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Climate change and rainfall variability in the city of Campina Grande-PB: analysis from historical series of precipitation

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Abstract

Currently, the climate changes have generated many discussions, constituting one of the major concerns with regard to their effects. Several are the impacts arising from climate change, whether in social, economic and environmental context. Some climate models have shown trends of reduction of rains to the northeast in the wettest months, which could increase the frequency and intensity of droughts and reduce the availability of water resources. Thus, the objective of this work was to analyze the trends and variability of climatological precipitation series in the city of Campina Grande-PB, using daily series of pluvial precipitation over a period of 50 years. The statistical analysis and the preparation of the graphics were made with the ClimAp Software, which have been assessed the extremes of precipitation (days with rainfall ≥ 1 mm; days with rainfall ≥ 10 mm; days with rainfall ≥ 20 mm); Per95p and Pr99p (number of days with precipitation ≥ 95% and the 99%) of significant rainfall, highest rainfall in 1 day rain, annual total and its standardized deviation, monthly and quarterly averages of precipitation, annual total-linear regression, and sequential Mann-Kendall test. Through this research was possible to conclude that the city of Campina Grande presents annual distributions of irregular precipitation, with a slight increase in year-to-year variability, but without statistical significance.

Keywords: Rainfall; Climate change; Interannual variability.

1. Introduction

In current times, the theme climate change has generated many discussions on the scientific community, constituting one of the major concerns with regard to their effects.

As a result of this, it is predicted a lot of impact and interference in the environment related to climate change for next years, in various parts of the globe. Second Marengo and Valverde (2007) is expected to be changes in biodiversity, and sea level rise and impacts on health, agriculture and hydropower generation, which are already affecting Brazil as well as heat islands increase in big cities. It is designed the replacement of semi-arid vegetation on arid region, trends of desertification of agricultural land,changing patterns of desertification and water availability (IPCC, 2007 cited by Santos and Brito, 2007). In addition to environmental impacts, weather events resulting from climate change also bring: economic losses and increased losses of lives (Kostopoulo and Jones, 2005 quoted by Santos et.al., 2009).

The chlorophyll quantification, mainly those related to the vegetation with few species dominant assumes greater relevance when the intention is to evaluate its biological condition.

Different crop species were evaluated through chlorophyll quantification and hyperspectral indices of the canopy, in an area with different sizes (Ferri, Formaggio and Schiavinato, 2004; Jarocinska and Zagajewski, 2009).

Regarding the influences on hydrology, Santos et. al. (2009) states that the interference in the hydrological cycle will bring us water resources implications, the variability of precipitation events, causing floods and more intense droughts. Consequently, there will be changes in economic activities and environmental processes are highly dependent on rain.

In the semi-arid Northeast, the same features present high rates of sunstroke, high temperatures and low thermal amplitudes. Rainfall totals are low and have high variability in time and space. There are high rates of evapotranspiration and water deficit high (Zanella, 2014). And the view of future scenarios for the region does not reflect optimism, stressing even more what you already own. The projections of changes in rainfall regimes and distribution derived from the global models of the IPCC AR4.

For warmer climates in the future are not conclusive, and the uncertainties are still great, because they depend on the models and the regions that are considered. In the Amazon and in the Northeast, although some global climate models of the IPCCC AR4 report drastic reductions of precipitations, other models feature increased (Zanella, 2014). Still, the Intergovernmental Panel on climate change (IPCC – Intergovernamental Panel on Climate Change) showed a decrease rain in North and Northeast of Brazil during the winter months JJA (June, July and August), which can affect the rain in the eastern region of the Northeast, the peak of the rainy season this time of year. According to the reports of the IPCC for the Latin America and the INPE (Instituto Nacional de Pesquisas Espaciais – National Institute for Space Research), the semi-arid region will tend to become more arid, which may increase the frequency and intensity of droughts and reduce the availability of water resources (Marengo et al. 2007, Ambrizzi et al. 2007).

