International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(Review Article)

Check for updates

Precipitation buoyancy in the Ipojuca river basin area as a feeder source for hydrological systems

Raimundo Mainar de Medeiros [1, *], Romildo Morant de Holanda [1], Moacyr Cunha Filho [1], Victor Casimiro Piscoya [1], Alex Morais de Souza [1], Manoel Vieira de França [1] and Wagner Rodolfo de Araújo [2]

[1] *Federal Rural University of Pernambuco, Brazil.*
[2] *Estacio de Sa University, Brazil.*

International Journal of Science and Research Archive, 2022, 07(01), 090–097

Publication history: Received on 05 August 2022; revised on 12 September 2022; accepted on 14 September 2022

Article DOI: https://doi.org/10.30574/ijsra.2022.7.1.0192

Abstract

Precipitation has a chance to spread heterogeneously across the globe, the altercations between the radiation balance in the zonal bands and the association with atmospheric dynamics make it possible to distinguish the globally diffused rainfall regimes. The objective is to statistically analyze the buoyancy of precipitation in the area of the Ipojuca River basin - PE as a feeder source for the hydrological systems of the State of Pernambuco. Simplified statistical parameters were used to calculate mean, standard deviation, coefficient of variance, maximum and minimum absolute rainfall, annual rainfall amplitude and its anomalies for the period 1962-2017. There is increasing variability of annual and monthly precipitation. The variability is greatest during the spring and summer seasons and lowest in the winter and autumn seasons. Positive and negative anomalies were recorded in 7 and 18 municipalities respectively. Knowledge of local weather conditions on the occurrence of extreme rainfall events allows for the improvement of seasonal forecasts, and helps decision-makers in government agencies to avoid or minimize natural disasters. It is verified that the local rainfall pattern is under the influence of several precipitating systems that contribute to the quantity of local precipitation and their contributions are interconnected to the local and regional meso and micro scale systems, interacting with the use and land cover.

Keywords: Predictability and sustainability; Climate variability; Precipitation anomalies; Rainfall regimes

1. Introduction

Precipitation tends to spread heterogeneously across the planet, the differences between the radiation balance in the zonal bands and the association with atmospheric dynamics make it possible to differentiate globally distributed rainfall regimes.

The interplay of rainfall regimes becomes the main artifice for carrying out socioeconomic planning and conserving the natural environment [20]. According to [18], the understanding of the rainfall behavior of a given region are indicators for the composition of the calendar and implementation of agricultural projects. The analysis of rainfall distribution and its climatic variability in hydrographic basins is of fundamental importance for the conception of the natural functioning of water systems, the studies aimed at this purpose demonstrate an important role in the human scope guiding measures for the rational use of water resources.

Rainfall rates as a result of La Niña are due to percentages that are above average, compared to El Niño periods that can record a reduction between 60 and 65% in the rainfall index [13a]

* Corresponding author: Raimundo Mainar de Medeiros; E-mail: mainarmedeiros@gmail.com
Federal Rural University of Pernambuco, Brazil, Recife – Pernambuco.

The reduction in rainfall under the effect of El Niño in the Northeast region is a natural climatological phenomenon that is attributed to the increase in rainfall in the southern region of Brazil [16].

According to [7; 5] the precipitation induced by the river breeze towards the interior of the continent is not being accounted for in the measurements of the rain gauges of the automatic and conventional stations.

[10], in a study of the hydrographic basin of the Uruçuí Preto-PI river, specifically, in the contents of flow modeling, and of the elements precipitation, air temperature and relative humidity, and their climatic variability, providing technical support to the borrowers of decision, civil society, companies and state and municipal governments. More specifically, it suggests to farmers and the riverine population how the information contained in the meteorological data should be used, as well as advice to improve access to drinking water.

The oceans are of fundamental importance in rainfall buoyancy, since the deviations around the mean are totally related to the phenomena that occur on the surface of the oceans, in this way the variations in the Sea Surface Temperature (SST) and the correlation with the rainfall distribution by the terrestrial globe [17].

Improved knowledge of local climatic conditions on the occurrence of extreme rainfall events allows for the improvement of seasonal forecasts, and helps decision-makers in government agencies to avoid or minimize natural disasters.

