X International Symposium on
Lightning Protection
9th-13th November, 2009 – Curitiba, Brazil

First Results of Correlated Lightning Video Images and Electric Field Measurements in Austria

Schulz W.[1] and Saba M. M. F.[2]

[1] Austrian Lightning Detection and Information System (ALDIS), Austria, w.schulz@ove.at

[2] National Institute for Space Research (INPE), São José dos Campos, Brazil, msaba@dge.inpe.br

Abstract – In this paper we show the first data of time correlated lightning video and electric field measurements in Austria. During one thunderstorm on the June 1st, 2008 we recorded nine positive single stroke flashes to ground. The Austrian lightning location system (LLS) detected all nine positive flashes, although one was categorized as intracloud discharge. Additionally to the nine cloud-to-ground flashes the LLS detected some intracloud discharges and misclassified them as cloud-to-ground discharges. We further show some indication that positive flashes in Austria can also exhibit high peak currents and long continuing currents as shown for Brazil [Saba et al., 2006].

1 INTRODUCTION

Some years ago we developed a continuous field measurement (FM) system in Austria to check the performance of the Austrian lightning location system ALDIS [Schulz et al., 2005; Schulz and Diendorfer, 2006]. Data from this FM system was used in Austria, in Sweden and in Brazil, to shed some light on the topic of the ratio between first stroke peak fields and subsequent stroke peak fields [Schulz et al., 2008; Nag et al., 2008].

While it is possible to classify about 95% of the negative flashes based on the measured field waveform correctly (cloud-to-ground strokes versus intracloud discharges), this task is more difficult for positive cloud-to-ground (+CG) flashes. Therefore our measurement system was adapted to integrate a digital video camera. The combination of data from the FM system and video images from the camera allows to classify positive strokes correctly.

In this paper we will present first results from measurements performed during summer 2008. During one thunderstorm we measured nine positive CG strokes within about 20 minutes. Detailed analysis of those positive strokes will be given.

2 MEASUREMENT SYSTEM

The used FM system was already presented in different papers [Schulz et al., 2005; Schulz and Diendorfer, 2006]. This measurement system has recently been adapted to integrate the images of a digital video camera. The monochrome camera we are using is able to record up to 200 frames per second with VGA resolution (640x480 pixels). This monochrome camera (8 bit per pixel) produces, at a maximum frame rate of 200 frames per second, data of about 60 Mbytes per second. The camera is completely time synchronized to the FM system and therefore also the camera data is GPS synchronized. A red filter type 29 (dark red) was used in front of the camera lens in order to get better image contrast during daytime recordings.

The measurement system offers three different recording modes

- continuous recording
- triggered recording and
- combined recording

With the currently used PC hardware continuous recording for E-field and video data is only possible for video frame rates of up to 100fps because of the limited speed of the used standard SATA hard disk. With a RAID controller it should be even possible to record 200 fps continuously. Triggered recording is possible with a video frame rate of 200 fps because in this case all the data is continuously stored in the memory and after the system is triggered the data is written to the hard disc. In the combined recording mode it is possible to record E-fields continuously and trigger the video measurement manually.

3 DATA

The measurements were made on the June 1st, 2008 from about 16:12 to 16:31 (GMT) in the southwest of Vienna (48.1400°N / 16.1258°E). The camera was pointing eastward. We recorded data from five flashes with continuous video recording (at 100 fps) and four flashes with triggered video recording (at 200 fps). The interesting thing is that all the nine detected flashes were positive flashes and all positive flashes were single stroke flashes.

Fig. 3.1 shows all the +/-CG flashes detected by the lightning location system (LLS) during the measurement time within a maximum distance of 15km to the measurement site. Flash #8 is not shown because it was erroneously categorized as cloud discharge.