Huge droughts or floods has been part of the history of the Northeast and drought, in particular, is always a synonym of suffering for the people of the Northeast, especially for rural populations (Marengo and Valverde, 2007). So, this region has been the subject of great concern given the scenarios set out as a result of climate change.

For Souza (2011), the growing concern is associated with the various existing studies that point increase in frequency and intensity of natural disasters associated with climate variability and possibly climate change. These climate variances exert a significant influence on human activities, since they change the temperature, precipitation and the frequency of extreme events such as: droughts and heavy rains, resulting in impacts on agriculture, water resources, health, about the environment in several scales (Santos, Assis and Souza, 2014).

According to Monteiro (2007), among the sectors of the economy is agriculture as an activity extremely vulnerable to climate change. This is because the sustainability of agricultural production systems depend on the weather. In the northeastern region, agriculture and cattle raising are the economic activities responsible for securing the population in semi-arid region, and family farming activity developed in 80% of the northeastern agricultural establishments responsible for the livelihood of families (INCRA/FAO – Instituto Nacional de Colonização e Reforma Agrária - National Institute of Colonization and Agrarian Reform / FAO – Food and Agriculture Organization of The United Nations, 2000 cited by Monteiro, 2007). Monteiro (2007) states, this way, the family farmer does not have economic conditions and access to technological alternatives with a view to the improvement of seeds adapted to the semi-arid region, for example.

Therefore, the agriculture in this management system is highly dependent on weather conditions. Faced with these phenomena, the society as a whole becomes the main victim due to its high vulnerability vis-à-vis the dynamics of nature. The predictive power of such phenomena coupled with knowledge on natural and man-made systems allows us to reduce this vulnerability (Barbosa, 2007).

The State of Paraiba has about 80% of its area in northeastern semi-arid region and has high rainfall irregularity (Azevedo and Silva, 2004). The Agreste region in the State of Paraíba, in which is located the city of Campina Grande, is regarded as a transitional area between the zona da mata (coastal sub-region) and caatinga region, with almost as moist as the coast and others such as in the backwoods (Pereira et al., 2002). This makes the rainfall of this sub region with wide spatial and temporal variability.

Therefore, the objective of this work was to analyze the trends and variability of climatological precipitation series in the city of Campina Grande-PB, through the ClimAp model, noting the interference of phenomena related to climate change in precipitation regimes.

2. Materials and methods

2.1 Study Area

Campina Grande (7° 14 ' S, 35° 54 ' W and 552 m) is located in rural Brazil, in the eastern part of the Borborema plateau. It has the climate type Aw ' i, according to the Köppen climate classification and is considered as dry sub-humid. The rainy season is between the months of March to July and the climatological normal is about 800 mm (1974-2004). The average annual maximum temperature is 28.7° C and the minimum of 19.8° C which varies little throughout the year.

