Original Research Article

Historical projection of the rainfall distribution in the North Region of Brazil

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ABSTRACT

From a set of primary and secondary monthly data from 1991 to 2022, the annual and seasonal climatological pattern of the North region of Brazil, where most of the Amazon Biome is located, was analyzed. An incomplete Gamma distribution model was applied to the climatological precipitation data (mm); atmospheric pressure (mb); incidence of solar radiation (kJ/m²); air temperature and dew (ºC); relative humidity (%); wind intensity (m/s) with direction and maximum gust. Data normalization techniques and spatial similarity identified different patterns and trends of precipitation in the region, with significant seasonality, especially in terms of rainfall. The highest precipitation rates occurred in the N-NW axis, inside the northern Amazonian area, while the lowest values were observed in the southern equatorial zone, on the limits of the ParáState with the Cerrado Biome. Four zones and one climate range were established: southern, central, northern west and northern east zones and extreme north area, all with significant similarity in precipitation and humidity.A trend was observed in the number of days with precipitation between 25 and 50% in the southern and central zones, and an increase in precipitation of 50 to 75% for the northern zone. The wind distribution model showed a tendency towards the presence of isotropic climate phenomena, presenting the same properties or characteristics. The results obtained are relevant to support research aimed at understanding global warming and its consequences, in addition to contributing to forest management programs, and establishing more effective protocols for cultivation in agricultural areas in the Amazon.

Keywords: Climatic model; Seasonality; Spatial analysis; Land use; Historical series.

1. INTRODUCTION

The Amazon Region plays an important role in controlling and balancing the global atmospheric circulation and hydrological cycle. This is due to its large territorial dimension, associated with water availability and priority location in the equatorial zone, with high incidence of solar radiation and precipitation. The regional climate presents a direct correlation with the ocean currents and, consequently, with the transport of heat, this one for several extensions of both the southern and northern hemisphere[1-2]. The existingclimate results from the interaction of several factors at different geographic scales. On a large scale are circulations of global air massesand, interrelated to the movement of ocean currents. On a regional scale, geographical aspects such as relief, altitude and latitude, all directly associated with the typology of biomes. The resulting climate has been altered and enhanced in the last 50 years by the expansion of the irregular use and occupation of regional soils[2-4]. Thus, ecological maintenance and restoration programs, as well as the expansion of agricultural projects throughout Brazil, must take into account the regional Amazonian climate analysis, especially when associated with extratropical phenomena[4-6].

The North region of Brazil covers most of the Brazilian Amazon (91.8%) and Legal Amazon (76.8%). Despite its importance in the global climate context, the study of climatological data through historical series in the region still faces challenges, due to the insufficiency or discontinuity of regionalized data.It is a condition that repeats for every north and northeast area of Brazil[5-7]. The presence of large unmonitored empty spaces is the main obstacle in serial climatological studies. To compensate for this lack of information, new statistical techniques have been appliedat the global level, aiming to interpolate and group historical series data, allowing a more unified space-time analysis[8-10]. Rainfall distribution models have been increasingly applied in ecological and agricultural studies, as precipitation directly interferes with the balance of ecosystems, in the production of organic matter, in the maintenance of vegetation cover, in plant and animal physiology, in the regional hydrological regime and in agricultural and livestock production as a whole [11-14].

The application of historical series in the study of the climate of the Amazon has been more effective, especially because of the global climate change associated with extratropical meteorological phenomena[3,5,14]orlocal and regional deforestation, in this sense, can be cited the recent contributions [5,15-16].The use of landscape units has been an increasingly applied practice within the line of climate modeling[17,18]. Landscape units or physiographic units are directly associated with landforms, which in turn establish a natural division of the landscape, with a distinct mosaic from an ecological point of view. Through the study of landscape units and subunits, it is possible to predict the potential of the physical environment, establishing a set formed by a terrain system, broader and with less detail; terrain unit, considered an intermediate system, and terrain element, the latter of smaller dimensions, but with more detailed information[12,13,15]. According to [19], the application of this segmented analysis model allows the effective individualization of their similarities, especially in studies involving watersheds. Thus, the current study aims at analyzingthe space-time distribution of climatic events in the North region of Brazil, based on the historical series from 1991 to 2022,through the application ofsimilarity analysis and a theoretical model of distribution adjusted to the data series.

2. MATERIAL AND METHODS

2.1 Study Area

The northern geographic region of Brazil covers 45.2% of the national territory, comprising portions of seven Brazilian states: Acre, Amazonas, Amapá, Pará, Rondônia, Roraima and Tocantins. The large water network established in the region plays an important role in the exchange of energy, humidity and biomass for the system, resulting in the maintenance and regulation of the climate from the local to the global level. The distribution of rainfall in the northern region is related to the dynamics of important atmospheric systems, including Continental Equatorial Air Mass (mEc); Intertropical Convergence Zone (ITCZ); Tropical Instability Line (TIL); General Circulation of the Upper Bolivia (AB); in addition to meteorological phenomena on a global scale such as the Southern Oscillation (ENOS) and the Atlantic Dipole. The predominant climate is hot and humid Equatorial (Af), with a strong influence of the monsoon climate (*Am*) to the east, with hot and humid air masses coming from the ocean and dry savannah climate (*Aw*) to the S–SE of the states of Amazonas and Pará. According to the survey of geodiversity prepared by CPRM [20], regional precipitation ranges between 1800 and 3100 mm/y, with an average of 2200±200 mm/y for the central region.

