Lightning and Atmospheric Electric Field Data Acquisition Site: Preliminary Data and Possibilities

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Abstract

An observational site is being implemented to provide data to study lightning characteristics and the atmospheric electric field. Several facilities already operating and some to be implemented are described in this work. Auxiliary data to be used are also mentioned.

INTRODUCTION

Atmospheric electricity and thunderstorms can be studied through several different aspects: fair and foul weather electric field, thundercloud structure and evolution, electromagnetic lightning-related radiation waveform, lightning channel characteristics, pressure waves, etc. In order to obtain information on these aspects to better understand them, several observing facilities were grouped in one site located very close to INPE, National Institute for Space Research, where other important auxiliary data are available.

THE SITE

Located at São José dos Campos (45.864^{o} W, 23.215^{o} S) at an altitude of 630m, the observational site has nearly 360^{o} field of view at a height of 25m (Figure 1). It is possible to visualize distant thunderstorms occurring within a radius of 25 km from the site. The room, situated over a metal structure, has water and power supplies, a telephone line and a small crane on the roof.

EQUIPMENT AVAILABLE

WAVEFORM-DIGITIZING SYSTEM

The developed system shown in Figure 2 comprises an antenna, a selectable band-pass filter (2 or 200 Hz to 200 kHz), an amplifier and a digital output to a PC. It records the electric field at a 27 kHz rate. In order to analyze the electric waveform in more details, we plan to have this rate increased to 1 MHz. This system has also a sound alarm for every flash detected whose amplitude is above a preset value. This sound is recorded by video recorders and a tape recorder making later analysis easier.

VIDEO IMAGES

Three video cameras are used simultaneously in order to cover a wider field of view. They are previously synchronized with the electric field acquisition. When a lightning occurs, the file number of the electric field acquisition is said aloud, and so recorded in the video cassette tape. The successive frames of the image are then compared to the waveform of the strokes (Figure 3). A full video frame comprises two fields, which are successive scans of alternate (interlaced) horizontal lines on the image. Since the frame rate is 30 Hz, the time interval between successive fields is just under 17 ms, which is just enough to record each stroke separately. In the near future, a new camera with recording speed of 1000 pictures per second will be available.

ELECTRIC FIELD MILL

This equipment records the ambient electric field at a lower frequency. The Electric Field Mill is capable to record variations up to 50 Hz in the electric field caused by nearby lightning and by foul and fair weather field variations. Figure 4 shows the plot of the electric field changes caused by lightning at an acquisition rate of 5 Hz.

THUNDERSTORM SENSOR SYSTEM - TSS 430

This sensor provides information about of cloud-to-ground lightning occurring at distances up to 190 km from the sensor. It displays information through a desktop PC dividing the screen into octants with range rings at 0-6, 6-19, 19-55, 55-190 km. The octants change color to indicate the lightning flash count within a running 15-minute period. The actual flash count is also displayed within each octant at each range (Figure 5). The ranges 0-6 and 6-19 km use the static electric field to determine the range, and the range regions 19-55 and 55-190 km use radiated signal strength. Since the signal strength depends on both the peak current in the return stroke and the range, it is assumed that all negative flashes beyond 19 km have a peak current of 30 kA, and the range is calculated. The sensor can provide data for each flash detected, and the data for each stroke in a flash. It provides time (precision of milliseconds), angle and signal strength of the first stroke of the flash, and the multiplicity of the flash.

PRESSURE WAVES - TAPE RECORDER

A tape deck and microphone record pressure waves generated by thunder. The pressure wave and its spectrogram can be then analyzed and compared to other characteristics of the flash: type of flash, multiplicity, tortuosity, time between strokes, etc. The spectrogam displays sound information in a time-by-frequency-by-amplitude format (Figure 6). The time (x) axis is aligned with the waveform time axis (in milliseconds). The frequency (y) axis indicates ascending frequency from a low to a high frequency cutoff value. Finally, sound amplitude at every time-by-frequency is displayed in shades of gray. The record of the sound alarm triggered by the arrival of electromagnetic radiation and the thunder gives a rough estimate of the distance of the lightning.

AUXILIARY DATA

LIGHTNING LOCATION SYSTEM

Data from a lightning location system is available. The two closest Impact/LPATS antennas are located within 100 km from the site and a third one is being implemented nearby. Figure 7 shows a recent lightning occurrence map for March 10, 1999. Video images, photographs, electric field waveforms and electric field mill data were also acquired for this thunderstorm event. Table I shows examples of data given by the system for each stroke detected.

Table I - Data given for each stroke detected.

Date (mm/dd/yy) / Time (UTC)	Latitude	Longitude	Intensity (kA)
03/10/1999 20:01:29.704	-23.1135	-45.8907	-40
03/10/1999 20:02:56.170	-23.1182	-46.0465	-26
03/10/1999 20:03:59.768	-23.1284	-45.9026	-47
03/10/1999 20:04:00.039	-23.1321	-45.9193	-33

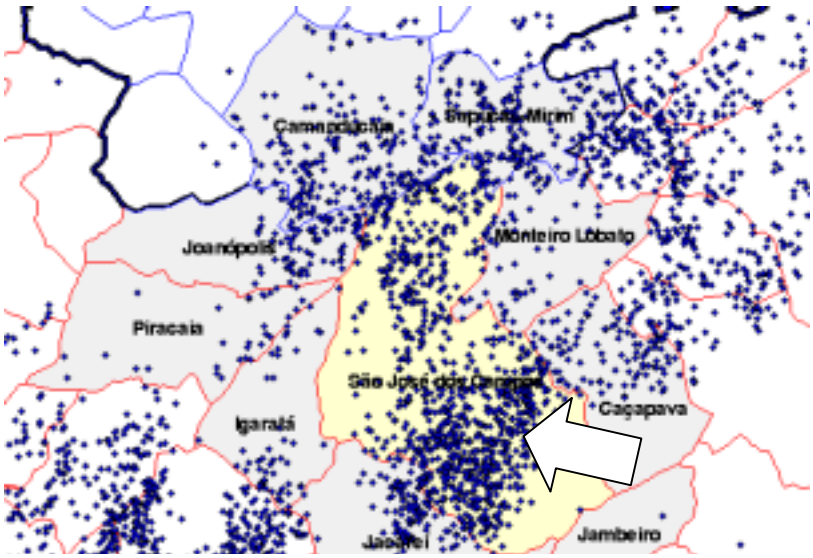

Figure 7 - Lightning occurence nearby São José dos Campos. The white arrow indicates the location of the observing site.

RADAR AND SATELLITE IMAGES

The characteristics of the thunderstorm system responsible for the electrical activity studied can be analyzed using radar images and METEOSAT and GOES satellite images.

METEOROLOGICAL STATION

Surface wind speed and direction, precipitation, temperature, humidity data are some of the available information that is provided by INPE's meteorological station 1km apart from the observation site. In near future, some basic meteorological instruments logged to a PC will be working in the site.

5 CONCLUSIONS

The observing site is a unique place in Brazil to obtain a set of data on atmospheric electricity and lighting activity. The analysis of some recorded data during the 1999 summer is already being performed and will help to understand the convective storms and lightning in this region of Brazil. During fall and winter, meteorological data and fair weather electric field relationships will be studied, thus keeping the site operational during the whole year.

ACKNOWLEDGMENTS

The authors would like to thank the Fundação de Amparo à Pesquisa do Estado de São Paulo - FAPESP for providing support through the project 1996/2239-3. The authors would also like to thank the Centro Tecnológico da Aeronáutica (CTA) for the permission given to use the observing site.