ANALYSIS OF THE RELATIONSHIP INTENSITY, DURATION, FREQUENCY OF DISAGGREGATED DAILY RAINFALL IN SOUTHERN RIO GRANDE DO SUL, BRAZIL

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ABSTRACT: The intensity, duration, and frequency relationship (IDF) of rainfall occurrence may be done through continuous records of pluviographs or daily pluviometer values . The objective of this study was to estimate the intensity-duration-frequency relationships of precipitation, using the method of daily rainfall disaggregation, at weather stations located to the southern half of the state of Rio Grande do Sul; comparing them with those obtained by rain gauge records, in places considered homogeneous from the meteorological point of view. The IDF equation parameters were estimated from daily rainfall disaggregation data, using the method of nonlinear optimization. To validate the equations confidence indices and efficiency and the "t" Student test, among maximum intensity values obtained from the disaggregated daily rainfall durations of 10; 30; 60 min and 6; 12 and 24 h and those extracted from existing IDF equations. For all studied stations and return periods, the trust index values were regarded as "optimal", i.e., greater than 0.85. The maximal intensity of rainfall obtained by daily rainfall disaggregation have similarity with those obtained by relations IDF standards. Thus, the method constitutes a feasible alternative in obtaining the IDF relationships.

KEYWORDS: hydrology, daily rainfall disaggregation, heavy rain.

RELAÇÃO INTENSIDADE-DURAÇÃO-FREQUÊNCIA DA PRECIPITAÇÃO PLUVIAL DIÁRIA DESAGREGADA NO SUL DO RIO GRANDE DO SUL

RESUMO: A obtenção da relação intensidade-duração-frequência (IDF) de ocorrência de chuvas pode ser feita mediante registros contínuos de pluviógrafos ou de valores diários de pluviômetros. O objetivo do presente trabalho foi estimar as relações intensidade-duração-frequência de chuva, utilizando a metodologia da desagregação da chuva diária, para estações localizadas na metade sul do Estado do Rio Grande do Sul, comparando-as com as obtidas mediante registros pluviográficos, em locais considerados homogêneos do ponto de vista meteorológico. Os parâmetros da equação IDF foram estimados a partir dos dados de desagregação de chuva diária, utilizando o método de otimização não linear. Para validar as equações, foram utilizados índices de confiança e de eficiência, e o teste “t” de Student, entre os valores de intensidades máximas obtidos a partir da chuva diária desagregada, nas durações de 10; 30; 60 min e 6; 12 e 24 h e aqueles extraídos de equações IDF já existentes. Para todas as estações estudadas e períodos de retorno, os valores do índice de confiança foram considerados “ótimos”, ou seja, maiores do que 0,85. Os valores de intensidade máxima de precipitação pluvial obtidos por desagregação da chuva diária apresentam similaridade com os obtidos por relações IDF padrões. A metodologia de desagregação de chuva diária constitui-se em alternativa viável na obtenção das relações IDF.

PALAVRAS-CHAVE: hidrologia, desagregação da chuva diária, chuva intensa.

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INTRODUCTION

For measuring hydraulic structures such as spillways, drainage channels, soil and water conservation structures, it makes necessary the knowledge of maximum flow value of the watercourse associated with return period to elaborate the project. However, there is a scarcity of historical water flow data. To overcome this problem, hydrological models are used that make the rainfall-flow transformation (DAMÉ et al., 2010), being rain an input data, which is frequently determined by the ratio intensity-duration-frequency occurrence (IDF). However, the IDF relationships are traditionally determined from rain gauge records, which in turn are scarce compared to rainfall data.

The lack of IDF relationships for the current research locality constitutes as limiting factor to estimate a rain project. In this case, the IDF from a location near the project area can be used, as long as it has similar climate conditions (DAMÉ et al . , 2008). Alternatively, according to DAMÉ et al. (2010), is to use a data series of maximum daily rain per year from where the hydrological study will be conducted, and from this, a disaggregation model (Jennings et al., 2010; HANAISH et al., 2011; ENGIDA & ESTEVES, 2011; SAFEEQ & FARES, 2011; ORSINGHER & POLITO, 2012) to obtain rain ranges at sub-daily time intervals.

