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Extreme Events of Precipitation for The Municipality of Santa Filomena - Piauí, Brazil

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ABSTRACT

Extreme precipitation events are associated with several natural disasters. This paper analyzed occurrences of these events in Santa Filomena - Piauí, in the period 1990-2014, using higher daily values of precipitation for each year. The rainfall data were provided by (EMATER-PI) Instituto de Assistência Técnica e Extensão Rural of the State of Piauí. Extreme precipitation events were more evident between the months of the rainy season with 78% of cases and only 22% were observed in the dry season. Change in the behavior of rainfall in the 90s was found with spatiotemporal variability in intensifying annual maximum rainfall, presenting more events with precipitation values less than 60 mm.

INTRODUCTION

Understanding and establishing standards in studying rainfall anomalies and their trends assist in decision making, regarding measures necessary to minimize the damage caused by climatic irregularities in productive activities and subsidies for high-risk situations for society. In addition, help in the understanding on meso and micro-scale climate change.

The constant climate changes are causing occurrences of increase in extreme weather events worldwide. In Brazil, these events occur mainly as floods (heavy rains) and prolonged drought (Marengo et al., 2010). In Northeast Brazil (NEB) impacts are even greater because of the great variability in the occurrence of rainfall in this region. The main systems responsible for the occurrence of precipitation in the NEB are Intertropical Convergence Zone (ITCZ), Cyclonic Vortices of high levels (VCAN), Squall Lines (LI), South Atlantic Convergence Zone (SACZ), Breezes (Maritime and terrestrial), and the wave disturbances in the trade winds (POAS) (Molion and Bernardo, 2002). The El Niño - Southern Oscillation (ENSO) is another climate variability that influences the occurrence of precipitation in the NEB.

More detailed studies on the intrinsic characteristics of extreme events have been targets of numerous studies (Min et al., 2003; Piccarreta et al., 2004; Blain, 2010; Zhai et al., 2010). In this sense, the Standardized Precipitation Index (SPI) is widely accepted and used by the scientific community, for it determines the intensity and the length and duration of extreme drought events (rain). Initially, McKee et al. (1993) proposed the index to quantify dry, but many studies have used to quantify rain event (Wu et al., 2001; Bordi et al., 2004).

The increase in the thermal indexes and, consequently, the probable modification in the hydrological cycle, in quantity and quality of the main indexes, the projections, and scenarios of global and regional climate change, by the end of the 21stcentury, present that the situation of the water resources could worsen, causing a strong impact on the quality of populations. From a Brazilian perspective, an example of this scenario is the Rio São Francisco, one of the twelve (12) hydrographic regions of Brazil, which already has an adverse to the amount of water and that a part of it is inserted in the climate semiarid (Easterling et al.,2000).

Rainfall is one of the meteorological elements with great variability, both in quantity and in monthly and annual distribution from one region to another (Almeida, 2003). Aragon (1975), the main reason for the existence of the northeastern semi-arid region is the absence of a dynamic mechanism that causes upward movements.

Extreme events are the main cause of most natural disasters in recent years and have directly affected the population. As consequences of these disasters occur loss of human and animal lives, damaging the economy, agriculture, transport, health, and housing, in addition to causing severe impacts on various ecosystems.

Heavy rains cause flooding in rural and urban areas, and consequently deaths by drowning, landslides, collapsing buildings, and other disasters. Medeiros (2012) analyzed the climatology of precipitation in the municipality of Bananeiras - PB, from 1930 to 2011, as a contribution to agribusiness and found that rain gauges indices are essential to agribusiness sustainability.

Studies have analyzed changes in heavy rainfall registering increases over the 20th century in Australia, except in the southwest of this country, where there was a reduction in rainy days and rain extremes. Already in the UK, intense winter events have increased and intense summer events reduced; and in the Sahel region of Nigeria and throughout Sudan no Sahel area, the largest daily amounts of precipitation have decreased, combining with the overall reduction in annual precipitation (Easterling et al., 2000).

Prolonged droughts make the water a scarce resource unavailable and even causing the migration of the population to other regions in search of better living conditions for survival. The lack of rainfall hinders the development of agriculture bringing negative consequences for the region's economy. In plants, lack of water impairs development in various stages of their growth, especially when this problem occurs during phenological stages in which are required larger quantities of water, for example, during flowering and fruiting (Fietz et al., 1998).

Marengo et al. (2010) made a comparison of observed extreme events and simulated precipitation and temperature during the last half of the twentieth century. They found that there were positive developments in this period of extreme precipitation events (R50 mm) in Southeast South America, Central Northern Argentina, northwestern Peru, and Ecuador, while negative trends were observed in southern Chile.

