

# Direct Lightning Current Measurements in Southeastern Brazil

## I. Current Waveform

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This paper shows for the first time in the scientific literature data of 22 natural negative cloud to ground lightning discharges in South America captured by a 60 m metallic tower between 1985 and 1994. The technique for obtaining the data is briefly described. We show current waveform for several return strokes with resolution of 1  $\mu$ s, 0.5  $\mu$ s and 0.2  $\mu$ s. The average current waveform shows some differences when compared with data from Switzerland tower.

### INTRODUCTION.

Between 25/11/85 and 26/02/94 data were obtained in the research station of atmospheric discharges, also called "CACHIMBO", which belongs to the *Companhia Energetica de Minas Gerais, CEMIG*, in Belo Horizonte, Brazil. It was acquired from the National Electric Engineering Research Institute (NEERI), Pretoria, South Africa, and installed under orientation of Dr. A. J. Eriksson. The system CEMIG LIGHTNING RESEARCH STATION (CLRS)<sup>(2)</sup> (43° 58' 26"W, 20°00'39"S), is located 15 km distant of Belo Horizonte. The CLRS allow to record: lightning ground flash activity (recorded continuously); atmospheric electric field (recorded either continuously or during thunderstorms only); photographic records and video images of lightning within view of the two video cameras; current waveform and current wavefront of lightning strikes to the tower<sup>(2)</sup>. The CLRS is operated for technical personnel of CEMIG.

### DATA ANALYSIS

The 60 m metallic tower is located on the top of a mountain about 1600 m above sea level and 200 m above any other mountain in the region. It is isolated of the earth in a manner that the electric current of stroke passes through an electric circuit before to be dissipated on ground. The circuit consists of a current transformer that generate a voltage proportional to the current. The voltage then is digitized and stored.

Between 1985 and 1994 the tower was stricken by 63 discharges (totalizing 122 strokes), with an average of 7 stricken each year. 27 (43%) discharges were descendent negatives. 17 out of 27 (63%) were single and 10 (37%) were multiple, with an average of 6 strokes for multiple discharge. The median peak current value,  $I_{peak}$ , was 41,3 kA for first strokes and 16,0 kA for subsequent strokes<sup>(3)</sup>.

For the analysis presented in this paper 22 descendent negative discharges were considered. The data were obtained in three temporal scales, respectively: group G1, 1  $\mu$ s (25/11/85 to 17/03/92, 12 discharges / 38 strokes); group G2, 0.5  $\mu$ s (05/09/92 to 10/03/93, 3 discharges / 9 strokes); group G3, 0.2  $\mu$ s (08/11/93 to 26/02/94, 7 discharges / 43 strokes). The current resolution for all groups was 0.79 kA.

Figure 1 shows the normalized average current waveform for first strokes obtained in Switzerland<sup>(4)</sup> and in Brazil and, figure 2, for subsequent strokes. The normalized average curve for first strokes (fig. 1) in Switzerland decreases slower and has a peak earlier than the curve in Brazil. The time to half value,  $t_{half}$ , is consequently greater: about 88  $\mu$ s for CLRS and about 112  $\mu$ s in Switzerland. For subsequent strokes (fig. 2), the cumulative mean was calculated for stroke order,  $n$ . We start with  $n \geq 6$  (19 strokes) and finish with  $n \geq 2$  (50 strokes). The time to peak is around 4  $\mu$ s for CLRS against 1.1  $\mu$ s in Switzerland. All cumulative mean (CLRS) shows the same behavior, that is, they increase up to a peak and then decrease, initially slower than Switzerland data and, after about 8  $\mu$ s, lightly faster. The Switzerland curve is more intense than the CLRS curve before 3  $\mu$ s and after about 100  $\mu$ s, and less intense between 3  $\mu$ s and 100  $\mu$ s.

Figure 3 shows the average curve for subsequent strokes. The number in each curve represents the order of the subsequent stroke and the number between brackets represent the number of events. We can see in this figure that the third and fourth strokes are more intense than the second. Rakov and Uman<sup>(4)</sup> obtained similar result comparing just the geometrical mean of the electric-field peak. In our data, the average values of the third and fourth strokes, totalizing 15 cases, are also more intense than the second (10 cases). Note that all current value in third and fourth stroke curves are more intense than in the second stroke curve. Even though the difference was not statistically significant at 0.02 significance level.

this agreement suggests that there may be a physical mechanism to explain this difference.

