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SEASONAL AND INTER-ANNUAL ANALYSIS OF PRECIPITATION ON THE PIAUIENSE COAST BY THE METEOROLOGICAL STATION OF PARNAÍBA-PI

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Abstract: This work deals with the behavior of annual and historical precipitation in Lagoa do Portinho, through data from the automatic meteorological station of the Instituto Nacional de Meteorologia (INMET) located in Parnaíba, Piauí. Based on the bibliography on the climate, it was sought to explain the behavior of rainfall in the region, from the global to the local scale, with the objective of clarifying the behavior of the climatological normal elaborated, as well as its accumulated precipitation values in each month. Data were found for the climatological normal for the period from 1961 to 1990, but monthly precipitation data were only available from 1971 to 1985 and from 1994 to the present. In this way, it was not possible to have uninterrupted coverage from 1960 to the present, but it was still possible to show the behavior of the rains from 1994 to today, as well as annual rainfall totals for the same period. The results showed that the drought occurs in the second semester of the year, with minimum values in August, while the rainy season occurs in the first half of the year, with maximum values in April. Rainfall is mainly regulated by global-scale phenomena, such as the warming of the waters of the Pacific (ElNiño) and the displacement of the ITCZ to the south during the summer, the former justifying the drought period, while the latter is responsible for the rains.
Keywords: Lagoado Portinho, Coast, Precipitation, Normal weather, Parnaíba.

INTRODUCTION

Rainfall is the most important component of the hydrological cycle, with its maximum importance translating from the agricultural point of view and being directly responsible for the agrarian development of a region. Vieira (2010) and Sampaio (2000) emphasize that in addition to being the most environmentally correct method of using water in agriculture, their study is also capable of reducing the operation and maintenance costs of irrigation systems, as it makes the amount of rainfall predictable and reduces the need for drainage.

The total amount of rain accumulated, in a given period and region, is expressed by the height of water falling on a flat and impermeable surface, in millimeters, obtained by rain gauges distributed in the studied region, and in the considered interval (PINTO et al, 2008). It is important to remember that precipitation contributes to the annual total it is not, almost always, regularly distributed over the months (REBOITA et al, 2010), therefore, we have that the total amount of accumulated rain and its variability throughout the year are the main parameters of agricultural forecasts and planning.

It is in this context that the objective is to analyze the total annual amounts of precipitation in Lagoa do Portinho, as well as its behavior over the months, to finally present the climatological abnormality of the region until the present moment. from Piaui. The data comes from the meteorological station of Parnaíba-PI, available on the portal of the Instituto Nacional de Meteorologia (INMET).

CHARACTERIZATION OF THE STUDY AREA

Lagoa do Portinho is the result of the accumulation of water from the RioPortinho watershed, with an area and perimeter of approximately 393 km² and 153 km, respectively; serves as a geographic divider at the meeting of the cities of Parnaíba, Luiz Correia and Bom Princípio do Piauí, the latter being further south, its waters flow into the Igaraçu River, a tributary of the Parnaíba River (SOUSA, 2016).

The surroundings of Lagoa do Portinho are characterized by the presence of dunes to the north and northeast, with significant territorial expression and oriented according to the direction of the winds of trades (PFALTZGRAFF; TORRES & BRANDÃO, 2010). The coastal dunes are subdivided into fixed dunes and mobile dunes, the latter are displaced by the action of the winds, the former are capable of maintaining some vegetation, usually of low size, preventing their movement. In other directions, the Lagoon is surrounded by shrubby vegetation, typical of the mountains.

Figure 1 indicates the location of the Lagoon and the automatic meteorological station of Parnaíba. The station is identified by the number 82287 in INMET and has the following coordinates: 03°05'S, 41°46'W, 46.8m, with a distance of approximately 17km from the lagoon (BASTOS, 2015). The watercourses of the basin were traced through metadata obtained from the website of the National Water Agency (ANA, 2013). The aerial image is courtesy of the Landsat 8 satellite, obtained from the United States Geological Survey website (USGS, 2015).

