MICROCLIMATE AND (OR) TOPOCLIMATE - REPRESENTATION OF CLIMATE FACTORS IN DEFINING THE CLIMATE ELEMENTS

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Determination of prevailing weather conditions over some area is related to a specific point where the climatic parameters are measured during the climatic period. The section of the climatic conditions, based on climatological monitoring, refers to the immediate environment of the weather station with the identical climate factors. Thus, defined climate for the given space is called microclimate. Microclimate is a climatic determinant that manifests itself in its own typological definition (greek: micros; small) only on small districts of identical natural factors that determine the climatic elements. It is the climate of a certain place and is often called a local climate, and more often the topoclimate.

Key words: climate, climatic elements, climatic factors, microclimate, local climate, topoclimate

INTRODUCTION

For determination of the prevailing weather conditions over some place, area, region, state, continent or natural zone, the term climate is introduced. It defines all the climatic parameters that manifest over the given area. The climatic parameters of which are the most important thermal and isohyetal regime in the given period of time are mostly determined by climatic factors of the place where they are defined. Therefore, the climate is a spatial-time category. It applies spatially only to a specific place where the climatic elements are measured, and temporally it includes the time distance, which, according to the international convention, is determined by the 30 years period. On the basis of this perceived spatial and time distance, the climate is defined by the average of meteorological weather conditions, which shows the statutory fluctuations in the predicted period of time. Unlike the weather, which is the current and the changing category, the climate is persistent and its changes are long-lasting and insignificant in the period of a human life.

When determining the spatial category in the definition of the climate, the meteorological or climatological monitoring data are taken into account. If climate monitoring is more dense, i.e if more climatological observatories are deployed on a certain area, then the climate determination of this area is more credible and vice versa, a smaller number of climatic data are defining the climate uncertainly.

The time category that determines the climatic elements is defined by the climatic period which is determined by the convention of an uninterrupted sequence of 30 years. The first climatic period is determined from 1931 to 1960. According to the agreed beginning of the calculation of climatic periods, this year we find ourselves in the second decade of the third climatic period.

The climate time distance of 30 years in international climatological circles is called the standard climate. Of course, the standard climate is a problematic category for several reasons. According to the definition of a climate that defines the average weather from the

cross section of the weathers or the arithmetic mean of the meteorological elements and phenomena, then every thirty-year average should be standard; approximately identical, which obviously is not and does not have to be. In addition, weather in a given period can be characterized by one or more severe weathers, as opposed to others that do not have such a series of severe weathers. If these climatic periods were to move forward or backward, according to previously studied millennium fluctuations, then we would probably get a different, more balanced and accurate climate of a certain place or territory.

On the fundament of the meteorological monitoring, the climate or the average of the meteorological factors are determined. The monitoring is based on a networked monitoring system of meteorological elements and the phenomena, observed on the meteorological instruments or visually. If the climate networked system is denser, both zonal-horizon and vertically-zonal, the data are more reliable for defining of climate types.

MICROCLIMATE AS A SPATIAL CATEGORY

According to spatial categories, the climate is divided into: macroclimate, mesoclimate, topoclimate and microclimate.

Macroclimates define approximately the same quantitative-qualitative values of climatic elements on large, wide-ranging areas in the rank of geosystems or natural zones on the Earth, such as: wet tropical climates, desert climates, moderate climates, cold climates, snowy climates, etc. The climatic types such as humid tropical climates, savannah climates and monsoon climates within a humid tropical climate; and within the desert macroclimates, the hot desert and the cold desert climates, etc. In the definition of certain macro-climates, certain climatic ranges of climate elements are used, especially air temperatures and rainfalls from the monitoring of the standard meteorological station network for given climatic period.

The mesoclimate spatially encompasses regional geographic entities within a certain macroclimates. So, within Bosnia and Herzegovina that macroclimatically belongs to a moderate climate the several climatic types can be determined, such as moderate warm and humid climatic type, mediterranean type, continental type, etc. Also, conditioned predominantly by azonal factors, where is crucial the altitude – bendwidth, there are differences that define the subtypes, and in Bosnia and Herzegovina: perymountain and mountain mediterranean modified type of climate from south and southwest in the Dinaric system and perymountain and mountain continental type from the north in the same morphostructure. The highest morphological peaks, over 2000 m, are characterized by the alpine climatic type. In the study of the mesoclimate, the same methodology of data processing of meteorological monitoring is used, as well as for macroclimate.

