CHAPTER «GEOGRAPHICAL SCIENCES»

CLIMATIC FEATURES OF THE BILOOZERSKYI ARRAY OF THE RIVNE NATURE RESERVE

Mykhailo Melnyichuk[1]
Oleksandr Koval[2]

DOI: https://doi.org/10.30525/978-9934-588-53-2-46

Abstract. *The purpose* of the study is to characterize the climatic conditions in the Biloozerskyi array of the Rivne Nature Reserve and to identify its peculiarities according to the indicators from the meteorological stations in Sarny, Liubeshiv and Manevychi.

Subject of study. Climatic features in the Biloozerskyi array of the Rivne Nature Reserve in modern conditions of global warming.

Methodology. In the article results of observations of the period 2006-2018 from the meteorological stations in Sarny, Liubeshiv and Manevychi are used, namely: atmospheric pressure, wind regime, air temperature, humidity, cloudiness, precipitation, snow cover. These materials are freely available in the Internet network: http://www.pogodaiklimat.ru, http://rp5.ua. Climatological information has been analyzed in the course of the research. Calculations of mathematical statistics and methods of constructing graphical model (Excel) have been used. Furthermore, interpolation techniques have been performed with help of Vertical Mapper 3.0 in MapInfo Professional 9.5. Indicators of radiation and light regime, partial pressure of water vapor and its deficiency have been analyzed according to the results of observations in the Kovel meteorological station. The scientific work is based on statistical, analytical, comparative, graphic and descriptive methods of research.

[1] Candidate of Geographical Sciences,
Associate Professor at the Department of Physical Geography,
Lesya Ukrainka Eastern European National University, Ukraine
[2] Postgraduate Student of the Department of Physical Geography,
Lesya Ukrainka Eastern European National University, Ukraine

Conclusions of research. In the course of the study, the main meteorological indicators of the climate regime in the Biloozerskyi array of the Rivne Nature Re-serve have been established. The radiation regime of the study area is determined by the position of the Sun on the sky and the time of sunrise and sunset. Anticyclones dominate in the general circulation of the atmosphere. They move from the west, southwest, northwest, north, northeast and southeast, while cyclones move from the west, southwest, northwest, south, or are of local origin. The average annual atmospheric pressure is 996.1 hPa with an amplitude within 5.5 hPa. In wind regime, during the cold period, western, southwestern, southern and southeastern winds, dominate, in the warm season – the western, northwestern, southwestern and southeastern winds, there is a high proportion of calm. The average annual wind speed is 2.0 m/s with an amplitude of 0.7 m/s. The maximum wind speed is in January is 2.4 m/s, and the minimum is in August – 1.7 m/s. The average annual air temperature is +8.7°C with a maximum in July – +20.2°C and a minimum in January – -3.5°C. The average relative humidity of the study area is 77.7 %, the maximum is in December – 87.9 %, and the minimum is in April – 68.6 %. The average annual total cloudiness of the ter-ritory is 6.5 points, and lower cloudiness is 4.3 points. The maximum cloudiness occurs in December, and the minimum is in August. The territory is located in the zone of sufficient humidity, therefore, the amount of precipitation is 656.5 mm, of which: in the warm period falls 443.5 mm, in the cold period – 213 mm. The maximum amount of precipitation falls in July – 91.9 mm, and the minimum is in February – 32.5 mm. Tables and graphs have been used for better representation of information.

The materials of this research can be used for further meteorological research of nature reserves, in recreational and agrometeorology purpose, in the educational process, namely for studying homeland subjects.

1. Introduction

Rivne Nature Reserve is nature protection territory. It was created in 1999 on the base of four wildlife preserves of the national value, separated one from other territorially: “Biloozerskyi” – Volodymyretskyi district, “Somyno” – Sarnenskyi district, “Syra Pohonia” – Rokytnivskyi district, “Perebrodivskyi” – Dubrovytskyi and Rokytnivskyi districts. From the moment of formation of Rivne Nature Reserve, each of them has ceased to exist as an independent object of the natural reserve fund and has become its part. The Biloozerskyi forest district embraces that territory of former landscape wildlife preserve of national value of "Biloozerskyi" that has entered in the complement of Rivne Nature Reserve and Biloozerskyi is named as an "array".

Formulation of the problem. In the conditions of the growing anthropogenic loading on the natural complexes, study of the climatic features and dynamics of the meteorological indexes of territories is relevant. The nature reserve territories have the special interest among natural complexes. Therefore, research of the weather elements within the limits of Biloozerskyi array of Rivne Nature Reserve has large scientific interest.

Analysis of researches and publications on the problem. This direction of the climate researches at the last decades is actively developed by the employees of the Lesya Ukrainka Eastern European National University. Thus, these ques-tions are exposed better of all in the monograph "Nature of Western Polissia, adherent to Khotyslavsky quarry of Belarus". In particular, the radiation and light mode, features of atmospheric circulation and wind, thermal mode and mode of moistening, atmospheric phenomena are analyzed [3].

The research of climate of the northeast Volyn Polissia, where Rivne Nature Reserve is located, comes true only on the data basis of the Sarny meteorological station. Thus, at the works of Tarasiuk F. P. and Tarasiuk N. A., the question of the atmospheric circulation, wind and thermal modes [7], the mode of moistening and cloudiness is considered [8]. At the works of Voloshynova N. O. and Gorbach A. O., the question of the temperature features condition and the mode of moistening of Rivne Nature Reserve is considered, according to the meteorological station of Sarny for the period 2000-2008 [2].

The results of the previous researches are not presentable enough for all the territory of Rivne Nature Reserve because three arrays of reserve are located to the close proximity to Sarny, while Biloozerskyi array is located over 60 kilometres to the west of Sarny. Therefore, at the study of climatic terms of this territory, it is worth considering to the account data of the Manevychi and Liubeshiv meteorological stations at the Volyn area that is located much closer.

2. Radiation and light mode

Solar radiation is the main source of energy for almost all natural processes and phenomena occurring in the geographical envelope and one of the main factors of climate formation [4, p. 41]. The radiation regime is determined primarily by astronomical factors: the position of the Sun on the sky at different times of the day and year as well as the time of sunrise and sunset. The duration of the day changes throughout the year. The shortest day (7.5 hours) and the lowest Sun (h = 15°) at noon are recorded in December. The longest day (16.5 hours) and maximum sunshine at noon (62°) can be traced in June.

Duration of sunshine. An important indicator of the radiation regime is the duration of the sunshine, which is determined by the number of hours, during which the sun illuminated the terrain. The number of sunshine depends on the length of day, cloudiness and the horizon. The length of the day, which depends on the latitude of the place and the time of year, determines the theoretically duration of the sunshine, the duration of the sunshine in a cloudless sky at a particular latitude [4, p. 42].

Therefore, on the latitude of the studied territory, the Sun shines 1864 hours per year, 1529 hoursof them are in the warm period from April to October.

