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Selection of Hydrological Probability Distributions for Extreme Rainfall Events in the Regions of Colombia

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Abstract: Frequency analysis of extreme events is used to estimate the maximum rainfall associated with different return periods and is used in planning hydraulic structures. When carrying out this type of analysis in engineering projects, the hydrological distributions that best fit the trend of maximum 24 h rainfall data are unknown. This study collected maximum 24 h rainfall records from 362 stations distributed throughout Colombia, with the goal of guiding hydraulic planners by suggesting the probability distributions they should use before beginning their analysis. The generalized extreme value (GEV) probability distribution, using the weighted moments method, presented the best fits of frequency analysis of maximum daily precipitation for various return periods for selected rainfall stations in Colombia.

Keywords: maximum rainfall; Colombia; regionalization; probability distribution

1. Introduction

Frequency analyses of extreme events are used to estimate maximum rainfall associated with different return periods [1–3], and their results are used to plan stormwater network projects, longitudinal dikes, overflows, drainage channels, cofferdams, gutters, circular and box culverts and bridges, among other infrastructure works [4,5]; they can also be used to carry out erosion analysis in hydrographic basins [6].

In recent years, due to the influence of global warming as well as changes in the magnitude and patterns of extreme precipitation events, it is necessary to periodically update the magnitudes of the maximum rainfall that are used to design hydraulic works [7]. In particular, extreme weather events such as floods, droughts and storms can increase in frequency over time [8–10]; thus, it is necessary to determine probability functions that best represent current trends in the data.

In Colombia, there are several meteorological factors that influence the climate and therefore the maximum precipitation over a 24 h period, among which are: (i) the relative position of subtropical high pressure centers, (ii) the equatorial convergence zone, (iii) the intertropical front, (iv) the prevailing winds, and (v) the effects of the local topography [11]. It is recommended that each region be analyzed (Andean, Caribbean, Pacific, Orinoquía and Amazonas) to take into account the geographic variability in maximum precipitation. The Institute of Hydrology, Meteorology and Environmental Studies (Instituto de Hidrología, Meteorología y Estudios Ambientales - IDEAM) is the governmental entity in Colombia that operates and manages the maximum 24 h rainfall records.

However, regional autonomous corporations are also responsible for compiling hydroclimatological records.

When carrying out projections of maximum rainfall associated with specific return periods, it is necessary to perform frequency analysis [12–14]. In frequency analysis of extreme precipitation events, the hydrological probability distribution that best represents the trend of maximum 24 h rainfall data can be determined using functions such as the generalized extreme value (GEV) [15], Gumbel [1,3,13], log-Pearson type III [1,16], normal [3] and Pearson type III [17]. The parameters of the probability distributions are determined mainly by applying the method of maximum likelihood (ML) or the method of weighted moments (WM) [3,18]. To select the probability distribution function that best fits the trend of the data, different goodness of fit tests are usually used, such as the chi-square test or the Kolmogorov-Smirnov test [19–21]. The ML method uses a lot of calculations for determining parameters of hydrological distributions. Despite, the WM method is simpler than the ML method; it provides a good accuracy in the estimation parameters. In this sense, Mahdi & Cenac [22] showed that the Gumbel probability distribution was fitted adequately using the WM method than the ML method. A similar analysis showed how the WM method predicted better the behavior of extreme values using the GEV and Log-Pearson Type III distributions than the ML method; however, the Log-Normal distribution with the ML method provides the best prediction [23]. The Log-Pearson III distribution uses the SAM method for estimating parameters of extreme values.

Typically, to design hydraulic structures, a return period must be selected that varies between 5 and 100 years depending on the importance of the structure. In Colombia, Resolution 0330 of 2017 [24] outlines the return periods that should be used for urban drainage projects, the Manual on Drainage Design for Highways [25] provides the values for road works, and international recommendations are often used for other types of structures. An inadequate selection of a hydrological distribution could oversize or undersize a hydraulic structure, then the current research provides a starting point for selecting hydrological distributions since there has not been any official recommendation.

However, the probability distribution that should be used to make the statistical projections is never known a priori [26]. Therefore, in this study, we analyzed 362 stations with 24 h maximum rainfall records distributed throughout Colombia. The most representative probability distributions in each region of Colombia were selected and analyzed using the Gumbel, log-Pearson type II, Pearson, normal and GEV distributions and the chi-squared goodness of fit test. This study can be used by designers and engineers to determine a priori the hydrological distribution that should be used in a particular project.

