



Identification of small summers in Southern Brazil and its relation with El Niño and La Niña events

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Abstract

The Southern Brazil is located in the region of the subtropical latitude belt, which corresponds to well defined seasons. Due to the existing phenomena in these latitudes, this pattern undergoes changes and is often unconfigured throughout the year. Machado (1950) cited in Jacobsen (1999) associated this event in Rio Grande do Sul to the weather phenomenon called small summer (in portuguese, “veranico”). Meteorological factors such as El Niño and La Niña are also extremely important in the study region. More precisely, Rio Grande do Sul is affected due to ENSO (El Niño-Southern Oscillation) accounting for temporary changes in climate, in several meteorological parameters (Kousky & Cavalcanti, 1987). Nascimento et al. (2014) found that for Rio Grande do Sul in the 1991-2010 period there was a greater amount of small summers in neutral years (51%) followed by El Niño years (35%) and La Niña (14%). For the identification of small summers, Luz et al. (2012) developed a new methodology of identification using values based on the averages and standard deviations of climatic elements. They analyzed the incidence of small summers in the city of Passo Fundo (Rio Grande do Sul) in the seasonal period from May to September. Conceição et al. (2013) applied the methodology of Luz et al. (2012) on twelve locations in Rio Grande do Sul for the same period. The aim of this study is to analyze the incidence of small summers over Southern Brazil based on criteria that takes into account the climatic characteristics of each location, and correlate with El Niño and La Niña events.

Introduction

Southern Brazil is located in the subtropical latitude belt, whose weather presents well defined seasons, being July the most regularly colder period, typical of winter, and with higher precipitation levels due to midlatitude synoptic systems. However, occasionally, these seasonal patterns suffers from interruptions, which causes temperature increase, with interruption of precipitation. Such changes are associated with the meteorological phenomenon called small summer (veranico), first identified over Rio Grande do Sul by Machado (1950) cited by Jacobsen (1999), using the criteria of daily maximum and minimum temperature increase which surpasses 25°C and 12°C, respectively, over a period of 4 or more days with absence of precipitation or under 1mm. Further studies adopting this methodology characterized the occurrence of small summers in Rio Grande do Sul (Jacobsen, 1999; Braun et al, 2000; Acosta, 2004 and Assis et al, 2006). The studies cited above use the same way of identification, based on standard and fixed values, fact that can be pointed as responsible for a lack of precision in identifying cases due to local influences such as geographical variations.

Another weather phenomenon affecting the southern region of Brazil are the events of El Niño and La Niña; more specifically, Rio Grande do Sul is sensitive to ENSO (El Niño - Southern Oscillation). The influence of ENSO in temporary changes in climate is also expressed in the variation of several meteorological variables (Kousky & Cavalcanti, 1987).

Nascimento et al. (2014) found that for Rio Grande do Sul in the 1991-2010 period there was a greater amount of small summers in neutral years (51%) followed by El Niño years (35%) and La Niña (14%). Recently, Luz et al. (2012) using a methodology for the identification based on average and standard deviation values of climatic elements, analyzed the incidence of small summers in the city of Passo Fundo (Rio Grande do Sul) in the seasonal period from May to September. The authors identified a peak incidence in August and minimum in July and point to differences in comparison to previous studies that used the methodology from Machado (1950) cited in Jacobsen (1999). They argue that this may be due to climatic factors influencing the local climate regime of each study site associated with the application of a methodology based on fixed criteria for the identification of small summers.

The methodology of Luz et al. (2012) was applied by Conceição et al (2013) on twelve locations in Rio Grande do Sul on the same seasonal period, leading to results

that clearly show a maximum occurrence of the event in August. The authors also point out an uneven occurrence over the study area, with a distribution of higher incidences west and northwest and minimum south, east and northeast of the state. The results found by Conceição et al (2013) were more consistent when compared to works based on the identification of small summers with fixed criteria, but the analysis are superficial and lack in detail with respect to the geographic scope of the phenomenon over the region, so a deeper study of incidence of small summers in Rio Grande do Sul, Santa Catarina and Paraná through this methodology is still needed for better and expressive results.

