Monthly precipitation in southeast Brazil - for analysis of random and trend changes

Precipitação mensal no sudeste do Brasil - para análise de mudanças aleatórias e de tendência

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ABSTRACT
In this work, statistical analysis tools of the computational program were used: the computational statistical package R. Data from the monthly precipitation series were analyzed in five airports. It was shown that monthly rainfall showed variability associated with three distinct subgroups, with different intensities of precipitation and represent an overlap in cascades of different spatial and temporal scales, acting on the pattern of precipitation behavior. The use of the chi-square test using as reference the main maximal centroids, obtained by the group analysis technique, allows characterizing the variability of the maximal and possible analysis of the frequency change in the behavior of the time series. In the Spearman Coefficient test, he presented two locations with a trend, Guarulhos and Santa Cruz. However, considering the results and analyzing the metadata information from the observation stations
on the surface, we can consider that there is evidence that the variability is within randomness and without showing changes in trends.

**Keywords:** monthly rainfall, multivariate analysis, hierarchical clusters analysis.

**RESUMO**

Neste trabalho utilizou-se de ferramentas de análise estatística do programa computacional: o pacote estatístico computacional R. Foram analisados os dados da série de precipitação mensal em cinco aeroportos. Mostrou-se que as chuvas mensais apresentaram uma variabilidade associada a três subgrupos distintos, com diferentes intensidades de precipitação e representam uma sobreposição em cascatas de diferentes escalas espaciais e temporais, atuantes no padrão do comportamento da precipitação. O uso do teste qui-quadrado usando como referencia os centroides principais maximos, obtidos pela tecnica de analise de grupos, permitem caracterizar a variabilidade dos maximos e possível analise da alteração da frequencia no comportamento das series temporais. No teste do Coeficiente de Spearman apresentou em duas localidades a existencia de tendencia, Guarulhos e Santa Cruz. Porem considerando os resultados e analisando as informacoes dos metadados das estações de observação na superficie, podemos considerar que existe evidencias de que a variabilidade esta dentro da aleatoriedade e sem apresentar alterações de tendencias.

