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OBTAINING THE INDEX-FLOOD FOR HOMOGENEOUS REGIONS OF MINAS GERAIS, BRAZIL

Obtenção do "Index-Flood" para regiões homogêneas de Minas Gerais

Obtención del "Index-Flood" para las regiones homogéneas de Minas Gerais, Brasil

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Abstract: The evaluation of heavy rainfall is important because rainfall data are frequently used to design storm drainage and erosion control systems in agricultural areas. Because it is difficult to obtain local rainfall data, heavy rainfall regionalization techniques are necessary. One such technique is known as the Index-Flood method, which standardizes data obtained for different areas within a region considered homogeneous to use as a single sample set. The objectives of this study were to divide the state of Minas Gerais, Brazil, into hydrologically homogeneous regions and to use the return periods and duration to obtain the respective Index-Flood values for each state to aid the design rainfall estimation. Maximum annual rainfall and total annual rainfall data from 494 weather stations in Minas Gerais were used. K-means cluster analysis was used to identify homogeneous regions and generated a total of three groups in the state. For each group, the regional intensity–duration–frequency (IDF) relationships were generated and were related to the rainfall intensity values associated with different durations, resulting in the Index-Flood value. Subsequently, the regional dependent variable equations were obtained and were associated with the Index-Flood and the local rainfall value to obtain the local design rainfall used in the design storm drainage and erosion control systems in agricultural areas. The coefficient of determination was used to evaluate the accuracy of the estimates, and the r^2 values were close to 1.0 for all fittings, which indicated a good fit of the data and allowed the equations generated to be used in the design rainfall estimation.
Keywords: IDF relationship. Intense rainfall. Rainfall regionalization. Cluster analysis.

Resumo: A importância de avaliar as precipitações intensas é devido à sua frequente utilização no dimensionamento de obras hidráulicas. Existem dificultadores relacionados à disposição de informações locais de precipitação, tornando necessária a utilização de técnicas de regionalização de chuvas intensas. Uma delas é a técnica conhecida como “Index-Flood” que visa uniformizar dados obtidos em pontos distintos de uma região considerada homogênea, para utilizá-los como um conjunto amostral único. Desta forma, o objetivo deste trabalho foi separar o estado de Minas Gerais em regiões hidrologicamente homogêneas e obter seus respectivos “Index-Flood” em função dos tempos de retorno e duração para contribuir na estimativa das chuvas de projeto. Foram utilizados dados de precipitação máxima diária anual e total anual referentes à 494 estações pluviométricas localizadas em Minas Gerais. Para a separação das regiões homogêneas utilizou-se a análise de agrupamentos k-médias, gerando um total de três grupos no estado. Para cada grupo foram geradas as relações IDF regionais, que relacionadas aos valores de intensidade de precipitação para diversos tempos de duração resultaram no “Index-Flood”. Posteriormente, foram obtidas as equações regionais de variável dependente, que associadas ao “Index-Flood” e o valor de precipitação local, possibilitam a obtenção da chuva de projeto local utilizada para os dimensionamentos hidráulicos. Para todos os ajustes realizados, utilizou-se o coeficiente de determinação para avaliar a precisão das estimativas, sendo que, para todos os ajustes os valores de r^2 foram próximos a 1,0, indicando um bom ajuste dos dados permitindo que as equações geradas possam ser usadas na estimativa das chuvas de projetos.
Palavras-chave: k-médias. Regionalização de chuvas. Análise de cluster.

Resumen: La importancia de evaluar las lluvias intensas se debe a su uso frecuente en el diseño de obras hidráulicas. Existen obstáculos relacionados con la disponibilidad de las informaciónes de la precipitación local, siendo necesario el uso de técnicas de regionalización de las lluvias intensas. Una de ellas es la técnica conocida como “Index-Flood” que tiene como objetivo estandarizar los datos obtenidos en diferentes puntos de una región considerada homogénea, para ursarlos como un conjunto único de muestras. De esta forma, el objetivo de este artículo fue separar el estado de Minas Gerais en regiones hidrológicamente homogéneas y obtener sus respectivos “Index-Flood” en función de los períodos de retorno y duración para contribuir a la estimación de las lluvias de diseño. Fueron utilizados datos de precipitación máxima diaria anual y total anual refiriéndose a las 494 estaciones pluviométricas ubicadas en Minas Gerais. Para la separación de las regiones homogéneas se utilizó el método de k-means, generando un total de tres grupos en el estado. Para cada grupo, se construyeron las curvas IDF regionales, que relacionadas con los valores de intensidad de precipitación para diferentes tiempos de duración dieron como resultado el “Index-Flood”. Posteriormente se obtuvieron las ecuaciones regionales de la variable dependiente, que asociado al “Index-Flood” y el valor de la precipitación local, se permite obtener la lluvia del diseño local para los dimensionamientos hidráulicos.