The climate of the region is classified as Savannah. Equatorial with dry winter, acronym Aw, according to the world climate

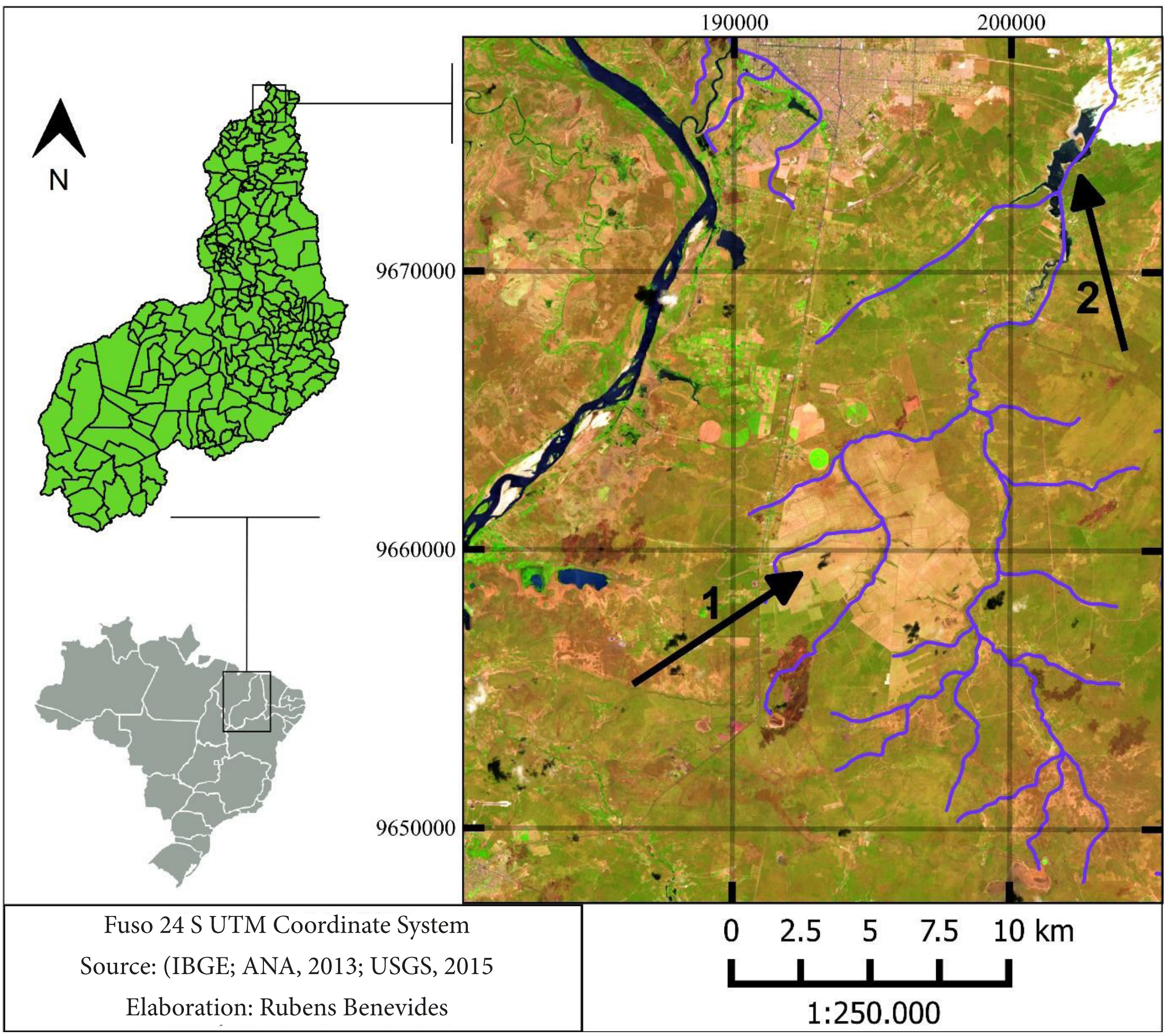

Figure 1 – Image Landat-8 showing the drainage network of Lagoado Portinho (blue lines), city of Parnaíba to the north and Rio Parnaíba on the left. Arrow 1: Approximate position of the meteorological station; arrow 2: Lagoado Portinho.

map ofKöppen-Geiger. This implies thatall months of the year have an average monthly temperature greater than 18°Cand that, in at least one of the winter months, the accumulated precipitation will be less than 60mm (PEEL; FINLAYSON&MCMAHON, 2007).Other known ways of classifying this same climate are:tropical with dry season, savanna climate or semi-humid tropical climate.

