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Studies of meteorological elements in the River Basin Uruçuí Preto - PI, Brazil

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Abstract

The goal is to show the variability of meteorological elements in the catchment area of the river Uruçuí Preto - PI (BHRUP), aimed at contributing to sustainable development in the productive areas of agriculture, grain, fruit growing, fishing, laser and hydrology. Weather elements studied are temperature (maximum, minimum and average) air, and their maximum and minimum fluctuations, temperature range, relative humidity, wind (direction and intensity), total insolation, cloud cover, evaporation, evapotranspiration, rainfall. The data discussed are the series of 1960-1990, acquired by the Northeast Development Superintendency and the Company for Technical Assistance and Rural Extension of Piauí State. The maximum annual air temperature is 32.1 °C, annual minimum is 20 °C and the average annual temperature of 26.1 °C. We used climate classification according Köppen systems, which are distinguished two climatic types in the River basin Uruçuí Preto - PI, Aw, tropical hot and humid, with rains in summer and dry in winter; Bsh, hot semi-arid, with summer rains and dry winter. The variation of the temperature range is from 11.9 to 14.9 °C. The average relative humidity of the air is 47-79%, the average annual rainfall is 937.7 mm, it was observed that the annual march of relative humidity accompanies the annual distribution of rainfall because precipitation is the process of supply of natural sources of water vapor and moisture. The total area of Sunstroke BHRUP ranges between 2520 to 2750 hours. The annual evaporation ranges 100-226 mm and the annual evapotranspiration fluctuates between 1160-1600 mm, the intensity of the annual wind with the following highlights in the area of small wind intensity in the far south and in the central and northern part of the southern region found if higher intensities, moderate winds in the northern sector of the central region and in every area of the northern region. The annual cloud cover ranges from 0.4 to 0.6 tenths.

Keywords: Climate variability; Water balance; Monthly and annual fluctuations; Meteorological elements

1. Introduction

The conditions of the climatic and hydrological elements of a given region are the main parameters in the estimation of water availability in that territory and/or region. In the hydroclimatological studies, the basic premises that will guide the development of the work in the definition of the planning and management model of water resources to be implemented. In this way, the compatibility between water availability and demand can only be done when the climatic parameters, especially precipitation, evaporation and evapotranspiration, and hydrological parameters, such as the movement and quantification of surface and underground water in time and space, are duly considered.

The climate also exerts great influence on the environment, acting as a factor of interactions between biotic and abiotic components. The climate of any region, located in the most diverse latitudes of the globe, does not present itself with

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the same characteristics each year [28]. In a region with contrasting climates with nearby areas (one rainy side and the other semi-arid), such as the Northeast of Brazil (NEB) and in particular the state of Piauí, monitoring precipitation, especially during the rainy season, is very important for taking decisions that benefit the population. A good monitoring of rainfall is an indispensable tool in mitigating droughts, floods, inundations, inundations [15 and 22]. Among the climatic elements of tropical areas, rainfall is the one that most influences agricultural productivity [21], especially in the semi-arid region, where the rainfall regime is characterized by short-term and high-intensity events [25], as a result of this, the seasonality of precipitation concentrates almost all of its volume during the five to six months of the rainy season [21: 27].

Spatial and temporal variation are characteristics of weather and climate. Temporal variation is a characteristic that should be studied with greater particularity and in different chronological scales. Because these studies will allow the knowledge of the climate in the past, present and even make predictions and diagnoses for future climate situations from the mathematical models used [11; 22].

Several studies have been prepared with the theme of variability and its climatic characteristics, so it is still far from reaching a consensus, especially regarding the local influence on global trends. However, studies of local climate variability, mainly on temperature and relative humidity and precipitation are essential to understand the impacts that these variations can bring to the population in general. If the fluctuations are really significant at the local level, these changes could cause socioeconomic impacts (in agricultural and livestock production), environmental impacts (changes in ecosystems) and social impacts (proliferation of disease vectors) [10; 20].

Precipitation is essential for climate characterization [12], and its monitoring is of fundamental importance for the management and maintenance of water resources, as it provides data that contribute to public planning and studies that seek the sustainable use of water. Rainfall data, for example, are essential for studies such as those by [8; 7; 24 and 5], who concluded that the deforestation of the Amazon forest is directly influencing the imbalance of the environment, especially in the hydrological cycle, where simulations showed a significant decrease in evapotranspiration and precipitation.

[26] Showed that the state of Piauí has different climatic conditions, with fluctuation in rainfall rates whose origin is highly individualized, also presenting relatively variable annual average temperatures. The rainfall shows great spatial and temporal variability, showing two rainfall regimes: in the south of the state it rains from November to March; in the center and north, the rainy season begins in December and lasts until May. Rainfall rates vary between 700 and 1,300 mm in the southern region, between 500 and 1,450 mm in the central region and between 800 and 1,680 mm in the north of the state. The objective was to analyze the municipal rainfall variability between the different rainfall regimes for the state of Piauí (North, Central and South regions), and it was proved that they have common areas of rainfall occurrences with their respective provoking and inhibiting systems. In the North region the rainfall indexes have a more regular distribution than in the Central and South areas, showing the physiographic aspects, relief, fauna, flora and distance from the sea. Due to the great variation in rainfall over the years, it was possible to observe that the phenomena of macro, meso and micro scales are of great importance for the rainfall regimes of the state of Piauí, which follow chronological time of their activities and duration.

[17] Showed that variability is one of the best known elements of climate dynamics, and the impact produced by this phenomenon, even within the expected range, can have significant repercussions on human activities. It aimed to analyze the climatic variability of the relative humidity of the air and the maximum temperature of the air in the hydrographic basin of the River Uruçuí Preto - PI, focusing on such variations as a means to understand future changes. Maximum air temperature and relative humidity data and monthly and annual rainfall totals from 1960 to 1990 were used. Socioeconomic conditions, as well as human health. From the data, it was also verified that the relative humidity of the air is decreasing along the studied series, a fact that may be related to the increase in temperature and, consequently, to a greater evaporation of water. Regarding the annual rainfall totals, it was noted that the values are gradually increasing, and this increase may be related to the increase in temperature, which causes greater evaporation and consequently greater precipitation.

According to [10], the thermal amplitude for the Southern Region of Brazil showed sharp negative trends in the period 1960-2002, indicating that the minimum temperatures were more intense than the maximum ones, especially in summer. For [23] negative trends in diurnal thermal amplitude are due to positive variations in minimum temperature trends. According to the analysis of [12], the observed warming seems to be more intense in winter than in summer, which is probably related to the increase in the number of hot days in winter [1].

The air temperature is expressed in a simple way to the energy contained in the medium. During the course of a day, the energy available in the environment oscillates between two extreme values, that is, between the minimum and maximum temperature. As this energy goes from one extreme to the other, it acts in the continuous stimulus to the vital physiological processes in living beings, such as the development and growth of plant species, such as: transpiration, breathing, germination, growth, flowering and fruiting. At each stage of plant development there are suitable temperature ranges for its perfect development [6]. In addition, the daily cycle of temperature predominates in thermal comfort and in the adequacy of human and animal in certain places. [23] Showed that the variability of the minimum temperature for the city of Lavras/MG has been changing in the minimum values.

[19] Analyzed the prevailing monthly wind directions over the Uruçuí Preto river basin. The predominant wind direction was described from the frequency of occurrence in a given direction, the methodology adopted by [13]. The predominant wind directions for the basin and the referred predominant contributions to the rainy and dry season were represented. [15] Clarified that the possibilities of mobile dune bars must be worked on in the highest entrances of predominance of winds and their intensities. A counter was performed in order to calculate the prevailing wind inlet frequency for the studied area. The predominant directions with higher frequencies of entry were: northeast-southeast with 19 times, east-southeast with 13 times and northeast with 5 times around the basin.

The objective of this work is to demonstrate that the meteorological elements studied such as: maximum air temperature, minimum air temperature, average air temperature and its maximum and minimum fluctuations, thermal amplitude, relative humidity, wind (intensity and direction), total insolation, cloud cover, evaporation, evapotranspiration and rainfall have their contributions to climate variability and their oscillations aiming climate chang.

2. Material and methods

2.1. Characterization of the study area

The region is drained by the Uruçuí Preto River and the tributaries Ribeirão dos Paulos, Castros, Colheres and Morro da Água, and by the streams of Estiva and Corrente, both perennial. The Uruçuí Preto river basin is predominantly embedded in the Parnaíba river sedimentary basin, constituting one of the main tributaries on the right bank. It has a total area of approximately 15,777 km2, representing 5% of the territory of Piauí and covers part of the southwest region, projecting from south to north in the form of a spear [4].

The total area of the basin lies between the geographic coordinates that determine the rectangle from 07°18'16'' to 09°33'06''south latitude and 44°15'30'' to 45°31'11' ' of longitude west of Greenwich. In accordance with [4], the Uruçuí Preto river basin shows a single set of regional relief forms, dominated by tabular-plateaus and plateaus, characteristic of sub-horizontalized sedimentary rocks.

Only the Plateau of the Parnaíba Sedimentary Basin is identified as a morphostructural unit in the region and, in addition to being located in the central-eastern portion of the Piauí-Maranhão Sedimentary Basin, it is constituted by a sequence of sand-clay sediments, composing the various sedimentary formations. [4]

According to [10], the three most frequent soil classes identified in the Uruçuí Preto river basin are Yellow Latosols (predominant in the basin), Quatzarencio and Hydromorphic Neosols and Neosols.