From the large regional climatic oscillation, were identified five rainfall regimes for the extensive region: the first located in the northern axis W–NW close to the Pre-Andean region, with greater precipitation between April and June; the second in the northern area of the Amazonas and Roraima states, with the rainy season concentrated between June and August, and the dry season between December and February; the third in the Central

Amazon region, with greater precipitation between March and May and severe drought between June and August; the fourth rainfall regime is located on the NE–E northern axis, between the coast of Amapá and Pará (Eastern Amazon), with greater rainfall between February and April and dry season between August and October; and the fifth in the southern limit of the Amazon with rains concentrated between December and February.

2.2 Methodology

For the period between 1991 and 2022, climatological data from the North region of Brazil were analyzed, totaling 393 monitoring stations (Fig. 1) in 95 municipalities. Primary data were obtained directly through field measurements. Secondary data were obtained from consultations with the hydrometeorological network and the National Water Agency database [21,22]; Brazilian Institute of Geography and Statistics [23]; Center for Weather Forecast and Climatic Studies [24]; National Institute of Meteorology [25]; Geological Survey of Brazil [20] and National Department of Transport Infrastructure [26]. Historical data were tabulated and their consistency verified using the CLIMA software [27], developed by the Agronomic Institute of Paraná (IAPAR). Quantitative and qualitative analysis of precipitation (mm); atmospheric pressure (mb); global solar radiation incidence ((kJ/m^2); air temperature and dew (ºC); relative humidity (%); wind intensity (m/s) with direction and maximum gust were analyzed.

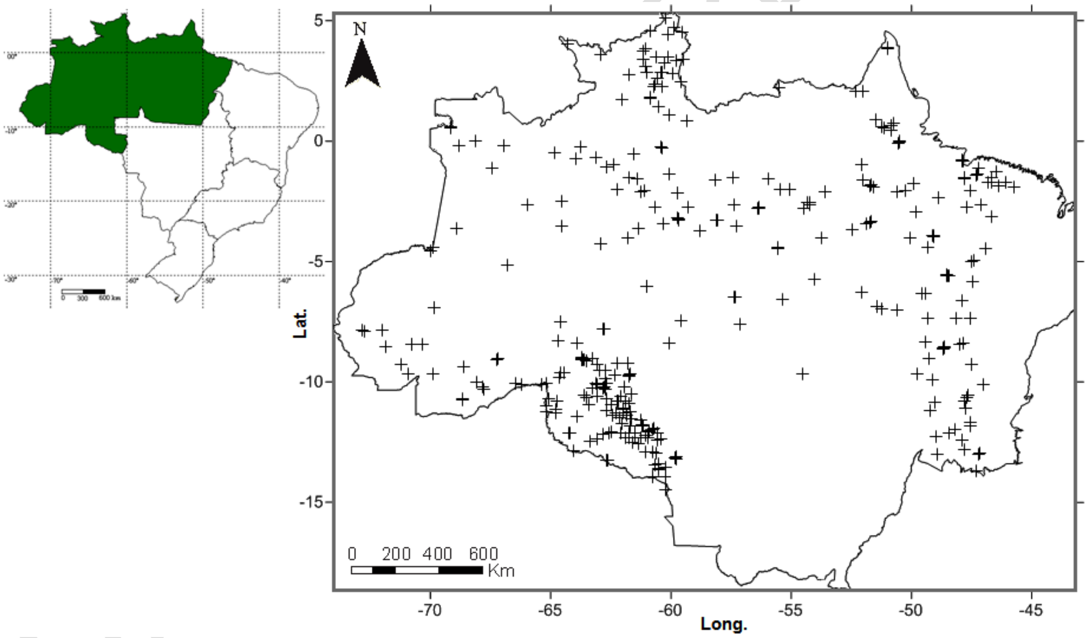

Figure 1: Conventional and automatic meteorological stations consulted for the application of the rainfall model in the Amazon – North Region, Brazil (generated in ArcGis® 9.3©2008)