Excess rainfall, combined with other factors in the biophysical environment, can cause flooding, flooding, flooding, cause barriers to fall, roads and when there is no excess or rainfall below the climatological level, they result in droughts, silting of rivers, affecting the productive sectors, socioeconomic and environmental [20].

Rainfall impacts are generated by the intensity of rains that occur in a short period of time in most Brazilian cities, causing floods and landslides and gaining prominence in the media given the high number of homeless people, in addition to the proliferation of diseases, economic losses, damage to the environment, deaths, among [15].

Precipitation is of great importance in the hydrological process, since the annual distribution, in a hydrographic basin, is the basis for decision making, planning and prevention related to irrigation, agriculture, industrial and domestic water supply, in addition to soil erosion control. in floods, inundation, among other factors [4].

The importance of analyzing and diagnosing rainfall fluctuations in the Northeast region of Brazil was shown by [12] and specifically for Paraíba especially for its irregularity, since climate variables are fundamental to the climate approach. The results confirmed trends of reduction in rainfall rates, with rainfall fluctuations throughout the series studied, showing the recurrence of maximum annual precipitation values within the intervals of 15, 12 and 7 years.

The daily rainfall distribution for southern Italy is important because it understands the variability of rainy days in their annual distribution, as well as the possible risks of flooding and soil instability in the erosive power [6].

[14] in the analysis of the climate and the availability of surface and underground water resources for the Uruçuí Preto-PI river basin area, detected that in the Köppen climate classification two climate types are distinguished: the “Aw” type (tropical climate). With dry winter season) and the “BSh” type (Climate of the hot steppes of low latitudes and altitudes). With an annual maximum temperature of 32.1 ºC, an annual minimum of 20 ºC, and its annual thermal amplitude of 12.1 ºC, an average annual temperature of 26.1 ºC; mean annual relative humidity of 64.2%, an annual evaporation of 2098.7 mm and annual evapotranspiration of 1.470.7 mm. The total annual insolation is 2.701.8 hours per year. The fluviometric stations located in the municipalities of Jerumenha and Cristino Castro record average flows of 6.9 m^3s-1 to 6.1 m^3s^{-1} in the driest quarter and average flows between 90 and 54 m^3s^{-1} in the wettest quarter.

The distribution of precipitation is quite irregular in time and space, and the rainy seasons occur differently, in quantity, duration and distribution. The objective is to statistically analyze the buoyancy of precipitation in the area of the Ipojuca-PE river basin as a feeder source for the hydrological systems of the State of Pernambuco.

2. Material and methods

The Ipojuca River basin (BHRI) is located, in a large area of the State of Pernambuco, between 08º09’50” and 08º40’20” South latitude, and 34º57’52” and 37º02’48” West longitude. The upper, middle and sub-middle spaces of the basin are located in the Sertão and Agreste regions, in the lower spaces where most of the BHRI is inserted in the Mata Pernambucana area and the coastal area of the State.

The rainy season begins in February with pre-season rains (rains that precede the beginning of the rainy season) and ends in August. In BHRI, the rainy quarter occurs between the months of May, June and July and its dry quarter occurs between the months of October and December. The inhibitory and/or rain-causing elements in the BHRI area are the positioning of the Intertropical Convergence Zone further south of the equator, the help of high-level cyclonic vortices, the contribution of the northeast trade wind in the transport of steam and moisture. , activations of instability lines, orography and its local and regional effects increasing cloud cover and causing moderate to heavy rains throughout the studied area [10a].

The Köppen climate classification model for the studied area recorded the climate types “As” (tropical climate with dry summer season), the types “Am” (monsoon climate) and the “BSh” (hot steppe climate of low latitudes and altitudes), these classifications are in agreement with the studies by [9; 1].

Precipitation data provided by the Water and Climate Agency in the State of Pernambuco [2] were used, corresponding to the 25 pluviometric stations that surround the BHRI, with a historical series of 53 years between the period 1962 and 2015. Data analysis carried out through the basic statistics under study. The calculations of means, standard deviation, coefficient of variation, maximum and minimum absolute precipitation and their variabilities, anomaly and normalized standard deviation percentage were performed. [8] Shows that it is important to have a notion of the degree of dispersion of values in relation to the average value. The coefficient of variation (CV) which, according to the author, when performing comparisons in relative terms, expresses the variability of each set of data normalized in relation to the mean, in percentage.