The objective of this study is to analyze the incidence of small summers over the entire southern Brazil, applying an identification methodology based on criteria that takes into account the climatic characteristics of each location analyzed and correlate with El Niño and La Niña events.

Method

The analysis of the incidence of small summers is made for the period 1991-2011, comprising 21 years of data. The data set used were daily values of maximum and minimum air temperature and precipitation for the period 1961 to 2011, totaling 51 years of data, generated by 23 conventional surface weather stations in Rio Grande do Sul, Santa Catarina and Paraná, operated by the National Institute of Meteorology (INMET). The period from 1961 to 1990 (30 years of data) is used as reference for the calculation of limit values that make up the criteria for identification of small summer events. The identification of small summers is made over the seasonal period from May to September. The criterion for identification of characteristic conditions of the events comprises a recurring period of at least 04 consecutive days with daily rainfall of less than 01 mm, associated with anomalies of maximum and minimum temperature values exceeding limits defined for each month of the seasonal period of study by location. The limit values of maximum and minimum monthly seasonal temperature are determined by the sum of monthly averages and standard deviations of each location.

The calculation of the monthly climatological normal and monthly standard deviation of the series of maximum and minimum daily temperature for the months from May to September is obtained over the period 1961 to 1990 (30 years of data). The identification of small summers was taken between 1991 and 2011 from the maximum and minimum temperature thresholds obtained from 1961 to 1990 for the states of Rio Grande do Sul, Santa Catarina and Paraná. For the state of Rio Grande do Sul, as it can be seen in Figure 1, to the north, there is the city of Iraí and Passo Fundo, in the northwestern part São Luiz Gonzaga and Bom Jesus, and in the west Uruguaiana. In the central part there is the city of Santa Maria and Encruzilhada do Sul, in the eastern region the cities of Porto Alegre and Torres and in the southern, Pelotas, Bagé and Santa Vitória do Palmar.

For the state of Santa Catarina, there is, in the northwestern part the city of Indaial, in the western Campos Novos and Chapecó. In the eastern portion of the state there is Florianópolis and in the southern São Joaquim. In Paraná, the analysis of the northern part was

held in the city of Maringá, in the west Campo Mourão, in the eastern the cities of Castro, Curitiba and Paranaguá and in the southern part Irati.



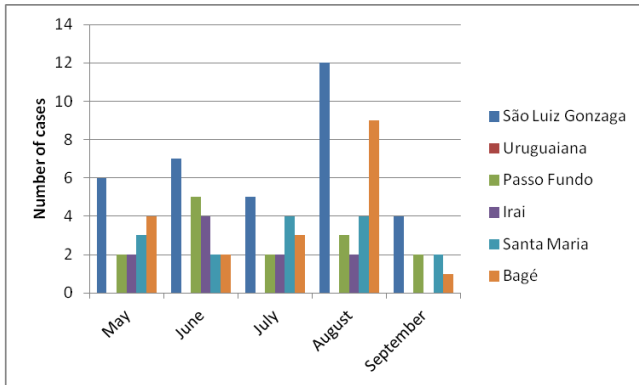
Figure 1 – Southern Brazil and the study locations

For the study of the El Niño and La Niña events, values of the Oceanic Niño Index (ONI) were used. According to this classification, anomalies of sea surface temperature (SST) over 0.5 in the Niño 3.4 region are related to warm periods/heating and occurrence of El Niño events. Values of less than or equal to -0.5 are defined as cold/cooling and are related to La Niña events. Anomalies between -0.5 and 0.5 are defined as neutral. The identification of Modoki or canonical events was based on the results obtained by Cavalcanti et al. (2010).

