ATMOSPHERIC PARAMETERS RELATED TO LIGHTNING ACTIVITY: EVENTS FROM THE DRY SEASON INTERDISCIPLINARY PANTANAL EXPERIMENT IN BRAZIL

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ABSTRACT: The tracking of cloud-to-ground lightning flashes could be helpful in weather nowcasting guidance. However, for this purpose it is necessary an investigation of the atmospheric structure in depth and of its relation to the lightning activity, in order to ultimately establish a nowcasting methodology. Thus, this work studied the lightning and atmospheric relationship during the dry season of the Interdisciplinary Pantanal Experiment (IPE), that took place at the Pantanal Sul Matogrossense, Brazil, in 1999. Two events of thunderstorm, Sept. 15 and 19, 1999, were recorded by a brazilian lightning detector network. Those data were analyzed and integrated to atmospheric parameters in order to obtain the characterization of the thunderstorm. As result, a unexpected polarity ratio for lightning flashes was obtained and some questions are raised.

INTRODUCTION

In several countries, the mostly used tools to monitor lightning activities are the cloud-to-ground lightning positioning and tracking systems (Bass, 1996; Diniz et al., 1996; Cummins et al., 1998). It is suggested that the tracking of cloud-to-ground lightning flashes could be used to help weather nowcasting (Holle and Lopez, 1993). However, for this purpose it is still necessary an in depth research of the atmospheric structure and the relation to the lightning activity. This work studied the lightning-atmosphere relationship during the data collection campaign of the Interdisciplinary Pantanal Experiment (IPE) at the Pantanal Sul Mato-grossense, Brazil, in 1999. The major atmospheric scenario of this campaign is associated with a dry season when few convective systems occur and are associated with cold front moving-from Southeastern Brazil. The soil is dry during this season, whereas it is flooded during the wet season. Due to the dry shrub vegetation, many burning regions spread across the central part of Brazil.

DATA DESCRIPTION

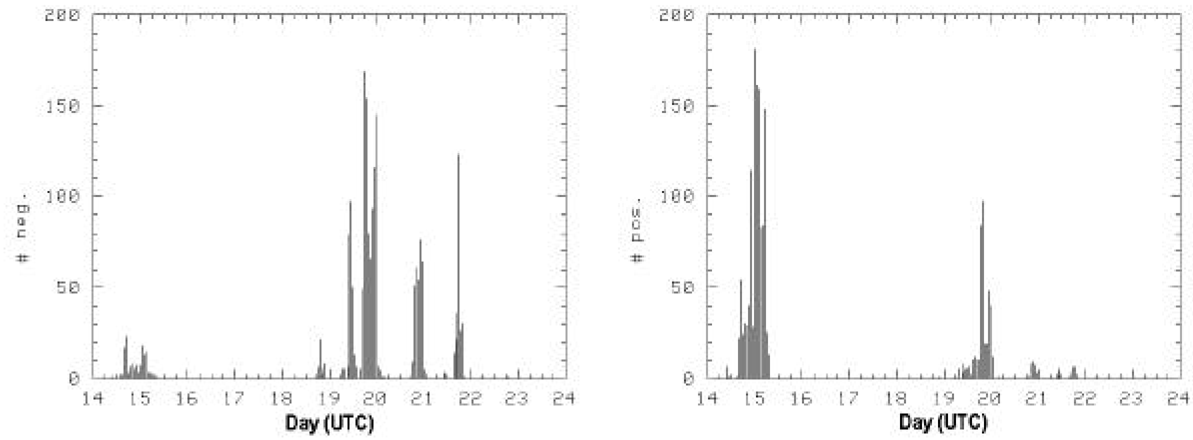
IPE 2 is part of a broad experimental program to study the characteristics of the weather and the climate of the central region of Brazil. In a site (19^o 57' 43.8"S 57 ^{o} 1' 51.6"W) at this tropical region, meteorological radiosondes were launched from Sept. 14 to 23, 1999, with a 3-hour time interval between launches. Two thunderstorm events (Sept. 15 and 19, 1999) were recorded by a brazilian lightning detector network, composed by LPATS and IMPACT sensors (Beneti et al., 2000). Lightning flashes are derived from stroke records through a numerical process (Mendes and Domingues, 2000) based on empirical criteria: subsequent strokes in a flash were considered to be within 500 ms of the previous stroke and within 2-second interval and 10 km-distance from the first stroke. Those data were analyzed and integrated to satellite data (IR, WV and VIS channels and burning positioning data) and regional numerical atmospheric model output. The atmospheric parameters (Williams, 1995) and the lightning features were calculated and discussed in order to obtain the characterization of the thunderstorm.

