average of the low cloudiness was recorded in the north of Central Plateau of Moldavia, at Iaşi station, with a maximum of 5.8 tenths in December and the minimum of 3.0 tenths in August. At Negrești and Plopana stations, the maximum annual average was 5.3 respectively 5,0 tenths, recorded in December, and the minimum at both stations had values of 2.3 tenths in August. The same minimum was recorded at Vaslui station, but the highest monthly average was 5.4 tenths, representing the secondary maximum. To the west of the studied area, for the Roman station, the annual maximum average recorded a value of 4.8 tenths, and the average of the lowest monthly was 2.2 tenths, being the lowest monthly average for all stations taken into consideration (tab. 2).

The low nebulosity had a similar layout to the total one but given the fact that cumuliform and stratiform clouds are considered, we could observe that in the warm season, the class of values 4-6 tenths is deepening at 13 hour term, until June-July. On the basis of the heating of the active surface and the conditions favorable to convective phenomena, is observed from April, the rapid increase of

lower nebulosity during the afternoon, due to the manifestation of a thermal bounce (Fig.5).

Tab. 2. Monthly average (tenths) of low cloudiness on the Central Plateau of Moldavia

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Huşi	5.1	4.9	4.4	3.5	2.8	2.7	2.4	2.1	2.6	3.3	5.0	5.4	3.7
Vaslui	5.2	4.7	4.2	3.5	3.0	2.8	2.5	2.3	2.8	3.5	5.1	5.4	3.7
Negreşti	5.0	4.7	4.2	3.6	3.0	3.0	2.7	2.4	2.7	3.4	4.9	5.3	3.7
Iaşi	4.6	4.6	4.2	3.5	3.0	2.8	2.6	2.3	2.6	3.2	4.7	5.0	3.6

