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Unusual Lightning Strikes in Austria During a Winter Thunderstorm

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Abstract

On December 26, 1996, during a late evening winter thunderstorm, several flashes with extraordinary characteristics were located by the Austrian Lightning Detection Network ALDIS. In a time period of about 90 minutes 22 flashes with a total of 435 strokes were detected at almost the same location on top of a mountain. One of the flashes had a multiplicity of 40 strokes in 1442 ms, five more flashes had a multiplicity of higher than 30 strokes.

1. Introduction

Thunderstorm season in Austria typically ends in September. Each year a few winter thunderstorms occur and most of the time winter lightning occurs combined with snow and graupel showers. Typical for a winter storm in Austria is a high percentage of positive flashes in the range of about 50% compared to 5 - 10% observed in summer thunderstorms.

Late in the evening of December 26, 1995, 21:45 to 23:15 UTC (local time is UTC plus one hour) a small thunderstorm cell was located in the southern mountainous region of Austria, called “Koralpe” (see Fig.1). The top of this mountain is at an altitude of 2140 meters. The meteorological service reported heavy snowfall in this part of the country. Lightning activity on top of the mountain started at about 21:45 UTC. An image of the weather radar at 21:55 (UTC) is shown in Fig. 2 and does not exhibit any significant thunderstorm cell in the particular region.

