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Generation of Intensity Duration Frequency Curves and Intensity Temporal Variability Pattern of Intense Rainfall for Lages/SC

Célio Orli Cardoso[1*], Idelgardis Bertol[2], Olívio José Soccol[1] and Carlos Augusto de Paiva Sampaio[1]

[1]Departamento de Agronomia; Universidade do Estado de Santa Catarina; Lages - SC - Brasil. [2]Departamento de Solos e Recursos Naturais; Universidade do Estado de Santa Catarina; Lages - SC - Brasil

ABSTRACT

The objective of this work was to analyze the frequency distribution and intensity temporal variability of intense rainfall for Lages/SC from diary pluviograph data. Data on annual series of maximum rainfalls from rain gauges of the CAV-UDESC Weather Station in Lages/SC were used from 2000 to 2009. Gumbel statistic distribution was applied in order to obtain the rainfall height and intensity in the following return periods: 2, 5, 10, 15 and 20 years. Results showed intensity-duration-frequency curves (I-D-F) for those return periods, as well as I-D-F equations: $i = 2050.Tr^{0,20}.(t+30)^{-0,89}$*, where i was the intensity, Tr was the rainfall return periods and t was the rainfall duration. For the intensity of temporal variability pattern along of the rainfall duration time, the convective, or advanced pattern was the predominant, with larger precipitate rainfalls in the first half of the duration. The same pattern presented larger occurrences in the spring and summer stations.*

Key words: maximum rainfall, I-D-F curves, Gumbel distribution, intensity rainfall

INTRODUCTION

Knowledge on intense rainfall characteristics is highly valued in Engineering and Agronomy for the dams dimensioning and hydraulic projects for irrigation, drainage and the control of water erosion, as well as facilitating the understanding of hydrological processes of river basins. Hence, it is desirable to know the magnitude and frequency of intense rainfall characterized by its duration, intensity and return period, using among other techniques, the probability principles. According to Pruski et al. (2002), the knowledge of the intense rainfall characteristics is scarce in most Brazilian's regions, and even at regions with satisfactory rainfall recording rain gauges, the available data are poor for immediate utilization. Thus, it is necessary to determine the intensity-duration-frequency (I-D-F) relations of the intense rainfall. This is made by analyzing the relations among the observed rainfalls; identifying what is the equation to characterize them better one different return period; and characterizing the representative model of intense rainfall temporal distribution for several durations and return periods. According to Santos et al. (2009), the equations I-D-F, also called by intense rainfall equations, become more efficient when besides using the local data, these present longer series of observed data starting from recording the rain gauges.

*Author for correspondence: a2coc@cav.udesc.br

Parameters for equation of intense rainfall are obtained by a non-linear regression based on pluviograph data. According to Costa and Brito (1999) and Silva et al. (1999), the determination of intense rainfall equation shows greater difficulties due to the scarcity of rainfall records; significant barriers to obtain them, low density of rainfall pluviograph data, and the small observation period to get them. Furthermore, the methodology used to achieve the rainfall records demands an exhaustive work of data tabulation, analysis and interpretation of a large quantity of pluviograph data. For this reason, few studies in Brazil have been developed on this subject. In Brazil, according to Silva et al. (1999), rainfall recording rain gauges are more restrictive than pluviometric ones, because most of the recordings are still on the shelves of the office in charge, waiting for someone to scan the pluviograph records. Hence, some methodologies were developed in order to get rainfalls intensity from the pluviometric data, by scanning the pluviograph records and, to some extent, solving the matter highlighted before. Those methodologies apply the coefficients to transform "one day" (or 24 h) rainfalls in shorter duration rainfalls. Among those methodologies, one is the disaggregation of "one day" or 24 h rainfall data by CETESB (1986).

According to Genovez and Zuffo (2000), it is important to highlight that DNOS (National department of Sanitation Works) studies made in 1957 and used by CETESB (1986) to determine the relations between 24 h rainfalls and shorter duration rainfalls. Besides being late, they were based on a reduced number of pluviographs stations. However, rainfalls from different Brazilian regions can be provoked by different mechanisms. Accordingly, those relations do not substitute recording rain gauges data, but only indicate an approximate relation among rainfall durations. Because this is a medium relation, it is much more representative when more reliable is the region where it will be applied. Thus, those relations should be determined for smaller regions with water homogeneity.