THEORETICAL FOUNDATION

THE BEHAVIOR OF THE ATMOSPHERE

Occurrence Rainfall is a consequence of the winds that blow in a region, these operate due to differences in pressure, which in turn are a consequence of differences in temperature, resulting from the irregular heating of the earth by the sun. Clearly, there must be water in the atmosphere for it to precipitate, and since evaporation is also caused by the sun, then, ultimately, rainfall depends on the incident radiation (FERREIRA & MELLO, 2005).

Based on the global circulation of winds in the atmosphere, the most important variables to understand it are: incidence of solar radiation, earth rotation, asymmetric distribution of the oceans, continents and, finally, the topography of the latter. For better understanding we have divided them into the following scales: (LUTGENS & TARBUCK, 1995 apudMARTINS, GUARNIERI & PEREIRA, 2008):

- Planetary scale: dimensions vary from 1000 to 40000 km lasting from weeks to years, the phenomena are mainly governed by incident solar radiation and terrestrial rotation.
- Synoptic scale: dimensions from 100 to 5000 km and lifetimes from days to week, we have mainly the distribution of oceans and continents as regulators, as well as the topography of the latter.
- Mesoscale: dimensions from 1 to 100 km and lifetimes from minutes to days. In this scale, the topography of the terrain and the proximity to oceans and other large bodies of water (breezes) act mainly.
- Microscale: dimensions of less than 1km and lifetimes in seconds, the main variable here is the presence of obstructions, roughness of vegetation and soil. (RIBEIRO, 1993).

PLANETARY-SCALE RAIN REGULATION

Medium and microscale movements are particularly defined for their location, however, planetary and synodic scale air mass movements can be conceptually modeled by observing some features on the planet. Figure 2 illustrates the global behavior of winds in the atmosphere, considering an earth in rotation, with no inclination of its axis and with the action of solar radiation.

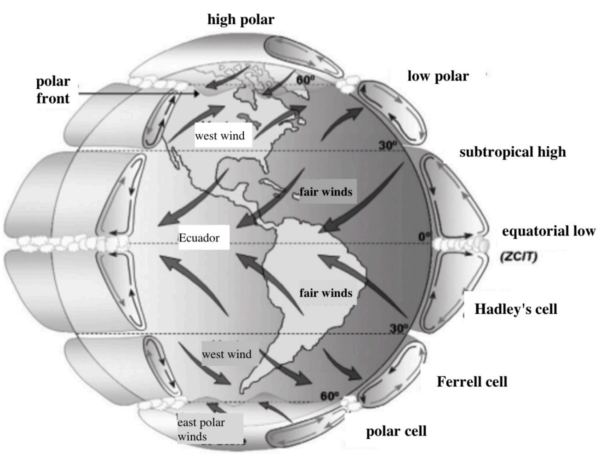

Figure 2–Model of three cells with ideal movement of atmospheric masses influenced only by rotation and incident solar radiation.

Source: (LUTGENS &TARBUCK, 1995 apud MARTINS, GUARNIERI & PEREIRA, 2008).

It is noticed that the equatorial masses reach higher altitudes in relation to the others, this is due to the combined action of two phenomena considered: rotation tends to exert a centrifugal force expelling objects from the earth, with greater intensity at the equator, where the radiation also affects with greater intensity, providing greater heating and elevation of air masses.

The air in the atmosphere contains water and when heated, it expands, decreases in density, rises and cools, which condenses its moisture and causes rain and other forms of precipitation. After reaching high altitude, now cold and dry, it is pushed by currents that continue to rise, gradually descending around 30° north and south latitude. Part of the descending air flows towards the equator at low levels, closing off the circulation of what is known as the Hadley Cell.(MARTINS, GUARNIERI & PEREIRA, 2008).