**Palavras-chave:** precipitação mensal, análise multivariada, análise hierárquica de grupos.

**1 INTRODUCTION**

The analysis of the behavior of the time series allows us to observe and obtain much information about the physics of the natural dynamical systems, their frequency, and spatial variability. An environmental variable such as rainfall has behavior that can be dismembered at different spatial scales such as mesoscale or macroscale, as well as at a regional synoptic level. In addition, the statistical properties of the temporal variability of precipitation behave with stochastic pattern, and are spatially organizes itself at the mesoscale level in clusters or random or fractal behavior. Kim, *et al.* (2013) shows that the stochastic rainfall generators are classified into the three following categories: (1) the multi-scaling models, which are based on the observation that rainfall patterns have “self-similarity” at a given range of timescales, (2) the nonparametric resampling models, which forms the new rainfall time series by borrowing the fragments from the instrumental data with similar statistical properties, and (3) the Poisson cluster rainfall models, which is being considered in this study. The Poisson cluster rainfall models (Rodriguez-Iturbe *et al.* 1987, 1988), are characterized by presenting a stochastic pattern and represent rainfall as a sequence of storms composed of rain cell clusters, Kavvas & Delleur (1975). Brunsell (2010) shows that the physical processes encompassing rainfall range from microscales (e.g. turbulence, cloud formation processes) to interannual climatic variability (e.g. Pacific Decadal Oscillation, El Niño Southern Oscillation, the Atlantic Ocean multidecadal and interdecadal processes), which is essential for understanding precipitation. This has led researchers to adopt many
of the techniques used in chaos theory and non-linear dynamics, Sivakumar (2001), Dhanya & Nagesh Kumar (2010), Jothiprakash & Fathima (2013), Yildirim & Altinsoy (2017) and multifractals as the work of Breslin & Belward (1999), Veneziano et al., (2006) and Maskey, et al. (2019). The low-frequency variabilities with decadal or multimillennial periodicity, geophysical and astronomical aspects showed that the duration of the solar cycle in the last five centuries was associated with the Earth's Climate according to the work of Lassen & Friis-Christensen (1995). There was a well-defined activity with an approximate cycle of eleven years in the number of sunspots. This cycle solar activity in approximately 11 years ranged from 8 to 17 years within a period of 80-90 years. In Yamakawa et al. (2016) concluded in their study that relationships were observed between the time of maximum solar activity and variations in sea surface temperature (SST) and atmospheric circulation. The global distribution of correlation coefficients between annual relative numbers of sunspots (SSNs) and SSTs from July to December was examined over a 111-year period from 1901 to 2011. Areas with a significant positive correlation were observed to represent 11.7% of the sea surface in December, mainly in three regions of the Pacific. The influence of solar activity on changes in global atmospheric pressure and circulation in peak years was also analyzed from 1979 to 2011. The results indicated that the SST distribution in the Pacific produced a pattern that resembled teleconnection patterns such as the Decadal Oscillation Pacific (ODP) and El Niño Modoki (ENM). They suggested that solar activity influences the troposphere, not only by the stratosphere but also by the surface of the sea. Similarly, Corrêa et al. (2019), using wavelet and cross-wavelet analysis, multimillennial cycles were observed between the monthly number of spots and the South Oscillation (IOS) and Pacific Decadal Oscillation (DOP) indexes. Showing cycles of 2.66, 5.33, 10.66 and 21.33 years. It was also compared to the average monthly rainfall in the meteorological stations of the airports of Belém, Fortaleza, São Luiz, and Natal, showing that in the north/northeast of Brazil the multimillennial cycles of precipitation accompanied the variability of the sunspots. Corrêa, et al. (2020) used the Atlantic Meridional Mode (AMM) Index consists of two parts, one associated with the SST and the other to the wind field over the tropical Atlantic region. In this aspect, the results of this work show an association between the series of the AMM Index and the sunspot time series, through the analysis of cross-wavelet, presented the existence of multimillennial cycles. In the SST Index series, it showed a well-defined 5.33, 11 and 21.33 years signal. The rainfall data of long time series can show signs of multimillennial cycles, due to the great physical complexity involved and overlapping of physical and temporal scales, with the influence of solar activity and its cycles inducing low frequencies in the series of precipitation. However, rainfall process can be understood as a set of different overlapping scales from micro to macro scales, in this work the aim is to analyze in the southeast of Brazil the existence of low frequencies and multimillennial oscillations using hierarchical multivariate cluster analysis techniques
using dendrograms. Like other semi-stationary systems, such as the high-pressure stationary system of the Atlantic Ocean, as well as under the influence of transient meteorological systems of high latitudes, short waves and meteorological systems associated to jet stream at the altitude that affect seasonally throughout the year. As well as convective systems in the summer season in the southern hemisphere as circulation of the Bolivian High and can characterize semi-stationary circulations as the Zone Convergence of the South Atlantic (ZCSA), modulating the convection on the South American continent. The complexity of the interaction of these synoptic systems is very large and the resultant precipitation observed indicates the presence and influence of many overlapping systems, some overweight or have a certain degree of association. It presented a significant signal in 128 months (including the 11-year cycle (Schwabe, 1844; Wilson, 1998)), which may characterize an association and modulation by solar activity in multidecadal cycles in the rainfall and signal interval with longer periods of 11 years up to 256 months (22 years, Hale & Nicholson, 1938), which could characterize modulations induced by solar activity and also characterize multidecadal cycles in precipitation, Courtillot, et al. 1982; Zanchetti, et al. 2008; Shepherd, 2008; Corrêa, et al. 2019 and Wallace, 2019. There are scientific studies the Ozone in the stratosphere with the Brewer-Dobson circulation, transports water vapor and ozone, with implications for radiative forcing and climate, Roscoe, 2006; Abalos, et al. 2014 and Liz, et al. 2019. As also that relates the variability of the angular speed of rotation of the earth and the length of the day variability with solar activity influence of the magnetosphere that would cause long-term changes of the order of decadal until 150 years or more, Kramarova & Kuznetsov, 2009; Efstathiou, et al., 2009; Bozhkova, et al. 2019 and He, et al. 2020. In the work of Lambert, et al. 2017, which exemplifies what would affect El Niño – Southern Oscillation (ENSO) events are classically associated with a significant increase in the length of the day, with positive mountain torques arising from an east–west pressure dipole in the Pacific driving rise of atmospheric angular momentum and consequent slowing of the Earth's rotation. Therefore, the complexity is very great because the rainfall variability, long time series has a set of different time scales, which can contribute to different return times, working constructively or not. However, the present study seeks to use cluster techniques to obtain the relationship in which there is a frequency associated with a dominant cluster that serves as a relative reference for the chi-squared statistical test and the Spearman Coefficient test. With these tests, we seek to obtain a result that allows us to answer whether in the last 70 years in southeastern Brazil there have been changes in rainfall maximum and if there were trends.
2 MATERIAL AND METHODS