The lowest values of duration of sunshine are recorded in winter, which is caused by the shortest day duration and the highest cloudiness. On the investigated territory, the minimum duration of sunshine is fixed in December and it is 37 hours per month (Table 1).

In January, the duration of the sunshine increases slightly and in February it almost doubles – 55 hours (21 %) and 67 hours (24 %), compared to December. In spring, the length of the day is increasing and the cloudiness is reducing, which causes an intense increase on the duration of the sunshine and its quality indicators. Thus, in March, these are 131 hours (36 %), 186 hours in April (45 %) and 269 hours in May (56 %) (Table 1). However, in June, despite the increase from the length of day, the number of hours of sunshine decreases due to the increase in cloudiness and these are 252 hours or 51 %. The maximum duration of the sunshine reaches 278 hours in July or 55 % due to a decrease in cloudiness and an increase at the number of clear days. In August, the duration of the sunshine is 254 hours (56 %). The reason is a decrease in cloudiness and an increase in the ratio of the true duration of the sunshine, which reaches its maximum.

Table 1

Indicators of solar radiation*

	Direct solar radiation on a horizontal surface, MJ/m²	Scattered solar radiation, MJ/m²	Total solar radiation, MJ/m²	Radiation balance, MJ/m²	Reflectance, %	Duration of sunshine, hours
January	27	56	83	–34	59	55
February	37	84	121	–18	52	67
March	117	160	277	59	36	131
April	154	196	350	141	19	186
May	262	255	517	217	19	269
June	285	258	543	259	19	252
July	264	279	543	245	19	278
August	247	226	473	187	19	254
September	149	163	312	101	19	157
October	71	99	170	29	20	133
November	26	53	79	–8	26	45
December	11	41	52	–34	48	37
Winter	75	181	256	–86	53	159
Spring	533	611	1144	417	27	586
Summer	796	763	1559	691	19	784
Autumn	246	315	561	122	22	335
The cold period	218	394	612	–35	44	335
The warm period	1432	1476	2908	1179	19	1529
Year	1650	1870	3520	1144	23	1864

** – according to the source [1, pp. 40–41; 3, p. 67]*

In autumn, the duration of the sunshine decreases significantly due to the increase in cloudiness and the decrease on the length of day, at the same time the quality index decreases. Thus, in September, the number of hours of sunshine de-creases to 157 hours (41 %), 133 hours in October (40 %), 45 hours in November (17 %) (Table 1). The greatest relative stability of sunshine is traced 51-56 % from May to August. With duration of sunshine, there is a number of days without a sun. In general, there are 95 days without sun during the year. Most of them are observed in the cold period, 18-20 days, with a maximum in December. In spring, the number of days without sun decreases and in May these are 1-4 days. In summer, the days without the sun are rarely 1-3 days. In autumn, their number increases and in October there are 6-9 days [4, p. 45].

Radiation balance of underlying surface. Total radiation depends on many factors: the height of the sun, the length of the day, the transparency of the atmosphere, the cloudiness. The daily course of total and direct radiation is determined by the height of the Sun, so its maximum in the absence of cloud accounted for noon [4, p. 52]. In the warm period, at the real terms of cloudiness, the change of direct solar radiation during a day is asymmetrical relatively for noon to noon sums more than after noon [4, p. 45]. The maximum of the scattered radiation during the warm season is shifted by the first half of the day as the amount of water vapor that absorbs solar radiation increases during the day [4, p. 50]. At cloudy days, the normal course of total radiation is disturbed according to the actual change of cloud cover. This contributes not only to the reduction but also to the increase in solar radiation and in particular scattered radiation. Due to the reflection of solar radiation from pile clouds, not only scattered but also total radiation can increase. The share of direct radiation fluc-tuates throughout the year. From November to February, the proportion of direct radiation is 21-33 % and 42-53 % from March to October (Table 1).

In the annual course, the maximum monthly sums of total radiation account 543 MJ/m^2 for June-July and the minimum (52 MJ/m^2) for December (Table 1). During the year, there is a sharp increase in the monthly sums of total radiation from February to March (an average of 156 MJ/m^2), which is caused not only by an increase in the sun's height and by the length of the day but also by better transparency of the atmosphere in March. A sharp decrease in total radiation by 142 MJ/m^2 can be traced from September to October.

The radiation balance of the underlying surface is determined by the difference between the radiation energy input and its consumption. Therefore, it can be both positive and negative. The formation of the radiation balance is determined by the duration of the sunshine, the cloudiness, the state of the atmosphere, the underlying surface [4, p. 61].

The annual radiation balance is negative -34 MJ/m^2 from November to February with a minimum in December-January, which is caused by low total radiation and the highest reflectance. The maximum values of the radiation balance are fixed in June – 259 MJ/ m^2. The radiation balance for the year reaches 1144 MJ/m^2, 32.5 % of total radiation (Table 1).

The daily course of the radiation balance depends on the height of the sun above the horizon, cloudiness and transparency. At the daytime, the radiation balance is usually positive during the day with a high at noon and negative at night with a low after sunset. The transition of the radiation balance from positive to negative values and vice versa occurs at an altitude of the Sun above the horizon of approximately 5-15°. The significant effect on the daily course of the radiation balance and passing it through zero is made by the cloud, which at night weakens the effective radiation and in the daytime reduces the total radiation [4, pp. 63–64].

3. General circulation of the atmosphere, atmospheric pressure and wind

Features of atmospheric circulation. Solar radiation causes uneven warming of the earth's surface, which leads to the displacement of air masses. It is the circulation of the atmosphere, which is an important climatic factor. The interaction of atmospheric circulation and solar radiation is reflected in the peculiarities of the annual and daily course of meteorological elements.

The formation of the climate of the territory of Ukraine is significantly influenced by the western transfer of air masses from the Atlantic, which is accompanied by cyclone and anticyclone activity. Ukraine has an average of 63 % of days with anticyclones and 37 % with cyclones a year.

In Ukraine, low pressure regions (cyclones and basins) become 42 % of all bar formations. There are an average of 43 cyclones and 60 basins annually and local cyclogenesis generates an average of 17 cyclones, most of them in summer (7) [4, p. 89].

Low atmospheric pressure barricades are mainly displaced from the west, south and northwest but the southern cyclones are the most intense and long lasting. Local cyclones are less frequent and their duration is much shorter. The duration of cyclone formations increases from summer to winter with only southeastern and southern cyclones, having the highest duration in summer. Southern cyclones last up to 57 hours in summer and local ones last up to 15-18 hours [4, p. 90].

Notable areas of low atmospheric pressure – basins – occupy a significant place among bar systems. Their recurrence in separate seasons makes 12-16 cases.