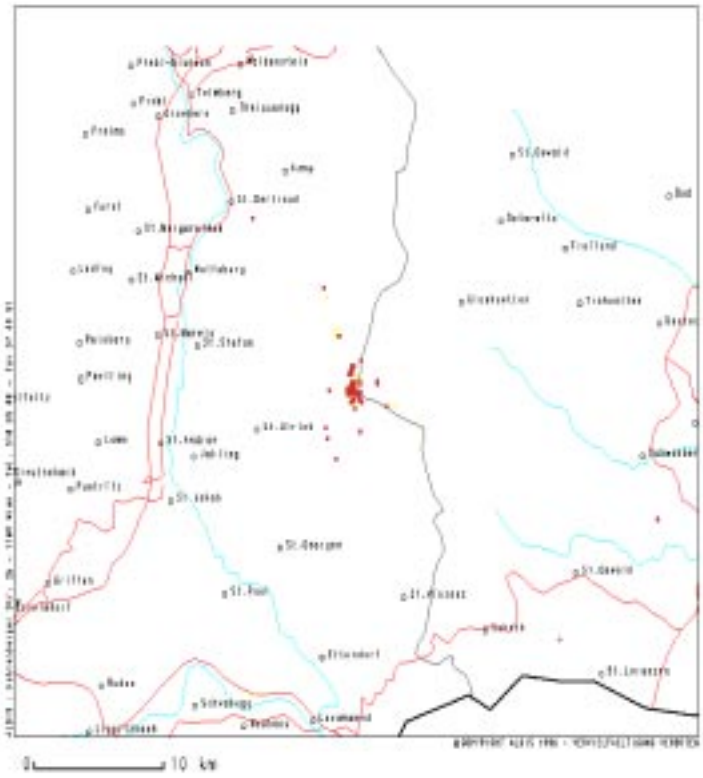

Fig.1.: Isolated thunderstorm cell in Austria on December 26, 1995

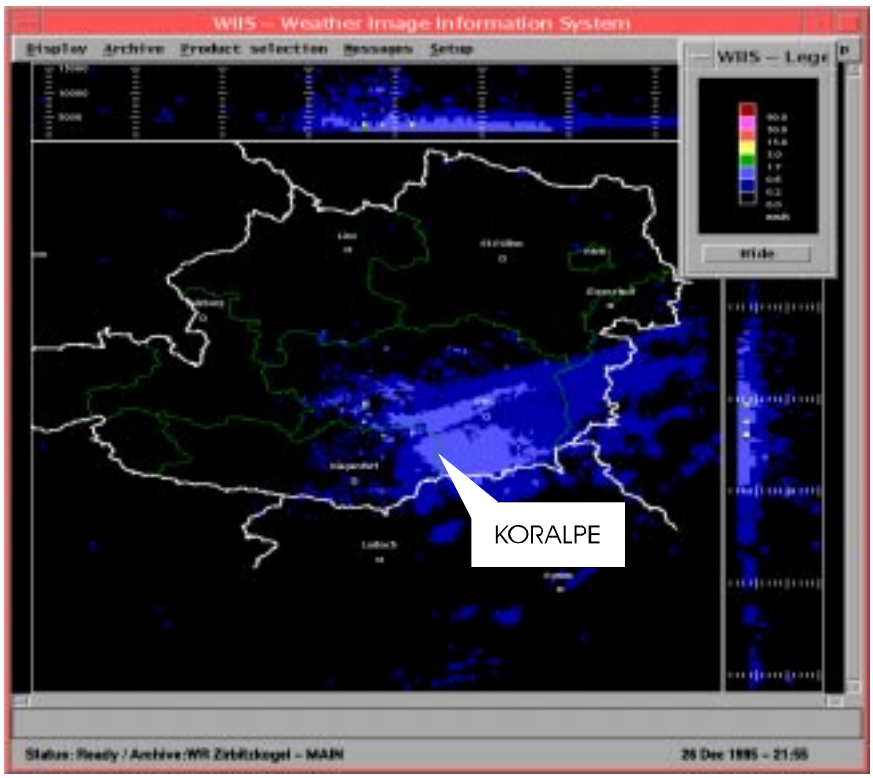

Fig.2: Weather Radar image at 21:55 UTC, December 26, 1995

On top of this mountain there are two objects equipped with air traffic radar facilities. Both objects have installed an extensive lightning protection system and grounding of both objects is interconnected. The distance between the two objects is about 70 m.

During the storm minor damage to some electronics equipment was reported by the local staff but this was called a typical problem anytime a thunderstorm occurs at this location.

Detailed analysis of the lightning location data showed a high accumulation of the calculated striking point locations at 46,78 N and 14,97 E. This location is about 300m southeast to the two objects on top of the mountain as shown in Fig.3.

A recalculation of the striking point locations assuming different initial parameters for the optimization algorithm provided a better clustering of the individual strokes, but there was no agreement of the cluster with one of the locations of the two objects. Fig.3 shows a detailed map of the location with the cluster of stroke locations at an average distance of about 300m to the objects.

