Features of lightning that result on fires in some regions of Brazil

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Abstract

Fires caused by lightning are long studied worldwide. In Brazil, however, little is known about this issue and the characteristics of lightning that cause these fires. In order to study the characteristics of these natural fires a climatology of lightning that hit two important parks in Southeast and Center regions of Brazil, the National parks "Serra da Canastra" (PNSCa) in Minas Gerais and "Emas" (PNE) in Goiás, was made for the period from 2002 to 2007. The analysis was carried out using lightning data obtained from BrasilDat (Brazilian Lightning Detection Network) considering multiplicity, positive and negative peak current, number of flashes, percentage of positive flashes, complemented by temperature and relative humidity data. It was observed that the PNSCa has annually around 40% more lightning than PNE, although they are located in very close latitudes, but in the three months more critical for the occurrence of fires (August, September and October), the number of lightning is larger in the PNE.

Introduction

In many parts of the world where fires have significant importance for nature and human life, lightning is the main source of ignition of this process. In Australia lightning has always been the most important cause of fires according to a research since 1980 (Mcguiney et al., 2005). Lightning is also a major cause of fire occurrence in Canada (Anderson, 2002). In Brazil the lightning-related fires are still unknown and are little studied although they are frequent. The majority of fires in the country, however, have anthropogenic origin even though a large percentage is caused by lightning. In most current fire regimes the proportion of anthropogenic ignitions is high, but the average size of the area burned is typically smaller than that of lightning-ignited fires (Weber and Stocks, 1998).

Fires influence climate both directly and through changes in vegetation. Cases of fires are registered in Brazilians national parks. The changes that occur as a result of fires affect the air quality and contribute to the greenhouse effect (Ward and Hardy, 1991), (Amiro et al., 2001). Fires can also change the lightning characteristics as reported by Murray et al. (2000), Fernandes (2005) and Pinto et al. (2006), who found a decrease in peak current of negative flashes in thunderstorms injected by smoke from fires.

The objective of this study is to know the behavior of lightning that causes fires in two important parks: "Parque Nacional da Serra da Canastra (PNSCa)", in Minas Gerais, and "Parque Nacional das Emas (PNE)", in Goiás (Figure 1). The study about the climatology of lightning is important for future projects such as a model to predict lightning caused fires occurrences in Brazil.

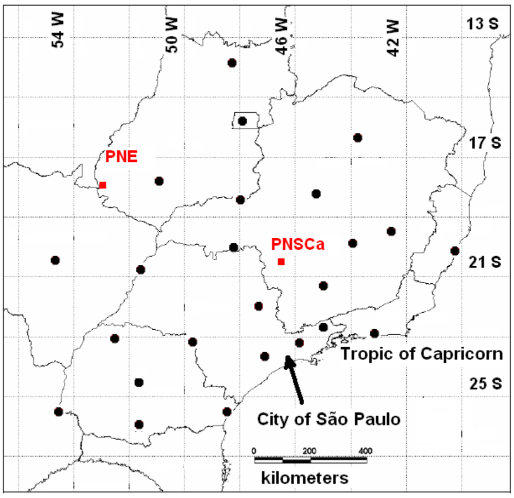

Figure 1: Localization map of the parks in Brazil: PNE in Goiás (18,11°S and 52,93°W) and PNSCa in Minas Gerais (20,37 °S and 46,60 °W) and the sensors of the BrasilDat network.

Fire ignitions by lightning are especially interesting because they are typically the only possible source of ignition in natural fire regimes (Pyne et al., 1996). In Brazil, country with high incidence of lightning, natural fires are caused almost exclusively by atmospheric discharges, but there is no studies quantifying them. Many questions regarding the genesis of fires caused by lightning in Brazil and their properties cannot be answered without further research.

The characterization and quantification of atmospheric discharges in regions of fires is an important contribution to the area of atmospheric electricity and climate changes. In the current scenario, in which the global warming may cause an increase in the number and severity of storms and, therefore, of lightning and natural fires, the study of these events contribute to the clarification and possible prevention of incidents that can harm the nature and threaten the human and animal life.