3. Results and discussion

The Ipojuca River watershed (BHRI) has an average rainfall of 882.6 mm, corresponding to the period 1962-2017. The wettest municipality is Ipojuca with an annual total of 1.946.3 mm with a percentagens of 220.51 mm above it normal and the least rainy municipality is Caruaru with an annual total of 565.5 mm which represents 64% of the basin average.

Table 1 shows the fluctuations of the mean, standard deviation, coefficient of variance, absolute maximum and minimum of precipitation and its representative amplitude of the 25 municipalities that surround the BHRI, in the period 1962-2017.

Table 1 Average values for the period 1962-2017 in the Ipojuca river basin area

Período	Average (mm)	DP (mm)	CV (%)	Máxima (mm)	Mínima (mm)	Amplitude (mm)
1962-2017	882,6	387,5	43,9	1946,3	565,5	1380,8

Legend: Average = Climatological average; DP = Standard Deviation; CV = Coefficient of variance; Maximum = absolute maximum precipitation; Minimum = Absolute minimum rainfall; Amplitude = Rainfall amplitude (difference between maximum and minimum); Source: Medeiros, (2022).

Table 2 Variability of seasonal average precipitation for the area of the Ipojuca river basin - Pernambuco

Season	Average Rainfall (mm)	Standard Deviation (mm)	Median (mm)	Variance Coefficient	Absolute Maximum Precipitation (mm)	Absolute Minimum Precipitation (mm)	Amplitude (mm)
Winter	47.1	12.7	83.2	0.284	83.2	32.5	50.7
Spring	119.9	39.1	230.9	0.330	230.9	85.3	145.6
Summer	101.3	66.5	265.9	0.684	265.9	39.4	226.4
Autumn	77.8	47.2	206.5	1.758	206.5	29.6	176.9

Source: Medeiros, (2022).

The precipitation with the highest indices are recorded in the spring and summer seasons and intermediate values in the winter and autumn seasons, the deviations and the median are well above normal, the coefficient of variance is higher than that observed annually in the summer and autumn season and between the normality in the summer and spring seasons, as can be seen in Table 2, this occurs because during the spring and summer there are the influences of the factors that provoke rain in activities that directly affect the rainfall volume. In the winter and autumn seasons as the ones with the lowest registered rainfall.

The months with the highest rainfall recorded for the BHRI area are April (128.6 mm), June (120 mm) and July (124.3 mm). The months with the highest variation coefficients are from May to November. The absolute maximum rainfall occurred from April to July, and the absolute minimum rainfall was recorded between the months of October and November. The amplitude fluctuations oscillate between 37.7 mm in the month of November to 263.9 mm in July. (Table 3).

[8] Showed that the calculation of the standard deviation is essential to have the notion of the "degree of dispersion of the values in relation to the average value". According to the author, the coefficient of variation is used to make comparisons in relative terms.

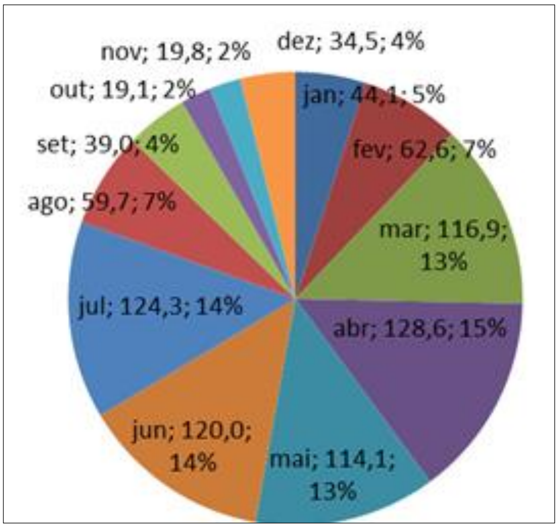
Table 3 Variability of seasonal average rainfall for the Ipojuca river basin, corresponding to the 25 surrounding municipalities