According to Genovez and Zuffo (2000), the methods that are based in the relationships among intense rainfalls of different durations have regional validity, although the medium values of these relationships are very close of several parts of the world. For the estimates at different places, it is convenient to establish new coefficients, related to the characteristics of the climatic places. When studying intense rainfall, it does not matter to know the maximum rainfall observed in a rainfall series, but mainly to predict what kind of rainfall can occur in certain region with determined frequency (Villela and Matos 1975). By correlating the rainfall intensity and duration for a specific return period, the more intense the rainfall, the shorter its duration, showing a hyperbolic-type curve (Huff 1967). According to Linsley and Franzini (1978), this relation can be represented by two types of equation; one for the rainfalls with duration between 5 to 120 min, and another one for rainfalls with duration higher than 120 min, known as Talbot's equations. More complex I-D-F equation can just be established by the statistical examination of long series of local rains (Santos et al. 2009), and the results cannot be extended to other regions. These results can be showed graphically as curves relating the intensity and duration and defining one curve for each return period. After a number of previous observations, hydrologists have developed an equation, which fits in well within the experimental data, named "Equation of Intense Rains", or "Intensity-Duration-Frequency Equation". Cardoso et al. (1998), using a daily rain disaggregation model and the method of relations proposed by CETESB (1986), from "one-day rain" data, obtained I-D-F rainfall equation for Lages/SC as follow: $i = 2050Tr^{0,17}(t + 29,42)^{-0,89}$, where *i* was the intensity (mm h^{-1}), *Tr* was the return period (year) and *t* was the rainfall duration (minute). In this study, authors used duration from 5 to 120 min and more than 120 min for return periods from 2 to 100 years.

Other similar studies were accomplished with the use of the relationships of disaggregation rainfall to obtain the I-D-F relationships of intense rainfalls for another Santa Catarina´s cities such as Florianópolis (Back 2000), Chapecó (Back 2006) and Urussanga (Back 2010). Studies such as by Miller et al. (1973); Frederick et al. (1977); Vieira and Souza (1983); Goulart et al. (1992) and Mello et al. (1994) have been made aiming to adjust a theoretical distribution to observed the rain data in order to determine the precipitation values for several probability levels, or to set I-D-F relation. However, in most of cases, rain data were assessed like prompt values, when they should be assessed in a temporal distribution (Sivapalan and Bloschl 1998) for an effective characterization of its variability, which was necessary, for example, for hidrographies analysis.

Back (2001) studying the daily data of maximum rainfalls of a hundred pluviometrics stations of Santa Catarina' State observed that the Gumbel's distribution presented the best adjustment to the data observed in 60% of the stations and in 93% of the stations with less than twenty years of data. Silva et al. (1999) adapted a theoretical model of probability distribution to rainfall data for Rio de Janeiro and Espírito Santo states and established the I-D-F relation of the rainfalls in this cites. A similar study was made by Damé et al. (1996) for the annual rainfall and monthly maximum and minimum precipitation for some regions in Rio Grande do Sul. In another study, Robaina (1996) developed a model to estimate the rainfalls shorter than 24 h in Rio Grande do Sul, which was more appropriate when estimated rainfalls were compared to observed ones. Other works using the similar methodologies were carried in this and another Brazilian's states to obtain the I-D-F relationships in these places. These included by Eltz et al. (1992) in Rio Grande do Sul, Fendrich (1998) at Paraná's State, Pinto et al. (1999) in Minas Gerais, Genovez and Zuffo (2000) in São Paulo, Oliveira et al. (2000) in Goias, Silva et al. (2002) in Bahia, Silva et al. (2003) in Tocantins, Oliveira et al. (2005) in Goias and Distrito Federal, Santos et al. (2009) in Mato Grosso do Sul, Moruzzi et al. (2009) in Rio Claro, SP, Castro et al. (2011) in Cuibá, MT, and Back (2002) e Nerilo et al. (2002) to Santa Catarina's State.

