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GENETIC FACTORS OF CLIMATE IN THE CRIŞUL NEGRU HYDROGRAPHIC BASIN

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Abstract: This paper summarizes the genetic factors that determine the climate from the Crişul Negru hydrographic basin, namely the solar radiation, the movement of air masses and the active subjacent surface. The bibliographic information is supplemented with data calculated on the basis of well-established formulas in climatology. It highlights the role of each factor in the genesis of climate in the Crişul Negru Hydrographic Basin.

Key words: genetic factors, solar radiation, Crişul Negru Hydrographic Basin

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INTRODUCTION

The climate of a geographical area is generated by certain genetic factors (solar radiation, baric centers, proximity or remoteness to/from the ocean or the sea, ocean currents, physical-geographical factors) and is characterized by various climatic factors: air temperature, air humidity, atmospheric precipitations, clouds, wind and meteorological phenomena. This paper aims at highlighting the factors that generate the climate in the Crişul Negru Hydrographic Basin.

DATA AND METHODOLOGY

The radiation potential was calculated using the Ångström-Savinov formula; the atmospheric circulation was synthesized from the most prestigious dynamic climatology works and, in order to highlight the role of the active surface, proper determinations were made, completed with the results of several specialty studies.

RESULTS AND DEBATES

THE RADIATION FACTORS

The solar radiation is the most important genetic factor and it depends on: latitude, atmospheric transparency, crossed air mass, cloudiness. Unfortunately, there is no weather station in the Crişul Negru hydrographic basin at which to perform actinometrical observations and we

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will consequently highlight the potential of solar energy available for this hydrographic basin based on calculations made according to the Ångström-Savinov formula.

$Q = Q^o [1 - (1-k)\, n]$, where:

Q^o - total solar radiation during clear weather;
K - coefficient which varies depending on latitude (0.35);
n - monthly average cloudiness value (tenths of covered sky).

The data in table 1 shows that the average annual total solar radiation (the sum of direct and diffuse radiation) in the Crişul Negru Hydrographic Basin exceeds 100 kcal/cm², the highest being registered at the plain floor (113 kcal/cm²/an Ineu) and the lowest at Stâna de Vale, 102 kcal/cm²/year in the mountain area where the dynamic thermal convection is stronger, the nebulosity is greater, the role of relief being essential in the distribution of the values of this climatic factor in the studied area. As we get closer to the hilly areas, the total solar radiation drops to 105-108 kcal/cm²/year as recorded at Holod, respectively Ştei and even more at Moneasa (104 kcal/cm²/year) and Zece Hotare (107 kcal/cm²/year) at an altitude of over 600-700 m. An exception is Dumbrăviţa de Codru station located nearly at the same altitude as the Zece Hotare station (only 50 m below) where, due the frequent thermal inversions that cause a roof of the clouds below the station position (Gaceu, 2009), there is a higher value than 110 kcal/cm²/year.

The monthly and annual values of the total solar radiation (kcal/cm², calculated for the Crişul Negru hydrographic basin (1978-2007)
(Data source: Data from the A.N.M. Archives)

Station		Stâna de Vale	Moneasa	Zece Hotare	Dumbrăviţa de Codru	Ştei	Holod	Ineu	Chişineu Criş	Salonta
Alt.(m)		1108	703	642	586	278	163	110	96	95
Monthly and annual total solar radiation (kcal/cm²)	I	3.48	3.30	3.42	3.30	3.30	3.13	3.24	3.13	3.07
	II	5.49	5.30	5.49	5.40	5.49	5.30	5.58	5.40	5.12
	III	7.93	7.80	8.40	8.35	8.35	8.07	8.62	8.35	7.93
	IV	10.05	10.05	10.41	10.77	10.77	10.41	11.13	11.13	10.05
	V	13.00	12.50	13.14	13.14	13.36	12.93	14.22	13.92	12.93
	VI	13.01	13.01	14.09	13.66	13.88	13.66	14.96	14.53	13.66
	VII	13.42	**15.43**	**15.88**	**16.33**	**15.88**	**15.43**	**16.78**	**16.33**	**15.88**
	VIII	**13.82**	14.42	14.23	15.43	14.63	14.23	15.23	15.03	14.23
	IX	9.11	9.68	9.11	10.11	9.68	9.54	10.25	10.11	9.40
	X	7.11	7.43	7.22	7.54	7.33	7.11	7.54	7.43	7.22
	XI	3.77	3.70	3.64	3.90	3.64	3.51	3.77	3.64	3.57
	XII	***2.40***	***2.23***	***2.27***	***2.52***	***2.27***	***2.23***	***2.15***	***2.15***	***2.15***
	Year	102.60	104.85	107.30	110.45	108.58	105.55	**113.55**	111.15	105.21

