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Scientific Note

Oscillations of meteorological elements and their climate variations in the municipality of Barbalha – CE

Oscilações dos elementos meteorológicos e suas variações climáticas no município de Barbalha – CE

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Abstract

The impact of climatical variability, even within the normal range, can have significant representation in agricultural activities. Thus, the aim of this study was to analyze climate variability in Barbalha, State of Ceará (CE), focusing on the variations as a means to understand future climate change, in order to analyze the climatic variables that influence agriculture. For this research we used data of maximum air temperature, relative air humidity and total rainfall monthly and yearly in the period 1973-2013, the Conventional Meteorological Station belonging to INMET, city Barbalha - CE. The data showed variations in the temperature of maximum annual air showed great variation among the studied period, also it appears that the relative humidity is being incremented along the series studied, which may be related to increasing temperature. The years with the lowest relative humidity were the years of 1981 and 1983 and the larger 2009 and 2011 were years related to the effects El Niño and La Niña. Fluctuations of meteorological elements and its climatic changes Barbalha - CE contributes significantly to the knowledge of the climatic situation of the municipality aiding decision making in agricultural crops and other economic sectors in the municipality partners.

Additional keywords: agricultural activities; El Niño; La Niña; semiarid.

Resumo

O impacto da variabilidade climática, mesmo dentro da normalidade, pode ter representações significativas nas atividades agrícolas. Assim, objetivou-se com o presente estudo analisar a variabilidade climática em Barbalha - CE, enfocando as variações como um meio para compreender futuras mudanças climáticas, tendo em vista analisar as variáveis climáticas que influenciam na agricultura. Para realização desta pesquisa, utilizou-se de dados de temperatura máxima do ar, umidade relativa do ar e totais pluviométricos mensais e anuais, no período de 1973 a 2013, da Estação Meteorológica Convencional pertencente ao INMET, da cidade de Barbalha - CE. Os dados evidenciaram variações na temperatura do ar máxima anual e demonstraram grande variação entre o período estudado. Verifica-se, ainda, que a umidade relativa do ar está sendo incrementada ao longo da série estudada, fato que pode estar relacionado com o aumento da temperatura. Os anos com menor umidade relativa foram os anos de 1981 e 1983, e os de maiores foram 2009 e 2011, anos relacionados com os efeitos El Niño e La Niña. As oscilações dos elementos meteorológicos e suas modificações climáticas de Barbalha – CE, contribuíram de forma significativa para o conhecimento da situação climática do município, auxiliando na tomada de decisão nos cultivos agrícolas e nos demais setores socioeconômicos do munícipio.

Palavras-chave adicionais: atividades agrícolas; El Niño; La Niña; semiárido.

Introduction

The Brazilian semiarid region is one of the largest, most populous and wetter in the world, situated in the central portion of the Northeast region, in whole or in part, 1,133 municipalities, nine states in an area of approximately 969,589.4 km^2 and 21 millons of inhabitants. Its typical ecological conditions are represented

in ecoregions where the predominant vegetation is the caatinga (Cirilo, 2008). According to the (IPECE, 2009) the Ceará semiarid region has the characteristics of a climate with average annual temperatures between 26 and 28 °C, higher insolation to 3000 h year^{-1}, relative humidity around 65%, annual rainfall below 800 mm, shallow soils and predominantly crystalline substrate.

Climate changes are changes that occur in the general climate of planet earth, and are produced in different time scales in one or more meteorological factors such as: maximum and minimum temperatures, rainfall, ocean temperatures, cloudiness, humidity air, promoting impact on the lives of current and future generations (IPCC, 2007).

Variability is one of the most popular elements of climate dynamics, the impact of this variability, even within the expected can have a significant impact on human activities. But it is noteworthy that the abnormalities may disrupt both the environmental system, and the socioeconomic (Queiroz & Costa, 2012). Studies prepared by Pinto et al. (2003) show that climate variability in Brazil, depending on the region analyzed, can cause continuous changes in meteorological elements (precipitation, wind, air temperature and relative humidity).

The spatial and temporal variations are characteristics to weather and climate, the first is a feature that should be studied in greater detail and in different chronological scales. Because these studies will allow the climate of knowledge in the past, present and even make projections for future climate situations, from models (Queiroz & Costa, 2012; Todisco & Vergni, 2008).

