Paper presented at the 25th International Conference on Lightning Protection (ICLP), Rhodos, Sept. 2000

LIGHTNING CURRENT MEASUREMENTS IN AUSTRIA – EXPERIMENTAL SETUP AND FIRST RESULTS

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Abstract: In a recent investigation on ground flash density around elevated objects in Austria it was found, that the telecommunication tower at mount Gaisberg near Salzburg would be one of the most suitable sites for an experiment to measure direct lightning currents. This about 100 m tall telecommunication tower is located 1287 m above sea level and about 5 km east of the city of Salzburg.
Based on the data from the Austrian Lightning Location System (ALDIS), 40 - 50 flashes with about 200 strokes per year were expected.
The installation of an automatic measuring system to record currents of direct lightning strikes to the tower was started in August 1998. In this paper we present a detailed description of the experimental setup and show first results of recorded current waveforms in 1999.

Keywords: Lightning, Lightning Current, Tower Measurements, Lightning Location

1. INTRODUCTION

Results of an investigation in Austria on ground flash density nearby elevated objects were presented in [1]. Based on the data from the Austrian Lightning Location System (ALDIS) it was found that several sites in Austria would be suitable for an experimental investigation to measure direct lightning currents. One of the most promising sites was the radio transmission tower at mount Gaisberg near Salzburg (Figure 1) where we expect about 40 - 50 direct lightning strikes per year. By recording the current waveforms of direct lightning strikes to the tower we expect more detailed information on the characteristics of natural cloud-to ground discharges.

Furthermore this project offers a perfect arrangement to verify ability and limits of the Austrian Lightning Location System (ALDIS) to determine the lightning peak current inferred from peak field measurements. A comprehensive description of the ALDIS system is presented in [2].

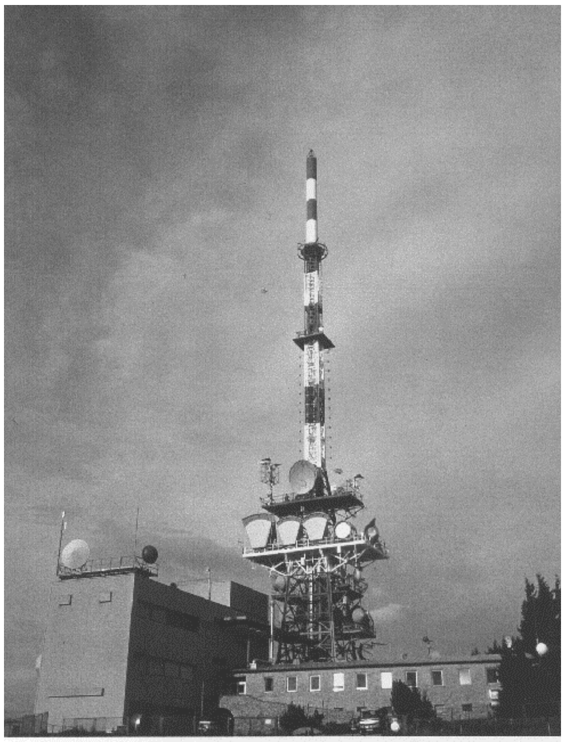

Figure 1. Radio transmission tower at mount Gaisberg

The radio tower with a height of about 100 m is located 1287 m above sea level about 5 km east of the city of Salzburg. The distance to the nearest sensor of the ALDIS system (DF1) is approximately 30 km (Figure 2). In August 1998 installation of an automatic measurement system for the recording of current waveforms of lightning discharges to the top of the tower was started. Until the end of 1999 data of about 100 lightning flashes were recorded.

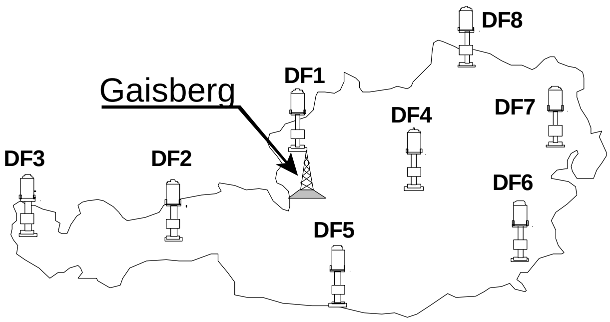

Figure 2. Location of the Gaisberg tower and the sensor sites of the Austrian Lightning Location System (ALDIS)

1. EXPERIMENTAL SETUP

The experiments started in fall 1998 with the registration of lightning currents on top of the tower. In summer 1999 additional measurement equipment for recording the static atmospheric electric field and a high-speed video system were installed at a distance of 200 m from the tower. Figure 3 shows an overview on the overall measurement setup.