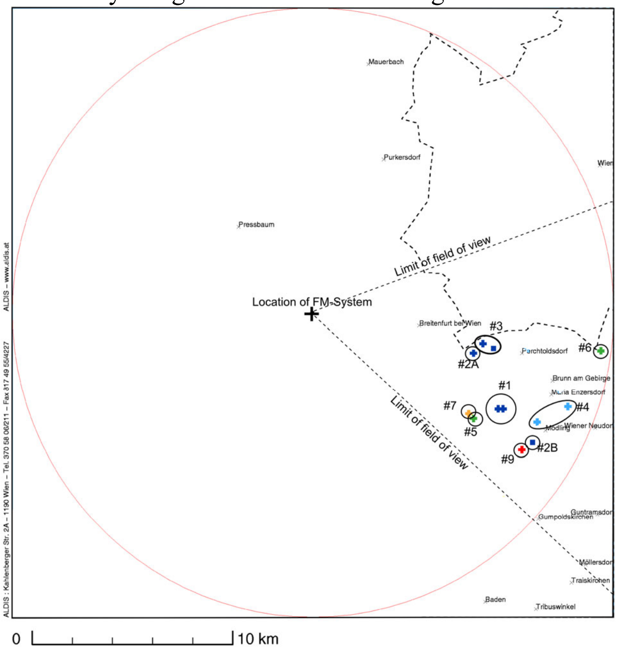

Fig. 3.1: Strokes measured on 1.6.2008 16:12 to 16:31 and categorized as CG stroke by the LLS

4 RESULTS

Data from the FM system was compared to stroke data from the Austrian lightning location system ALDIS. The locations given by the LLS were calculated with the "old" location algorithm, which was used at this time. It is known today that this version of the location algorithm has sometimes problems in separating the ground wave from the ionospheric reflections. The LLS detected all the nine positive flashes, five of them were correctly detected as single stroke flashes and four of them wrongly detected as two strokes flashes. In three cases a double detection (LLS detected ground wave and ionospheric reflection) and in one case a misclassified cloud discharge were the reasons for the reporting of a second stroke. The double detections should be eliminated with the currently used location algorithm. One correctly detected single stroke flash was misclassified as cloud discharge.

Waveforms from strong cloud processes occur usually together with return stroke waveforms of positive strokes in the electromagnetic field recordings. Sometimes they may be misclassified as CG strokes. Figure 4.1 shows the electric field waveform of a cloud discharge misclassified as a –CG with an estimated peak current of -14kA. As it occurred 570ms before the +CG flash #2, this "negative" stroke was not grouped to the positive stroke because the time interval between the "negative" and positive stroke was larger than 500ms.

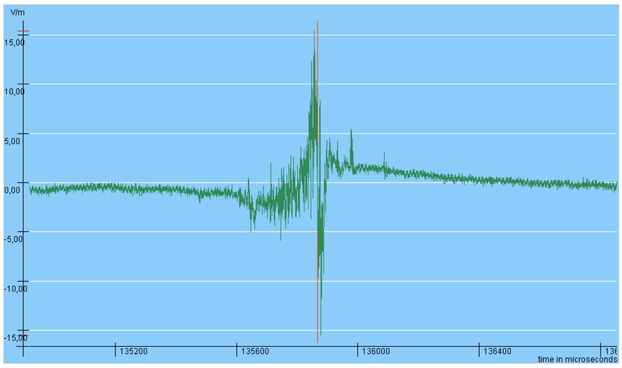

Fig. 4.1: Misclassified cloud discharge before +CG flash #2

Fig. 4.2 shows the electric field waveform of a cloud discharge misclassified as a +CG with an estimated peak current of +6 kA. It occurred 182 ms before the real +CG stroke. The reason why this stroke was not categorized as cloud discharge is that the waveform had a peak-to-zero time greater than 15ms, which is quite unusual for cloud discharges.