In Rio Grande do Sul State, there is availability of rainfall data collected in rain gauges that are disaggregated into hourly or lower durations, what allows the establishment of IDF relationships for such locations. For the city of Pelotas - RS, DAMÉ et al. (2008) applied four methods of disaggregation of daily rainfall. For that, they used the historical IDF curve of municipality (GOULART et al., 1992), and the method of relations (DAMÉ et al., 2008; BACK et al., 2012), and the and Bartlett - Lewis Rectangular Pulse Modified Model (BURTON et al., 2008). The authors concluded that the method of relations represented the sample data of maximum intensities for the location (BACK et al., 2012; ARAGÃO et al., 2013).

TEIXEIRA et al. (2011) determined two IDF relationships, one from disaggregated daily data and another from annual series, and found that the values of rain intensity obtained by daily rainfall disaggregation showed no statistical difference compared to those obtained from IDF relation established by GOULART et al. (1992) through rain gauge records.

This study aimed to estimate the intensity-duration-frequency relationships of precipitation, using the method of daily rainfall disaggregation at stations located to the southern half of the state of Rio Grande do Sul, comparing them with those obtained using local rain gauge records that are considered homogeneous from the meteorological point of view.

MATERIAL AND METHODS

We used data of daily rainfall of eleven rainfall stations located in the southern half of Rio Grande do Sul State, obtained from the National Water Agency (ANA) (www.hidroweb.ana.gov.br). Table 1 shows the gauge station descriptions (code, name and county) as well as its geographic coordinates, altitude and number of observation years.

After station selection, the series of annual maximum daily rainfall were set up using the PROCEDA software (Agroclimatological data processing) (VIEGAS FILHO et al., 2004). After series organized, Gumbel distribution parameters (RODRIGUES et al., 2008; ZEILHOFER & MOURA, 2009) were set using the WINSTAT software (MACHADO & CONCEIÇÃO, 2006) for 5; 10; 20; 50 and 100 return periods. To verify the adjustment suitability of the Gumbel model, the adjusted and observed values were plotted onto a probability paper.

For the IDF relationship from precipitation records, we applied the method of daily rainfall disaggregation by TEIXEIRA et al. (2011) for the periods of 10; 30; 60 min and 6; 12 and 24 h. Disaggregation was carried out using the method of relations (CETESB, 1979; ARAGÃO et al., 2013), which is based on two characteristics observed in IDF. These characteristic are when the probability curves for different periods remain in parallel to each other, and the similarity of the relationships between maximum average rainfall of varied durations and locations.

TABLE 1. Description of the gauge stations with their respective geographical coordinates, altitude, and observation period.

Code	Station Name	County	Latitude	Longitude	Altitude (m)	Period (years)
3051004	Cerro Grande	Tapes	30º55'38''	51º45'24''	120	28
3053022	Caçapava do Sul	Caçapava do Sul	30º31'10''	53º29'30''	420	14
3054002	Dom Pedrito	Dom Pedrito	30º58'41''	54º40'33''	120	53
3055003	Fazenda Encerra	Santana do Livramento	30º41'44''	55º58'28''	300	27
3152003	Canguçu	Canguçu	31º24'16''	52º40'24''	400	49
3152004	Cascata	Pelotas	31º28'00''	52º31'00''	224	10
3152005	Vila Freire	Pedro Osório	31º40'10''	52º46'22''	250	25
3152008	Granja São Pedro	Pelotas	31º40'08''	52º10'50''	3	30
3152010	Morro Redondo	Morro Redondo	31º38'00''	52º39'00''	245	10
3252003	Estação do Curtume	Rio Grande	32º26'00''	52º36'00''	4	5
3252008	Granja St. Maria	Rio Grande	32º24'16''	52º33'21''	12	40

