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Analyses of Maximum Precipitation in Brazil and the Variability of Diurnal Cycle †

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Abstract: According to recent works, the diurnal cycle is more geographically pronounced in places such as South America; and this analysis aims to observe how climate variability is associated with meteorological phenomena at different scales. For this, a set of hourly data from rain gauges throughout Brazil was collected, and through 411 automatic rain gauges, the data were selected between 1 January 2008 and 31 December 2020. Clustered multivariate statistics were performed for regional characterization of the data, with sets of 4, 5, and 6 groups. The identification of the occurrence of different daily cycles on the sub-daily scale demonstrates intense rainfall associated with different meteorological phenomena and spatial variations.

Keywords: sub-daily; cluster analysis; climate change

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1. Introduction

The diurnal variability is directly related to surface drag such as friction drag, heat flows, mass, and energy [1]; thus, it is the first climatic mode affected by climate change, with possible implications for the occurrence of events in extreme conditions. Studies concerning the diurnal cycle depend on observing data collected in situ, since there are few sets of meteorological data with sub-daily sampling for most continental parts of the globe despite some incipient initiatives (for example, [2]).

Systematic analysis of diurnal cycle can be used for understanding relevant scientific issues in different environmental variables, such as radiation, cloudiness, air and sea surface temperature [3,4], atmospheric activity of rays [5,6], particulate matter, and air pollution in urban areas and forested regions [7,8]. Due to the complexity of the physical processes that modulate the diurnal cycle of precipitation, simulations of this cycle have been used to evaluate the efficiency of climate models [9–11]. In other way, some studies have analyzed the diurnal cycle in a perspective of the difference between present and future climate, identifying changes in the precipitation intensity during 0300 and 1200 UTC worldwide, including South America [12,13].

From January 2008, the National Institute of Meteorology (Instituto Nacional de Meteorologia) (Brasília, Brazil) started to monitor different meteorological variables with one-hour sampling through automatic stations in all continental areas of Brazil. From this perspective, the present research is the broadest analysis of sub-daily precipitation performed with data collected in loco in Brazil. In this sense, the objective is to characterize the space–time aspects of the diurnal cycle of precipitation in Brazil during a continuous period of 13 years. In addition, we demonstrated the regional aspects using multivariate statistical analysis and showing the seasonal variability of the diurnal cycle.

2. Materials and Methods

2.1. Database

The Brazilian territory is the fifth largest country in the world with 8,547,403 km^2 of territorial extension, of which 50% are constituted by the Amazon region. The database used was obtained from the project "Meteorological Data Set for Teaching and Research" of INMET (www.inmet.gov.br, accessed on 30 September 2020) and consists of rainfall collected by 411 automatic weather stations (Figure 1) with 1-hour sampling during the period from 1 January 2008 to 31 December 2020.

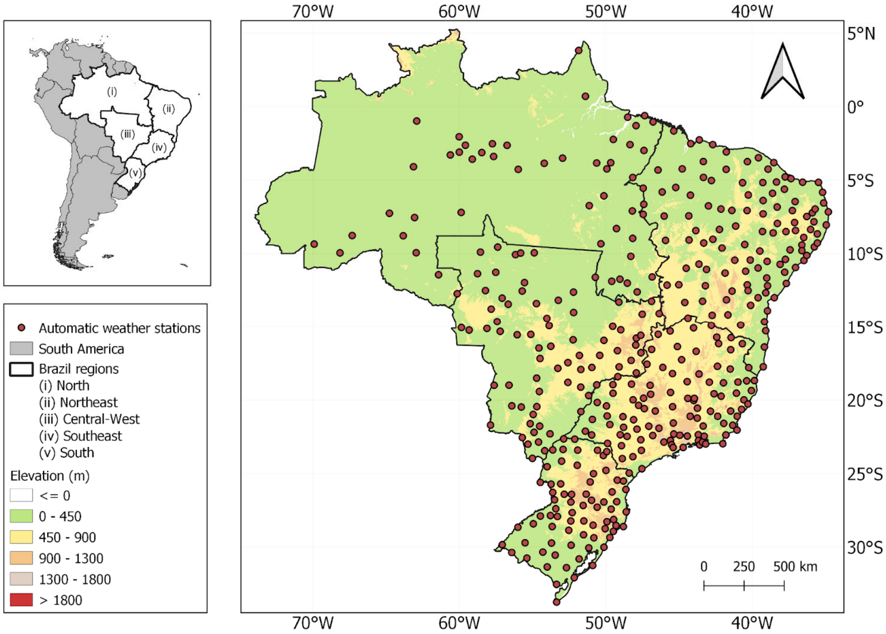

Figure 1. Geographic location of Brazil with spatial distribution of automatic stations used in this study.

