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RESEARCH ARTICLE

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VERANICOS EM AMPARO DE SÃO FRANCISCO, SERGIPE – BRASIL

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ABSTRACT

The availability and seasonal distribution of rainfall in a given region are determining factors to justify the need to use irrigation for plants, studies on water supply for domestic and industrial use and its storage, as well as the occurrence of floods, the design of drainage channels, heavy rains and periods of drought, among many other applications. The objective of this study was to determine and group the summer intervals into different classes: 5 to 10 days; 11 to 15 days; 16 to 20 days; 21 to 25 days; 26 to 30 days and 31 days of duration for the city of Amparo de São Francisco - Sergipe between the years 1964-2020, in the rainy season corresponding to the months of April to July. The daily rainfall data were established in an electronic spreadsheet, by the sum of the monthly values of the rainy season. The years were classified as rainy, very rainy, dry, very dry and normal. The dry day was defined as the one that registered rainfall of less than 2 mm and the summer with five or more consecutive dry days. The biggest episodes of summers in the classes of 5-10 days and 11-15 days of duration, were registered in the month of April and May. The years with the highest rainfall rates showed lower frequency of dry spells, whereas in the years with lower rainfall, the highest incidences of dry spells were recorded. The methodology applied here allows simulating summer events with different durations and with high reliability.

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INTRODUCTION

The different atmospheric circulation systems that operate in this semi-arid region of Brazil (SAB) make the climatology complex, reflecting oscillations in time and space (SILVA, 2004). In order to decide on the duration of a dry period, it is necessary to assess the establishment of a threshold value of rainfall indices below which a day can be considered as dry. Rainy days are those in which rainfall levels exceed a pre-established limit. To determine dry periods of different durations, all occurrences of sequences interspersed between rainy days must be observed (SOUSA, 1999). Known for the strong droughts and summer actions (dry seasons in the rainy season), Brazil needs an excellent optimization of the rational use of its water resources. As for the summer seasons, their characteristics should be investigated, for a better understanding of their variability (CARVALHO *et al*., 2013; BAI *et al*., 2010; ASSIS *et al*., 2007). Rainfall in the semi-arid region of Brazil (SAB) is concentrated between 4 and 5 months of the year and has interannual and intraseasonal variability (BRITO *et al*., 2018). According to the authors (MARENGO *et al*., 2011; SANTOS *et al*., 2013; ANDRADE, 2017) the SAB records average rainfall of 550 to 700 mm, relative humidity of 50%, total insolation of 2,800 hours/year and potential evapotranspiration greater than 2,000 mm/year. The forecast of dry spells is significant for the agricultural sector, as it provides additional warnings to agricultural planning for rainfed and irrigated planting, helping to maximize the efficient use of water in cultivated areas (MENEZES, 2006; MENEZES *et al*., 2010; CARVALHO *et al*., 1999). Another characteristic of this region is the spatial irregularity. These climate fluctuations affect several sectors, such as economy, agriculture, agribusiness, engineering, energy production, water storage and leisure. Agriculture is responsible for a large part of Brazilian exports and for the generation of thousands of jobs, but they are vulnerable to the occurrence of climate change, as regional agricultural systems can be affected with serious consequences for food production (SILVA *et al*., 2009). Large crops are practically cultivated in a rainfed regime, which makes them depend exclusively on natural rainfall events. Therefore, agricultural activity becomes exclusively seasonal, being practiced mainly in the regional rainy season (SOUSA *et al*., 1997). Menezes *et al*, (2015) verified the relationship between the duration, in days, of the longest dry spells in the production of rice, sugarcane, fava beans, beans, cassava, corn, banana and orange for Santa Filomena - PI, for the period from December 1992 to March 2010 and the annual agricultural production of these crops made available by the Brazilian Institute of Geography and Statistics (IBGE). Summer was considered as the number of consecutive days without rain or with rain below 2.0 mm/day. The long summer period of the rainy season (December to March) did not record any occurrences. It was found that the production of corn and banana in the municipality of Santa Filomena - PI presented directly proportional relationships to the highest summers that occurred in the studied period. The orange production was inversely proportional to the longer summer periods and the production of rice, sugar cane, fava beans and cassava was independent of the duration of the summer periods. The aim of this study is to determine and group the summer periods into different classes: 5 to 10 days; 11 to 15 days; 16 to 20 days; 21 to 25 days; 26 to 30 days and 31 days of duration for the city of Amparo de São Francisco - Sergipe between the years 1964-2020 in the rainy season (April to July).