Spatial Similarity (Cluster) for the categories System, Unit and Element, with the respective identification of the seasonal effect, was applied to the results. In this study, the method of minimum variance was chosen [28], by allowing the smallest variance in relation to the possible values of a given parameter or variable. This is a statistical technique that is highly appreciated in studies that involve an extensive set of historical series or correlated variables. From the application of a theoretical distribution model adjusted to the data series, probabilistic terms were established. For this, precipitation was considered as a continuous random variable. Through the incomplete Gamma distribution model [29], probability levels of 25, 50 and 90% were determined, based on the density function *F(x)* and gamma function (Γ)*f(x)*(equations 1 and 2). The estimate of the α and β coefficients of the Gamma distribution was estimated from the method of moments (equations 3 and 4) established by [30], which aims to equal or to approachthe mean ($\overline{X}$) and variance (S^2) of the samplewith the respective individual measures of the population.To confirm the trend shown in the precipitation model, the Kolmogorov-Smirnov test (K-S) was applied with 5% significance, based on the module of the greatest difference between observed probability (D_o) and estimated or critical probability (D_{cr}), considering the number of observations of the analyzed series. Considering that the classification variables are measured in different units, the technique suggested by [31] was adopted, whose values are previously standardized, in order to have zero mean and unitary variance.This technique allows analyzing a set of variables, of different orders or units, allowing the simultaneous analysis of multiple measurements for each individual, object or phenomenon observed.

$$F(x) = \frac{1}{\beta^{\alpha}\Gamma(\alpha)} x^{\alpha-1} e^{-x/\beta} \qquad \text{(eq. 1)}$$

$$\Gamma(\alpha+1) = \sqrt{2\pi\alpha}\ \alpha^{\alpha} e^{\alpha} \left(1 + \frac{1}{12\alpha} + \frac{1}{288\alpha^2} - \frac{139}{51840\alpha^3}\right) \qquad \text{(eq. 2)}$$

$$\alpha = \frac{\overline{X}^2}{S^2} \qquad \text{(eq. 3)}$$

$$\beta = \frac{\overline{X}}{\alpha} \qquad \text{(eq. 4)}$$

Where: *F(x)* is the probability of a value ≤ x occurring; α is the shape parameter (dimensionless); β is the scale parameter (mm); *x* is the random variable, equivalent to the monthly or seasonal precipitation (mm) and established as 0< x <∞; Γ is the gamma function [*f(x)*] of parameter α, defined according to equation 2; $\overline{X}$ is the arithmetic mean; and S^2 is the Variance (mm^2). Still having as condition of existence α and β >0 and *f(x)*= 0 for x <0.

3. RESULTS AND DISCUSSION

3.1 Seasonal Projection

Rainfall is the most influential element in environmental conditions, with a direct effect on the water balance in the Water – Atmosphere – Soil system, which is directlycorrelating with temperature, air humidity and solar radiation [32-34]. Precipitation also has an important effect on hydrological conditions, interfering with the patterns of ebb and flow in watersheds. The monthly averages of precipitation, in the period from 1991 to 2022, for the state capitals of the North Region are shown in Figure 2A. In general, the results demonstrate a pattern of regional seasonality, with different periods of drought and rain. The municipalities located in the southern part of the North Region, represented by the cities of Rio Branco (Acre), Porto Velho (Rondônia) and Palmas (Tocantins), showed a pattern of drought centered between the months of June and September, with average rainfall for the period from 11.7 mm/month in Palmas to 36.9 mm/month in Porto Velho. In the Central Amazon, Manaus (AM) had a similar rainfall pattern, with a dry period between July and September, but with a more pronounced average precipitation for the period, with 60.1 mm/month. The northern zone showed divergent patterns between the east and west regions, in addition to a certain significance in the extreme north of the Amazon. In NE axis, the municipalities of Belém (PA) and Macapá (AP) had the dry period defined for the months of July to November in Belém (average 110.3 mm/month), and between August and October in Macapá (average 52.9 mm/month). This region is under the greatest influence of humid air masses originating from the ocean, highlighting the ITCZ and the TIL. Historically, the relative humidity of the air in these capitals has never been below 69%[35], suggesting that there is an attenuation of the drought by the entry of oceanic wet masses throughout the entire annual hydrological cycle. On the NW northern zone, the municipality of Boa Vista (RR) had a longer dry period, oscillating between November and March, coinciding with the summer season in the Southern Hemisphere. The average for the dry season in Boa Vista was 29.4 mm/month.