2.1 MONTHLY RAINFALL DATA

Monthly rainfall data from airports in the Brazilian southeast region were used for cluster analysis. It seeks to use monthly information from five airports in southeastern Brazil with complete time series, from January 1951 until June 2018, total of 810 months. This information was obtained from the site http://clima.icea.gov.br/clima/. The airports used were Guarulhos, Congonhas and Campinas airports in the São Paulo state and in the Rio de Janeiro state with Santa Cruz airbase and Santos Dumont airport. To perform the analysis a text file saved in CSV format was mounted, mounting an array of 5 columns x 810 rows. Figure 1 shows the geographic positions of the airports in the São Paulo state with the Campinas airport in the most continental position and the Congonhas and Guarulhos airports closer to the coast. In the state of Rio de Janeiro the positions of the Santa Cruz airbase next to the Airport of Santos Dumont in the city of Rio de Janeiro.

Figure 1 - The map of southeastern Brazil with the geographic locations of the Congonhas (SP), Guarulhos (GR) and Campinas airports (KP) in São Paulo state and Santa Cruz Airbase (SC) and Santos Dumont Airport (RJ) in Rio de Janeiro state, location with small blue triangles.

2.2 CLUSTER DENDROGRAM IN R PACKAGE

Statistical Computing (R) software was used to perform a deeper analysis of the clusters. A set of packages was used to analyze the series of precipitation in the Brazilian southeast. It tried to analyze the metric of the clusters with the Euclidean distance and the method was the complete link. The packages used were the Gaussian Mixture Modeling for Model-Based Clustering, Classification, and Density Estimation (Mclust package version 5.4.4), Extract and Visualize the Results of Multivariate Data Analyses (Factoextra package version 1.0.5), this package provides ggplot2-based elegant
visualization of partitioning methods including Mclust (mclust package), Extending 'dendrogram' Functionality in R (Dendextend Package version 1.12.0), which offers a set of functions for extending 'dendrogram' objects in R, letting you visualize and compare trees of 'hierarchical clusterings' and Methods for Cluster analysis (Cluster package version 2.1.0), what is the much extended the original from Struyf, et al. (1996), based on Kaufman and Rousseeuw (1990) "Finding Groups in Data".

2.3 NON-PARAMETRIC CHI-SQUARED TEST

It can be used to compute the Chi-square test involving only the observed frequency, Spiegel and Stephens (2008) and Thompson (1988). To carry out this frequency estimate, the maximum values obtained by the cluster analysis technique of the monthly precipitation time series are used; whose maximum value were uses as reference the most frequent value in the series 180 mm. What will be calculated the rainfall occurrence of the frequency values equal and greater than 180 and greater than 300 mm, exclusionary and independent frequencies. Contingency tables of 2 x 2 will be used (Table 1), the series will be divided in two a period of 1951-1985 and the second period of 1986-2018.