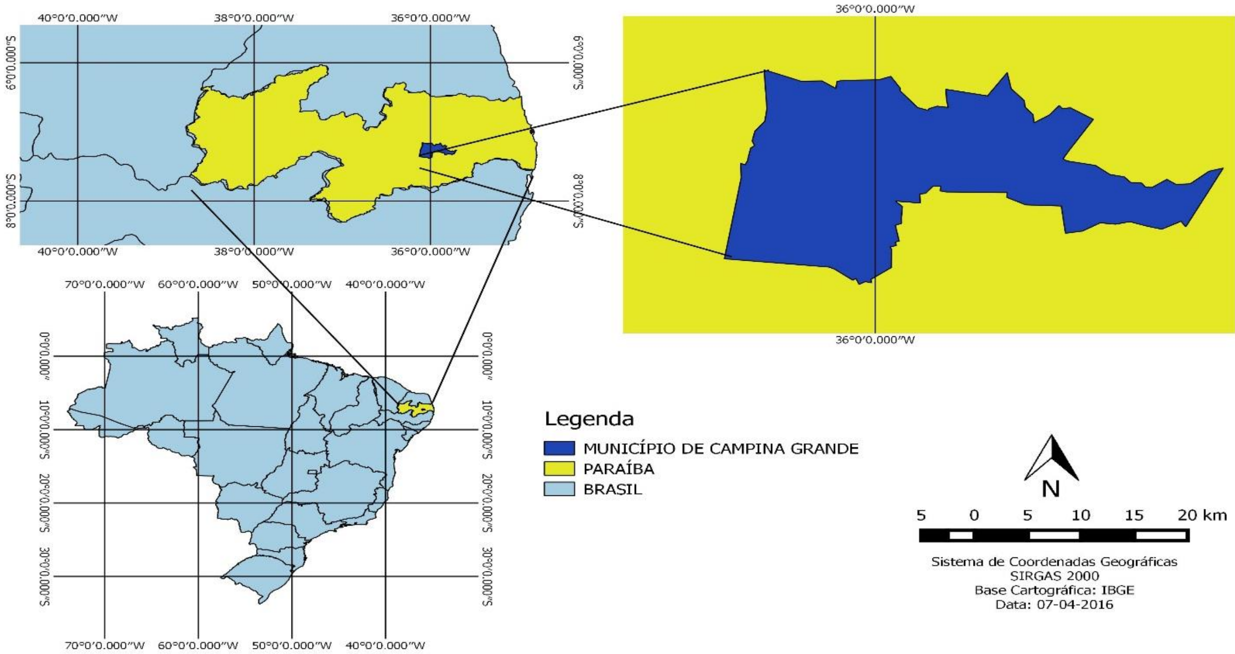

Figure1- Location map of the study area city Campina Grande-PB.

2.2 Rainfall data

For this study we used daily series of pluvial precipitation for a rainfall station in the city of Campina Grande - Paraíba, corresponding to the period 1/1/1962 to 12/31/2014. Rainfall data were transferred by the Executive Agency for the Management of Waters of the State of Paraíba (AESA).

The statistical analysis and the preparation of the graphics were made with the ClimAp Software. The ClimAp is a GUI application for the analysis of series of weather data and air temperature, having been developed in graduate studies in Meteorology at the Universidade Federal de Campina Grande (UFCG) (2014).

The charts presented in this work are related to: extreme precipitation (days with rainfall ≥ 1 mm; days with rainfall ≥ 10 mm; days with rainfall ≥ 20 mm); Per95p and Pr99p (number of days with precipitation ≥ 95% percentile and the 99%) of significant rainfall; greater rainfall in 1 day rain; annual and total your standardized deviation; monthly and quarterly averages of annual total precipitation; and linear regression test sequential Mann-Kendall.

3. Results and discussion

According to figure 2, the highest monthly average precipitation occurring between the months of March to July (≥ 100 mm), with the highest average occurring in the month of June. The quarterly maximum is observed in the months of May, June and July. After this period, there is a considerable decrease of rainfall, reaching minimum values in the last three months of the year.

These results are consistent with studies that indicate that the period of most abundant rains in the East of Northeast of Brazil covers the months from April to July (Nobre and Molion, 1988). During this period two weather systems produce precipitation: the Intertropical Convergence Zone (ITCZ) and the Waves or Eastern Systems, being the last of the major contribution to the rains that fall during the year in the Northeast region of (Limeira, 2008).