Para todos los ajustes realizados, el coeficiente de determinación se utilizó para evaluar la precisión de las estimaciones, siendo que, para todos los ajustes, los valores de r^2 fueron cercanos a 1,0, indicando un bueno ajuste de los datos permitiendo que las ecuaciones construidas se utilicen en la estimación de las lluvias de diseño.
Palabras clave: k-means. Regionalización de lluvias. Análisis de Conglomerados**.**

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1. INTRODUCTION

The assessment of intense rainfall is an important step in the analysis of hydrological risk. This topic is one of the main focal points in theoretical and applied hydrology studies because rainfall characteristics are often used to design water management and flood risk mitigation infrastructures and erosion control in agricultural areas (MELLO and VIOLA, 2013; GHANMI, BARGAOUI and MALLET, 2016).

The frequency of occurrence of extreme events has increased, making it necessary to know their spatial and temporal distribution to reduce the vulnerability to disasters caused by floods, erosion and sediment transport (MIRHOSSEINI, SRIVASTAVA and STEFANOVA, 2013; UPADHYAYA and RAMSANKARAN, 2014; SINGH; LO and XIAOSHENG, 2017).

It is important to understand how rainfall is distributed within regions that subdivide a larger area because physical and climatic factors vary according to their geographical position and intrinsic characteristics of the site, thus establishing hydrologically homogeneous regions (BESKOW *et al.*, 2016; MIRANDA, 2016). To distinguish these regions, statistical homogenization techniques are used that capture the similar and unique characteristics of each site, generating a regionalized rainfall similarity pattern (FREITAS *et al.*, 2013; SINGH; LO and XIAOSHENG, 2017).

In statistics, one of the most commonly applied techniques for identifying hydrologically homogeneous regions is cluster analysis, which was used in the studies of Farsadnia *et al.* (2014), Beskow *et al.* (2016), Miranda (2016), and Singh, Lo and Xiaosheng (2017).

According to Manly (2008), cluster analysis algorithms are subdivided into hierarchical and non-hierarchical methods. Among the non-hierarchical methods, the k-means algorithm (MACQUEEN, 1967) is one of the most popular and well known because of its low execution time, its efficiency for processing large datasets with numerical attributes and its simple implementation and interpretation because parameters are not involved (YIN *et al.*, 2016; AGARWAL *et al.*, 2016).

This algorithm classifies objects by segregating data into X groups by minimizing the sum of the squares of the distances between the data and the centroid of the corresponding group, represented by the mean vectors of the group (FARSADNIA *et al.*, 2014; GOYAL and

GUPTA, 2014). However, even when a region is known to be homogeneous, its identification may be impeded by a lack of historical rainfall series; therefore, alternative methods for developing regionalization are needed (BACK *et al.*, 2011).

Naghettini and Pinto (2007) describe three types of regional analysis procedures: methods that regionalize the quantiles associated with a specific risk, methods that regionalize the parameters of probability distributions, and methods that regionalize a curve of dimensionless quantiles, called the Index-Flood.

The Index-Flood (IF) standardizes data obtained at different points within a region considered homogeneous to use as a single sample set (CALEGARIO, 2014; NAGHETTINI and PINTO, 2007). The critical characteristic of this method is that the observation points constitute a statistically homogeneous region and their probability distributions are identical, except for a local scale factor called the nondimensionalization factor (BASU and SRINIVAS, 2016; GADO and NGUYEN, 2016).

The initial IF method was introduced by Dalrymple (1960) and then Hosking and Wallis (1997) proposed applying the L-moment parameter estimation method to the IF (NAGHETTINI and PINTO, 2007).

The IF is widely used for flow through the regionalization of floods, but it has also been applied to rainfall, such as in Yin *et al.* (2016) and Basu and Srinivas (2016). In Brazil, the main study that has used IF to analyze heavy rainfall is that by Davis, Naghettini and Pinto (2000), which focused on the state of Rio de Janeiro; however, other studies, such as that by Dantas and Pinto (2011), exist for the São Francisco River basin.

Following these previous studies, the objective of this study was to segregate the state of Minas Gerais into hydrologically homogeneous regions according to their maximum annual rainfall and to obtain the respective Index-Flood for each region according to the return periods and duration, to contribute to the estimation of the design rainfall of drainage systems and erosion control in agricultural areas.

