Diurnal patterns in lightning activity over South America

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Satellite and ground network observations of lightning flash distribution data are used to examine the diurnal cycle of lightning activity over the tropical and subtropical regions of South America. The results show in the subtropical South America, particularly the area limited by [-25°; -40°] of latitude and [-70°; -50°] of longitude, the time of maximum lightning activity was shifted to nocturnal hours, extending from close to midnight to early morning hours. This behavior can be associated to the peak in MCSs in the morning hours in the region. A close connection between peak time of lightning activity and peak time of precipitation events have been observed by comparing the current results with other published studies. On the other hand, storms over northern Argentina are known as leading Transient Luminous Events (TLE) generators on Earth (Thomas et al., 2007).

1. Introduction

Numerous studies show that convective cloud systems produce most of the precipitation and severe weather in the tropical and subtropical part of the continent of South America. Particularly, Zipser et al. (2006) [1] and Romatschke and Houze (2010) [2] found a maximum of extremely deep convective cores in the continental subtropics of South America. The conditions leading to the development of mesoscale convective systems (MCSs) and mesoscale convective complexes (MCCs) in different regions of South America have been studied by Salio et al. 2007 [3], Romatschke and Houze (2013) [4], among others.

2. Methodology and Data

The lightning data used in this study came from two independent lightning detection systems LIS-OTD and WWLLN.

In order to characterize and quantify the local diurnal cycle on lightning activity, a harmonic analysis was performed in each grid cell. The diurnal cycle was fitted using a sinusoidal function with a 24 hours period as follow,

$$FR_{DC}(t) = a + b\sin\left(\frac{2\pi}{24}t + c\right)$$

where FR_{DC} is the mean diurnal flash rate (flashes km^{-2} h^{-1}), a is the mean value of the lightning activity during the 24 hours period (flashes km^{-2} h^{-1}), b is the amplitude of the lightning activity oscillation on the period considered (flashes km^{-2} h^{-1}) and c the phase of the diurnal cycle (radians) which is an indicator of the time when the maximum lightning activity occurs. To obtain information on the shape of the diurnal distribution, the ratio between the amplitude and the mean value (NA=*b/a*) was calculated for each grid cell and the following criteria were used,

- NA < 0.5 indicates a lack of a well-defined peak on lightning activity or a double maximum,
- 0.5 < NA< 1.0 indicates a diurnal trend with a clear peak, and
- 1< NA indicate a well developed diurnal cycle with a clear peak in the diurnal lightning activity.

These criteria are consistent with those proposed by Easterly and Robinson (1985).

Figure 1 shows a map of South America along with the local time of maximum lightning activity (vector plot) and the NA values (color plot) during the 24 h daily cycle derived from LIS-OTD data and Figure 2 shows the same information but derived from WWLLN data. The arrows pointing indicate time of maximum at 0:00 LT (north), at 6:00 LT (east), at 12:00 LT (south), 18:00 LT (west).

The results of both data set are in good agreement and show that in north and center regions of South America, the time of maxima for lightning activity was mainly concentrated in the late afternoon to evening hours (between 17:00 and 19:00 LT) which can be associated with the peaking of the local convective activity associated with heating of the surface in the interiors of the landmasses and display a marked diurnal cycle of lightning activity with NA values around or higher than 1

In the area limited by [-25°; -40°] of latitude and [-70°; -50°] of longitude, which includes Paraguay, northeastern Argentina, south Brazil and Uruguay, including La Plata basin, the time of maximum lightning activity is more variable and it is mainly shifted to nocturnal hours, extending from close to midnight to early morning hours and show NA values lower than 0.5 indicating a lack of a well-defined peak on lightning activity or a double maximum.

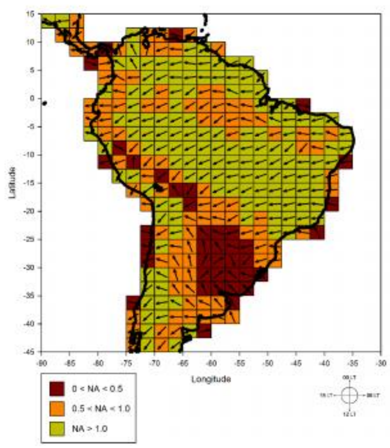

Figure 1 local time of maximum lightning activity (vector plot) and the NA values (color plot) during the 24 h daily cycle for data from LIS-OTD

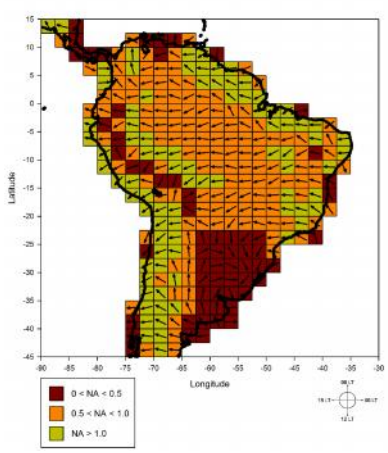

Figure 2 local time of maximum lightning activity (vector plot) and the NA values (color plot) during the 24 h daily cycle for data from WWLLN

3. Conclusions

A close connection between peak time of lightning activity and peak time of precipitation events have been observed by comparing the current results with other published studies.

Generally, in the north and center regions of South America the time of maxima lightning activity was concentrated in the late afternoon to evening hours, which may be associated with the peaking of the local convective activity. While, in the subtropical South America, particularly the area limited by [-25°; -40°] of latitude and [-70°; -50°] of longitude, the time of maximum lightning activity was shifted to nocturnal hours. This behavior can be associated to the peak in MCSs in the morning hours over the region. A significant portion of precipitation in the area is contributed mainly by large MCCs, which tend to develop initially from convective cells triggered in the afternoon in the region of southern foothills of the Central Andes.

On the other hand, the storms over this regions are known as leading Transient Luminous Events (TLE) generators on Earth (Thomas et al., 2007) [5], Therefore the results of this study provide valuable information about convective processes in tropical South America and could help in future studies of generating TLE storms over northern Argentina.

3. References

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