PROPERTIES OF LIGHTING DISCHARGES TO AN INSTRUMENTED TOWER AND THEIR IMPLICATION ON THE LOCATION OF THOSE FLASHES BY LIGHTNING LOCATION SYSTEMS

Dr. Gerhard DIENDORFER, Dipl.-Ing. Hannes PICHLER
OVE-ALDIS, Austrian Lightning Detection & Information System
Kahlenberger Str. 2A
1190 Vienna, Austria

Introduction

Since 1998 direct lighting strikes to a radio tower are measured at Gaisberg, a mountain next to the City of Salzburg in Austria. First results of an evaluation analysis have been published by Diendorfer et al. [2000]. In this presentation we analyze the flashes to the tower in more detail regarding to the performance of the LLS to locate the different types of discharges.

The vast majority of the flashes to the tower are upward initiated (see Table 1).

Table 1: Types of flashes and strokes within the observation period

	2000	2001	2002	2003	Total
Flashes (including NRS)	90	61	59	32	242
No Return Strokes	30	18	15	9	72
Strokes (pulses > 1 kA)	458	340	259	171	1228
Upward Flashes	60	42	40	22	164
Pos. Upward Flashes	7	2	1	0	10
Neg. Upward Flashes	51	38	37	21	147
Bipolar Upward Flashes	1	2	2	0	5
Neg. Downward Flashes	1	1	3	1	6

From 2000 to 2003 at the tower we have directly measured a total of 129 negative flashes containing 723 strokes with amplitudes greater than 2 kA.

In this contribution we analyze the Detection Efficiency (DE), Location Accuracy (LA) and Peak Current Estimates (PCA) of the LLS separately for the so called α- and β-pulses. The α-pulses are current pulses superimposed on the initial continuing current, whereas the β-pulses occur after a short period of no current flow in the lightning channel and are assumed to be very similar to subsequent strokes in natural downward lightning.

Discrimination between α- and β-pulses is done based on the continuing current flowing in the lighting channel prior to the occurrence of the current pulse. A minimum of 20 A (resolution of digitizer) of continuing current is required to classify a pulse as α-pulse.

DETECTION EFFICIENCY

Flash DE (FDE):

In Table 2 we have summarized the Gaisberg flash data of all directly measured flashes independent of the number and type of strokes (α- or β-pulse) for the period 2000 – 2003. A total of 129 negative flashes with flash amplitudes greater than 2 kA were recorded at the tower, 114 of them were detected by the LLS (88% FDE). Flash peak current I_{Fl} is defined as maximum amplitude of all strokes within the flash. The FDE increases with flash peak amplitude from 88% for all flashes with I_{Fl} > 2 kA to 100% for flashes with I_{Fl} greater than 10 kA (see also Fig.7.1).

Table 2: Gaisberg flash data (2000-2003)

I_{Fl}	N Gaisberg	N LLS	Flash DE (FDE)
> 2 kA	129	114	88%
> 3 kA	122	113	93%
> 4 kA	117	110	94%
> 5 kA	107	102	95%
> 6 kA	103	99	96%
> 7 kA	97	96	99%
> 8 kA	94	93	99%
> 9 kA	86	85	99%
> 10 kA	77	77	100%

Stroke DE (SDE)

For the evaluation of the SDE we have separated the measured data in α-strokes and β-strokes for

different ranges of stroke peak current (see Table 3).

Some of the α-pulses in natural upward lightning have wave shapes that are similar to the wave shape characteristic of return stroke pulses. Their rise time is in the range of a few µs and the peaks are larger than 2 kA. The selected class of β-strokes is assumed to be a good representation of subsequent strokes in natural downward lightning.

