

Influence of LLS Detection Efficiency on the Measured Distribution of Interstroke Intervals

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Abstract—Interstroke intervals can be estimated from Lightning Location Systems (LLS) data. We present here a methodology to assess the effect of an imperfect stroke detection efficiency on the measured statistical distribution of the interstroke intervals.

Keywords—lightning location; lightning parameters

I. INTRODUCTION

Numerous studies have investigated the remote estimation of lightning parameters from LLS data [1-3]. In this paper, we propose a methodology to study the effect of the imperfect stroke-detection efficiency of lightning location systems on the statistical distribution of interstroke intervals.

II. METHODOLOGY

The methodology can be summarized as follows. Use a computer to generate a control dataset composed of flashes with the same stroke-multiplicity and interstroke-interval statistical-distributions as those observed in experimental measurements. Out of the control dataset, select a subset at random to simulate the imperfect detection efficiency of an LLS. Finally, compare the statistical distribution of the interstroke intervals of the subset to that of the original dataset.

The following steps describe the methodology.

1. Select a histogram of measured multiplicities [4] and call $n_{\text{hys}}(m)$ the number of flashes of multiplicity m .
2. To obtain a large enough dataset for the interstroke intervals, select a positive integer q and calculate the number of m -stroke flashes $n_s(m)$ as

$$n_s(m) = qn_{\text{hys}}(m). \quad (1)$$

The value of q is selected so that the interstroke dataset in point 5 below passes a lognormality test.

3. Calculate the total number of flashes in the control set as,

$$N = \sum_{m=1}^{m_{\text{max}}} n_s(m) \quad (2)$$

where m_{max} is the maximum multiplicity in the histogram.

4. Calculate the total number of strokes in the set as

$$n_{\text{total}} = \sum_{m=1}^{m_{\text{max}}} m \cdot n_s(m) \quad (3)$$

and the total number of interstroke intervals as

$$r = \sum_{m=1}^{m_{\text{max}}} (m - 1) \cdot n_s(m) \quad (4)$$

5. Generate a set of r interstroke intervals Δt_i belonging to a

lognormal distribution with geometrical mean and standard deviation similar to those reported in the literature based on continuous measurements (not based on LLS data).

6. Generate a table for each stroke in each flash (see Table I).

TABLE I. GENERATED TABLE FOR ALL THE CONSIDERED STROKES

Overall stroke number	Stroke number in flash	Multiplicity	Interstroke interval
1	1	1	N/A
...
$n_{\text{total}} - 1$	$m_{\text{max}} - 1$	m_{max}	Δt_r
n_{total}	m_{max}	m_{max}	N/A

7. Assume a LLS stroke detection efficiency of $de\%$. The number of missed strokes can be evaluated as

$$n = \text{abs}\left(n_{\text{total}} \frac{100-de}{100}\right) \quad (5)$$

8. Generate n random integers from 1 to n_{total} .
9. Based on Table I, create a table of interstroke intervals measured by the considered LLS using the following rules:
 - a) If the missed stroke is the first or the last in a flash, delete the corresponding line in the table.
 - b) In all other cases, add the interstroke interval of the missed stroke to that of the previous stroke and then delete the line of the missed stroke.
10. Compare the statistical distribution of interstroke intervals from the resulting table to that of the original Table I.

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