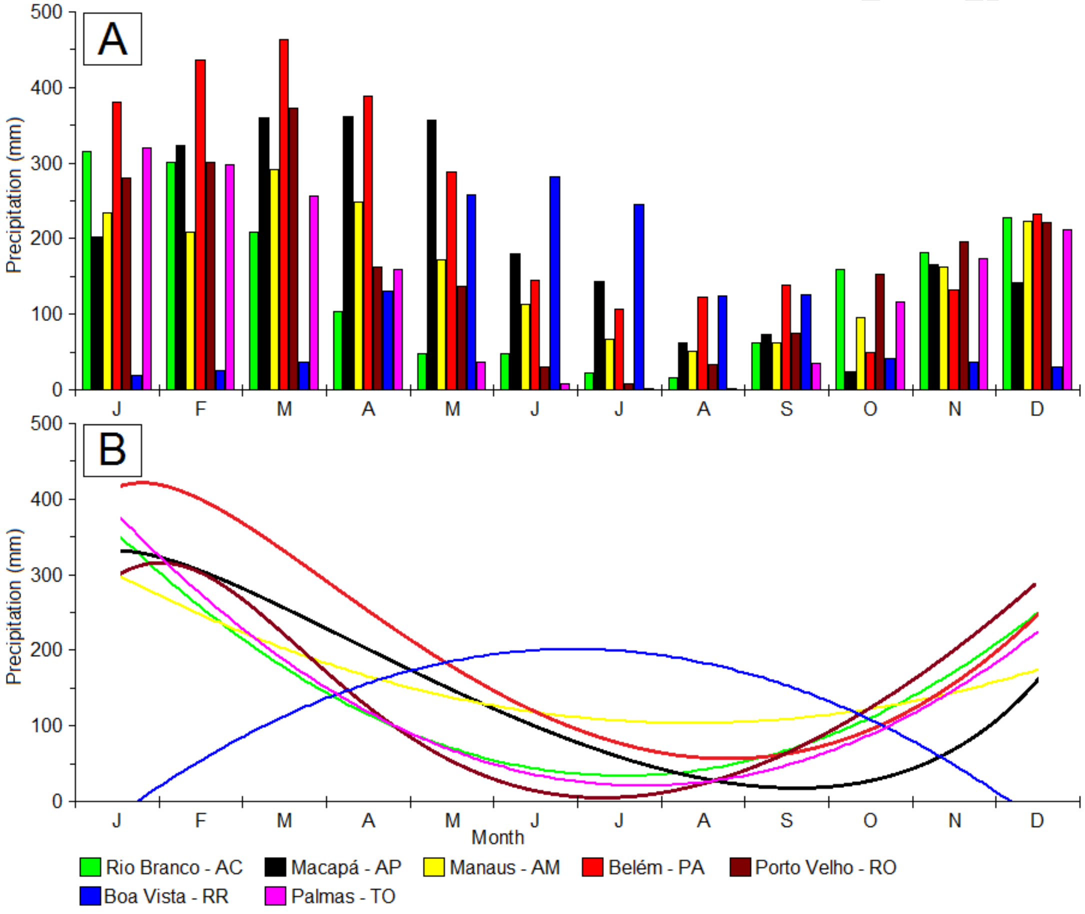

Figure 2: Average monthly precipitation (mm) for the period from January 1991 to December 2022 for the capitals of the northern region of Brazil (2A) with their respective annual trend curves (2B)

Especially the north area is under the influence of high troposphere anticyclones, which during the hot months displace dry air masses from the Pre-Andean region towards the coast, which interferes with the total volume of precipitation. Municipalities located in the extreme north of the Amazonas State presented high average precipitation, comparing to the precipitation volume observed in the eastern region. This is due to contributions from humid air masses from the ITCZ that travel through a narrow corridor directed towards this area specifically. Despite the divergences found on the E-W axis, the drought was much milder compared to the patterns observed in the central and southern climate zones, as can be seen through the trend curves (Fig. 2B). This trend, observed over a long historical period, shows that oscillations in the patterns of distribution and intensity of rainfall in the aforementioned regions overlap the influence of extratropical meteorological phenomena. Thus, it can be stated that rainfall distribution trends followed regional seasonality patterns.

Seasonality, despite being remarkable, was not equal for periods of rain and drought or for the monitored sub-regions. An analysis of Figure 3 showed that, in general, the rainy months were numerically more frequent in the North Region than the dry periods, in the order of 58% of rainfall in the year in Pará, Roraima and Tocantins; 67% in Acre and Rondônia, and 75% in the Amazonas and Amapá states. Within this panorama, the most evident drought was observed in Tocantins, with annual records of no rain between June and August. Although the northern eastern zone of Pará has a high precipitation rate, the south of that state is marked by an intense and lasting drought, largely due to the dry air masses originating from the Central Plateau and Cerrado Biome. This influenced the frequency distribution results in the state.