Huşi, 1961-1998; Plopana, 1961-1999; Bârnova, Nov. 2003-2016. Data Source: ANM

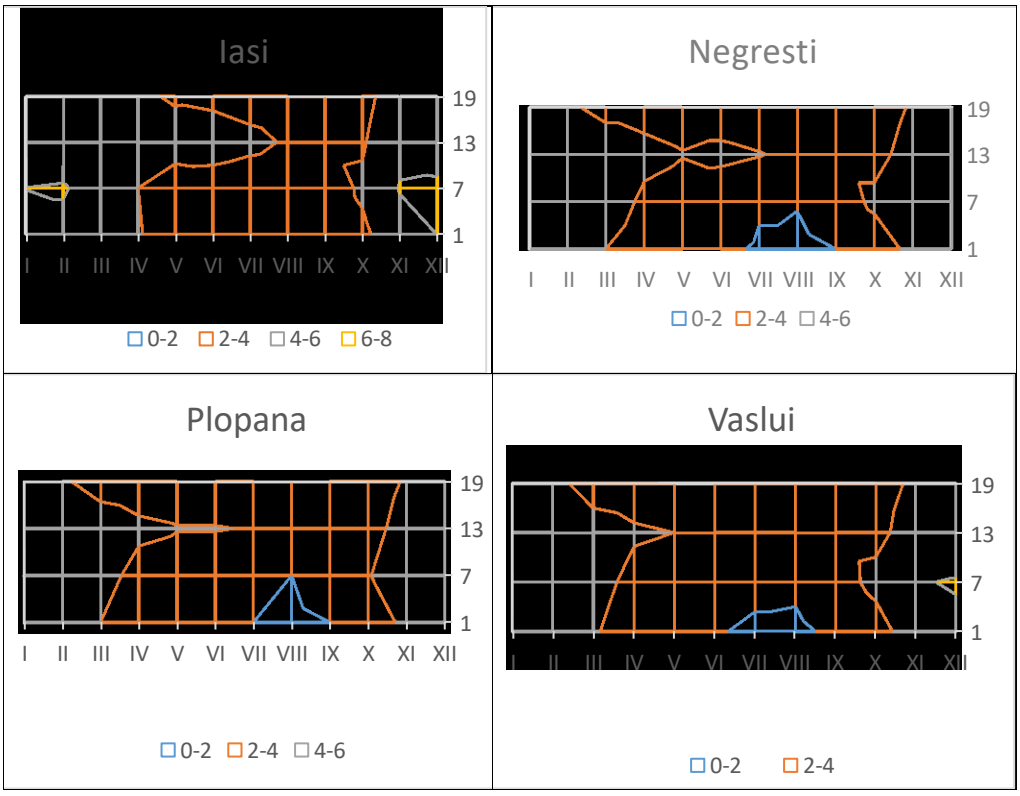

Fig. 5. The low cloudiness on the Central Plateau of Moldavia (1961-2007)

Class of values from 0-2 is only noted during the night in July and August. There has been also records of the hourly values above 6 tenths, in Iasi around 7 o'clock in November - February, as well at Vaslui station in December.

The predominant hourly values are those in classes with values between 2-4 tenths, with a high variability between March and October and 4-6 tenths, which are recorded between the months of October - March, the exception being north of the area studied, where values over 4 tenths are recorded until April. Heating the underlying surface makes the difference between the months of the warm semester when a large diurnal amplitude is observed, compared to the months of October - November where the amplitude is lower.

Diurnal, the low cloudiness exceeds 6 tenths only in the mornings of December, in Vaslui and values below 2 tenths occur only on the nights of June, July, August and September in whole area.

4. Average number of days with clear, cloudy and covered sky (for total cloudiness)

Diurn, the lower cloudiness exceeds 6 tenths only in the mornings of December, at Vaslui, and values below 2 tenths occur only on the nights of June, July, August and September.

The number of days with clear sky represents the days with a daily average total cloudiness ≤ 2 tenths, cloudy between 3 and 7 tenths, and the covered sky represent the days when the average total cloudiness is ≥ 8 tenths.

In Romania, during the year, the monthly distribution of the number of days with clear skies manifests a non-uniformity according to the topo - climatic conditions. Taking into consideration the low and total cloudiness, the plain areas have a higher number of clear sky days, the values steadily dropping to higher altitude areas, from 15-18 days in August to 12-15 days (Clima României, 2008).

In the Central Plateau of Moldavia, we have analyzed characteristic days of different cloudiness cover on the back of to the total cloudiness**.** These are shown as monthly average values, below, on tab. 3.

Annually, the average number of days with clear sky recorded a maximum in the south, south-vest side, at the Plopana meteorological station (54 days), followed by the west area of the Central Plateau of Moldavia, in the Corridor of Siret, where at the Roman meteorological station registered 53.5 days, and the rest of the stations has been recorded the clear sky average below 50 days. Days with cloudy sky are more registered to the west of the area studied, at Roman station (199.6 days) followed by Vaslui station, in the south, with 199 days. On the north side of the plateau, the lowest average of the cloudy sky (188.3 days) was recorded at Iași. Average number of days with covered sky on the entire Central Plateau of Moldavia, registered a percentage of 34% of the total year.

The characteristic days with different thresholds of cloudiness represent a very important aspect both at social level, but especially economically, for the pursuit of various activities, but it has an important impact, as it decides the duration of brightness of the sun and through it, solar radiation captured by the underlying surface, important factor for agriculture, but also for capturing radiation for energy development purposes.

Tab. 3. Monthly average of the characteristic cloudiness days in the Central Plateau of Moldavia (1961-2016)