The dynamics of the hydrological cycle in the basin can be better understood by the simple water balance (BHS) or climatic water balance (BHC). The studies of the water balance are employed in numerous activities, such as the determination of irrigation intervals in predicting agricultural productivity, time of sowing and harvesting, climate classification, among other various activities involving the management and planning water resources (Vestena & Lange, 2008).

The visualization to trends of climate change on weather time series, and represents important scientific data, is characterized as a need to establish the effect of climate change on climate dynamics, key to the future planning of water resources, human health and production foods (Obregón & Marengo, 2007).

The attempt to identify the climatic variability in weather records is of paramount importance to the socioeconomic studies, since it can present trends, visualization of future scenarios for a better understanding of climate dynamics.

In this context, there is consensus that changes in climate have direct and significant impact on crops, ecosystems and socioeconomic factors, whose variability results in multiple impacts, often even irreversible. Thus, the aim of the present study to analyze climate variability in Barbalha - CE, focusing on the changes as a means to understand future climate change and in order to analyze the climatic variables that influence agriculture.

Material and methods

Location of the study area

The municipality of Barbalha is located in the state of Ceará, representing an area of 479,184 km^2, ie 0.34% of the state of Ceará. His position is between the parallels 7 19' 18" south latitude and between the meridians 39º 18' 07" west longitude. Inserted in the middle region South of the Ceara State, in the Cariri micro limits with the municipalities of Crato, Juazeiro and Missão Velha (Figure 1). It has a population of 55,373 inhabitants according to IBGE (2010), and a population density of 115, 56 inhabitants per km^2 (IPECE, 2009).

According to Köppen the climate is Bsh type, the rains begin around the first half of December, increases in volume in the first days of January and lasts until May, being the wettest quarter of February, March and April (Vianello & Alves, 1991). Provocateurs rain factors in the municipality are formations of instability lines on the coast, transported into the trade winds from the southeast / northeast, development of convective clusters, from the heat stored in the surface and transferred to the atmosphere, terrain, training contributions cyclonic vortices, and with the main system the position of the Intertropical Convergence Zone ITCZ (Molion & Bernardo, 2002).

Besides having an irregular annual average rainfall distribution (1061.9 mm). Climate variability from one region exerts important influence on various socioeconomic activities, especially in agricultural production. As the climate consists of a set of integrated elements crucial for life, this becomes relevant, since its configuration can facilitate or hinder the fixation of man and the development of its activities in the various regions of the planet (Soares & Ribeiro, 2006).

Physiographic features

The relief is formed by a plateau, represented by the “Chapada do Araripe” and some mountains among which stand out the Serra Cruzeiro, Boca da Mata, Boa Vista and Serra Portal. The culmination is the cut of the cruise with 1,100 m of altitude. The rest of the city is flattened characterizing the hinterland region (Soares & Ribeiro, 2006).

The vegetation is very diverse, with areas of caatinga and cerrado. Within its area is the Araripe National Forest (Brandão et al., 2012).

According to Soares & Ribeiro (2006), hydrography is formed by a river, the River Garden, Dry periodically by streams: Jacundá, Porcos, Gravatá and Boca da Mata. Of the Chapada foot there is the upwelling of groundwater in the form of beautiful fountains of crystalline water are a major tourist attraction. The sources totaled 72, these 30 dried 22 are currently with their reduced flow rates and only 20 remain unchanged; among which the best known are: Boca da

Mata (which supplies the city) and Boa Vista (tourist attraction).

The soil types that stand out are Bruno non Calcic, Neosol, Eutrophic Red Latosol - yellow dystrophic and Vertisol, of potential use in: diverse cultures, fruit, cotton and extensive livestock.

Figure 1 - Location of the municipality of Barbalha on the State of Ceará, Brazil.

Data obtainment

To understand the existing climate variability in the municipality of Barbalha - CE, worked up with the weather series of maximum air temperature, relative humidity and monthly and annual rainfall, which comprise the series of years 1973-2013 to contain minor faults and good consistency, data were acquired from Meteorological Conventional Station at Barbalha - CE, provided by the National Institute of Meteorology (INMET). Was used for the preparation of charts Microsoft Office Excel software, the data always observed the same synoptic times.

