Statistical analysis of the precipitation trends in Rio Largo, Alagoas, Brazil

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Summary

Global climatic changes caused by the increase of the atmospheric greenhouse gases concentration had become more evident in the last few decades (Marengo, 2010). The accumulation of greenhouse gases tends to modify the atmospheric radiation balance, causing temperature increase, changes in precipitation distribution standards and others climatic elements. One of the main consequences of climate changes could be related to changes in hydrological cycle (Santos et al., 2009). Global climatic variations have been investigated in some studies that search to understand as temperature increase is contributing for the changes observed in climate and precipitation variability. So, the objective of this study is to identify possible trends in distribution of the precipitation for the city of Rio Largo, Alagoas, which is situated in eastside of Brazil´s northeast region. In this study was used average monthly precipitation data ranging between 1973 and 2008. For the data, analysis of regression, Student´s t-test and the non-parametric statistical test of Mann-Kendell had been carried through. The results showed agreement in the indication of the trends obtained with the statistical tests used. The trend obtained showed a decrease in precipitation for almost all months of the year, with exceptions in January, June and August showed that increased precipitation. Although the results indicate a reduction for the precipitation, there was no statistically significant trend for the tests.

Keywords: climate changes; precipitation variability; statistical tests

Resumen

Los cambios climáticos globales causados por el aumento de la concentración de gases de efecto invernadero en la atmósfera se han vuelto más evidente en las últimas décadas (Marengo, 2010). La acumulación de gases de efecto invernadero tiende a modificar el equilibrio de la radiación atmosférica, causando aumento de la temperatura, los cambios en las normas de distribución de las precipitaciones y otros elementos climáticos. Una de las principales consecuencias de los cambios climáticos podrían estar relacionados con cambios en el ciclo hidrológico (Santos et al., 2009). Las variaciones climáticas en el mondo han sido investigados en algunos estudios que buscan entender como aumento de la temperatura está contribuyendo para que los cambios observados en el clima y la variabilidad de las precipitaciones. Por lo tanto, el objetivo de este estudio es identificar las posibles tendencias en la distribución de las precipitaciones en la ciudad de Río Largo, Alagoas, que se encuentra en lado este de la región nordeste de Brasil. En este estudio se utilizó los datos de precipitación media mensual que oscila entre 1973 y 2008. Para los datos, el análisis de regresión, prueba t de Student y la prueba estadística no paramétrica de Mann-Kendell se había llevado a través. Los resultados mostraron acuerdo en la indicación de las tendencias obtenidas con las pruebas estadísticas utilizadas. Las tendencias obtenidas mostraron una disminución en las precipitaciones para casi todos los meses del año, con algunas excepciones, en enero, junio y agosto que mostraron aumento de las precipitaciones. Aunque los resultados indican una reducción de la precipitación, no había una tendencia estadísticamente significativa para las pruebas.

Palabras clave: cambios climáticos; variabilidad de precipitación; pruebas estadísticas

1. Introduction

The global climatic changes, caused by the increase of the concentration of the gases of the effect greenhouse in the atmospheric due to human activity, had become more evident in the last few decades (Marengo, 2010). The accumulation of the concentration of these gases tends to modify the atmosphere radiation balance, causing temperature increase, changes in precipitation distribution standards and others climatic elements.

To understand how global changes may affect the precipitation distribution and water systems would be essential especially for regions with high agricultural potential. Precipitation distribution forecasts, although there is great uncertainty with respect to predictions about spatial and temporal variability, are not encouraging (IPCC, 2007). Changchun et al. (2006) found that both hydrological cycle and precipitation distribution regimes have suffered significant changes.

Global climate changes affect, directly or indirectly, the society. The consequences of these climatic changes is causing increase in frequency of occurrence of many extreme climatic events, such as floods and droughts, which are more harmful to society, both economically and productively.

Different climate scenarios and gases emission rates projections by human activities, causing greenhouse effect, show a warming trend in earth´s surface (Cueto et al., 2009), as well as, variations in precipitation and temperature trends (positive and negative).

This study aimed to identify possible trends in precipitation distribution in Rio Largo, Alagoas, Brazil.

2. Methods

In this study was used average monthly precipitation data ranging between 1973 and 2008. For the data, analysis of regression, Student´s t-test and the non-parametric statistical test of Mann-Kendell had been carried through. The analysis of regression was used to indicate possible climatic alterations by means of the test of significance of the slope (Equation 1).

$$Y = \alpha + \beta x \quad (1)$$

Considering a linear regression of "Y" with random variable in time "X", the null hypothesis "Ho" which trend does not exist is tested by Student´s t-test with (n-2) degrees of freedom (Equation 2). The Student´s t-test consists of using the data of the sample to calculate statistics t and later compare it with distribution t to identify the probability of obtaining the observed result, if the null hypothesis is true. This hypothesis is rejected when "t" value calculated by equation-2 is bigger in a absolute value than a critical value $t_{(\alpha,\ n-2)}$, related, to a level of significance α_o.

$$t = \frac{r\sqrt{n-2}}{1-r^2} = \frac{b}{s/\sqrt{ss}} \quad (2)$$

Where n is the sample size, r is Pearson's correlation coefficient, s is the standard deviation, b is the slope and ss is the sum of the squares.