From the disaggregated daily rainfall, transformed into average maximum intensity, the equation parameters were adjusted as proposed by MICHELE et al., 2011:

$$I = \frac{KTr^{a}}{(t+b)^{c}} \quad (1)$$

in which,

I - average maximum rainfall intensity, mm h^{-1};

Tr - return period, years;

T - rain duration, min, and

K, a, b, c - equation parameters that must be adjusted to the observed data.

The parameter estimations of intense rainfall equation was performed by minimizing the objective function (fobs - fmod)², using the Solver program from EXCEL digital spreadsheet using nonlinear optimization code, called "Generalized Reduced Gradient".

Validation of analytical equations that represent the IDF relationships was obtained by comparing them with those presented by TEIXEIRA et al. (2011) for Pelotas, RS and PRUSKI et al. (2006) for the other stations, considering the weather similarity among them (Table 2). For both the methods of "t" Student test with n-k degrees of freedom, "n" is the sample size and "k" the number of explanatory variables for the linear and angular coefficients, confidence index (c) were used and adjusted efficiency ratio (E') as CECÍLIO et al. (2009).

The confidence index (c), proposed by PEREIRA et al. (2009), is determined by multiplying the linear correlation coefficient (r) and Willmott index (d). The index is interpreted for such authors as "great" (c > 0.85); "very good" (between 0.76 and 0.85); "good" (between 0.66 and 0.75); "average" (between 0.61 and 0.65), "poor" (between 0.51 and 0.60), "bad" (between 0.41 and 0.50) and "awful" (c < 0.40). In addition to this was used adjusted efficiency coefficient (E'), according to SILVA et al. (2011).

TABLE 2. Intensity, duration, and frequency relationship (IDF) of rainfall occurrence used for validation, for eleven weather station of southern half of Rio Grande do Sul State.

County	Standard IDF	Station name	City
Porto Alegre	$I = \frac{627.54\,Tr^{0.31}}{(t+7.90)^{0.74}}$	Cerro Grande	Tapes
Encruzilhada do Sul	$I = \frac{431.09\,Tr^{0.19}}{(t+3.70)^{0.64}}$	Canguçu Caçapava do Sul	Canguçu Caçapava do Sul
Bagé	$I = \frac{604.90\,Tr^{0.21}}{(t+3.25)^{0.72}}$	Dom Pedrito Fazenda Encerra	Dom Pedrito Santana do Livramento
Rio Grande	$I = \frac{774.14\,Tr^{0.23}}{(t+6.90)^{0.74}}$	Estação do Curtume Granja Santa Maria	Rio Grande Rio Grande
Pelotas	$I = \frac{5684.10\,Tr^{0.10}}{(t+52.23)^{1.01}}$	Cascata Vila Freire Granja São Pedro Morro Redondo Pelotas	Pelotas Pedro Osório Pelotas Morro Redondo Pelotas

I - Average maximum intensity of rainfall (mm h^{-1}); Tr - Return period (years); t - precipitation duration (min).

RESULTS AND DISCUSSION

Table 3 shows the values of maximum daily rainfall obtained for return periods of 5; 10; 20; 50 and 100 years to the study sites, using the Gumbel probabilistic model. Whereas the recommendation of return period for hydro-agricultural works is 10 years (MESQUITA et al., 2009), it can be observed that for the study area, the value of annual maximum daily precipitation ranged from 113.15 mm to 176.97 mm, for Morro Redondo (3152010) and Santana do Livramento (3055003) stations, respectively. It is noteworthy that 3152010 is located in the southern State, while 3055003 in west region, where climatic and meteorological characteristics are distinct. FREIRE et al. (2013) studying the probable maximum precipitation for the municipality of São João do Jaguaribe (EC), at return periods of 2; 5; 10; 20; 50 and 100 years, concluded that proper selection is important for soil conservation areas, design of roads, dam spillways, urban drainage and the best crop to be grown.