Other important aspect of intense rainfalls is the intensity variation pattern during the rainfalls duration time. Sentelhas et al. (1998) analyzed and characterized the rainfall time distribution with 4-h duration for Piracicaba, SP, showing an intensity distribution model with higher occurrence probability, from October to March. In 85% of these cases, the predominant model was a negative exponential distribution, with fractions of total precipitation of 69.3% (first hour), 16.3% (second hour), 9.4% (third hour) and 5% (fourth hour), typifying an advanced, frontal, or convective rainfall distribution.

There are very few studies in Brazil involved on the characterization of rainfall intensity variation during its occurrence, while this kind of study is very common in other countries (Huff 1967, Preul and Papadakis 1973; Olsson and Berndisson 1998; Evangelista et al. 2005). According to Cruciani (1986), the knowledge of the intensity makes the temporal distribution model of intense rainfall in a specific region more realistic for the hydrological forecast for engineering projects in the rural and urban areas. He suggested the characterization and quantification of the run-off more precisely, which was possible by the application of hidrographies analysis methods, as Shemtan's and Soil Conservation Service ones, among others. According to Machado et al. (2008), rainfall erosivity is calculated based on its physical characteristics, and according to Evangelista et al. (2005) the temporal variation pattern of the rainfall intensity is one of the most important factors in soil erosion, and its characterization is fundamental to conservationist planning. Despite studies on erosive potential of rainfalls in several Brazilian regions (Eltz et al. 2001; Bertol et al. 2002; Moreti et al. 2003; Albuquerque et al. 2005; Evangelista et al. 2005), there are few studies on the physical aspects of rainfall as those related to rainfall intensity variation during its occurrence, that is, with rainfall intensity temporal variation patterns.

Thus, the aim of this study was to describe the representative model of temporal distribution for intense rainfall with duration from 10 min to 18 h, and their occurrence probabilities in Lages/SC and, from these, the I-D-F equation to analyze the 1) frequency distribution of maximum rainfall values from recording rain gauges observations, 2) intensity temporal conducts of intense rainfalls, 3) to get the characteristics of intense rainfalls, such as the average intensity, duration and frequency and their relations, and 4) to draw the intensity-duration-frequency curves of the observed rainfalls and the equation of intense rainfalls.

MATERIALS AND METHODS

Diary data of maximum rainfall were obtained from the recording rain gauges (pluviograph data) in Estação Meteorológica do Centro de Ciências Agroveterinárias (CAV) (CAV Weather Station) of the Universidade do Estado de Santa Catarina – UDESC, Lages/SC, Brazil, located as follow: altitude: 920 m; latitude: 27º 49' S; longitude: 50º 20' W. In 2010, the height, duration time, maximum average intensity and occurrence frequency of intense rainfall were recorded from a 10-years observation during 2000-2009. The pluviograph data reading was made visually and the events were selected and rated manually in intervals of 10 min and typed (Excel spreadsheets), according to the corresponding rainfalls heights.

Intense rainfall events were selected according to criteria established by Cruciani et al. (2002), subdivided at four equal intervals (quarters) according to their duration and arranged in histograms, selecting the more frequent patterns of temporal distribution for analyzing. For statistical analysis of intense rainfall probability and return period by Gumbel distribution, in each historical observation, the maximum height for each selected duration (10, 20, 30, 40, 50 and 60 min, 2, 4, 6, 12 and 18 h) was obtained from the diary pluviograph data tabulation, constituting an annual maximum series for each duration.

Based on these values, the following systematic procedure was made: an annual maximum series was set in descending order for each durations, calculating the statistical elements of the sample: mean (μx) and standard deviation (Sx); the observed frequencies (F_i) was calculated according to the formula by Kimbal.