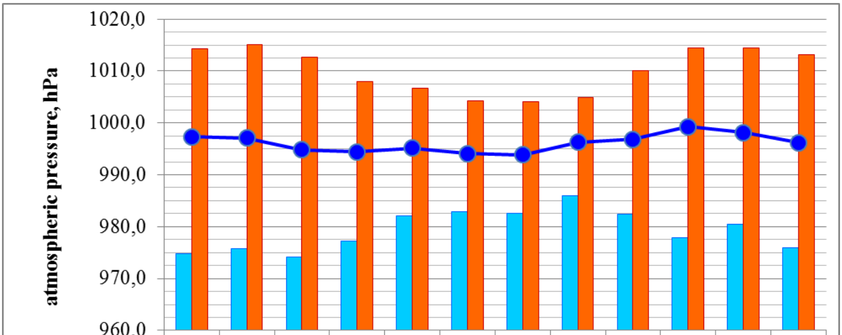
The anticyclone type of weather in terms of quantity and duration during the year is dominated by cyclone. The main trajectories of anticyclone movement in Ukraine are western, southwestern, northwestern, northern, northeastern and southeastern. Among the local processes of anticyclogenesis, the development and extension of the southeastern projection to the west of the Donetsk highlands are highlighted as well as the formation of a barrier of high atmospheric pressure in summer over the central part of the country [4, p. 92].

Spurs and protrusions with the western and eastern orientation of the axis are equally important for the formation of synoptic processes and the most wide-spread. It is mainly the periphery of the Azores and Asian anticyclones, the boundaries of their further eastern or western distribution, bearing the provisional name "Voyikov axis" [4, p. 92].

Atmospheric pressure. Atmospheric pressure is one of the main characteristics of the physical state of the atmosphere. It is characterized by spatial and temporal changes that depend on climatic factors [4, p. 101].

The annual course of atmospheric pressure. Features of the annual course of atmospheric pressure are determined by seasonal changes in the atmosphere's circulation. Higher pressure is observed in the cold season, lower is observed in the warm season, which is caused by the general warming of the atmosphere. In the annual course, the main maximum of atmospheric pressure is observed in October (999.3 hPa) and the secondary one in January (997.3 hPa) (Figure 1). The basic minimum atmospheric pressure is observed in July (993.8 hPa). Thus, the annual amplitude is 5.5 hPa. The highest rise in atmospheric pressure occurs from July to August and from September to October by 2.5 and 2.4 hPa. This is due to a decrease in heat input and a change in macrocirculation. The greatest fall in atmospheric pressure occurs from November to December and from February to March by 2.0 and 2.3 hPa. The second fall is explained by the end of winter and the diminishing role of circulation processes.

Maximum atmospheric pressure. Given the variability of the averages, the extreme values of the atmospheric pressure and their amplitude are more indicative. The annual course of maximum atmospheric pressure is similar



	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
average min	974,7	975,8	974,2	977,2	982,1	983,0	982,6	985,9	982,5	977,8	980,4	975,9
average max	1014,3	1015,1	1012,7	1008,0	1006,7	1004,2	1004,2	1004,8	1010,1	1014,5	1014,4	1013,1
average	997,3	997,1	994,8	994,4	995,2	994,1	993,8	996,3	996,9	999,3	998,2	996,2

Figure 1. Annual atmospheric pressure at station level, hPa*

** – developed by the authors according to sources [5]*

to the annual course of average atmospheric pressure. The highest maximum atmospheric pressure is observed in the period from October to March and reaches values above 1014 hPa in January-February and October-November. The lowest maximum pressure is observed in the summer, 1004.2 hPa in June-July. Thus, the maximum atmospheric pressure has an amplitude of 10.9 hPa and exceeds its average values by 8.5-18.0 hPa (Figure 1).

The absolute maximum of atmospheric pressure is the highest pressure recorded during the observation period. The highest absolute maximum of atmospheric pressure is observed above 1022 hPa in January-March and the lowest in June-August. The highest absolute maximum pressure was recorded in January 2006 – 1024.1 hPa, and the lowest absolute maximum was recorded in August 2015 – 1006.0 hPa [5]. In general, the absolute maximum atmospheric pressure has an amplitude of 18.1 hPa, exceeds the average maximum values by 1.2-9.8 hPa and the average by 10.5-27.6 hPa during the month.

Minimum atmospheric pressure. The annual course of minimum atmospheric pressure is the opposite of the annual course of average atmospheric pressure. The highest minimum atmospheric pressure is observed in the period from May to September and reaches values above 982 hPa and in November 980.4 hPa. The lowest minimum pressure is observed from December to March – 974-976 hPa. Thus, the minimum atmospheric pressure has an amplitude of 11.7 hPa and less than its average values of 10.4-22.6 hPa (Figure 1).

Absolute minimum atmospheric pressure is the lowest pressure recorded during the observation period. The highest absolute minimum of atmospheric pressure is observed from May to September – 973-978 hPa, and the lowest does not exceed 970 hPa from October to April. The highest absolute minimum pressure was recorded 978.2 hPa in May 2007 and the lowest absolute minimum was 956.0 hPa in October 2017 [5]. In general, the absolute minimum of atmospheric pressure has an amplitude of 22.2 hPa during the month is less than the average minimum values of 4.8-21.8 hPa and the average of 15.9-43.3 hPa.

Therefore, the maximum values of the absolute amplitude of the atmospheric pressure are characterized for the period from October to March and range from 52.5 hPa in February to 65.6 hPa in October. From April to September. the absolute pressure amplitude decreases to 28.6-35.8 hPa due to weak advection and a stable temperature regime.

The daily course of atmospheric pressure. Atmospheric pressure also has regular patterns in the daily course. The daily course of atmospheric pressure is characterized by the presence of two maxima and two minimum, the daily amplitude and changes in pressure between observation periods. The daily course of pressure is determined by its increase in the first half of the day (12 h) and an additional increase in the evening. The time of occurrence of the maximum and minimum pressure in the daily course is closely related to the time of sunrise and sunset [4, p. 107].

The maximum is clearly expressed throughout the year and reaches a value of about 12 hours. The secondary maximum is less clear, tends to decrease and is observed in the evening (21 hours) or night (0 or 3 hours). The basic minimum of atmospheric pressure is observed in the afternoon (15 or 18 hours), the secondary is in the morning (6 hours) (Table 2).

In the daily course, the atmospheric pressure decreases most intensively from 12 to 15 hours from 0.2 hPa in summer to 0.9 hPa in autumn. The most significant increase in pressure occurs: in the cold period from 9 to 12 hours by 0.4 hPa, in the warm period from 6 to 9 hours by 0.3-0.6 hPa. Pressure fluctuations during the day are determined by the average daily amplitude and insignificant: 0.7-1.1 hPa (Table 2).