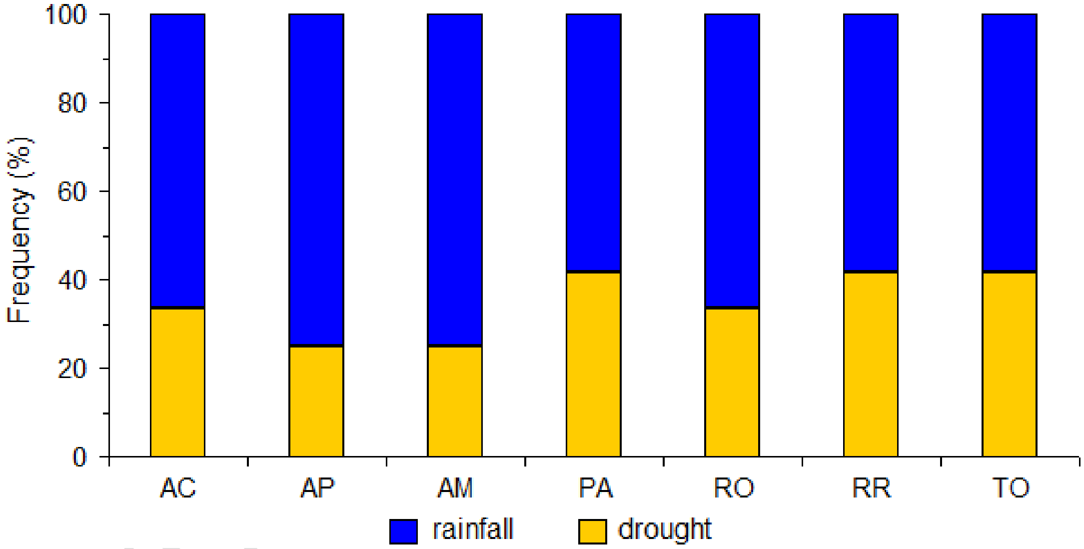

Figure 3: Annual frequency of rainfall and drought for the states of the North Region for the period from 1991 to 2022

Based on the analysis of daily and monthly data, the regional seasonality was established for each of the states that make up the study area. Considering the monthly average and standard deviation of precipitation for the period (1991 to 2022), it was observed that the number of rainy days, with significant precipitation, predominated in relation to dry days or days of low precipitation. In fact, recent studies on climate change in the Amazon have shown that periods of rain have increased in the last decade [2,5,17,36-38], especially under the influence of extratropical events, with emphasis on the La Niña phenomenon.

3.2 Annual Projection

Within the space-time perspective, the climate zones were classified and grouped as follows: in the southern zone (SZ) – Acre, Rondônia, Tocantins and southern portion of Amazonas; in the central zone (CZ) – part of Amazonas and Pará; in the northern eastern zone (NEZ) – the northern portion of Pará and Amapá; and in the northern west zone (NWZ) – part of Amazonas and Roraima. In addition, it was possible to observe a trend or climate variation in the extreme north zone (NZ), in the territorial limits between the states of Amazonas and Roraima. Once the climatic precipitation zones were identified, the distribution of average annual rainfall was established (Fig. 4). Especially the monitoring stations located in Roraima and in the climatic zones of Amazonas and Pará had greater fluctuation in annual averages for the study period. Some of these oscillations result directly from the influence of global meteorological phenomena[5,6,14,37]. Others, however, derive from punctual and regional events, such as cold phenomena "*friagem*"[39]or changes in the intensity and direction of warm and humid air masses coming from the ocean. The highest annual rainfall for the study period was observed in the extreme north climate zones of the northern zone (NZ), with average of 2299±99 mm/year; and the northern east zone (NEZ), in Amapá with average of 2246±86 mm/year and Pará with average of 2103±112 mm/year. The lowest annual rainfall was observed in Tocantins (1371±68 mm/year) and Rondônia (1558±85 mm/year). The trends and behavior of annual oscillation were confirmed through the curves proposed in Figure 3, highlighting the average values above 2100 mm/y representing 72% of the sample for NZ and 69% for NEZ. A second group also was highlighted with absolute frequency of occurrence close to 66% for Acre, Rondônia and Tocantins, all belonging to the southern zone (SZ).

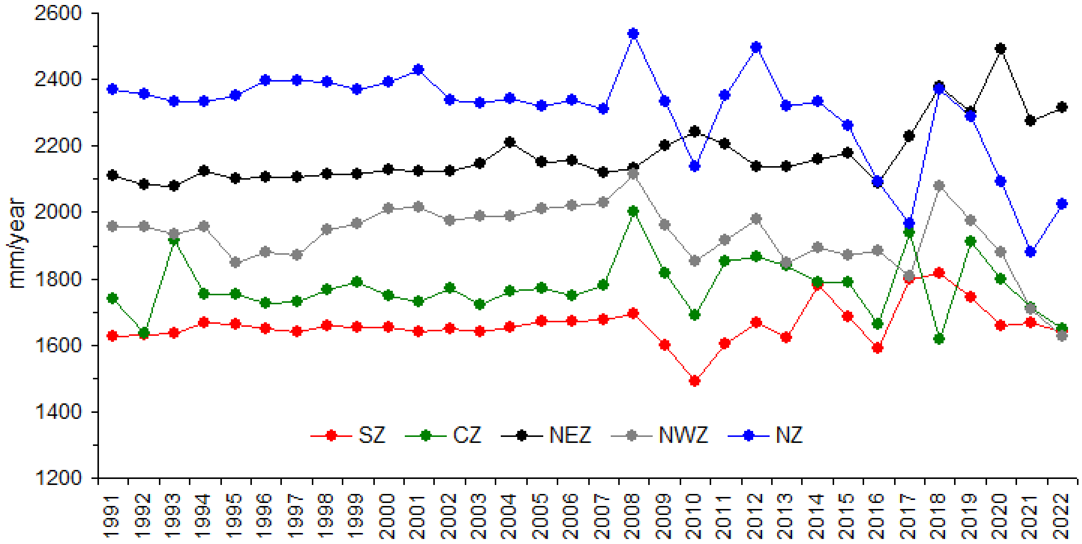

Figure 4: Average annual distribution of rainfall in the climatic zones of the North Region of Brazil