Topoclimate represents the climate of a place or relief in a rank of: valleys, ravines, fields, slopes, karst sinkholes, etc. In the study of the topoclimatic characteristics of some place, the standard and additional, periodic and occasional meteorological measurements and observations are used.

Microclimate is the climate of a very small spatial entities, such as the climate of tree tops, caves, rooms and even air around the human body. In the case that the microclimate is determined in the open area, it goes up to 2 m in height. The study of microclimate requires the implementation of special meteorological measurements.

MICROCLIMATE AND TOPOCLIMATE

As already mentioned, there are obvious differences in the treatment of the object and the landscape units that refer to the definition of topoclimate and microclimate.

The microclimate refers to the climate of a small area such as climate in the tree top, in soil to the depth of the root system, the climate that forms around the human body, the climate in human hair, in the fur of the animals, etc. Topoclimate is understood as the average state of the weather on a certain territorial surface, which is named in a certain place and is therefore called the topoclimate (Greek: topos - place) Thornthwaite, C.W. (1948). Therefore, it may also be named a local climate and refer to a limited territory, environment or surrounding area around some known defined point or place.

According to these definitions, topoclimate is a more approximate term for naming the climate of a place and has an applicative significance. It is a climate of habitats that defines the natural circumstances of the life of some plant or animal species. Todays, this climate gains more and more importance and is referred to as an *ecoclimate* that is divided into *phytoclimate* and *zooclimate*. All the above mentioned topoclimates refer to the influence of climatic elements on the growth and development of the wildlife. It implies an analysis of certain climatic elements that govern the interior of plant stands, determines its vegetation period and other vital elements.

Topoclimate are highly dependent on climatic factors, so it differs from place to place. There are quite different conditions in dense forest ecosystems than in the barren lands, such as drastic differences between the northern and southern exposure. Topoclimatic differences are bigger if there is dense and high vegetation of northern exposures and low vegetation at southern exposures. The first are colder, humid and have a uniform thermal regime, while the southern slopes are warmer, more arid and show more significant daily and annual fluctuations in the thermal regimes. The topoclimate of the forest openings and the barren lands differ significantly from the phytoclimate of a dense forest vegetation. The barren lands, especially of southern exposure, are affected by a daily direct and diffuse radiation and therefore intensively warmed. At the same time, the earth's radiation increases. In this way, a greater distribution of heat is performed in the relation: solar insolation, warming of the surface layer, accumulating of the heat in the soil and the earth's radiation, from which the ground layer of air is heated.

Due to this type of warming of soil and the ground layer of air above the clearings, the amplitude of the air temperature increases due to greater differences in daytime warming and nighttime radiation of the barren lands. In the forest ecosystems of approximately the same topographic qualities, the daily intake of direct radiation is far smaller and is mostly transformed into diffuse radiation due to the shading of the forest vegetation. Because of this, the amount of solar insolation has been reduced, which reduces the warming of the earth's surface layer, and therefore its radiation. All this reduces the daily fluctuations of the temperatures because the differences between the daily warming of the surface layer and its night radiation are reduced.

Unequal thermal oscillations on the same topographic terrains on different substrates conditioned by the absence and presence of the vegetation, is significantly reflected in their thermal regimes. Above the mountain barren lands the snow is melting earlier and the appearance of late spring and early fall frosts is present.

The forest ecosystems have their own microclimates. They are less aerated, they are less windy, soils and air are saturated with humidity, they have a homogenous soil

temperature, etc. The forest microclimate that is binded to the habitat climate of a particular forest ecosystem called phytoclimate or ecoclimate has a very uniform thermal regime and is beneficial to a human organism.

According to the research object, the climate is divided into the climate of the soil and the climate of the atmosphere. The soil climate includes the Earth surface layer, to the depth where the annual warming fluctuations in the ground can be felt, while the climate of the atmosphere mainly refers to the ground layer of the troposphere. The vertical thermal profile of the ground layer of air is very disturbed by the earth's surface radiation, that is manifested to a maximum of 2 meters in height, which is reasonable due to the active radiation layer through which the heat flows to the ground and into the ground layer of air. In the air above this layer are registered the highest thermal gradients, the maximum vaporization, maximum relative air humidity, significant air turbulence etc. Such topoclimatic conditions are more pronounced during a clear and silent time. In the cloudy and windy weather this topoclimatic traits are lost.