Table 2

Daily atmospheric pressure at station level, hPa*

Period	Observations, hours								Amplitude
	0	3	6	9	12	15	18	21	
Winter	996.2	996.0	995.7	996.0	996.4	995.9	996.0	996.2	0.7
Spring	994.3	994.2	994.1	994.4	994.5	993.9	993.5	993.9	1.0
Summer	994.5	994.7	994.4	995.0	994.8	994.6	993.9	994.4	1.1
Autumn	998.1	998.0	997.9	998.2	998.6	997.7	997.7	997.8	0.9
Year	995.8	995.7	995.6	995.9	996.1	995.5	995.3	995.6	0.8

** – developed by the authors according to the source [9]*

Wind. Wind is one of the main and changing characteristics of the atmosphere. The movement of air masses is caused by the circulation of the atmosphere and is determined by the presence of bar centers, the nature of the underlying surface and the shape of the relief. The annual course of wind characteristics is determined by the seasonal displacement and intensity of the centers of action of the atmosphere, so the prevailing wind direction and velocity change during the year [4, p. 108].

Wind direction. In the cold season, the distribution of wind directions over Ukraine is caused by the presence of high pressure bands formed by spurs of anticyclones from the east (Siberian) and west (Azores), so southeastern, southern, southwestern and western winds prevail.

In spring, due to the general decrease in the intensity of cyclonic circulation, the wind direction is more influenced by the local conditions, so southeastern and northeastern winds are dominant.

During the summer, the Azores anticyclone is activated, the spurs and nuclei of which spread to the territory of Ukraine, so from June to August western and northwestern winds prevail.

In autumn, the impact of the Azores anticyclone decreases, so the wind direction changes from the south and west in early autumn to southeast in the second half, which precedes the transition to winter type atmospheric circulation [4, p. 108].

However, within the study area, certain differences can be traced (Figure 2, Table 3). Thus, the prevailing winds in winter are western, southwestern and southeastern, which recur at 53.7 % of cases. Northern and northeastern winds have the lowest recurrence rates only 4.8 % and 5.5 %.

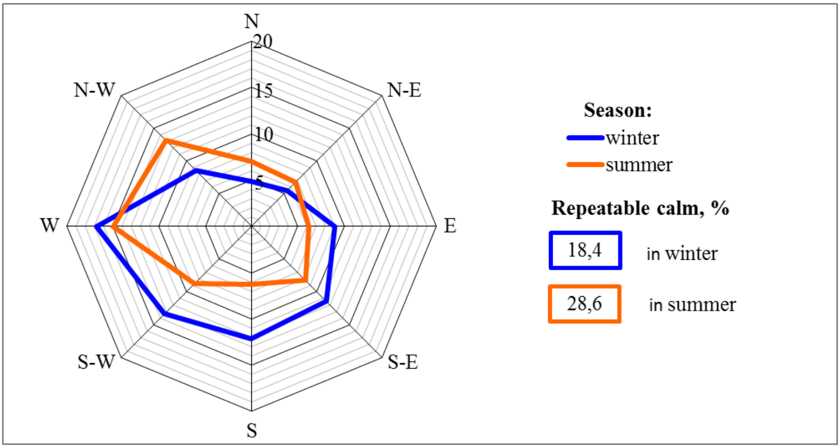


Figure 2. Repeatability of winds by the main direction, %*

** – developed by the authors according to the source [6]*

With the onset of summer, the wind regime changes (Figure 2). The prevailing wind directions are the western and northwestern ones – 28.1 %, again the share of calm is 28.6 %. However, the recurrence of other directions decreases significantly, especially the eastern and southern directions are 6.2 and 6.3 % (Figure 2, Table 3).

Table 3

Repeatability of wind directions by major directions, %*

Season	Repeatability of winds by the main direction, %								Calm, %
	North	North-East	East	South-East	South	South-West	West	North-West	
winter	4.8	5.5	9.0	11.4	12.1	13.4	16.8	8.6	18.4
spring	8.5	7.5	7.8	9.1	8.4	9.2	14.2	11.7	23.6
summer	7.1	6.8	6.2	8.2	6.3	8.7	15.0	13.1	28.6
autumn	3.9	5.5	7.5	12.3	11.0	12.4	14.6	8.3	24.5

** – developed by the authors according to the source [6]*

During the transitional periods. the atmospheric circulation changes, spring winds of different directions have more or less the same frequency. The prevailing winds in spring as well as in summer are the western and northwestern ones, which together account for 25.9 % (Table 3), increasing the share of calm at 23.6 %. The frequency of winds in other directions is 7.5-9.2 %.

In autumn, the atmospheric circulation switches to winter type, so the distribution of wind directions has similar features to the winter one (Table 3). Thus, the prevailing wind directions are the western, southwestern, southeastern and southern, which together make up 50.3 %. The proportion of calm is reduced by 24.5 %. The northern and northeastern winds have the lowest recurrence rates – 3.9 and 5.5 %.

Wind speed. An important characteristic of the wind regime is the wind speed, which is determined by the bar gradient and atmospheric circulation conditions [4, p. 109]. During the year, consecutive changes in wind speed have been made. The annual average wind speed is characterized by higher speeds in the cold season from November to March: 2.2 m/s.

An important indicator of the annual wind speed is its maximum performance. So the highest values of the maximum wind speed are characterized for the period from October to April as well as in July: more than 7 m/s. The absolute maximum occurs 9.4 m/s in March (Figure 3).

The lowest values of maximum wind speed are recorded 6.3-7.0 m/s in May–June and August-September (Figure 3). Also winds with speeds of 17-18 m/s are usual for the investigated territory, although they are recorded in the native. In general, the absolute maximum of the fixed wind speed is 22-24 m/s [5; 6].

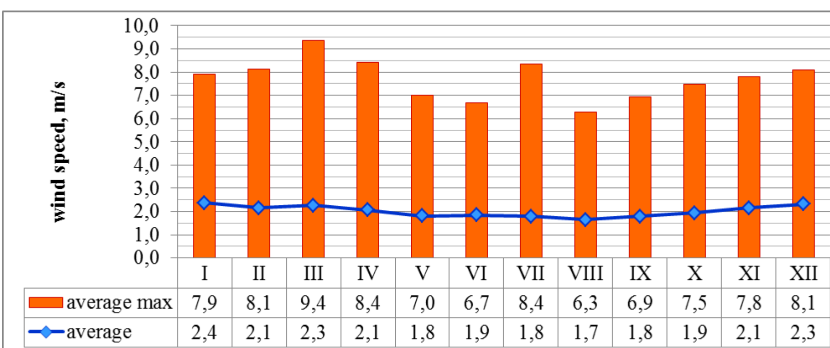


Figure 3. Annual wind speed, m/s*

** – developed by the authors according to sources [5; 6]*

Daily wind speed. Wind speed is also characterized by daily flow, which de-pends on the intensity of turbulent exchange during the day [4, p. 109]. The daily course of the wind speed of the study area meets the general laws. Thus, the maximum values of the average wind speed at different times of the year are fixed at 15 hours and the minimum values at 3 hours or at 0 and 6 hours (Table 4).