<table>
<thead>
<tr>
<th></th>
<th>≥180 mm</th>
<th>≥300mm</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1951-1985</td>
<td>a₁</td>
<td>a₂</td>
<td>Nₐ</td>
</tr>
<tr>
<td>1986-2018</td>
<td>b₁</td>
<td>b₂</td>
<td>Nₐ</td>
</tr>
<tr>
<td>TOTAL</td>
<td>N₁</td>
<td>N₂</td>
<td>N</td>
</tr>
</tbody>
</table>

Where \( \Delta = a₁b₂ - a₂b₁ \), \( N = a₁ + a₂ + b₁ + b₂ \), \( N₁ = a₁ + b₁ \), \( N₂ = a₂ + b₂ \), \( Nₐ = a₁ + a₂ \), and \( Nₐ = b₁ + b₂ \), this becomes:

\[
\chi^2 = \frac{N(a₁b₂ - a₂b₁)^2}{N₁N₂NₐNₐ}
\]  

The values obtained will be tested at 1 degree of freedom at a 5% level and 1% level of significance with the following hypotheses, critical values for the test for a degree of freedom, correspond to 6.63 (1%) and 3.84 (5%), Sheskin (2004):

\( H₀ \) = it is true if the random variables are independent, the monthly maximum values of precipitation are independent.

\( H₁ \) = it is true if the random variables are not independent, the monthly maximum values of precipitation are related, will be to have trends.
2.4 SPEARMAN'S COEFFICIENT TEST

The Spearman coefficient test or the Spearman ordered correlation test is a test of independence between two paired series (an x value of one series corresponds to a y value of the other series). Considering a hypothesis of normality and serial autocorrelation and, as well as, a certain degree of stationarity in the analyzed series, Gauthier (2001).

Based on the calculation of the correlation coefficient of the respective ranks of x and y in the set of all pairs of values, a measure of their association. In the case of time series, it serves to detect any trend, increasing or decreasing, of their values over time. It was applied by fixing the orders of x in the natural form (1, 2, 3, ... n) and exchanging only the order of y (ascending order). The $r_s$ coefficient is calculated using equation 2.

$$r_s = \frac{1 - 6 \sum_{i=1}^{n} d_i^2}{n^3 - n}$$  \hspace{1cm} (2)

Where $r_s$ is the Spearman coefficient, $d_i$ is the difference between the ranks for each $x_i$ and $y_i$ of the data pair and $n$ is the number of the data pair. In which, $r_s$ is a random variable with symmetric distribution, with mean and variance given by equations 3 and 4, according to Silveira (2000).

$$E(r_s) = 0 \quad \text{(III)} \quad \text{and} \quad \text{var}(r_s) = \frac{1}{n - 1}$$  \hspace{1cm} (3)

The distribution of $r_s$ was established by statistical theory, but for practical use, working with its relationship with Student's t-statistic, when the number of elements is greater than 30 elements can be considered a good approximation given by equation 4.

$$t = \frac{r_s \sqrt{n - 2}}{\sqrt{1 - r_s^2}}$$  \hspace{1cm} (4)

Where $t_{n-2}$ is the t statistic with $n$-2 degrees of freedom ($n = 810$ elements). The $t_{n-2}$ statistic calculated is compared with the critical t value (Student table), bilaterally, for a given level of
significance. If the calculated value \( t_{n-2} \) is greater than the table value \( t_{n-2, a} \) the hypothesis of independence of the samples \( x \) and \( y \) (natural order and ascending order) is rejected, calculations were performed in excel spreadsheets, Zwillinger and Kokoska (2000).

3 RESULTS AND DISCUSSIONS

Continuing in cluster analysis it was used the R package to generate greater detail the series of rainfall data, with Euclidean distance metric and complete link method. The cluster package was used with the "Agnes" class objects representing a hierarchical and agglomerative grouping of a dataset. The "Agnes" class has methods for the following generic functions such as cutree \((x, *)\), which can be used to "cut" the dendrogram and produce cluster assignments. Table I shows the result of the cutree function with six subgroups, showing that the first three subgroups represent important parts of the Dendrogram. Such representation resulted in an agglomerative coefficient of 0.9714 estimated among the clusters, an appropriate value.

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centroid</td>
<td>181</td>
<td>54</td>
<td>567</td>
<td>6</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

In the table 2 present the values of subgroups in order to show the three first subgroups have values that can characterize the differences of the physical and dynamic mechanisms and their behavior during the time series of the precipitation in the Southeast Brazil, historical series of approximately 70 years. The subgroup 3 has the highest value, it is conjectured that it is associated to the physical processes causing rainfall with deep convection, and intense precipitation, possibly intense mesoscale systems or other processes of intense vertical convection with great vertical development in the atmosphere.