2. Case Study

Colombia was selected as a case study (Figure 1) to determine the hydrological distributions that best represent the trend in the maximum 24 h rainfall data. During the compilation of the maximum 24 h rainfall records in Colombia, the following aspects were taken into account for each station: a minimum recording period of 30 years, eliminating outliers, using the entire available recording period and ensuring that the stations were distributed throughout each of the five regions that make up Colombia (Caribbean, Pacific, Andean, Orinoquía and Amazonas).

Table 1 and Figure 2 show the number of stations analyzed in Colombia. The maximum 24 h rainfall records were obtained from the IDEAM (Institute of Hydrology, Meteorology and Environmental Studies), which is the more important database in Colombia for collecting rainfall records. The stations in each region were selected to ensure they were distributed over the entire study area and had at least 30 years of records.

Table 1. Number of stations in each region.

Region	Number of Rainfall Stations	Percentage of Used Rainfall Stations (%)	Location of Rainfall Stations by Departments of Colombia
Andean	250	69	Antioquía, Boyacá, Caldas, Cauca, Cundinamarca, Huila, Quindío, Risaralda, Santander, Tolima
Caribbean	59	16	Atlántico, Bolívar, César, Córdoba, Magdalena, San Ándres y Providencia, Sucre
Pacific	37	10	Valle, Cauca
Orinoquía	11	3	Arauca, Vichada, Meta, Casanare
Amazonas	5	2	Vaupés, Putumayo, Guaviare, Amazonas, Caquetá
Total	362	100	N/A

