

Direct Lightning Current Measurements in southeastern Brazil III: M-Component

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In this paper it is analyzed 13 M-component of 11 subsequent return stroke (of order three or higher) of natural negative cloud to ground lightning captured by a 60 m metallic tower of Cemig Research Lightning Station (CLRS) in Brazil. The CLRS has registered M-components in times less than 1.2 millisecond after the preceding return stroke. The M-components are more intense than those recorded in triggered lightning flashes and occur during periods of higher continuing current level. The half peak width was found to be shorter than those obtained in triggered lightning flashes.

INTRODUCTION

M-component is a stage of a discharge between two successive strokes in which is produced a variation in electric field, in a shape of a hook, and corresponds in time with faint components in the continuing luminosity of the channel⁽⁴⁾. It represents the transference of charge between the cloud and earth through a luminous channel which the conductivity is apparently still sufficiently high to allow an increase of current without a leader process before⁽²⁾. The derivative current before peak current is less intense than that of a return stroke current. When these variations occur just after the first stroke they can be associated with branches of a discharge⁽⁴⁾ and are not treated as M-component in this paper. Associated with M-component, the luminosity of channel was recently studied by Jordan et al.⁽¹⁾, the electric field by Thottappillil et al.⁽⁶⁾, and currents measured at triggered lightning channel base by Thottappillil et al.⁽⁷⁾.

In this paper we present register of variations in current waveform after the third stroke in natural negative cloud-to-ground lightning, chosen among 22 discharge obtained for the CLRS (Cemig Lightning Research Station) between 1985 and 1994⁽³⁾. As described in Lacerda et al.⁽³⁾, the CLRS allow to record: lightning ground flash activity; atmospheric electric field, photographic records and video images of lightning; current waveform and current wavefront of lightning strikes to the tower⁽¹⁾.

DATA ANALYSIS AND DISCUSSION

We have used for this study 11 return stroke current waveform listed in table 1. Eight return strokes out of 30 of group G1, one out of 9 of G2, and four out of 31 of G3, chosen after the second return stroke,

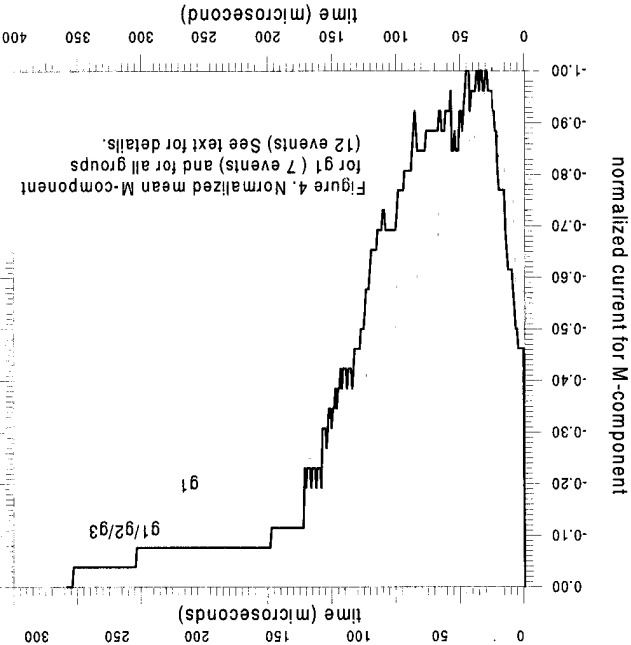
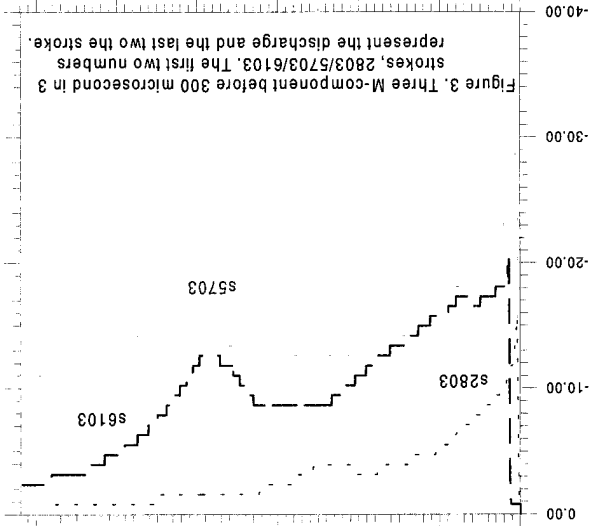
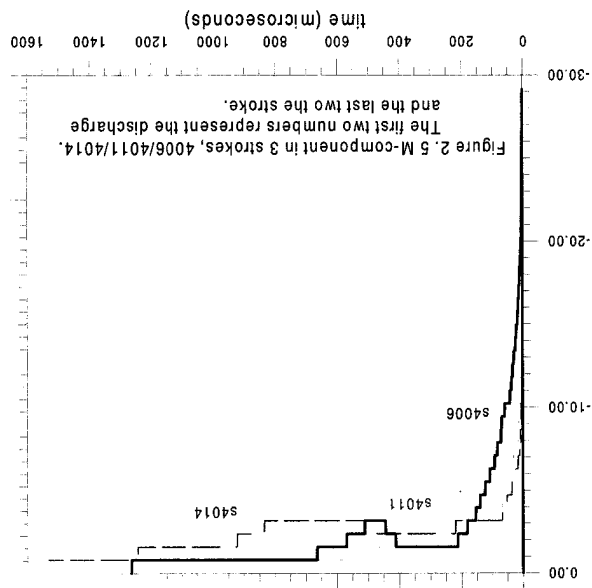
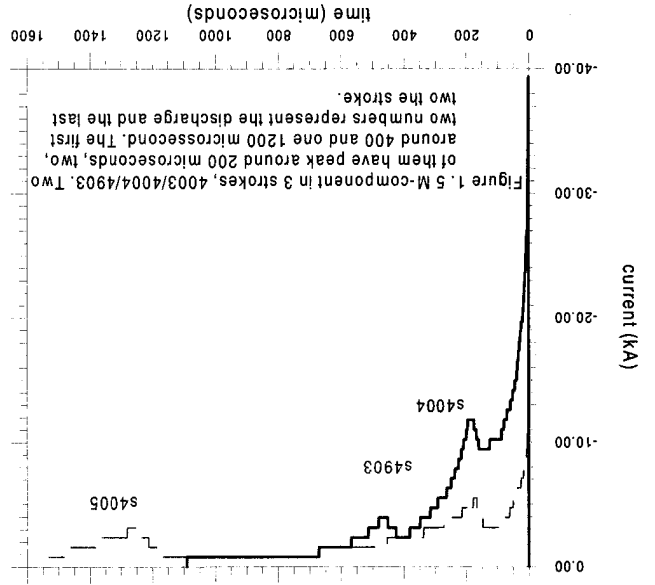
presented current wave form variations similar to those associated with M-component. The waveform register in group G1 was made until 1600 μ s with resolution of 1 μ s. In group G2 it was made until 800 μ s with resolution of 0.5 μ s and in G3, until 400 μ s with resolution of 0.2 μ s. Figure 1 to 3 show eleven M-components in return stroke waveform. Note in figure 3 a possible corona near 30 μ s, in stroke 61.

