IJSRM
INTERNATIONAL JOURNAL OF SCIENCE AND RESEARCH METHODOLOGY
An Official Publication of Human Journals

Human Journals
Research Article
January 2021 Vol.:17, Issue:3

Oscillations of Mean Air Temperatures in the Ipojucariver Basin - Pernambuco, Brazil

IJSRM
INTERNATIONAL JOURNAL OF SCIENCE AND RESEARCH METHODOLOGY
An Official Publication of Human Journals

Raimundo Mainar de Medeiros*[1], Fernando Cartaxo Rolim Neto[1], Romildo Morant de Holanda[1], Manoel Viera de França[1], Luciano Marcelo Fallé Saboya[2], Wagner Rodolfo de Araújo[3]

[1]*Universidade Federal Rural de Pernambuco, Brasil*
[2]*Universidade Federal de Campina Grande, Brasil*
[3]*Universidade Estácio de Sá, Brasil*

Submitted: 01 December 2020
Revised: 20 December 2020
Accepted: 10 January 2021

HUMAN JOURNALS

www.ijsrm.humanjournals.com

Keywords: Local or Regional Climatic Variability, Thermal Oscillations, Historical Averages

ABSTRACT

Thermal fluctuations are related to latitude and orography, expressing the energy contained in the medium. The objective of this work is to analyze the temporal space oscillations of the air temperature, plotting they have referred monthly and annual average graphs and their anomaly in the area of the Rio Ipojuca watershed in the state of Pernambuco. Average air temperature series were generated by the Estima-T software, for the period 1962-2018. The fluctuations in the average temperature come from the predominant atmospheric systems of the rainy and dry seasons and their conflicts with the environment and the performance of the meso and micro-scale transient factors, aided by local and/or regional contributions. The physical aspects combined with the characteristics of land use and occupation are responsible for the variability of temperatures. Densely built and flawed vegetation areas showed high temperatures. In places with dense vegetation coverings and with smaller constructions, temperature decreases occurred, and this decrease was also caused by the local orography. The results obtained in this work may serve as subsidies to public and private managers regarding decision making in case of possible occurrences of extreme weather events.

INTRODUCTION

The World Meteorological Organization (OMM, 1989) proposes, in comparative climate studies, the use of historical average series for periods with more than 30 years of observations, for the series understudy, so the data must have consistency and homogeneity in the comparison of their analyzed values.

The temperature of the air propagates its energy contained in the environment in which it finds itself. During the 24 hours, the energy in an environment flows between the maximum and minimum values. As this energy fluctuation oscillates between its extremes, acting on the stimulation of its vital physiological processes and living beings, such as development and growth of plant species, such as transpiration, breathing, germination, growth, flowering, and fruiting. In the expansion stages of the plant, there are adequate temperature ranges for its perfect development (Costa *et al*., 2011).

Medeiros *et al.* (2020) analyze the variability of mean air temperatures and their temporal space behavior for the area of Mata Pernambucana composed of 44 municipalities from the period 1950-2017. The values of maximum, mean, and minimum air temperatures estimated by the software Estima_T (Cavalcanti *et al*., 2006) were used. Estima_T is software for estimating air temperatures in the northeast region of Brazil. The coefficients of the quadratic function were determined for the maximum, average, and minimum monthly temperatures as a function of the local coordinates: longitude, latitude, and altitude. It was verified that the time series presents a tendency of reduction and a seasonal component with a periodicity of 0.7 to 1.4 months. We obtained a good fit for the models of the moving average series selected for the 5 and 10 years of the studied variable, with the expected values being within the confidence interval, which is a satisfactory result, taking into account the uncertainties of the standard error and the weather and climate which may change the expected results. In the agricultural part, the risks of greater stresses are presented with the increase of the evapotranspiration and evaporation, the recurrence of the use of irrigated water is not discarded. Altitude and latitude are the physiographic variables that best explain the variation of mean air temperature in the study area.

Knowledge of the climatic classes of a given location is indispensable so that tactics can be sophisticated aiming at the correct guidelines on natural resources, seeking to find sustainable expansion, and applying new techniques for agriculture and livestock with improvement for local and regional biomes Sousa *et al*. (2010).

According to Nogueira *et al*. (2012) and Correia *et al*. (2011), air temperature is one of the atmospheric variables which stands out among the most studied on environmental conflicts with changes in the variability of hydro-meteorological studies.

Medeiros *et a*l. (2012) studied the daily fluctuations in air temperature for the municipal areas of Parnaíba, Picos, and Gilbués in the State of Piauí with different methodologies and concluded that the methods measured with the normal standard obtained behavior classified as “Very good and Great”, with reliability indicator flowing between 0.83 to 0.98, and that the referred methods can be applied in the evaluations of the referred air temperatures. According to the author in 2018 thermal fluctuations were one of the physiographic variants that best explain the monthly and annual temperature variation in the state of Pernambuco.

Melo *et al*. (2015) evaluated the fluctuations in maximum, average and minimum air temperatures in the state of Pernambuco, to understand future climate changes in their behavior, providing important information for studies of the weather forecast and for agricultural and livestock planning developers.

Alves (2014) evaluated the changes in maximum and minimum absolute temperatures followed by oscillations in relative humidity to obtain relationships with the physical aspects of the environment and its urban morphology for the city of Iporá – GO. This author established that the presentation of slopes, vegetation density, patterns of land use and occupation influence the fluctuations in the extreme values of the temperatures under study.

Marengo et al. (2007) studying the oscillations of the thermal amplitudes in the South Region of Brazil registered negative trends that occurred from 1960 to 2002, stating that the minimum temperatures presented high intensities when compared to the maximum temperatures, especially in the summer season. According to the authors, the registered heating seems to be more intense in the winter season than in the summer season. This variability is related to the increase in the number of hot days in the winter season (Campos, 2010).

Rusticucci *et al*. (2004) registered negative trends in the variability of the daytime thermal amplitude, caused by the positive fluctuations in minimum temperatures. Strassburger et al. (2011) stated that fluctuations in thermal amplitudes influence the sowing times, the choice of cultivars, and the ways of management practices that may change the cultivation environment.