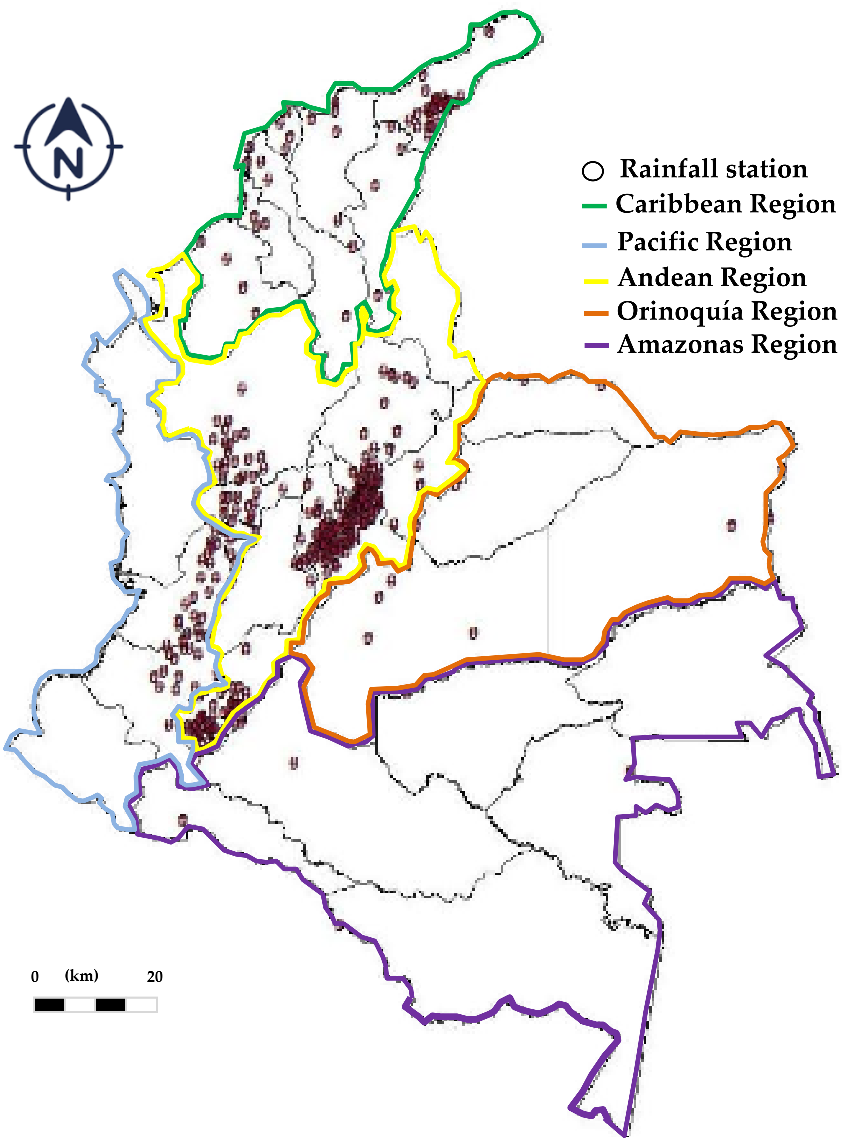

Figure 1. Location of rainfall stations used in the study.

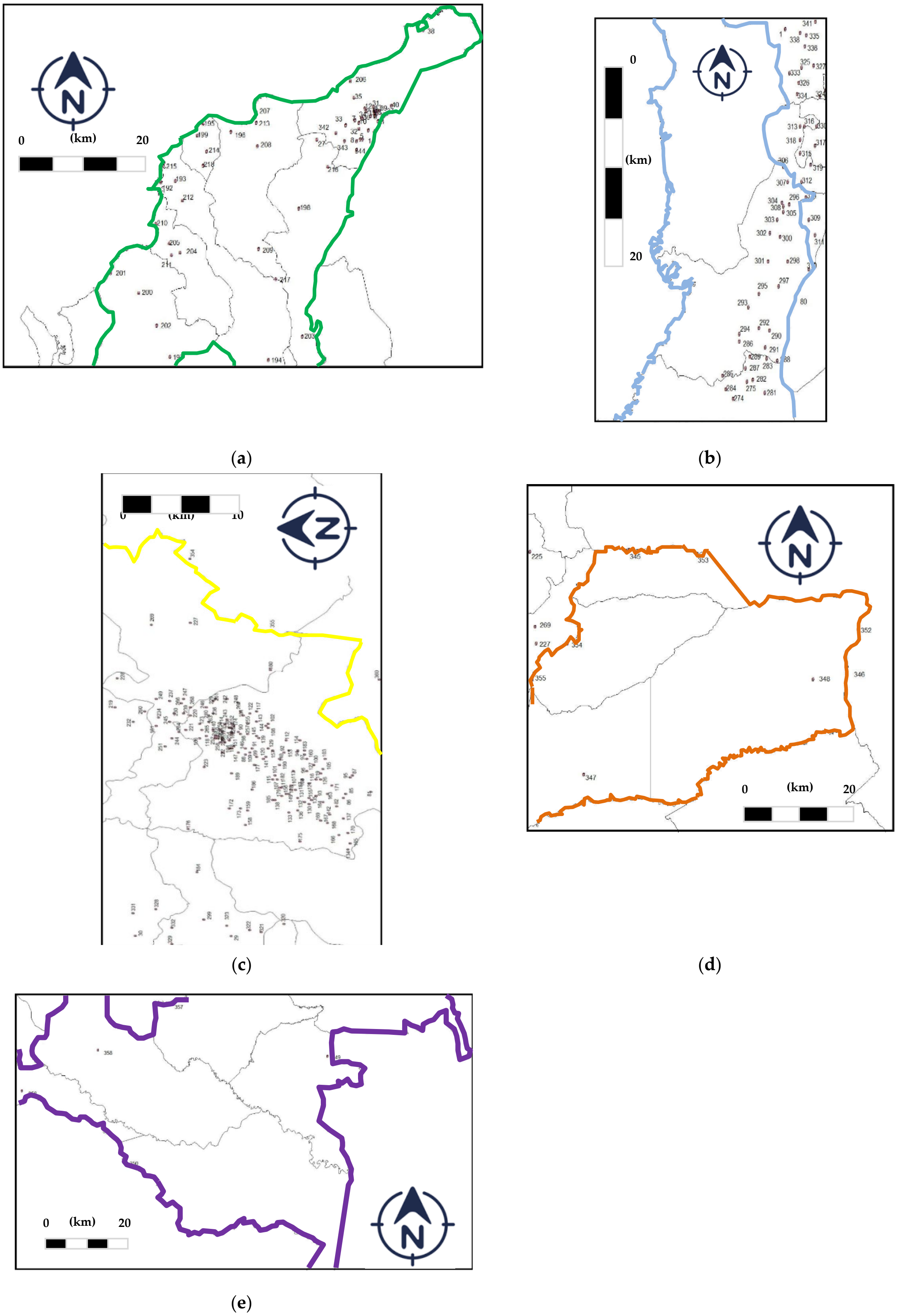

Figure 2. Location of rainfall stations in each region. (**a**) Caribbean Region; (**b**) Pacific Region; (**c**) Andean Region; (**d**) Orinoquía Region; (**e**) Amazonas Region.