RESULTS AND DISCUSSION

The amount of lightning flashes is presented according to polarity in Figure 1. The results of lightning analysis show a difference between the ratios of polarity in the thunderstom events. The first event, Sept. 14-15, presents the highest percentage of positive flashes (~70%, in the other cases ~20%). Although the efficiency of the lightning detecting network is about 30%, all events happened in the same region. This suggests that there is no influence of detection system. Figure 2 presents the GOES infrared images, in which the white pixels indicate the low temperature. The first event was associated with convective systems induced by a strong cold front passage through Southeastern Brazil (Figure 2a). Figure 3 shows a satellite imagery product that indicates the position of the burning sites on a vegetation map and the IPE 2 site as a white star. A strong low-level wind transported the smoke from the burning area into IPE 2 site (Figure 3a). It produced a polluted air condition with very low visibility, less than 400 m, as shown by Figure 4. From the radiosonde data of Sept. 15 0000UTC, the estimated CAPE (Convective Available Potential Energy) was 777 Joules/kg, which is a relatively small value, although the K index, 37, indicated the possibility of organized convection. In this sense, this index does not show agreement to be applied for nowcasting. On the other hand, in the other major event, Sept. 19-20, the cold front moving through Southeastern Brazil was very weak (Figure 2b). There was a weak low-level wind in the IPE 2 area and the air quality was much less polluted, without reduction of visibility. In this case, the CAPE was

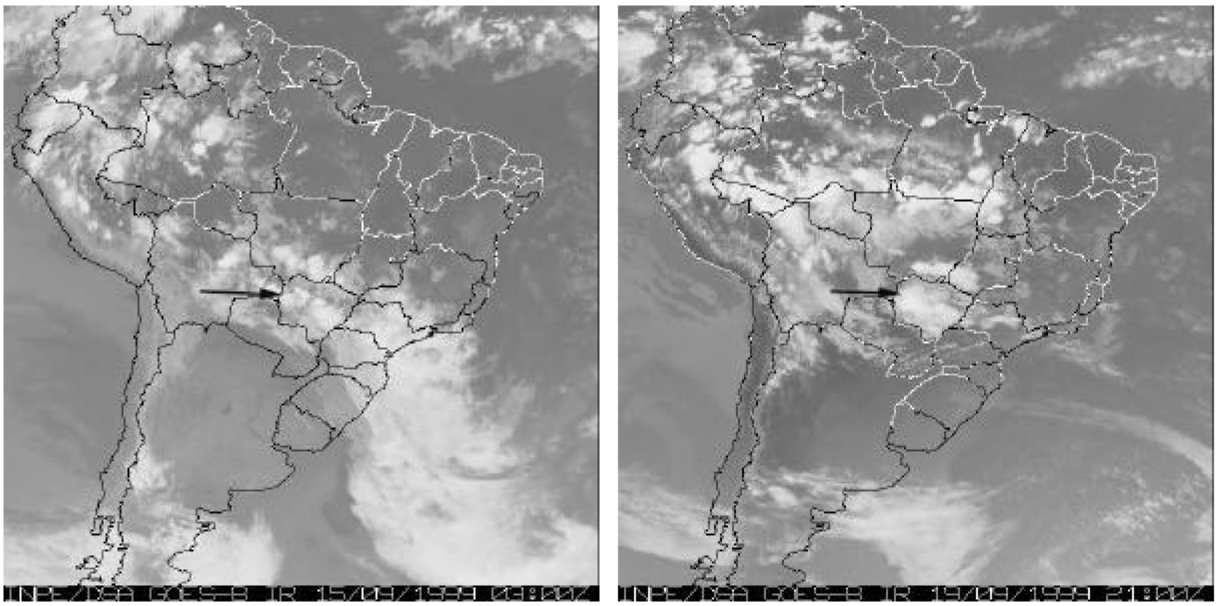
3000 joules/kg, which is considered a high value usually and is related to deep convection. The K index was 34, which also indicates deep convection. In both cases the 0^o C occurs at 600 hPa, -10^o C occurs at 500 hPa, and the estimated cloud top could reach 130 hPa.