In the Brazilian case, extreme weather events, whether positive or negative, occur mainly as floods (due to heavy rains) and prolonged droughts (Marengo et al., 2010; Medeiros et al., 2014). According to Marengo et al. (2009), the high rainfall indexes show an increase in the frequency and intensity of rainfall in the South and Southeast of Brazil and, to a lesser extent, in western Amazonia and the coastal area of eastern the Amazon and the north of the Northeast region. Rain decreases along the coast east of the Northeast of Brazil, in the range of Rio Grande, do Norte to Espírito Santo states (Marengo et al, 2009).

Manton et al. (2001) stated that in Australia, especially no consistent pattern of trends extreme precipitation indices were checked. In Indonesia, there was no significant increase in any of the extreme levels of rain. In Japan generally, rainy days decreased and extreme precipitation rates increased.

In general, it can be said that global warming, soon, tends to present a more extreme climate setting, with higher instances of drought and flooding. Therefore, it is important to know the frequency and intensity of this weather phenomenon that has occurred in recent decades.

MATERIALS AND METHODS

The Santa Filomena municipality is located in the region of Alto Parnaíba Piauiense, comprising an area of 5,369 km^2. It is limited to the north by the municipality of Ribeiro Gonçalves and the state of Maranhão, to the south by the Gilbués municipality, to the west to the Maranhão state, and the east by Gilbués, Baixa Grande do Ribeiro and Ribeiro Gonçalves municipalities. The municipal seat has the geographical coordinates of 09º06'44" south latitude and 45º55'20" west longitude of Greenwich and an average altitude of 277 meters above sea level.

The soils of the region have sandstones, siltstone, shale, conglomerate, limestone, and silexito as the parent material. They are thick, young, with the influence of the underlying material, comprising Latossolos Amarelos, dystrophic, medium texture, associated with Neossolos Quartzarêncios and /or Argissolos Vermelho Amarelos concretionary, plinthic or not plinthic. The vegetation is tropical savanna, semideciduous phase, forest Cocais (Jacomine et al., 1986). The predominant morphological accident is the wide tabular reworked surface, flat or gently undulating, bordered by abrupt cliffs that can reach 600 m, displaying a dissected relief with recessed areas (Jacomine et al., 1986).

The rainfall is caused by the formation of lines of instabilities, traces of cold fronts, heat exchange, and the local effects. The rainy season starts in October with the pre-rainy season and lasts until April, with its wettest quarter December, January, and February. The average annual temperature is 25.7 °C and its monthly fluctuations flow between 24.3 to 28.3°C, showing maximum annual temperature around 32.2 °C and a monthly oscillation around 29.2 to 36°C. The minimum temperature occurs with monthly fluctuation of 18.4 °C to 21 °C and a relative humidity of annual air around 64.5%. The annual value of potential evapotranspiration (1489.6 mm) is the same as the precipitation (1436.9 mm), and the real evaporation value is 36.33% of the annual precipitation (Medeiros, 2013).

Figure No. 1. Geographic location of the municipality of Santa Filomena - PI.

Source: CPRM (2004).

Table No. 1 shows the rainfall scenario and the types of climate for dry, regular, rainy, and humid regimes for the studied area.

Table No. 1 - Climate rating has been held for four predominant climate types.

Climate classification according to Thornthwaite& Mather using the water balance and water, aridity, and humidity indexes

Prevailing climatic types				
Pluviometric scenario	Dry	Regular	Rainy	East
Rating	semiarid	dry sub-humid areas	sub-humid areas	sub-humid areas

Source: Medeiros, (2016).

Daily rainfall data, comprising the years 1990 to 2014, were provided by the Instituto de Assistência Técnica e Extensão Rural of the State of Piauí (EMATER-PI)). Statistical analyzes of the data were developed by spreadsheets. The occurrence of more intense extreme precipitation events evaluated each year, as well as the day of their occurrence.

The analysis of the characteristics of extreme events with the events of ENOS - El Nino Southern Oscillation (Table No. 2), were conducted for classifying year by year of occurrence of an event and El Nino, and years of a La Nina event, as a study series.

RESULTS AND DISCUSSION

The diagnosis of extreme events in the 1990-2014 period precipitation, for the city of Santa Filomena – Piauí (Figure 2), shows that in the 90 there was greater variability in precipitation rates, ranging between 35 and 115 mm, with emphasis on 1994, 1997, 1998 and 1999, showing that rain levels were higher than 60 mm. From the 2000s there was variability in intensifying annual maximum rainfall events presenting higher numbers with rainfall less than 100 mm in 2004, with 127 mm in 2006, and 2007 with 100 mm. In recent years (2010-2014) the varied extreme events in their spatial and temporal fluctuations with maximum daily rainfall ranged between 14-35 mm.