Table 4

Daily average wind speed, m/s*

Season	Observations, hours								Amplitude
	0	3	6	9	12	15	18	21	
Winter	2.3	2.2	2.3	2.2	2.7	2.9	2.4	2.3	0.7
Spring	1.5	1.4	1.5	2.2	3.1	3.3	2.9	1.6	1.9
Summer	0.9	1.0	0.9	1.8	2.7	3.0	2.6	1.1	2.1
Autumn	1.8	1.6	1.7	2.0	2.6	2.9	2.1	1.8	1.3
Year	1.6	1.6	1.6	2.0	2.8	3.0	2.5	1.7	1.4

** – developed by the authors according to the source [6]*

The best daily course of wind speed is manifested in summer during anticyclone weather. At night and early morning, a minimum of wind speed is recorded, which increases in the day and reaches a maximum in the afternoon, then decreases slightly and approaches the minimum in the evening (Table 4). The amplitude of the average wind speed is 2.1 m/s. In the transition periods, the amplitudes are smaller: in spring it is 1.9 m/s, 1.3 m/s in autumn. In winter, the daily course of wind speed is smoothed, the amplitude is only 0.7 m/s but the course remains (Table 4).

Local winds. In the general circulation of the atmosphere there are two types of local winds. Their formation is caused by the influence of changes in the air currents of the general circulation of the atmosphere and the physical and geographical features of the territory but they are of limited distribution. A breeze (the White Lake, 453 ha) is observed among the local winds in the study area. It belongs to winds arising from uneven heating or cooling of adjacent areas of the underlying surface and are characterized by daily frequency and velocity. The breeze changes direction twice during the day: in the daytime it is from the lake to the land, at night it is from the land to the lake. Its occurrence is caused by the difference between the air temperature of the land and the water surface, so vertical thermal circulation in the coastal zone is formed. The temperature contrast between the lake and the land is greater during the day, so the breeze develops more strongly. Also, the breeze creates more comfortable conditions: it lowers the temperature of the air and increases its humidity. The greatest development of the breeze reaches the summer (July-August), and in spring and autumn it noticeably weakens [4, pp. 112–113].

4. Thermal mode

Air temperature is one of the important meteorological values. All phenomena and processes occurring on the Earth's surface are directly conditioned by the thermal conditions of the environment. The air temperature also determines the features and weather conditions. In winter, the thermal regime is determined by the atmospheric circulation and associated air advection. In the warm period, the thermal regime depends mainly on radiation factors, along with which the underlying surface also has a significant effect [4, p. 114].

The average monthly air temperature. The annual course of air temperature generally coincides with the annual course of solar radiation but is slightly delayed and has slight fluctuations between the months of winter and summer and the sharp ones in autumn and spring [4, p. 115].

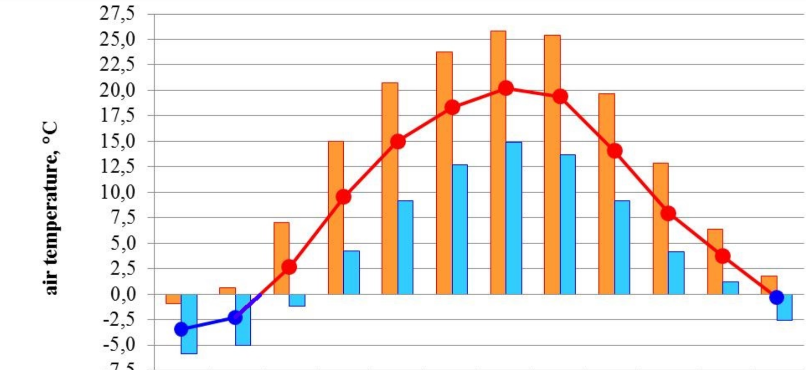
So the lowest average monthly air temperature is characteristic for winter is -2.0 °C. The minimum air temperature is observed -3.5°C in January, in February is -2.3°C and December is -0.3°C (Figure 4).

Spring is characterized by a significant increase in the average monthly temperature, so in March it is already +2.7°C, in April is +9.6°C and in May is +15.0°C.

The highest average monthly air temperature is characterized +19.3 °C for summer. The maximum air temperature is observed +20.2 °C in July, in June is +18.3 °C and August is +19.4 °C.

The autumn is characterized by a decrease of the average monthly temperature: September is +14.1 °C, October is +8.0 °C, and November is +3.7° C. Accordingly, the average monthly temperature in autumn falls by 6.1°C and 4.3°C in two months (Figure 4).

The average annual air temperature of the Biloozerskyi array of Rivne Nature Reserve in 2006-2018 year was +8.7°C with an average monthly temperature amplitude of 23.7°C.



	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
average max	-0,9	0,7	7,0	15,0	20,7	23,8	25,9	25,4	19,7	12,9	6,4	1,7
average min	-5,8	-5,0	-1,2	4,2	9,1	12,7	14,9	13,7	9,2	4,2	1,2	-2,6
average	-3,5	-2,3	2,7	9,6	15,0	18,3	20,2	19,4	14,1	8,0	3,7	-0,3

Figure 4. Annual course of air temperature, °C*

** – developed by the authors according to sources [5; 6]*

The maximum air temperature. The maximum air temperature characterizes the hottest part of the day and is observed for about 14-15 hours. The annual course of maximum air temperature is similar to the annual course of the average monthly temperature. Therefore, the lowest values of the maximum temperature are typical for winter: from -0.9°C in January to +1.7°C in December (Figure 4).

The highest values of maximum air temperature are observed in summer: from +23.8°C in June to +25.9°C in July. In general, the maximum air temperature exceeds the average air temperature: from 2°C in December to 6°C in August.

Absolute maximum air temperature is the highest air temperature, recorded during the observation period. The highest absolute maximum of air temperature is observed in July-September and is above +35 °C [5; 6]. From April to September the absolute maximum temperature is above +30°C. The lowest absolute maximum is characterized for January +11.2 °C. The absolute maximum air temperature amplitude is 24.5°C.

Thaw. Thaw day is the day when a maximum temperature above 0°C is ob-served against a constant negative air temperature [4, p. 133]. Thaws are observed several times during the winter, on average 8-10 periods with thaws of different duration and intensity. There are 54 days of thaw in the studied territory in winter [1, p. 78; 5].

The minimum air temperature. The minimum air temperature characterizes the coolest part of the day and is observed before sunrise. The annual course of the minimum air temperature is similar to the annual course of the average monthly temperature [4, p. 138]. Therefore, the lowest values of the minimum temperature are typical for winter: from -2.6°C in December to -5.8°C in January (Figure 4). The highest values of the minimum air temperature are observed in summer up to +14.9°C in July. In general, the minimum air temperature is lower than the average air temperature: from 2,3°C in December and January to 5,9°C in May (Figure 4).

Absolute minimum air temperature is the lowest air temperature recorded during the observation period. The lowest absolute minimum air temperature is observed above -28°C in January-February. From December to March, the absolute minimum temperature is above -20°C. The highest absolute minimum is characterized for summer, during this period it is positive and in July is +7.6 °C [5; 6]. The amplitude of the absolute minimum air temperatures is 36.5°C.