Station	Sky	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Plopana	Clear	3.3	2.4	3.5	2.7	4.0	4.4	6.3	**8.3**	7.7	6.4	3.0	**2.2**	**54.0**
	Cloudy	14.0	**12.9**	14.1	16.4	18.1	19.1	**19.9**	17.7	16.7	16.5	14.0	13.7	193.1
	Covered	13.8	12.8	13.4	10.9	8.9	6.5	4.9	5.0	5.6	8.1	13.0	15.1	117.9
Negreşti	Clear	2.3	1.9	2.8	2.5	3.4	3.1	5.0	**6.5**	5.4	4.6	2.5	**1.9**	42.0
	Cloudy	13.0	**12.4**	14.4	15.9	18.5	19.7	**20.9**	19.4	18	17.5	13.0	12.7	195.5
	Covered	15.6	13.7	13.8	11.6	9.1	7.2	5.1	5.1	6.6	9.0	14.5	16.4	127.5
Vaslui	Clear	2.5	2.1	3.1	2.9	3.9	3.9	6.0	**8.0**	6.6	4.9	2.5	**1.8**	48.1
	Cloudy	13.4	**12.7**	14.9	16.6	19.	20.2	**20.6**	18.7	17.5	18.1	13.5	13.1	199.0
	Covered	15.1	13.2	13.0	10.5	7.4	5.9	4.4	4.4	5.9	8.0	14.0	16.1	117.9

Plopana, 1961-1999 Data Source: A.N.M.

In august - the month with minimum cloudiness, Roman station recorded an average of 8.9 days with clear sky, compared to the south - west of the Central Plateau of Moldavia, where, at Plopana has been recoreder only 8.3 days. As we move away from the Carpathians we have observed a decrease in the clear sky number of days, the minimum of 37.8 days is recorded at Iași station due to higher nebulosity, generated by the many condensing cores and rise of the air masses in the dominant direction, northwest, over the coast of the Iași.

In December, the number of days with clear sky recorded at Plopana 2.2 days, on the west side of the plateau, on the Siret corridor at Roman station, 2.0 days and to the east, the average values fall below 2 days.

Annually total number of days with covered sky recorded a maximum in the north, at Iasi meteorological station, followed by Negreşti. From an annual amplitude point of view, the highest one is being registered at Iasi with an average of 21 days.

If the clear and covered sky averages pursue the annual trend of nebulosity, the average of cloudy sky has a different monthly layout, with a maximum

recorded in July (west of the area studied, in June), and with a minimum in February. Monthly highs are recorded with values from 20.9 days at Negreşti, with