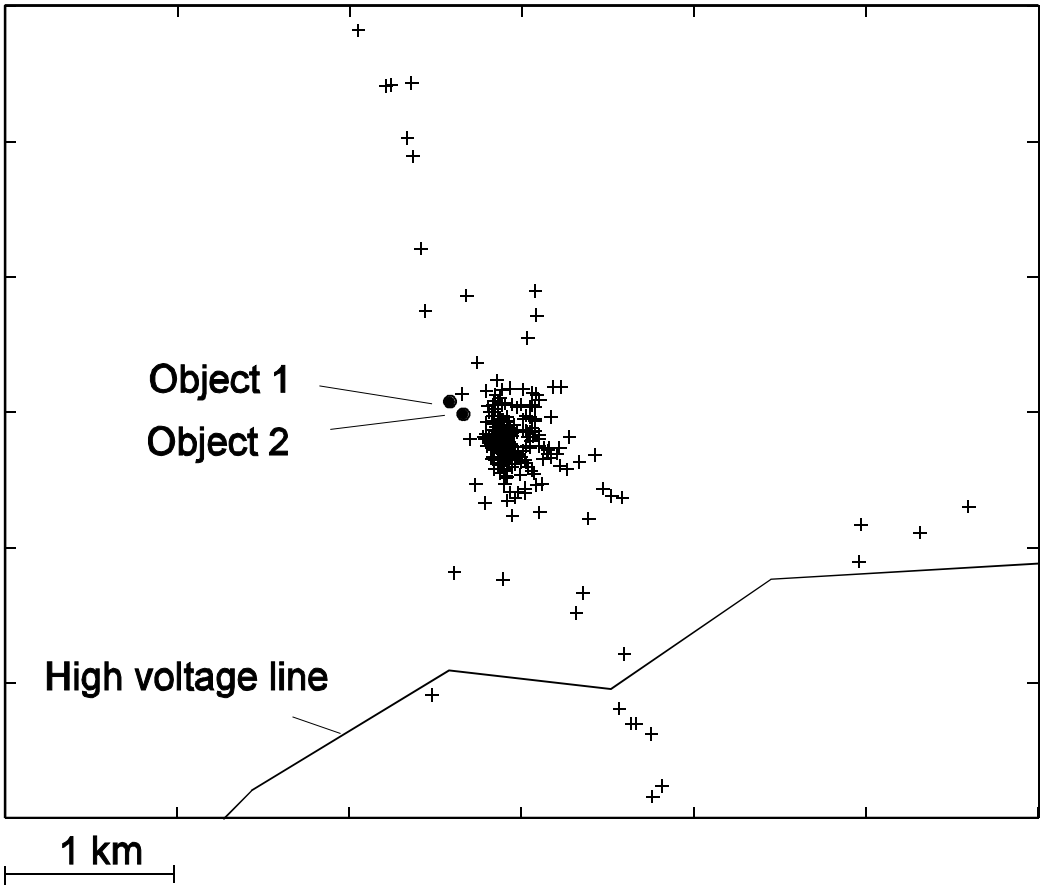

Fig.3.: Cluster of striking points near the two objects on Koralpe

A visit of the location in summer 1996 and all the information collected up to now does not allow a definite decision whether all these flashes - or at least most of them - really hit ground some hundred meters away from the objects or they hit one of the objects. In the second case, the average distance of 300m in the location data would be caused by a systematic error of the location system.

2. Flash characteristics

In Austria a high gain lightning location system based on the IMPACT sensors, manufactured by LLP, is installed. The system is operated in real time in the so called ASR (All Stroke Reporting) mode, where only one of the strokes in a flash is located, although the sensors provide information for each individual stroke.

A recalculation of the DF data in ASP (All Stroke Positioning) mode provides location, time and current peak amplitude information for each individual stroke. In our analysis we assume strokes to be part of the same flash as long as their interstroke time interval is less than 500 ms and the distance between the individual stroke locations is less than 5 km. Most of the strokes had distances of a few hundred meters to each other.

The IMPACT sensor is able to report strokes with a minimum interstroke interval of 4 ms. This limit is due to a dead time required by the sensor to process the previous stroke.

A total of 22 negative flashes was registered in a time period of about 83 minutes (see Table 1). As already mentioned before, all these flashes hit ground at almost the same location.

All these flashes have been multiple stroke flashes and many of them had an extraordinary high number of strokes per flash (see column 4 in Table 1). A minimum of three strokes in 67 ms and a maximum of 40 strokes in 1442 ms was detected. Typically four or more IMPACT sensors have located many of the strokes. For most of the strokes the optimization algorithm gave a very small chi-square value (<5) and therefore it is very unlikely that the system erroneously detected intra- or intercloud lightning. We strongly believe that this high multiplicity occurred in negative cloud to ground flashes.

TABLE 1: Flash characteristics of the December 26, 1995 Storm

Flash Nr.	Flashtime (UTC)	Flash Duration ms	Number of Strokes
1	21:44:29.1705856	67	3
2	21:47:27.2793473	1156	33
3	21:50:34.8994618	1442	40
4	21:53:15.2858449	1070	16
5	21:59:01.6159682	588	16
6	22:04:17.2659717	556	22
7	22:07:07.9611695	1288	32
8	22:10:01.7609071	1476	39
9	22:13:02.0275485	462	7
10	22:15:42.0296622	1404	25
11	22:19:18.9844325	208	14
12	22:22:36.3815830	139	4
13	22:26:16.6522077	447	20
14	22:29:54.6928709	248	9
15	22:37:53.3897537	1490	18
16	22:40:53.4776297	1353	33
17	22:44:11.9631438	1119	16
18	22:46:22.9696958	1200	26
19	22:48:17.8138319	907	30
20	22:52:11.5641562	1089	21
21	22:56:21.9118876	322	5
22	23:07:54.1646250	696	6
	Total Number of Strokes		**435**

