A short analysis of lightning data from meteoLCD

Luca Mathias (luca.29@hotmail.com, http://metteochannel.blogspot.fr)
Francis Massen (francis.massen@education.lu, http://meteo.lcd.lu)

Version 1.01 25 September 2013

Abstract:

This is a very short analysis of lightning data collected at the meteorological station of the Lycée classique Diekirch, Luxembourg from May 2009 to September 2012. The Noise to Signal ratio is fair and the statistics of IC/CG flashes are close to those given in the literature with a possible excess of the CG+ count.

1. The equipment and it's characteristics

meteoLCD uses a BOLTEK Storm Tracker system [1] installed in June 2003 to detect and locate thunderstorms and lightning flashes. This system is based on a special PCI card and an external antenna system. The PCI card is managed by specific Boltek drivers and the Lightning 2000 software from Aninoquisi [3], both running on a dedicated computer..The Stormtracker has a range exceeding 300 miles (almost 500 km) and is able to locate the lightning type, position and direction. Lightning types include CG (cloud to ground) and intracould (IC) flashes, positive or negative The accuracy of the Boltek detector is determined by many factors - placement of the detector, electromagnetic interference, distance from flashes, storm intensity …

The antenna system is a dual antenna module mounted in a single enclosure. This means that the location accuracy can not match that of the very expensive multi-antenna systems like those of the Siemens BLIDS system [2]

The Lightning 2000 software has been upgraded at regular intervals. The data given in this paper correspond to version 4.x and above.

Fig.1. Antenna system of the Boltek Storm Tracker. The antenna module is mounted inside a PVC tube for rain and environmental protection.

2. The records

Several types of records are available:

1. An archive holds all lightning activity and allows, using a player specific to the L2k software, to play back archived records which are in a proprietary format. This play back displays among others a daily summary of the totals and various types of flashes.

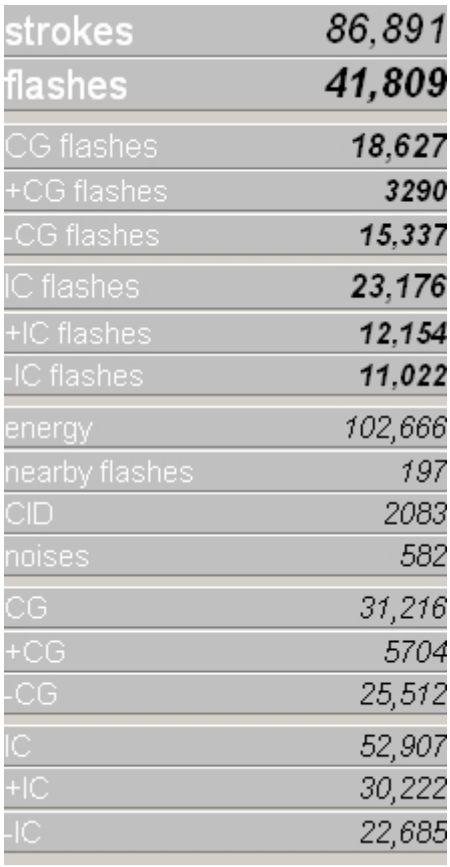

Fig.2. Lightning summary given by the L2K archive player for the 10 June 2004, a day of exceptional heavy thunderstorm activity.

2. meteoLCD has written special software that makes a daily mpg movie out of the minutely screen dumps from the computer running L2K; there is a lower limit (usually 60 flashes per hour) that must be exceeded for making these videos (see http://meteo01.lcd.lu/~lightning/previous_days_lightning/).

The following table shows the daily summaries for the period from 13 May 2009 to 29 Aug 2012, omitting days without data..