The results of Table 1 show that the Andean region represents 69% of the stations compiled, the Caribbean region 16%, the Pacific region 10% and the Orinoquía and Amazonas regions 3% and 2%, respectively. It is important to bear in mind that the regions with the lowest percentage of stations used in the present study (Orinoquía and Amazonas) also have the fewest stations installed.

Appendix A shows the codes of the stations with maximum 24 h rainfall data. Figure 2 shows the distribution of the stations used in each region of Colombia.

3. Methodology

The methodology used to determine the hydrological distribution that best represents the trends in 24 h maximum rainfall data associated with different return periods is presented as follows.

3.1. Selection of Rainfall Stations

The 24 h maximum rainfall records were collected from 362 rainfall stations distributed across Colombia (see Appendix A). Once the 362 stations with maximum rainfall records were selected, the error percentage of the selected stations with respect to the total installed stations in Colombia was 7determined. The equation used for a finite population is shown below [27]:

$$e = \sqrt{\frac{\frac{N z_\alpha^2 pq}{n} - z_\alpha^2 pq}{N-1}} \quad (1)$$

where

n = sample size, compiled from 362 stations;

N = population size, of 2977 stations installed by IDEAM;

α = the level of confidence chosen, assumed at 95%;

Z_α = z value (where z is a normal centered and reduced variable), which leaves a proportion of the individuals out of the interval $\pm Z_\alpha$;

p = proportion at which the variable studied occurs in the population;

$q = 1 - p$. The most critical condition was assumed ($p = q = 0.5$);

e = estimation error.

Taking into account each of the previous variables, an estimation error of 4.83% was obtained.

3.2. Frequency Analysis

For each of the 362 stations, the annual series of maximum precipitation values was adjusted over 24 h with the Gumbel, GEV, Log-Pearson, Pearson and Normal probability distributions using the Hyfran Version 1.1 program [28].

- Gumbel distribution

The Gumbel distribution has typically been used to adjust the maximum 24 h precipitation values for different return periods. Parameters of this function are determined based on the recorded data. Its probability density function is given by:

$$f(x) = \frac{1}{\propto} e^{\left[-\frac{x-u}{\propto} - e^{-\frac{x-u}{\propto}}\right]} \quad (2)$$

where

$f(x)$: probability density function

x: random variable

u: mean of the data

$\propto$: scale parameter

- GEV distribution

The generalized extreme value distribution is widely used by hydrologists worldwide and in Colombia due to its versatility.

$$f(x) = \frac{1}{\propto}\left[1 - \frac{k}{\propto}(x-u)\right]^{\frac{1}{k}-1} e^{-\left[1-\frac{k}{\propto}(x-u)\right]^{1/k}} \quad (3)$$

where

k: shape parameter.

If $k = 0$, then the Gumbel distribution is obtained (see Equation (2)).

- Pearson type III distribution

This distribution is characterized by taking the gamma function to perform the frequency analysis and has three parameters that must be determined when performing the probabilistic adjustment.

$$f(x) = \frac{1}{|\propto|\gamma(k)} \left(\frac{x-\beta}{\propto}\right)^{k-1} e^{\left[-\left(\frac{x-\beta}{\propto}\right)\right]} \tag{4}$$

where

γ: gamma function.

β: location parameter.

- Log-Pearson type III distribution

By taking the natural logarithm of the Pearson type III distribution, the following distribution is obtained, which also consists of three parameters:

$$f(x) = \frac{1}{|\propto|x\gamma(k)} \left[\frac{\ln x-\beta}{\propto}\right]^{k-1} e^{\left[-\frac{\ln x-\beta}{\propto}\right]} \tag{5}$$

- Normal distribution

The Normal distribution can be applied for estimating maximum daily precipitation for several return periods:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{\left\{-\frac{(x-\mu)^2}{2\sigma^2}\right\}} \tag{6}$$

where,

σ and μ are the parameters of the distribution.