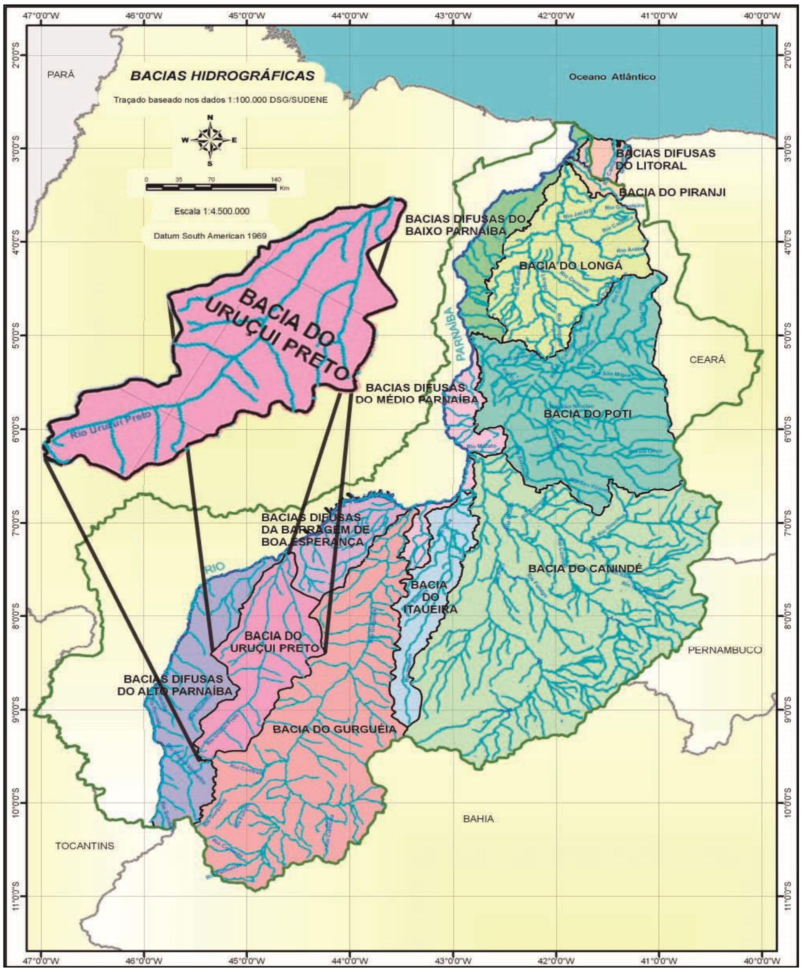
For [4], the supply of groundwater in the Uruçuí - Preto river basin occurs through 04 (four) aquifers, Serra Grande, Cabeças, Poti/Piauí and Pedra de Fogo Formation. The Serra Grande Formation is predominantly composed of coarse and medium sandstones, conglomeratic and conglomerates at various levels (cream to white), with flat cross bedding. In addition, although it is one of the most outstanding in the Northeast, it is even distributed throughout the Parnaíba Sedimentary Basin, it does not offer efficient possibilities for exploration in the Uruçuí Preto river basin region due to the great depths.

According to [4] the identification and description of vegetation in the Uruçuí Preto river basin region are:- from the top of the chapadas, with the typical plant community of the savannas consisting of a discontinuous stratum composed of shrub and arboreal elements characterized by tortuous trunks, thick bark, leathery leaves and an almost always asymmetrical canopy. Among the most frequent species are the barbatimão, the broad-leaf pau terra and the simbaíba, and the soil surface is covered by a grassy layer of wild grass;- starting from the slopes between the top of the chapadas and the flat stretch through which the Uruçuí Preto river flows. In this aspect, the cerrado develops in a more closed way, composed of larger species, including the pau d'arco, the Gonçalo Alves.

The area of interest of the study has a small and poorly distributed network of meteorological stations, which makes a good characterization of climatic conditions difficult. Therefore, we used interpolated data, estimated and generated by multiple linear regression lines, through the estima_T software [2; 3]. For the analysis of the inter-municipal climatic behavior of the Uruçuí Preto river basin, precipitation data acquired through the Northeast Development Superintendence [29] and the Technical Assistance and Rural Extension Company of the State of Piauí [9] for the period from 1960 to 1990, which comprises 49 pluviometric stations located in the study area. The Uruçuí Preto river basin is formed by 25 municipalities and 24 farms that contain rainfall data with a series of 30 years (1960-1990 period). The maximum annual temperature is 32.1 °C, its annual minimum is 20.0 °C and the average annual temperature is 26.1 °C. The climatic classification was used according to the Köppen systems, where two climatic types are distinguished in the Uruçuí Preto river basin – PI, the Aw, hot and humid tropical, with rain in the summer and dry in the winter; is Bsh, hot semi-arid, with summer rains and dry winter [17].

The precipitation regime that comprises the study area begins with pre-season rains, starting in the second half of October. The characterization of the rainy season begins in the first days of November and continues until the month of March, with the wettest quarter being December, January and February.

The factors that cause rain that are predominant in the Uruçuí Preto river basin are the formations of instability lines carried by the Southeast-Northeast trade winds, they exchange heat, traces of cold fronts when they penetrate more actively, Convective cluster formations, orography, contributions of cyclonic vortex formation, conveyor belt, orography and local effects, are factors that increase the transport of water vapor and humidity and consequently the cloud cover.



Source: Medeiros (2022)

Figure 1 Location of the Uruçuí Preto river basin – PI

Normally, the rains are of moderate intensity (regular weather and around seven to eight hours of discontinuous rains daily), followed by irregularities due to failures in the current meteorological systems. It should be noted that the occurrence of summer periods (occurrences of several consecutive days without rain during the rainy season) in the four-month period (December, January, February, and March) is expected. Its magnitude varies depending on the season and weather factors disabled. There have been occurrences with summer periods exceeding nineteen (19) days in the time interval that occurred within the four-month period. [10 and 17].

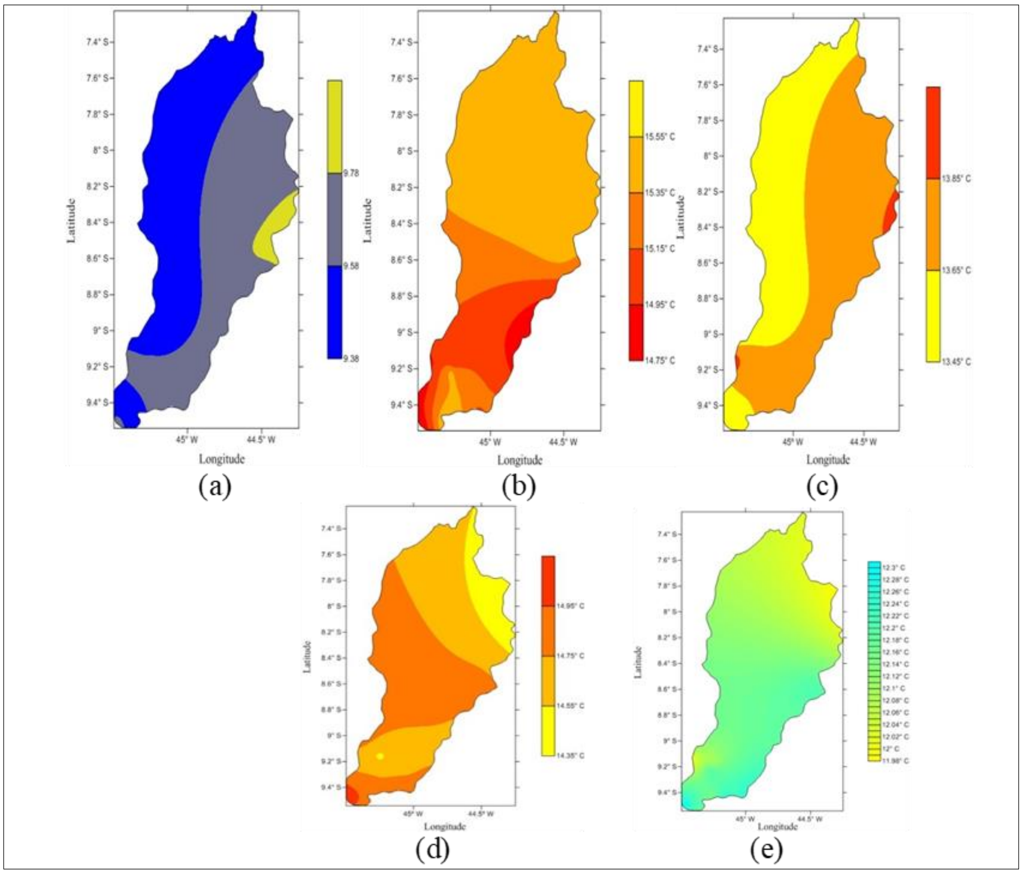
3. Results and discussion

Figure 2 (a, b, c, d, e) represents the thermal amplitude (a) of the coldest month; (b) the warmest month; (c) coldest quarter (d) warmest quarter; (e) and annual, for the Uruçuí Preto river watershed area – PI.

Figure 2a shows the thermal amplitude of the coldest month (January) for the BHRUP area, it is observed that in the western part and in the extreme southwest the area of the lowest amplitudes predominates, the predominant average amplitude range occurs throughout the area (north, central and south region) with its fluctuation oscillating between 9.58 and 9.78 °C, a small area of thermal amplitude greater than 9.78 °C was also observed in the eastern sector of the study area.