In conclusion, the territorial distribution of the annual average amount of total solar radiation is determined by the dynamics of the atmosphere and by altitude.

In what concerns the annual distribution of the total solar radiation, we find that the lowest monthly average is recorded in December, with values between 2.15 kcal/cm²/month at Chişineu Cris and 2.52 kcal/cm²/month at Dumbrăviţa de Codru due to fact that the daytime is shorter, the nebulosity is greater, and fog has a high frequency (table 1, figure 1, 2).

We have to note that, due to the frequent thermal inversions recorded at Dumbrăviţa de Codru (Gaceu, 2009) and to the high altitude Stâna de Vale station is located at (Gaceu, 2005), the highest values of total solar radiation are recorded in December (greater than in the plain areas), 2.52 kcal/cm²/month, respectively 2.40 kcal/cm²/month.

The highest average monthly values of total solar radiation occur at Ineu with 16.75 kcal/cm²/month in July, when nebulosity is lower and not in June, the month of the summer solstice, when the daytime is the longest and when the nebulosity is very pronounced, June being the month of the pluviometric maximum. All stations in the basin recorded the maximum total radiation in July, except for Stâna de Vale, where the highest value occurs in August, 11.80 kcal/cm²/month, due to the prevalence of the anticyclone regime, to lower air temperature, to reduced convective processes and to cloudiness.

