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Cloud-to-ground lightning observations over the eastern Amazon Region

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ABSTRACT

Cloud-to-ground (CG) lightning variables, space and time distributions near the equator, over Eastern Amazon, were analyzed in this work. Over seven million lightning flash events of this type, detected by a VAISALA lightning detection network were processed. This data set was collected by the Brazilian Amazon Protection System between 2006 and 2008. The results showed the sub-areas of higher occurrence densities, polarity types, current peak intensity intervals, as well as, the hourly distributions of CG lightning, for this region. A considerable percentage (7%) of discharges with stroke current peaks above 100 kA, was observed. An attempt was made to compare the statistical results of this work with observations made elsewhere in Brazil and other regions of the world. The differences found suggest that, some regional peculiarities of the CG lightning parameter values should be taken into consideration, for electric and telecommunication systems protection against atmospheric electric discharges, in the Amazon Region.

1. Introduction

Considering its large area, humid tropical climate and frequent cumulonimbus cloud cover, the Brazilian Amazon Region is supposed to be the target of most of the lightning discharge occurrences in Brazil. The performance of the electric distribution systems in Amazonia is significantly affected by cloud-to-ground (CG) lightning events (Santos et al., 2011).

This fact has to be considered since several hydroelectric power generating dams are being built now, and are supposed to supply electric energy to the center and southern regions of Brazil in the next decade, through very long transmission lines.

The electric energy and telecommunications sectors have often suffered disruptions attributed to lightning, which resulted in heavy economic losses to the most populated states in southern Brazil. Therefore, the determination of lightning occurrence characteristics in the Amazon Region is of great importance for economic interests in this country.

Except for some pioneering studies made, in the past decades (Souza et al., 1999; Rocha et al., 1996), lightning observations with modern equipment remained scarce in that region The demand for characteristics of lightning in the Amazon began to be supplied more recently after the installation of regional lightning location systems. It is expected that this study will contribute to establish parameters to optimize the choice of appropriate facilities and equipments, capable of withstanding a large percentage of CG lightning direct strikes on the local transmission lines.

The lightning location systems (LLS) represent important remote data sources on lightning variables and cover several regions of the Earth. There are more than 60 LLS networks worldwide (Cummins and Murphy, 2009). As examples of large LLS networks, one may mention: the European networks (EUCLID and LINET) (Diendorfer, 2002; Betz et al., 2008), the Austrian Lightning Locating System (ALLS) (Diendorfer et al., 1998; Schulz et al., 2005), the Canadian Lightning Detection Network (CLDN) (Burrows et al., 2002),

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the U.S. National Lightning Detection Network (NLDN) (Cummins et al., 1998; Biagi et al., 2006; Zajac and Rutledge, 2001; Orville et al., 2002), and others in Australia (Kuleshov et al., 2005), China (Chen et al., 2004), and Japan (Shindo and Yokoyama, 1998).

In Brazil, there is the Brazilian Lightning Detection Network (BrasilDAT) which is composed of 47 sensors as a result of the integration of three regional networks: RINDAT, SIDDEM in southern Brazil, and SIPAM, in eastern Amazonia (Pinto Jr. et al., 2007; Pinto Jr. and Pinto, 2008; Naccarato and Pinto Jr., 2009; Pinto Jr. et al., 1996).

It is known that lightning occurrence space and time distributions, depend on the regional climatology (Ribeiro et al., 2011a), prevailing meteorological systems (Mattos and Machado, 2011), land surface cover and uses (Ribeiro et al., 2011b), topography (Bourscheidt et al., 2009) and other factors. Previous analyses using data collected by the SIPAM-LDN, gave preliminary indication that the regional events, seemed to present higher spatial density of occurrences, and produced higher average intensity of the first stroke peak currents, than the worldwide average values (Almeida et al., 2010), adopted in electrical discharge protection projects. It has been observed also that the regional lightning occurrence densities show a significant seasonal increment during the months between December and May, which correspond to the regional rainy season (Ribeiro et al., 2011b).

This paper pursues this line of study, given the relevance of these variables to the adequate protection of people, buildings, telecommunications and electric systems in the Amazon Region.

2. Methodology

2.1. The SIPAM Lightning Detection Network

During the year 2005, the Brazilian Amazonian Protection System Agency (SIPAM) began to operate its VAISALA, 12 LPATS IV sensor network centralized at a CP 8000 model station located in Belém, in the northern portion of Brazil. Fig. 1 shows the geographical locations of the SIPAM LDN sensors.

The data collected by this system are stored in a continuous sequence at the central station and recovered as text files in UALF format, with twenty five attributes associated to each stroke event.

A data set of flash events observed between October 2006 and December 2008 was selected for analysis. These data correspond to a good maintenance and improved performance period of the system. The data processing deliberately excluded lightning flashes identified as cloud-to-cloud (CC) or intra cloud (IC) events, as well as, preliminarily those with estimated peak currents above 250 kA.

The intra-cloud flashes were excluded considering their small significance to the subject of protection of electric

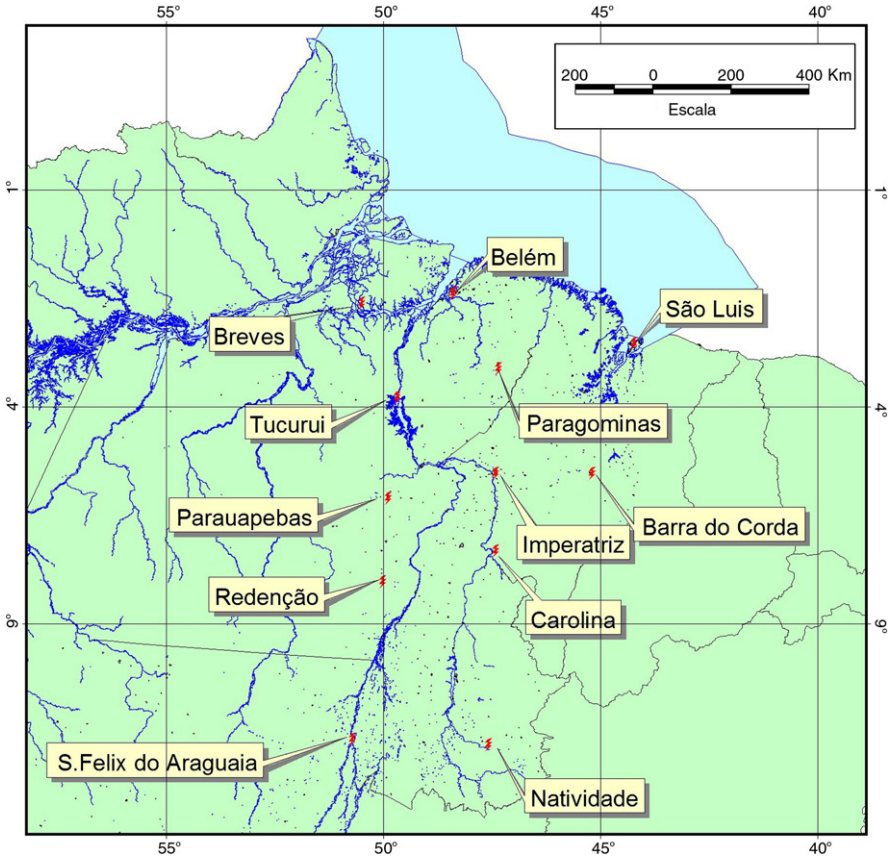

Fig. 1. SIPAM-LDN sensor locations.