The physical process involved in a lightning-caused fire occurrence can be divided into three distinct stages: ignition, survival and arrival. Studies indicate that during the ignition stage, a lightning flash in general with a long

continuing current triggers an ignition within the forest floor or a snag. The ignition then acts as a source for a smoldering fire within the duff layers, capable of surviving for several days. Finally, if fire weather conditions are conductive, the smoldering fire bursts into flaming combustion and the fire is considered to arrive (Anderson, 2002). The knowledge of the characteristics of a natural fire is important to provide the deleterious effects or not that it will be able to lead in the environment.
The smoke produced by a forest fire can generate new clouds, as well as change the electrical properties of clouds that already exist. This situation creates complex relationships of feedback (Rakov and Uman, 2003), (Beerling and Osborne, 2006). Therefore, the fire itself has a fundamental role in the possibility of occurrence and characteristics of a subsequent fire, and acts directly on the availability of fuel, exerting an important influence on the feedback (Whelan, 1995).

Method

Analyses of the lightning behavior in the two national parks were carried out using lightning data obtained from BrasilDat (Brazilian Lightning Detection Network) considering different parameters: multiplicity, positive and negative peak current, number of lightning and percentage of positive lightning. Flashes with peak current less than 20kA were eliminated because the different detection efficiency (DE) of BrasilDat in the location of the parks (higher in PNSCa than in PNE) and also to avoid intracloud contamination.
It was initially performed a monthly analysis for the two parks for the whole year and then a detailed study, considering only August, September and October, since these months include the peak in the fires which apparently occurs in October and the preceding months.
Reanalysis data of temperature and relative humidity provided by NCEP (National Centers for Environmental Prediction) with a resolution of 2.5^{o} were also used in the analysis.

Results

Initially it was calculated the average number of lightning in every month for the years from 2002 to 2007 in both parks separately. The results are shown in Figures 2 and 3.

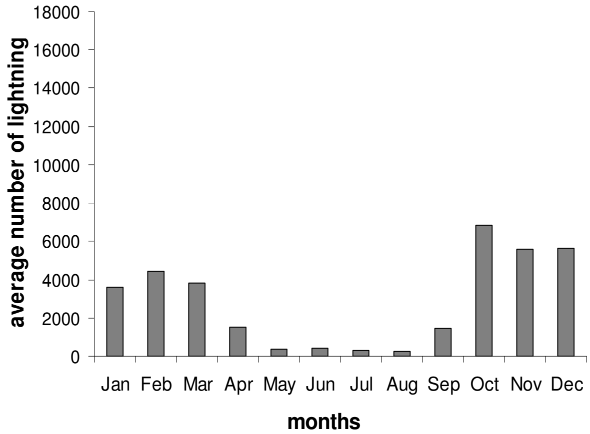

Figure 2: Average number of lightning in all months for the period from 2002 to 2007 in the PNE.

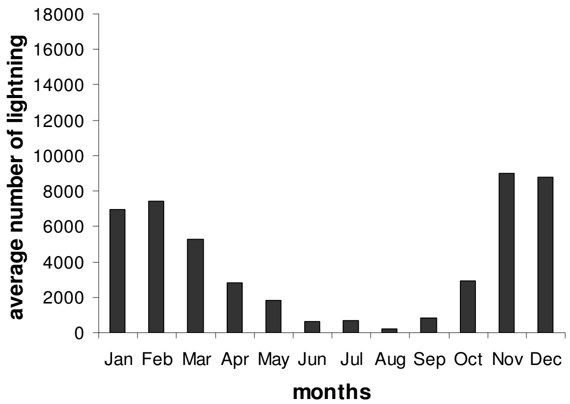

Figure 3: Average number of lightning in all months for the period from 2002 to 2007 in the PNSCa.

It was observed that the PNSCa has annually on average around 40% more lightning (3942 flashes) than PNE (2857 flashes), although they are located in very close latitudes (Figures 2 and 3).
Considering that most fires occur in the period from August to October, a more detailed analysis was done for theses months, considering all lightning parameters available, as shown in Figures 4 to 7.