From the disaggregation method (BACK et al., 2012) and the maximum daily precipitation data were obtained the precipitation-duration-frequency relationship; and, therefore, equations representing maximum intensity values (Table 4).

TABLE 3. Maximum daily rainfall values (mm) obtained by adjusting the Gumbel probability distribution, considering the return periods (Tr) of 5; 10; 20; 50 and 100 years, for eleven stations in southern half of Rio Grande do Sul State.

Code	Station Name	Tr (years)				
		5	10	20	50	100
3051004	Cerro Grande	113.47	127.87	142.27	161.30	175.70
3053022	Caçapava do Sul	119.25	132.55	145.86	163.45	176.75
3054002	Dom Pedrito	122.13	139.26	156.40	179.06	196.19
3055003	Fazenda Encerra	155.29	176.97	198.65	227.32	249.00
3152003	Canguçu	101.61	113.48	125.34	141.02	152.88
3152004	Cascata	110.77	123.99	137.20	154.67	167.88
3152005	Vila Freire	121.42	135.79	150.17	169.17	183.55
3152008	Granja São Pedro	118.72	134.95	151.18	172.63	188.86
3152010	Morro Redondo	105.81	113.15	120.49	130.19	137.53
3252003	Estação do Curtume	111.00	121.48	131.96	145.81	156.29
3252008	Granja St. Maria	127.69	143.55	159.40	180.35	196.20

Table 5 shows the basic statistical values for parameters "K", "a", "b" and "c" of IDF disaggregation equations estimated by considering the eleven studied sites. Despite these parameters are empirical, that is, without any physical meaning (GENOVEZ & ZUFFO, 2000), the maximum and minimum values were compared and their respective percentage differences, whose higher values occurred for the coefficients "K", "a" and "b", or approximately 110; 100 and 78%, respectively; while "c" showed the smallest difference (23.1%).

TABLE 4. Intensity-duration-frequency relationships derived from daily rainfall disaggregation technique for eleven stations in southern half of Rio Grande do Sul State.

Code	Station name	City	Analitical equation
3051004	Cerro Grande	Tapes	$I = \frac{883.73\, Tr^{0.1427}}{(t + 8.9676)^{0.7164}}$
3053022	Caçapava do Sul	Caçapava do Sul	$I = \frac{838.64\, Tr^{0.1301}}{(t + 7.9668)^{0.6894}}$
3054002	Dom Pedrito	Dom Pedrito	$I = \frac{1362.40\, Tr^{0.1543}}{(t + 12.1859)^{0.8011}}$
3055003	Fazenda Encerra	Santana do Livramento	$I = \frac{1247.18\, Tr^{0.1541}}{(t + 9.3669)^{0.7271}}$
3152003	Canguçu	Canguçu	$I = \frac{838.44\, Tr^{0.1341}}{(t + 9.3677)^{0.7271}}$
3152004	Cascata	Pelotas	$I = \frac{734.21\, Tr^{0.1369}}{(t + 7.5350)^{0.6776}}$
3152005	Vila Freire	Pedro Osório	$I = \frac{1103.94\, Tr^{0.1357}}{(t + 10.2071)^{0.7499}}$
3152008	Granja São Pedro	Pelotas	$I = \frac{1543.18\, Tr^{0.1513}}{(t + 13.4694)^{0.8341}}$
3152010	Morro Redondo	Morro Redondo	$I = \frac{934.11\, Tr^{0.08687}}{(t + 9.3702)^{0.7272}}$
3252003	Estação do Curtume	Rio Grande	$\mathrm{I} = \frac{943.38\, \mathrm{Tr}^{0.1128}}{(\mathrm{t} + 9.3670)^{0.7271}}$
3252008	Granja Santa Maria	Rio Grande	$I = \frac{1218.48\, Tr^{0.0768}}{(t + 9.3661)^{0.7271}}$

I - Average maximum inetsity of rainfall (mm h^{-1}); Tr - Return time interval (years); t - precipitation duration (min).