MICROCLIMATIC ELEMENTS AND THEIR MONITORING

Determination of microclimatic or topoclimatic elements belongs to climatological monitoring, obtained on the basis of long-term observations and measurements of time-defined parameters and based on their averages or cross-sections, the climate of specific place or topos. The choosing of sites for meteorological or climatic elements monitoring is the general choice of site selection and ranking, according to the number of measurements of weather or climatic elements. Therefore, each climatological station, regardless of rank, is distinguished by its location, that belongs to a particular topographic surface, and its own instrumentarium and measures only the topoclimatic elements of the site. As mentioned above, it should be noted that the measured topoclimatic indicators are evidently modified by topoclimatic factors, although they pretend to the meso and macroclimatic characteristics.

Forming of microclimate on a limited topographic surface, as demonstrated in two surfaces of the same or very similar exposure conditions, and different climatic factors, where one is barren and the other is forested, the shown differences are defined as ecoclimatic. These differences are even more apparent on the same topographic surface of different exposures and edafic factors. The north topographic exposures, especially if they are forested, are colder and fresher for a longer period of time than the nearby topographic surfaces at the southern exposures. The researches that are carried out during the 2017. on various topographic sites of southern and northern exposures in the valley of Krivaja River and its tributaries with the mobile instruments, such as: aspiration thermometers, soil thermometers, aneroid and hygrometer, showed the significant differences between the northern forested and barren southern exposures. The northern slopes, during the colder period of the year, are about 5°C cooler in relation to the barren slopes of southern exposure, in the immediate topographic environment. There, in stable weather conditions, the snow covering is longer retained, even for up to 25 days compared to the southern slopes. As a result, daily temperatures are lower, especially during the noon, compared to the southern barren slopes and without snow, and because of that warming up sooner, so daily temperature fluctuations are evident and can range up to 10°C. Above colder northern exposureslopes a higher air pressure is formed, so the isobaric tendency is facing the south expositions. These conditions are present during the stable anticyclonic weather, and the

winter period is prolonged for the duration of the anticyclonic weather. Often, above these surfaces, there is an advection fog as a result of the warm air flow over snowy forested northern slopes. In addition, the forested slopes have a higher humidity and advection of fresh air, especially at southern expositions during the summer days, when in the forested, narrow, north facing, deep river valleys, the vjetrenice are formed, M. Spahić (2017). The start of the vegetation period at the southern exposition begins 5 days earlier than in the forested northern exposures. If two meteorological stations were placed on two topographic surfaces, then they would show daily, monthly, yearly and therefore long-term differences in the measured elementary metorological-climatic elements. The evident differences would be so pronounced because the forest northern surfaces would have the characteristics of the mountain climate, and the south ones would look more like perymountain, although the topographic distance is only 150 m.

TOPOCLIMATE AND MACROCLIMATE IN BOSNIA AND HERZEGOVINA

The definition of climate and climatic types is based on climatological monitoring, which is a system of networked meteorological stations of different rank in a certain teritory, such as a region, an administrative unit, a state, a continent or the whole globe. The networked meteorological station system should, according to the climatological arrangement, be within a distance of 20 km and on a relative height between neighboring meteorological stations up to 200 m. Such meteorological networking stations should also have the criterium for the site selection, especially in relief indented territories. In the criterium of a site selection, except that it must be representative, there is no other condition for it. In addition, the notion of representativity is not fully defined in the morphologically indented area.

The question is, how to choose a representative site for meteorological monitoring, in the area of several thousand m², where almost all slopes of basic relief exposures are alternated. In such a case, the representativeness of the meteorological data would only be credible if all meteorological elements and phenomena could be monitored on all slopes. The arithmetic mean of the measured meteorological elements and phenomena on meteorological stations of all slopes would simultaneously represent the average state of the climatic elements and phenomena.