2.2. Clustering Method

The diurnal precipitation cycle was analyzed from a perspective of homogeneous regions. In order to separate homogeneous groups, we applied a multivariate statistical technique of cluster analysis. This method joins elements with similar characteristics, thus increasing the similarity between the groups and the difference between the groups [14,15]. The first step of the process is to estimate the degree of similarity or dissimilarity among the data and, in the present study, the Euclidean distance that according to [16] was used, which is frequently used for this purpose in climatic studies in Brazil [17,18]. Additionally, we choose the Ward method, which is a hierarchical clustering [19] based on the minimum variance within a cluster [20]. For the grouping was performed in four, five, and six groups.

3. Results

The annual average of the diurnal precipitation cycles for the three types of groups is shown in Figure 2. Hourly rates are less than 0.35 mm/h when set up for 4 or 5 groups. However, with 6 groups, a maximum of 0.42 mm/h was observed in the new cluster, group 6 in the 1900 UTC range, located in the coastal and inland region of the Amazon.

In the configuration of four clusters, it is made by three dominant types of variability. The first, with the presence of group 1 and 2, has a maximum at 1900 UTC and is typical of continental regimes and associated with a strong convective activity in the middle and late afternoon. Group 1 is more observed in the South and also in the Southeast and

Midwest. Group 2 is geographically located in the Midwest region of the country; the highest rainfall intensity is more pronounced in the South, in relation to the next variability group, group 3, which comprises the northeastern coastal region, with a maximum of 0.30 mm/h at 09:00 UTC.

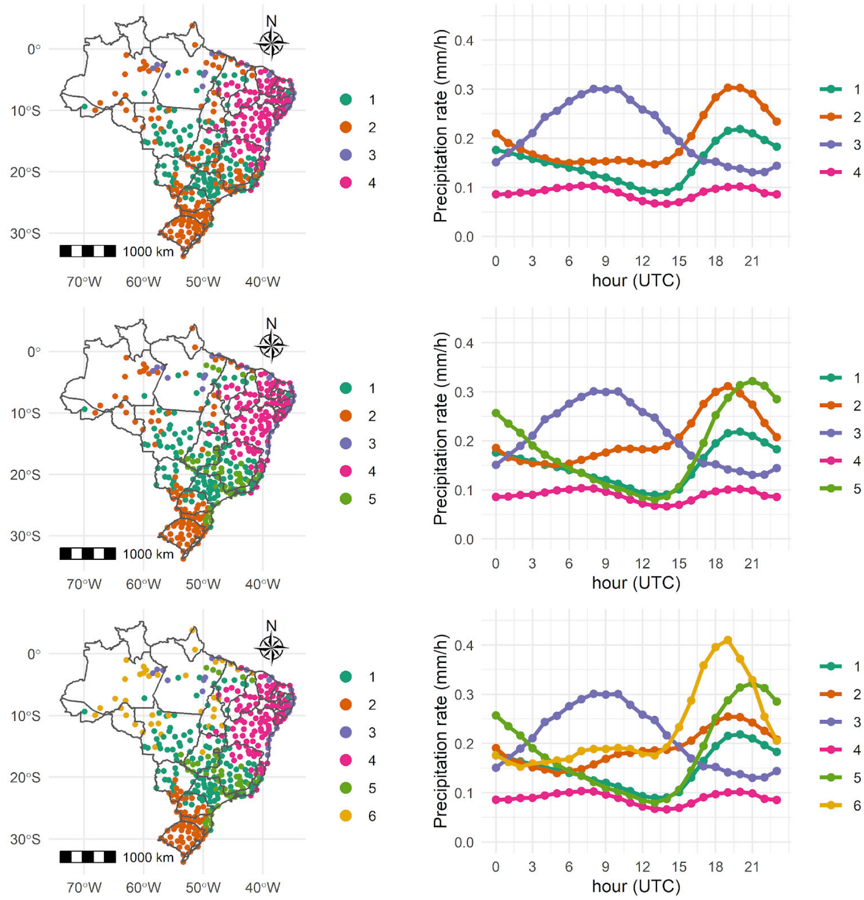

Figure 2. Annual Average of the daytime precipitation cycles for 4, 5, and 6 clusters in the Brazilian territory.

Another mode is group 4 characterized by maximums at 07:00 UTC and 19:00 UTC. And the Amazon, with a mixture of diurnal cycles, in addition to the rain in the middle of the afternoon (more common in group 1) also has precipitation during the night and early morning.

4. Conclusions

From an analysis of precipitation in the Brazilian territory, it was possible to understand the general aspects of diurnal cycle of precipitation in Brazil. Therefore, from a multivariate analysis in data from 1 January 2008 to 31 December 2020, by cluster clustering method, it was possible to conclude that there are different types of diurnal cycle and several meteorological mechanisms that model it. This study demonstrates the need to better understand the cycle of rainfall in Brazil, how they behave in the face of atmospheric phenomena, and how the climate is undergoing changes. The evaluation of the correlation between precipitation and other atmospheric variables, can further improve the accuracy of the forecasts.

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