Apparently the thunderstorm of Sept. 15 was much more organized and stronger than the one of Sep. 19. However, the meteorological indices did not forecast it and the polarity ratio was very different from the usual values in Brazil. On the other hand, the atmospheric conditions were much more polluted in the first case. The question is: how this atmospheric disturbance contributes to this unexpected result?



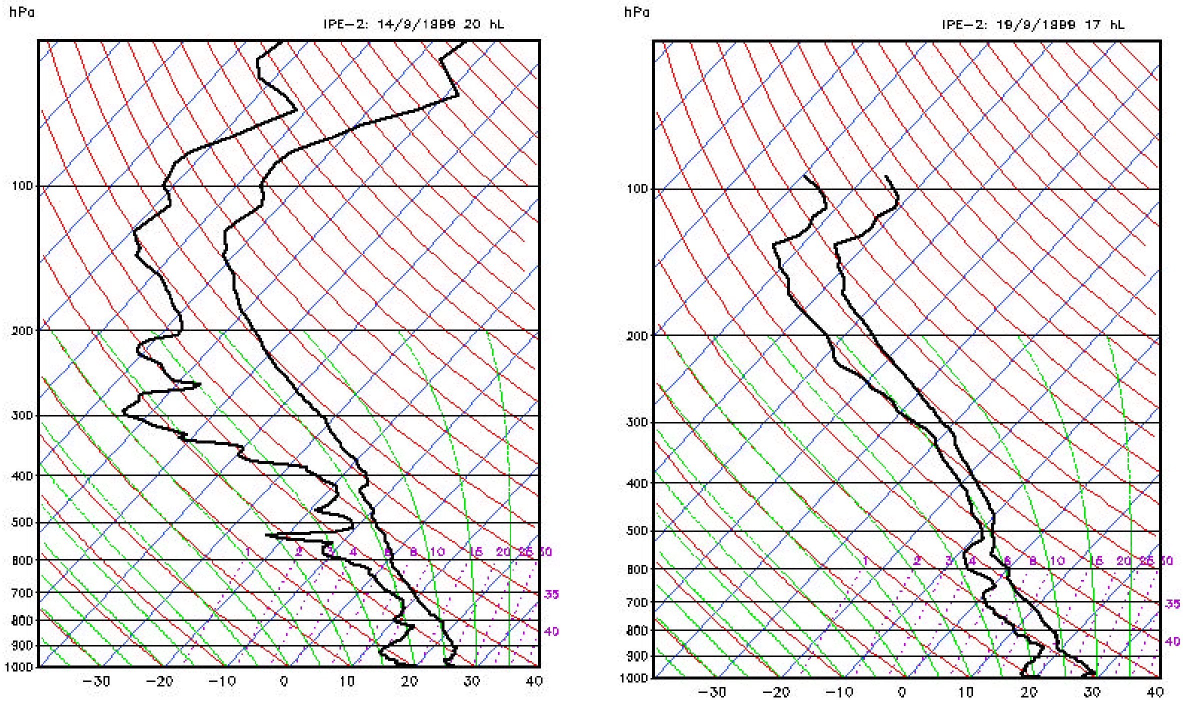
(a) (b)

Fig. 1 – The amount of lightning flashes is presented according to polarity: (a) negative flashes and (b) positive flashes, in the IPE 2 region.