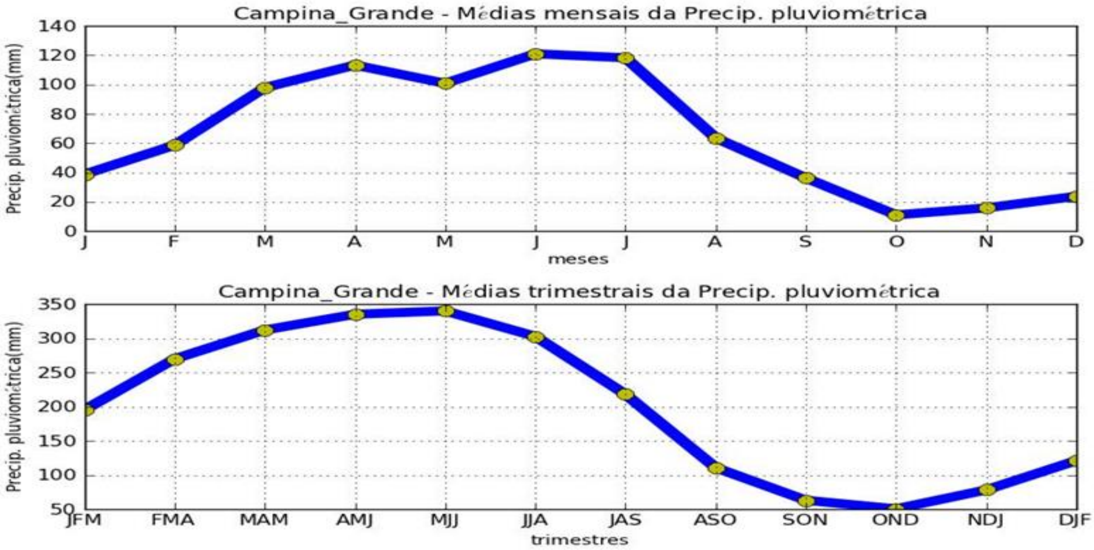

Figure 2- Historical monthly and quarterly averages of precipitation in the city of Campina Grande-PB.

The average rainfall in Campina Grande in the analyzed period was 799.3 mm per year. According to Sousa, Morais and Silva (2011), the climate of Northeast of Brazil in the State of Paraíba, region that is part of Campina Grande, is tropical semi humid with rainfall between 800 and 1000 mm/year.

You can see in Figure 3 that the highest values of rainfall, above 1000 mm/year, took place in the years 1985, 1986, 1994, 2000, 2004, 2009 and 2011. This information corroborates with the study of Macedo, Guedes and Sousa (2011), with the exception of the year 2011 (year not contemplated by the series analyzed by cited authors) as years with high precipitation. According to these authors, in these years, except for the years 2000 and 2009, there was the La Niña phenomenon. On the other hand, the DPP chart, Figure 3 (b), that from 1975 to 2000 was a period in which there was predominance of years with below-average rainfall. The figure 3 (a) complements this information by presenting the years 1976, 1993, 1994 and 1998 as lower rainfall, recording values below 500 mm/year. The phenomenon acting in those years was the El Niño (Macedo, Guedes and Sousa 2011). According to Philander (1990) El Niño years are unfavorable to the rains in the Northeast.

Annual variations occurred in the total volume of precipitation during the rainy season, which lasts from May to July. Total precipitation series of the quarter May-June-July (MJJ) showed that there were no trend or were not statistically significant at the 5% level (p-value > 0.05) (Figure 4) (a) (b).

Also, it was found in the DPP chart (Figure 4), the quarter MJJ, period of higher occurrence of rains, performed below average rainfall between 1979 and 1999. These data corroborate with the study done by Almeida and Cabral Junior (2014) when show that in the decades of 80 and 90 there was a downward trend of average rain precipitation in the rainy season (autumn and winter). Also, it was between the years of 1979 to 1983 and 1998 and 1999 that the water supply system of the city of Campina Grande almost collapsed due to drought events in the region (Macedo, Guedes and Sousa 2011).