Since 1992 when we have started the operation of a LLS in Austria, typically an average stroke multiplicity of 2.5 for negative flashes and 1.15 for positive flashes has been observed. With an average of 19.8 strokes per flash this particular storm is very untypical. Also unusual for this winter thunderstorm is the occurrence of only negative discharges. Typically we observe about 50% positive flashes during winter time in Austria.

The distribution of the peak amplitudes of all 435 strokes in the 22 flashes is shown in Fig.4. A mean value of the stroke peak currents of 8.5 kA is 20% lower than a mean value of 10.5 kA for all the negative strokes detected in Austria in 1996.

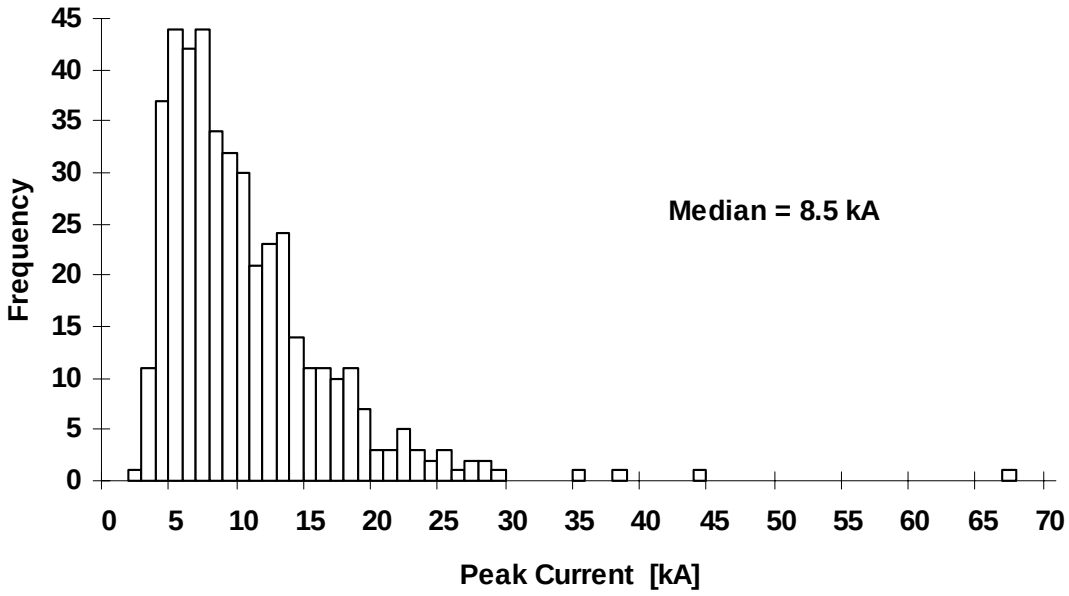

Fig.4: Peak current distribution for the 435 strokes

Similar to the peak current distribution, the median of the interstroke intervals of 22 ms is smaller than typical values given in literature (see Fig.5). The interstroke time intervals are in the range from 4 ms (limitation of the location system due to dead time) to 200 ms.