3.3. Goodness of Fit Test and Methods of Estimation of Parameters

The chi-squared test was used as a measure of goodness of fit to evaluate whether the probability distribution adequately fit the trend of the data.

$$X^2 = \frac{\sum_i^n (R_i - M_i)^2}{M_i} \tag{7}$$

where

X^2: value of the chi-square test,

R_i: recorded value,

M_i: modeled value.

To adjust the parameters of each probability function, the methods of the ML, WM, and SAM were employed using the Hyfran program.

The methods of estimation of parameters were used for the following hydrological distributions: the GEV distribution, the ML and WM; the Gumbel distribution, the ML and WM; the Pearson Type III distribution, the ML and WM; the Log-Pearson Type III distribution, the SAM; and the Normal, the ML.

3.4. Selection of Hydrological Distribution

To select the best hydrological distribution the following analysis was conducted:

- For each rainfall stations the mean, maximum and minimum values, and standard deviation of the chi-squared test were computed for the Gumbel-ML, Gumbel-MV, Log-Pearson Type III-SAM, Pearson Type III-ML, Pearson Type III-WM, Normal-ML, GEV-ML and GEV-WM. These eight methods were used because they have adequately fitted the trend of maximum daily precipitation in various publications [22,23]. Based on this analysis, a regional mean value of the chi-squared test for Colombia was calculated based on the number of stations using a weighted mean.
- Estimation of percentage that establishes times where a hydrological distribution reaches the best fits of the trend of maximum daily precipitation records considering the minimum value of the chi-squared test.

4. Analysis of Results

This section presents the results that determine which probability density function best fits the 24 h maximum rainfall data of the 362 stations located in Colombia and should therefore be included in the maximum precipitation projections associated with different return periods. The error percentage of the selected rainfall stations was computed using Equation (1), obtaining a value of 4.83% based on the total number of rainfall stations of the IDEAM database.

Taking into account the methodology previously presented, the results presented in Table 2 were obtained. The results should be interpreted in a way that allows planners to know a priori the hydrological distributions that can occur in the regions of Colombia to save calculation time.

Table 2. Adjustments for the hydrological probability distribution.

Region	**Sta.**	**Probability Distribution**							
		Gum ML	**Gum WM**	**LP SAM**	**Pea ML**	**Pea WM**	**Nor ML**	**GEV ML**	**GEV WM**
		Values of the Chi-Squared Test							
Andean	Me	5.85	5.63	6.40	45.01	7.09	8.04	5.11	4.60
	Mx	24.60	25.78	273.0	360.0	252.0	64.9	27.6	18.2
	Mn	0.26	0.26	0.36	0.26	0.29	0.29	0.29	0.29
	Sd	4.30	4.13	18.55	77.43	17.89	7.63	4.05	3.52
Caribbean	Me	7.72	5.64	16.81	91.57	6.34	7.41	5.41	5.18
	Mx	26.12	20.61	287.0	392.0	27.22	42.5	12.9	14.8
	Mn	0.43	0.74	0.89	0.89	0.50	0.89	0.89	0.50
	Sd	5.08	3.72	50.57	111.0	4.67	6.35	3.04	3.48
Pacific	Me	9.85	8.89	9.06	48.21	8.16	9.87	8.13	7.52
	Mx	22.42	25.52	20.40	280.0	24.89	23.9	17.8	16.4
	Mn	1.66	1.46	0.92	0.80	0.80	2.00	0.80	1.20
	Sd	5.25	6.00	5.19	91.97	5.47	5.97	4.44	4.26
Orinoquía	Me	13.91	8.09	33.49	102.1	7.35	9.24	8.89	6.31
	Mx	34.48	16.62	252.0	252.0	20.97	20.9	31.6	13.7
	Mn	4.15	2.42	2.64	4.11	3.00	3.68	1.50	1.50
	Sd	9.06	3.99	72.82	101.1	5.31	5.60	9.03	3.83
Amazonas	Me	6.64	6.32	87.14	183.0	4.93	6.70	4.37	4.36
	Mx	15.50	17.62	416.0	416.0	7.50	11.7	7.00	7.50
	Mn	1.60	0.92	1.46	4.00	1.46	0.38	1.46	1.46
	Sd	5.83	6.71	183.9	171.1	2.28	4.09	2.24	2.70
Regional mean for Colombia based on the number of stations	Me	6.82	6.05	10.31	56.57	7.06	8.14	5.57	5.04