Figure 2b represents the thermal amplitude of the hottest month (September) for the BHRUP area, there is a small range of thermal amplitude in the extreme south of the study area above 15°C, a small area in the southeast and southwest sectors as amplitude ranging from 14.7 to 15.2 °C and part of the southern region, part of the central region with thermal amplitude oscillating between 14.5 to 15.2 °C, the predominant thermal amplitude in the central part and in the entire northern area is of 15.3°C.

Figure 2c shows the thermal behavior of the coldest quarter (December to March) which follows the characteristics of figure 1a.



Source: Medeiros (2022)

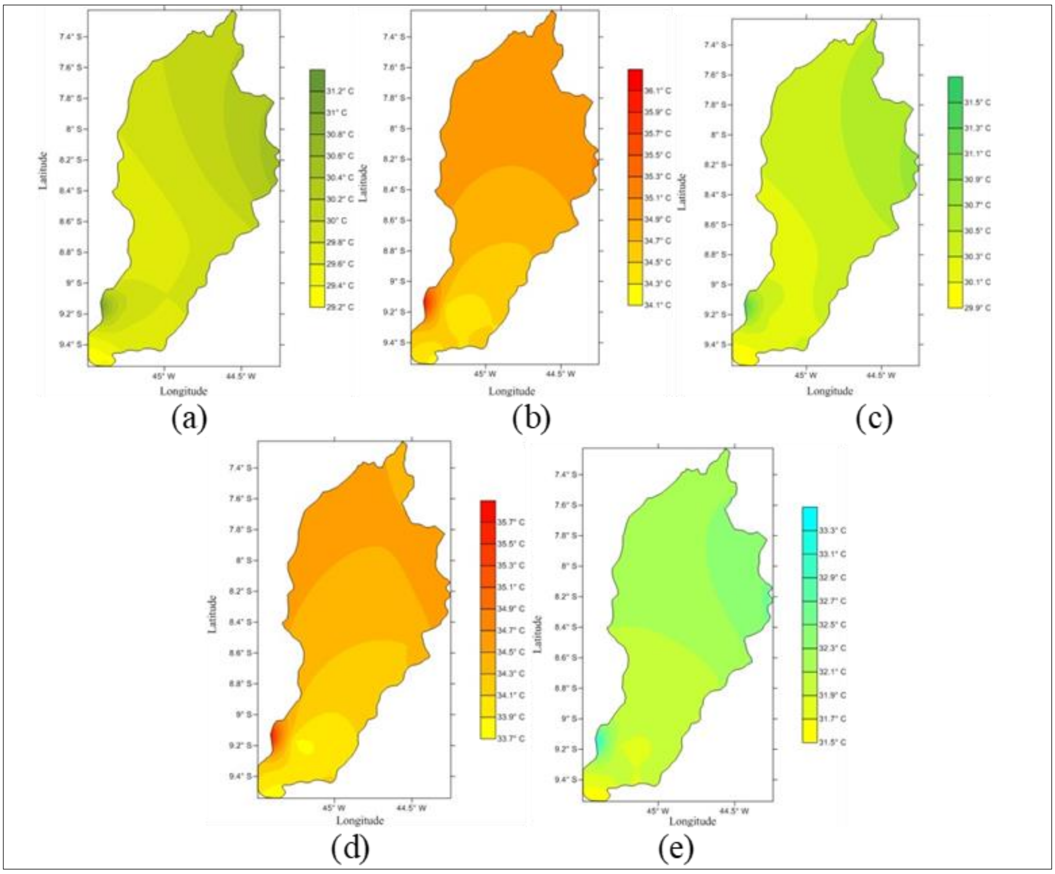
Figure 2 Thermal amplitude (°C): (a) cold month; (b) warmer; (c) coldest quarter (d) warmest quarter; (e) and annual

Figure 2d demonstrates the behavior of the variability of the thermal amplitude for the hottest four months (June to September), there is a small area of maximum amplitude in the extreme southwest and an area of minimum amplitude in the north and northeast sectors, in addition to a small area next to the municipality of Gilbués. In the South, Central and North regions, the variability of the thermal amplitude stands out, oscillating between 14.3 and 14.7 °C.

In figure 2e, an increase in the north-south direction is observed, it is noteworthy that the areas of smaller amplitudes are located in the north and northeast and a small strip in the southwest, in the central, south and part of the south of the northern region. If the variability of the thermal amplitude fluctuating between 12 and 12.3 °C is observed, it is noted that in the southeast to southwest range it is characterized by the highest annual thermal amplitudes.

Figure 3 (a, b, c, d, e) represents the variability of the maximum temperature: (a) of the minimum; (b) of the maximum; (c) coldest quarter; (d) warmest quarter; (e) and annual, for the Uruçuí Preto river watershed area – PI.

In figure 3a, a gradual increase in the south-north direction is observed, it can be seen that the greatest buoyancy of the maximum temperature of the minimum occurs to the north of the central region and in the entire area of the north and northeast region, also seeing a small region in the extreme southwest.



Source: Medeiros (2022)

Figure 3 Maximum temperature (°C): (a) minimum; (b) of the maximum; (c) coldest quarter (d) warmest quarter; (e) annual

Figure 3b shows the persistence of the gradual increase in the maximum temperature from the south to the north, a small area in the southwest sector with maximum temperature. Areas predominate high temperatures of the maximums.

Figure 3c shows the maximum temperature variability for the coldest four-month period (December to March) in which we highlight an increase in the south-north direction with its most intense oscillations in the central and northern sector and a small area in the southwest sector, the south sector and west of the central sector register the lowest values of the maximum temperature of the four-month period.

Figure 3d represents the maximum temperature oscillations for the warmest four months (June to September) in the BHRUP area, there is a small area of maximum temperature in the southwest sector and a gradual increase in that parameter in the south-north direction, with its highest values centered in the northern region and part of the central region.

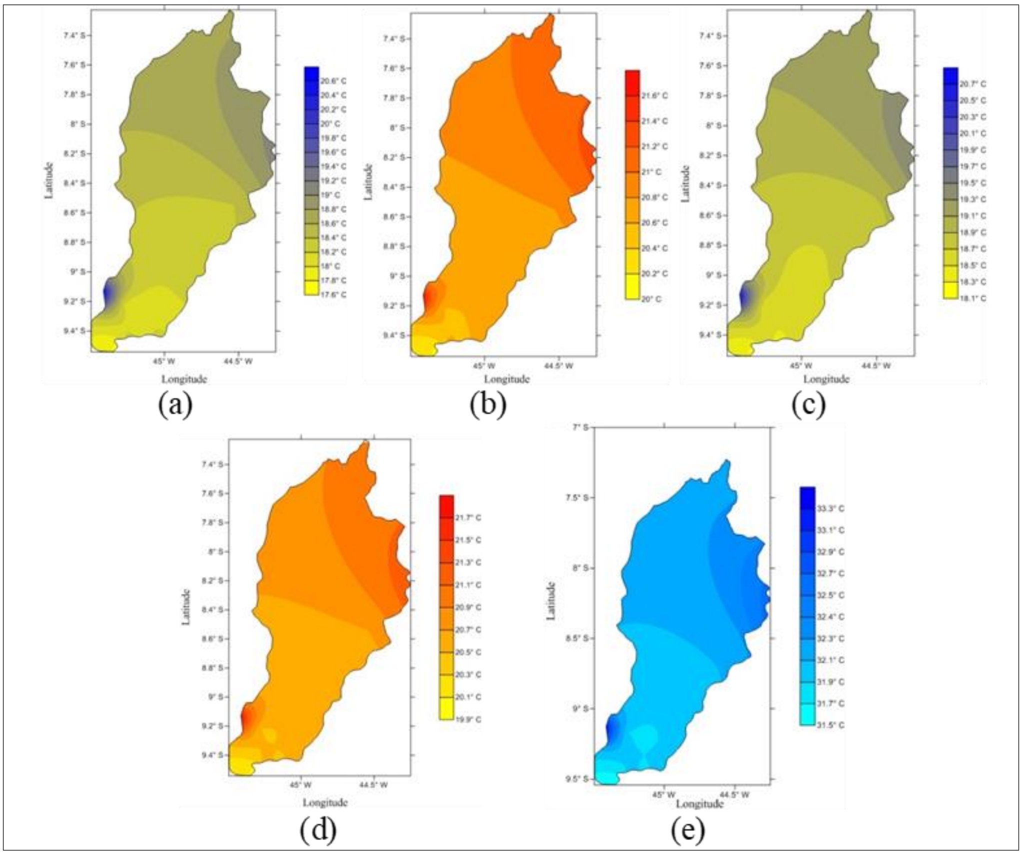
The annual variability of the maximum temperature occurs with greater intensities in the isolated areas of the southwest and northeast sectors and in a small band of the central region, according to Figure 3e. Annual variability occurs in the range of 31.5 to 33.3 °C throughout the basin under study.

Figure 4 (a, b, c, d, e) represents the variability of the minimum temperature: (a) of the minimum; (b) of the maximum; (c) quarter minimum of minimum; (d) minimum of the maximum four-month period; (e) and annual, for the Uruçuí Preto river watershed area – PI.

Figure 4a shows the variability of the minimum temperature that occurs in the month of June, where a gradual increase in the south-north direction can be seen, there is also a small area to the southwest with 19 °C and another area located to the northeast with oscillation, between 18.6 to 20°C.