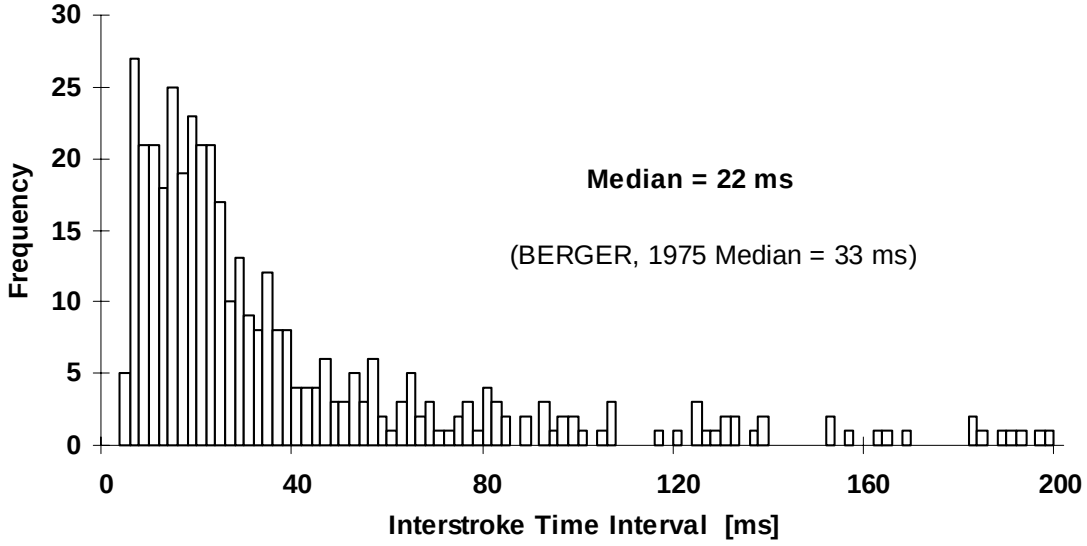

Fig.5.: Interstroke time interval for the 435 strokes

3. Some details of flash #3 (21:50:34.8994618 UTC)

Flash #3 in Table 1 was the flash with the highest multiplicity (40). The occurrence of the individual strokes in time and their peak current amplitudes in flash #3 is shown in Fig. 6.

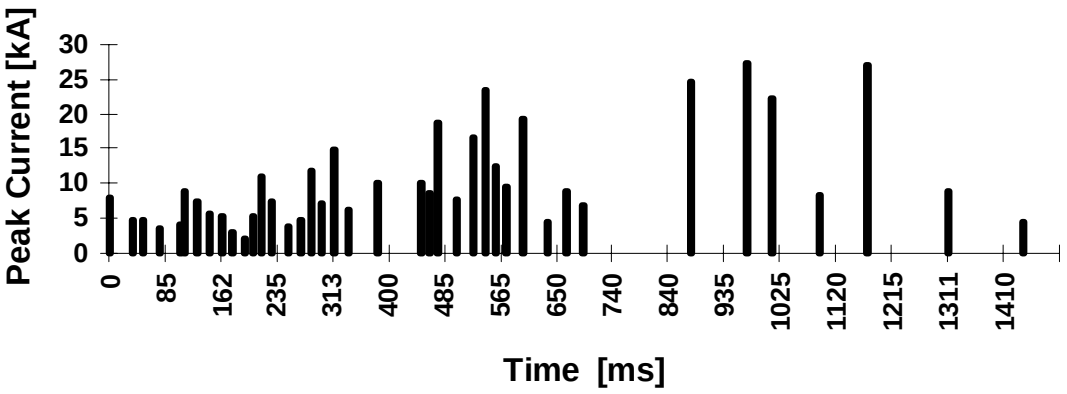

Fig.6: Time and peak current of the individual strokes in the 40 stroke flash (negative amplitudes are drawn positive)

All the other flashes show very similar characteristics regarding stroke peak amplitudes and interstroke intervals. Although it is often assumed that the first stroke in a flash has the highest peak current, in Fig.6 we can observe almost an increase of the peak currents with the number of strokes. Peak currents in this flash are in the range of -2 kA (stroke 11) to -27 kA (stroke 35).

SUMMARY

The 22 flashes located on December 26, 1995 are very different compared to the average lightning characteristics observed in Austria. Unfortunately we do not know whether these flashes were triggered by the objects on top of the mountain, or they occurred independent on the presence of the objects.

Initiated by the unusual events observed in this particular storm, we have started a more detailed analysis of lightning characteristics on mountain tops.