MATERIAL AND METHODS

The city of Amparo de São Francisco is located in a region characterized by two well-defined seasons, its four months occur from April to July. The period takes place between the months of September to January. According to the climate classification of (Köppen, 1928; Köppen *et al*., 1931), the study area has an “As” climate (hot and humid Tropical rainy). Average annual rainfall of 1138.2 mm and average temperature of 25.9°C. (MEDEIROS, 2020; ALVARES *et al*., 2014). The series of rainfall data for the years 1964-2020 for the studied area was acquired from the Northeast Development Superintendence (SUDENE, 1990) and the Agricultural Development Company of Sergipe (EMDAGRO - SE, 2020). Amparo de São Francisco is located at the geographic coordinates of 10°08' south and 36°55' west, with an altitude of 51 meters. The daily rainfall data were established in an electronic spreadsheet, by the sum of the monthly values in the rainy season (April - July). The years were classified as rainy (C), very rainy (MC), very dry (NS), dry (S) and normal (N) (Table 1).

Table 1. Precipitation classification according to the Pinkayan model (1966)

Classification	Rain classes
Very Dry (MS)	P < 267,51
Dry (S)	267,51 < P < 388,27
Normal (N)	388,27 < P < 520,44
Rainy (C)	520,44 < P < 729,62
Very rainy (MC)	P > 729,62

Source: Pinkayan, (1966).

Years with precipitation less than 520.44 mm were used to separate the summers, seeking to verify the frequencies in years classified as non-rainy or very rainy. Therefore, for the classification of the phenomena, only the daily data from April to July of the dry, very dry and normal years were used. For classification, the dry day was defined as one that registered less than 2 mm of precipitation and the summer as five or more consecutive dry days (GAIA et al., 2017). The summers were subdivided (Table 2).

Table 2. Types of classes by dry spells and their respective consecutive days without precipitation for the municipality of Amparo de São Francisco – Sergipe, Brazil

Classes	Consecutive days without precipitation
C_1	5 a 10
C_2	11 a 15
C_3	16 a 20
C_4	21 a 25
C_5	26 a 30
C_6	31

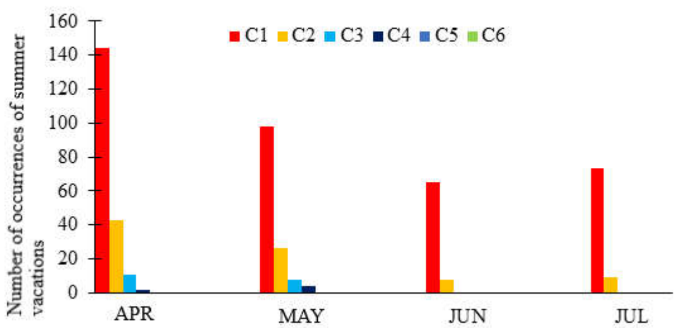
Source: Gaia et al., (2017).

The calculations of the basic statistical parameters (mean, standard deviation and coefficient of variation) were used for the total annual precipitation, and their respective graphs were generated.

RESULTS AND DISCUSSION

In order to recognize the characteristics and behavior of the temporal spaces of rainfall in a given location, it is common to use descriptive statistics associated with indicators that make it possible to explain the fluctuations in the properties of the dry spells, such as the different types of probability distribution models: geometric, negative binomial, exponential, mixed models, among many others. Table 3 shows the monthly rainfall totals for the rainy season (April - July) and the climate classifications according to the Pinkayan model (1966). Twelve years classified as very rainy (MC) were recorded; 27 years as rainy (C); two years very dry (MS); nine years classified as normal (N) and eight years as dry (S). These variabilities are in accordance with the studies by Marengo et al. (2011); IPCC (2007); IPCC (2013) and IPCC (2014).

Table 4 shows the variations in the number of summer events by their classes as a function of the months in the study area. Class C1 for the months under study recorded the largest events. In the C2 class, the summer events were smaller than the C1 class, the C3 and C4 classes registered only isolated summer events in April and May (Table 4), considering the normal, dry and very dry years. Adekalu et al., (2009); Nobilis (1986) in his studies on dry spells identified it as a certain consecutive period of days when there was a minimum amount of rain. They described the summer as a sequence of at least 5 dry days with a rainfall threshold of 2 mm. These studies corroborate the numbers of summers obtained in the city of Amparo de São Francisco - SE. Figure 1 shows the number of events according to the months, for the classifications: normal (1976; 1990; 1992; 1998; 2003; 2004; 2008 and 2015), dry (1980; 1981; 1983; 1987; 1993; 192; 2016; 2018 and 2019) and very dry (1970; 1980;) with fluctuations to Amparo de São Francisco – SE. In the months of April and May, atmospheric blockages were recorded, as well as the occurrence of a high pressure center in the South Atlantic closer to the continent, causing reductions in rainfall and generating summers. The local and regional effects of the blocks did not have their full activities, for this reason low magnitude rains were verified. The studies by Marengo et al., (2011) and Marengo et al., (2015) corroborate the results presented here.