Figure 4b shows the behavior of the minimum and maximum temperature for the BHRUP area that occurs between the months of August and September, with a gradual increase in the south-north direction, and the variations in minimum temperature with greater significance in the southern sectors and part of the central region, the highest intensity of minimum maximum temperature occurs to the north of the central region and throughout the northern area of the BHRUP, small areas in the southwest and east-northeast sectors with high minimum temperatures stand out.

Figure 4c represents the four-month period of occurrence of the minimum temperature of the minimum in which the areas with greater intensity located to the southwest and northeast of the figure stand out, with oscillation ranging from 18.1 to 20.7 °C, a gradual increase in the temperature is observed, referred parameter in the south-north direction and a low minimum temperature range in the south sector.



Source: Medeiros (2022).

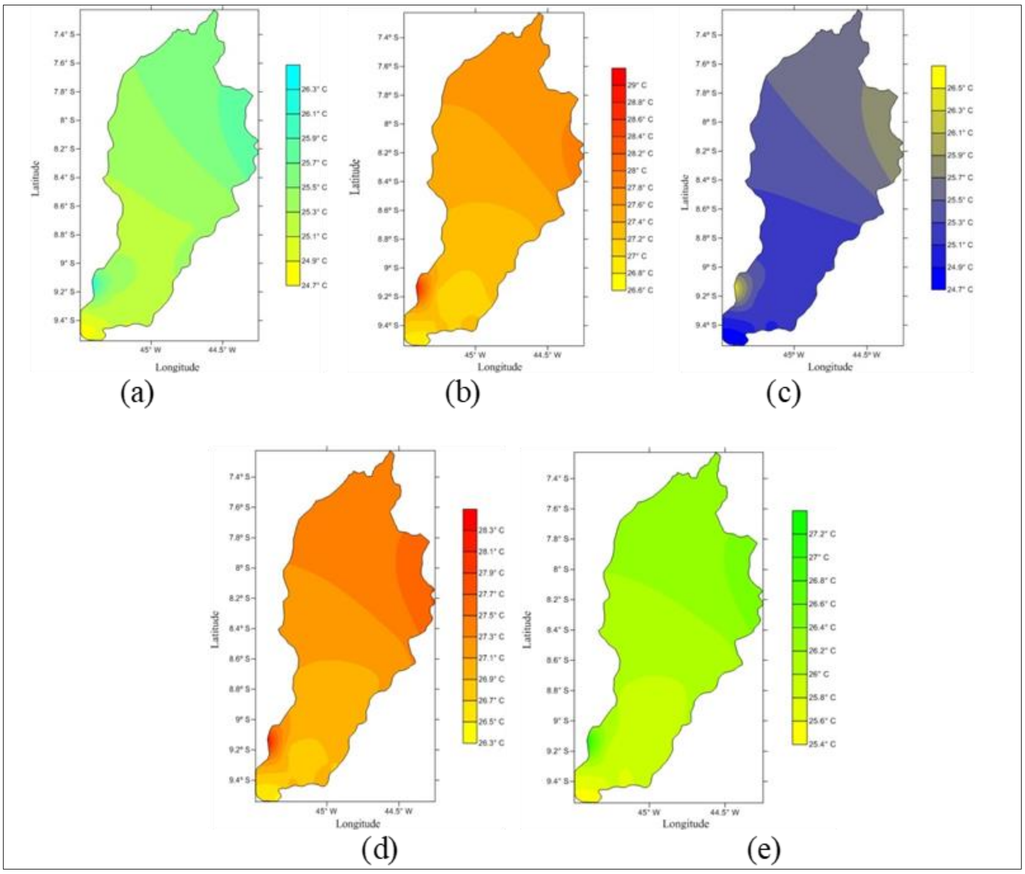
Figure 4 Minimum temperature (°C): (a) minimum; (b) of the maximum; (c) quarter minimum of minimum; (d) minimum of the maximum four-month period; (e) and annual

The buoyancy of the minimum temperature for the four-month period is observed with the minimum occurrences of the maximum as shown in Figure 4d, where the area of maximum elevations in the southwest position and the north and northeast of the northern region is highlighted, in the other areas there are gradual increases with oscillations varying between 19.9 and 21.7 °C, the lowest variability of this parameter occurs in the southern region.

Figure 4e shows us the variability of the annual minimum temperature in the BHRUP area, the highest minimum temperatures are located in the southwest and in part of the north and northeast region, in the south region there are two areas where the smallest are located. Minimum temperature variability.

Figures 5 (a, b, c, d, e) represent the variability of the average temperature: (a) of the minimum; (b) of the maximum; (c) coldest quarter; (d) warmest quarter; (e) annual, for the Uruçuí Preto river basin area – PI.

Figure 5a shows the behavior of the average temperature that occurs in the BHRUP. Bands with higher temperatures are observed in the southwest, north and northeast sectors, in the south and central region, the lowest average temperature variability is located. Figure 5b shows the maximum average temperature oscillations in which the high temperature cores stand out in the southwest sector, in the northeast sector and in the north region, the south and central regions have moderate average temperatures. Figure 5c shows the average temperature oscillations for the four-month period of the minimum averages that occurred between the period 1960-1990. The southern and northern regions of the central region have the lowest average temperature, followed by a gradual increase from the central sector to the north. The high average temperatures are located in the northeast and southwest position of the basin.



Source: Medeiros (2022).

Figure 5 Average temperature (°C): (a) minimum; (b) of the maximum; (c) four-month low (d) four-month high; (e) and annual

The variabilities of the average maximum temperature for the four-month period of the maximum average can be observed in figure 5d, the areas in the southwest and northeast sectors are highlighted as the highest and in the extreme south areas with lower values of that parameter, the central region fits between the moderate medium temperature area and the northern region as the high temperature.

Figure 5e shows the behavior of the annual mean temperature, in which its oscillations occur in the range of 25 to 27 °C, in the southern regions and part of the central region, the smallest fluctuations of this parameter are observed, while in the north of the central region, the highest minimum temperatures are concentrated throughout the northern region.

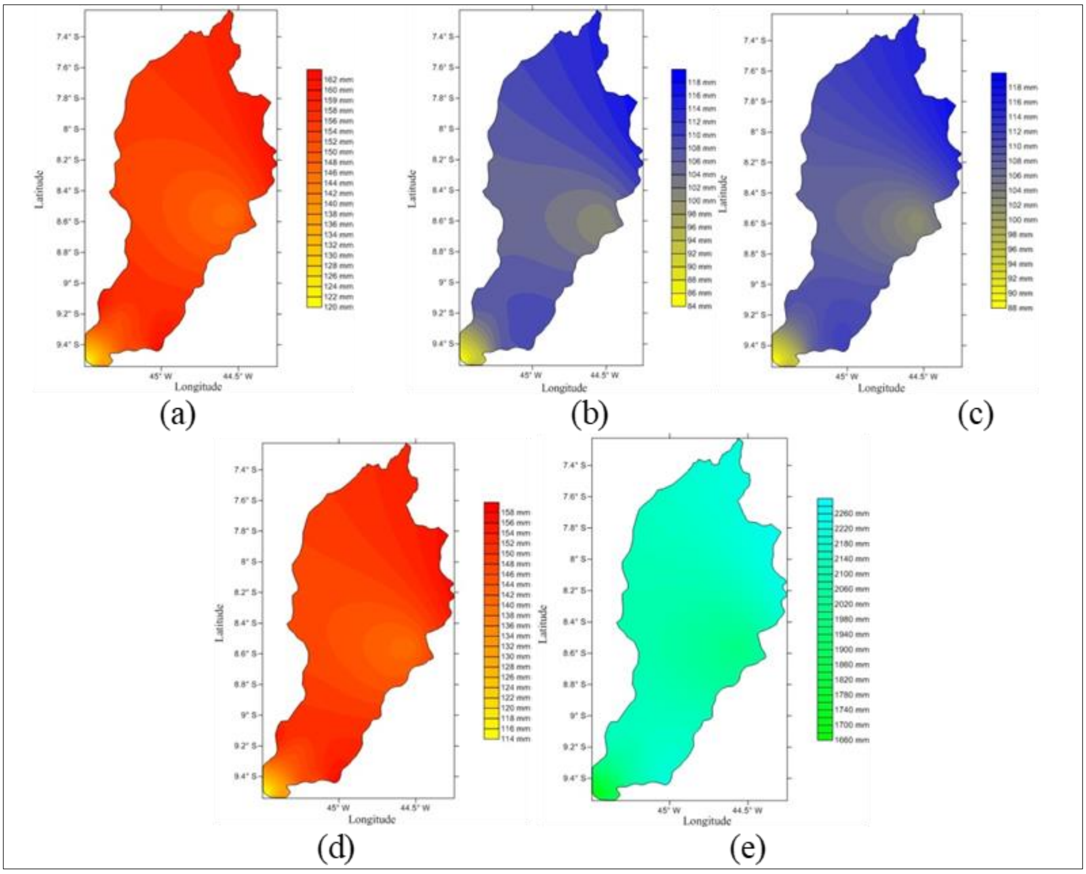
[14] analyzed the annual trends of the minimum, maximum and compensated average temperatures and the absolute minimum and maximum temperatures of twenty-four locations in the Northeastern North Region, between the states of Ceará, Rio Grande do Norte, Paraíba and Pernambuco, where they used series historical data from 1961 to 1990. The authors verified an increase in minimum, compensated average, maximum and absolute minimum temperatures in almost the entire study area, these results are in accordance with what was observed in figures 2, 3, 4 and 5.