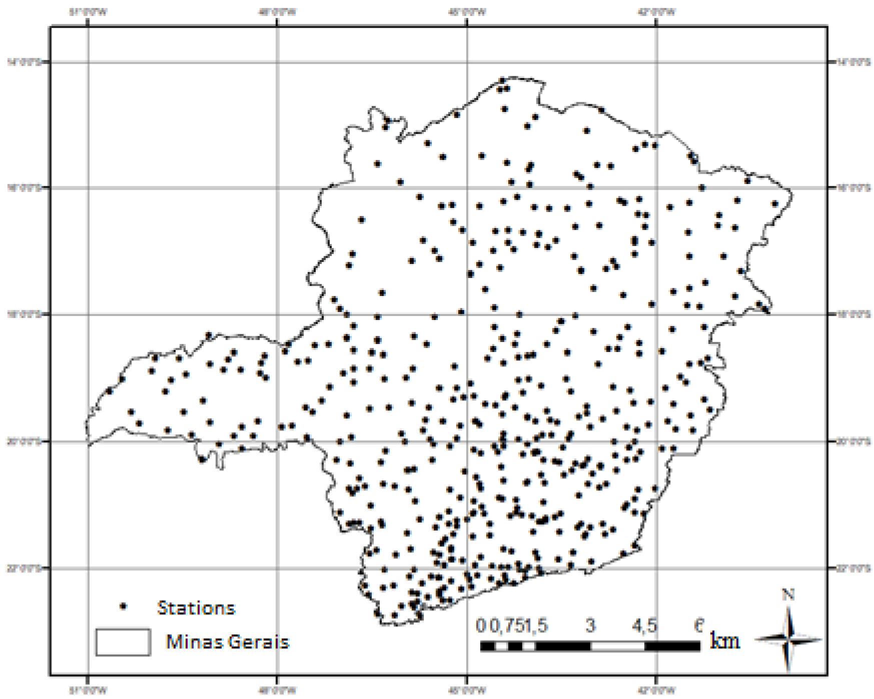
2. METHODOLOGY

The state of Minas Gerais, 586,520.732 km² (IBGE, 2019) in area, is the largest in the southeastern region of Brazil, and therefore, its mesoregions have different topographic and climatic characteristics. The main elements of the topography in Minas Gerais are the Mantiqueira mountain range to the south, the Espinhaço mountain range from the east to the northeast and the Canastra mountain range in the central-west part of the state (MELLO and VIOLA, 2013).

Reboita *et al.* (2015) obtained the Köppen-Geiger climate classification for Minas Gerais and found that the predominant climate class is Aw (67% of the area). In the south of the state, due to high altitude regions, are found Cwa climates (21%), and, in smaller areas, Cwb (11%). The north of the state has a predominance of the Aw climate and a small area with Bsh and Bwh climates and, in the far west, there is the Am climate. These results are consistent with those obtained by Sá Junior (2009), Machado (2014) and Martins *et al.* (2018).

The study used data from 494 weather stations (Figure 1) distributed throughout the state, whose historical annual series of maximum daily rainfall were obtained from the Hydroweb - Hydrological Information System (SNIRH, 2018). Historical series with long observation periods (over 15 years) that were distributed throughout the state were selected for analysis.

Figure 1 - Weather stations used for the study in Minas Gerais.



Source: Elaborated by the authors (2021).

The first step to regionalize the rainfall data was to determine the hydrologically homogeneous regions in the state by k-means cluster analysis using the Stats package (R Core Team, 2018) in the R programming language (R Core Team, 2007). Because the algorithm requires a predefined initial number of groups, the optimal number of groups was estimated for the data series studied using the command “fviz_nbclust ()” in R (R Core Team, 2007), which determines and visually displays the number of groups using the sum of squares of each group. Having defined the ideal number, the algorithm at each iteration assigns the group formed to the center of the nearest group according to the Euclidean distance between the two. Then, the center of the new group is recalculated until the results from the algorithm converge with the initial number defined.

The output of the cluster analysis is usually not the final result. Subjective adjustments are often necessary to improve the physical coherence of the regions to reduce their heterogeneity (YIN *et al.*, 2016). The groups formed using the algorithm were adjusted following Hosking and Wallis (1997): one or more points were moved from one region to another and the regions were subdivided or combined to reclassify the groups.