months	Average (mm)	Standard Deviation (mm)	Median (mm)	Variance Coefficient	Absolute Maximum Precipitation (mm)	Absolute Minimum Precipitation (mm)	Amplitude (mm)
Jan	44.1	11.9	83.0	0.269	83.0	30.7	52.3
Feb	62.6	13.4	103.8	0.214	103.8	46.6	57.2
Mar	116.9	23.8	176.8	0.204	176.8	88.2	88.7
Apr	128.6	32.1	225.5	0.250	225.5	100.7	124.8
May	114.1	61.2	290.3	0.536	290.3	66.9	223.4
Jun	120.0	74.5	320.2	0.621	320.2	56.3	263.9
Jul	124.3	76.1	286.8	0.612	286.8	46.7	240.0
Aug	59.7	49.0	190.6	0.820	190.6	15.3	175.3
Sep	39.0	26.0	111.5	0.668	111.5	14.3	97.2
Oct	19.1	11.0	51.5	0.578	51.5	9.5	41.9
Nov	19.8	10.1	43.5	0.512	43.5	5.8	37.7
Dec	34.5	12.7	62.8	0.367	62.8	20.3	42.5
Annual	882.6	387.5	1946.3	0.439	1946.3	565.5	1380.8

Source: Medeiros, (2022).

In a scenario of future climate change, mainly due to the increase in greenhouse effect concentrations, it is often assumed that only the mean may change, with the standard deviation remaining unchanged in accordance with [3].

The months from March to July have a contribution of 69% of the monthly rainfall, in the months of August to February their contributions are 31% of the annual value. In agreement with [11b] (Figure 2).

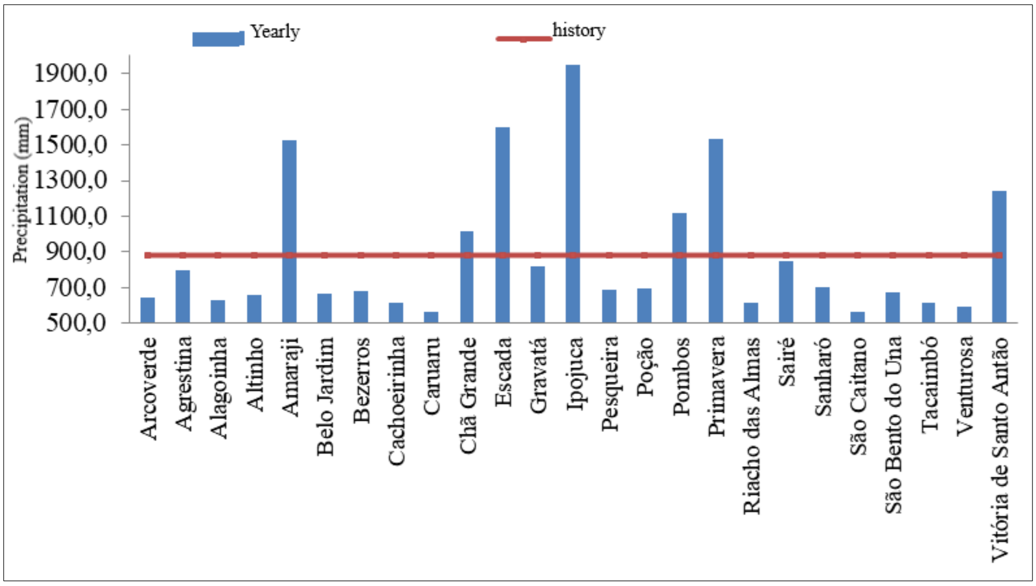


Source: Medeiros, (2022)

Figure 2 Monthly rainfall distribution in the BHRI area from 1962 to 2017

The months of April, June and July are of high rainfall and those with low contributions occur between October and November, respectively.

Figure 3 shows the annual and historical precipitation by municipality of the entire historical series, around the basin under study, there is an irregularity in the distribution of precipitation in the 55 years observed. In the municipalities of Amarají, Escada, Ipojuca, Primavera and Vitória de Santo Antão, rainfall above 900 mm is recorded, for the other municipalities in the area under study, rainfall below 900 mm is recorded. These irregularities are due to factors that inhibit and/or provoke rains in the BHRI, being part of the rain regimes in the coastal, forest and wild areas, respectively.