Ometto (1981) in his studies stated that in the tropical region the temperature difference between short distances occurs due to the variation in altitude and cloud cover and not latitude, registering thermal oscillations between windward and leeward areas of a mountain.

The objective of this work is to analyze the temporal space oscillations of the average air temperature by plotting its referred monthly average graphs, annual and its anomaly in the basin area under study, providing subsidies to government agencies in case of decisions on possible occurrences of extreme events that may come.

MATERIAL AND METHODS

The Hydrographic Basin of the Rio Ipojuca (HBRI), is located between 08º09'50” and 08º40'20” south latitude, and 34º57’52” and 37º02’48” west longitude. Due to its elongated conformation in the west-east direction, this basin has a strategic position in the state space, serving as a great water link between the metropolitan region of recife and the Sertão region. The upper, middle, and sub-middle sections are located in the Sertão and Agreste regions of the State. The lower section has its area located in the Mata Pernambucana zone, including the coastal strip of the State (Figure 1).

Figure No. 1. Profile of HBRI and its surrounding municipalities. Source: Medeiros, (2020).

Medeiros (2016) established the period of the rainy season in the state of Pernambuco, beginning in February through the pre-season rainfall index and ending at the end of August and sometimes extending into the first half of September. The rainy quarter focuses on May, June, and July, the dry quarter occurs between October to December. The factors that provoke and/or inhibit rainfall in the studied area are Intertropical Convergence Zone, the formation of high-level cyclonic vortices, the influence of the contribution of northeast trade winds in the transport of steam and humidity, the formation of the instability lines, orography and their local contributions forming clouds and causing moderate to heavy rainfall. (Figure 2).

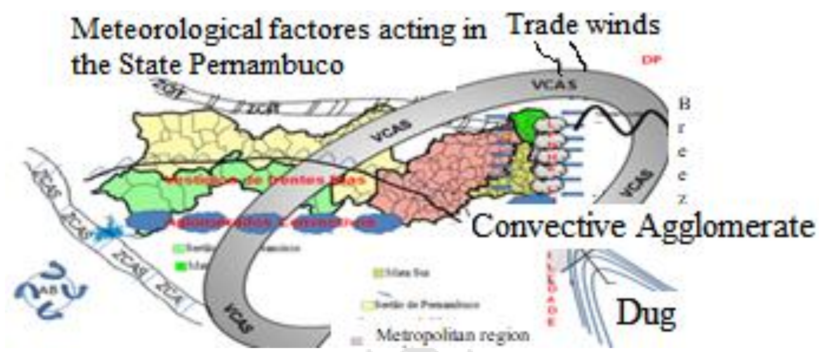

Figure No. 2. Meteorological factors that cause and / or inhibit rainfall in the state of Pernambuco. Source: Medeiros, (2016).

The Estima_T software (Cavalcanti et al. Silva, 1994; 2006) was used to generate estimated air temperature values for the period 1962-2018 expressed by the equation:

$$T = C0 + C1\lambda + C2Ø + C3h + C4\lambda2 + C5Ø2 + C6h2 + C7\lambda Ø + C8\lambda h + C9Øh$$

where C0, C1, ..., C9 are the constants; λ, λ2, λ Ø, λ h longitude; Ø, Ø2, λ Ø latitude; h, h2, λ h, Ø h height.

Complementation was used for the temperature time series, adding to it the temperature anomaly of the Tropical Atlantic Ocean (Silva et al., 2006).

$$Tij = Ti + AATij \quad i = 1,2,3, ..., 12 \quad j = 1950, 1951, 1952, ... 2015$$

where i = 1,2,3, ..., 12; j = 1950, 1951, 1952, 1953, ..., 2017.

Calculations of means, standard deviation, coefficient of variation, maximum and minimum absolute precipitation and their variability, anomaly and standardized, and percentage standard deviations were performed. Galvani (2011) reports that it is of fundamental importance to know the degree of dispersion of the worked values with the average value. The Coefficient of Variance (CV) used to make comparisons in relative terms expressed the variability of each set of data normalized about the mean, in percentage.

RESULTS AND DISCUSSION

HBRI's climate according to the classification of Köppen (1928, 1931), Thornthwaite and Mather (1948; 1955), is shown in Table 1. The studies by Medeiros *et al*. (2018) and Alvares *et al*. (2014) corroborate the results found by Köppen. According to the Köppen classification, the HBRI area records the type of climate “AS” (tropical climate with a dry summer season), “Am” (monsoon climate), and “BSh” (climate of the hot low-latitude steppe and altitude).

Table No. 1: Location of municipalities, geographical coordinates, and climatic classifications using the models proposed by köppen and Thornthwaite for the HBRI área.Source: Medeiros, (2020)

Municipalities	Parameters		Classifications	
	Longitude	Latitude	Köppen	Thornthwaite
Arcoverde	-37,0556	-8,4336	As	$C_1B'_4S_2a'$
Agrestina	-35,9536	-8,4578	As	$C_1A'S_2a'$
Alagoinha	-36,7739	-8,4661	As	$C_1B'_4S_2a'$
Altinho	-36,0597	-8,4906	As	DB'_4S_2a'
Amaraji	-35,4472	-8,3778	Am	$C_1A'S_2a'$
Belo Jardim	-36,4208	-8,3333	As	$C_2B'_4Sa'$
Bezerros	-35,7528	-8,2433	As	$C_1B'_4S_2a'$
Cachoeirinha	-36,2375	-8,4839	AS	$C_2B'_4S_2a'$
Caruaru	-35,9158	-8,2383	As	$C_1B'_4S_2a'$
Chã Grande	-39,2361	-7,7211	As	$C_1A'S_2a'$
Escada	-35,2333	-8,3667	Am	$C_2A'Sa'$
Gravatá	-35,5431	-8,2006	As	$C_1A'S_2a'$