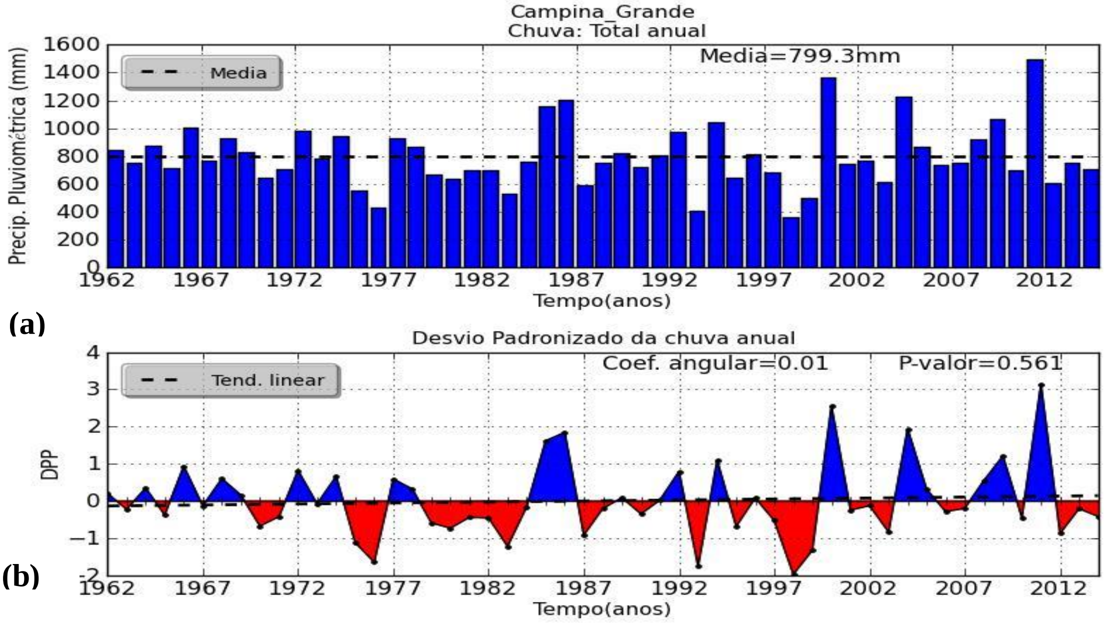

Figure 3- Total rainfall precipitation (a) and DPP (b) annual from Campina Grande-PB.

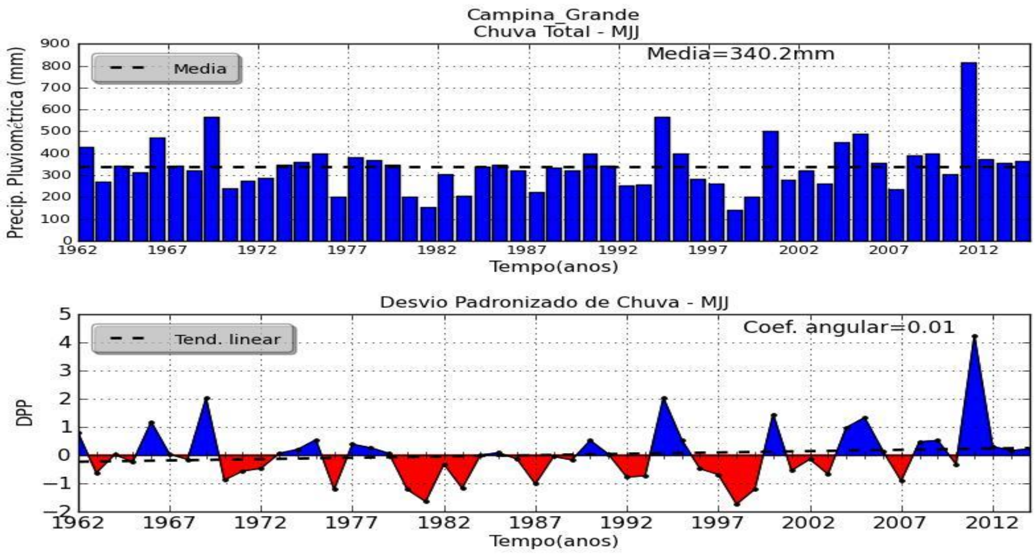

Figure 4- Annual precipitation totals and DPP of May, June and July in Campina Grande-PB.