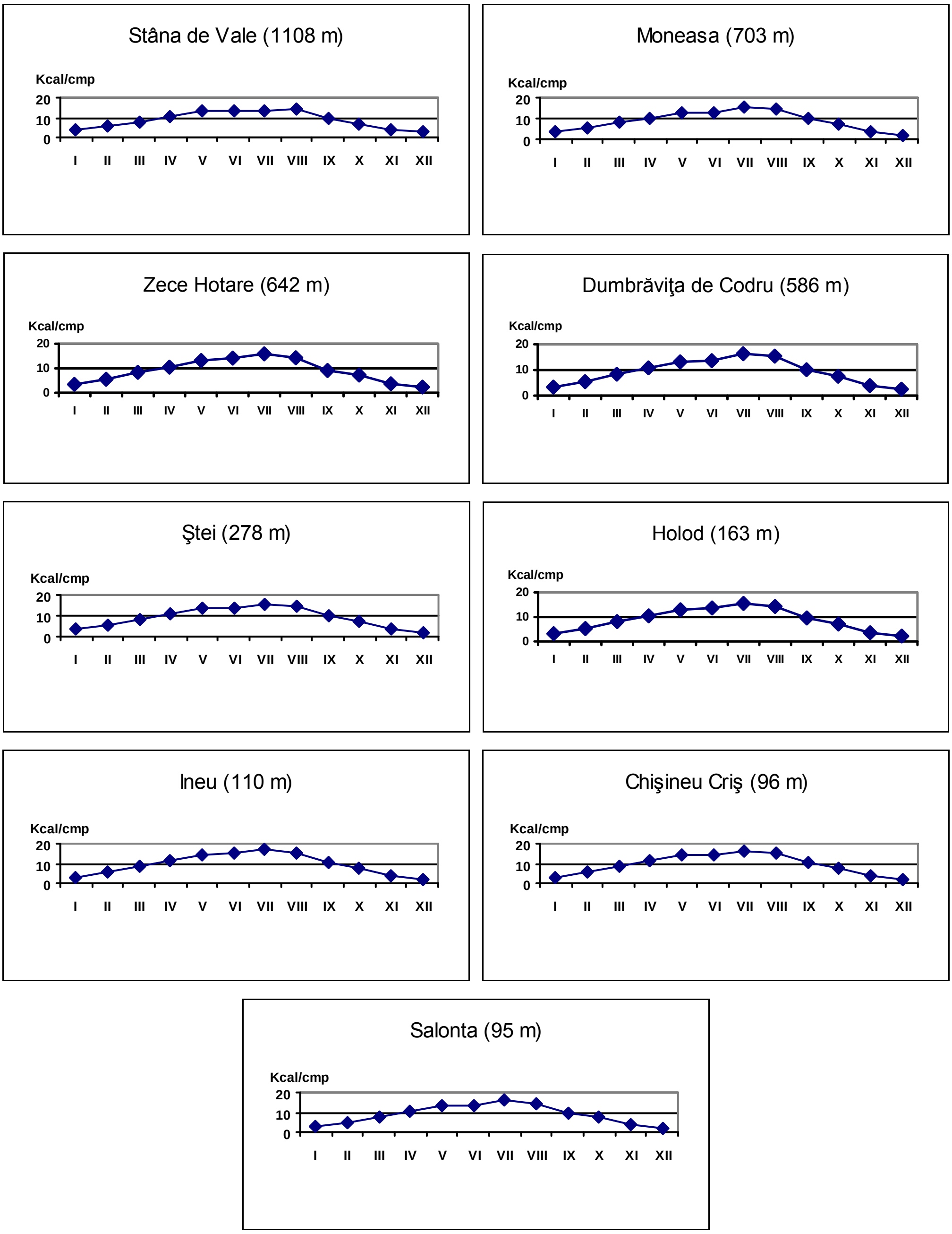


Figure 1. The monthly values of the total solar radiation (kcal/cm²), calculated for the Crişul Negru hydrographic basin (1978-2007)

Moreover, the total solar radiation decreases as altitude increases due to development of the thermal convective processes that generate clouds and precipitations that reduce insolation: 11.80 kcal/cm²/month at Stâna de Vale, compared to 16.75 kcal/cm²/month at Ineu (table 1, figure 1, 2).

In conclusion, following the monthly distribution of the total solar radiation values we discover that they are 3-4 times higher in summer than in winter due to a more favorable incidence angle, which causes higher temperatures and cumuliform clouds through which sunlight crosses, unlike in winter months when the low temperatures, the thermal inversions and the stratiform clouds last for days and reduce the direct radiation which is an essential component of the total radiation.