The reduced variable (y_i) of Gumbel's statistical distribution was calculated by the equation:

$$y_i = \frac{\sigma y}{Sx}.[x_i - (\mu x - Sx.\frac{\mu y}{\sigma y})] \quad [1]$$

Where: y_i was the reduced variable of Gumbel's distribution; μy was the mean and σy was the standard deviation of the reduced variable; μx was the mean; Sx was the standard deviation of the sample; and x_i was the random variable (maximum annual rainfall). The expected theoretical probability (P_i) was calculated according to Gumbel, by the equation:

$$P_i = 1 - e^{-e^{-y_i}} \quad [2]$$

Where: P_i was the expected probability; **e** was the basis of Nepierian logarithm and y_i was the Gumbel's reduced variable. The expected return period (Tr_i) was calculated by:

$$Tr_i = \frac{1}{P_i} \quad [3]$$

Where: P_i was the expected theoretical probability.

An analytical line for estimating rainfalls heights for each durations according to the expected return period without graphics was obtained through [1] equation: $\frac{\sigma y}{Sx} = w$ e $\mu x - Sx.\frac{\mu y}{\sigma y} = z$; having:

$$y_i = w.(x_i - z) \quad [4]$$

Isolating the random variable x_i, resulted an analytical line according to the reduced variable by the equation

$$x_i = \frac{y_i}{w} + z \quad [5]$$

Setting the reduced variable according to the return period (Tr_i), resulted in the equation:

$$y_i = -\ln.[-\ln(1 - \frac{1}{Tr_i})] \quad [6]$$

So, the analytical line according to the return period showed the following rating:

$$x_i = \frac{-\ln[-\ln(1 - \frac{1}{Tr_i})]}{w} + z \quad [7]$$

Where x_i was the random hydrologic variable, that is, the maximum rainfall height expected for a given return period; Tr_i was the expected return period; ln was the natural logarithm; w e z were the parameters of linear equation obtained according to the statistical elements of the sample and the reduced Gumbel's variable. Gumbel's distribution adherence to the annual rainfall series was verified by Kolmogorov-Sminorv Test with 5% of significance.

From the equation [7], the analytical frequency lines of the maximum rainfalls for each duration was obtained, which allowed the determination of the expected maximum rainfall heights according to return period. The values of the analytical equations parameters are shown in Table 1.

Intension-Duration relationships for the rainfall duration until 120 min were obtained by Talbot equation, in order to express the relation between intensity and duration for a determined return period as follow:

$$i = \frac{a}{b + td} \quad [8]$$

For the durations larger than 120 min, the analytical expression for curves, which adjusted to the observed data was:

$$i = \frac{c}{td^d} \quad [9]$$

Where: *i* was the rainfall intensity for an specific return period; *t* was the rainfall duration; a, b, c and d were the adjusted local parameters to determine statistically.

To estimate the adjusted parameters of the equations, an anamorphosis process was applied on their linearization. After linearization, the linear equations were obtained by "least squares" statistical method. "Intensity-Duration-Frequency" curves were obtained by a general equation, which described the relation among the intensity, duration and return period. It is called as “intense rainfall equation”, or “intensity-duration-frequency equation”, shown as below:

$$i = \frac{k.Tr^{m}}{(b + t)^{n}} \quad [10]$$

Where: i was the rainfall intensity; t was the rainfall duration; Tr was the return period; k, m, n and b were the adjusted local parameters to determine statistically.

Table 1 - Values of “w” and “z” from analytical equations of expected rainfall heights for duration periods considered to Lages/SC (eq. [5]).

Rainfall duration	Parameter	
	w	*z*
10 min	0.3119	9.84
20 min	0.2753	16.72
30 min	0.1945	21.79
40 min	0.1420	25.03
50 min	0.1266	27.01
60 min	0.1211	28.65
2 h	0.1105	30.97
4 h	0.1065	33.09
6 h	0.0912	37.72
12 h	0.0695	40.71
18 h	0.0354	6.49

The parameters of an equation that provides, for any return period, the intensity for several duration periods observed were established. Parameter "b" was obtained through the arithmetic average of coefficients “b” from the Talbot equations over the selected return periods. For determining other parameters from the rainfall equations, a non-linear regression procedure was applied on the basis of the information extracted from pluviograph data.