Results and discussions

The absolute maximum temperature, mean absolute, absolute minimum, monthly and annual minimum Barbalha - CE are shown in Table 1. It is noted that the month of October was the one that showed the highest temperatures (36.1, 34.6 and 31.6 °C), respectively, have the highest absolute minimum average was observed for the month of January to 20.1 °C. The smallest absolute maximum temperature was in July with 32.6 °C; the lowest absolute maximum average in June with 30.3 °C; the absolute lowest temperature was observed for the month of July 27.9 °C and the lowest absolute minimum average was recorded in June corresponding to 17.2 °C.

According to Viana et al. (2012) in a study on the analysis of the spatial distribution of the minimum air temperature for the state of Ceará from SRTM warmer months data were February, March, September, October, November and December where about 85% of the areas of the state presented with temperatures above 24 °C, and in some areas of the state came to reach 25 °C. Agreeing with the data observed in this study that has values higher than quoted.

Table 1 - Absolute maximum temperature (Abs. max. temp.); absolute average maximum (Abs. max. ave); minimum air temperature (Abs. min. temp) and absolute minimum average monthly temperature(Abs. min. ave) and annual in Barbalha - CE (1973-2013).

Parameters / Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Yearly
Abs. max. temp.	34.6	33.4	33.7	33.0	33.8	32.9	32.6	34.0	35.0	36.1	36.2	35.6	33.7
Abs. max. ave	32.0	31.0	30.7	30.6	30.4	30.3	30.5	32.2	33.7	34.6	34.3	33.6	32.0
Abs.min. temp	29.7	29.4	28.9	28.9	28.2	28.1	27.9	30.1	32.1	31.6	31.0	30.3	30.4
Abs. min. ave	20.1	19.8	19.9	19.2	18.1	17.2	17.8	16.9	18.8	19.7	19.7	19.6	19.1

The air temperature is an agrometeorologic factor that influences the vital functions of plants such as germination, perspiration, respiration, photosynthesis, growth, flowering and fruiting. It is present in several irrigation management studies, project and estimation of crop development. Among

the climatic elements, the air temperature is higher that promotes direct and significant effects on many physiological processes occurring in plants and animals; therefore, their knowledge becomes fundamental in studies of agricultural planning and in adaptation analyzes crops in certain regions with distinct characteristics (Medeiros et al., 2005; Viana, 2010).

The absolute minimum temperature recorded in the city of Barbalha - CE was 20 °C; the absolute maximum and absolute minimum and absolute average were greater than 27 °C during all months of this series 40 (Figure 2a). Emphasizing that the highest temperatures were recorded in the months of September to November. Over the analyzed period there is a tendency to increase in the annual maximum temperatures. Dantas et al., (2008) study on the evaluation of the meteorological elements in Recife - PE in the period 1961-2000, found the highest average values of temperatures were recorded in the decade from 1991 to 2000 in the months from January to March with temperatures above 27.0 °C.

The annual change in the absolute maximum temperature and to the variable regression are shown in Figure 2b. It is noted that the year lower temperature of 1973 to 2013 was the series 1976 with a temperature of 32.89 °C; since the year 2008 with higher temperature was 36.15 °C. According to Silva (2004) also found positive trends statistically positive air temperature in several Northeast locations.

Queiroz & Costa (2012) studying the characteristics and climate variability in temperature series, relative humidity and rainfall in Ituiutaba - MG found that the maximum annual of the air temperature fluctuated during the period analyzed, especially for the years 1994, 1997, 2000, 2004 2007 and 2008 with the occurrence of annual maximum temperatures exceeding 40 °C, with increasing temperature trend. Agreeing with the data obtained in this study even if for different regions of the country.

The absolute maximum relative humidity was observed for the month of February with 93%, the highest historical average for March with 81% and the lowest absolute humidity for the month of October with 37% from 1973 to 2013 (Table 2). Similar results were cited by Dantas et al., (2008) where higher values were around 85%, while the smaller are the low 74%.

Relative humidity is the ratio of the amount of water in the air (absolute humidity) and the maximum amount which could be, at the same temperature (saturation point). The relative humidity is presented with large daily and monthly fluctuations, according to the standards of the regions of transition between semiarid and humid. The mean minimum relative humidity ranging from approximately 25 to 75% throughout the year (Medeiros et al., 2013).