You can see in Figure 5 below there was a slight increase in year-to-year variability with the angular coefficient indicating a rate of increase of 1.18 mm per year. Despite this, the linear regression coefficient showed no statistical significance, as well as the sequential test of Mann-Kendall, both featuring p-value > 0.5. Thus, according to linear regression, it can't be said expressly that the annual total precipitation in Campina Grande has increased over the analysis period. From Mann-Kendall's test cannot be detected climate change too. As Goossens and Berger (1986) the application of Mann-Kendall's test is intended to detect changes climatical order in meteorological series, as well as to locate the starting point of this amendment.

Similar results were found by Santos and Brito (2006) with regard to the increasing trend of annual total precipitation in the States of Paraíba and Rio Grande do Norte. Sousa, Morais and Silva (2011) found growing trends of rain in counties in the State of Paraíba, with the exception of the Northeast region of rural area, where there were a greater number of towns with decreasing tendency of precipitation.

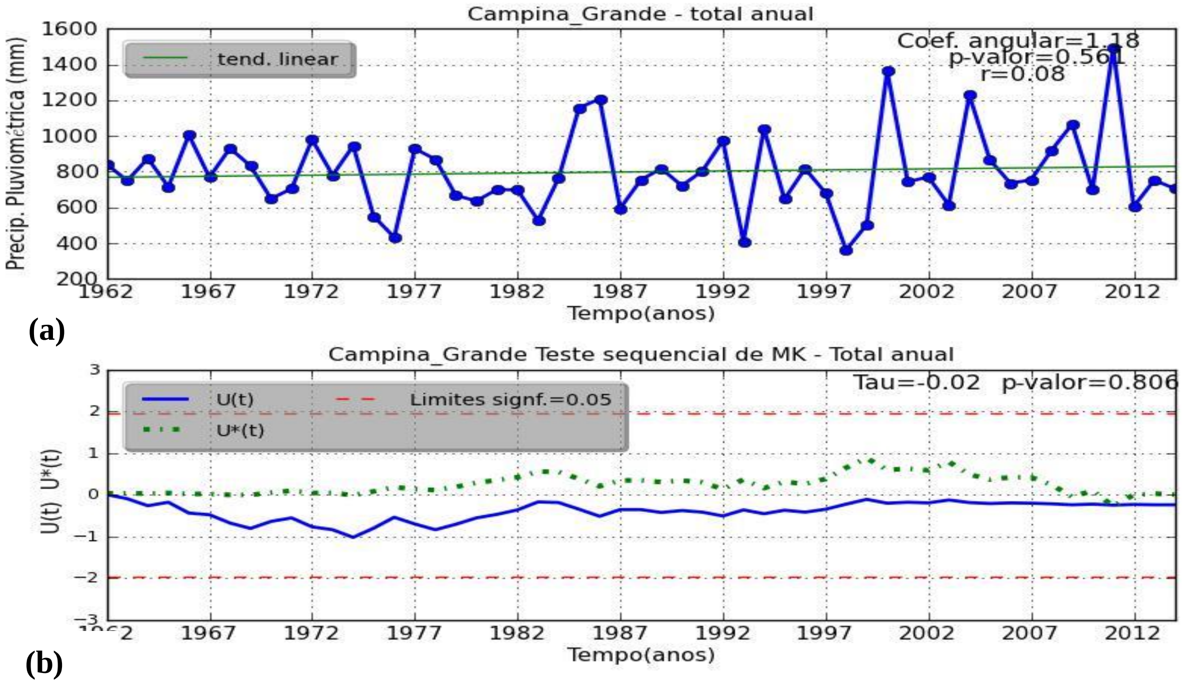

Figure 5- RL chart (a) and sequential test of MK (b) for annual rainfall of Campina Grande-PB.

The figures below show the extremes of deficit or excess rainfall, where are represented the spatial distributions of precipitation indices Pr1, Pr10, Pr20, Pr95p, Pr99p and Prnax1d.

On the analysis of Figure 6, it is observed that the number of days with rainfall extremes – that is, equal to or greater than 95% (29.0 mm) and 99% (52.0 mm) that was positive with rate of 0.03 and 0.02 cases per year, in Pr95p and Pr99p, respectively.