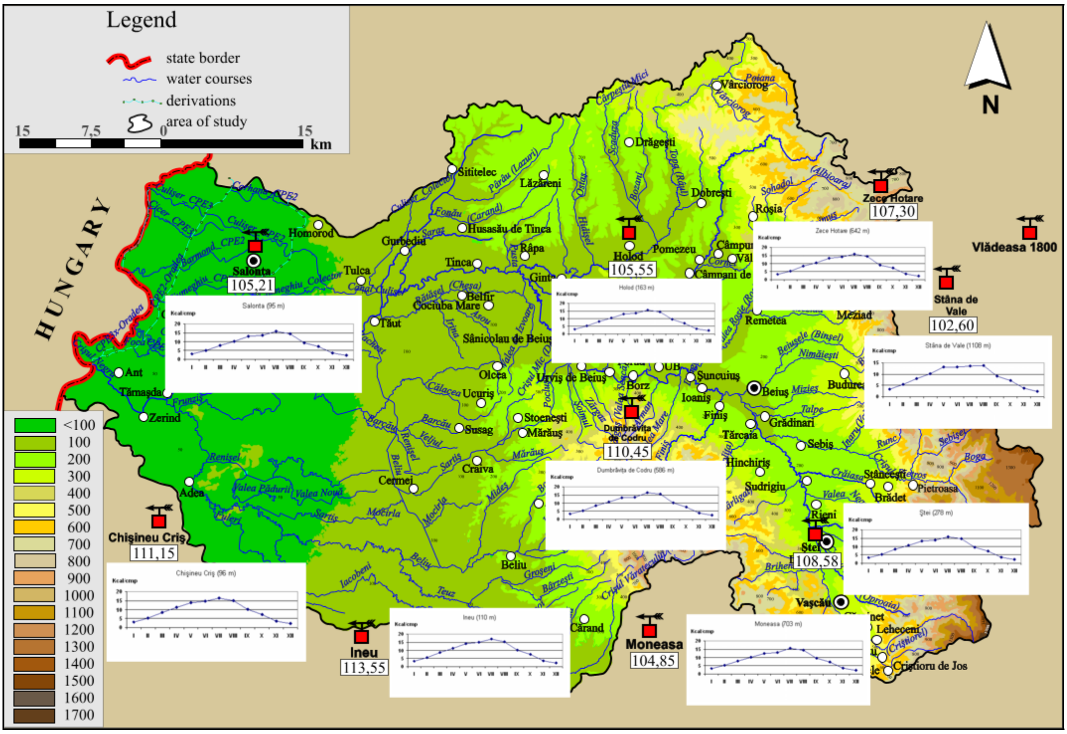


Figure 2. The annual distribution of the total solar radiation and the monthly variation in the Crişul Negru hydrographic basin