It was also noted that, in general, there was no direct relationship between intensification in precipitation and events with ENSO events (Figure 2). However, in some years the relationship was found. In general, in the northeast, ENSO alters rainfall totals in the region and also the occurrence of dry periods (Carvalho, 2009). Extreme precipitation events are most evident between the months of the rainy season, which extends from October to March (Table 2), with 16 occurrences, with a total of 24, representing 66.6% of the occurrence of chances. In this period were recorded the most intense events with values greater than 100 mm (1994; 1997; 1998; 2003; 2006 and 2007). The dry season (April to September) showed 15 instances of extreme precipitation events thus representing 33.4% of the occurrence of chances. However, most of these events possessed little lower precipitation values than 15 mm. These events, although not as frequent as having a lot of water, are enough to cause great damage and local losses.

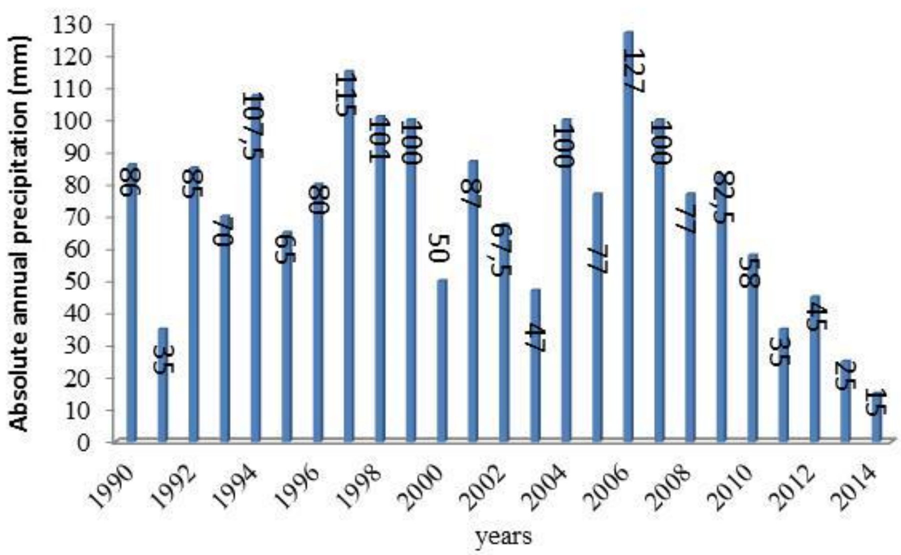

Figure No. 2: maximum annual rainfall (mm) during the period from 1990 to 2014 in Santa Filomena, Piauí

Table No. 2: Day of occurrence of maximum annual rainfall during the period from 1970 to 2014 in Santa Filomena - Piauí

Year	Day	Month	Index
1990	08	Nov	86
1991	25	Oct	35
1992	29	Nov	85
1993	14	Dec	70
1994	05	Jan	107,5
1995	30	Nov	65
1996	16	Oct	80
1997	19	Oct	115
1998	16	Jan	101
1999	20	Nov	100
2000	18	Feb	50
2001	01	Mar	87
2002	03	Jan	67,5
2003	20	Feb	47
2004	10	Jan	100
2005	01	Jan	77
2006	11	Mar	127
2007	30	Nov	100
2008	02	Dec	77
2009	14	Mar	82,5
2010	27	Jan	58
2011	25	Feb	35
2012	08	Mar	45
2013	05	Nov	25
2014	26	Nov	15

Table No. 3: Period Rating Classification and intensity (Full-Bright.) to El Niño - Southern Oscillation from 1990 to 2014.

Classification Period		Full-Bright.
1990-1993	El Ñino	Strong
11997-1998	El Ñino	Strong
2004-2007	El Ñino	Strong
2010-2011	El Ñino	Strong
1994-1995	El Ñino	Moderate
1998-2001	La Ñina	Moderate
2008	La Ñina	Strong
2011-2012	El Ñino	Weak
1995-1996	La Ñina	Weak
2002-2003	La Ñina	Moderate
2009-2010	El Ñino	Weak
2013-2014	El Ñino	Strong

CONCLUSION

There was a direct relationship between the intensification in precipitation and events with ENSO events and a certain year is realized the influence of ENSO;

Extreme precipitation events were more evident between the months of the rainy season with 78% of cases, and only 22% were observed in the dry season;

Change in the rainfall pattern in the 90s was found with spatiotemporal variability in intensifying annual maximum rainfall, presenting more events with precipitation values less than 60 mm.

Knowledge of the climate, in particular the rainfall indexes of a given hydrographic region, is essential for monitoring the dynamics of the natural system and for human activities, taking into account the fact of the occurrence of climate change. Even though there are still uncertainties about the possible effects on a local and regional scale.

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