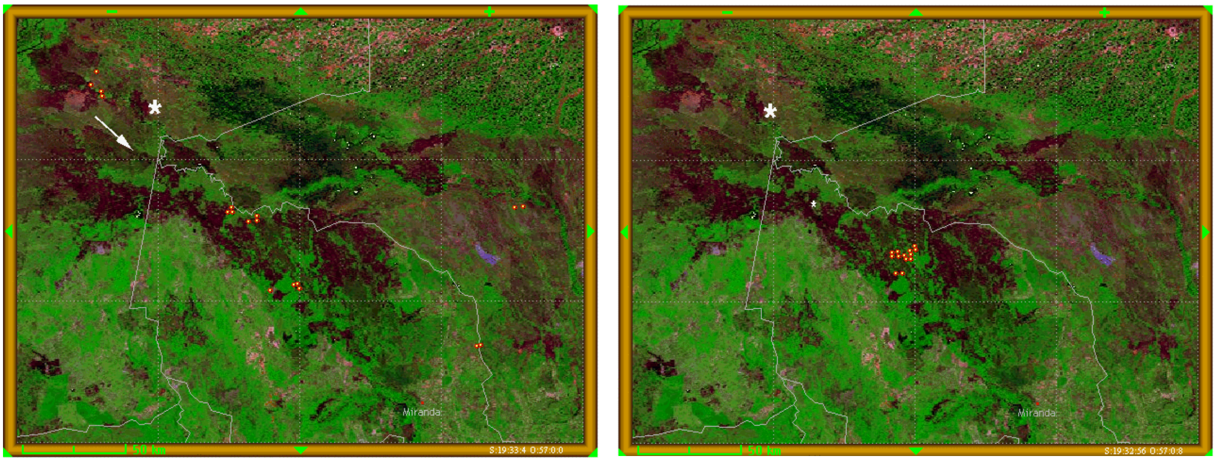
(a) (b)

Fig. 2 – Goes 8 satellite images from infrared channel. The arrows show the position of IPE 2 region: (a) Sept. 15, 0030UTC and (b) Sept. 19, 2100UTC.



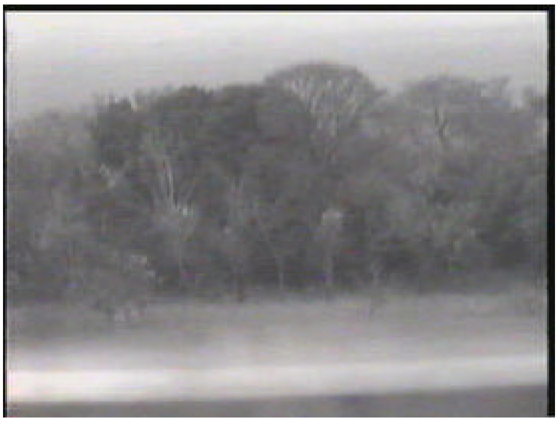
(a) (b)

Fig. 3 – The skewT/logP diagrams from the IPE 2 region: (a) Sept. 15, 0000UTC and (b) Sept. 19, 2100UTC.



(a) (b)

Fig. 1 – From the satellites images this product indicates with the red circles the position of the burning sites on a vegetation map. The white star indicates the position of the IPE 2 site. (a) Burning sites from Sept. 13 to 14. (b) Burning sites from Sept. 18 to 19. The wind was very weak. The white arrow indicates the wind direction.



(a)

(b)

Fig. 4 – Examples of the local atmospheric condition in IPE 2 region: (a) in Sept. 14, with low visibility (less than 400 m) and (b) in Sept. 19, with good visibility (higher than 5 km).

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