To analyze the temporal variation pattern, maximum rainfall events for each 10-day period of the year were subdivided at four equal intervals (1º, 2º, 3º and 4º “quarters”) and disposed in histograms. The rainfall temporal distributions was analyzed and characterized with four equal sub-periods of variable duration, selecting the distribution models most likely to occur in each season and totaling the rainfall volume (rainfall height) for each quarter.

RESULTS AND DISCUSSION

The maximum intensity of rainfall in 2002 was 118.8 mm h^{-1} (during 10 min), in 2003, it was 41.6 mm h^{-1} (for 1 h), and in 2005, it was 4.6 mm h^{-1} (during 18 h). In 2002, 2003, 2004 and 2009, intense rainfalls showed duration lower than 18 h (Fig. 1). With the increase of the rainfalls duration, their maximum average intensity was reduced as expected, because, according to Huff (1967), the average rainfall intensity decreased with the duration increase and, naturally, it increased with the diminution of the return period. This was because the rainfall intensity showed higher temporal variability for long-duration rainfalls, passing by low intensity and sometimes drought, which diminished the average intensity. This did not occur in short-duration rainfall, which resulted in larger average intensities of the rains.

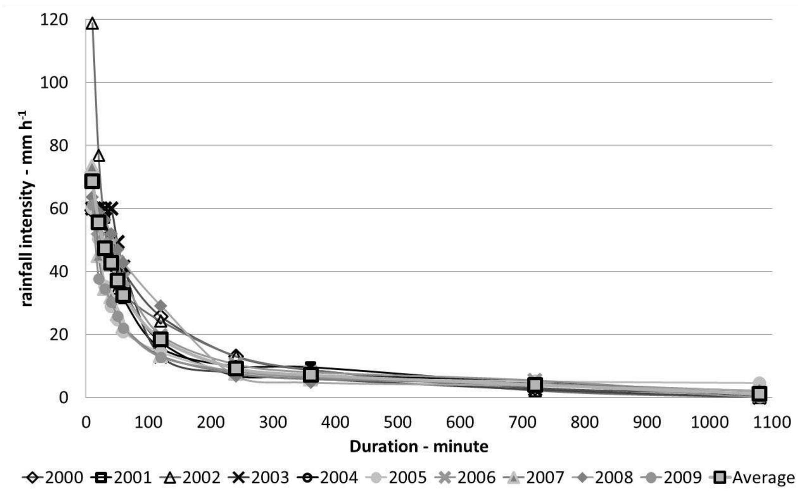

Figure 1 - Maximum rainfall intensity for different durations from 2000 to 2009 and maximum rainfall intensity average for this period, Lages/SC.

There was a gradual decrease in rainfall average intensity expected values as duration of the rainfalls increased (Table 2), in according to data obtained from other researchers (Huff 1967; Souza Pinto et al. 1973; Linsley and Franzini 1978; Righetto 1998; Pinto 1999; Soccol et al. 2010). According to Silveira (2000), it was probably due to higher intensity values, which were related to rainfall events from connective processes that by observation, passed from a condition in short-term, even in temperate climates and, sometimes, during the winter. On the other side, lower intensity values could easily be associated to the rainfalls from the frontal processes in the displacement of air masses, which passed from a long-term scale. Intensity-duration relations allowed higher convenience and precision in obtaining maximum heights of the expected rainfalls, so facilitating the use of the rainfall data in the projects in which needed to size the hydraulic works of controlling the flow.

Table 2 - Values of rainfall average maximum intensity expected for return periods and durations selected for Lages/SC.