Conventions	Gum: Gumbel	
Sta.: Statistic	LP: Log-Pearson III	ML: Maximum likelihood
Me: mean	Pea: Pearson III	WM: Weighted moments
Mx: maximum	Nor: Normal	SAM: SAM method
Mn: minimum	GEV: Generalized extreme value	
Sd: standard deviation		

Based on the results in Table 3 the following can be deduced:

- In all regions of Colombia, the best fits of the chi-squared test were obtained with the GEV probability distribution. The weighted moment method best fits the parameters for this distribution and has an average regional value for Colombia of 5.04. There are other probability distributions that also fit the trend of the data similarly well: GEV with the maximum likelihood method, Gumbel with the weighted moment and maximum likelihood methods and Pearson's with the method of weighted moments. The Gumbel distribution using the WM method brings a better estimation of maximum daily precipitation for several return periods in comparison with the ML, obtaining a similar result reported in the literature [22].

- In Colombia, the poorest fits were obtained when employing the Pearson type III probability distribution with the maximum likelihood method, where an average value of the chi-square test of 56.57 was obtained, and the log-Pearson type III distribution with the SAM method which had a value of 10.31. This finding is also verified by analyzing the maximum and minimum values and the standard deviation in these probability functions.
- In the Amazonas region, the best fit in the chi-squared test was obtained with the GEV probability distribution and the weighted moment method, with a value of 4.36. This value may have been obtained because few stations were used in the analyses.

Table 3 shows values of chi-squared test for a sample of rainfall stations in Colombia in order to show how a hydrological distribution is selected in each rainfall station. The green cells represent the obtained minimum values that best fits a hydrological distribution. It is of utmost important to mention that a rainfall station can be represented by various hydrological distributions, for instance, Doña Juana rainfall station (Andean region) can be simulated using the Gum-WM, LP-SAM, Pea-ML, Pea-WM, GEV-ML, and GEV-WM since these present a chi-squared value of 1.53.

Table 3. Values of chi-squared test for a sample of rainfall stations.

Station	Code	Region	Gum ML	Gum WM	LP SAM	Pea ML	Pea WM	Nor ML	GEV ML	GEV WM
Doña Juana	2120630	Andean	2.79	1.53	1.53	1.53	1.53	3.42	1.53	1.53
Apto Rafael Núñez	1401502	Carribean	7.71	7.71	7.43	7.43	4.57	7.14	7.14	7.71
El Placer	2610069	Pacific	5.51	3.87	7.56	7.97	5.92	19.87	9.21	7.56
Santa Rita	3306001	Orinoquía	10	7.00	5.00	168.00	5.00	5.00	7.00	5.50
Puerto Asis	4701003	Amazonas	15.5	5.46	416	416	5.46	6.15	5.46	5.46

Table 4 shows, for a hydrological distribution, the best agreement using the minimum value of the chi-squared test considering the ML, MP, or SAM methods, which are marked in blue cells. Andean, Caribbean, Pacific, and Orinoquía regions were adjusted appropriately by the GEV distribution (using ML or WM method) with percentages of 52, 44, 54, and 73%, respectively, which implies the percentage of rainfall stations where the GEV distribution reaches the minimum value of chi-squared test (best agreement). The Gumbel and Pearson Type III fit adequately the parameters in the Amazonas region with a value of 60%. The GEV distribution presents the best fit with an overall value of 52%. Results are in agreement with the study conducted by Gonzalez-Alvarez et al. (2019) for the Caribbean region [24].

Table 4. Selection of a hydrological distribution based on the minimum value of chi-squared test.