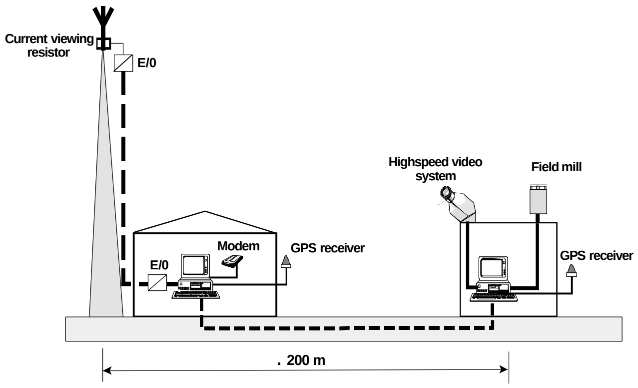

Figure 3. Schematic overview of the experimental setup at Gaisberg tower (E/O: Electrical/Optical signal converter).

2.1 Lightning current measurement system

For current measurement a current sensor on top of the tower, a fiber optic link for transmission of the measurement data and a recording system were installed in a building next to the tower (Figure 3).

An appropriate air termination was installed on top of the tower in order to capture most of the lightning discharges to the tower (Figure 4). The lightning current is measured at the base of the air termination by a wide band current viewing resistor (shunt) of 0.25 mΩ with a bandwidth of 0 Hz to 3.2 MHz, manufactured by T&M Research Products Inc.

For reasons of electromagnetic compatibility a fiber optic link (Nicolet Isobe 3000) is used for transmission of the shunt output signal. Due to the wide range of expected current peak amplitudes two separate fiber optic channels of different sensitivity are installed:

- Channel 1: 0 - 2.1 kA
- Channel 2: 0 - 40 kA

The shunt output signal is recorded by an 8 bit digitizing board installed in a Personal Computer. The digitizing board (National Instruments PCI-5102) with a bandwidth of 15 MHz and a memory of 16 MB per channel is operated with a sampling rate of 20 MS/s. The trigger of the recording system is set to a corresponding lightning current level of ±200A. All recorded waveforms are time stamped using the time information provided by a GPS clock (Meinberg GPS167PC) in order to be able to compare them with the data from the lightning location system. GPS timing is appropriate to identify correspondence of individual strokes recorded at the tower and by ALDIS.

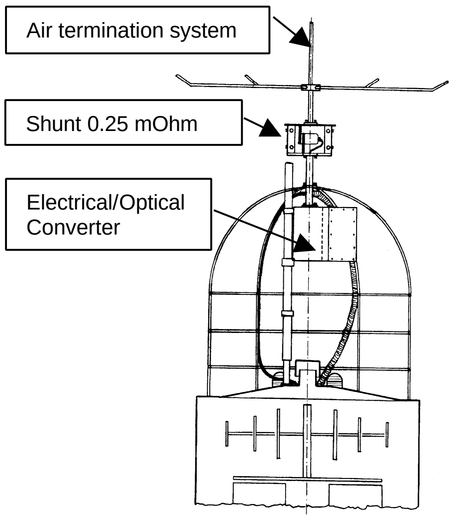

Figure 4. Configuration of the measuring equipment on top of the transmission tower

2.2 Electric field measurement and video recording

In summer 1999 an electric field mill (ARSI EFM) and a high-speed video recording system were installed on a trailer at a distance of about 200 m from the tower. With data from the field mill the relationship between the electrostatic atmospheric field component at a certain distance from the tower prior to discharges can be investigated.

A high-speed video system (Kodak Motion Corder Analyzer SR-1000) was set up for recording the lightning strikes to the tower over a time period of about 1 second with a frame rate of up to 1000 frames per second. The camera is triggered simultaneously with the current measurement system described in section 2.1.

For triggering and for remote control of the video system a fiber optic link between the building next to the tower and the trailer is installed.

With the information from the video system a more distinct classification of the different kinds of lightning strikes to the tower (upward discharges, side flash etc.) and the corresponding current waveforms should be possible.

3. FIRST RESULTS

3.1 Lightning occurrence

The Gaisberg tower has been chosen for the experiment because this location revealed an outstanding number of lightning strikes over the past few years. Unfortunately, in 1999 the lightning activity in Austria was significantly lower than in previous years (see Table 1) and therefore the number of direct strikes to the tower was not as high as expected based on historical data.