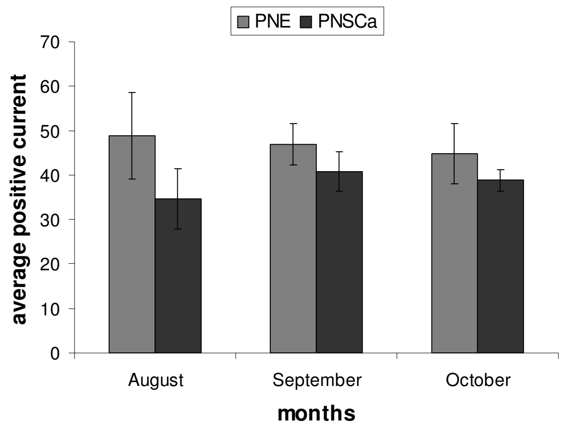

Figure 4: Average positive peak current in August, September and October for the period from 2002 to 2007 in the PNE and PNSCa.

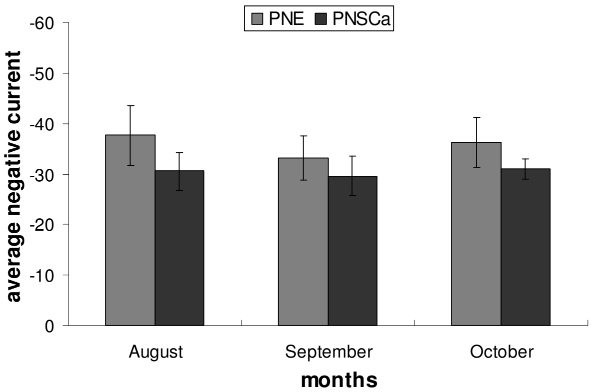

Figure 5: Average negative peak current in August, September and October for the period from 2002 to 2007 in the PNE and PNSCa.

Regarding the peak current, both parks did not show changes in the August to October period, as shown in Figures 4 and 5.

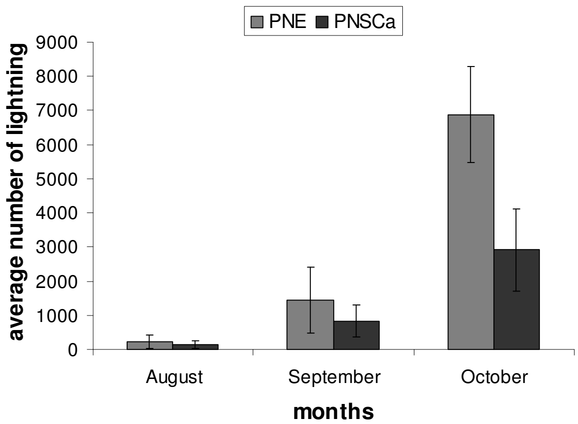

Figure 6: Average number of lightning in August, September and October for the period from 2002 to 2007 in the PNE and PNSCa.

PNE has two times more flashes than PNSCa in the months studied (Figure 6).
In Figure 6 it can also be seen that for both parks the number of atmospheric discharges increase markedly in October and in the following months, which suggest that the peak in the fires occur in the beginning of the lightning season. This result agrees with Hall (2007) who observed peaks in the number of cloud-to-ground lightning weeks after the peaks occur on the number of fires.

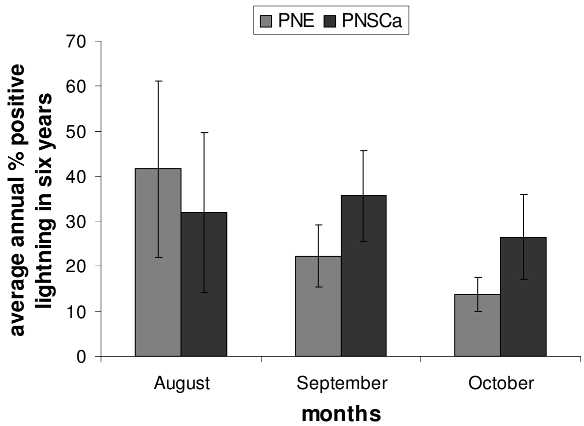

Figure 7: Average annual percentage of positive lightning in August, September and October for the years 2002 to 2007 in the PNE and PNSCa.

