ABSTRACT: The lightning research in Brazil is reviewed based on recent direct measurements of natural lightning captured in the Morro do Cachimbo field station, and triggered lightning in the International Center for Triggering Lightning, located in Cachoeira Paulista, both in the Southeast part of the country. Their characteristics (multiplicity and peak current) are revised and compared with similar data obtained outside the tropics by other instrumented towers in Europe, Japan, and Canada and by a similar triggering lightning facility in Florida, United States. The influence of the different techniques used in these measurements on the results are also discussed. The comparison of the multiplicity and peak current measurements in the Morro do Cachimbo station with other similar measurements was done considering the different current threshold adopted and the different location of the current sensor in the tower. The comparison of the triggered lightning characteristics, in turn, was done considering the different triggered methods used.

INTRODUCTION

There is no possible way to predict where and when a natural lightning will strike a given point on the Earth’s surface. In consequence, close observations of lightning are not common. This is the reason why measurement equipment has been placed nearby tall man-made structures, in general metallic towers, located on mountaintops. Although some close range data has been obtained in this way, the analysis of an appreciable amount of data requires years of continuous data recording, even in areas of relatively high lightning activity. Another more effective technique is the initiation of a lightning launching a small rocket trailing a thin copper wire toward the charged cloud overhead. The two common techniques used in rocket-and-wire lightning triggering are the classical and altitude techniques. Other techniques to stimulate the occurrence of lightning between an overhead cloud and a designated point on the ground are being developed, such as, laser beams and salt water jets going upward. However, at the present time they do not get complete success.

In Brazil, lightning observations in instrumented towers began in 1985 in the Morro do Cachimbo station, located in the southeast part of the country. Since then, almost a hundred flashes were captures. By turn, triggering lightning observations started very recently (in 2000). Up to the present, 11 triggered flashes were reported.

In this paper, a summary of the results obtained by these observations is presented, in terms of the multiplicity and peak current characteristics. The results are compared with similar observations done in other regions of the world, and discussed in terms of influence of the different techniques used in these measurements.

MORRO DO CACHIMBO STATION
Morro do Cachimbo station (MC) was acquired by Companhia Energética de Minas Gerais (CEMIG) from the National Electric Engineering Research Institute (NEERI), located in South Africa, and installed under the orientation of Dr. A. J. Eriksson. The station is very similar to that operated in South Africa (Eriksson, 1979). Located at 43°58′W and 20°00′S, MC initiated its operations in 1985. It records the nearby cloud–ground lightning activity, the atmospheric electric field, and the direct current measurements. In addition, it provides photograph records and video images of the flashes striking the 60-m metallic tower. The tower is located on the top of a mountain about 1430 m above the sea level and 200 m above any other mount in the region. The current is measured by two current transducers (CT) that induce proportional voltage pulses. In a lightning event in the tower, the discharge crosses a gap before the principal CT. Current values up to 200 kA can be measured. One shunt of 0.5Ω is prepared in a parallel path with other CT to allow the measurement of small (lower than 20 kA) current values with higher accuracy. The MC uses a fiber optic link, with converters E/O and O/E, installed into an open duct with a copper plate ground system from the sensor to equipment room. The accuracy of current resolution and sampling time of the data analysed in this work was initially limited to 760 A – 1μs and 116 A – 0.2μs for the principal CT and the parallel CT, respectively. The sampling time of the principal CT was changed to 0.5μs in 1992 and to 0.2μs in 1993, remaining unchanged up to the present. All events in the tower with peak current above 116 A are recorded. For more details, see Pinto Jr. et al. (2003).

THE INTERNATIONAL CENTER FOR TRIGGERED-LIGHTNING IN BRAZIL

The International Center for Triggered Lightning is located inside the National Institute for Space Research (INPE) campus at Cachoeira Paulista (S 22°41.2; W 44°59.0; altitude: 625 m), a small city located halfway between São Paulo and Rio de Janeiro, where there are on average about 80 thunderstorm days per year. The research institutes involved in the Center are INPE and UNICAMP from Brazil, CNRS/UPS from France, and the companies INDELEC from France and MAKER from Brazil. The triggering site is located on a flat 120m x 70m area of a hilltop (Figure 2). The control instrumentation is located 45 m away from the rocket launcher that has a capability of launching up to 12 rockets during the same event. The ambient electric field, a crucial parameter to decide if lightning triggering is viable, is monitored by a field mill connected to the control room via fiber optic link. The plastic maiden rockets are 0.85 m long and carry the wire spool with them. Around the launcher several instruments were mounted: standard video cameras, a high-
speed digital camera, allowing the acquisition of high-speed sequences up to 8000 frames per second, current, fast E-field and optical sensors. More details can be found in Saba et al. (2002).

SUMMARY OF RESULTS AND DISCUSSION

From 1985 to 1998, 51 flashes with strokes larger than 2 kA and current waveform were captured. From them, 29 were downward flashes. Out of 29 downward flashes, 14 flashes were single flashes and 15 were multiple flashes. The total number of strokes of all multiple flashes was 89. The percentage of multiple negative downward flashes at Morro do Cachimbo station (51.7%) is higher than those at San Salvatore station (around 35%). Figure 3 shows the distribution of the number of strokes per flash in downward negative flashes at both station (for both towers in Switzerland, separately. Two hypotheses may be invoked to explain this difference: different latitudes or different predominant meteorological systems. Recent results obtained in the United States by Orville and Huffines (2001) have indicated that the multiplicity of negative flashes has regional variations. The authors speculate that these variations may be related to variations in the horizontal dimensions of the thunderstorms at different locations. Such a hypothesis, if proved, could explain the observed difference found in this work.

The peak current observations in Morro do Cachimbo station shows a geometric mean value around 45 kA. This value is much higher than that reported in Switzerland (around 30 kA). The current observations in Morro do Cachimbo were done in the base of the tower, while the measurements in San Salvatore were done in the top of the tower. However, this difference in the location of the current sensor for a 60 m tower, like that used in both station, seems not be able to explain the large peak current difference reported.

From the analysis of the 11 flashes triggered from 2000 to 2003, we found that the multiplicity is similar to that observed in other regions (Fisher et al., 1993). From the 11 flashes recorded, peak current measurements were obtained for 3 strokes by the classical method and for 7 strokes by the altitude method (see Table 1). Even though the numbers of observations are not statistically significant, mainly for the classical events, they may indicate more intense triggered flashes in Brazil compared to other regions. It is worth noting that only a few observations of peak current by the altitude method are already reported in the literature.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Altitude (7 strokes)</th>
<th>Classical (3 strokes)</th>
<th>Classical (Fisher et al., 1993)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return-stroke current peak (kA)</td>
<td>33</td>
<td>26</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 1

ACKNOWLEDGEMENTS: The authors would like to thank the Companhia Energética of Minas Gerais for providing data from the Morro do Cachimbo station and the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) for supporting the research through the project 99/09165-3.
REFERENCES