Ipojuca	-35,0058	-8,5144	Am	$C_1A'S_2a'$
Pesqueira	-36,6972	-8,3531	As	$C_1B'_4S_2a'$
Poção	-36,7053	-8,1836	As	$C_1B'_4S_2a'$
Pombos	-35,3961	-8,1386	As	$C_1A'S_2a'$
Primavera	-35,3475	-8,3483	As	$C_1A'S_2a'$
Riacho Almas	-35,8592	-8,1381	As	$C_2B'_4Sa'$
Sairé	-35,7089	-8,3267	As	$C_2B'_4Sa'$
Sanharó	-36,5664	-8,3639	As	$C_1B'_4Sa'$
São Caitano	-36,1375	-8,3283	BSh	$C_1B'_4Sa'$
São Bento Una	-36,46	-8,5281	As	$C_1B'_4S_2a'$
Tacaimbó	-38,1533	-9,1089	As	$C_1B'_4S_2a'$
Venturosa	-38,9694	-7,9286	As	$C_1B'_4S_2a'$
Vitória S. Antão	-35,6347	-8,8383	As	$C_1A'Sa'$

Figures 3 to 17 show the monthly, annual and average air temperature anomalies at HBRI. Figure 3 shows the oscillations of average temperatures for January in the HBRI area and its surroundings. With a historical average temperature of 24.5 °C, comparisons can be made with temperatures in the cities surrounding HBRI. The municipalities that registered temperature above the historical were: Agrestina, Amaraji, Chã Grande, Escada, Gravatá, Ipojuca, Pombos, Primavera, Riacho das Almas and Vitória de Santo Antão, with fluctuations between 24.7 °C to 27 °C. The municipalities of Altinho and Caruaru presented an average equal to the historical temperature of the month studied. The other municipalities presented averages below the historical temperature.

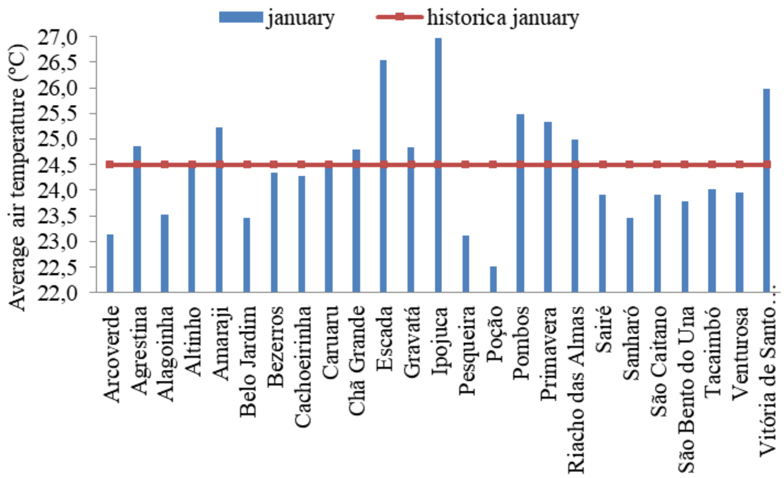

Figure 3. Average air temperature in January at HBRI. Source: Medeiros, (2020).

Figure 4 records the fluctuations of the average temperature of February in HBRI, the municipalities that registered temperature above the historical (24.3 °C) were: Agrestina, Amaraji, Chã Grande, Escada, Gravatá, Ipojuca, Pombos, Primavera, Riacho das Almas and Vitória de Santo Antão, ranging from 24.7 °C to 27 °C. The rest of the municipalities recorded average temperatures between 22.2°C in Pombos and 24.3 °C in Altinho and Caruaru.

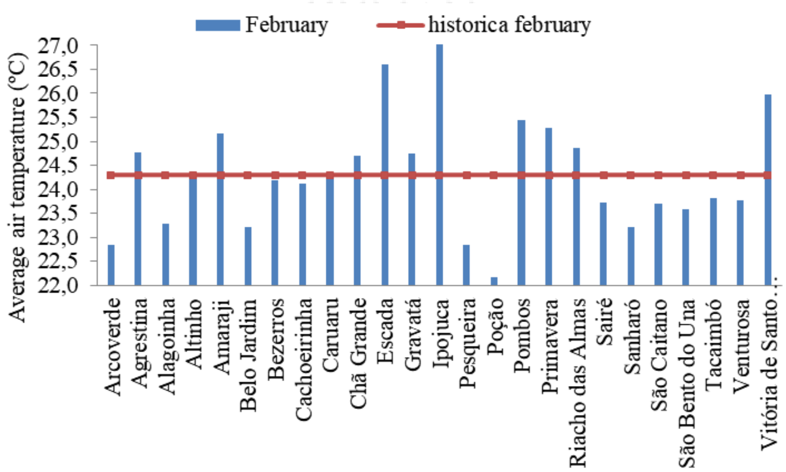

Figure No. 4: Average air temperature in February at HBRI.Source: Medeiros, (2020).

In March (Figure 5), the municipalities with the temperature above the historical average stand out, with fluctuations ranging from 24.3 °C in Altinho to 26.8 °C in Ipojuca. The thermal fluctuations are below the historical and their oscillations flow between 22.1 °C (Poção) to 24.1

°C in Bezerros and Caruaru. These fluctuations in the thermal indices are interconnected with the rainy season and the elevation quotas of the studied municipalities.

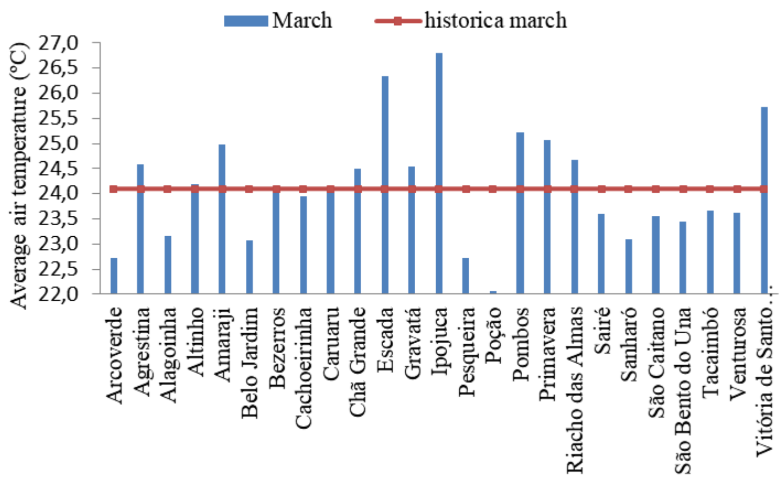

Figure No. 5: Average air temperature in March at HBRI. Source: Medeiros, (2020).