Figure 6 (a, b, c, d, e) represents the variability of (a) minimum evaporation; (b) maximum; (c) minimum four-month period; (d) maximum four-month period; (e) and annual, for the Uruçuí Preto river watershed area – PI.

Figure 6a represents the maximum evaporative power that occurs between the months of August and September with a fluctuation of 120 to 162 mm, the north, northeast, southeast and southwest sectors have the highest evaporative rates, there is a gradual increase from south to north.

Figure 6b shows the minimum evaporation that occurs in the month of February with a monthly evaporative rate ranging from 84 to 118 mm. the lowest evaporative indices are in the extreme south and east of the central region.

Figure 6c shows the variability of evaporation in the minimum four-month period (December to March), which varies between 88 and 118 mm. high evaporative power to the southeast, northeast and north of BHRUP, the southern sectors of the southern region, the central area to the west and the western sector of the northern region with intermediate evaporation.



Source: Medeiros (2022)

Figure 6 Evaporation (mm): (a) minimum; (b) maximum; (c) minimum four-month period; (d) maximum four-month period; (e) and annual

The evaporative variability of the four-month period of maximum evaporation can be seen in Figure 6d, which occurs in the range of 114 to 158 mm between the months of June and September, in the south-north direction with its evaporative extremes occurring in the north sector.

Figure 6e shows an annual variability of evaporation ranging from 100 to 226 mm per year, in the extreme south sector the lowest evaporative indexes are observed and an increase in the south-north direction stands out, whose evaporative power gradually increases.

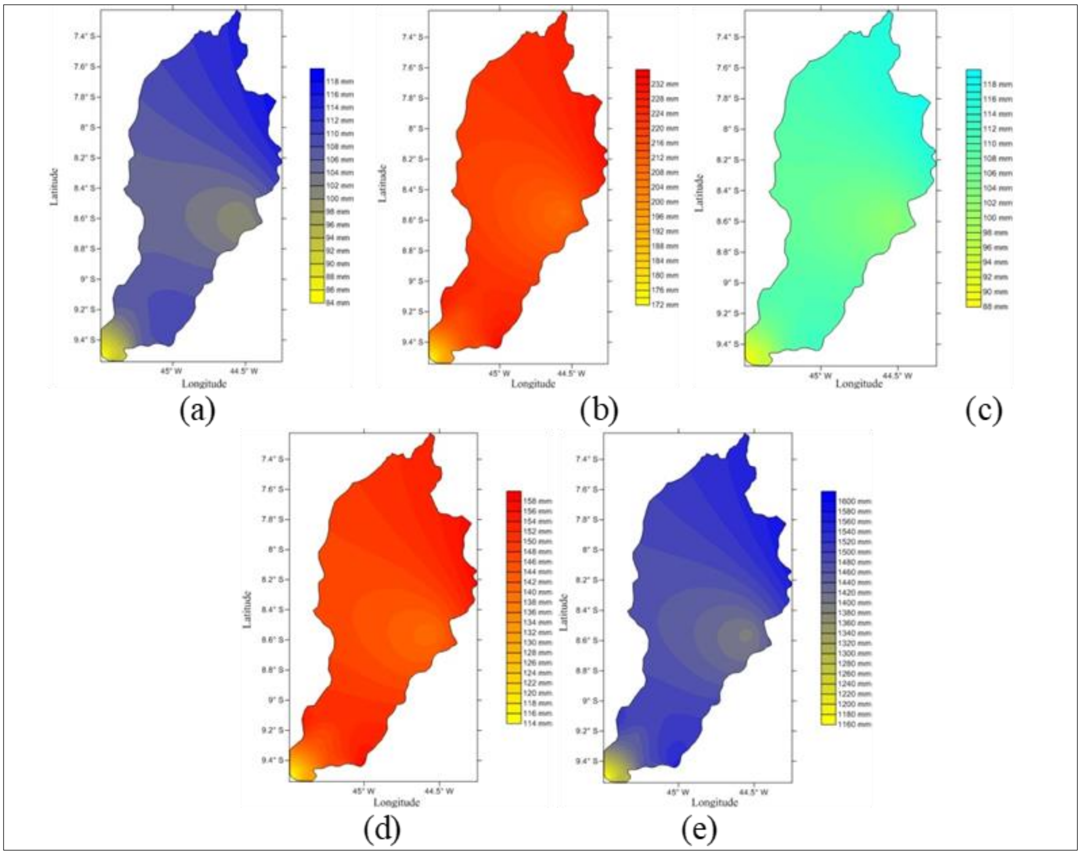
Figure 7 (a, b, c, d, e) represents the variability of evapotranspiration: (a) minimal; (b) maximum; (c) minimum four-month period (d) maximum four-month period; (e) and annual, for the Uruçuí Preto river watershed area – PI.

Figure 7a shows the minimum evapotranspiration rates that occur in February with a fluctuation from 84 to 118 mm, the areas with the lowest ETP rates are located in the extreme south and east of the central region, while in the northern sector, northeast and southeast are located the high rates of ETP.

Figure 7b shows an increase from south to north across the entire BHRUP, with its minimum and maximum values located in the extreme south and in a small strip to the east of the central area.

Figure 7c shows the evaporative behavior of the four-month minimum of ETP minimums, where they are located in the extreme south and in an east strip of the central region, the other areas show values in gradual elevations with variability ranging from 98 to 118 mm.

Figure 7d shows the variability of evapotranspiration in the maximum four months that occurs between the months of August and September, with its variability oscillating between 114 and 158 mm, the lowest evapotranspiration rates occur in the extreme south, and in the other areas there is a gradual increase in maximum evapotranspiration.



Source: Medeiros (2022)

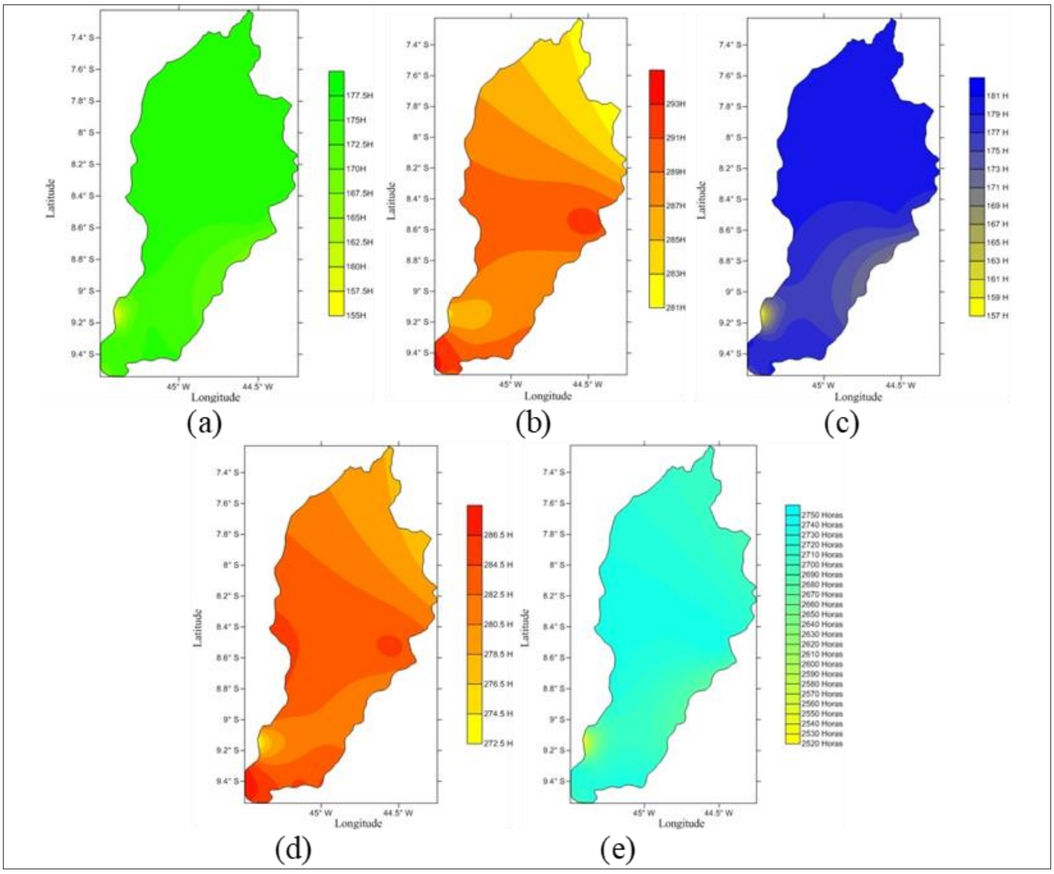
Figure 7 Evapotranspiration (mm): (a) minimal; (b) maximum; (c) minimum four-month period; (d) maximum four-month period; (e) and annual

Figure 7e shows the lowest rates of annual evapotranspiration in the extreme south and in the eastern area of the central region, the other areas present evapotranspiration in elevations and their maximum values occur in the north, northeast and southwest sectors. Its annual fluctuation occurs in the range of 1,160 to 1,600 mm.

Figure 8 (a, b, c, d, e) represents the variability of the total insolation (a) minimum; (b) maximum; (c) minimum four-month period; (d) maximum four-month period; (e) and annual, for the Uruçuí Preto river watershed area – PI.