Frosts. Frosts are short-term reductions in air or soil temperatures up to 0°C and below with a constant positive average daily temperature. Frosts occur at night or in the morning, quiet weather when conditions contribute to the intense cooling of the earth's surface and the ground layer of air. Frosts are usually recorded in transitional seasons [4, p. 146]. At the study area, spring frosts cease to cross in the middle of the third decade on April 26. Autumn frosts appear in the first decade on October 6. The part of the year, during which frosts are not recorded is called the frost-free period. The average duration of the frost-free period in the air (at an altitude of 2 m) is 162 days [1, p. 53; 4, pp. 147–149].

Daily course of air temperature. The daily course of the air temperature is conditioned by the radiation balance, which depends on the height of the sun, the length of the day, the cloudiness and the transparency of the atmosphere. The daily course of air temperature is characterized by uneven changes. After sunrise and noon there is an intense increase in temperature, then the growth slows down and at 15 hours the maximum. After 15 hours a gradual decrease in air temperature begins, which reaches a minimum before sunrise [4, p. 122].

Therefore, the maximum daily temperature is fixed at 15 hours during the year, the minimum at 9 hours in the cold period and 6 hours in the warm period (Table 5). The lowest amplitude of daily temperatures is typical for winter – 2.7 °C and the highest in summer is 9.9 °C.

Table 5

Daily course of air temperature, °C*

Season	Observations, hours								Amplitude
	0	3	6	9	12	15	18	21	
Winter	-2.3	-2.7	-3.0	-3.1	-1.8	-0.4	-1.0	-1.9	2.7
Spring	7.3	5.8	5.0	7.3	11.4	13.2	13.0	10.1	8.2
Summer	16.8	15.0	14.0	18.2	22.3	23.9	23.7	20.7	9.9
Autumn	7.4	6.5	6.0	6.6	10.4	12.2	11.3	8.6	6.2
Year	7.3	6.1	5.5	7.3	10.6	12.2	11.8	9.4	6.7

** – developed by the authors according to the source [6]*

5. Moisture and cloudy mode

Air humidity. Humidity is one of the important signs of moistening the area. The humidification mode is caused by radiation factors, atmospheric circulation, features of the underlying surface. Humidity has an effect on the intensity of evaporation, the occurrence of frost, the formation of fogs, clouds and more. It is determined by the amount of water vapor in the atmosphere and is described by three values: partial pressure of water vapor, relative humidity and humidity deficiency [4, p. 158].

Water vapor partial pressure. The annual course of the partial pressure of water vapor changes in parallel with the course of the air temperature has a pronounced annual course and increases from winter to summer [4, p. 159]. The lowest value of the partial pressure of water vapor is recorded 3.9 hPa in January. In February and December, it is slightly higher (4.1 and 5.0 hPa). In February, the partial pressure of water vapor begins to increase, which is most intensively manifested from April to May and from May to June by 3.0 and 3.1 hPa. In May, the partial pressure of water vapor is 10.4 hPa. In July, it reaches a maximum of 15.0 hPa and begins its gradual decline. The largest decline is observed from August to September and from September to October by 3.2 hPa. In September, the partial pressure of water vapor is 11.6 hPa and in November it is 6.7 hPa [3, p. 77; 4, pp. 159–161].

The daily course of the partial pressure of water vapor is similar to the daily course of air temperature but manifests itself less clearly, especially in the cold period.

Relative humidity. Relative humidity is the indicator that has the greatest practical interest at the degree of saturation of air with water vapor. Relative humidity in the surface layer has a daily and annual course, the reverse of air temperature [4, p. 161]. In winter, the average monthly relative humidity reaches the highest values. The maximum (87.9 %) is recorded in December (Figure 5).

From February, the relative humidity begins to decline. In April, it reaches a minimum 68.6 % and in May it is 69.5 %. In summer months the relative humidity is quite high 70.1-72.9 % (Figure 5). In autumn, the relative humidity increases and in November is 87.5 %.

The number of days with high (80 % and more) and low (30 % and less) relative humidity has a great practical interest. The days when the humidity in the daytime (at 1 pm) reaches 80 % are humid. If at least one of the observation periods had a humidity of 30 % or less, this day is considered dry. The recurrence of wet and dry days is affected by the temperature regime and the humidity at the atmosphere [4, p. 162]. Wet days are recorded throughout the year. The highest number of such days is observed in December and the smallest in the warm period from May to September (2-5 days). Dry days (with a relative humidity of 30 % and below) are most often recorded in spring: 3 days in April, 4 days in May (Figure 5). In summer there are generally 3-5 dry days. In autumn and winter there are very few days [1, p. 67; 4, p. 162].

Daily course of relative humidity. As the course of relative humidity is opposite to the course of air temperature, the daily minimum relative humidity corresponds to the daily maximum of the air temperature and is observed at 15 hours, the maximum of humidity with the minimum of the air temperature and falls at the time of sunrise at 6 hours [4, p. 162]. In general, the daily course of relative humidity is best manifested in summer, when the amplitude is 39 % and the weakest in winter with an amplitude of 10.4 % (Table 6).

Saturation deficiency. Water vapor saturation deficiency has an annual course corresponding to the air temperature. In winter with heavy clouds, frequent rainfall and almost complete absence of evaporation, water vapor is in

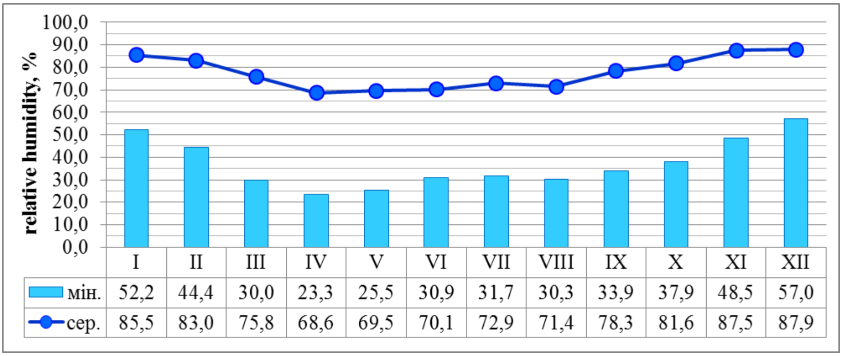


Figure 5. Annual course of relative humidity, %*

** – developed by the authors according to sources [5; 6]*

the air with a state close to saturation [4, p. 163]. According to the annual course of air temperature, the saturation deficit in this period is 0.7-0.8 hPa. In March, the saturation deficit begins to increase to 1.5 hPa, in April and May it is 3.7 and 6.1 hPa. In summer, the water saturation deficit of water vapor increases even more and as a partial pressure of water vapor, reaches its maximum of 7.4 hPa in July. In August, the saturation deficit still retains high values is 6.1 hPa but with the onset of autumn there is a sharp decrease: 4.1 hPa in September, 2.2 hPa in October, 1.0 hPa in November [1, p. 68; 4, pp. 163–164].