Source: França, (2022).

Figure 1. Number of events as a function of months, for Amparo de São Francisco – Sergipe

Short-term summers present a positive correlation with local agricultural production, since with the high frequency of short events, it is understood that there is minimally a periodic distribution of rainfall (RODRIGUES, 2016). For Marengo et al. (2011) this aggregation is clarified by means of the Tropical Atlantic Dipole (DAT) and by the anomalies of the Sea Surface Temperature (SST) that fluctuate and interfere in the basic phenomena, responsible for the rains in the Northeast. Table 5 shows the annual variations of summer classes for the 1970s; 1976; 1980; 1981; 1983; 1987; nineteen ninety; 1992; 1993; 1998; 2003; 2004; 2008; 2012; 2015; 2016; 2018 and 2019 in Amparo de São Francisco - SE. The occurrence of dry spells between 5 and 10 days were recorded with an overall total of 380 cases. With 10 to 15 days of occurrence of dry spells, 86 cases were recorded.

Table 3. Classification of rainfall in Amparo de São Francisco – Sergipe

Years	Total precipitation in the rainy season	Classes	Years	Total precipitatin in the rainy season	Classes	Years	Total precipitado no período chuvoso	Classes
1964	1671,0	MC	1983	291,2	S	2002	546,1	C
1965	686,6	C	1984	522,8	C	2003	413,1	N
1966	1683,3	MC	1985	583,0	C	2004	462,7	N
1967	643,1	C	1986	624,0	C	2005	686,7	C
1968	628,2	C	1987	487,4	S	2006	683,8	C
1969	722,8	C	1988	733,8	MC	2007	637,2	C
1970	248,6	MS	1989	1060,0	MC	2008	480,4	N
1971	1171,1	MC	1990	431,1	N	2009	859,6	MC
1972	560,7	C	1991	521,8	C	2010	991,9	C
1973	625,3	C	1992	468,5	N	2011	761,9	MC
1974	614,1	C	1993	278,5	S	2012	311,6	S
1975	600,0	C	1994	777,9	MC	2013	556,2	C
1976	450,0	N	1995	570,4	C	2014	538,2	C
1977	1126,0	MC	1996	710,6	MC	2015	482,1	N
1978	657,3	C	1997	586,6	C	2016	284,1	S
1979	573,3	C	1998	468,8	N	2017	918,0	MC
1980	192,9	MS	1999	514,2	N	2018	304,9	S
1981	281,9	S	2000	711,2	C	2019	385,3	S
1982	617,4	C	2001	614,9	C	2020	616,5	C

Caption: MC – very rainy; C – rainy; MS – Very dry; S – Dry; N - Normal,
Source: França (2022).

Table 4. Number of events according to the months in Amparo de São Francisco – Sergipe

Classes	APR	MAY	JUN	JUL	Total
C_1	144	98	65	73	380
C_2	43	26	8	9	86
C_3	11	8	0	0	19
C_4	2	4	0	0	6
C_5	0	0	0	0	0
C_6	0	0	0	0	0

Source: França, (2022).

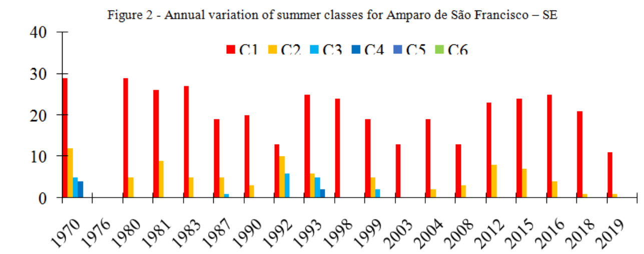
Tabela 5. Annual variation of summer classes for Amparo de São Francisco – SE

Classes	C1	C2	C3	C4	C5	C6
1970	29	12	5	4	0	0
1976	0	0	0	0	0	0
1980	29	5	0	0	0	0
1981	26	9	0	0	0	0
1983	27	5	0	0	0	0
1987	19	5	1	0	0	0
1990	20	3	0	0	0	0
1992	13	10	6	0	0	0
1993	25	6	5	2	0	0
1998	24	0	0	0	0	0
1999	19	5	2	0	0	0
2003	13	0	0	0	0	0
2004	19	2	0	0	0	0
2008	13	3	0	0	0	0
2012	23	8	0	0	0	0
2015	24	7	0	0	0	0
2016	25	4	0	0	0	0
2018	21	1	0	0	0	0
2019	11	1	0	0	0	0
TOTAL	380	86	19	6	0	0

Source: França (2022).