Figure 8a shows the behavior of the minimum total insolation (February) in the BHRUP, where its variability ranges from 155 to 178 hours, with emphasis on the small area to the southwest with 157 hours of total insolation. In the maximum total insolation (September) (Figure 8b) there are areas of maximum insolation in the extreme south and east of the central region, moderate insolation bands in the south and central region, intermediate band of insolation in the south and central sector and low insolations in an isolated area of the southern region and in the north and northeast of the northern region.

Figure 8c shows the oscillations of total insolation for the four-month period with minimum insolation (December, January, February and March) with an increase in the southeast-north position with a variability of 167 to 181 hours, a small area to the southwest in the municipality of Santa Filomena with 157 hours.



Source: Medeiros (2022)

Figure 8 Total insolation (hours): (a) minimum; (b) maximum; (c) minimum four-month period; (d) maximum four-month period; (e) and annual

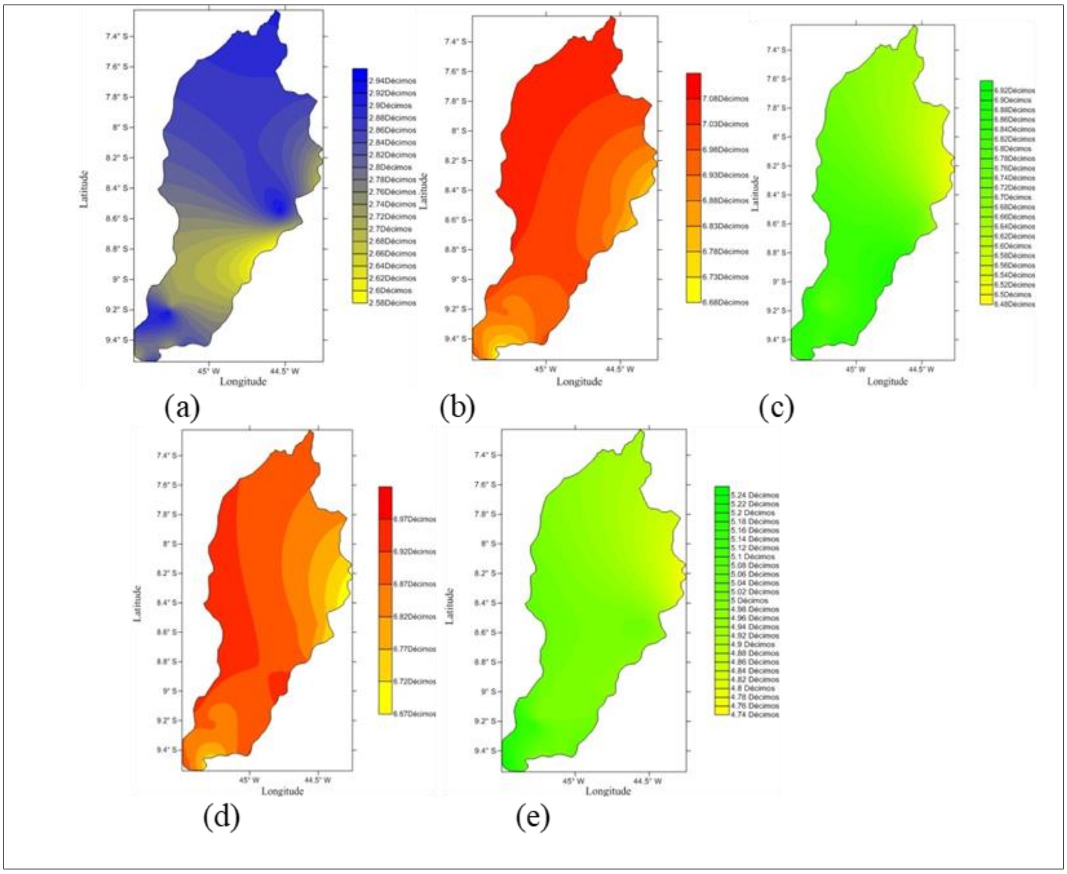
Figure 8d represents the total insolation for the four-month period of maximum insolation (June, July, August and September) small areas of low insolation can be seen in the southwest, extreme north and northeast sectors; extreme insolation in the southwest, west and east sectors of the central area, the insolation is reduced in the south-north direction. The variability of the total insolation ranges from 2520 to 2750 hours within the BHRUP, there is a small area to the southwest of the basin, in which its insolation is the minimum 2520 h, as shown in Figure 8e.

Figures 9 (a, b, c, d, e) represent the variability of cloud cover: (a) minimum; (b) maximum; (c) minimum four-month period; (d) maximum four-month period; (e) and annual, for the Uruçuí Preto river watershed area – PI.

Figure 9a demonstrates the variability of minimum cloud cover for BHRUP, the lowest cloud cover occurs in the south area of the central sector and north area of the south sector and in the east sector of BHRUP, in the south sector of the south area and in the north sectors from the central and almost the entire area of the northern sector, the buoyancy of the cloud cover ranges from 2.5 to 2.9 tenths.

In figure 9b, the variability of maximum cloud cover fluctuates between 6.6 to 7.1 tenths and its increases occur in the east-northwest direction, its smallest cloud cover areas occur in the eastern position and at the southern end of the BHRUP.

Figure 9c represents the cloud cover in the four-month period of minimum cloud cover in the BHRUP area (June to September), the area with the lowest cloud cover located to the east-northeast stands out, the other areas have a coverage variability oscillating between 6 to 6.9 tenths.



Source: Medeiros (2022)

Figure 9 Cloud coverage (tenths): (a) minimum; (b) maximum; (c) minimum four-month period; (d) maximum four-month period; (e) and annual**.**

Figure 9d represents the cloud cover in the four-month period of maximum cloud cover in the BHRUP area (October to March) there is a gradual increase in the east-west direction. The areas in the extreme south and east with low cloud cover and in the coastal part of the west region, where there is maximum cloud cover, stand out.

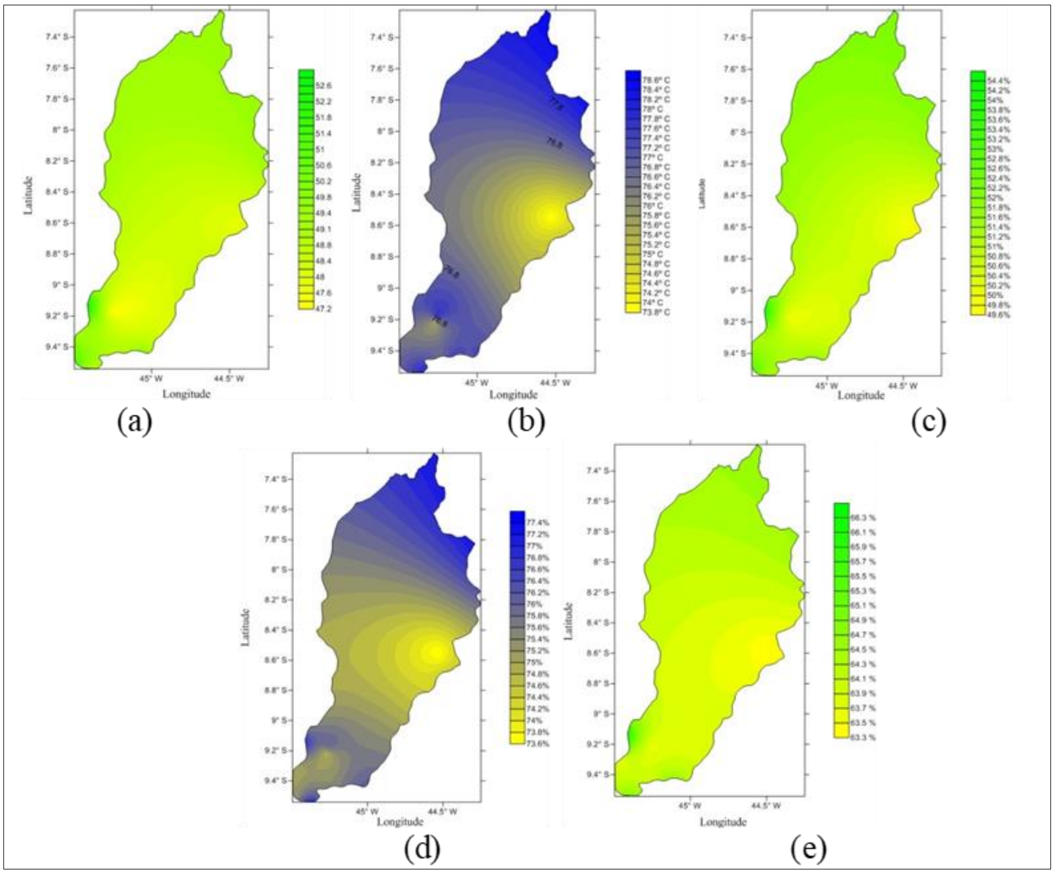
Figure 9e shows the annual variability of cloud cover for BHRUP, there is a gradual increase in the northeast-southwest direction, the largest areas with cloud cover are concentrated in the southwest region and in the coastal area of the west region, oscillating from 4.9 to 5.3 tenths and an area of low cloud cover in the northeast sector with an oscillation between 4.7 and 4.9 tenths of coverage.

Figure 10 (a, b, c, d, e) represents the variability of the relative humidity of the air (a) minimum; (b) maximum; (c) minimum four-month period; (d) maximum four-month period; (e) and annual, for the Uruçuí Preto river watershed area – PI.