Table 1: Lightning activity in Austria and the vicinity (R < 1 km around the tower location) of the experimental site

Year	Austria Total	Province Salzburg	Flashes R < 1 km	Strokes R < 1 km	Tower Triggers
1995	131.469	12.295	29	125	-
1996	119.602	11.853	54	261	-
1997	123.597	10.390	49	271	-
1998	179.851	15.089	33	110	-
1999	104.958	8.105	31	79	81
Jan/Feb 2000			15	47	31

The year 2000 started more promising with already 15 flashes (47 strokes) reported by ALDIS and 31 trigger events at the tower in the first two winter months.

As we can see from Table 1, the number of tower trigger events - in general corresponding to a flash to the tower - is much higher than the number of flashes detected by ALDIS for different reasons:

(1) Some of the tower trigger events are caused by continuing currents with either no or only very small superimposed current pulses (amplitudes of a few hundred amperes). The peak radiated fields from those weak current pulses are below the trigger threshold of the ALDIS sensors even for sensor DF1 closest to the tower at a distance of approximately 30 km (see Figure 1).

(2) Some flashes to ground nearby the tower (at distances of up to several kilometers) triggered the tower measuring system.

(3) Some current pulses of lighting to the tower are not detected by at least 2 or 3 sensors (minimum number of sensors required for a detection is dependent on sensor type).

3.2 Examples of recorded flashes

As a first example of a recorded lightning flash to the Gaisberg tower an event on March 22nd , 1999, 16:05:08 is shown in Figure 5.

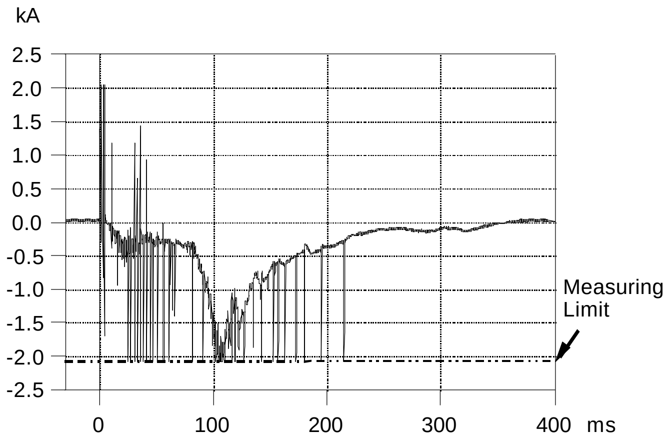

Figure 5. Recorded lightning flash current to the Gaisberg tower

The continuing current with a maximum value of about -2 kA lasted for about 370 ms and corresponds to a total charge transfer of 166 As. Superimposed on the continuing current are 35 strokes of amplitudes ranging from -0,42 kA to -10 kA.

Two samples of current waveshapes of superimposed strokes are shown in Figure 6 and Figure 7, respectively.

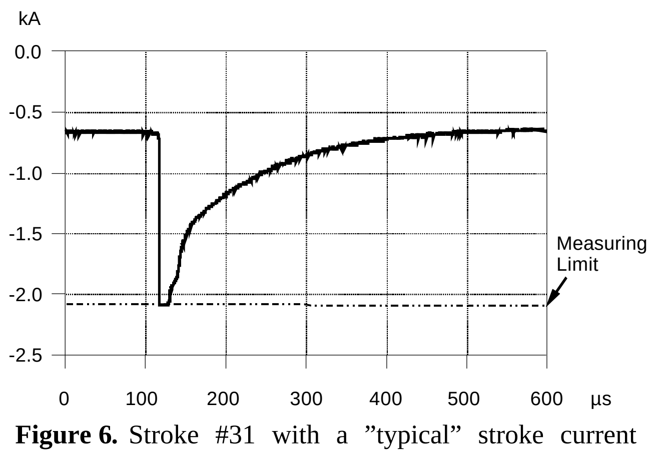

Figure 6. Stroke #31 with a "typical" stroke current waveshape

Figure 6 is a more detailed plot of stroke #31 of the flash with a waveshape assumed to be typical for return stroke currents. Peak amplitude is approximately 2.5 kA.

This stroke #31 was only detected by the nearest ALDIS sensor DF1 with a reported signal peak of –47 LLP-units that corresponds to a peak current estimate of about –3.5 kA. This value is based on the standard ALDIS configuration parameters for lightning peak current estimation (see [2]).