#### CONCLUSION

Data of 22 natural negative cloud-to-ground lightning discharge which striken a 60 m metallic tower in Brazil are presented and compared with similar data obtained in Switzerland. The main conclusions are:

1) The data of CRLS presents some important differences with respect to those obtained in Switzerland. The cause of such differences remains to be investigated.

2) In average, the third and fourth strokes are more intense than the second.

This difference may suggest that a physical mechanism could be involved.

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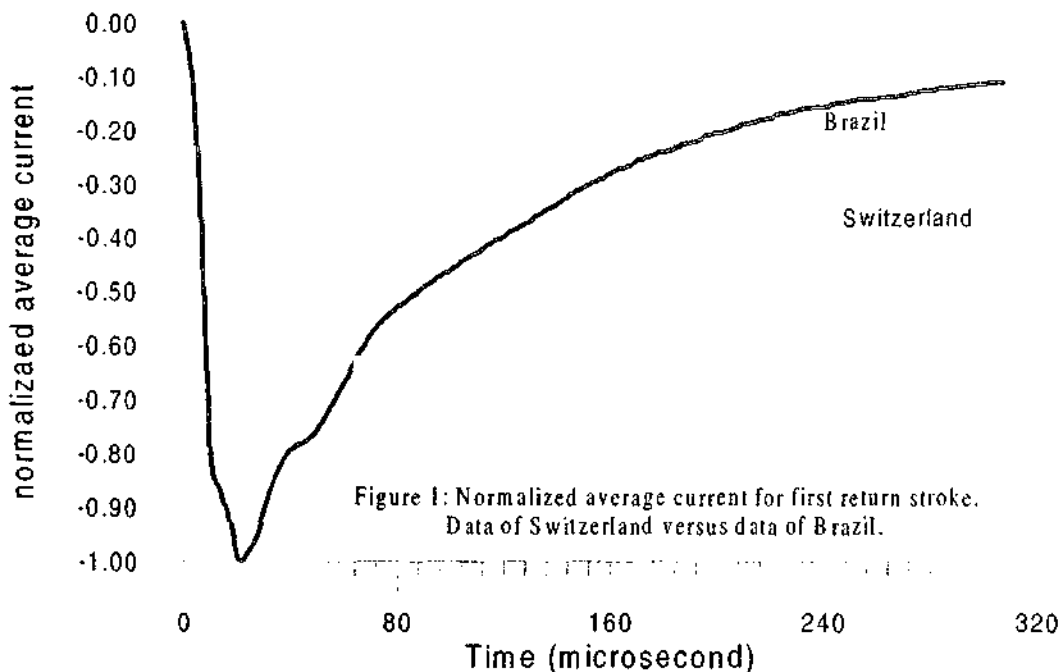
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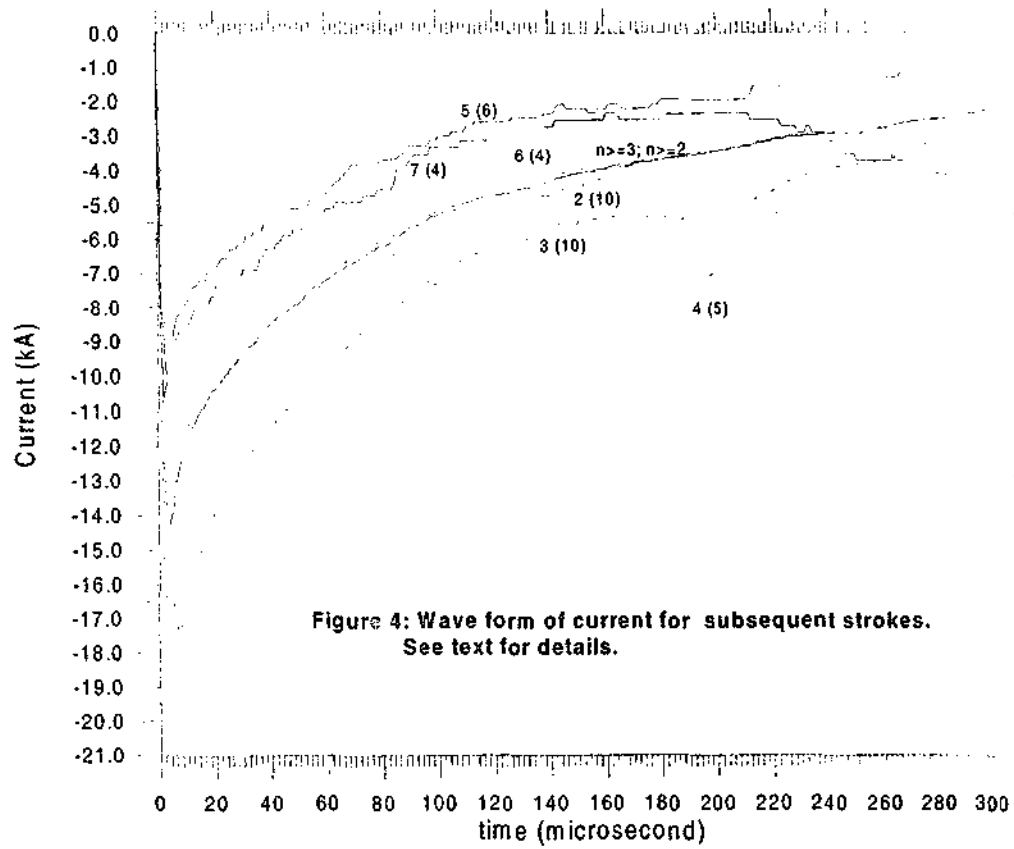