With a historical temperature of 23.3 °C representatives of April in the studied area (Figure 6), the municipalities with temperatures above the historical temperature range from 23.7 °C to 26 °C. The records of temperatures below the historical flow between 21.1 °C to 23.3 °C. Such variations are due to the energy potential of the region and the combination with the season, as explained by Medeiros *et al.*(2015) that the highest thermal averages occur during the summer, and the lowest, during the winter, even those that are in low latitudes.

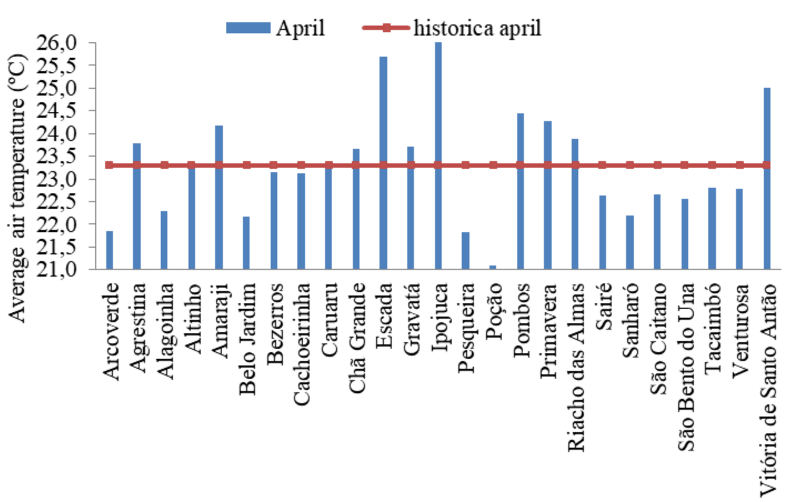

Figure No. 6: Average air temperature in April at HBRI. Source: Medeiros, (2020).

Intermunicipal fluctuations in the average air temperature at HBRI for May (Figure 7) have a historical temperature of 22.3 °C. Its oscillations flow between 22 °C (Poção) to 25 °C (Ipojuca).

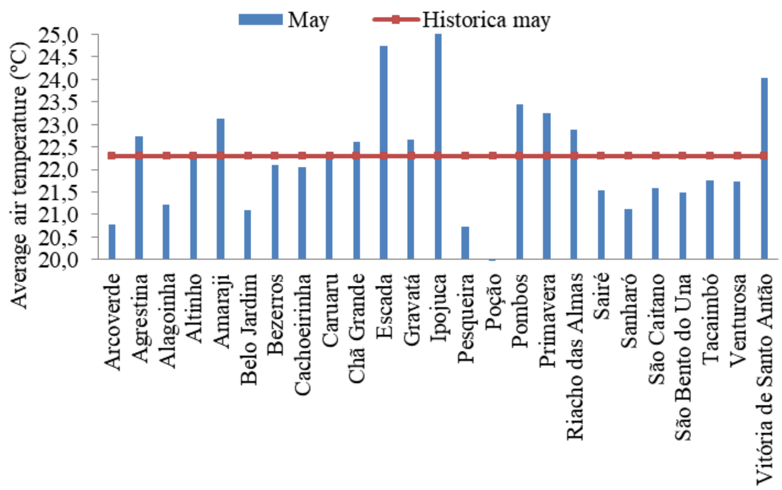

Figure No. 7: Average air temperature in May at HBRI. Source: Medeiros, (2020).

In Figure 8 the variability of the average air temperature in June, the historic intermunicipal temperature is 21 °C and its intermunicipal oscillations occur between 19 °C (Poção) to 24.4 °C in Ipojuca. These thermal variabilities are linked to atmospheric systems operating in the studied period.

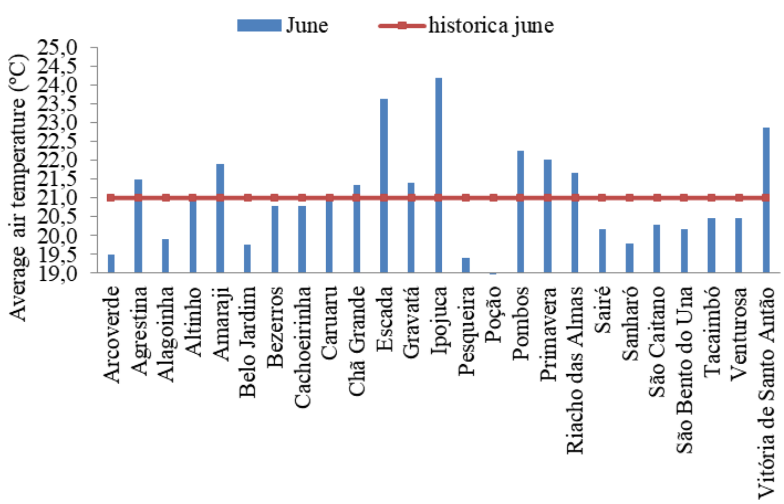

Figure No. 8: Temperature mediated air in June at HBRI.Source: Medeiros, (2020).

Fritzsons *et. al*(2008) clarified that the air temperature tolerates the influence of altitude and latitude and tend to decrease with increasing altitude, in the proportion of 1ºC per 100m, due to the process of ascending the dry air mass over a low-pressure system, which increases in its volume, weakening its temperature.

The average air temperature in July (Figure 9) for the study area has a historical average of 20.4°C. The inter-municipal fluctuations are registered between 18.1°C to 23.5°C, considered the month with the lowest thermal indexes in the studied area. This buoyancy is integrated with transient systems and meso and micro-scale climatic factors.