Duration	Return period (year)				
	2	5	10	15	20
	---------------------------------- mm h^{-1} ----------------------------------				
10 min	66.10	87.91	102.34	110.48	116.18
20 min	54.16	66.51	74.68	79.30	82.53
30 min	47.36	59.01	66.73	71.08	74.13
40 min	41.42	53.40	61.33	65.80	68.93
50 min	35.88	46.63	53.74	57.76	60.57
60 min	31.68	41.04	47.24	50.73	53.18
2 h	17.76	24.80	29.47	32.10	33.94
4 h	9.12	11.78	13.54	14.53	15.23
6 h	6.89	8.76	9.99	10.69	11.18
12 h	3.83	5.19	6.09	6.60	6.95
18 h	0.94	2.71	3.89	4.56	5.02

The values for "a" and "b" coefficients from the Intensity-Duration equations (I-D) shown in Table 3 were used in the equations for rainfall durations between 5 and 120 min (Talbot's equation). The "c" and "d" coefficients were used in the rainfall duration equations longer than 120 min. High values of the determination coefficient showed a proper adjustment of the equations obtained from the data.

The intense rainfall equation was obtained, which represented the Intensity-Duration-Frequency curves, predicting the average maximum intensity of the rainfalls from its duration and return period. Intense rainfall equation for Lages/SC from the analysis of diary pluviograph data was:

$$i = 2050.Tr^{0,20}.(t+30)^{-0,89} \quad [11]$$

where i was the intensity in mm h^{-1}, Tr was the return period in years and t was the rainfall duration in min.

Table 3 - Values of the coefficients "a", "b", "c", "d" from intensity-duration equations and from determination coefficients for the selected return periods (Tr), for Lages/SC.

Tr	Duration between 5 to 120 min			Duration longer than 120 min		
	a	b	r^2	c	d	r^2
2	3.179	38.09	0.82	2083	0.98	0.91
5	3.892	35.28	0.83	1014	0.81	0.88
10	4.364	34.12	0.83	834	0.75	0.89
15	4.630	33.45	0.85	779	0.72	0.88
20	4.817	33.09	0.81	751	0.71	0.87

The intense rainfall equation, or I-D-F equation obtained through the relations from the pluviograph data showed the values and shape similar to the equation determined by Cardoso et al. (1998). These authors worked with pluviometer data to which they applied a disaggregation model of diary rainfall and the relation proposed by CETESB (1986), whose methodologies were appropriated to estimate the short-duration rainfalls. It was observed that as the rainfalls duration increased and the gap between the estimate values increased as well in all the return periods analyzed (Fig. 2).

Therefore, a proper adjustment of the equation obtained in this study to the observed values from the pluviograph data in all the return periods was observed. Equation obtained from the pluviograph data estimated lower values than the equation obtained with the disaggregation model of one-day rainfalls from the pluviometers. Those differences were because the relations used in the disaggregation model between 24-h rainfall and lower-duration rainfalls, besides being very old, also had as basis a much reduced number of precipitation stations in Brazil as well as their bad distribution, being quite generalized and not representing the variability and specificity of each Brazilian region. As the in different Brazilian's regions could be provoked by different mechanisms, these relations did not replace the precipitation data registered *in locu* exactly, but just indicated an approximate relationship among the precipitation durations. Thus, although they were average and generalized relations, they did not represent accurately the intense rainfall behavior in the specific region that gave better confidence in the relations obtained from the observed pluviograph data obtained in this study. Therefore, there is the need for periodic updating of those equations due to the influence of urbanization and global warming on rainfall pattern to re-evaluate and regionalizing the relationships used in disaggregation model.