The climate of the Amazon is the result of the interaction of regional phenomena, attributed to the hydrological cycle in the Amazon Biome, and global events, involving the movement of large air masses such asContinental Equatorial Air Mass; Intertropical Convergence Zone; Tropical Instability Line; General Circulation of the Upper Bolivia and Southern Oscillation (ENOS).In this regard, monitoring the intensity and direction of the winds is essential for understanding the patterns of displacement of air masses in the region. From the determination of the direction and intensity of the annual winds between 1991 and 2022, a distribution model of the predominant winds in the northern region was established (Fig. 5). The resultant model suggests that the predominant winds in the region come from the east throughout the annual cycle, with two components: one in the E-W direction and the other SE-NW. The average intensity of the winds varied as follows: in the southern zone an average of 5.7 ± 4.7 m/s in Acre; 6.7 ± 5.3 m/s in Rondônia; 7.2 ± 5.4 m/s in Tocantins; 5.5 ± 4.9 in southern Amazonas and 6.2 ± 5.1 m/s in southern Pará. In the central area of the Amazon, the average value was 6.4 ± 7.3 m/s in the State of Amazonas and 6.6 ± 4.9 m/s in Pará. In the northern zone, mean values were 5.6 ± 4.3 m/s in Roraima; 5.8 ± 4.0 m/s in Amapá; 5.5 ± 4.8 m/s in Amazonas and 5.3 ± 4.6 m/s in Pará. The results suggest greater stability and constancy in the annual winds in the northern section, where the higher relief from Guiana and Cristalino shields and Pre-Andean region acts as a natural physical barrier to the movement of air masses. The results corroborate studies carried out in the Amazon, which claim that winds from the Eastern Amazon towards the Andes transport large amounts of water vapor, which extend to the South and Southeast of South America, constituting the main source of humidity for these regions [2,25,40].

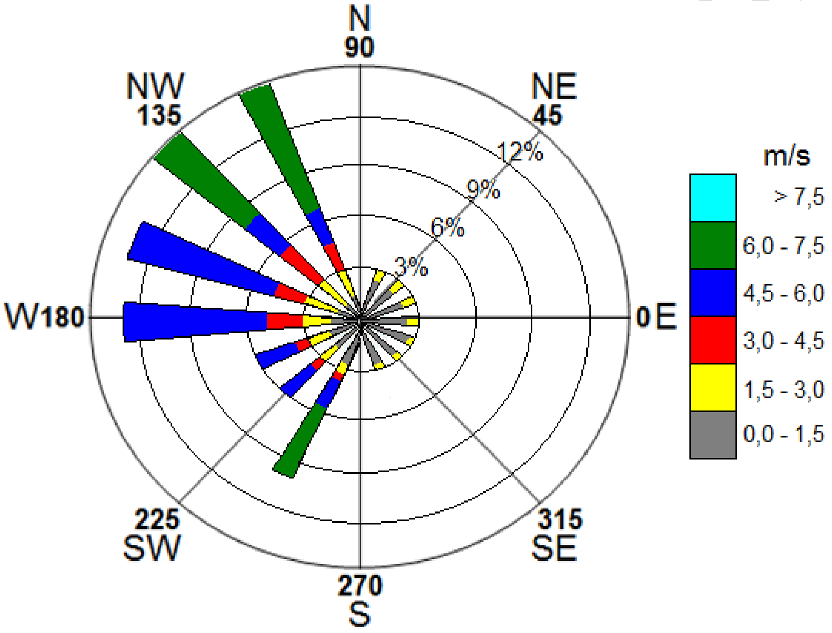

Figure 5: Model of mean annual wind direction and intensity for the northern region based on data analyzed between 1991 and 2022. (generated in Origin® 6.2© Microcal Soft. Inc. 2008)

The annual projection established by the model of direction and average intensity of the winds in the North Region suggests a predominance of the displacement of warm and humid air masses from the ocean in the E-NW axis, corroborating with the more accentuated precipitation results in the northern mesoregion of Pará, in particular in the Metropolitan Region of Belém, and in the central climate zone of the Amazonas State. The model indicates that 58% of the air masses move within the presented orientation axis, with winds of average annual intensity between 5.5 and 6.5 m/s and just over 11% move annually to the border zone between Acre and Rondônia (Fig. 5). In addition, the weak winds directed towards the southern region establish a range of dry air masses influenced by arid winds from the Cerrado Biome to the agricultural and livestock belt that extends from southern Pará to northern Rondônia. These projections, which must be periodically revised, can help both in the reforestation programs in the center-south of Pará, as well as continuously update the agricultural program in cultivated lands in the region, as suggested by [4,6,32,33].