Source: Medeiros, (2022)

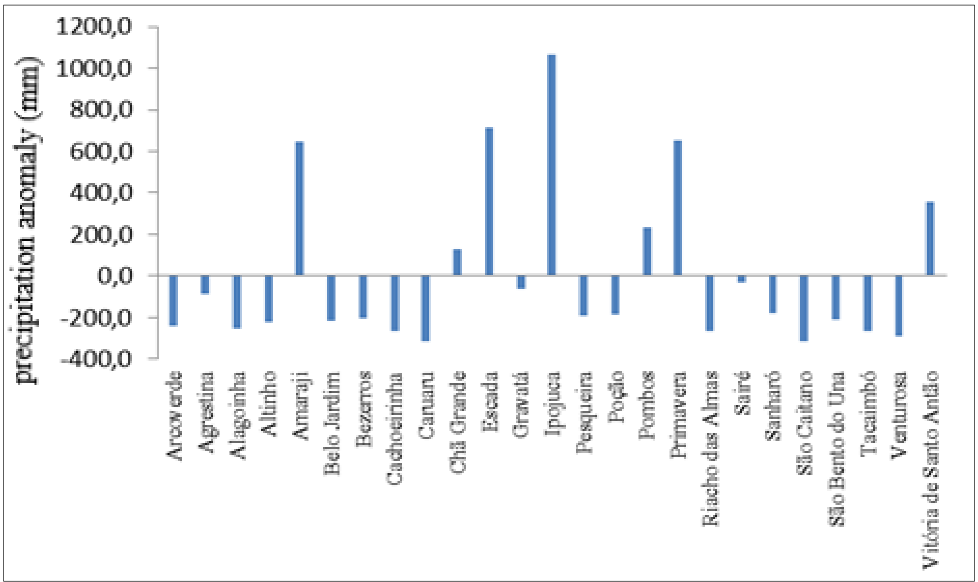
Figure 3 Average annual and climatological precipitation for the BHRI area in the period 1962-2017

Analyzing the precipitation anomalies presented in Figure 4, it is observed that in the 25 municipalities only 7 municipalities had positive anomalies, two municipalities with anomalies lower than 200 mm, one with an anomaly close to 400 mm and the others their anomalies exceeded 600 mm.

The variability of negative anomalies stands out in the municipalities Agrestina, Gravata and Sairé, which have the smallest anomalies recorded in the period between 1962-2017.

Positive anomalies are recorded in seven municipalities whereas negative anomalies occur in eighteen municipalities.

The study made it possible to identify the municipalities with extreme climatic conditions with high annual rainfall in Ipojuca, Escada, Primavera and Amaraji.



Source: Medeiros, (2022).

Figure 4 Average monthly rainfall anomaly for the Ipojuca River watershed area in the period 1962-2017

Table 4 shows the variability of the average rainfall anomaly for the Ipojuca river basin, corresponding to the 25 surrounding municipalities for the study period between the years 1962-2017.

Table 4 Variability of the average precipitation anomaly for the Ipojuca river basin, corresponding to the 25 surrounding municipalities