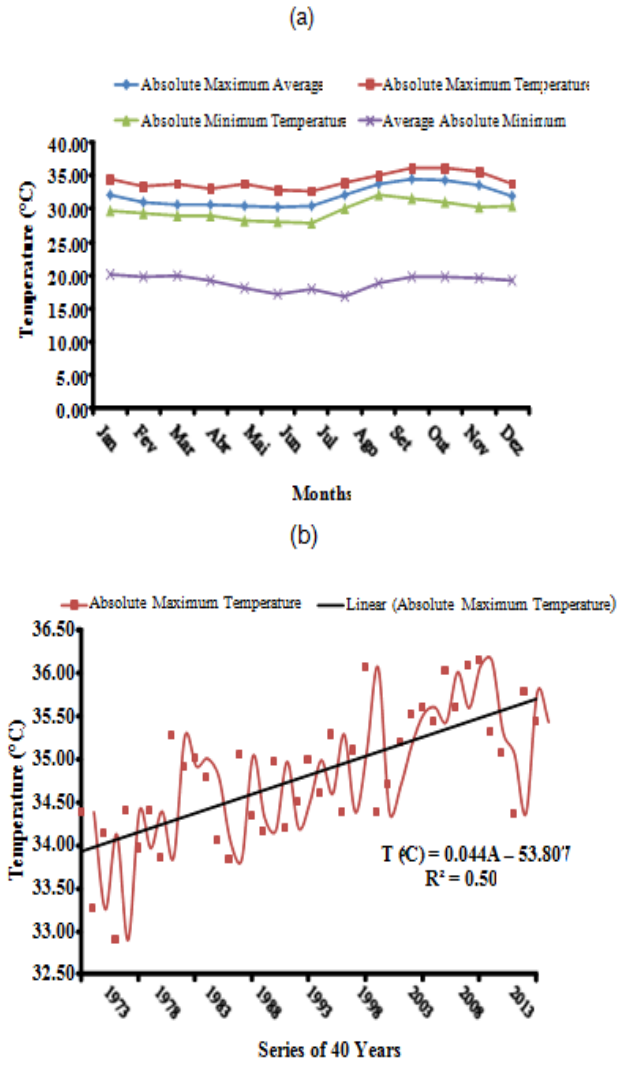

Figure 2 – Annual variation of the air temperature: (a) Absolute maximum , mean maximum, minimum and mean minimum; (b) Annual and linear maximum temperature in Barbalha - CE (1973-2013).

The absolute maximum relative humidity, absolute and average absolute monthly minimum average of the series studied is in Figure 3a. It appears that the lowest averages were observed for the month of September and the highest were in the months February to April. Note also that the relative humidity the temperature is inversely proportional. This fact is due to the air have higher vapor water retention capacity with increasing temperature, the air acts then as a reservoir which expands or contracts with increasing and temperature (Pereira et al. 1997). Medeiros et al. (2013) also found that the relative humidity goes on showed an annual increase of 63.6% in March (highest) 49% its lowest recorded value of relative humidity in September.

Dantas et al. (2008) study in the period 1961--1970 to the city of Recife - PE noted that the months from January to December there was the lower relative humidity values compared to other periods, except for the month of November that had a lower value.

Table 2 - Maximum relative humidity and absolute minimum and monthly and annual historical average in the municipality of Barbalha - CE, in the 1973-2013 period..

Parameters /Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
Absolute maximum relative humidity	85.8	93.2	88.8	91.0	88.1	82.8	79.0	74.1	70.6	76.2	83.2	77.9	82.1
Historical average	71.6	78.1	81.0	80.0	74.9	67.6	62.5	55.5	50.6	52.3	55.5	60.7	66.0
Absolute minimum relative humidity	58.3	65.2	73.1	71.6	58.1	53.0	46.2	40.6	38.4	37.0	40.7	46.8	55.0

The relative humidity for the series of 40 years of the municipality of Barbalha - CE is in Figure 3b. It is observed that the lower relative humidity of the air were observed in the years 1981 and 1983 corresponding to 55.00% and 55.67%, respectively. This is related to the interannual variability of the northeastern semiarid climate that is worthy of great attention, because after a period of severe drought from 1982 to 1983 due to El Niño which the main one consequence of the change in rainfall patterns, both in terms of rainfall as the change in standard time, which affects the crop from planting to harvest (Santos, 2006).