It is observed that the stations São Pedro (3152008) and Cascata (3152004) showed the largest amplitudes for "K", "b" and "c" parameters, which might be related to the altitude, since stations 3152008 and 3152004 are 3 m and 224 m, respectively. MELLO & SILVA (2009) in order to adjust linear models to rainfall predictions, based on geographical coordinates and altitude in Minas Gerais State, found that relief influences rainfall behavior and including altitude is crucial in rain modeling and mapping, avoiding biased and less precise estimates.

TABLE 5. Basic statistical values of "K", "a", "b" and "c" parameters of IDF relationships estimated by daily rainfall disaggregation.

Statistics	K	a	b	c
Maximum value	1543.18	0.15	13.47	0.83
Minimum value	734.21	0.08	7.54	0.68
Amplitude	808.97	0.08	5.93	0.16
Average	1058.88	0.13	9.74	0.74
Difference (%)	110.18	100.91	78.76	23.10

Estimating IDF equations for Fortaleza (CE) and Pentecoste (PE), RODRIGUES et al. (2008) observed that the equations generated had its specific values for each station parameters, and "K" and "a" parameters of representative general equation for Fortaleza had the respective values of 3458 and 0.193, whereas for Pentecoste the values were 2246 and 0.185, respectively. The authors say that such variations may occur due to the characteristics of hydrological events in semi-arid region of Northeast Brazil, which have high spatial and temporal variability.

Regarding the estimates of IDF equation parameters for eleven stations in southern half of Rio Grande do Sul (Table 4), whose climate is characterized by Köeppen as subtropical, there is also greater amplitude, due to high spatial and temporal variability of rains.

SILVA et al. (2003) found values for the coefficients "K" between 2113.85 and 9989.56 (Natividade and Alvorada stations); "a" from 0.155 to 0.229 (Tupiratins and Araguatins stations); "b" from 30.296 to 71.072 (Natividade and Projeto Rio Formoso stations); and "c" ranged from 0.845 to 1.098 (Natividade and Guaraí stations), respectively. Authors found that for most of stations in Tocantins State, the largest values of "b" are related to higher values of "K", which was also observed in this work. Moreover, they stressed that other combinations of coefficients can be obtained for the relationship between intensity, duration and frequency, without a significant reduction in accuracy.

The results obtained from linear fit ($Y = \beta_0 + \beta_1 X$) between the values of maximum intensity (mm h^{-1}) obtained from IDF curve (PRUSKI et al., 2006) for the eleven stations and return periods of 5, 10, 20, 50 and 100 years are presented in Table 6. It was found that the maximum intensity values obtained of estimated IDFs using the disaggregation technique do not differ from those obtained by PRUSKI et al. (2006). This was observed for all studied return periods; since the calculated statistical "t" values, for gradient (β_1), were lower than the critical value of "t" at 5% probability level.

TABLE 6. Results obtained by linear fit ($Y = \beta_0 + \beta_1 X$) between maximum intensity values (mm h^{-1}) obtained from PRUSKI et al. (2006) for the eleven evaluated stations and return periods of 5; 10; 20; 50 and 100 years.