These differences show that the part of the tree associated to subgroup 1 and 2 are the clusters with differences of similarities between the groups and that possibly the differences in the temporal and frequency scales of rainfall can be associated. In figure 2, it shows that part of the cluster dendrogram (a) the tree is divided into three more significant parts, one larger and two others with smaller branches, this characteristic is associated to table I, with the values of the first three subgroups. In part (b) cluster plot shows the six subgroups spatially, the dispersion of the subgroups is associated with the axes of the main components, the first component has 55.5 percent of the variance and the second component has 18.8 percent, in total the two components have 74.3 percent of the total variance.
In the analysis carried out, it allows significant statistical evidence of the existence of characteristics that show in the time series of the precipitation the existence of a model of variability with different physical and temporal scales. This structure would be divided into three subgroups represented in the tree of figure 5 (a) cluster dendrogram.

![Cluster Dendrogram](image)

**Figure 2** - Shows the Dendrogram with Euclidean metric and with the method used complete link (a) and colored graph with the subgroups reunited to the average centroids related to the first two main components (b).

### 3.1 CHI-SQUARED TEST

The methodology used with the first component has 55.5 percent of the variance with 181 mm total monthly. A criterion was proposed to use the first component as a reference in all analyzed stations. The monthly maximum values were also analyzed and it was observed that the value of 567 mmm is not frequent in all series and used a lower value, being equal to or greater than 300 mm. In this respect, the relative frequencies for each station and period analyzed were estimated. Table 3 shows the observed values of the frequencies that were used to calculate the Chi-squared test.
Table 3 - The monthly rainfall occurrence of the frequency values equal and greater than 180 and 300 mm. The frequency of rainfall between the two periods of 1951-1985 and 1986-2018.

<table>
<thead>
<tr>
<th></th>
<th>Congonhas</th>
<th></th>
<th>Guarulhos</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≥180 mm</td>
<td>≥300mm</td>
<td>total</td>
<td>≥180 mm</td>
<td>≥300mm</td>
</tr>
<tr>
<td>1951-1985</td>
<td>52</td>
<td>12</td>
<td>64</td>
<td>1951-1985</td>
<td>121</td>
</tr>
<tr>
<td>total</td>
<td>115</td>
<td>23</td>
<td>276</td>
<td>total</td>
<td>190</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Campinas</th>
<th></th>
<th>Santos Dumont</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≥180 mm</td>
<td>≥300mm</td>
<td>total</td>
<td>≥180 mm</td>
<td>≥300mm</td>
</tr>
<tr>
<td>1951-1985</td>
<td>49</td>
<td>20</td>
<td>69</td>
<td>1951-1985</td>
<td>50</td>
</tr>
<tr>
<td>total</td>
<td>116</td>
<td>36</td>
<td>304</td>
<td>total</td>
<td>89</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Santa Cruz</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≥180 mm</td>
<td>≥300mm</td>
<td>total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1951-1985</td>
<td>45</td>
<td>22</td>
<td>68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1986-2018</td>
<td>33</td>
<td>9</td>
<td>42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>78</td>
<td>31</td>
<td>219</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4 shows the results obtained from the Chi-square tests, in which the Congonhas, Santos Dumont and Santa Cruz airports equal at the level of 5% and 1% that there is no evidence of trend in the analyzed series. However in Campinas at the level of 5% the calculated value showed that there could be a trend in the time series, however at the level of 1%, it presented in this case the calculated value less than the tabulated value, which makes us accept that there is no trend at the level 1%, in this case being more stringent. In the locality of Guarulhos, there was a tendency in the case of decreasing frequencies in rainfall intensities from 1951 to 1985. But analyzing the metadata information from the Aeronautics climatological database, it is observed that in Guarulhos in 1984 the location was modified from the São Paulo Air Base surface station to the new Guarulhos airport. This situation characterized a geographic alteration of the order of two kilometers of distance. In this case, we cannot consider the result of the test, as it inevitably changed the historical series of data.