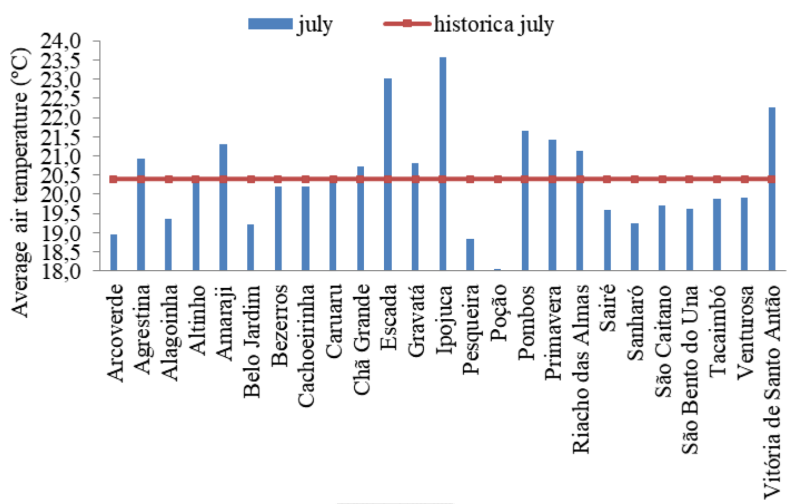

Figure No. 9: Average air temperature in July at HBRI. Source: Medeiros, (2020).

Figure 10 shows the average and historical thermal fluctuations in August for the HBRI area. The average temperature flows between 18.4°C to 23.4°C. The average historical temperature is 20.5°C. The month of August is considered as one of the months of low temperature, linked to the transient synoptic systems, the factors of the meso and micro-scale climate, and their local and regional effects.

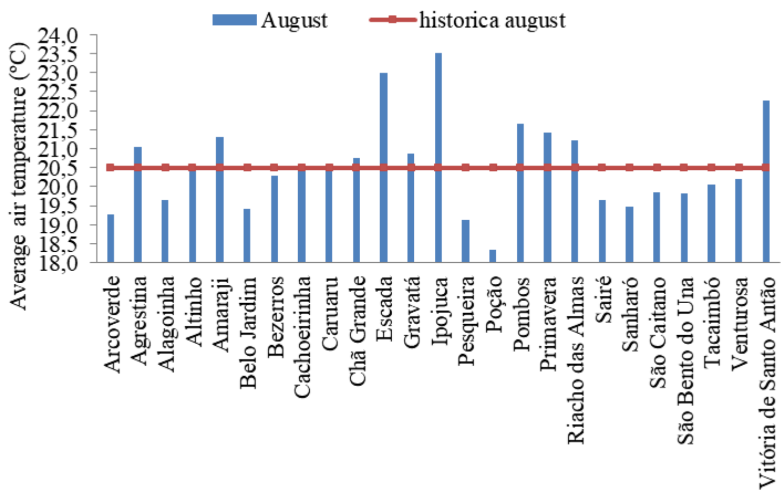

Figure No. 10. Average air temperature in August at HBRI. Source: Medeiros, (2020).

The historical temperature in September is 21.9°C (Figure 11). Inter-municipal thermal variability ranges from 19.9°C in Poção to 24.4°C and Ipojuca. These oscillations below the averages are recorded in the first half of the month and are caused by the transient systems of meso and micro-scale acting at HBRI.

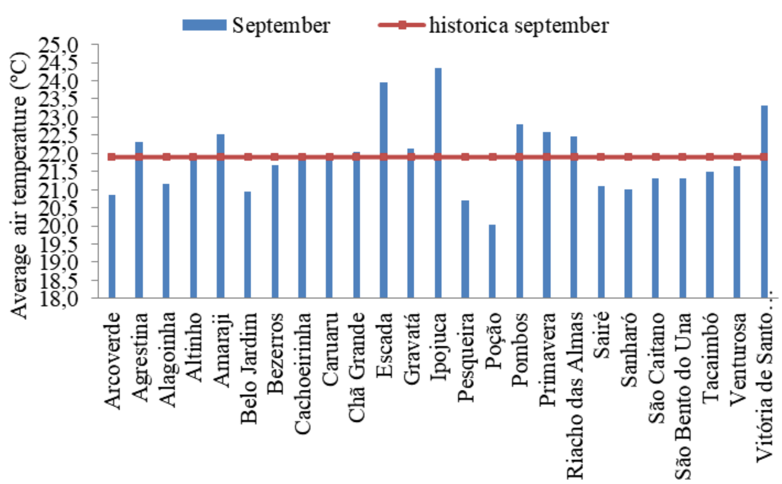

Figure No. 11: Average air temperature in September at HBRI.Source: Medeiros, (2020).

Figure 12 represents the variability of average air temperatures in the basin area. The month of October is characterized by an average historical temperature of 23.1°C. Temperature fluctuations between municipalities range from 21.2°C in Poção to 25.7°C in Ipojuca. Carvalho *et. al*(2016) stated that high temperatures, influence the intensity of evaporation through air saturation.

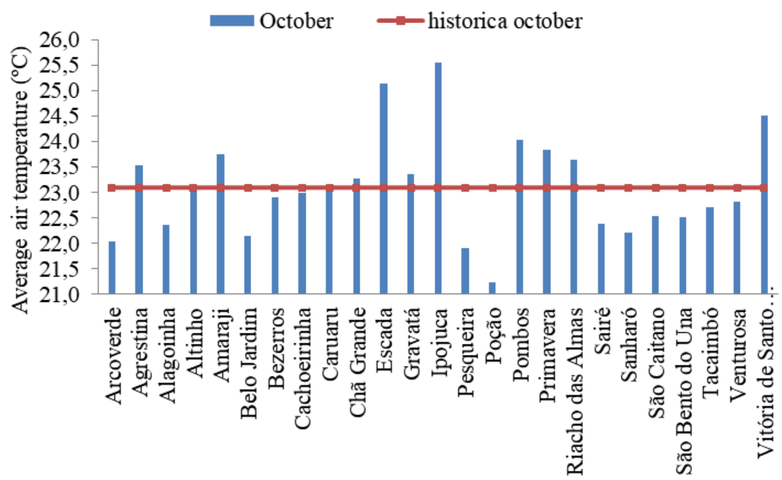

Figure No. 12: Average air temperature in October at HBRI. Source: Medeiros, (2020).