It can be seen that dry winds converge towards the tropics, while humidity is concentrated at the equator, precisely in the tropics the largest deserts occur, while tropical forests tend to accumulate at the equator (Idem). The behavior of the other cells is similar, they follow the same dynamics of convection, redistributing heat through the earth and thermodynamically balancing the system, we will not go into details of its functioning because they are outside our study area, which is located in the Intertropical Convergence Zone (ITCZ).

Returning to figure 2, we still have the orientation of the trade winds. This direction is a consequence of the Coriolis force, which causes deviations to the right for winds coming from the north and deviations to the left for winds from the south. Figure 3 shows how rotation causes this force that diverts the movement of air currents (GRIMM, 2017). It is worth remembering that due to the inclination of the Earth's axis, the position of the ITCZ and all other cells undergo changes during the seasons of the year.

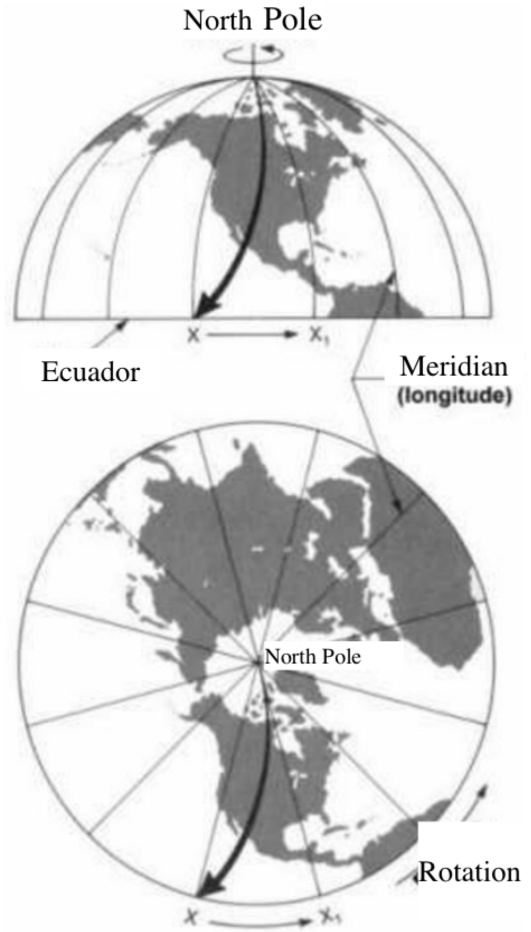

Figure 3 – Deviation caused by the Coriolis Force in a particle that moves from the North Pole to the equator.RotationmovethepointXtoX1, but the currents keep moving toward X.

Source: (GRIMM, 2017).

One of the implications of the previous fact seems to justify the orientation of the dunes observed in the surroundings of Lagoa do Portinho. As stated in item 1.1, they are oriented from NE to SW, descending diagonally towards the interior of the continent. This is the same orientation of the winds that descend towards the equator from the north. Although the Lagoon is 3° to the south, the tilt of the Earth's axis shifts the ITCZ to the south during the summer in this hemisphere, which justifies the arrivals of trade winds below the equator.

This is a valid hypothesis, the agreement of the direction of the dunes is cited byPfaltzgraff, Torres and Brandão (2010) and the displacement of the ITCZ to the south by Reboita et.al (2010), however, it is important to remember that the winds in Lagoado Portinho are influenced by other phenomena, such as El Niño, Anomalies in the Sea Surface Temperature (ATMRs), sea breezes, among others that may also be the cause of its orientation (ANDREOLY and KAYANO, 2007).

TYPES OF RAINS

The thermodynamics of air currents provides three generic forms for the origin of rains, namely: frontal, convective and orographic rains. of altitude; 2: the lower, the more water present in the air; therefore, the water present will condense (precipitate) when pushed upwards or lose heat in some other way.

Frontal rains occur when a front of warm and humid air meets another of cold, dry air, without the need for a marked change in altitude for its precipitation.

In orographic rain, humid air rises due to the encounter with topographical barriers, in convective rains, on the other hand, it is the heating of the surface by solar radiation that raises it.