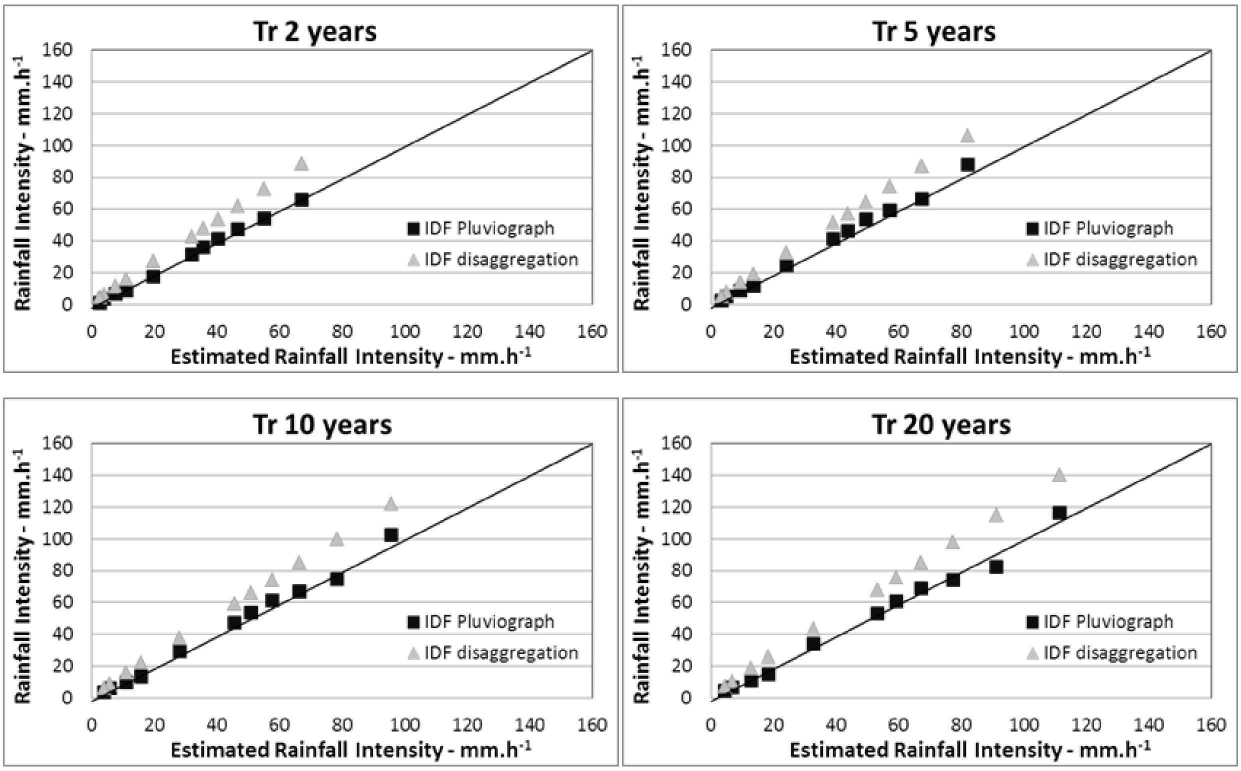

Figure 2 - Observed rainfall intensity compared to the intensity estimated by IDF equation from pluviograph data (IDF pluviograph) and to the intensity estimated by IDF equation from disaggregation model (IDF disaggregation), for Lages/SC.

The I-D-F equation coefficients obtained in this work starting from the pluviograph data too were different from those obtained by Back for other cities in Santa Catarina, such as Florianópolis (Back 2000), Chapecó (Back 2006) and Urussanga (Back 2010). This was mainly due to the methodology employed and possible effects of geography as well as the local climate characteristics of the rainfall in the respective regions. According to Genovez and Zuffo (2000), a possible physical explanation for this could also probably be the dimensions and properties of the common mechanisms of convective rainfall, responsible for the high intensity and short duration of heavy rains in different parts of the world. Thus, one should not ignore the differences that regional rainfall featured due to local characteristics. In the model of disaggregation of rainfall a day relationships are used whose values represent the national averages, which should be revised to consider the regional averages, gazing up, thus rainfall prevailing in each region. Diversity exists and cannot be ignored due to political boundaries, should prevail analysis of regional climate. According to Genovez and Zuffo (2000), the methods based on generalized equations and empirical coefficients may at any time replace the pluviograph information site under study, but may provide a reasonable estimate for regions where data are sparse rain gauges. In this aspect, this work could be enhanced when increasing the availability of observations of precipitation, demonstrating the importance of the continuity of hydrological data collection.