To verify the homogeneity of the regions obtained, a Scott-Knott significance test was performed in the statistical program SISVAR (FERREIRA, 1998). Once the significance of the hydrologically homogeneous regions was verified, the Index-Flood, or nondimensionalization factor, values were obtained by adapting the methodology used by Davis, Naghettini and Pinto (2000). The regional parameters of the intensity–duration–frequency (IDF ratios were initially adjusted by the disaggregated rainfall values from the annual maximum daily rainfall (Equation 1), as follows:

$$i_{(t,\ TR)} = \frac{K\ TR^{a}}{(t+b)^{c}} \qquad (1)$$

Where:

i - maximum mean intensity (mm h^{-1});

TR - return time (5, 10, 25, 50 and 100 years);

t - rainfall duration (5 min ≤ t ≤ 1,440 min);

K, a, b and c - regional adjustment parameters.

The parameters of Equation 1 were adjusted and optimized by minimizing the sum of squares of the deviations (Equation 2) between the observed values and those estimated by the Gumbel distribution.

$$SSD = \sum(i_{obs}-i_{calc})^2 \tag{2}$$

Where:

SSD - Sum of squares of deviations;

i_{obs} - rainfall intensities estimated by the Gumbel distribution (mm h^{-1});

i_{calc} - rainfall intensities calculated by the IDF ratio (mm h^{-1}).

With the adjusted regional IDF ratio ($i_{(t, TR)}$) parameters and the regional mean rainfall intensities ($\bar{i}$) obtained from the maximum annual daily rainfall, it was possible to obtain the regional quantiles ($\mu_{(t,TR)}$) using Equation 3, as follows.

$$\mu_{(t,TR)} = {i_{(t, TR)}}/{\bar{i}} \tag{3}$$

The second necessary adjustment was made by obtaining the dependent variable equation $\bar{i_d}$ described in Equation 4, as follows.

$$\bar{i_d} = A\ t^{-B}\ P^{C} \tag{4}$$

Where:

$\bar{i_d}$ - maximum regional mean rainfall intensity for the duration of the rainfall (mm h^{-1});

t - rainfall duration (5 min ≤ t ≤ 1,440 min);

P - mean annual total rainfall (mm); and

A, B and C - adjustment parameters of the regional model.

By adjusting the parameters of Equations 3 and 4 for each homogeneous region of the state, it was possible to estimate the intense rain ($i_{(t,TR,j)}$) of duration t (min), at site j, associated with the return time TR (years), described by Equation 5, as follows.

$$i_{(t,TR,j)} = \bar{i}_d \times \mu_{(t,TR)} \quad (5)$$

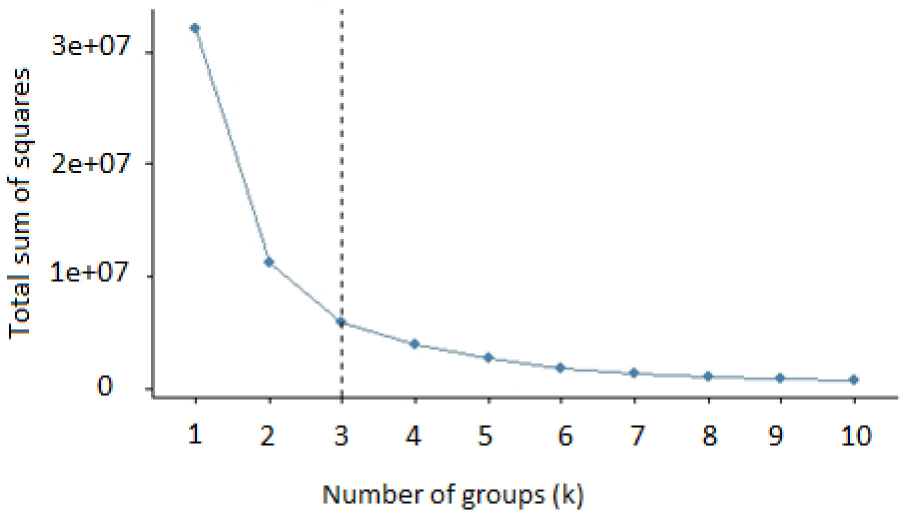
Where:

$\mu_{(t, TR)}$ - dimensionless frequency quantile, of regional validity, associated with duration and return time (Index-Flood).

3. RESULTS AND DISCUSSION

The cluster analysis resulted in three ideal groups (Figure 2). The definition is based on the significant reduction of the total sum of squares, meaning that increasing the number of groups does not improve the representation of homogeneity.