Station code	Tr (years)	β0	β1	t(β0)	t(β1)	Significance (p) (β0)	Significance (p) (β1)
3051004	5	2.2121	1.1041	2.0030	0.0942	0.0800	0.9272
	10	2.4422	0.9833	2.4827	-0.0170	0.0379	0.9869
	20	2.6962	0.8757	3.0780	-0.1647	0.0150	0.8732
	50	3.0730	0.7512	4.0890	-0.3310	0.0035	0.7491
	100	3.3926	0.6690	4.5115	-0.4404	0.0020	0.6713
3053022	5	1.2472	1.3129	0.9489	0.2381	0.3704	0.8178
	10	1.3650	1.2595	1.0820	0.2058	0.3106	0.8421
	20	1.4938	1.2083	1.2349	0.1722	0.2519	0.8676
	50	1.6830	1.1438	1.4697	0.1256	0.1798	0.9032
	100	1.8419	1.0973	1.6085	0.0850	0.1464	0.9344
3054002	5	4.6178	1.1375	4.0359	0.1202	0.0037	0.9074
	10	5.1390	1.0944	4.6683	0.0857	0.0016	0.9338
	20	5.7191	1.0530	5.3998	0.0500	0.00064	0.9613
	50	6.5875	1.0006	6.5456	0.00060	0.00018	0.9995
	100	7.3310	0.9627	7.2843	-0.0370	0.000085	0.9713
3055003	5	7.9333	1.4235	5.5430	0.2959	0.00054	0.7748
	10	8.8279	1.3695	6.4116	0.2684	0.00021	0.7952
	20	9.8234	1.3171	7.4162	0.2397	0.000075	0.8166
	50	11.3140	1.2517	8.9900	0.1999	0.000019	0.8465
	100	12.5890	1.2042	10.0030	0.1622	0.0000085	0.8751
3152003	5	0.2097	1.1318	0.1850	0.1163	0.8578	0.9103
	10	0.2301	1.0888	0.2111	0.0810	0.8381	0.9371
	20	0.2525	1.0474	0.2408	0.0452	0.8158	0.9650
	50	0.2855	0.9951	0.2865	-0.0491	0.7817	0.9962
	100	0.3133	0.9573	0.3144	-0.0430	0.7612	0.9669
3152004	5	-3.7699	1.3322	3.2547	0.1141	0.0116	0.9119
	10	-4.1452	1.1615	3.4883	0.1359	0.0082	0.8952
	20	-4.5578	1.1916	3.7387	0.1572	0.0057	0.8790
	50	-5.1670	1.2326	4.0970	0.1844	0.0034	0.8582
	100	-5.6813	1.2645	4.5054	0.2097	0.0019	0.8391
3152005	5	-6.2380	1.2641	4.8258	0.2043	0.0013	0.8432
	10	-6.8533	1.2958	5.1721	0.2232	0.00085	0.8289
	20	-7.5293	1.3283	5.5433	0.2417	0.00054	0.8151
	50	-8.5264	1.3725	6.0753	0.2654	0.00029	0.7974
	100	-9.3675	1.4069	6.6746	0.2899	0.00016	0.7792
3152008	5	-8.0333	1.2635	6.2215	0.2041	0.00025	0.8434
	10	-8.9213	1.3092	6.6679	0.2311	0.00016	0.8230
	20	-9.9075	1.3566	7.1465	0.2572	0.000090	0.8035
	50	-11.3800	1.4218	7.8319	0.2903	0.000051	0.7789
	100	-12.6390	1.4733	8.6984	0.3257	0.000024	0.7529
3152010	5	-4.8484	1.0863	4.3640	0.0780	0.00240	0.9399
	10	-5.1493	1.0765	4.6776	0.0690	0.00160	0.9463
	20	-5.4689	1.0667	5.0133	0.0610	0.00103	0.9527
	50	-5.9220	1.0540	5.4944	0.0501	0.00058	0.9613
	100	-6.2895	1.0444	5.8353	0.0412	0.00039	0.9681
3252003	5	2.7943	0.9518	2.9329	-0.0510	0.0189	0.9609
	10	3.0217	0.8775	3.4399	-0.1394	0.0088	0.8925
	20	3.2675	0.8091	4.0340	-0.2357	0.0038	0.8196
	50	3.6235	0.7267	4.9809	-0.3757	0.0011	0.7169
	100	3.9183	0.6701	5.3861	-0.4535	0.0007	0.6622
3252008	5	3.4070	1.1602	2.9336	0.1379	0.0190	0.8937
	10	3.5933	1.0433	3.4406	0.0415	0.0088	0.9679
	20	3.7899	0.9382	4.0350	-0.0658	0.00376	0.9491
	50	4.0663	0.8154	4.9820	-0.2262	0.00108	0.8267
	100	4.2887	0.7332	5.2545	-0.3269	0.00077	0.7521