Table 1. Percentage (%) of slope exposures (left) and slope inclinations (right) in Bosnia and Herzegovina

Exposures	**%**	**Slope inclinations**	***%***
Plain	**4,6**	**< 4°**	**21,34**
N	**12,46**	**5° - 9°**	**18,8**
NE	**13,73**	**10° - 14°**	**18,35**
E	**11,5**	**15° - 19°**	**14,9**
SE	**10,77**	**20° - 24°**	**11,05**
S	**11,46**	**25° - 30°**	**7,96**
SW	**13,19**	**31° - 36°**	**5,05**
W	**11,42**	**37° - 46°**	**2,18**
NW	**10,85**	**> 46°**	**0,37**

According to the Table 1, it is evident that Bosnia and Herzegovina is a reliefly very indented country, where on a very small territory, the slopes are turned towards different horizon orientations, which the percentage is shown in Table 1. Due to uneven daily warming, they have different heat exchange, hence all other meteorological elements and phenomena. They define the climatic types and determinants they belong to, primarly to agroclimatology and bioclimatology.

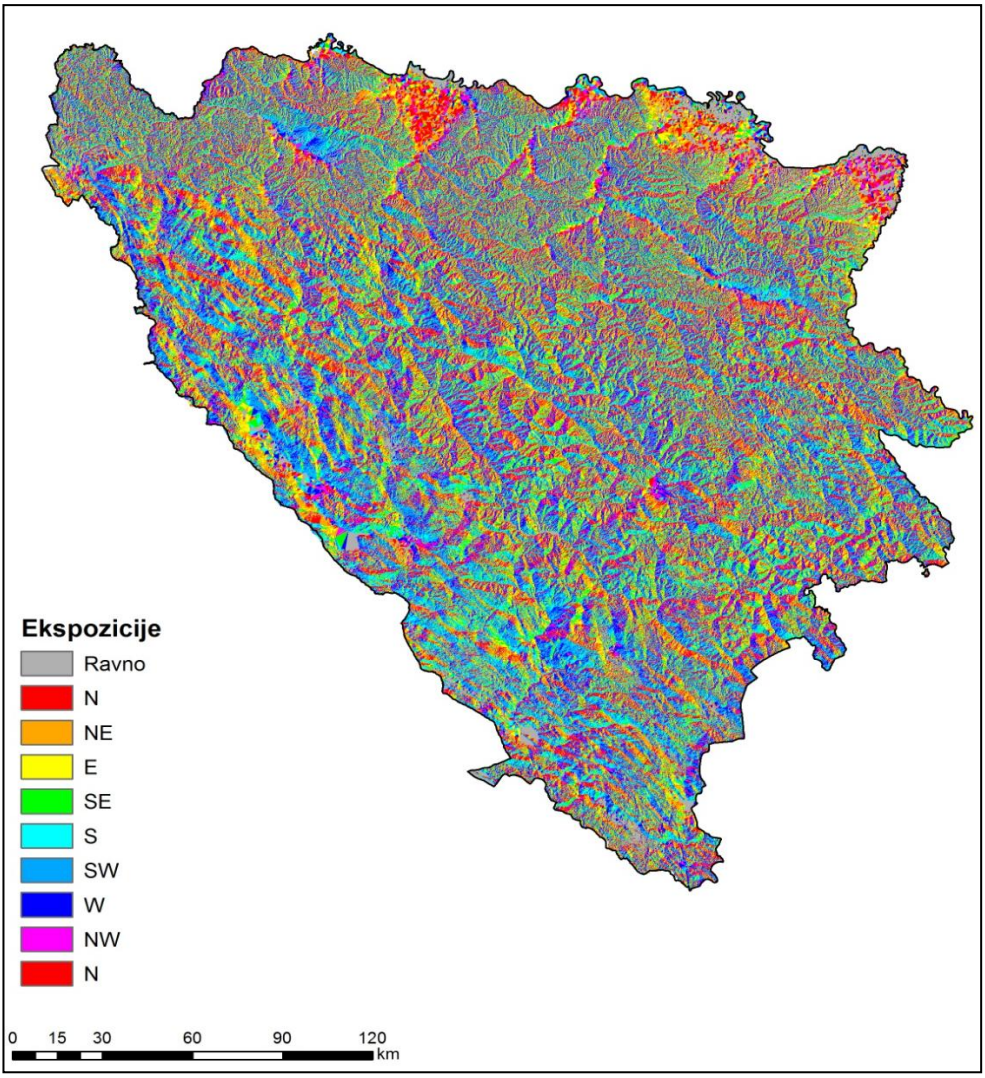

Fig.1. Slope exposure map of Bosnia and Herzegovina

Therefore, each meteorological station in Bosnia and Herzegovina, except in the plains, have their own climate characteristics and belongs to microclimate or topoclimate.