Municípios	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Arcoverde	3.9	11.2	5.4	-19.2	-45.3	-53.1	-66.5	-30.6	-24.7	-9.0	1.2	-11.3	-237.9
Agrestina	-9.0	-15.0	-25.7	-15.5	-10.9	-2.2	5.8	5.5	1.6	-4.1	-4.4	-10.8	-84.7
Alagoinha	-1.6	6.8	-3.5	-16.2	-40.0	-57.3	-68.7	-42.3	-19.9	-4.9	-4.9	-1.0	-253.3
Altinho	-10.7	-16.0	-28.8	-21.8	-30.5	-32.2	-31.7	-17.2	-8.2	-6.0	-7.0	-10.2	-220.2
Amaraji	12.4	10.4	27.6	41.4	88.0	130.0	157.2	84.0	34.4	16.3	21.2	23.3	646.2
Belo Jardim	-4.8	-2.1	-2.0	-14.4	-38.2	-47.7	-44.1	-26.4	-21.7	-8.7	-3.1	-2.1	-215.2
Bezerros	-10.5	-12.9	-20.2	-16.7	-24.6	-35.5	-32.0	-21.3	-6.0	-5.3	-10.0	-10.1	-205.1
Cachoeirinha	-7.3	-11.2	-22.1	-21.5	-39.3	-45.4	-49.3	-30.1	-14.7	-5.8	-5.8	-12.8	-265.3
Caruaru	-13.4	-14.0	-26.2	-27.9	-43.9	-50.1	-55.9	-30.5	-17.2	-9.6	-14.0	-14.2	-316.8
Chã Grande	1.5	-1.2	8.1	14.1	25.7	23.4	32.6	5.1	12.4	4.6	3.9	1.2	131.5
Escada	21.9	24.0	46.2	70.7	122.9	126.0	112.9	91.7	49.2	19.5	15.3	15.6	715.8
Gravatá	-3.4	-6.5	-3.7	1.9	3.4	-15.6	-17.0	-17.9	4.9	0.5	-2.5	-8.4	-64.2
Ipojuca	38.9	41.2	59.9	97.0	176.2	200.2	162.5	130.9	72.6	32.4	23.7	28.3	1063.7
Pesqueira	-0.1	6.6	5.8	-14.1	-37.6	-42.0	-50.2	-28.8	-20.2	-6.6	-2.1	-2.7	-192.0
Poção	0.9	5.6	19.5	-11.8	-43.6	-39.9	-41.6	-27.1	-23.5	-9.2	-3.8	-10.6	-185.2

Pombos	2.8	-1.4	10.4	12.5	33.5	46.2	66.3	25.0	16.7	6.8	5.2	11.6	235.7
Primavera	12.8	11.5	30.0	40.7	85.9	134.4	155.4	90.1	34.8	15.8	18.7	23.5	653.7
Riacho Almas	-13.4	-15.0	-24.5	-26.4	-35.9	-37.4	-40.6	-30.1	-13.7	-7.3	-13.0	-10.0	-267.5
Sairé	-3.1	-6.4	-8.0	1.2	2.8	-12.7	-0.5	-8.3	7.0	0.7	-2.8	-3.8	-33.9
Sanharó	-0.3	1.9	4.8	-12.0	-37.4	-46.6	-42.4	-26.4	-19.8	-7.0	-5.1	9.1	-181.2
São Caitano	-11.8	-12.9	-27.0	-26.1	-47.1	-56.0	-54.1	-33.2	-17.5	-9.0	-9.7	-12.5	-317.1
S Bento do Una	-3.0	-4.1	-14.6	-17.4	-36.3	-43.8	-46.6	-27.1	-15.2	-3.2	-0.6	3.1	-208.7
Tacaimbó	-7.6	-8.2	-18.0	-20.4	-43.3	-51.1	-47.4	-32.7	-17.9	-7.8	-3.6	-8.2	-266.2
Venturosa	-3.2	4.5	-13.2	-21.5	-42.5	-63.8	-77.5	-44.4	-20.7	-3.8	-3.6	1.6	-288.1
Vitória S Antão	8.0	3.3	19.6	23.4	58.0	72.2	73.2	42.3	27.2	10.7	6.8	11.5	356.1

Source: Medeiros, (2022).

The municipalities that presented negative anomalies every month were: Altinho, Belo Jardim, Cachoeirinha, and Caruaru, Riacho das Almas, São Caitano and Tacaimbó. While the municipalities of Amaraji, Chã Grande, Escada, Ipojuca, Primavera and Vitoria de Santo Antão registered positive anomalies every month, the other municipalities presented with alternation in their months, that is, anomalies fluctuations negative and positive.

4. Conclusion

There is increasing variability of annual and monthly precipitation. The variability is greater during the spring and summer season and with less variability in the winter and autumn seasons.

In general, it is verified that the local precipitation patterns are influenced by several precipitating systems that contribute to the quantity of local precipitation and that their contributions are interconnected to the systems of meso and micro scale and local scale, orography and with the interaction of use and ground cover.

The rainfall irregularities in the basin and its surroundings are mainly linked to the main factor that causes moderate to heavy rain in the studied area and the warming of the South Atlantic Ocean basin.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest.