Figure 2 - Graph of the optimal number of groups for annual total rainfall data in Minas Gerais, defined as three (3).

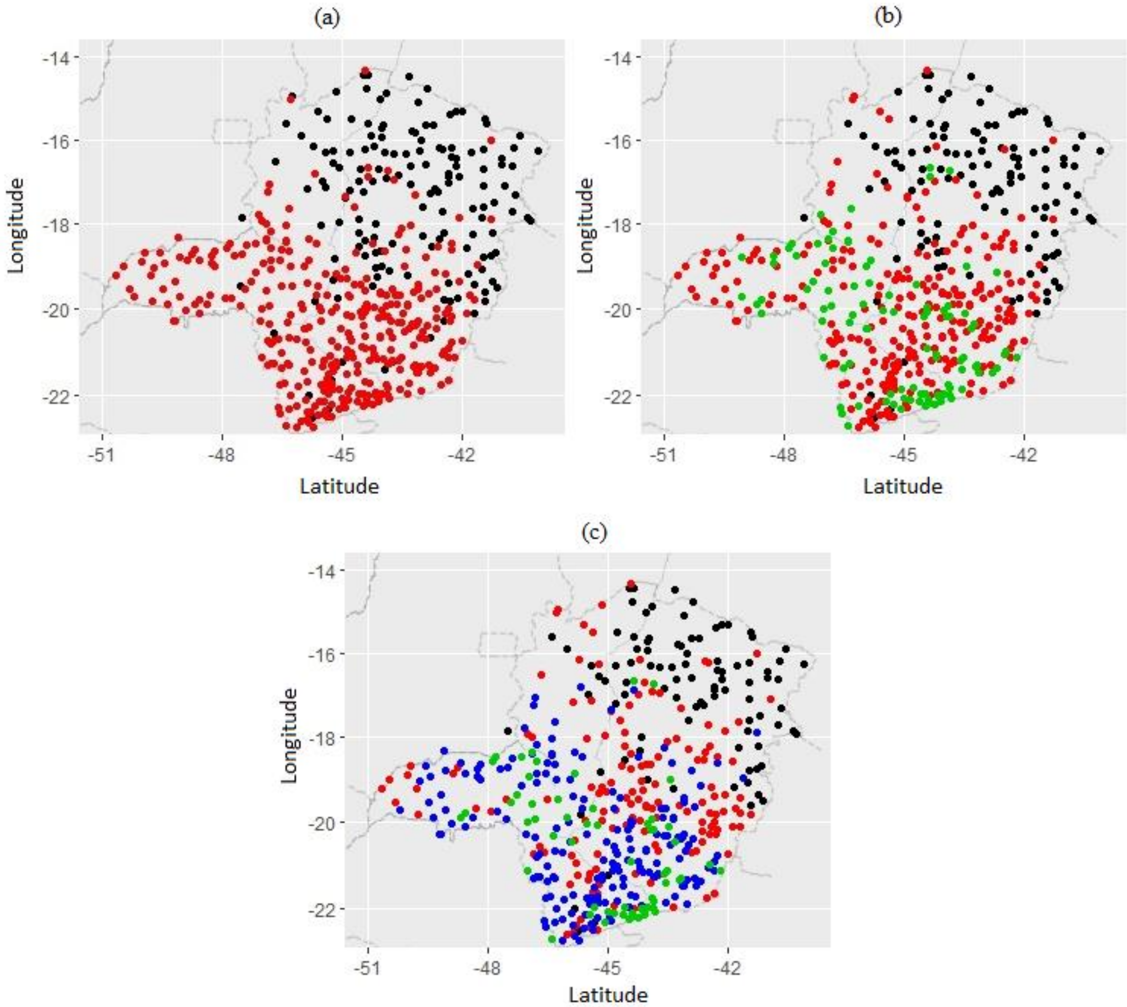


Source: Elaborated by the authors (2021).

The hydrologically homogeneous regions were then identified using the Stats package (R Core Team, 2018) and the k-means algorithm, which resulted in the clusters shown in the maps of Minas Gerais in Figure 3, indicating two (a), three (b) and four (c) groups. It is important to note that the groups formed are not perfectly outlined; therefore, subjective adjustments were necessary, as recommended by Hosking and Wallis (1997).

Dantas and Pinto (2011) and Davis and Naghettini (2000) made subjective adjustments to better delineate homogeneous regions using previously adjusted data, relief characteristics, vegetation and rainfall-forming processes for the state of Rio de Janeiro and the São Francisco river basin, respectively. Yin *et al.* (2016), in their study in China, also used the k-means algorithm and subsequently made subjective adjustments to obtain better-delimited regions.