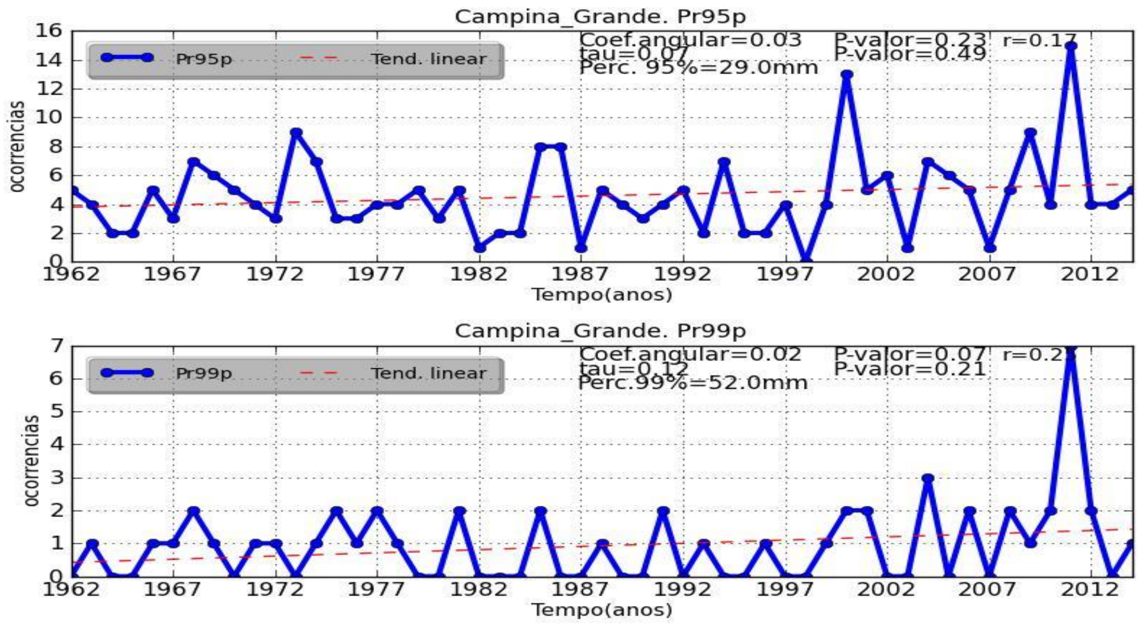

Figure 6- Trend chart on Pr95p indices and Pr99p of the county of Campina Grande-PB.

On the other hand, the data of the series showed significant positive trend in the number of days with rainfall ≥ 1 mm/day (Pr1) and ≥ 20 mm/day (Pr20), with angular coefficient indicating a rate of increase of 0.26 0.03 occurrence/year, respectively (Figure 7).

It is checked on the same Figure 7 that the number of days with rainfall ≥ 10 mm/day (Pr10), there was no statistically significant downward trend, with angular coefficient − 0.07 occurrences per year.