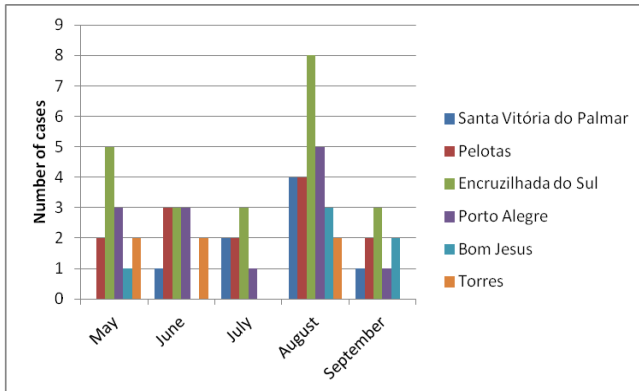
Results

In Rio Grande do Sul, the total occurrences recorded for the period at each site reveals an incidence pattern that grows significantly to west and northwest from minimum incidences on the eastern of the state (Torres - 2 cases), but also with lower values to north. The city of São Luiz Gonzaga, located in the northwest of the state, has the highest overall occurrence, with a total of 34 cases identified during the analysis period. The cities analyzed in Santa Catarina also reveal the same pattern found in the state of Rio Grande do Sul, with higher occurrences in the western, central (Campos Novos - 14) and Southeast (São Joaquim - 21 cases) and minimum in the north (Indaial - 6 cases) and eastern of the state (Florianópolis - 6 cases). The city of Chapecó, in the western of the state, has the highest number of occurrences of the phenomenon for the study period (30 incidents). In the

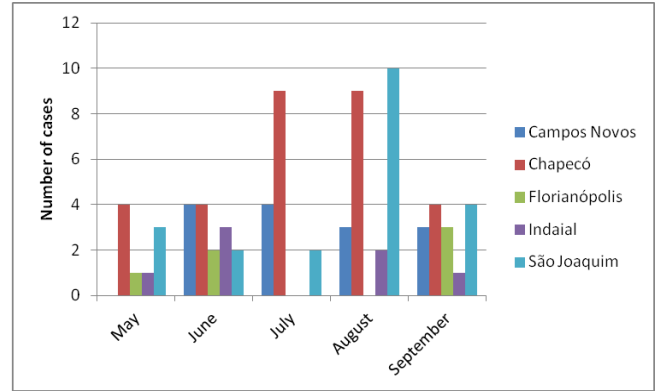
state of Paraná, located north of the region, the greater presence of the phenomenon occurs in the north/northwestern region, and the city of Maringá has the record of more cases of small summers, totaling 24. The seasonal analysis of the phenomenon occurrence, through the graphs of figure 2, reveals that Rio Grande do Sul was the state with the largest representation of events, which were more incident in August and further characterized by an increase pattern towards north/northwest and minimum at east, a fact that is due to the influence of water bodies (ocean and Patos lagoon). This pattern of behavior also extends to the state of Santa Catarina, mainly in the cities of São Joaquim and Chapecó, who had high occurrence rates. Because of the latitudinal position, the values found for the cities in the state of Paraná go against the profile registered to the other two states, with minor occurrences and with higher incidence peaks in the months of transition.



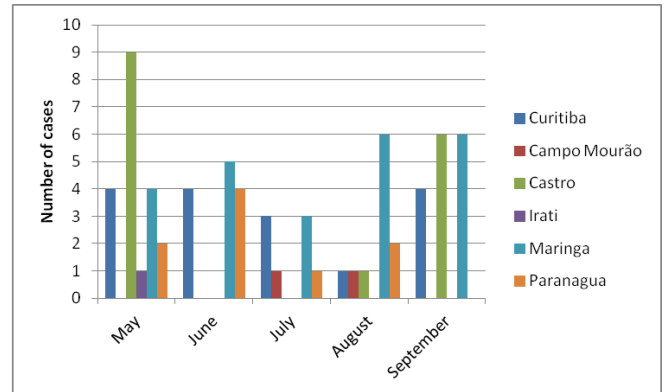
(a)