The waveshape of stroke #35 shown in Figure 7 exhibits two peaks separated in time by about 300µs and amplitudes of -2.0 kA and -1.3 kA respectively. This more unusual waveshape was detected by two sensors of the lightning location system (LLS) - by DF1 in Austria (distance 30 km) and a LPATS III sensor of the German Lightning Location System in Munich, at a distance of 117 km to the tower.

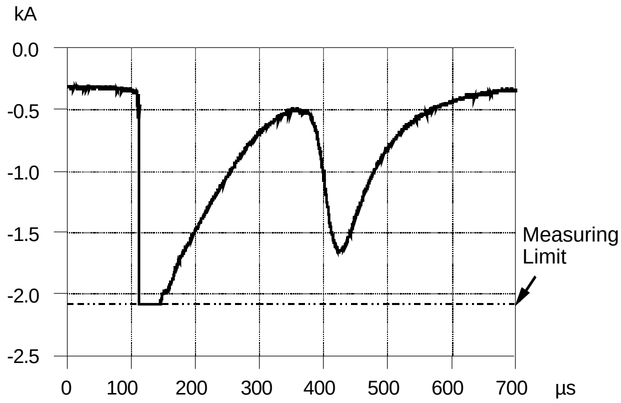

Figure 7. Stroke #35 with a double peak current waveshape

From the total of 35 strokes in this flash for 17 strokes no correlated LLS reports are available. Only one of those strokes had a peak current greater than -3 kA and therefore radiated field signals are too small to be detected by remote sensors. For another 7 strokes sufficient LLS reports (2 or more sensors) are available and therefore ALDIS provided a stroke location and a peak current estimate. Measured peak currents at the tower for those strokes are in the range from -4 kA to-10 kA. For the remaining 11 strokes only reports of either a single DF or an additional LPATS sensor in Germany is available. These limited sensor data are not sufficient to calculate a stroke location. For these group of strokes measured peak currents at the tower are in the range from -2 kA to -7 kA.

In Figure 8 the recorded current waveshape of a more unusual event at April, 18th 1999, 9:47:51 is plotted. The continuing current exhibits a bipolar structure superimposed by 39 impulses.

4. SUMMARY

First results of the tower experiment, that started in fall 1998, confirmed that the chosen site is a perfect location for direct lightning current measurements. The past year was mainly used to adjust and improve the technical equipment. Although there are still some more improvements planned for the upcoming lightning season, data collected by this experiment should provide fundamental information to analyze the following topics in lightning research:

- Lightning characteristics to tall structures
- Effects of finite ground conductivity on the field propagation to the nearby sensors of the LLS.

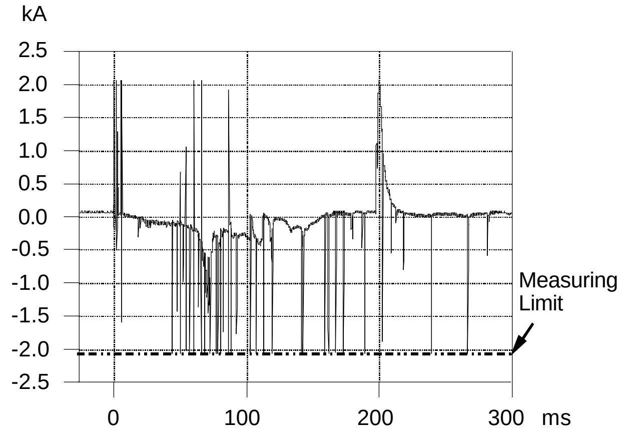

Figure 8. Continuing current with bipolar structure superimposed by 39 strokes

5. ACKNOWLEDGEMENTS

The Gaisberg tower experiment is supported by VERBUND and KELAG (contract V08/4500021357), by the Austrian Science Fund (Project Nr. P12977-TEC) and by Hochschuljubiläumsstiftung der Stadt Wien (Project H77/98). The authors would also like to thank the staff of the Austrian Broadcasting Corporation (ORF) for their support and hospitality at the tower site.

6. REFERENCES

[1] Diendorfer, G., Schulz, W.: Lightning incidence to elevated objects on mountains. Proceedings of the 24th International Conference on Lightning Protection (ICLP), pp. 173-175, Birmingham 1998.

[2] Diendorfer G., Schulz W., Rakov V.A.: Lightning Characteristics Based on Data from the Austrian Lightning Locating System. IEEE Transactions on EMC, 40 (1998), pp. 452-464.

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