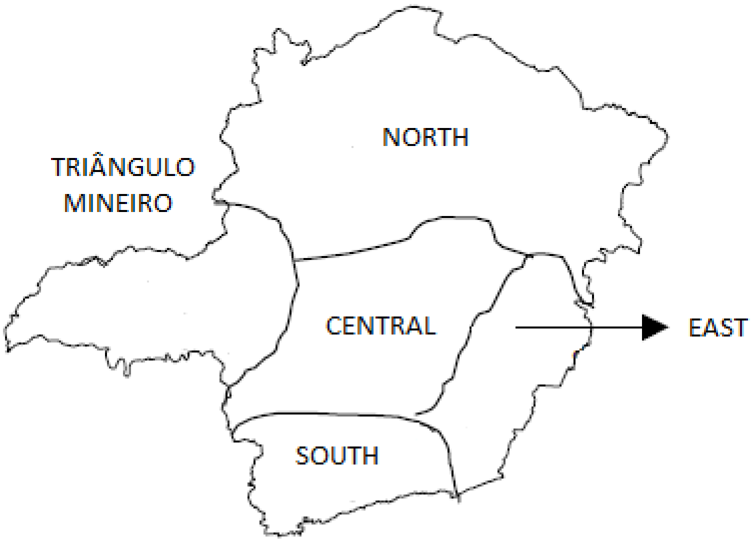
Figure 3 - Maps of homogeneous regions in Minas Gerais with clusters generated in R two (a), three (b) and four (c) homogeneous groups.



Source: Elaborated by the authors (2021).

Several criteria were considered when performing subjective adjustments. First, a permanent cluster in the northern region of the state was visually observed to remain constant in (a), (b) and (c). This was observed for the black dots in Figure 3 and thus the first of three homogeneous groups was defined. The rest of the state showed no visual trend; therefore, the criterion used followed Mello et al. (2003) and separated Minas Gerais into regions according to the climate differences observed for the prediction of the design rainfall shown in Figure 4.

Figure 4 - Map of Minas Gerais and its respective regions.



Source: Adapted from Mello *et al.* (2003).

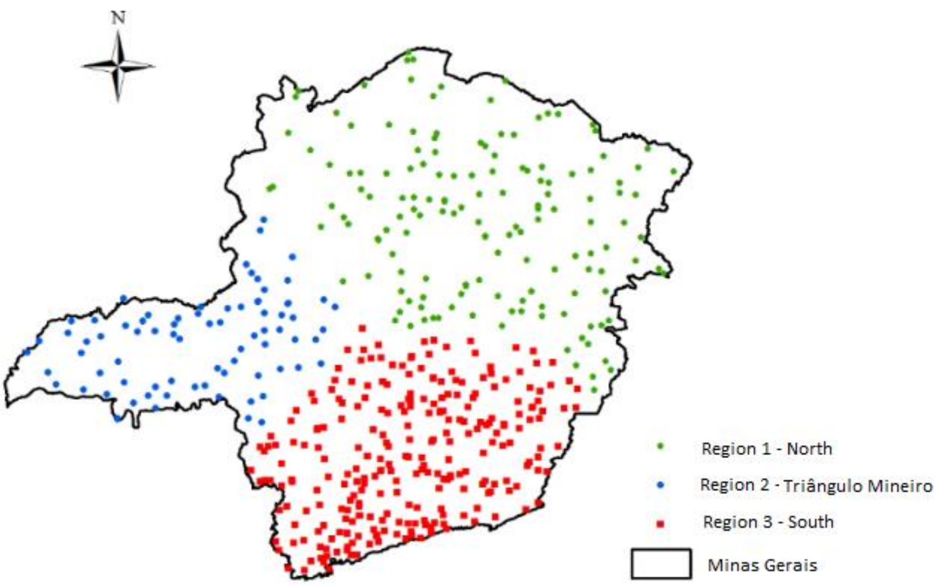
Using the map presented in Figure 4, the second homogeneous group, the Triângulo Mineiro, was defined. The remainder of the state was considered unique and was defined as the last homogeneous group because the ideal number of groups was three, as shown in Figure 2. The following homogeneous regions were thus formed:

1) North: characterized by the rare presence of large mountain ranges, a climate tending toward semi-arid with typical cerrado and caatinga vegetation cover (MELLO *et al.*, 2003), climate classification predominantly Aw and with small areas of type Am, Bsh and Bwh, according to Sá Junior (2009), Machado (2014),