All climatological stations in Bosnia and Herzegovina could be regarded as microclimatic or topoclimatic, particularly in reliefly indented areas, which is illustrated in the map of slope exposures of Bosnia and Herzegovina (Figure 1).

The slopes facing north are defined as cold and humid. The reason is their orientation away from the sun's insolation. That's why, the incidence angles of the sun insolation are smaller and the duration of the daily warming is shorter. People call these slopes „osojne“, contrary to „prisojne“ southern exposures. At northern exposures due to reduced warming, the colder air is stationary, so the air pressure and relative humidity are higher, which is why they are called the frigid slopes.

The south slopes are facing the sun's insolation, so they are warming longer and more intense than the northern exposures. Because of this, people called them „prisojne“ slopes; which are facing the Sun. They collect the most of solar radiation, hence they radiate the most of heat. The southern slopes are drier, with less humidity in the soil and air above the soil, and are more suitable from the bioclimatic aspect.

The eastern and western slopes receive less solar insolation in relation to the southern slopes, and at the same time, more than the slopes of northern exposure. Eastern slopes are somewhat colder than the western ones, because the morning heat is used to vaporize moisture from the eastern slopes, which is not the case in the western slopes during the afternoon when they're the most intensely heated, and the absorbed heat of the sun is spent on radiation only.

The other slopes: east-northeast and west-northwest are cooler than slopes from the southern quadrants such as: east-southeast and west-southwest. Of all, the best from the bioclimatological aspect, are: west-southwest, then east-southeast, west-northwest, and the most adverse are the east-northeast slopes.

If to the exposure is added the slope inclination, then we have a clear perspective of their uneven warming. On excessive warming, besides the exposure, the type of substrate as a climatic factor has a significant influence. The lithological substrate constructed of volcanic rocks with slate structure, due to a reduced albedo, absorbs a higher amount of sun radiation compared to a carbonate-based substrate, particularly light limestones, which significantly increases albedo, and the warming is weaker. As a rule, the substrates under vegetation have a higher thermal capacity, because it warms slower and radiates longer. This substrate has smaller daily and monthly amplitudes than southern slope exposures without vegetation.

Daily warming is significantly affected by (among other) the angle of slope inclination. The greater inclination in southern slopes increase the incidence angle of solar insolation, so the warming is faster. Given that Bosnia and Herzegovina is intersected by a 43 parallel, and that the summer zenith position of the Sun above the horizon on the Tropic of Cancer is at 21st June, it imply practically that all slopes of southern exposures with the inclinations over 15.5° have the zenith position of the Sun in the noon. With higher inclinations, the length of the pseudozenith position of the Sun above these slopes is longer.

The knowledge about slope exposures and their inclinations is very important for bioclimatic purposes. Tree-nursery (hotbed) activities, especially in plants that have a slightly longer and warmer vegetational period compared to flat habitats, is transmitted to the southern slopes of higher inclintions of 15.5° to obtain more heat, because the incidence angle of solar insolation approaches the zenith. Likewise, when hotbeds for plants that succeed in colder soil and ground air are formed, then the northern slopes are chosen.

CLIMATOLOGICAL MONITORING IN BOSNIA AND HERZEGOVINA

The climate of Bosnia and Herzegovina is defined on the weather averages, determined by meteorological-climatological monitoring. It is a system of meteorological stations of different rank. It usually follows the basic climatological indicators, on the basis of which the climate is defined. Bosnia and Herzegovina has several meteorological stations of the first rank, which have a period of instrumental monitoring of meteorological elements and phenomena over a century (Sarajevo, Tuzla and Mostar).

By the WWI, the Austro-Hungarians have set up a climatological monitoring of 78 meteorological stations in the territory of Bosnia and Herzegovina. They covered an average of 655 km² of Bosnia and Herzegovina territory. After the Austro-Hungarian departure the number of meteorological stations, instead of increasing, decreased, and in one period (1945.) only eight meteorological stations were operating.