(b)



(c)



(d)

Figure 2 – Seasonal occurrence of small summers over Southern Brazil, where (a) and (b) refer to the state of Rio Grande do Sul (c) Santa Catarina and (d) Paraná

From Figure 3, it can be analyzed the behavior of the number of annual small summer occurrence throughout the study period for the Southern region of Brazil. The year of 1994 was the most relevant, as it represented the peak records, totaling 34 cases. In 1998 there was no record of small summers, making it the year of less frequency and less important for the study from the record point of view.

Another fact of great importance that is evident from Figure 3 is the marked increase in the trend line related to the growth in the number of small summers over the study period.

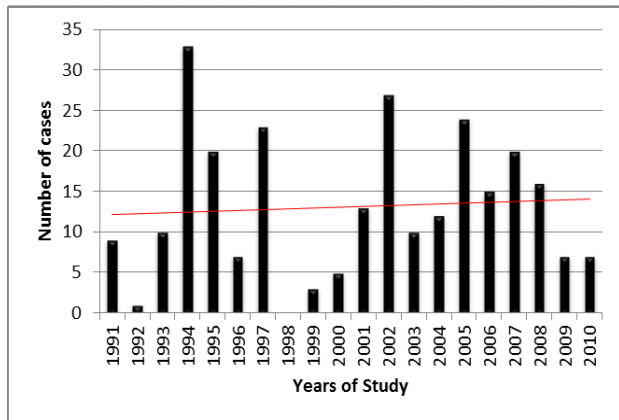


Figure 3 – Annual number of occurrence of small summers for southern Brazil

With regard to the El Niño and La Niña phenomena, among its variations (Modoki and Canonical) it can be observed that most cases of small summers during the study period occurred in years without the presence of such phenomena (54%). Small summer events, also related to the occurrence of El Niño were the most representative after the neutral years, being classified as 15% El Niño Modoki, 8% El Niño Canonical, 4% neutral El Niño and 2% El Niño Modoki and Canonical. As for the periods with the occurrence of small summers along with La Niña it can be observed that 5% are related to Neutral La Niña, 5% La Niña Canonical, 4% La Niña Modoki and 3% La Niña Canonical and Modoki, as it can be observed Figure 4.

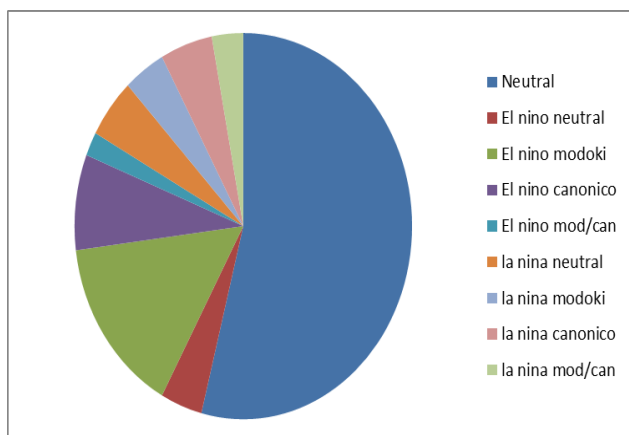


Figure 4 – Representativity of each phenomenon with the occurrence of small summer.

Conclusions

The results show that the small summer phenomenon acts in different ways in the Southern region of Brazil, both for the seasonal and regional aspect, featuring also the proximity of the study site with large water bodies, along with the continental influence and mainly latitude –

these are factors that inhibit their occurrence. Although preliminary, within the period studied, the analysis showed that the occurrence of small summers has greater representativeness in years without the occurrence of El Niño and La Niña. When there is the occurrence of both events (small summer, El Niño or La Niña), El Niño Modoki is more likely to occur. The one with less tendency of occurrence is El Niño Modoki/Canonical.

Acknowledgments

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