3.3Climate Similarity

Cluster for the terrain systems category, which, being considered broader, incorporated the four climate zones and a climate variation in the extreme north zone (NZ); terrain units considering the perspective of each of the seven incorporated states in the North Region; and terrain elements, with more detailed information about the metropolitan regions of the respective state capitals, were prepared for the study period (Fig. 6). From the perspective of the cluster analysis, the best response as a function of the connection distance was observed for the climatic zones established in the terrain system category (Fig. 6A), with good similarity between the NZ and NWZ, followed by a cluster with the CZ, especially in the states of Amazonas and Pará. In this same grouping, the NE climate zone, where territories of Amapá and Pará are located, proved to be independent and the SZ, which incorporated territories mainly from the states of Rondônia, Pará and Tocantins, remained isolated from the others. Considering the cluster by terrain units (Fig. 6B), Acre and Pará remained isolated under historical climatic conditions. The isolation of Acre is due to its climatic individuality in relation to the other states located in the southern zone. Pará, on the other hand, due to its large territorial extension, presents climatic discrepancies between the north, central and south strips, isolating the state when it is analyzed from the perspective of its geographical limits. The terrain elements category (Fig. 6C) presents greater detail of the climatic characteristics of its metropolitan regions, increasing the distance of association between the analyzed elements. The highlight was the isolation of the Metropolitan Region of Belém in Pará.

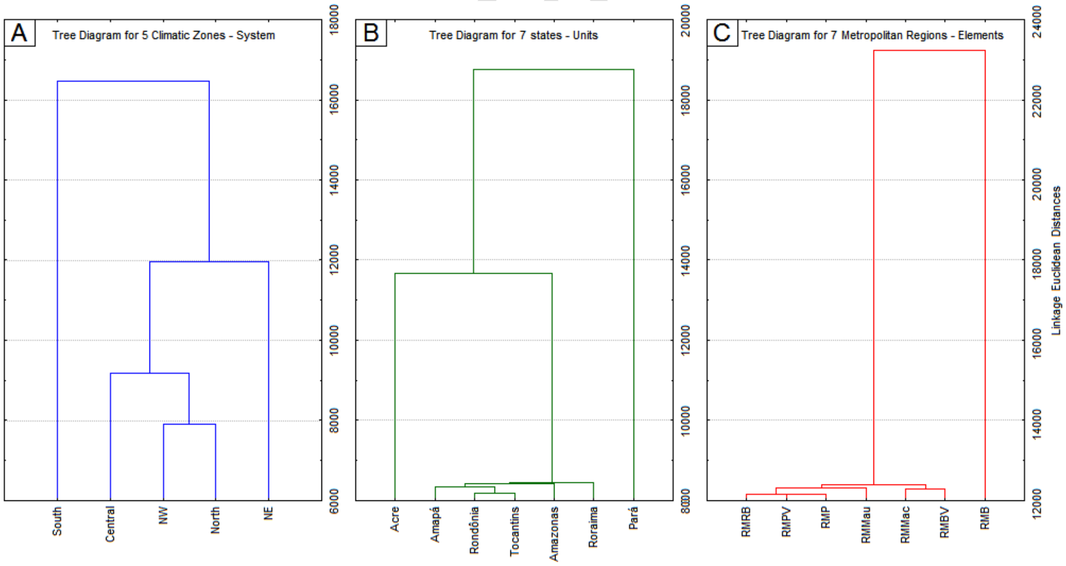

Figure 6: Spatial similarity of climate variables for three moments A- System, B- Unit and C- Element for the historical series from 1991 to 2022 in the North Region of Brazil. Diagrams established by Ward's method with Euclidean distance (generated in Statistica 7.0© Stat Soft. Inc. 2004)

3.4Seasonal Distribution Model

A rainfall distribution model adjusted to the historical series was established. Based on the principle of likelihood, whose function (*fx*) contains all the information about a given parameter, the probability of obtaining the most likely sample was maximized, which allowed establishing both numerically and graphically a behavioral pattern. For the study period, high data asymmetry was evidenced for the northern geographic region due to seasonality. The α indices values ranged between 0.4 and 2.8 during the dry season, and from 6.3 to 11.0 during the rainy season (Table 1). From the zonation point of view, the lowest α indices were calculated during the dry season for the southern climate zone (SZ). Despite numerical variation, all indices were well below the maximum acceptance limit (α= 100) of the model recommended by [29]. In this way, the low values calculated for the α brought confidence in the application of the Gamma distribution model for the seasonal analysis. The values of the β indices ranged from 12.4 to 24.6 mm in the dry season, and from 22.7 to 47.4 mm in the rainy season, with the highest indices (> 30 mm) being observed in the NEZ and NWZ, respectively in the states of Amapá and Roraima. The oscillation of the results is due to the high variance determined, a consequence of the significant difference in precipitation between the dry and rainy months. The α and β indices confirmed the possibility of using the Gamma distribution model in seasonal conditions for the climatic phenomena of the study area. Several studies have confirmed this trend of applying the Gamma model, whose results have shown good fit and efficiency for the data set, especially in determining monthly precipitation totals, estimating probabilities and simulating daily, monthly, seasonal or annual climate data [11,41-44].