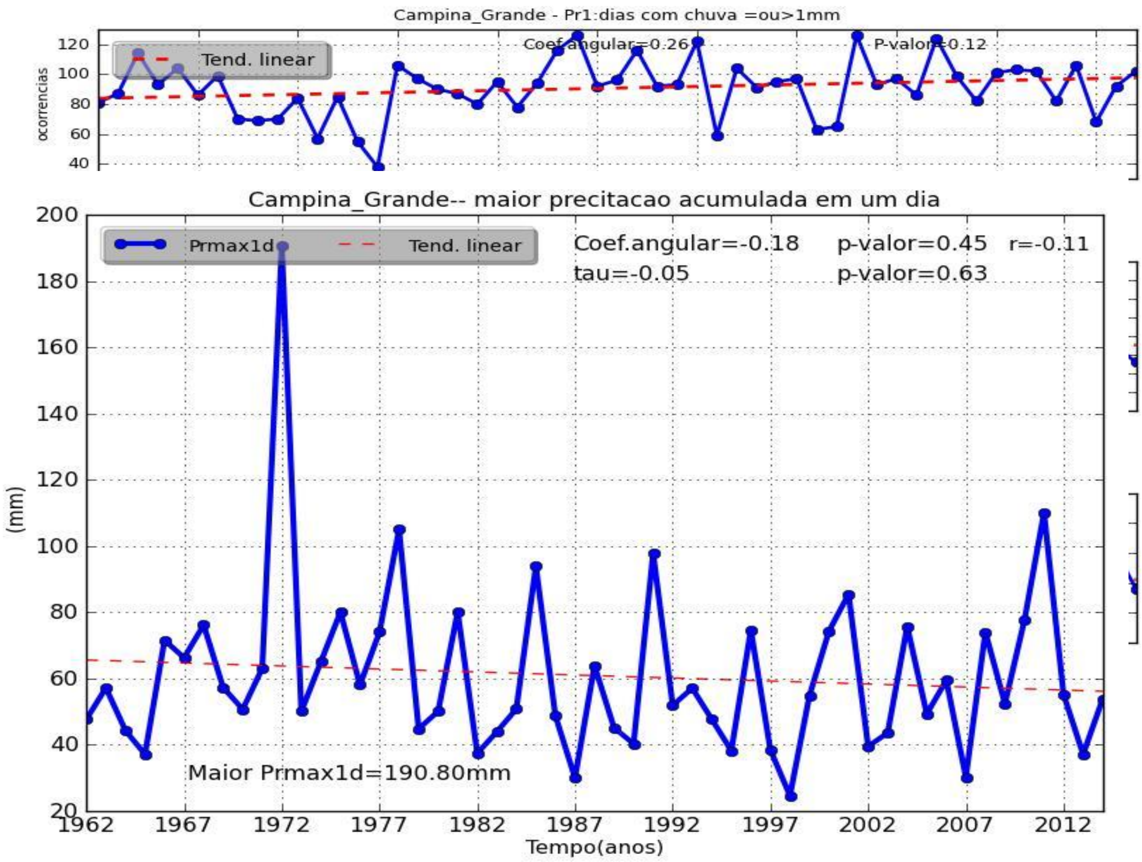

Figure 7- Trend charts in the index series Pr1 and Pr10 Pr20, in the city of Campina Grande-PB.

As for the annual records of precipitation is possible to identify the biggest record in the analysis period to 190.80 mm in the year 1972. This series shows a slight decline, with a rate of -0.18 mm/year (Figure 8).

The authors Medeiros, Sousa and Gomes Filho (2014) performed analyses of extreme precipitation events in the period from 1970 to 2010 and found results that show that in the 70's occurred a greater variability of precipitation with indexes varying between 50 and 190 mm. The extreme event of 1972, featured here, occurred in the month of March, collaborating with the work of Medeiros, Sousa and Gomes Filho (2014) in which the extreme precipitation events were most evident among the months of the rainy season, which runs from March to July.

4. Final considerations

The ClimAp application, which has been used in this article, showed up with an interface simple to use and efficient, enabling a comprehensive analysis on the climatic behavior of precipitation and providing subsidies for more decisive conclusions about changes in the climate series. On the results, it is considered that for the city of Campina Grande that the annual precipitation distributions are irregular. Within 50 years there was only one record of annual rainfall below 400 mm. Annual variations also occurred in the rainy season, from May to July, with rainfall below average in that quarter in the decades of 1980 and 1990.

1970's was the one that presented a greater variability of precipitation. The series, as a whole, showed a slight increase in year-to-year variability. However, we could not say specifically that the annual total precipitation in Campina Grande has increased over the analysis period. Nor, it was possible to highlight signs of decrease of rainfall in recent years. From the analysis of graphs, we can't assert that variations presented in sets of rainfall, are from climate change. Therefore, more studies will be necessary in order to identify better the impacts of climate change.

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