The variability of minimum relative air humidity (RH) (September) in the BHRUP area is represented in Figure 10a, which ranges from 47.2 to 52.6%, it is observed that its lowest rates are concentrated in the areas south and part of the central one, in the other areas there is a gradual increase.

The maximum RH oscillations (February) are shown in Figure 10b, highlighting the area to the east and the northern sectors of the central and southern regions of the northern region, as well as a small area in the southern sector with low RH concentrations.

In figure 10c, the RH fluctuations in the four-month period of minimum humidity can be observed, lower RH values for the minimum four-month period.



Source: Medeiros (2022)

Figure 10 Relative air humidity (%): (a) minimum; (b) maximum; (c) minimum four-month period; (d) maximum four-month period; (e) and annual

Figure 10d has the representation of the four-month maximum RH of the area under study, the central region has the lowest concentration of RH as well as a small area in the southern sector, in the northern sector of the central area and in the entire northern sector and in isolated areas the southern sector has the highest UR concentration indices.

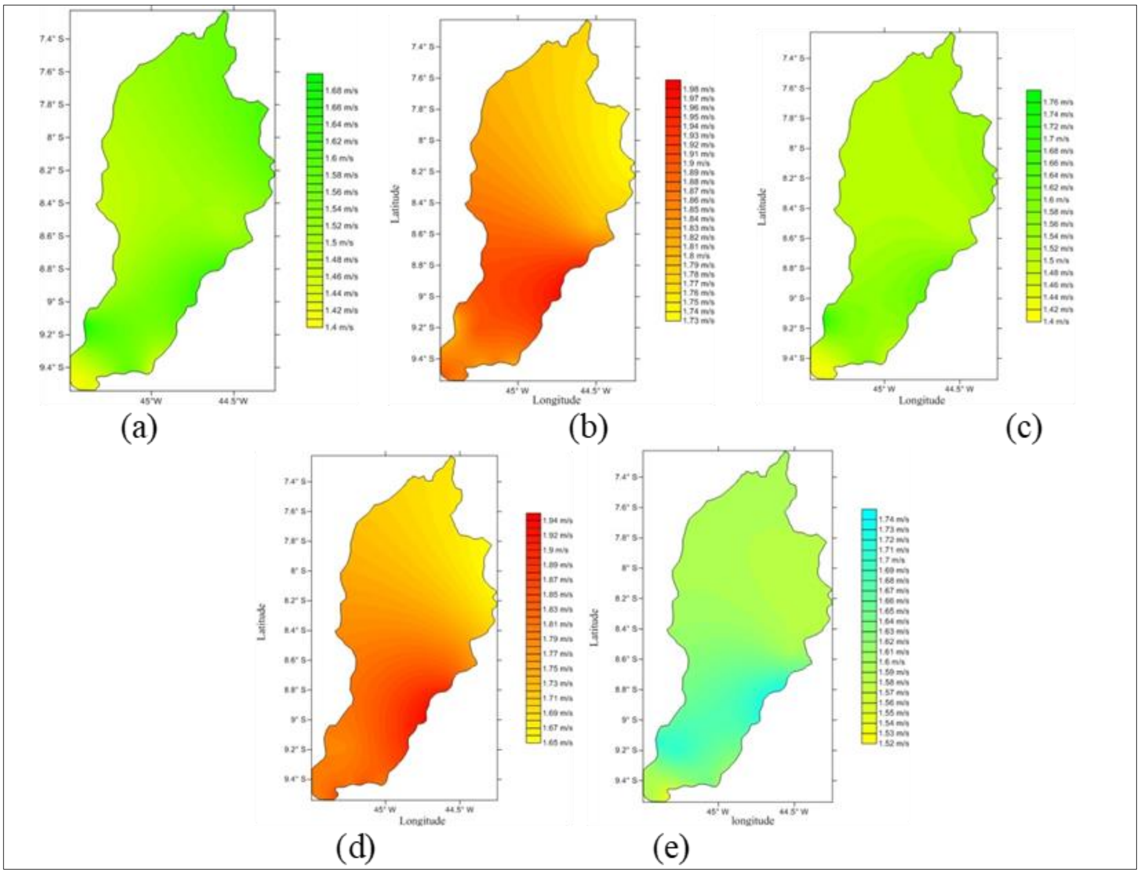
Figure 10e shows the annual RH fluctuations for the BHRUP area, where its variability varies between 63.3 to 66.2%, it is observed that the highest RH concentrations occur in the southwest, southeast and north sectors of the central region and throughout the northern sector, while the lowest annual rates occur in the southeastern sector of the central region and in the northern part of the southern region.

Figure 11 (a, b, c, d, e) represents the variability of wind intensity (a) minimum; (b) maximum; (c) minimum four-month period; (d) maximum four-month period; (e) and annual, for the Uruçuí Preto river watershed area – PI.

Figure 11a represents the minimum wind intensity in the BHRUP, observing a reduction in intensity in the east-west direction and the areas with lower intensities located to the extreme south and west of that figure.

The maximum wind intensities are represented in figure 11b, where their intensities fluctuate between 1.71 to 1.98 ms^{-1}, it is noteworthy that their highest intensities are concentrated in the north of the south region, in the central region in the south sector and in the extreme south of BHRUP, in the northern region of the central sector and in the entire area of the northern region, the lowest wind intensity is observed.

Figure 11c shows the wind intensity oscillations for the four-month period of minimum intensities, the area in the extreme south is highlighted as low intensity, in the south region high wind intensities are observed and also in the riverside strip of the eastern sector, in the other areas have moderate intensities.



Source: Medeiros (2022)

Figure 11 Wind intensity (MS-1): (a) minimum; (b) maximum; (c) minimum four-month period; (d) maximum four-month period; (e) and annual

Figure 11d shows the predominance of the intensity of the four-month period with maximum wind in the southwest sector and in the areas of the south and central regions, in the northern and eastern regions of the central area there are the lowest intensities of the wind representative of the four-month period.

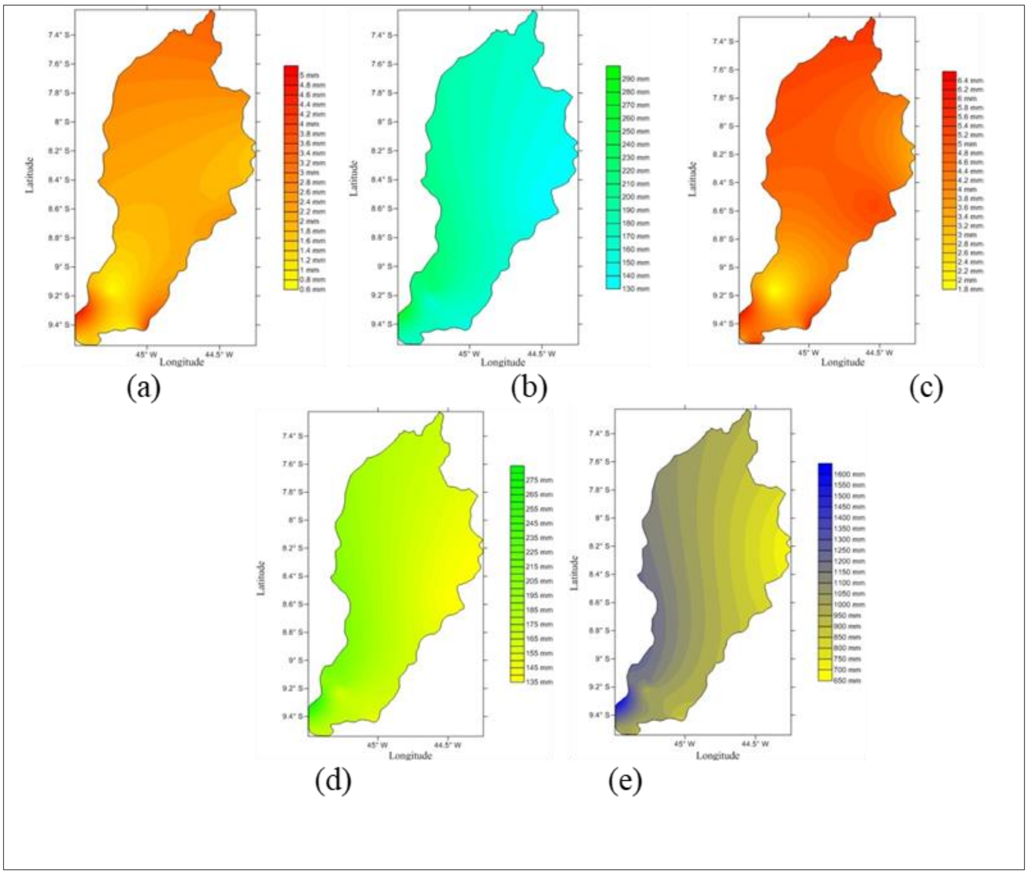
Figure 11e represents the annual wind intensity, with the following highlights in the area of low wind intensity in the extreme south and in the central part to the north of the south region, the highest intensities and moderate winds are found in the northern sector of the central region and in throughout the northern region.

Figure 12 (a, b, c, d, e) represent the variability of maximum rainfall (a); (b) minimum; (c) rainy quarter; (d) dry quarter; (e) and annual, for the Uruçuí Preto river watershed area – PI.