The test of Mann-Kendall considers that, in the hypothesis of stability of a time series, the succession of values occurs of independent form, and the probability distribution must always remain the same (simple random series), assuming the null hypothesis "Ho", no trend (Back, 2001). The null hypothesis is rejected when the calculated value for “Z” exceeds a critical value related to a confidence interval α_o of significance. In this study, a significance α_o = 5% was adopted for all tests realized. The statistic sign “Z” indicates if the trend is increasing (Z > 0) ou decreasing (Z < 0) (Equation 3).

$$Z = \begin{cases} \frac{(S-1)}{\sqrt{Var\ (s)}} & se\ S > 0 \\ 0 & se\ S = 0 \\ \frac{(S+1)}{\sqrt{Var\ (s)}} & se\ S < 0 \end{cases} \quad (3)$$

Goossens and Berger (1986) affirms that the test of Mann-Kendall is the method most appropriate to analyze climatic changes in climatology series and also allows to the detention and approximate location of the starting point of a certain trend.

3. Results and discussion

The statistical tests used showed agreement for the trends obtained in this study. There was a precipitation decrease in almost all months, except January, June and August. However there was no statistically significant trend with the tests used (Table 1).

Table1. Statistical data of precipitation (1973-2008).

Months	Mean	S.D	**Z**	β_1	t
January	65,18	53,80	-0,96	0,2778	0,31
February	83,65	78,47	-0,17	-0,5147	0,39
March	140,49	85,46	-1,23	-1,8977	1,38
April	211,60	99,55	-1,56	-2,8101	1,78
May	258,89	147,38	-0,09	-1,5617	0,64
June	279,88	110,40	0,12	0,0455	0,02
July	274,58	114,88	-0,58	-1,2152	0,64
August	167,40	76,83	1,43	1,7047	1,38
Setember	108,32	79,90	-0,77	-0,9636	0,73
October	63,47	64,16	-0,39	-1,6179	1,58
November	45,02	51,06	-0,85	-0,8085	0,97
December	39,09	39,33	-1,15	-0,7434	1,16
Annual	286,77	32,13	-1,26	-0,7003	1,35

Analyzing the precipitation variation is possible to notice a reduction of 6 mm per decade, with 5% significance (Figure 1). Throughout the period there was a reduction of 25 mm in precipitation.

Carvalho et al., (2010), using precipitation data, found that Rio largo has shown a reduction in total precipitation in the last few decades and increased extreme events occurrence more intense.

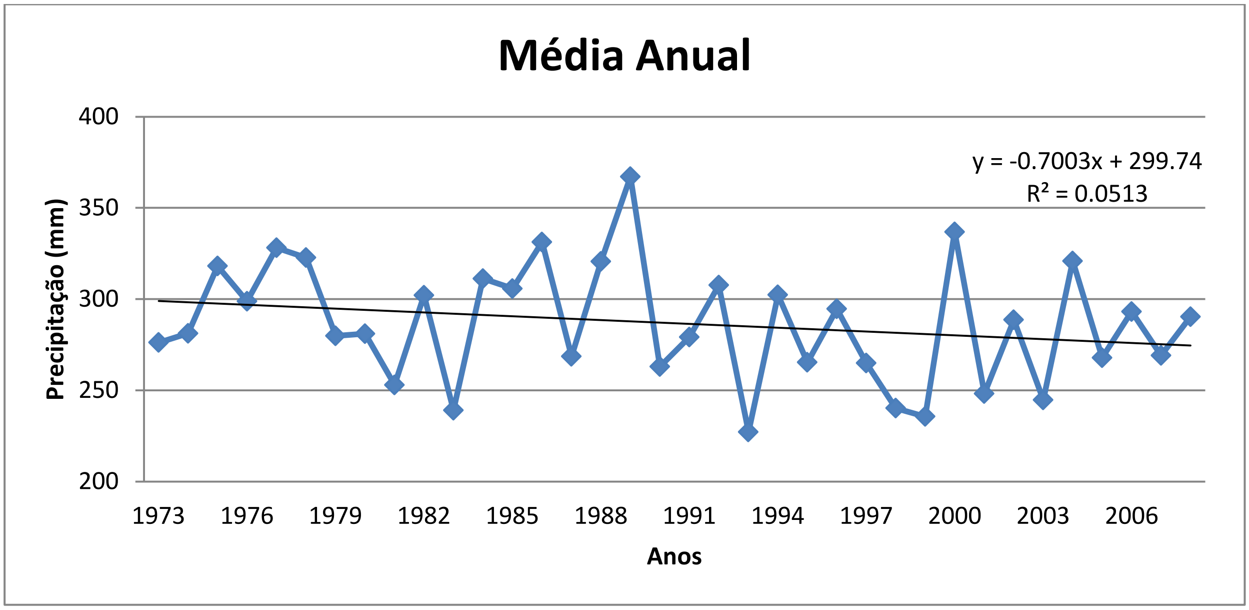

Figure1. Precipitation trend in Rio largo between 1973 and 2008.

4. Conclusion

The results showed agreement in the indication of the trends obtained with the statistical tests used. The trend showed a decrease in precipitation for almost months of the year, with exceptions in January, June and August which showed an increase in precipitation. Although the results indicate a decrease in the precipitation, there was no statistically significant trend for the tests.

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