Reboita *et al.* (2015) and Martins *et al.* (2018) and average total annual precipitation of 989 mm;

2) Triângulo Mineiro: region with typical plateau relief, with an average altitude of 752 m, ranging from 428 m in the municipality of Limeira do Oeste to 1120 m in the Serra do Salite, with cerrado vegetation cover (MELLO *et al.*, 2003, Novais, 2011), climate classification Aw and Cwa, according to Sá Junior (2009), Machado (2014), Reboita *et al.* (2015) and Martins *et al.* (2018) and a mean annual total rainfall of 1,386 mm;
3) South: a region of significant relief and mountain ranges with vegetation cover ranging from Atlantic forest remnants to cerrado (MELLO *et al.*, 2003), Cwa and Cwb climate classifications, according to Reboita *et al.* (2015), and a mean annual total rainfall of 1,394 mm.

Figure 5 - Map of Minas Gerais with the three hydrologically homogeneous regions obtained from the cluster analysis and subjective analysis**.**



Source: Adapted from Mello *et al.* (2003).

The results shown in Table 1 refer to the Scott-Knott significance test performed in SISVAR. The results of this test indicate high significance between the three regions (a1, a2 and a3 for regions 1, 2 and 3, respectively), indicating that the regions are hydrologically homogeneous.

Table 1 - Report provided by SISVAR for the significance test of regions 1, 2 and 3.

Regions	Test results
1 - North	a1
2 - Triângulo Mineiro	a2
3 - South	a3

Source: Elaborated by the authors (2021).

After the regional heterogeneity tests, Dantas and Pinto (2011) found that the São Francisco River basin is a unique homogeneous region, while Davis and Naghettini (2000) divided Rio de Janeiro into four homogeneous regions, following similar methods to those of Yin *et al.* (2016) in their study in China. The parameters of the regional IDF ratios obtained are contained in the IDF ratio equations in Table 2.

Table 2 - Regional IDF ratios with their respective r^2 ($i = mmh^{-1}$; t = min, TR = years).

Homogeneous Regions	Regional IDF ratio	r^2
1 – North	$i = \frac{575.5021\ TR^{0.3055}}{(t + 7.6622)^{0.6514}}$	0.9947
2 - Triângulo Mineiro	$i = \frac{617.6256\ TR^{0.3079}}{(t + 7.6513)^{0.6511}}$	0.9946
3 – South	$i = \frac{285.2976\ TR^{0.3080}}{(t+ 1.9002)^{0.4724}}$	0.9199

Source: Elaborated by the authors (2021).

To determine whether the fit found for the observed and calculated rainfall intensities was satisfactory, the r^2 values were calculated (Table 2). As shown in Table 2, the r^2 values were close to 1, indicating a good fit of the regional equation.

The regional quantiles were obtained ($\mu_{(t,TR)}$) using Equation 3, and the regional IDF ratio and the regional mean rainfall intensities are presented in Tables 3, 4 and 5 for the North, Triângulo Mineiro and South regions, respectively.

Table 3 - Regional quantiles ($\mu_{(t,TR)}$) or Index-Flood for different rainfall return times (TR) and duration (t) for region 1 (North).

TR (year)	t (min)											
	1440	720	600	480	360	60	30	25	20	15	10	5
5	2.338	2.153	2.017	1.863	1.679	1.706	1.688	1.696	1.699	1.679	1.707	1.683
10	2.889	2.661	2.493	2.302	2.075	2.108	2.086	2.096	2.100	2.075	2.109	2.080
25	3.823	3.520	3.299	3.046	2.746	2.789	2.760	2.774	2.778	2.745	2.790	2.752
50	4.724	4.350	4.077	3.764	3.393	3.447	3.411	3.428	3.433	3.392	3.449	3.402
100	5.839	5.376	5.038	4.651	4.193	4.260	4.216	4.236	4.243	4.193	4.262	4.204

Source: Elaborated by the authors (2021).

Table 4 - Regional quantiles ($\mu_{(t,TR)}$) or Index-Flood for different rainfall return times (TR) and duration (t) for region 2 (Triângulo Mineiro).