In Figure 12a, the southern area in its center is highlighted, which recorded the highest rainfall intensities, whereas in the southwest and southeast sectors there were the lowest rainfall, while in the other areas of the basin the rainfall indices are insignificant for agriculture and livestock storage and storage. Water.

Figure 12b represents the maximum rainfall occurred in the BHRUP, it is observed that the rains occur in the east-west direction and their maximum values occur in the extreme southwest and in the coastal area of the basin.

Figure 12c shows the behavior of the dry four-month period, in which the highest rainfall in the southern region stands out and its graduais reduction to the northern region, where the lowest rainfall indices can be observed.



Source: Medeiros (2022)

Figure 12 Precipitation (mm): (a) minimum; (b) maximum; (c) rainy quarter; (d) dry quarter; (e) and annual

In Figure 12d, it should be noted that the occurrence of rains for the dry four-month period occurs with greater significance in the central part of the basin towards the west, in the east sector up to half of the basin the lowest rainfall is concentrated, these rains are of low magnitudes and short time intervals.

Figure 12e shows the behavior of the distribution of annual precipitation in the area of BHRUP, which highlighted an increase in the east-west direction, an area of maximum rainfall is observed at the height of the municipality of Santa Filomena and around the coastal area west of the aforementioned basin, rainfall is still predominant in the western sector of the southern, central and southern areas of the northern region. To the east of the basin, there is an area with low rainfall and its increase fluctuations towards the center of the basin are highlighted.

4. Conclusion

The presented results indicate possible climatic variations in the air temperature, in the relative humidity of the air and in the precipitation, pointing to a trend of warmer and rainy conditions;

An anomalous effect is observed in the distribution of rainfall during the January summer seasons. The variability of maximum increased air temperature fluctuations, the reduction of the relative humidity of the air and the increments in the pluviometric indexes, can be related to the local changes;

The annual maximum air temperature showed great variation between the studied period, the absolute maximum temperature was increased by 10.8% and the absolute minimum temperature increased by 9.5%;

The total annual precipitation showed a gradual increase in its indexes from the 1980s, which may be related to the increase in temperature, it is observed that since the 1990s, a gradual reduction that may be related to the increase in temperature and consequently with greater water evaporation. It is observed that the relative humidity of the air, in the dry months, reached critical levels below 15%;

The extreme (maximum and minimum) and average temperature can contribute to desertification and soil degradation because it causes the drying and defragmentation of the soil and makes the wilting point in the vegetation;

The relative humidity of the air can be an active or passive contributor to the degradation and desertification of the soil, because with other meteorological elements benefiting or disfavoring the drying and the defragmentation of the soil, it can contribute to the increase or reduction of fires and air quality;

The directions and speeds of the wind are responsible for the transport of dust, smoke and soil grain, in addition to causing the drying of the soil and causing erosion, lodging of plants, diffusion of pests and diseases, it contributes to a better rate of evaporation and evapotranspiration, increases the intensity of flames in fires and fires, reduces the thermal sensation;

Thus, through the data inferred in this work, we can have subsidies to plan future actions, in projects for the recovery of degraded areas and urban development, as well as assistance in projects for the generation of clean and renewable energy (wind energy, for example), in large agricultural projects, minimizing the chances of lodging through the wind barriers that can be implemented, in addition to contributing to the planning of cities, industrial and leisure parks;

The meteorological variables analyzed can be contributing factors to the sustainability process. Considering consecutive years, in which the extremes seen occur systematically, there may be factors that added together would induce sustainability, causing problems directly related to the flora and consequently the fauna of the place under study;

The meteorological elements studied do not show evidence of occurrences of climate change.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest.

Author's contribution

All authors had equal participation in the development of the article.

References

[1] Campos, CGC. Current and Future Climate Patterns of Air Temperature in Southern Brazil and Their Impacts on Peach and Nectarine Crops. 2010. 191 f. Thesis (Doctorate in Meteorology) – National Institute for Space Research, São José dos Campos. 2010.

[2] Cavalcanti, EP, Silva, VPR, Sousa, FAS. Computer program for the estimation of air temperature for the Northeast region of Brazil. Brazilian Journal of Agricultural and Environmental Engineering, Brazil. 2006; 10(1): 140-147.

[3] Cavalcanti, EP, Silva, EDEstimation of air temperature as a function of local coordinates. IN: Brazilian Congress of Meteorology. 8. Belo Horizonte, Anais... Belo Horizonte: SBMET. 1994; 1: 154-157.

[4] COMDEPI. Piaui Development Company. Feasibility study for hydro-agricultural exploitation of the Uruçuí Preto river valley. Teresa. 2002.

[5] Coe, MT, Costa, MH, Soares Filho, BS. The influence of historical and potential future deforestation on the stream flow of the Amazon River – Land surface processes and atmospheric feedbacks. Journal of Hydrology. 2009; 369: 165-174.

[6] Costa TSA, Costa Filho JF, Baracho DC, Santos TS, Marinho ECS. Analysis of air temperature in Areia - PB, in years of El Niño occurrence. Presented at the XVII Brazilian Congress of Agrometeorology – July 18 to 21, 2011 – SESC Guarapari Tourism Center, Guarapari – ES.

[7] Costa MH. Climate change in Amazonia caused by soybean cropland expansion, as compared to cause by pastureland expansion. Geophysical Research Letters. 2007; 34: 1-4.

[8] D'Almeida C, Vörösmarty CJ, Marengo JA, Hurtt GC, Dingman SL, Keim BDA. Water Balance Model to Study the Hydrological Response to Different Scenarios of Deforestation in Amazonia. Journal of Hydrology. 2006; 331: 125-136.

[9] EMATER-PI. Technical Assistance and Rural Extension Company of the State of Piauí.

[10] EMBRAPA Exploratory survey-recognition of soils in the State of Piauí. SNLCS. Rio de Janeiro. 1986.

[11] Fernando, C. A. Discourse Analysis: Introductory Reflections. 2nd ed. San Carlos: Claraluz. 2008.

[12] Ferreira CR. Daily variability of precipitation in forest and pasture regions in the Amazon. Amazon Act. 1998; 28: 395-408.

[13] Galvani E, Klosowskia ES, Cunha AR.; Martins, D. Characterization of the predominant wind direction in Maringá – PR. Brazilian Journal of Agrometeorology, Santa Maria. 1999; 7(1): 81-90.

[14] Lima, RAFA, Menezes, HEA, Brito, JIBB. Diagnosis of trends in air temperature changes in the northern northeast. Caatinga Magazine. 2010; 23(2): 117-124.

[15] Medeiros, RM, Dal Poggetto LR; Rocha, FC. Study of the predominant wind direction in Lagoa do Portinho, locality between the municipalities of Luis Correia and Parnaíba – Piauí, from December 2008 to February 2010. On display on poles at science fairs in colleges of Teresina and on Fridays at the Environmental Education Center of SEMAR-PI. 2010.

[16] Marengo, JÁ, Camargo, CG. Trends in Extreme air temperatures in Southern Brazil, International Journal Climatology. 2007; 28: 893-904.

[17] Medeiros RM. Agrometeorological study for the State of Piauí. 2013; 122.

[18] Medeiros RM, Santos, DC, Sousa, FAZ, Gomes Filho, MF. Climatological Analysis, Climatic Classification and Variability of the Climatological Water Balance in the Uruçui Preto River Basin, PI. Brazilian Journal of Physical Geography. Recife – PE. 2013; 6: 652 - 664.

[19] Medeiros RM, Sousa FAS, Gomes Filho MF. Variability of relative air humidity and maximum temperature in the Uruçuí Preto river basin. Higher Agricultural Education Magazine. Brazilian Association of Higher Agricultural Education – ABEAS. 28(1): xx-xx.

[20] Maluf RS, Rose TS. Climate change, social inequality and vulnerable populations in Brazil. Building Capacity: Technical Report. 2011; 2: 307.

[21] Ortolani AA, Camargo MBP. Influence of climatic factors on production. Ecophysiology of Agricultural Production. Piracicaba: Potafos. 1987; 249.

[22] Paula, RK, Brito, JIB, Braga, CC. Use of principal component analysis to verify rainfall variability in Pernambuco. XVI Brazilian Congress of Meteorology. Anais... Belém do Pará, PA. CD ROM. 2010.

[23] Rusticucci, M, Barrucand M. Observed trends and changes in temperature extremes in Argentina. Journal Climate. 2004; 17: 4099-4107.

[24] Sampaio G. Regional climate change over eastern Amazonia caused by pasture and soybean cropland expansion. Geophysical Research Letters. 2007; 34: 1-7.

[25] Santana MO, Sediyama GC, Ribeiro A, Silva DD. da. Characterization of the rainy season for the state of Minas Gerais. Brazilian Journal of Agrometeorology. 2007; 15(1): 114-120.

[26] Silva VMA, Medeiros RM, Santos DC, Gomes Filho, MF. Rainfall variability between different rainfall regimes in the State of Piauí. Brazilian Journal of Physical Geography. Recife - PE. 2013; 1463 - 1475.

[27] Silva, VPR. On climate variability in Northeast of Brazil. Journal of Arid Environments. 2004; 58: 575-596.

[28] Soriano, BMA. Climatic characterization of Corumbá - MS. Corumbá: EMBRAPA-CPAP. 25p. (EMBRAPA-CPAP. Research Bulletin. 1997; 11.

[29] SUDENE. Monthly rainfall data for the Northeast: state of Piauí. Recife. 1990.