Table 3: DE of strokes of different amplitude ranges

Gaisberg Tower				Lightning Location System LLS				
I [kA]	N	N_α	N_β	N_α	N_β	SDE_α	SDE_β	SDE
2 - 3	103	84	19	11	2	13%	11%	13%
3 - 4	77	60	17	19	3	32%	18%	29%
4 - 5	89	61	28	33	16	54%	57%	55%
5 - 6	59	25	34	17	27	68%	79%	75%
6 - 7	56	20	36	15	25	75%	69%	71%
7 - 8	49	9	40	9	33	100%	83%	86%
8 - 9	48	16	32	14	28	88%	88%	88%
9 - 10	44	8	36	8	34	100%	94%	95%
> 10	198	36	162	35	162	97%	100%	99%
SUM	723	319	404	161	330	50%	82%	68%

It is interesting to note, that the overall SDE is lower for α-strokes (50%) then for β-strokes (82%). From all directly measured strokes with a peak current I > 5 kA (N = 454) the LLS detected 407 and missed 47 (SDE = 90%) for I > 8 kA (N = 290) the LLS located 281 and missed 9 strokes (SDE = 97%).

LOCATION ACCURACY

Fig.1 shows the plotted LLS locations around the ground truth location of the tower for α- and β-pulses, respectively. There is no obvious difference in the accuracy of the locations. Independent of pulse type (α, β) we observe a constant shift to the North-East with a mean of 450 m. Speculations of the reasons for this systematic location error are given in Diendorfer et al.[2002].

PEAK CURRENT ESTIMATE

In Fig.2 we have plotted the regression line for the correlated peak current data from the direct measurement and the LLS for α- and β-strokes, respectively.

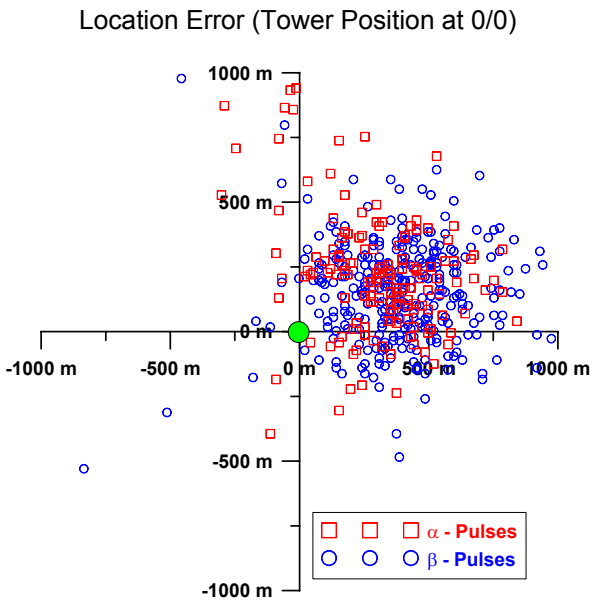

Fig.1: Location accuracy for α- and β-pulses

Independent of the pulse type there is an excellent correlation between the two measurements.

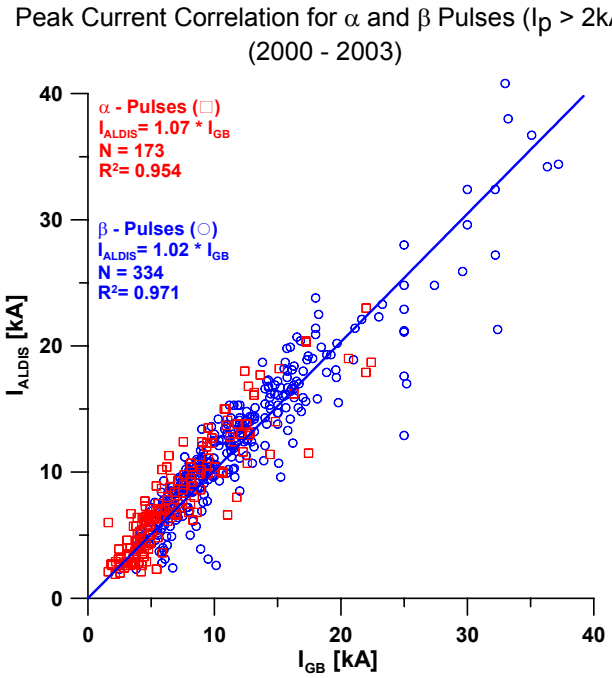

Fig.2: Correlation of directly measured peak currents and peak currents inferred by the LLS

REFERENCES

Diendorfer G., Hadrian W., Hofbauer F., Mair M., Schulz W.: Evaluation of Lightning Location Data Employing Measurements of Direct Strikes to a Radio Tower. CIGRE Session Paris, 2002.