TR (year)	t (min)											
	1440	720	600	480	360	60	30	25	20	15	10	5
5	2.342	2.156	2.020	1.865	1.681	1.707	1.689	1.698	1.700	1.680	1.708	1.685
10	2.899	2.669	2.501	2.309	2.081	2.113	2.091	2.101	2.104	2.080	2.114	2.085
25	3.844	3.539	3.316	3.061	2.760	2.802	2.773	2.786	2.790	2.758	2.803	2.765
50	4.758	4.380	4.105	3.790	3.416	3.469	3.433	3.449	3.454	3.414	3.470	3.423
100	5.890	5.422	5.081	4.691	4.229	4.294	4.249	4.270	4.276	4.226	4.296	4.237

Source: Elaborated by the authors (2021).

Table 5 - Regional quantiles ($\mu_{(t,TR)}$) or Index-Flood for different rainfall return times (TR) and duration (t) for region 3 (South).

TR (year)	t (min)											
	1440	720	600	480	360	60	30	25	20	15	10	5
5	4.176	3.406	3.093	2.748	2.360	1.833	1.694	1.682	1.665	1.634	1.666	1.712
10	5.170	4.217	3.829	3.403	2.922	2.269	2.097	2.082	2.062	2.022	2.063	2.119
25	6.856	5.592	5.078	4.512	3.874	3.009	2.781	2.760	2.734	2.682	2.735	2.810
50	8.487	6.923	6.286	5.586	4.796	3.726	3.443	3.417	3.385	3.320	3.386	3.479
100	10.507	8.570	7.782	6.915	5.938	4.612	4.262	4.231	4.190	4.110	4.192	4.307

Source: Elaborated by the authors (2021).

Tables 3, 4 and 5 show that the regional quantiles ($\mu_{(t,TR)}$) increase as the rainfall return time and duration increase, consistent with the results of Dantas and Pinto (2011) and Davis and Naghettini (2000). For region 1, the values ranged from 1.68338 to 5.83867, for region 2 the values ranged from 1.68463 to 5.89027, and for region 3, the values ranged from 1.71170 to 10.50737. This increase is related to the increased risk posed by intense rainfall as its duration increases.

The second stage consisted of obtaining the maximum regional rainfall intensity equations ($\overline{i_d}$), shown in Table 6. The r² values close to 1 indicate that the fit for all equations was satisfactory.

Table 6 - Maximum regional rainfall intensity equations and respective r² ($\overline{i_d}$= mm h^{-1}; t = min; P = mm).

Homogeneous Regions	Maximum regional rainfall intensity equation	r²
1 - North	$\overline{i_d} = 64.2419\ t^{-0.4653}\ P^{0.1922}$	0.9686
2 - Triângulo Mineiro	$\overline{i_d} = 23.9628\ t^{-0.4653}\ P^{0.3296}$	0.9713
3 - South	$\overline{i_d} = 28.7623\ t^{-0.4653}\ P^{0.2995}$	0.9664

Source: Elaborated by the authors (2021).

By associating the equations in Table 6, the regional quantiles of tables 3, 4 and 5 and the local mean annual rainfall values (P), it is possible to estimate the intense rainfall ($i_{(t,TR,j)}$) or local IDF ratio using Equation 5; this value can then be used as the design rainfall value for the dimensioning of hydraulic works. The final regional IDF ratios are:

1) North: $i_{(t,TR,j)} = \left(64.2419\ t^{-0.4653}\ P^{0.1922}\right)\mu_{(t,TR)}$;
2) Triângulo Mineiro: $i_{(t,TR,j)} = \left(23.9628\ t^{-0.4653}\ P^{0.3296}\right)\mu_{(t,TR)}$;
3) South: $i_{(t,TR,j)} = \left(28.7623\ t^{-0.4653}\ P^{0.2995}\right)\mu_{(t,TR)}$.

The variations in A (23.9628 to 64.2419), B (0.4653) and C (0.1922 to 0.3296) are consistent with the ranges determined for Rio de Janeiro (A: 16.204 to 85.264; B: 0.339 to 0.789 and C: 0.234 to 0.564) by Davis and Naghettini (2000). This regionalization allows a simplified calculation of design rainfalls in Minas Gerais and contributes to the optimization of the hydrological studies necessary for correct dimensioning of rainwater drainage systems and erosion control in agricultural areas.

4. CONCLUSIONS

The regionalization of the state of Minas Gerais resulted in three highly significant hydrologically homogeneous regions, namely, the North, Triângulo Mineiro and South regions (a1, a2 and a3), which indicates that these regions have different characteristics.

The parameters adjusted for the regional IDF ratios and the Index-Flood values showed a good fit of the data, evidenced by the high r^2 values (higher than 98%). This finding indicates that the regional maximum average precipitation intensities can be obtained from the relationships generated in this work, especially in locations where rainfall data is not collected.

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