Region	Total Used Rainfall Stations	Reached Percentage of Hydrological Distributions				
		GEV	Gum	Pea	LP	Nor
Andean	250	52%	36%	31%	28%	22%
Caribbean	59	44%	42%	32%	20%	27%
Pacific	37	54%	30%	43%	19%	22%
Orinoquía	11	73%	18%	36%	27%	27%
Amazonas	5	40%	60%	60%	20%	20%
Total	**362**	52%	36%	33%	25%	23%

Since the Gumbel distribution corresponds to the scenario when the parameter $k = 0$ for the GEV distribution, then the percentage when both the Gumbel and GEV distribution is achieved using ML and WM methods is shown in Table 5. According to the analyzed sample, the 74% of rainfall stations in Colombia can be simulating using these hydrological distributions since the minimum values of the chi-squared test are reached.

Table 5. Percentages for GEV and Gumbel distributions.

Region	Total Used Rainfall Stations	GEV and Gum
Andean	250	74%
Caribbean	59	73%
Pacific	37	73%
Orinoquía	11	82%
Amazonas	5	60%
Total	362	74%

To know the actual ranges of maximum daily precipitation for various return periods and the spatial variability in each region, the GEV distribution was applied to the analyzed rainfall stations. A summary of extreme values is presented in Table 6. Considering a return period of 100 years, the minimum value is reached in Andean region with a value of 42.6 mm (gray cell); and the maximum value is obtained in Caribbean region reaching an extreme precipitation of 306 mm (green cell). It is important to mention that there are no rainfall stations located in all departments in each region: in Andean region, Manizales and Norte de Santander are missing; in Caribbean region, La Guajira; in Pacific region, Chocó and Nariño; and in the Amazonas region, Guainía.

Table 6. Maximum daily precipitation for several return periods using the GEV distribution.

Region	Extreme Values	Return Period				
		5 yr.	10 yr.	25 yr.	50 yr.	100 yr.
Andean	Min	37.4	39.6	41.3	42	42.6
	Max	147	173	218	259	242
Caribbean	Min	64.6	84.3	97.5	99.3	100
	Max	167	199	241	272	306
Pacific	Min	35.3	40.5	47.8	53.9	60.4
	Max	121	135	151	162	172
Orinoquía	Min	119	131	141	145	149
	Max	145	152	186	220	262
Amazonas	Min	124	134	144	150	154
	Max	139	158	183	200	217

5. Conclusions and Recommendations

To estimate the maximum daily rainfall associated with different return periods for a particular project, it is recommended that designers and planners use the following hydrological distributions: the GEV, with the weighted moments and maximum likelihood methods; the Gumbel, with weighted moments and maximum likelihood; and the Pearson, with weighted moments. It is of utmost important to note that the GEV hydrological probability distribution (weighted moments method) best fits the trend of the data in all regions of the country.

For future studies, it is recommended to collect more data in the Amazonas and Orinoquía regions and to apply other goodness of fit tests. Similarly, it is recommended to perform a similar analysis using distributions that analyze non-stationary trends to evaluate the impact of climate effects, where the changes over time of rainfall records can be identified. This kind of analysis should be implemented for all regions in Colombia.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Stations of Maximum Rainfall Accumulated in 24 h.