For the larger relative humidity (RH) were recorded in 2009 and 2011 with 79.45% and 82.11%, with increased humidity trend over the historical series, Figure 3b. It is observed that this fact be related to the return of the phenomenon La Niña 2009 and 2011, years that showed changes in temperature of the Central Pacific waters ranging from low intensity to moderate in the period with the formation of negative dipole phenomenon Atlantic which was pretty intense, they contributed to the occurrence of many rains that were accompanied by floods including the semiarid northeast (Marengo et al., 2011).

Medeiros et al. (2013) studied the climatic water balance and climatic classification for banana producing area in the municipality of Barbalha - CE, noted that in 1994; 2005; 2006; 2007; 2008; 2009; 2010 and 2011 the highest levels of moisture of the air and the years 1998 and 1999 as the lower rates of said parameter being studied, and the average relative humidity of the study area is less than the annual average of 80%.

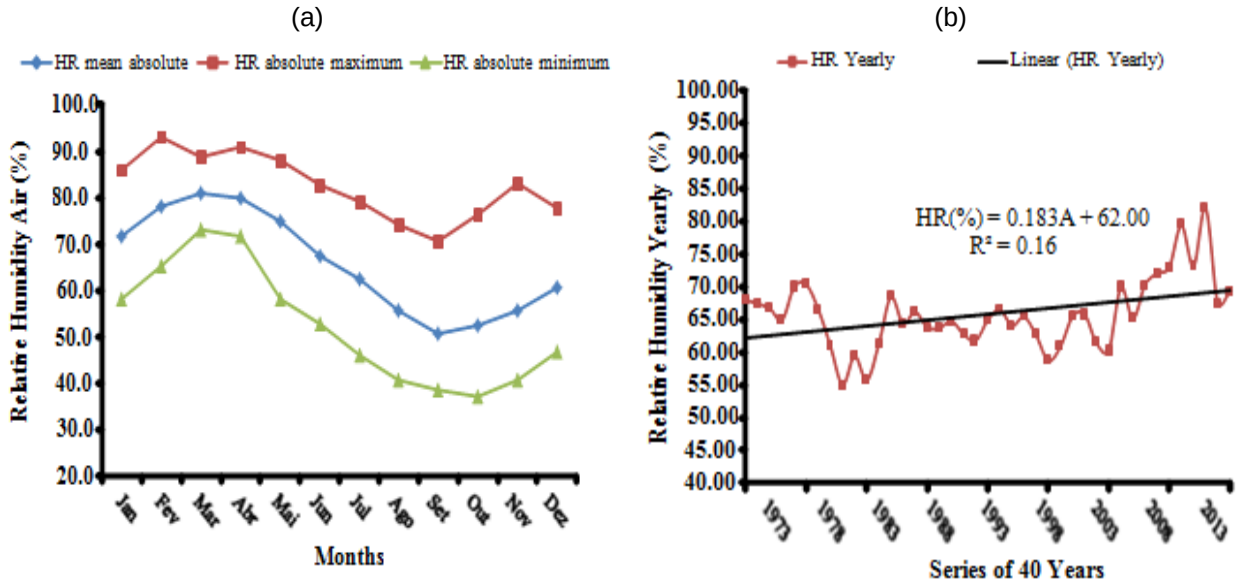

Figure 3 – Relative air humidity (RH): (a) Absolute maximum, mean absolute and absolute minimum and (b) yearly, in Barbalha - CE, in the 1973-2013 period.

The monthly average absolute maximum and absolute minimum rainfall in the city of Barbalha - CE, the historic series covering the period from 1973 to 2013, is in Figure 4a. They are checked and larger average absolute minimum and maximum rainfall in the months from January to March; It is the lowest observed in the months of June to October. The total monthly rainfall is the total amount of rainfall that occurred in the course of a month, in millimeters. It can be considered that there are two seasons: the rainy and dry. This rainy season (January to May) is responsible for approximately 85% of rains in the city.

According to Santos & Silva (2012) in May the rainy season has started to slow, the dry season intensifies and the water stored in the soil clearly decreases, causing the water deficit in the soil and requiring irriga-

tion on crops, this setting reflects the importance of the study of the rainy spatiotemporal distribution. In addition, knowledge of this feature can guide decisions on the necessary measures to minimize the damage from irregular rainfall.

The annual rainfall of the series from 1973 to 2913, in Figure 4b. It appears that the year of highest rainfall was in 1985 with 1976.20 mm and the lowest in 1982 with 522.90 mm, the historical average of about 1,000 mm of rainfall.