That normally occur during the summer and are characterized by strong intensity, given the speed with which the wind ascends (FERREIRAeMELLO, 2005)

RAIN REGULATION IN THE NORTHEAST

The El Niño phenomenon is characterized by the above-normal warming of the waters of the Pacific Ocean and is directly linked to the drought in the Northeast.(FERREIRA and MELLO, 2005; ANDREOLY e KAYANO, 2007; REBOITA et.al, 2010). Due to the warming of the Pacific, another convective cell is formed, known as the Walker cell (Figure 4), with an east-west direction and which acts in various regions of the globe.

La niña occurs when the waters of the Pacific are colder than normal and tend to reverse the currents created in the Walker Cell by El niño. If associated with ATMRs in the Atlantic Ocean, the temperature of the two oceans can dramatically accentuate the currents, either in the direction of El niño or La niña, which influences the rains and droughts in the areas where the air rises and falls, respectively. It is important to remember that although they have opposite causes, Laniña does not necessarily cause opposite effects to El niño.

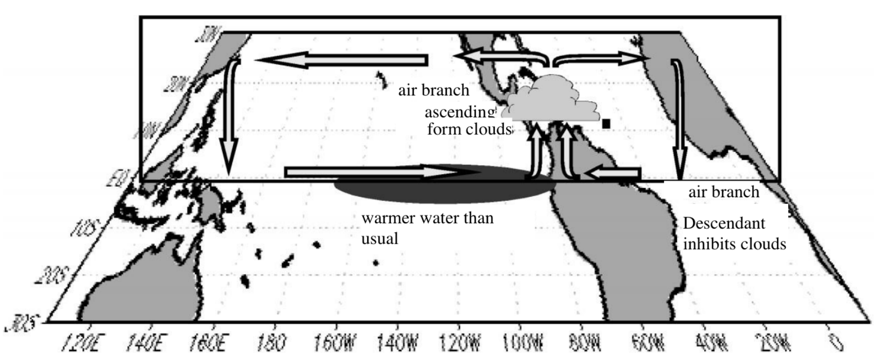

Figure 4 – Walker convective cell. Ascending air masses carry moisture from the oceans and tend to create clouds, on the other hand, when the cold air descends, it prevents the formation of clouds and rains in that region.

Source: (FERREIRA and MELLO, 2005).

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Kousky (1980) suggests that the shock of the NE trade winds with the sea breeze from the northeastern coast is responsible for the nocturnal rains during the southern winter (in the southern hemisphere), while during the summer, due to the displacement of the ICZ, the trade winds would change, favoring precipitation no longer on the coast, but on the oceans.

Consider the influence of topographic barriers in this mesoscale context, which also contributes to the absence of precipitation in the Northeast (REBOITA et. al, 2010).

The existence of South Atlantic Convergence Zones (ZCANs) and high-level cyclonic vortices (VCAN), as well as the South Pacific (ASPS) and South Atlantic (ASAS) anticyclones, together with ITCZs and other mesoscale phenomena, make too complex the circulation of air in the atmosphere. Reviews of climate dynamics in the Northeast and South America can be found in more detail in Martins, Guarnieri and Pereira (2008),FerreiraeMello(2005),Andreoly and Kayano, (2007) andReboitaet.al(2010)).

METHODOLOGICAL PROCEDURES

This researchIt was developed through historical data on precipitation collected at the automatic meteorological station of Parnaíba, requested for the period from 01/01/1960 to 01/01/2016 on the INMET online portal, in addition to the climatological normal data from 1961 to 1990 of the same station. The requested data from 1960 to 2016 returned with the accumulated precipitation in each of the months, however, only from 1994 there was uninterrupted coverage until the present. Therefore, we elaborated the graph for the interannual behavior of the rains along these 22 years, finally, we elaborated the graph of annual variations in precipitation, evidencing its behavior in the two decades.

RESULTS

ANALYSIS OF THE GRAPHICS

Figure 5 shows the graph of the climatological normal from 1961 to 1990. In the graph of figure 6, we proceeded as in the previous one, but with data from 1994 to 2015, we cannot then classify it as a climatological normal, as for this it must comprise a minimum period with 30 years of observations (INMET, 2017). Figure 7 shows the behavior of annual precipitation totals over the last 22 years considered (1994-2015).