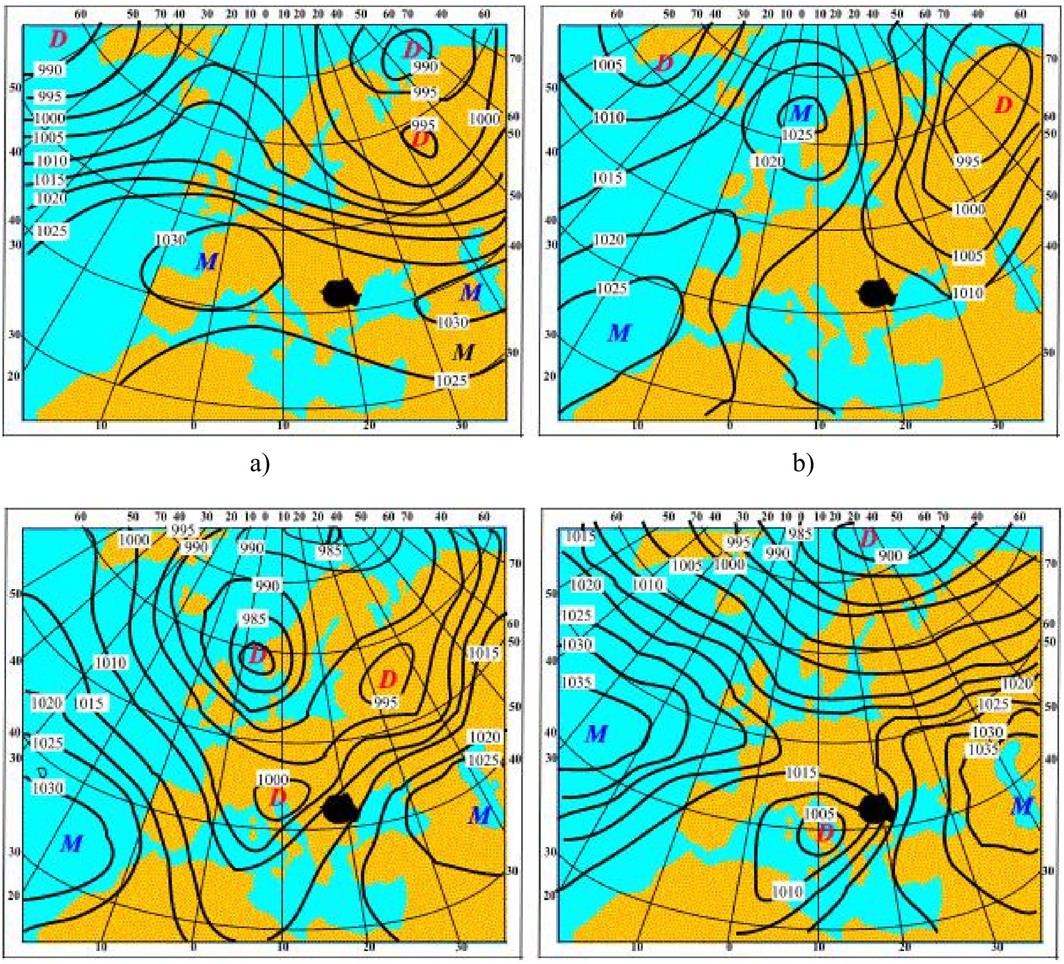
DYNAMIC FACTORS

Together with the solar radiation, the dynamic factors have a particularly important role in the genesis of climate in the Crişul Negru hydrographic basin since they transport the characteristics of climatic elements from one place to another, these mountain units being placed in the transition area of the different barometric centers of influence. In this sense, in order to have an overview of the dynamics of the atmosphere that generates weather and climate in the Crişul Negru hydrographic basin, we present the main characteristics for the types of atmospheric circulation.

Types of atmospheric circulation over Europe and their influence on weather and climate in the Crişul Negru hydrographic basin

Research on air circulation over Europe has shown that, in addition to the western elevation winds that are characteristic of middle latitudes, in the European region we can meet other orientations for the atmospheric circulation, such as from north to south (meridian). At the ground level there are four main forms of air circulation with direct implications for weather and climate in Romania and thus for the Crişul Negru hydrographic basin: the western circulation, the polar circulation, the tropical circulation and the blocking circulation, highlighted by Topor and Stoica (1965), based on the synoptic and air material analysis from the 1938-1961 period.

The western (zonal) circulation determines the air movement from west to east with a frequency of 45% (165 days/year). It is the most important for Romania and for the Crişul Negru hydrographic basin, as it is characterized by pronounced persistence (it may last more than 25-30 consecutive days) both in the warm and in the cold season. It occurs where there is a high atmospheric pressure field situated above the southern Europe and the depression areas in the northern regions (figure 3a). It causes mild winters with precipitations mostly in the form of rain and cool and moist summers with strong precipitations accompanied in Bihor and Vlădeasa mountains by lightning and hail.



a) b)

c) d)

Figure 3. Types of atmospheric circulation over Europe: a) western, b) polar c) tropical d) blocking (Source: according to *Geography of Romania*, 1983)

The polar circulation represents 30% of the cases (110 days/year), it takes 18 consecutive days at the most and is generated by the development and the expansion towards Iceland of the Azoric anticyclone, the movement of air masses being oriented northwest to southeast (figure 3 b). This circulation leads towards the territory of the Crişul Negru Basin oceanic polar air masses that lower the temperature, increase cloudiness and causes precipitations in the form of showers. Sometimes the ridge of the Azoric anticyclone joins with the Greenland anticyclone, the Scandinavian or Eastern European one and it facilitates the entering of the polar air masses from the north at the level of the Crişul Negru Basin. This causes a pronounced decrease in temperature, the early and late cooling in autumn and spring, very low temperatures during winter (especially in the intracarpathian depressions) and heavy snows sometimes accompanied by strong storms (100-150 km/h).

The tropical circulation represents only 15% (55 days/year) of the cases, but has a persistency of up to 18 consecutive days or 24 days in some cases. The orientation of the air currents specific to this movement ensure the transport of the warm tropical air towards the Crişul Negru basin area (figure 3c) through two directions:

- south-west, when air masses cross the Mediterranean, get loaded with water vapors and cause mild and wet winters and hot and humid summers with showers and thunderstorms;
- south-east, when air masses pass over Asia Minor, they become arid and they determine a nice weather, very hot and dry both in summer and winter.