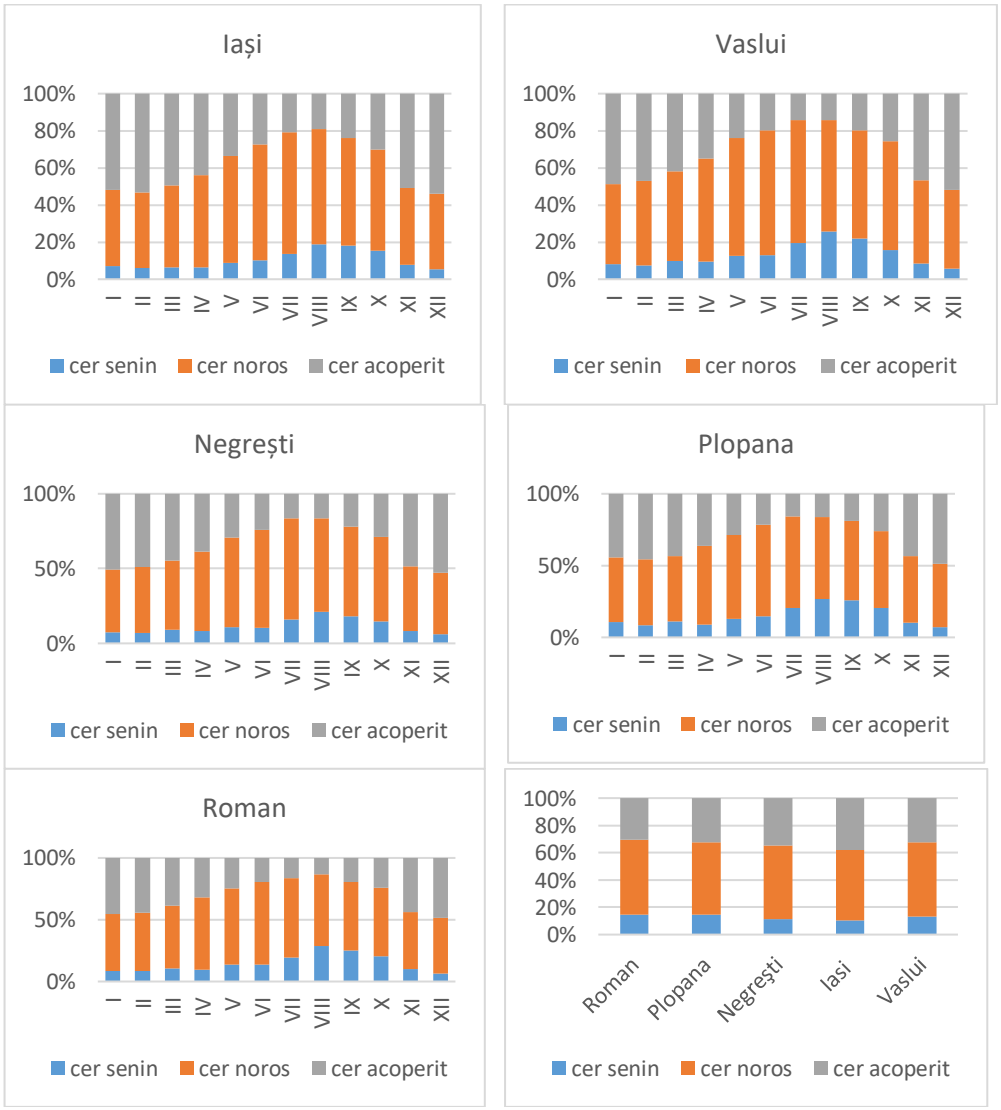

Fig.6. Monthly and annual frequency of clear sky, cloudy and covered sky (days)in the Central Plateau of Moldavia (1961-2016)

close average values of less than 20 days at Plopana station (19.9 days) and 20.0 days, in the west of the plateau, at Roman. The lowest average number of cloudy days, recorded in February, was observed at the Iași meteorological station, with 11.4 days, followed by Negreşti and Vaslui, and highest values in February was registered in the west, at the Roman station, with 13.2 days and to the southwest, at Plopana, with 12.9 days.

The annual average amount of cloudy days is highest in the west of the studied area, in the Corridor of Siret, where at the Roman meteorological station registered 199.6 days, followed by Vaslui station, with 199 days, Negrești, 195.5 days, Plopana, 193.1 days and on the north, at Iaşi, where has been registered a minimum, with less than 190 days (188.3 days).

In the Central Plateau of Moldavia, both the total and low cloudiness recorded the highest average in December and the lowest average in August. Total hourly cloudiness recorded two main classes of values between 4-6, with presence in the months of warm semester and 6-8 tenths, characteristic of the cold semester. The low cloudiness was within the classes of values ranging from 2-4 tenths, characteristic to the warm semester and 4-6, typical for the cold semester.

The characteristic days after the total cloudiness presented a majority of the cloudy days, with an annual average of 53%, followed by the days with the covered sky accounted for 34% and the clear sky days, with only 13%. The values in the territory are similar, only in the high altitude areas, we can see a slight increase in the number of clear sky days, with a corresponding decrease in the number of cloudy and covered days.

Conclusion

In the cold semester, the frequency, duration and intensity of the thermal investments, between Siret and Prut, are the highest among the plains and hill areas of Romania.

Due to the atmospheric moisture flow brought by the western circulation that arrive north of the Carpathians, in late spring and summer, the values of nebulosity on the Central Plateau of Moldavia are similar to those from the hilly areas of Romania, in the northern part of the Central Moldavian Plateau, even greater.

A decrease of the average annual values of the total nebulosity in the whole studied territory was observed, except for the Iasi Coast, where, the increase of the number of condensation nuclei, due to the pollution, especially with powders, from the city of Iasi, maintains the constant values, this area being, at the level of the entire Plateau of Moldova, an area with increased nebulosity.

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