Rainfall is a key attribute in the analysis of tropical climates, reflecting the performance of the main atmospheric circulation currents (Almeida & Silva, 2004; Almeida & Pereira, 2007;. Paula et al., 2010).

The annual average rainfall is 1075.8 mm, and can be divided into two periods. A rainy, between the months of December to May, with monthly fluctuations in their rates fluctuating between 42.8 to 227.1 mm, with a total of 962.5 mm, which corresponds to 89.46% of the total accumulated and a period less rain between the months of June to November, with a total of 113.3 mm which corresponds to 10.53% of the total (Medeiros et al., 2013) corroborating the results obtained in this study.

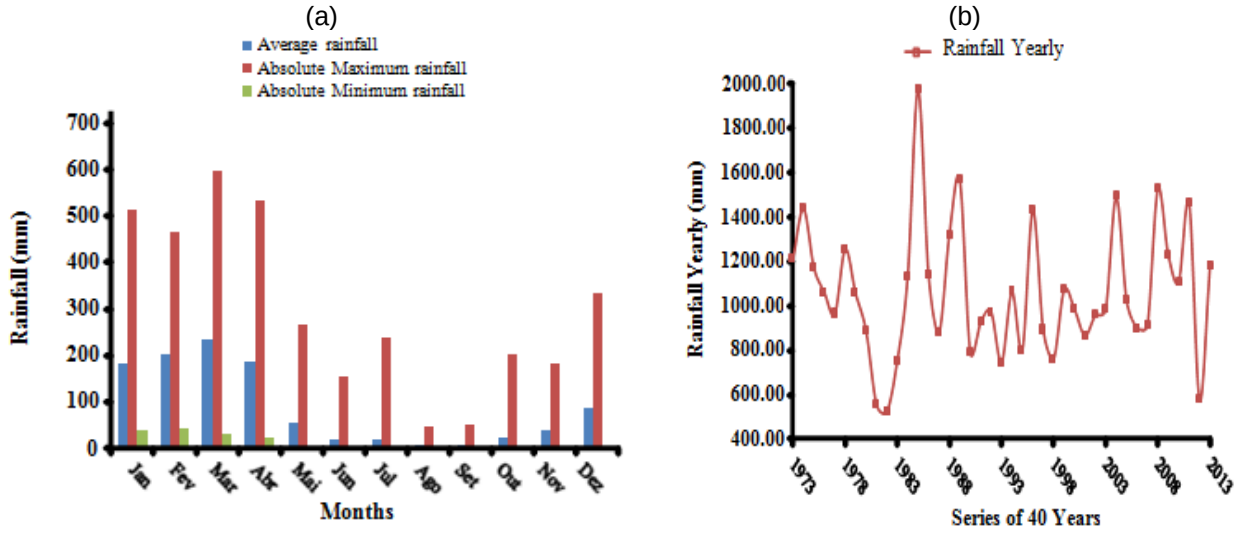

Figure 4 - Average rainfall absolute maximum and absolute minimum (a) historical annual precipitation (b) in Barbalha - CE, 1973-2013 period.

The northeastern semiarid region is characterized by the occurrence of low rainfall, irregular (spatial and temporal) of frequent droughts, and usual occurrence of high intensity and short duration events, devoid of volume flow of water from rivers, this may be explained in function of the temporal variability of precipitation and geological characteristics dominant in addition to the active weather systems (Silva et al., 2013; Santos et al., 2014).

Conclusion

The month of October was the one that showed the highest temperature 36.1; 34.6 and 31.6 °C and lower absolute relative humidity 37% for the series from 1973 to 2013 in the city of Barbalha - - CE; The historical average temperature was higher than 27 °C.

The years with smaller relative humidity were 1981 and 1983 and the highest were 2009 and 2011, years related to the effects of El Niño and La Niña.

The average precipitation in the municipality of Barbalha - CE for the series between the years 1973-2013 is 1061.9 mm year^{-1}. The municipality of Barbalha - CE has two distinct seasons: rainy season, between the months of January to May; dry period between the months of June to December.

The oscillations of meteorological elements and its climatic changes of Barbalha - CE contributes significantly to the knowledge of the climatic situation of the municipality assisting in decision making on agricultural crops and other economic partners sectors of the County.

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