The month of November records a temperature of 23.8°C. Its inter-municipal oscillations flow between 21.7°C (Poção) to 26.4°C (Ipojuca) (Figure 13).

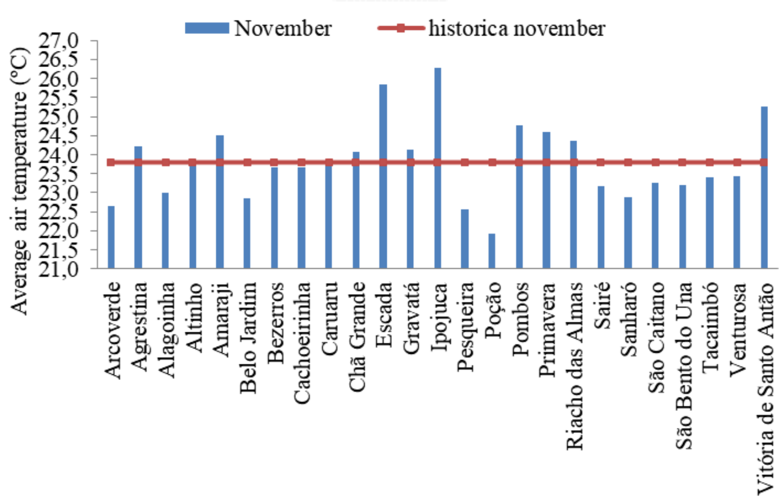

Figure No. 13: Average air temperature in November at HBRI. Source: Medeiros, (2020).

The inter-municipal thermal indexes flow from 22.1°C in Poção to 27°C in Ipojuca (Figure 14). The thermal oscillations are included with the declination of the orography and the slope of the inter-municipal lands, ground cover, low level of vertical buildings, and unpaved streets.

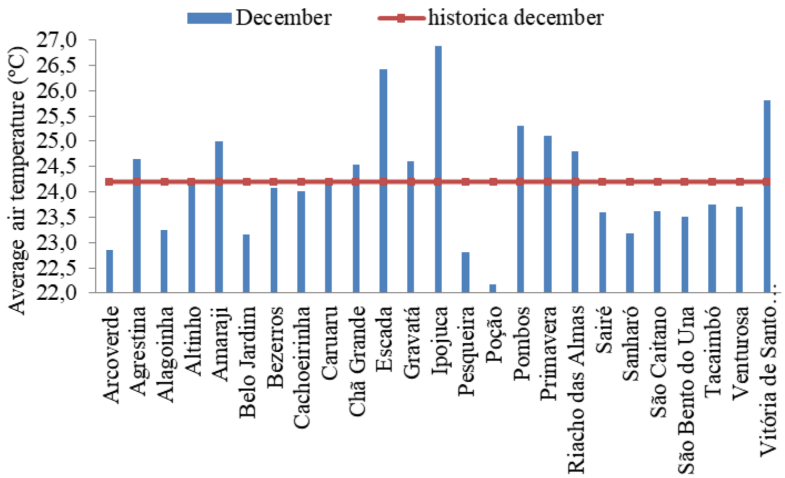

Figure No. 14: Average air temperature in December at HBRI. Source: Medeiros, (2020).

Figure 15 shows the oscillations of the average annual temperatures for the basin area and its surroundings. With average temperature oscillating between 23 °C in the municipality of Riacho das Almas to 24.1°C in Ipojuca with high temperatures, in addition to the other municipalities that are in red. The municipalities Altinho, Caruaru, and Chã Grande register annual temperatures equal to historical ones (22.8°C). Blue-colored municipalities with temperatures below historical levels fluctuate between 21.6°C and 22.6°C.

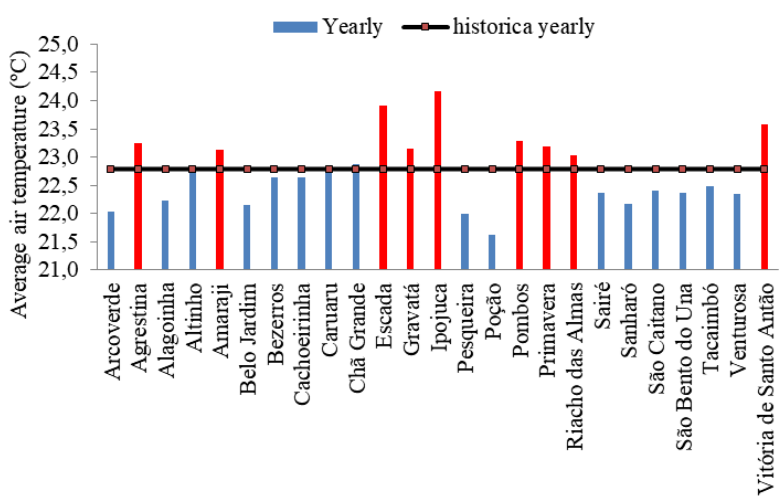

Figure No. 15: Average annual air temperature for the HBRI. Source: Medeiros, (2020).

Figure 16 shows the average annual temperature anomalies for the area surrounding HBRI. The municipalities of Agrestina; Amaraji, Escada, Gravatá, Ipojuca, Pombos, Primavera, Riacho das

Almas and Vitória de Santo Antão with positive anomalies flowing between 0.4°C to 1.4°C. The other municipalities registered negative anomalies ranging from 0.1°C to Caruaru to Poções with -1.2°C. These variations are due to atmospheric micro-scale systems and local aid and municipal altitudes. The study by Matos *et al*. (2015) corroborates the temperature variability exposed here.