It is noticed that most of the precipitation continues to occur in the first semester of the year, in line with what is explained in 2.2 to 2.4. According to Reboitaetal (2010, p.196), the excess of precipitation in the first semester is due to the displacement of 4º of the ITCZ to the southern hemisphere in the Atlantic ocean during the southern summer (December/March). Also noteworthy is the decrease in precipitation values, while the 1961-1990 chart shows maximum values of up to 400 mm, in the averages from 1994 to 2015, these do not exceed 250 mm.[1]

The average values of annual precipitation are proportional to those expected for transition zones between the semi-arid climate in the southwest and humid to the west (Amazon region), with precipitation around 1000 mm. The dry period covers the southern winter (June to September), with practically zero rainfall in August. The main inhibitory mechanisms of rain acting on the northeastern coast are the Elniño (global) and the regional topographic barrier in the east (REBOITA et. al, 2010; FERREIRA eMELLO, 2005).

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1. Accessible data after registration in the Meteorological Data Bank for Teaching and Research (BDMEP), on the INMET online page, available at: <http://www.inmet.gov.br/portal/index.php?r=bdmep/bdmep>. Accessed on: 15th Jan. de2017.

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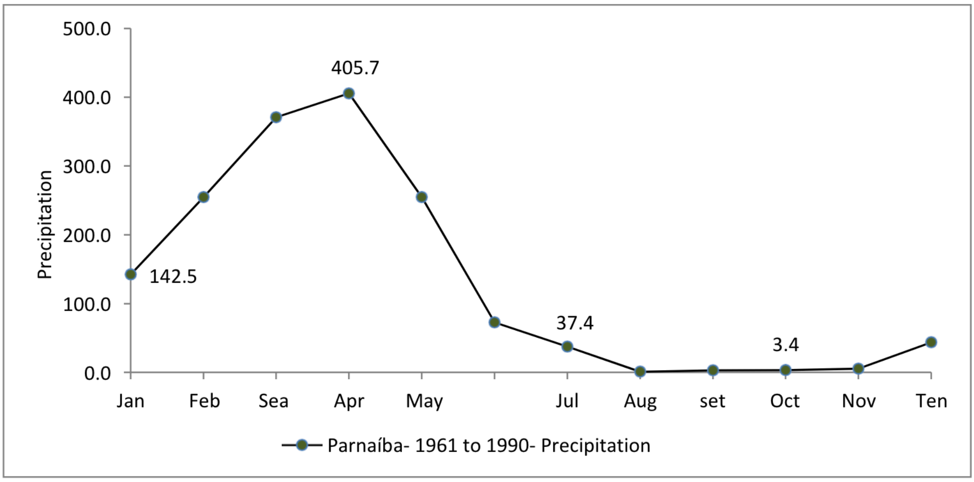

Figure 5–Graph of the climatological normal for 1961-1990. The average of 30 values of precipitation accumulated in that month in each of the 30 years is considered. Source: Own authorship, INMET data.

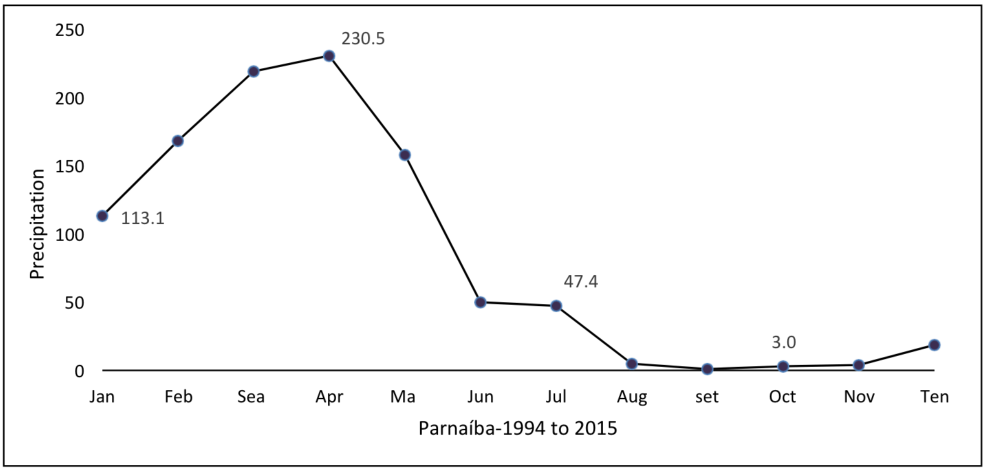

Figure 6–Precipitation behavior from 1994 to 2015.