The resolution of 0.79 kA for current measurement in all groups was not enough good for obtaining smooth curves, but some parameters like those showed in table 1, could be calculated. Unfortunately the best time resolution in G3 implied in truncating the measurement in around 400 μ s. The elapsed time Δt_m is the instant of time when the M-component starts after the beginning of return stroke, I_{cc} is the continuing current level, I_m is the magnitude of M component (peak value)⁽⁷⁾. These parameters presented mean values of 308 μ s, 5.03 kA and 3.22 kA respectively. Geometrical mean (GM) were 237 μ s, 3.69 kA and 2.37 kA, respectively. Thottappillil et al.⁽⁶⁾ and Thottappillil et al.⁽⁷⁾ have studied M-components in triggered lightning. Geometrical mean presented for Thottappillil et al.⁽⁷⁾ for elapsed time, is two orders of magnitude larger than the value showed in this paper for CLRS measurements. The geometrical mean value for continuing current level showed in reference 6 is less than 200 A, while in CLRS data is 3.69 kA and for the current magnitude is less than 200 A, against 2.37 kA of CLRS data, respectively. These differences are probably due the fact that we are dealing with M-components just after the return stroke. Registers of Malan and Schonland⁽⁴⁾ analyzing photography of channel luminosity and electric field data, showed that about 15% of M-component occurs in times less than or equal to 300 μ s. 3 M-component among 158 analyzed for Thottappillil and al.⁽⁷⁾ present elapsed time

Table 1 Some electrical parameter for M-components.

m-comp.	Δt_m (μ s)	I_{cc} (kA)	I_m (kA)
2803m1	103	3.15	0.79
4004m1	161	9.45	2.37
4004m2	426	2.36	1.58
4005m1	147	3.15	2.37
4005m2	1170	0.79	2.37
4006m1	412	1.57	1.58
4011m1	201	2.36	0.79
4014m1	481	2.36	0.79
4903m1	291.0	2.36	4.74
5703m1	143.2	12.6	3.95
5804m1	138.6	11.02	7.11
6103m1	165.4	8.66	3.95
6107m1	166.0	5.51	9.48
GM	237	3.69	2.37

of order of 1 ms. The half peak width, T_{hw} , was calculated from the arithmetic mean curve showed in figure 4, was found to be about 120 μ s, which is less than 50% of calculated value of Malan and Schonland⁽⁴⁾, for total time duration of luminosity and electric field records (270 μ s). Half peak width for triggered lightning flashes was found to be around 800 μ s⁽⁷⁾.



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CONCLUSIONS.

We analyzed 13 M-component associated with 11 subsequent return stroke (of order three or higher) of natural negative cloud to ground lightning captured by a 60 m metallic tower of Cemig Research Lightning Station (CLRS) in Brazil. The data were compared these data with those of Thottappillil et al ⁽⁶⁾ ⁽⁷⁾ and Malan and Scholand ⁽⁴⁾, using different techniques of measurement. The M- components registered for the CLRS should be considered as near M-components. They presented high level of continuing current and magnitude of current. Also they presented short elapsed time, and short half peak width. Such characteristics seems to reflect the fact that they occur soon after the return stroke.

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