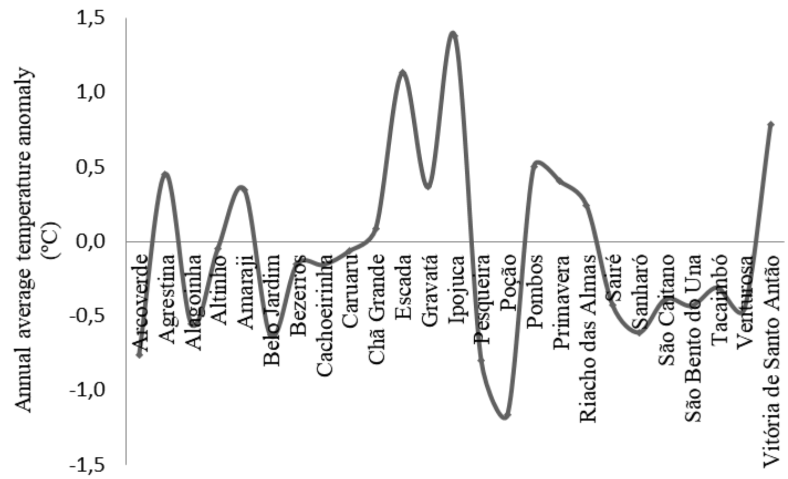

Figure No. 16: Anomaly of the average annual air temperature for the HBRI. Source: Medeiros, (2020).

The average annual temperature and its comparison with the historical one for the region around HBRI show two temperature regimes, a hot regime with variability from 23°C to 24.5°C between October to April and another with pleasant temperatures flowing between 20.2°C to 22.3°C in May to September (Figure 17).

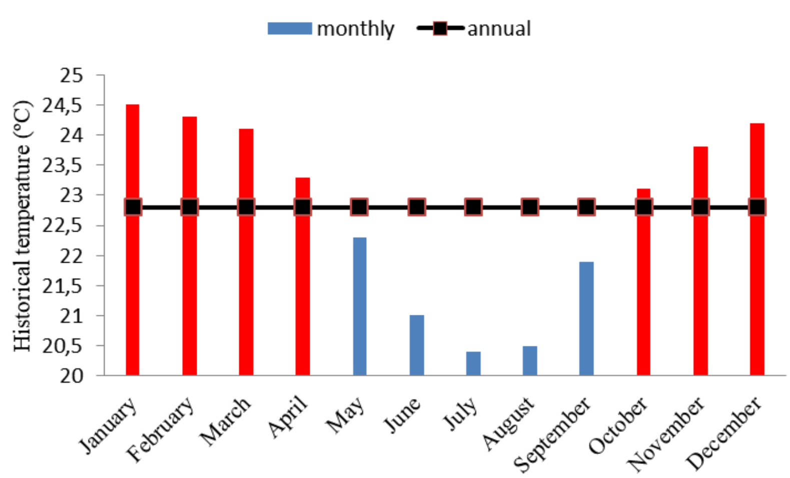

Figure No. 17: Average annual air temperature and its comparison with the climatological average for the region around HBRI. Source:Medeiros, (2020).

Table 2 shows the representation of the mean, median, standard deviation, coefficient of variance, maximum and minimum absolute temperatures recorded in the HBRI area and its surroundings. The average air temperature flows between 20.4°C in July to 24.5°C in January with an annual temperature of 22.7°C. With an annual median of 24.2°C and its monthly fluctuations between 23.5°C in August, at 27.1°C in February, there is a dispersion in relation to the average and its values have no portability of occurrences. The values of the standard deviations of the averages can be increased and / or reduced and with this, variability in the average can be expected. The coefficients of variances are of low significance and do not provide subsidies to predict the probability of changes. The maximum and minimum absolute values have the possibility of return between six to eighteen months. Similar studies were developed by Marengo *et. al*(2007) and corroborate the results presented here.

Table No. 2: Representation of the mean, median, standard deviation, coefficient of variance, maximum and minimum absolute temperatures recorded in the HBRI area and its surroundings.Source: Medeiros, (2020).

Months	Parameters					
	Average	Median	Standard deviation	Coefficient of variance	Absolute maximum	Absolute minimum
January	24,5	27,0	1,1	0,044	27,0	22,5
February	24,3	27,1	1,2	0,049	27,1	22,2
March	24,1	26,8	1,1	0,047	26,8	22,1
April	23,3	26,2	1,2	0,052	26,2	21,1
May	22,3	25,3	1,3	0,057	25,3	20,0
June	21,0	24,2	1,3	0,063	24,2	18,6
July	20,4	23,6	1,3	0,064	23,6	18,1
August	20,5	23,5	1,2	0,059	23,5	18,3
September	21,9	24,4	1,0	0,046	24,4	20,0
October	23,1	25,6	1,0	0,044	25,6	21,2
November	23,8	26,3	1,0	0,043	26,3	21,9
December	24,2	26,9	1,1	0,047	26,9	22,2
Yearly	22,7	24,2	0,6	0,027	24,2	21,6

Galvani (2011) showed that the variability of the standard deviation is important to have information on the "degree of dispersion of the values about the average value". Occurrences of extreme events of high magnitude and short time are expected Marengo et al. (2015), these results corroborate the study under development.

Ometto (1981) and Pereira *et al.* (2002) showed that fluctuations in the maximum and minimum air temperature indicators remain aggregated to the amount of solar energy received, cloud cover, relative humidity of the air and soil, wind, and geographical parameters of altitude, local latitude, and orography.

CONCLUSIONS

The variability of the elevations and the latitude of the municipalities surrounding HBRI are the physiographic elements that best explain the variation of the monthly and annual temperature in the studied area.

The average thermal fluctuations are derived from the synoptic atmospheric systems operating in the rainy and dry season and their impacts on the environment, followed by the transient systems of meso and micro-scale aided by local and regional contributions.

The physical aspects alongside the characteristics of land use and occupation are responsible for the variability of temperatures, where densely built and flawed vegetation areas showed high temperatures whereas in places with dense vegetation coverings and with smaller constructions there are reductions temperature, in addition to the contribution of its orography.

REFERENCES

1.Alvares, CA, Stape, JL, SentelhaS, PC, Gonçalves, JLM, Sparovek, G..Köppen's climate classification map for Brazil. Meteorologische Zeitschrift. 2014. 22, 711–728.