Cloudiness. Cloud mode is formed under the influence of synoptic processes that determine the moisture content of the air masses and the direction of their movement [4, p. 164].

Table 6

Daily course of relative humidity, %*

Season	Observations, hours								Amplitude
	0	3	6	9	12	15	18	21	
Winter	87.0	88.4	89.1	89.2	85.0	78.8	81.2	85.3	10.4
Spring	77.8	82.6	85.9	77.2	61.2	54.1	54.3	67.3	31.8
Summer	82.0	87.2	90.0	76.1	58.3	51.1	53.1	66.0	39.0
Autumn	87.5	89.1	90.3	89.1	76.9	68.2	73.9	83.6	22.1
Year	83.6	86.8	88.8	82.9	70.3	63.0	65.6	75.6	25.8

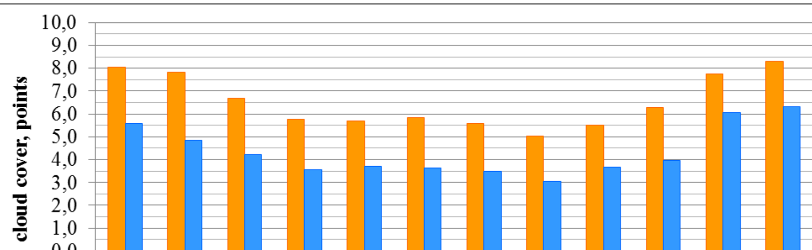
** – developed by the authors according to the source [6]*

Annual course of clouds. Cloudiness depends on seasonal changes at the atmosphere, so its annual course is clearly noticeable. The highest cloudiness is observed in winter at 7.8-8.3 points of total cloudiness and 4.9-6.3 points of the lower one (Figure 6). The maximum of cloudiness falls on December at 8.3 points of total cloudiness and 6.3 points of lower cloudiness. In spring the cloudiness gradually decreases. The lowest cloudiness is observed 5.0-5.8 points overall in summer and 3.0-3.6 points lower. The minimum is in August 5.0 points of general cloudiness and 3.0 points of lower cloudiness. In autumn cloudiness again increases (Figure 6).

In general, the recurrence of cloudy skies (8-10 points) with a total cloudiness in January is 75 % and in July is 45 %. Whereas the average number of cloudy days with a total cloudiness is 145 days a year while the lower one is only 85 days [4, pp. 165–168].

An important indicator of cloudiness is the fraction of lower cloudiness. The largest part is characterized 62.0-76.1 % for winter but the maximum is 78.3 % in November. In spring, the share of lower clouds in general decreases to 62.0-65.3 %. The lowest proportion of lower cloudiness in summer is 60.5-62.5% while the minimum is 60.5 % in August. In autumn, this indicator is rising again to 63.2-78.1 %. In general, the share of lower cloudiness has the same annual trend as that of cloudiness.

Daily cloud cover. In the daily course of general cloudiness in the warm period, the maximum falls on 15 hours and the minimum falls at night (0 and



	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
overall	8,1	7,8	6,7	5,8	5,7	5,8	5,6	5,0	5,5	6,3	7,8	8,3
bottom	5,6	4,9	4,2	3,6	3,7	3,6	3,5	3,0	3,7	4,0	6,1	6,3

Figure 6. Annual cloud cover, points*

** – developed by the authors according to the source [5]*

3 hours); in the cold period the maximum is observed in the morning at 9 hours, and the minimum is observed in the evening and night (18, 21 and 3 hours) (Table 7) [4, pp. 165]. In general, the daily amplitude of cloudiness in summer reaches 1.8 points and in winter is only 0.5 points (Table 7).

Table 7

Daily general cloud cover, points*

Season	Observations, hours								Amplitude
	0	3	6	9	12	15	18	21	
Winter	8.1	8.0	8.0	8.3	8.0	7.9	7.8	7.8	0.5
Spring	5.8	5.8	6.0	5.9	6.3	6.5	6.4	5.9	0.7
Summer	4.7	4.5	5.1	4.9	5.8	6.3	6.0	5.0	1.8
Autumn	6.6	5.7	6.5	6.8	6.7	6.8	6.5	6.6	1.1
Year	6.3	6.0	6.4	6.5	6.7	6.9	6.7	6.3	0.9

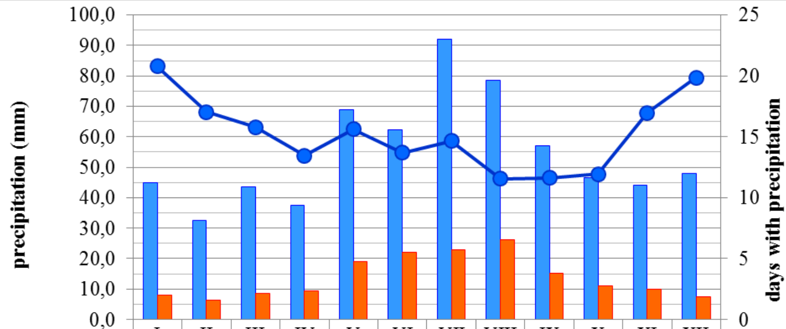
** – developed by the authors according to the source [9]*

Rainfall. Atmospheric precipitation is one of the most important characteristics of the climate. Rainfall is associated with various forms of clouds: layered-rain, high-layered, layered, and cumulus-layered [5].

Annual rainfall. The amount of precipitation that has fallen on the underlying surface is determined by the thickness of the formed layer of water (mm) that has fallen out over a period of time (hour, day, month, year). The study area is located on sufficient humidity, so 656.5 mm of precipitation falls during the year and 67,6 % or 443.5 mm of precipitation during the warm period (April-October) and 32.4 % or 213 mm during the cold period (November-March) (Figure 7).

According to the date, the minimum precipitation falls 32.5 mm in February. Most of the cold season falls 47.9 mm in December. The maximum precipitation falls in the warm period in July is 91.9 mm. The lowest rainfall in the warm period occurs at the beginning and at the end of the period is 37.4 and 46.7 mm in April and October (Figure 7). There is a sharp increase in rainfall from April to May (by 31.5 mm) and from June to July (by 29.5 mm) with a further decline. The largest decrease in precipitation is observed from August to September by 21.3 mm.

A maximum rainfall reaches the maximum in summer is 22-26 mm with an absolute maximum in August is 26 mm. The lowest values of maximum



	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
precipitation	45,0	32,5	43,5	37,4	68,9	62,4	91,9	78,4	57,1	46,7	44,2	47,9
max per 12 h.	8	6	9	9	19	22	23	26	15	11	10	8
days	21	17	16	13	16	14	15	12	12	12	17	20

Figure 7. Annual precipitation (mm) and days with precipitation*

** – developed by the authors according to sources [5; 6]*

precipitation are observed in winter is 6-8 mm of precipitation in 12 hours (Figure 7). So the maximum annual rainfall for 12 hours coincides with the annual rainfall.