No.	Code	No.	Code	No.	Code	No.	Code	No.	Code	No.	Code	No.	Code
1	1107013	56	2102002	111	2120112	166	2120637	221	2312009	276	2602025	331	2618019
2	1506001	57	2103003	112	2120113	167	2120639	222	2312012	277	2602503	332	2619010
3	1506002	58	2103005	113	2120115	168	2120640	223	2312014	278	2602507	333	2618502
4	1506004	59	2103006	114	2120133	169	2120641	224	2312019	279	2603003	334	2618504
5	1506005	60	2103008	115	2120134	170	2120644	225	2312024	280	2603005	335	2619009
6	1506006	61	2103009	116	2120136	171	2120646	226	2314502	281	2603007	336	2619502
7	1506007	62	2103011	117	2120138	172	2120647	227	2319070	282	2603503	337	2620012
8	1506008	63	2104001	118	2120141	173	2120652	228	2319511	283	2604026	338	2620507
9	1506009	64	2104002	119	2120156	174	2120659	229	2401002	284	2604031	339	2621007
10	1506010	65	2104003	120	2120159	175	2123502	230	2401011	285	2604501	340	2621008
11	1506011	66	2104004	121	2120166	176	2303502	231	2401015	286	2605006	341	2621009
12	1506013	67	2104005	122	2120167	177	2120046	232	2401018	287	2605027	342	2623013
13	1506014	68	2104006	123	2120168	178	2120049	233	2401020	288	2605507	343	2701077
14	1506015	69	2104007	124	2120169	179	2120139	234	2401021	289	2606003	344	2801020
15	1506016	70	2105006	125	2120170	180	2120151	235	2401024	290	2606020	345	2801028
16	1506018	71	2105007	126	2120172	181	2120189	236	2401026	291	2606502	346	2801029
17	1506020	72	2105014	127	2120173	182	2120691	237	2401027	292	2607011	347	3705001
18	4401503	73	2105027	128	2120174	183	2120611	238	2401028	293	2607076	348	3802002
19	3509510	74	2105029	129	2120176	184	2305504	239	2401029	294	2607501	349	3212001
20	2101005	75	2105502	130	2120177	185	2306014	240	2401030	295	2608007	350	3306001
21	2101006	76	2106004	131	2120178	186	2306019	241	2401031	296	2608501	351	4208001
22	2101010	77	2106007	132	2120179	187	2306033	242	2401033	297	2609523	352	4704003
23	2101011	78	2106008	133	2120180	188	2306034	243	2401035	298	2610030	353	3501006
24	2101004	79	2113006	134	2120181	189	2306507	244	2401036	299	2610069	354	3801003
25	2101013	80	2116501	135	2120182	190	2306516	245	2401037	300	2610077	355	3705005
26	2701507	81	2119022	136	2120183	191	2306517	246	2401038	301	2610079	356	3521001
27	2801013	82	2119046	137	2120184	192	2903037	247	2401039	302	2610511	357	3509004
28	2621502	83	2103010	138	2120185	193	1401502	248	2401042	303	2610516	358	4701003
29	2617026	84	2119026	139	2120186	194	2320503	249	2401043	304	2611004	359	3204002
30	2618020	85	2119047	140	2120187	195	2904023	250	2401044	305	2611006	360	4604001
31	1506027	86	2119514	141	2120188	196	2904502	251	2401046	306	2611007	361	3207001
32	1506504	87	2119515	142	2120190	197	2502516	252	2401049	307	2611011	362	3502006
33	1506505	88	2120026	143	2120193	198	2803504	253	2401051	308	2611012		
34	1506510	89	2120027	144	2120194	199	2904511	254	2401052	309	2611015		
35	1506511	90	2120033	145	2120195	200	1308504	255	2401053	310	2611504		
36	1506512	91	2120043	146	2120213	201	1204502	256	2401054	311	2612015		
37	1506513	92	2120044	147	2120214	202	2502519	257	2401055	312	2612017		
38	1507506	93	2120051	148	2120516	203	2321013	258	2401056	313	2612506		
39	1508011	94	2120055	149	2120525	204	2502508	259	2401057	314	2613018		
40	1508503	95	2120060	150	2120540	205	1309005	260	2401058	315	2613020		
41	2101002	96	2120069	151	2120541	206	1702502	261	2401059	316	2613514		
42	2101008	97	2120071	152	2120548	207	1506501	262	2401068	317	2614009		
43	2101012	98	2120073	153	2120557	208	1501505	263	2401110	318	2614012		
44	2101014	99	2120074	154	2120559	209	2906024	264	2401511	319	2614502		
45	2101016	100	2120075	155	2120561	210	2502530	265	2401515	320	2614503		
46	2101017	101	2120077	156	2120562	211	1309003	266	2401518	321	2615006		
47	2101018	102	2120080	157	2120565	212	2502013	267	2401519	322	2615015		
48	2101019	103	2120085	158	2120629	213	2903004	268	2401520	323	2615511		
49	2101020	104	2120088	159	2120630	214	1501502	269	2401521	324	2616010		
50	2101021	105	2120089	160	2120631	215	2904019	270	2401531	325	2616012		
51	2101022	106	2120096	161	2120632	216	2903078	271	2403041	326	2616016		
52	2101023	107	2120103	162	2120633	217	2803503	272	2405007	327	2617015		
53	2101024	108	2120104	163	2120634	218	1701501	273	2406006	328	2617018		
54	2101025	109	2120106	164	2120635	219	2502509	274	2406503	329	2617019		
55	2101028	110	2120111	165	2120636	220	2903508	275	2602002	330	2618018		

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