The blocking circulation has a duration of 36 days/year (10%) and is characterized by the installing of a high-pressure system both for high altitudes and at the ground level (figure 3 d). It diverts the Atlantic cyclonic disturbances towards the northern and the north-eastern part of the continent, so that the central and south-eastern Europe is located in a field of high atmospheric pressure, with beautiful and dry weather in summer, but with wet and insignificant precipitations in winter.

THE ACTIVE SUBJACENT SURFACE

The Crişul Negru hydrographic basin has an extremely heterogeneous active subjacent surface, with a varied relief, crossed by a dense hydrographic network, with varied soil the presents a vegetation distribution to which we add the quite high density of human settlements. All these elements of the geographical landscape collect, absorb and reflect differently the solar radiation so that this area has a truly active role.

The most important element of the active surface is created by the topography which in the Crişul Negru basin ranges from 90 m in the first floor of plains and over 1,800 m in the mountain area of the Bihor - Vlădeasa Mountains. The plain area is relatively flat, but the other levels of relief (the hills and mountains) are heavily fragmented. Even if the mountains are not very high, they induce however, through slopes, altitude, fragmentation and configuration, significant qualitative and quantitative changes in the regime of the climatic elements, allowing the emergence of numerous topoclimates.

Thus, the slopes are of great importance in the distribution of the solar radiation, the southern slopes being warmer than the northern ones, thanks to the longer duration of the sunshine, a fact that is also reflected in the natural setting of vegetation, soil and climatic elements (for example, the duration of the snow layer is reduced by one month on the southern slopes than on the northern ones). The eastern slopes heat up faster during the day, as compared to the western slopes where dew and hoarfrost persist. Moreover, the western slopes are wetter than the eastern ones: 1631 mm at Stâna de Vale (1108 m) compared to 847 mm at Băişoara (1360 m) (Gaceu, 2011).

The altitude determines the air temperature to decrease with 0,65 ºC/100 m, the cloudiness to increase with 0.1 tenths/100 m and the precipitations to increase with 100 mm/100 m, but all these values manifested in general are disturbed by certain local topoclimatic conditions.

The relief fragmentation favors the oceanic air masses to enter the Beiuş Golf-Depression which incorporates the Crişul Negru Basin, as the overall massiveness of the main ridge (Bihor-Vlădeasa) serves as an orographic barrier against the baric systems and their specific cloud associations that travel eastward, their traverse through this area characterized by intense thermodynamic transformation.

The configuration of the relief introduces significant differentiations between the climate elements that characterize the peaks and the valleys. We'll give as an example the values registered at Stâna de Vale (1108 m) and Ineu (110 m) stations. Thus, at Stâna de Vale the average annual global radiation is of 102.60 kcal/cm², the annual average temperature of 4.1 ºC, the annual average relative humidity of 89%, the annual average nebulosity of 6.0 tenths and the average annual precipitations of 1631.8 mm, while the average annual global radiation at Ineu is of 113.55 kcal/cm, the annual average temperature of 10.6 ºC, the annual average relative humidity of 77%, the annual average nebulosity of 5.5 tenths and the average annual precipitations of 617.0 mm.

Hydrography influences climate both through the hydrographic network and the lake basins due to the specific physical properties of water, namely high specific heat, high thermal conductivity, low thermal conductivity, properties directly reflected in the thermal regime, in the evaporation and in humidity. In the Crişul Negru hydrographic basin the hydrographic network's density is high and the network of irrigation or drainage canals and the lakes with hydropower or fishing role determine in the microclimatic space, during summer, a temperature drop with 2-4 C, as compared to the adjoining drier area. In addition, the thermal amplitudes are smaller, there are frequent fogs and thermal inversions due to the water's property to cool down more slowly (Bogdan, 1980a,b,c; 1989).