Table 4 - Chi-squared test result for a degree of freedom, correspond to 1% and 5%.

<table>
<thead>
<tr>
<th></th>
<th>Tabulated Chi-squared</th>
<th>Calculated value</th>
<th></th>
<th>Tabulated Chi-squared</th>
<th>Calculated value</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>3.84</td>
<td>0.745</td>
<td>5%</td>
<td>3.84</td>
<td>7.912</td>
</tr>
<tr>
<td>1%</td>
<td>6.63</td>
<td>6.63</td>
<td>1%</td>
<td>6.63</td>
<td>6.63</td>
</tr>
<tr>
<td>Campinas</td>
<td>Tabulated Chi-squared</td>
<td>Calculated value</td>
<td>Santos Dumont</td>
<td>Tabulated Chi-squared</td>
<td>Calculated value</td>
</tr>
<tr>
<td>5%</td>
<td>3.84</td>
<td>3.929</td>
<td>5%</td>
<td>3.84</td>
<td>3.182</td>
</tr>
<tr>
<td>1%</td>
<td>6.63</td>
<td>6.63</td>
<td>1%</td>
<td>6.63</td>
<td>6.63</td>
</tr>
<tr>
<td>Santa Cruz</td>
<td>Tabulated Chi-squared</td>
<td>Calculated value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5%</td>
<td>3.84</td>
<td>3.26</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1%</td>
<td>6.63</td>
<td>6.63</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.2 SPEARMAN'S COEFFICIENT TEST

Table 5 showed that the historical series of Guarulhos showed changes in both tests that characterize the existence of a trend in the chi-squared test in frequency and in the Spearman test also showing the existence of a trend. However, this time series presents metadata changes such as a change...
of location from the São Paulo Base to Guarulhos airport, which justifies in the period’s significant changes, the first period with the highest frequency of rainfall and the second period analyzed with a significant reduction. Campinas showed in the chi-squared test a change in frequency at the level of 5 percent but at the significance level of 1 percent without bias, which is confirmed with the spearman test without bias in the time series.

<table>
<thead>
<tr>
<th>Locality</th>
<th>Result</th>
<th>Sample Student T</th>
<th>Tabulated Student T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campinas</td>
<td>There is no trend</td>
<td>0.090 &lt;</td>
<td>2.330</td>
</tr>
<tr>
<td>Congonhas</td>
<td>There is no trend</td>
<td>0.677 &lt;</td>
<td>2.330</td>
</tr>
<tr>
<td>Guarulhos</td>
<td>There is trend</td>
<td>4.079 &gt;</td>
<td>2.330</td>
</tr>
<tr>
<td>Santa Cruz</td>
<td>There is trend</td>
<td>3.264 &gt;</td>
<td>2.330</td>
</tr>
<tr>
<td>Santos Dumont</td>
<td>There is no trend</td>
<td>1.597 &lt;</td>
<td>2.330</td>
</tr>
</tbody>
</table>

4 CONCLUSIONS

This work, using statistical analysis tools, showed that the historical series of monthly rains (approximately seventy years) in Southeast Brazil show results by analysis of dendrograms and cluster analysis, which showed that the monthly precipitation presents a variability associated with three subgroups distinct, with different intensities of precipitation and an overlapping cascade of physical scales of multi-decadal signals, being associated with meteorological systems and planetary dynamics, as possible other large-scale multi-decadal signals. The use of long historical series allowed to show real oscillations that occurred and to observe by the frequency that the tests did not show changes in the maximum frequencies of occurrence of the intensity of the rains, with random variability. Guarulhos and Santa Cruz presented in the second period a decrease in the maximum of rainfall but physical changes occurred in the location of the meteorological stations as well as changes from conventional to automatic meteorological stations, which can cause changes in observations, which may affect the information of the time series, as they presented a degree of decrease in the maximum rainfall, observed in the two Chi-squared and the Spearman's Coefficient tests. As a final analysis, it can be considered that it is within the limits of randomness for at least the last 70 years, without characterizing trends in the analyzed series.

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