β_0 and β_1: are linear coefficients and gradient of the linear fit; $t_{tab\,(5\,\%)} = 2.26$; Significance: 5%.

Figure 1 and Table 7 present the statistical indices calculated to analyze the performance of IDF relationships obtained by applying daily rainfall disaggregation technique compared to those obtained according PRUSKI et al. (2006).

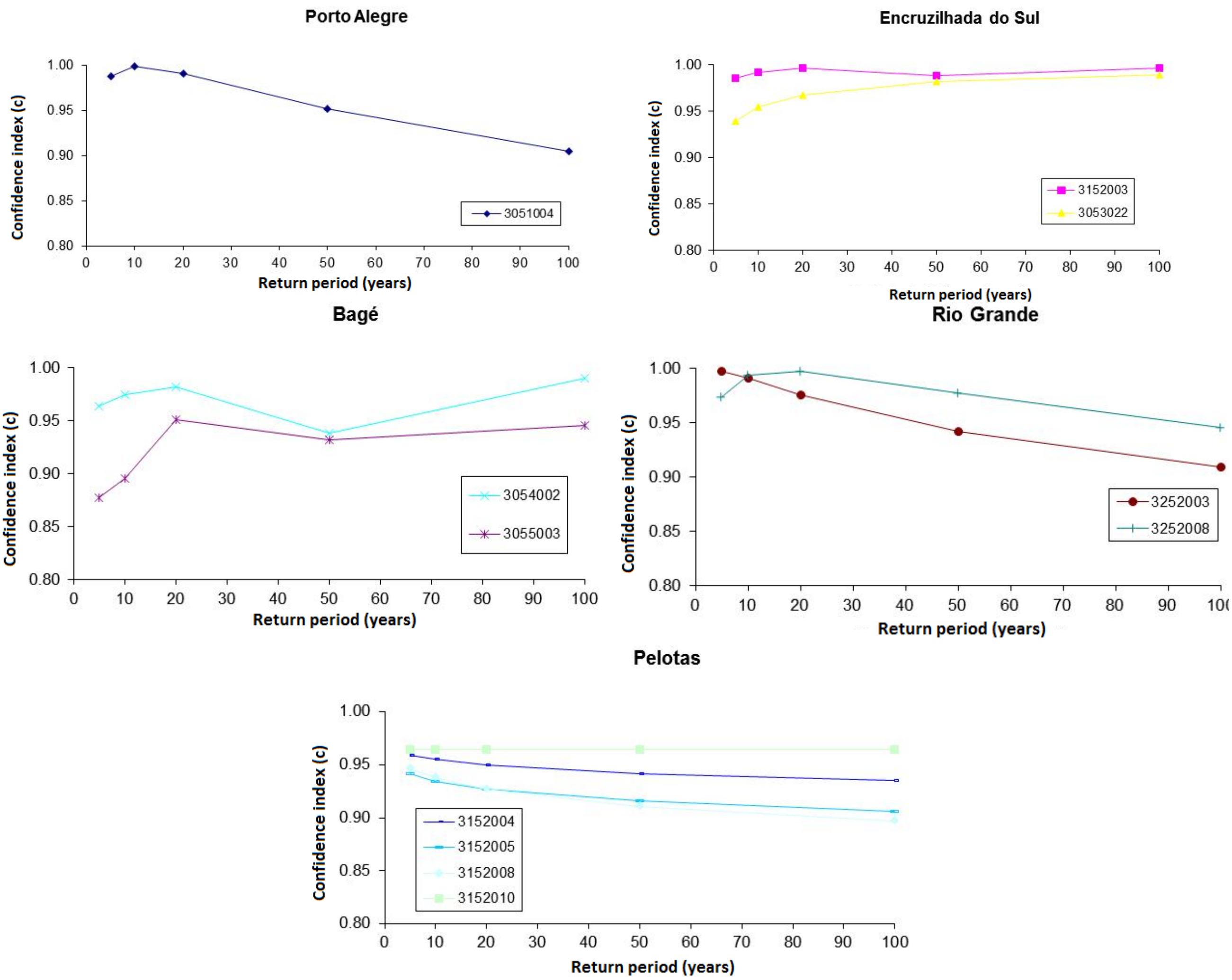

FIGURA 1. Confidence index (c) of IDF performance analysis for maximum intensity estimations (mm h^{-1}) for return periods of 5; 10; 20; 50 and 100 years.

According to criterion defined by PEREIRA et al. (2009), for all stations and return periods, the confidence indices (c) (Figure 1) were considered as "optimal ", i.e., greater than 0.85. The overall tendency is to better performance for return periods up to 20 years, with an appreciable decline for larger ones. Considering also average values of confidence index (c) for all return periods, the station 3152003 (Canguçu), when compared to Encruzilhada do Sul IDF, was the one with the highest confidence index values (0.99), very close to unity. The station 3055003 (Bagé) was the one that had the lowest average value of the confidence index (0.95), showing "great" performance. It is worth noting the behavior of the index analysis for the IDF's obtained by disaggregation technique for Pelotas city. The IDF's, obtained through disaggregation for the four stations showed same trend, i.e., similar behavior.

TABLE 7. Adjusted Efficiency Index (E') aiming at performance analysis of IDF to estimate maximum intensities (mm h^{-1}) for return periods of 5; 10; 20; 50 and 100 years.

City/ Standard IDF	Station code	Return period (years)				