Source: own authorship, data from INMET3.

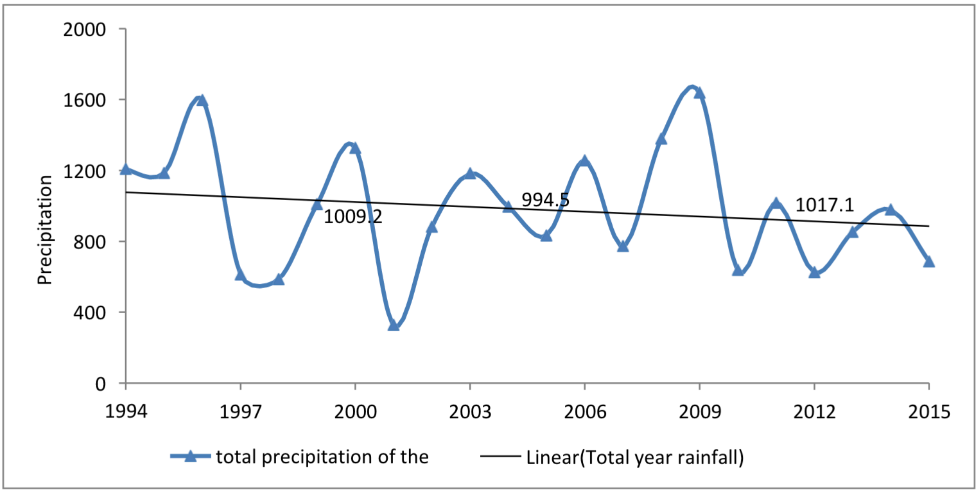

Figure 7–Total annual rainfall from 1994 to 2015. The annual average for the period is 981.5 mm.

Source: own authorship, data from INMET2.

Ferreira and Mello (2010) emphasize that the waters of the North Atlantic, if colder than normal, generate a high pressure system with winds that add to the NE trades. During the same period, the South Atlantic waters are warmer, so the SE trade winds attenuate, further favoring the displacement of the ITCZ to the south of the equator and providing convective rains.

As explained in night 2.3, cumulonimbus-type rains can occur, as well as others associated with mesoscale and frontline convective complexes (Idem, 2005). They usually occur during the summer, with high intensity and short duration, precisely when most precipitation is observed, which corroborates the behavior of the climatological normal shown in figure 5 and the graph in figure 6.

FINAL CONSIDERATIONS AND CONCLUSIONS

This work investigated the precipitation values in the surroundings of Lagoado Portinho in Parnaíba-PI through the INMET climatological station with the objective of evidencing and substantiating the behavior of the rains throughout the year. It was noticed a remarkable agreement between the climatological normal and the other data obtained at the station with the researched bibliography, characterizing the hydrological cycle in the region as rainy in the first semester and dry in the second, with maximum values in April and minimum values in December.

It was found that the southward displacement of the ITCZ during the summer is the main rainfall-causing mechanism in the region at a global level, acting through Hadley convective cells and associating with Atlantic ATMSs. The phenomena of regional scales act together, such as the mesoscale convective complexes and front lines, generating high-intensity rains during the summer (beginning of the semester).

On the other hand, the absence of rain in the second half of the year is associated with the drop in dry winds over the northeast caused by El Niño, explained by the Walker convective cell. On the north coast, the region where Lagoa do Portinho is located, favoring the displacement of the ITCZ above the equator is the other main mechanism responsible for the absence of rains observed in winter (second semester).

Joint analyzes with more seasons and more climate variables are recommended, such as the amount of incident radiation, wind speed and humidity values, since all these determine precipitation in a greater or lesser degree.

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