The Kolmogorov-Smirnov adherence test (5%) allowed estimating the obtained values (D_o) statistically lower than the critical values (D_{cr}) observed in the table for the validated sample number (*n*) (Table 1). The smallest difference between D_o and D_{cr} was observed in Pará, and the largest difference was determined for the Roraima State. This trend suggests that there was agreement between the observed and expected frequencies, as well as good fit of the Gamma distribution for the historical series. In fact, the great adherence of the Gamma distribution identified through the K-S test allowed considering the Gamma probability distribution function as adequate to represent precipitations for periods of drought and rain. The patterns of occurrence and distribution of meteorological phenomena can be predicted in probabilistic terms, through the use of theoretical distribution models, with probability density functions adjusted to a historical series. In this sense, the incomplete Gamma distribution model with density function *Fx* has shown good results in estimating probabilities and simulating of daily climate data [29,34,42,44,45]. From a space-time perspective, in the months with the highest occurrence of precipitation, the average rainfall remained between levels of 25 and 50% probability. This trend continued for the dry season, established between July and September for most states in the North Region. The exception was Roraima, whose dry period fell between November and March. In this case, the average occurrence of rainfall increased to levels of 50 to 75% probability, suggesting that in the months of lower precipitation, the temporal variation is less accentuated, with a greater probability of occurrence of values above the average.

Table 1. Gamma distribution and K-S adherence test (5%) for seasonal rainfall for states in the North Region, with probability levels of 25, 50 and 90% of precipitation

							K-S (p<.01)		Probability levels (%)		
	n	*X*	*m*	S^2	α	β	D_o	D_{cr}	90	50	25
AC*d*	896	36.8	32.6	479.5	2.82	13.04	0.050	0.056	10.6	32.6	51.7
RO*d*	896	22.2	12.0	519.3	0.95	23.40	0.061	0.068	0.6	12.0	34.8

TO*d*	3200	9.0	1.9	219.9	0.36	24.56	0.029	0.033	0.0	1.9	11.4
AM*d*	1920	41.0	39.6	664.4	2.53	16.19	0.031	0.034	10.8	39.6	61.0
PA*d*	4960	35.1	32.2	599.5	2.06	17.07	0.024	0.027	5.2	32.2	52.0
AP*d*	384	37.2	31.5	664.8	2.09	17.85	0.057	0.063	5.9	31.5	56.3
RR*d*	480	33.9	35.4	420.6	2.73	12.42	0.090	0.100	9.1	35.4	45.0
AC*r*	1792	241.9	236.8	5488.2	10.66	22.69	0.049	0.056	149.6	236.8	290.4
RO*r*	1792	274.3	272.2	6837.3	11.00	24.93	0.060	0.068	175.6	272.2	325.0
TO*r*	4480	238.3	232.1	5479.2	10.36	23.00	0.026	0.033	150.3	232.1	281.1
AM*r*	5760	271.0	262.8	8216.3	8.94	30.32	0.030	0.034	157.8	262.8	324.0
PA*r*	6944	286.2	277.4	11086.3	7.39	38.73	0.025	0.027	159.2	277.4	345.8
AP*r*	1152	300.4	288.9	9946.4	9.07	33.11	0.052	0.063	170.8	288.9	357.4
RR*r*	672	300.9	290.4	14268.5	6.35	47.42	0.089	0.100	138.2	290.4	382.7

Legend: *X*= mean; *m*= median; D_o= observed value; D_{cr}= critic value; *d*= drought; *r*= rainy periods.

4. CONCLUSION

From the point of view of rainfall distribution, it was possible to establish four climatic zones and one variation with distinct rainfall regime: southern (SZ); central (CZ); northern eastern (NEZ) and northern west (NWZ) zones, and extreme north zone (NZ), this referring especially to the transition territory between Amazonas and Roraima states. The results suggest a trend in the number of days with precipitation between 25 and 50% in most of the SZ and CZ, and an increase in precipitation of 50 to 75% probability for the NZ. Not all trends were statistically significant. The positive trend identified in the NW zone suggests an increase in rainfall events, especially in the last two decades. Furthermore, in general from 2008 onwards, rainfall events showed instability in their variation.The analysis contributed to a better understanding of the climate distribution in the North Region of Brazil. The results must help environmental management programs to aim at agricultural activities and urbanization in the region. The Spatial Similarity analysis showed better results for the terrain systems category, which presents less detail of the climatological data covering the region in climatic zones. The Gamma distribution model applied proved to be satisfactory under seasonal conditions for the climatic phenomena of the study area, confirming the propensityof its use with good adjustment and efficiency for the data set.The climate assessment of the Northern Region, ecologically important as it represents the majority of the Amazon, provides additional information to clarify an issue under debate; the global warming. It is a fact that the change in the global climate will have drastic sectoral consequences, including an increase in the volume of rainfall in the studied region, a pattern already identified in this study.

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