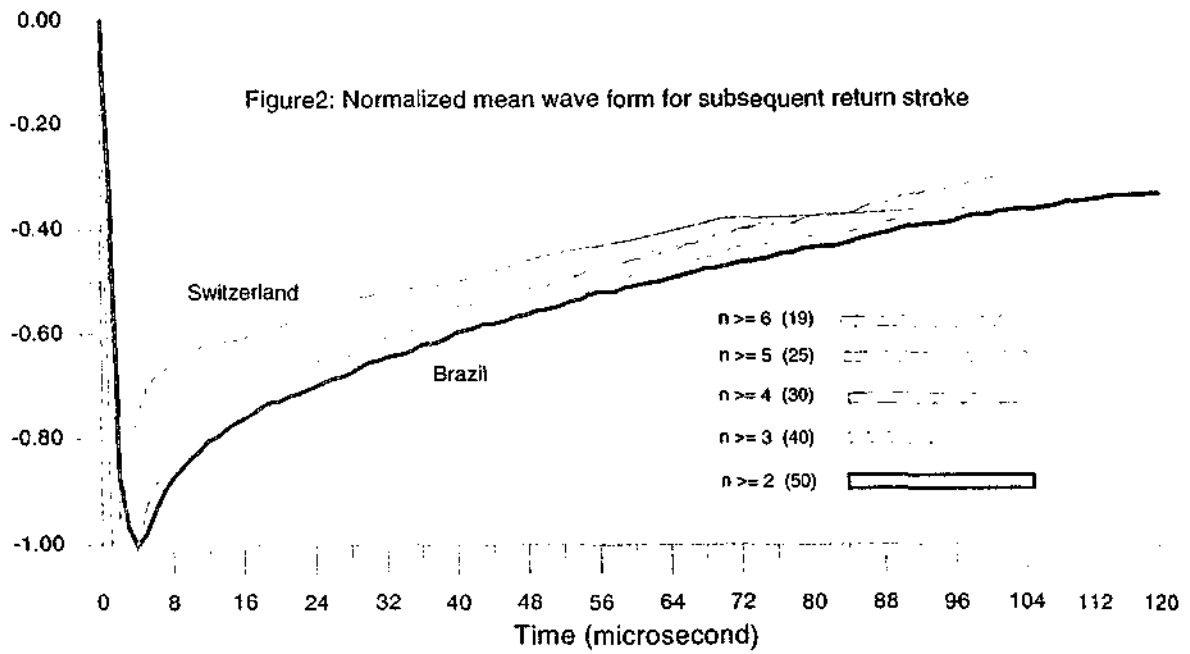
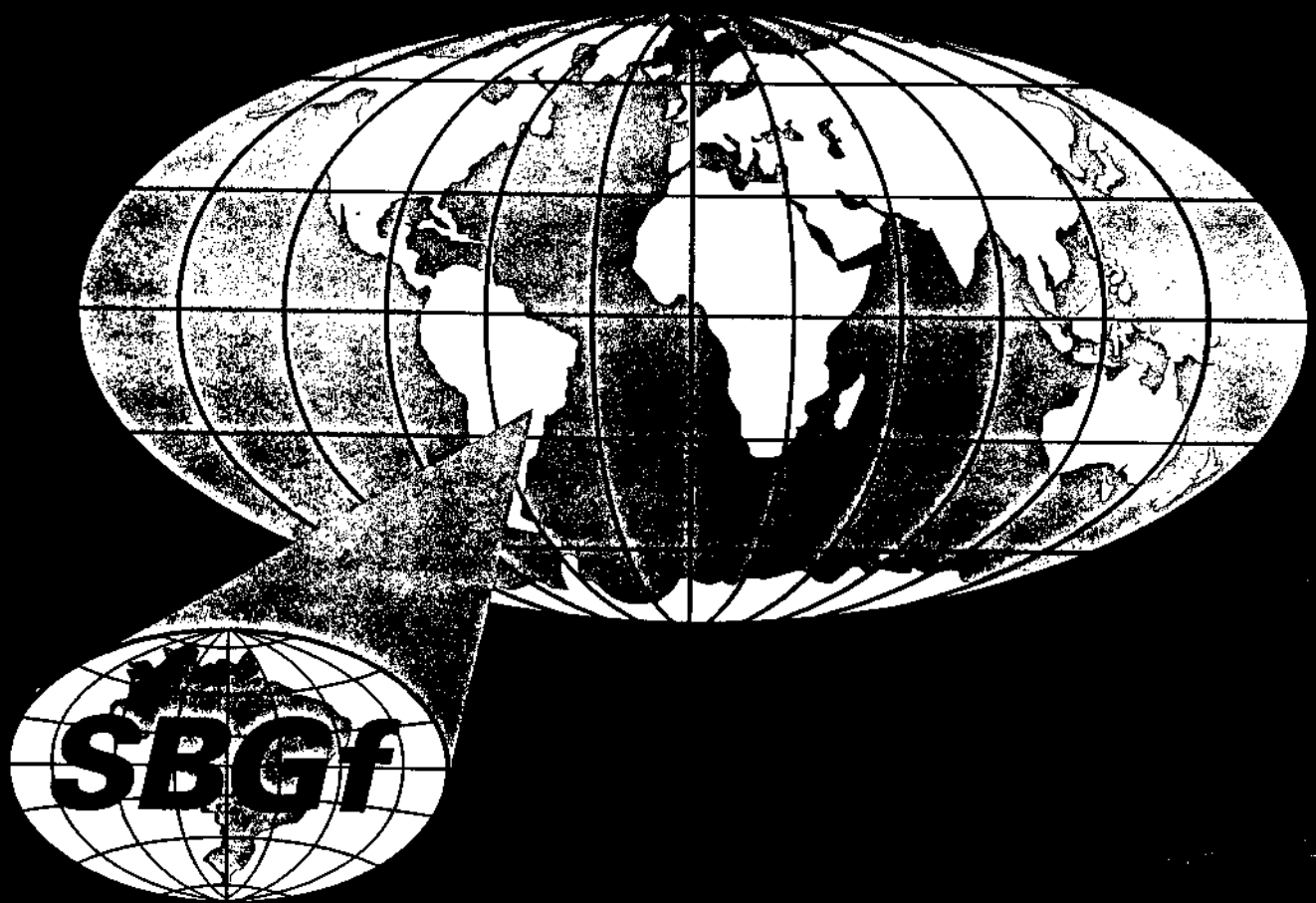


Figure 4: Wave form of current for subsequent strokes.  
See text for details.

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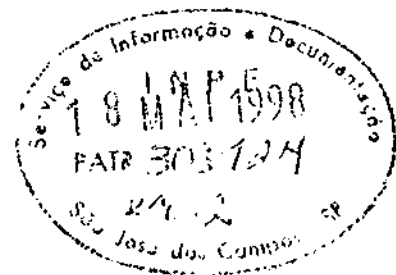
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