The characteristic feature of the weather is the recurrence of rainfall as more than 180 days are observed annually with rainfall with a layer exceeding 0.1 mm. Therefore, the highest number of days with precipitation during the month is recorded 17-21 days in winter and the smallest from August to October is 12 days. Other months the number of days with precipitation is 13-17 days [5].

Snow cover. In winter, snow cover has a significant impact on the climate formation of the territory. Snow cover has high reflectivity (albedo), sharply reduces radiation balance, promotes cooling of lower air layers and formation of stable anticyclones, increasing of wind speed [4, p. 191]. Permanent snow cover at the study area is set at the end of December. With the increase in air temperature, the destruction of the stable snow cover begins in early March. Persistent snow cover is typically stored for 60-70 days. However, the longest snow cover was from December 2012 to April 2013 – 124 days and the lowest was in winter 2014-2015 – only 37 days [5; 6].

The height of the snow cover is variable. Thus, from the moment of its appearance in November, it gradually increases to February from 1.5 to

8.5 cm. The maximum height of snow cover during the same period varies from 3 to 15 cm. In March, the height of the snow cover halves: average to 4 cm and maximum up to 7 cm (Table 8).

Table 8

Characteristics of snow cover*

Indicators	Months				
	November	December	January	February	March
Height of snow cover, cm Average	1.5	4.7	6.9	8.5	4.0
The maximum	3.0	9.0	1.,0	15.0	7.0
Number of days of snow cover	4	14	21	20	12

** – developed by the authors according to the source [5; 6]*

6. Conclusions

The radiation regime of the study area is determined by the position of the Sun on the sky and the time of sunrise and sunset. During the year, the length of day varies from 7.5 hours, in December to 16.5 hours, in June and the height of the Sun above the horizon from 15° in December to 62° in June.

The average duration of the sunshine is 1860, including 1529 hours in the warm period.

The radiation balance of the territory during the year is positive and amounts to 1275 MJ/m^2.

The average indicator for the year is 63 % of days with anticyclones and 37 % with cyclones. Anticyclones generally move from the west, south and northwest, north, southeast, cyclones move from the west, south and northwest.

During the year, the amplitude of atmospheric pressure is observed in the study area within 5.5 hPa with an average value of 996.1 hPa. Changes in atmospheric pressure during the day are less significant, but during the warm period the amplitudes are larger and amount to 1.0-1.1 hPa.

In the cold season winds are dominated by west, southwest, southeast and southeast winds and in the warm west, northwest, southeast and southeast winds, a high proportion of calm is 18.4 % and 28.6 %.

The average wind speed during the year is 2.0 m/s with an amplitude of 0.7 m/s. The maximum wind speed is 2.4 m/s in January and the minimum is 1.7 m/s in August.

The daily course of wind speed is best followed by summer when the amplitude is 2.1 m/s and maximum values of the average speed are fixed at 15 hours and the minimum values of the average speed are fixed at night.

The average annual air temperature is +8.7°C with a maximum in July and a minimum is -3.5°C in January.

The daily course of the air temperature is best manifested in the warm period and is characterized by an intense increase of temperature after sunrise and by noon with a maximum at 15 hours and a further gradual decrease with a minimum before sunrise.

The average relative humidity of the study area is 77.7 %, the maximum falls 87.9 % in December and the minimum is 68.6 % in April.

The average annual cloudiness of the territory is 6.5 points total and 4.3 points lower. The highest clouds are observed in December and the lowest in August.

The area is at the zone of sufficient humidity, so the amount of precipitation is 656.5 mm: in the warm period is 443.5 mm, in the cold period is 213 mm. The highest rainfall occurs in July is 91.9 mm and the minimum is 32.5 mm in February.

References:

1. Adamenko, T.I., Kulbida, M.I., & Prokopenko, A.L. (Eds.). (2011). *Ahroklimatychnyi dovidnyk po terytorii Ukrainy (seredni oblasni pokaznyky 1986-2005 rr.) [Agroclimatic Directory on the Territory of Ukraine (Average Regional Indicators 1986-2005)].* Kamianets-Podilskyi: PP Halahodza R.S. (in Ukrainian)

2. Voloshynova, N.O., & Horbach, A.O. (2009). Klimatychni osoblyvosti Rivnenskoho pryrodnoho zapovidnyka za 2000-2008 rr. [Climatic features of the Rivne Nature Reserve for 2000-2008]. *Zberezhennia ta vidtvorennia bioriznomanittia pryrodno-zapovidnykh terytorii. Materialy mizhnarodnoi naukovo-praktychnoi konferentsii, prysviachenoi 10-richchiu Rivnenskoho pryrodnoho zapovidnyka*, 755–759. (in Ukrainian)

3. Zuzuk, F.V., Netrobchuk, I.M., & Hanushchak M.M. (2014). Klimat [Climat]. *Pryroda Zakhidnoho Polissia, prylehloho do Khotyslavskoho karieru Bilorusi: monohrafiia – Nature of Western Polissia, adherent to Khotyslavsky quarry of Belarus: monohrafiia,* 66–90. (in Ukrainian)

4. Lipinskyi, V.M., Diachuk, V.A., & Babichenko, V.M. (Eds.). (2003). *Klimat Ukrainy [The climate of Ukraine].* Kyiv: Vydavnytstvo Raievskoho. (in Ukrainian)

5. Sait «Pogoda i klimat» [Site «Weather and Climate»]. Retrieved from: http://www.pogodaiklimat.ru/ (in Russian)

6. Sait «Rozklad pohody rp5.ua» [Site «Weather schedule rp5.ua»]. Retrieved from: http://rp5.ua/Arkhiv_pohody/ (in Ukrainian)

7. Tarasiuk, N.A., & Tarasiuk, F.P. (2008). Atmosferna tsyrkuliatsiia ta dynamika vitrovoho y termichnoho rezhymiv na terytorii pivnichnoho skhodu Volynskoho Polissia [Atmospheric circulation and dynamics of wind and thermal regimes in the north-east of Volyn Polissya]. *Pryroda Zakhidnoho Polissia ta prylehlykh terytorii: zb. nauk. pr. – Nature of Western Polissia and surrounding territories: a collection of scientific works,* 13–23. (in Ukrainian)

8. Tarasiuk, F.P., & Tarasiuk, N.A. (2014). Klimat mista Sarny ta prylehlykh terytorii [The climate of the city of Sarny and surrounding areas]. *Pryroda Polissia: doslidzhennia ta okhorona. Materialy mizhnarodnoi naukovo-praktychnoi konferentsii, prysviachenoi 15-richchiu Rivnenskoho pryrodnoho zapovidnyka ta 10-richchiu Ramsarskoho uhiddia «Torfovo-bolotnyi masyv Perebrody»,* 237–246. (in Ukrainian)