In respect of intensity values distribution over the intense rainfall duration, it was observed that the higher rainfall volume concentrated during the first quarter in all the seasons, showing higher percentage in the fall and summer. However, rainfall in its last quarter was less frequent, as shown in Table 4. In the summer in 46.8% of the intense precipitations, the higher rainfall volume was during the 1st quarter, but in the 4th quarter, the higher rainfall volume occurred in only 11.3% of the analyzed events. The higher concentration of rainfall volume during the 2nd quarter occurred in the winter (34% of the analyzed events). However, it did not overcome the rainfall concentrated during the same season but in the 1st quarter. In most of the analyzed events, the higher rainfall volume occurred in the first half of the rainfall duration time.

The predominant temporal distribution pattern for the rainfall was the advanced, or convective one (Table 5). This pattern characterized the short-duration and high-intensity rainfalls, with intensity peak mainly in the first half of the rainfall duration time and higher occurrence in the spring and summer, as found by Sentelhas et al. (1998) for Piracicaba, SP, in the period from October to March. The predominant model for the fall and the winter was the intermediate pattern, concentrating higher rainfall volume in the 2nd quarter. Other patterns, in which the higher rainfall volume was concentrated in 1st and 4th quarters, or 1st and 3rd quarters, or even 2nd and 4th quarters, were found as well, but with lower frequency. This information is important when analyzing the erosive power of rainfall. According to Sentelhas et al. (1998), on the occasion of erosive precipitation occurrence with intermediate and late pattern, that is, with the peaks of precipitation volumes in the middle and at the end of the rainfall duration time, higher potential soil losses by water erosion could be expected considering the higher preceding humidity of the soil. In moist and uncovered soils, the surface sealing is intense (Reichert et al. 1994), infiltration capacity is smaller and surface runoff is higher, facilitating the detachment of the soil by the impact of raindrops and surface runoff.

Table 4 - Occurrence of greater rainfall volume in each quarter of maximum rainfall duration time, from 2000 to 2009, for Lages/SC.

Greater rainfall volume by quarter	Seasons			
	Summer	Fall	Winter	Spring
	%			
1º	46.8	48.4	39.6	37.1
2º	17.7	22.6	34.0	22.6
3º	24.2	17.7	15.1	27.4
4º	11.3	11.3	11.3	12.9

Table 5 - Occurrence of temporal distribution pattern of predominant rainfall in each season, from 2000 to 2009, for Lages/SC.

Temporal Pattern	Season			
	Summer	Fall	Winter	Spring
	%			
Advanced	44.3	24.5	32.5	39.0
Intermediate (peak on 2nd quarter)	25.8	36.5	37.1	19.4
Intermediate (peak on 3rd quarter)	22.0	25.5	15.4	25.6
Late	4.7	7.8	7.9	10.3
Others	3.2	5.7	7.1	5.7

Knowledge on the physical characteristics of rainfall in relation to precipitation patterns, according to Hudson (1995), allows performing the studies with simulated rainfall more accurately, because it uses the conditions like to actual ones, that is, natural rainfall (Wischmeier and Smith

1978). According to Evangelista et al. (2005), most of the experiments using the simulated rainfall has used a single rainfall pattern (constant pattern), which is not coherent in the tropical regions where soil losses are more correlated to high-intensity and short-duration rainfalls. Those authors quantified the water and soil losses submitted to advanced, intermediate, late and constant patterns, using the simulated rainfall and they concluded that the soil loss rates were higher for the late pattern than for the other ones.

CONCLUSION

1. Based on the annual series of the selected rainfalls in a period of 10 years, an intensity-duration-frequency equation was obtained for Lages/SC, showing the following: $i = 2050.Tr^{0,20}.(t+30)^{-0,89}$, where i was the intensity in mm h^{-1}, Tr was the return period in years and t was the rainfall duration in min.
2. Temporal distribution pattern of the predominant rainfall for Lages/SC was an advanced, or convective one, with higher rainfall volume in the first half of its duration time.
3. The achievement of a new Intense Rainfall Equation represented an important contribution to Lages region, with the offering of updated estimates on maximum rainfall intensity, making possible a more rational work dimensioning in several subjects related to hydrology.
4. This work could be enhanced when increasing the availability of observations of precipitation, demonstrating the importance of the continuity of hydrological data collection.

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