2.Alves. WS. The spatial interactions and the urban climate of Iporá - GO. 2014. 122 p. Dissertation (Master in Geography). UFG/CAJ, Jataí-GO

3.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.

4.Carvalho, TO. Analysis of air temperature, precipitation, evapotranspiration and water index in the municipality of Itapetinga-BA. RGNE. 2016. v.2.

5.Cavalcanti, EP, Silva, VPR, Sousa, FAS.. Computer program to estimate air temperature for the Northeast region of Brazil. Brazilian Journal of Agricultural and Environmental Engineeringl, 2006. 10 (1), p. 140-147.

6.CavalcantI, EP, Silva, EDV.. Estimation of air temperature as a function of local coordinates. In: Brazilian Meteorological Congress,*8*, 1994. Belo Horizonte, Anais...,Belo Horizonte: SBMET, v.1, p.154-157.
7. Correia, MF, Silva, FS, Silva, AMRS, Santos, EP, Moura, MSB. Impacto da expansão agrícola na amplitude térmica diária em ambiente semiárido. Ciência e Natura, v. Suplementar2011., p.311–314.
8.Costa, TSA, Costa Filho, JF, Baracho, DC, Santos, TS, Marinho, ECS. Analysis of the air temperature in Areia - PB, in years of occurrence of “El Niño”. Presented at the XVII Brazilian Congress of Agrometeorology - 18 to 21 July 2011 - SESC Centro de Turismo de Guarapari, Guarapari – ES.
9.Fritzsons, E, Mantovani, LE, Aguiar, AV.. Relationship between altitude and temperature: A contribution to climatic zoning in the State of Pará. REA - Revista de Estudos Ambientalais 2008. v.10, n. 1, p. 49-64.
10.Galvani, E. Descriptive statistics in the classroom. In: Venturi, LAB. Geography: Field, laboratory and classroom practices. São Paulo: Editora Sarandi. 2011.
11.Köppen, W, Geiger, R.. “Klimate der Erde. Gotha: Verlag Justus Perthes”. Wall-map 1928150cmx200cm.
12.Marengo, JÁ, Schaeffer, R, Zee, D, Pinto, HSClimate change and extreme events in Brazil. Available at: http://www.fbds.org.br/cop15/FBDS_Mudancas Climaticas.pdf. Accessed 2019. . 2015.
13.Marengo, JA, Camargo, CG. Trends in Extreme air temperatures in Southern Brazil, International Journal Climatology, 2007.v.28, p. 893-904,
14.Matos, RM,Medeiros, RM, Silva, PF., Saboya, LMF. Average annual air temperature buoyancy, absolute maximum and minimum in the municipality of Barbalha - CE, Brazil In: Technical Scientific Congress of Engineering and Agronomy, 2015, Fortaleza - Ceará. Annals Technical Scientific Congress of Engineering and Agronomy. 2015. v.1.
15. Medeiros, RM, Holanda, Rm, França, MV, Cunha Filho, M, Piscoya, VC, Xavier Cunha, Al, Moreira, GR, Freitas, JR, Araújo Filho, NR. Floating of the Average Temperature in the Area of Mata Pernambucana, Brazil.ijsrm.humanjournals. 2020; Vol. 15 (3): 63-83.
16.Medeiros, RM, Kozmhinsky, M, Holanda, RM, Silva, VP. Average air temperature and its fluctuations in the State of, 2018. n.2, v.1. 081-093.
17.Medeiros, RM, Holanda, RM, Viana, M.A, Silva, V.P. Climate classification in köppen model for the state of Pernambuco - Brazil. Revista de Geografia (Recife). , v.35, 2018. p.219 - 234,
18.Medeiros, RM. Meteorological factors causing precipitation in the State of Pernambuco. Disclosure. 2016.
19.Medeiros, RM. et al.. Variabilidade da temperatura média do ar no Estado da Paraíba-Brasil. Revista Brasileira de Geografia Física. 2015. v.8 n.1.p.128-135.
20.Medeiros, RM,tavares, AL, Kassar, CB, Silva, JAS, Silva, VPR. Metodologias de cálculo da temperatura média diária do ar: aplicação para os municípios de Parnaíba, Picos e Gilbués, PI. Revista Brasileira de Agricultura Irrigada. 2012. v.6, nº. 4, p. 283 – 295.
21.Nogueira, VFB, Correia, MF, Nogueira, VS. Impact of Soybean Plantation and the Equatorial Pacific Ocean on Precipitation and Temperature in the City of Chapadinha - MA. Brazilian Journal of Physical Geography, 2012. v.5, p.708 –724.
22.OMM. Organização Meteorológica Mundial. Calculation of monthly and annual 30 - year standard normals. Geneva (WMO). Technical document, 1989. v.341; WCDP, n.10.
23.Ometto, JC. Plant bioclimatology. São Paulo: Ceres, 1981. 440p.
24. Pereira, AR, Angelocci, LR, Sentelhas, PC. Agrometeorology: fundamentals and practical applications. Agriculture, 2002.478p.
25.Rusticucci, M, Barrucand M. Observed trends and changes in temperature extremes inArgentina. Journal Climate, 2004. v.17, p. 4099-4107.
26. Sousa, ES, Lima, FWB, Maciel, GF, Sousa, JP, Picanço, AP. Water balance and Thornthwaite climate classification for the city of Palmas – TO. XVI Brazilian Congress of Meteorology, Belém-PA, Anais on line, 2010.
27.Strassburger, AS, Menezes, AJEA, Perleberg, TD, Eicholz, ED, Mendez, MEG, Schöffel, ER.Comparison of the air temperature obtained by a conventional and automatic meteorological station. Brazilian Magazine of Meteorology, 2011.26 (2), p.273-278.

28.Thornthwaite, CW. An approach towards a rational classification of climate. Geographical Review, London, 1948.v. 38, p. 55 - 94.
29.Thornthwaite, CW.; Mather, JR. The water balance. Publication in Climatology N.8, Laboratory of Climatology, Centerton, N. J. 1955.