The soils contribute, along with other physical and geographical factors to the emergence of numerous topoclimates in the Crişul Negru hydrographic basin. Therefore, the great variety of soils caused by pedogenetic factors (topography, rocks, water, human intervention) and highlighted by the zonal soils (mollissols, clay soils, cambisols) and by the azonal ones (hydromorphic, halomorphic) determine different processes of absorption and reflection of the solar radiation. For example, dark mollisols with low albedo, spread in the low plains of the Crişul Negru Hydrographic Basin, unlike the clay soils characteristic of the hilly habitat that are brighter, have a higher albedo, so they get warm differently and create different topoclimates. Moreover, the cambisoils encountered at higher altitudes, on greater or smaller slopes, covered with various herbaceous or forest vegetation, determine the presence of a mosaic of topoclimates. In contrast with the mentioned zonal soils, the azonal soils, respectively the hydromorphic ones, specific for lowlands where they occur insularly due to the presence of shallow groundwater (0.5-1 m) and to the migration of salts to the surface, have more intense evaporation and thermal amplitudes etc. (Măhăra, 1977; Bogdan, 1980a,b,c, 1983; Ciulache, 2002; Farcaş, 1988; Farcaş et al., 2003).

Vegetation generates different topoclimates according to its coverage degree, depending on the species of plants, their density, their height, their leaf shape and density, the grassland and crop height, the vegetation stage. Thus, all elements of vegetation influence the climate regime because, by their upper part, they assume the role of active area and retain over 80% of the global solar radiation and 15-20% of the precipitations amount, thus resulting and increased air temperature and a decreased relative humidity in the concerned areas (Măhăra, 1977, 2001; Ciulache, 2002; Farcaş, 1988; Farcaş et al., 2003).

Within the Crişul Negru hydrographic basin the vegetation is predominantly forest-steppe and altitudinal differentiated forest. In the plain area, where cultivated land occupies large surfaces, the topoclimates change depending on the stage of development of the vegetation (Bogdan, 1978, 1986), but in the hilly and mountain areas, where wooded areas prevail, the topoclimates are more stable, specific for the forest vegetation type. The forest reduces thermal amplitudes, diurnal temperature, wind speed, solar radiation and increases air humidity (up to 35%), the amount of precipitations (by 3-5% to 15% in forest clearings), the snow depth which is more uniform than in the open plain, etc. (Marcu, 1986; Ciulache, 2002; Fărcaş, 1988; Fărcaş et al., 2003; Mihăilescu et al., 1965).

The human intervention changes the values of climate elements through urbanism, industries, transport, etc. Among these activities the most significant changes are caused by urbanism since the city requires and important energy consumption for industrial, residential, transportation purposes, some of this energy being transformed into heat and the city becoming thus a source of heat. In addition, the architecture and the geometry of constructions, the nature of the construction materials, the road network, the urban facilities, etc. modify the radiative – thermal regime of the city which becomes a real "heat island", the air being warmer above it than in its surroundings. Higher temperatures and the waterproof asphalt that determines water to drain and discharge quickly through drains make the relative humidity to be lower in the city. The temperature and pressure differences between the city and the surrounding cause the emergence of urban breezes, while in the city the wind is channeled down the main streets, along the rivers, or vortices are formed in the squares.

The higher air temperature from the city causes an upward movement of the air (local thermal convection sometimes called "chimney effect"), thereby raising pollutants in the atmosphere where they become condensation nuclei and favor the creation of precipitations (Ciulache, 1980).

CONCLUSIONS

The climate of the Crişul Negru hydrographic basin is generated by:

- the solar radiation that decreases from 113 kcal/cm²/year at Ineu, in the plain area, at 102 kcal/cm²/year in the mountain area at Stâna de Vale ;

- the circulations of air masses that move predominantly from west in 45 % of the cases and from northwest in 30% of cases, the frequency of the southern (tropical) air masses being of 15%, the remaining 10% belonging to the blocking circulation;

- the active subjacent surface that is active especially through the relief (exhibition - wetter western slopes, more shaded than the eastern ones, altitude - the air temperature decreases with 0.65 ºC/100 m, increasing cloudiness 0.1 tenths/100 m, increasing precipitation amounts of 100 mm/100 m, fragmentation - golf type depression open for the western circulation), water, soils, vegetation plus human influence.

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