The average number of lightning increased significantly from August to October, mainly in the PNE (Figure 6), while the percentage of positive lightning did not show statistically significant changes (Figure 7).
According to the number of fires documented by parks (three in August, five in September and ten in October in the PNSCa; and two in August, three in September and six in October in the PNE), there is a greater number of natural fires in October, just the month where there is an abrupt increase in the lightning occurrence, even though the lightning incidence remains increasing in the next months. In November and December where the storms and consequently lightning are much more frequent, the incidence of fires, nevertheless, is much reduced, with one burn in November and one in December in both parks. This result agrees with Hall (2007) who observed a trend in the peak of fires months before the occurrence of the peak of lightning. Moreover, as noted by Whelan (1995), this result show that there is not always a clear link between the incidence of lightning and occurrence of burn, since many other aspects can be important, among them the characteristics of the countryside and the fuel can be important.
Finally, Figures 8 and 9 show the average monthly surface temperature and relative humidity in the three months: August, September and October in both parks.

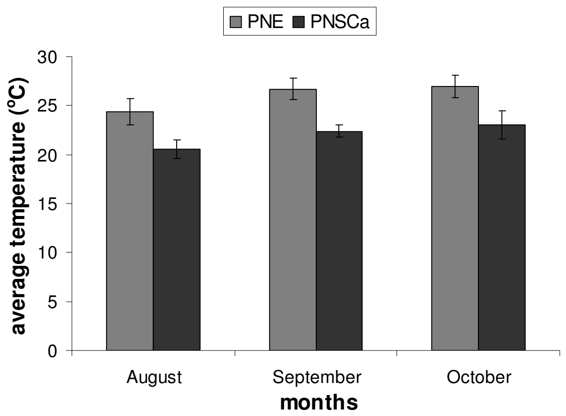

Figure 8: Average surface temperature in August, September and October for the period from 2002 to 2007 in the PNE and PNSCa.

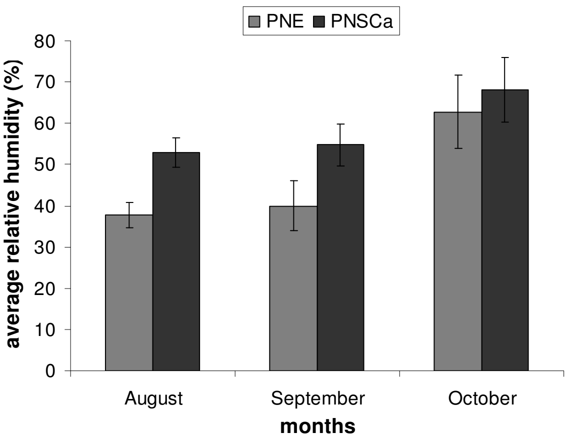

Figure 9: Average relative humidity in August, September and October for the period from 2002 to 2007 in the PNE and PNSCa.

During the three months studied, the temperature also increases slightly (Figure 8), while the relative humidity begins to increase significantly in October (Figure 9), which works to reduce the occurrence of fires. The temperature and relative humidity are key factors that affect the moisture content of fuel that is related to ignition of a fire (Hall, 2007), (Mcguiney et al., 2005), (Pyne et al., 1996).

Conclusions

Most cloud-to-ground flashes present continuing current after one or more return strokes and in 10-20% of the flashes at least one long continuing current occurs (Pinto, 2005). It is believed that strokes followed by continuing current have a high probability to cause ignition (Anderson, 2002).
The multiplicity in the two parks, however, due to limitations in BrasilDat are very small, with the PNE presenting 80% of single flashes and PNSCa with 70% of single flashes (data not shown), and for this reason were not considered in this study.
In this work it was observed in two national parks in Brazil that the peak in the number of natural fires caused by lightning occurs in the beginning of the lightning season when the relative humidity is still not much high. It was also observed that the PNSCa has 40% more lightning than PNE during the year, while the PNE has twice more lightning than PNSCa during the most significant months for fires: August, September and October. This result can be useful in future models to predict this type of fires in Brazil.

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