After the WWII, the meteorological stations were renewed, and since Austro-Hungarian times until the 1955., their number increased for another 10 stations. Bosnia and Herzegovina is a member of the World Meteorological Organization (WMO) since June 30, 1994. The network of meteorological stations in Bosnia and Herzegovina is unreliable, because from a 117 stations in Bosnia and Herzegovina's bigger entity, only 16 are observatory and have a continuous observations for climatic periods, haven't changed their locations and environmental anthropogenic changes did not affect the quality of the meteorological monitoring. In the smaller entity of Bosnia and Herzegovina, there are fewer observatory meteorological stations that work for climatic needs. If meteorological monitoring of Bosnia and Herzegovina includes rain gauge stations and local not officially registered stations as well, then Bosnia and Herzegovina has about 150 meteorological stations, each covering an average of 341 km² of territory. If to the issue is added the fact that most meteorological stations are located in its available territories, which are situated at lower altitudes and in the valley-basin relief, then we become aware of the fact that uninhabited regions of vast areas are uncovered by meteorological monitoring. This interferes with the question of the networking of meteorological stations up to 20 km in distance and up to 200 m of relative height. Obviously, the application of this criterion does not meet the needs of an optimal climatological monitoring network for Bosnia and Herzegovina climate defining.

Their territorial distribution was based on practical needs, and the choice of site did not meet the topographic conditions defined by exposure and slope inclination. Consequently, climatic monitoring in the conditions of relief diversity in Bosnia and Herzegovina is predominantly topoclimatic. It does not reflect the actual climatic state at the point of data gathering from the above-mentioned exposure and inclined slopes, that participate in the general relief habitat of the climatic monitoring area, to be representative for the networked system regarding the 20 km radius and relative height up to 200 m. Therefore, the defining of the climate in the territory of Bosnia and Herzegovina, according to the existing network of climatic monitoring is determined, according to its topoclimatic elements and factors.

CONCLUSION

The determination of prevailing weather over some place is related to a specific point where climatic parameters are measured during the climatic period. The cross-section of the weather conditions based on the climatological monitoring refers to the immediate

environment of the climatic station with the identical climatic factors. The climate is a spatial-time category. It applies spatially only to a specific place where the climatic elements are measured, and temporally it includes the time distance, which, according to the international convention, is determined by the 30 years period. On the basis of this perceived spatial and time distance, the climate is defined by the average of meteorological weather conditions, which shows the statutory fluctuations in the predicted period of time. Unlike the weather, which is the current and the changing category, the climate is persistent and its changes are long-lasting and insignificant in the period of a human life.

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Topoclimate represents the climate of a place or relief in a rank of: valleys, ravines, fields, slopes, karst sinkholes, etc. In the study of the topoclimatic characteristics of some place, the standard and additional, periodic and occasional meteorological measurements and observations are used.

Microclimate is the climate of a very small spatial entities, such as the climate of tree tops, caves, rooms and even air around the human body. In the case that the microclimate is determined in the open area, it goes up to 2 m in height. The study of microclimate requires the implementation of special meteorological measurements.

According to the above mentioned specifications, the topoclimate is local and defined by some nodus or habitat. Todays, this climate gains more and more importance and is referred to as an *ecoclimate*.

Topoclimate are highly dependent on climatic factors, so it differs from place to place. There are quite different conditions in dense forest ecosystems than in the barren lands, such as drastic differences between the northern and southern exposures. The unequal thermal oscillations on the same topographic terrains on different substrates conditioned by the absence and presence of the vegetation, is significantly reflected in their thermal regimes. Above the mountain barren lands, the snow is melting earlier and the appearance of late spring and early fall frosts is present.

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If two meteorological stations were placed on two topographic surfaces, then they would show daily, monthly, yearly and therefore long-term differences in the measured elementary metorological-climatic elements. The evident differences would be so pronounced because the forest northern surfaces would have the characteristics of the mountain climate, and the south ones would look more like perymountain, although the topographic distance is only 150 m.

The climate monitoring in the diverse relief conditions of Bosnia and Herzegovina is predominantly topoclimatic. It does not reflect the actual climatic state at the point of data gathering from the above-mentioned exposure and inclined slopes participating in the general relief habitat of the climatic monitoring area, to be representative of a networked system referring to a radius of 20 km and a relative height up to 200 m.

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