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] APAC Pernambuco State Water and Climate Agency. 2017.

[3] Bem-Gai T, Bitan A, Manes A, Alpert P, Rubin S. Spatial and temporal changer in Rainfall frequency distribution patterns in Israel. Theor. App. Climatol. 1998; 61: 177-190.

[4] Bertoni JC, Tucci, CEM, Precipitation. In: Tucci, CEM. Hydrology: Science and application. Porto Alegre: Ed. from the University – UFRGS, ABRH. 2001; 230.

[5] Cohen JCP, Fitzjarrald DR, Oliveira FAF, SaraivA I, Barbosa IRS, Gandu AW. Radar observed spatial and temporal rainfall variability near the Tapajós Amazon confluence. Brazilian Journal of Meteorology. 29: 23 30.

[6] Coscarelli R, Caloiero T. Analysis of daily and monthly rainfall concentration in Southern Italy (Calabria region). Journal of Hydrology. 2012; 416-417, 145-156.

[7] Fitzjarrald DR, SakaI RK, Moraes OLL, Oliveira RC, Azevedo OC, Matthew J. Spatial and temporal rainfall variability near the Amazon Tapajós confluence. JGR: Biogeosciences. 2008; 113: 117.

[8] Galvani E. Descriptive statistics in the classroom. In: Venturi, L. A. B. Geography: Field, laboratory and classroom practices. São Paulo: Editora Sarandi. 2011; 153.

[9] Medeiros RM, Holanda RM, Viana MA, Silva VP. Climate classification in Köppen model for the state of Pernambuco - Brazil. Journal of Geography (Recife). 2018; 35: 219-234.

[10] Medeiros RM. Climatological study of the Uruçuí Preto-PI river basin. Publisher of the Federal University of Campina Grande – EDUFCG. Federal University of Campina Grande – UFCG. 2016a; 287.

[11] Medeiros RM. Provoking and/or inhibiting factors of rain in the state of Pernambuco. Separate distributions. On Pages. 2016b.

[12] Medeiros RM, Matos RM, Saboya LMF. Diagnosis of rainfall fluctuations in the state of Paraíba. Brazilian Journal of Physical Geography. 2015; 8(4): 1017-1027.

[13] Medeiros RM, Santos DC, Belt DS, Oliveira VG Rafael AR. study of rainfall in the municipality of Campinas do Piauí. In: International Congress of Biological Sciences, 1, Recife, Anais. CPU. 2013; 1-11.

[14] Medeiros RM, Silva VPR, Gomes Filho MF. Hydroclimatic analysis of the Uruçuí Preto – Piauí river watershed. Journal of Engineering and Technology. 2013; 5(4): 151-163.

[15] Monteiro JB, Zanella ME. Extreme rainfall events and associated impacts in Fortaleza - CE: an analysis using the quantile technique, In: Silva, C. A. F. E. S.; Steinke, E.T. (Orgs.). UFGD, Dourados. 2014; 165-186.

[16] Oliveira NL, Marcuzzo FFN, Barros RG. Influence of El Niño and La Niña on the number of days of rainfall in the State of Mato Grosso. Science and Nature. 2015; 37(4): 284-297.

[17] Silva MÊS, Silva CB.Climate variability - Physical and dynamic processes in the oceans and atmosphere. Journal of the Department of Geography (USP). 2012; 2: 121-135.

[18] Silva VPR, Pereira ERR, Azevedo PV, Sousa FAZ, Sousa IF. Analysis of rainfall and rainy days in the Northeast region of Brazil. Brazilian Journal of Agricultural and Environmental Engineering. 2011; 15(2): 131-138.

[19] Simioni JPD, Rovani FFM, Iensse AC, Wollmann CA. Characterization of Pluviometric Precipitation in the Ibicuí River Watershed, RS. Journal of the Department of Geography – USP. 2014; 28: 112-133.

[20] Souza WM, Azevedo PV, Araújo LE. Classification of Daily Precipitation and Impacts Resulting from Disasters Associated with Rainfall in the City of Recife-PE. Brazilian Journal of Physical Geography. 2012; 2: 250-268.