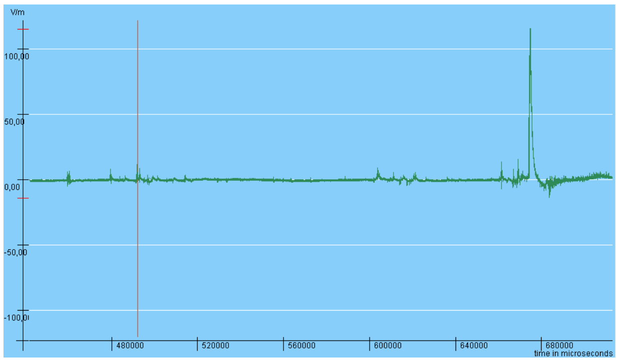

Fig. 4.2: flash #4 with misclassified stroke (vertical red line) 182ms before the +CG stroke.

All video recordings of the positive strokes exhibited a continuing current (CC). Due to the limited time resolution of the camera (either 10ms for 100fps or 5ms for 200fps) the duration of the continuing current cannot be precisely (to the millisecond) measured. The duration of the CC varied from about 10ms to about 70ms.

A scatter diagram in which the estimated peak current (Ip) given by the LLS is plotted versus the CC duration is given in Figure 4.3. This diagram shows some indication that, contrary to the 248 negative strokes analyzed by Saba et al. [2006], positives strokes may combine high peak current with long CC duration. We have to have in mind that the small sample size of nine flashes is too small for a final result especially because only three flashes are outside the so called "exclusion zone", defined by Saba et al. [2006], for negative flashes.

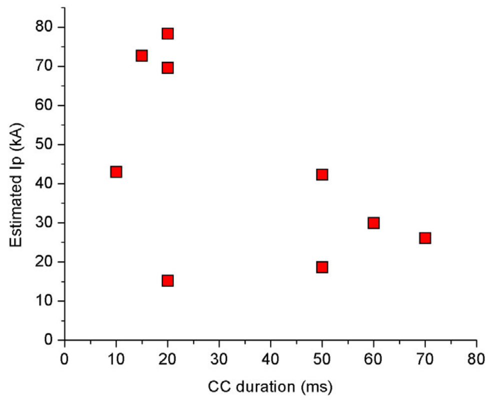

Fig. 4.3: Peak current (Ip) versus CC duration for 9 +CG strokes.

5 SUMMARY

The FM System in combination with a fast camera is a good tool to validate LLS data. The uncertainty in classifying positive strokes as cloud to ground or intracloud is basically eliminated if data from this system is used. For some of the recorded flashes we can even see the leader process before the return stroke.

The LLS detected all the positive cloud to ground flashes but one of the flashes was categorized as intracloud discharge, what means that 89% of the positive flashes were categorized correctly. The estimated peak currents, given by the LLS, for the positive strokes were in the range from 15kA to 78kA. Additionally the LLS detected four intracloud discharges. Two of these intracloud discharges (estimated peak current -14kA and +6kA) were misclassified as cloud to ground stroke.

We could further show some indication that positive flashes in Austria also combine high peak currents and long continuing currents as shown for Brazil.

6 REFERENCES

[1] Nag A., V. A. Rakov, W. Schulz, M. M. F. Saba, R. Thottappillil, C. J. Biagi, A. O. Filho, A. Kafri, N. Theethayi, T. Gotschl: First versus subsequent return-stroke current and field peaks in negative cloud-to-ground lightning discharges. Journal of Geophysical Research, Vol. 113, D19112, doi:10.1029/2007JD009729, 2008.

[2] Saba, M.M.F., O. Pinto Jr., and M. G. Ballarotti: Relation between lightning return stroke peak current and following continuing current. Geophys. Res. Lett., 33, L23807, doi:10.1029/2006GL027455, 2006.

[3] Schulz W., Lackenbauer B., Diendorfer G.: LLS data and correlated continuous field measurements. SIPDA, Sao Paulo, Brazil, 2005.

[4] Schulz W. and Diendorfer G.: Flash Multiplicity and Interstroke Intervals in Austria. ICLP, Kanazawa, Japan, 2006.

[5] Schulz W., Sindelar S., Kafri A., Götschl T., Theethayi N., Thottappillil R.: The ratio between first and subsequent lightning return stroke electric field peaks in Sweden. ICLP, Uppsala, Sweden, 2008.