In the summer class of 16 to 20 days, 19 cases were recorded. Summers lasting 21 to 25 days only occurred in 6 cases and summers longer than 25 days were not recorded in the years under study (Table 5). Figure 2 shows the annual variation of summer classes, highlighting class C1 with predominance in practically all the years observed. It is suggested that the occurrence of dry spells with frequency between 5 and 10 days, which should be alerted to farmers on the occasion of the calendar of agricultural practices. Class C2 is observed, occurring in almost every year, but with lower frequencies, but its occurrence should also be highlighted, since the occurrence between 11 and 15 days without rain makes several agricultural practices unfeasible.

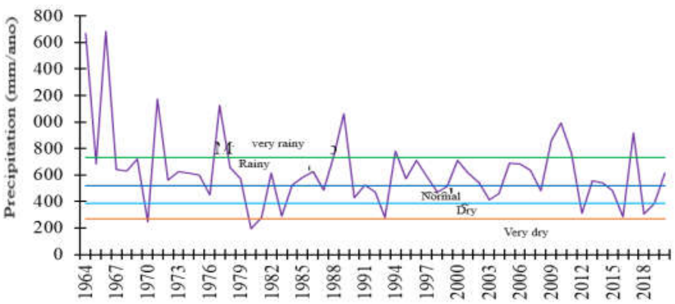
The years 1970, 1992, 1993 and 1999 had summer seasons classified as C3, between 16 and 20 days, which harmed agricultural activities in the region, corroborating the observations of Souza et al., (2020). Figure 3 shows the rainfall distribution and its classifications for the four-month period April - July 1964-2020 in Amparo de São Francisco - SE. In the very dry classification referring to the 1970s; 1977 and 1980. In the dry classification, the years 1981 stand out; 1983; 1987; 1993; 2012; 2016; 2018 and 2019. The meteorological factors that caused the dry years were the atmospheric blockages in the formation of the Lines of Instability, the relaxation of the Southeast Trade Winds and the positioning of the High Pressure Center of the South Atlantic, next to the continent, not allowing the movements local and regional to be coupled with the large-scale.



Source: França, (2022).

Figure 2. Annual variation of summer classes for Amparo de São Francisco – SE

Such fluctuations can be verified in studies by Marengo et al., (2011) and Andrade (2017). Rodrigues (2016) explained that occurrences of dry spells longer than 15 days have a negative correlation with agricultural production, and the long drought affects the metabolic processes of plants, reducing productivity. In the normal classification, the counter was applied for the days with dry spells according to the other dry and very dry periods. In the rainy and very rainy seasons, assuming that there were no summers such as those shown in Table 5. Information on the regional characteristics of summers is essential and must be incorporated into the management of water resources, both in the short and long term (MISHRA et al. ., 2011a; MISHRA et al., 2011b).



Source: França, (2022).

Figure 3. Rainfall distribution and its classifications for the four-month period April - July in the years 1964-2020 in Amparo de São Francisco – SE

CONCLUSIONS

The years with the highest rainfall had lower frequencies of dry spells, while the years with the lowest rainfall had the highest incidences of dry spells. The methodology applied here allowed simulating occurrences of dry spells with different durations and with high reliability according to the methodology applied. The highest occurrences of dry spells were observed in the classes of 5-10 days and 11-15 days of duration for the months of April and May. Filling in gaps in rainfall data may significantly interfere with the conclusions of this study. These gaps in the data tend to change the analysis of the behavior of the dry seasons in a given month or year, in two ways: the first is that a given dry season could have continued to the following month, if there had been a continuity of dry days for the month it had. failures. The second is that the summer period started after the failure could have started earlier than the one observed. In both situations, the summers would present longer lengths than those found. It is suggested that a study be carried out using the occurrences of El Niño and La Niña, their rainy days and determination of their probabilities and return periods.

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