		5	10	20	50	100
Porto Alegre	3051004	0.7487	0.9472	0.8499	0.6320	0.4877
Encruzilhada do Sul	3152003	0.7562	0.8280	0.8943	0.9468	0.9322
	3053022	0.3994	0.4954	0.5876	0.7036	0.7873
Bagé	3054002	0.6226	0.6984	0.7712	0.4901	0.8717
	3055003	0.0480	0.1460	0.4814	0.3590	0.4451
Rio Grande	3252003	0.9433	0.8735	0.7543	0.6095	0.5099
	3252008	0.6286	0.8340	0.9445	0.7653	0.6209
Pelotas	3152004	0.8048	0.7933	0.7734	0.7219	0.6679
	3152005	0.9648	0.9618	0.9586	0.9544	0.9511
	3152008	0.9922	0.9888	0.9852	0.9804	0.9765
	3152010	0.9742	0.9752	0.9762	0.9775	0.9785

The highest values of adjusted efficiency index (E') (Table 7) were found for stations 3152005, 3152008 and 3152010, in comparison with Pelotas IDF, whose values of E' were 0.96, 0.99 and 0.98, respectively, irrespective of return period. Thus, disaggregation technique use in rain estimation project constitutes an alternative for obtaining the hydrographic design of a project for those basins without IDF equations, obtained from rain gauge records.

Thus, daily rainfall disaggregation method can portray the reality of the hydrological basin under study, closer to an IDF relationship, where the application limits are not known.

CONCLUSIONS

The values of maximum intensity of rainfall obtained by disaggregation technique have similarity with those obtained by standard IDF relationships.

The method of daily rainfall disaggregation shows great performance for the eleven rainfall stations in southern half of Rio Grande do Sul State, Brazil.

The disaggregation method constitutes in a feasible alternative to obtain the intensity-duration-frequency relationships of rainfall occurrence.

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