Date	Total	CG	CG+	CG-	IC	IC+	IC-	Noises	IC/CG	CG-/CG+	NSR
13.05.09	4556	1252	487	765	3304	903	2401	24	2.64	1.57	0.0053
09.06.09	11106	3297	842	2455	7809	1844	5965	79	2.37	2.92	0.0071
26.06.09	36378	17145	1769	15376	19233	6042	13191	174	1.12	8.69	0.0048
10.05.10	1668	666	278	388	1002	291	711	3	1.50	1.40	0.0018
26.05.10	7782	2316	746	1570	5466	1428	4038	29	2.36	2.10	0.0037
06.06.10	17866	6392	1522	4870	11474	5541	5933	227	1.80	3.20	0.0127

27.06.10	449	289	95	194	160	49	111	5	0.55	2.04	0.0111
28.06.10	2177	1273	259	1014	904	237	667	11	0.71	3.92	0.0051
29.06.10	4002	2192	302	1890	1810	414	1396	14	0.83	6.26	0.0035
02.07.10	5830	2599	408	2191	3231	1227	2004	33	1.24	5.37	0.0057
03.07.10	46486	15996	3030	12966	30490	16708	13782	886	1.91	4.28	0.0191
10.07.10	42202	15529	3119	12410	26673	15689	10984	871	1.72	3.98	0.0206
12.07.10	33087	14598	4413	10185	18489	8518	9971	107	1.27	2.31	0.0032
14.07.10	50367	17106	4251	12855	33261	17736	15525	370	1.94	3.02	0.0073
23.07.10	12040	2853	1033	1820	9187	1889	7298	64	3.22	1.76	0.0053
28.07.10	6215	1480	324	1156	4735	1204	3531	36	3.20	3.57	0.0058
01.08.10	5378	2904	625	2279	2474	1305	1169	13	0.85	3.65	0.0024
02.08.10	3985	1863	469	1394	2122	939	1183	10	1.14	2.97	0.0025
04.08.10	2020	781	385	396	1239	368	871	9	1.59	1.03	0.0045
08.08.10	1837	710	175	535	1127	290	837	7	1.59	3.06	0.0038
12.08.10	2066	1163	449	714	903	328	575	12	0.78	1.59	0.0058
15.08.10	3726	2431	664	1767	1295	540	755	22	0.53	2.66	0.0059
22.08.10	17493	8137	1480	6657	9356	4924	4432	55	1.15	4.50	0.0031
30.08.10	638	189	79	110	449	88	361	0	2.38	1.39	0.0000
22.04.11	3986	967	470	497	3019	959	2060	32	3.12	1.06	0.0080
23.04.11	10644	2148	1094	1054	8496	1934	6562	64	3.96	0.96	0.0060
24.04.11	6705	1868	1243	625	4837	1288	3549	18	2.59	0.50	0.0027
28.04.11	3998	1204	644	560	2794	674	2120	17	2.32	0.87	0.0043
30.04.11	6971	2113	1195	918	4858	1023	3835	37	2.30	0.77	0.0053
10.05.11	10833	1999	843	1156	8834	2483	6351	150	4.42	1.37	0.0138
20.05.11	17694	3927	1641	2286	13767	2748	11019	256	3.51	1.39	0.0145
22.05.11	9565	2688	1496	1192	6877	1339	5538	35	2.56	0.80	0.0037
30.05.11	2481	980	470	510	1501	626	875	8	1.53	1.09	0.0032
31.05.11	3501	1982	986	996	1519	828	691	11	0.77	1.01	0.0031
04.06.11	30956	14454	2269	12185	16502	5952	10550	166	1.14	5.37	0.0054
05.06.11	45015	15611	3859	11752	29404	7518	21886	580	1.88	3.05	0.0129
06.06.11	19215	7085	2096	4989	12130	2635	9495	214	1.71	2.38	0.0111
22.06.11	27104	12911	2140	10771	14193	8095	6098	177	1.10	5.03	0.0065
28.06.11	58677	21396	4802	16594	37281	20133	17148	158	1.74	3.46	0.0027
17.07.11	525	199	101	98	326	102	224	1	1.64	0.97	0.0019
27.07.11	7186	2849	436	2413	4337	1171	3166	17	1.52	5.53	0.0024
05.08.11	7207	2386	493	1893	4821	1646	3175	8	2.02	3.84	0.0011
18.08.11	34276	13151	2570	10581	21125	7873	13252	48	1.61	4.12	0.0014
22.08.11	20508	9928	1557	8371	10580	5052	5528	63	1.07	5.38	0.0031
23.08.11	26492	10465	1560	8905	16027	8615	7412	38	1.53	5.71	0.0014
03.09.11	10120	4464	809	3655	5656	2198	3458	30	1.27	4.52	0.0030
11.09.11	28080	10203	2712	7491	17877	10186	7691	235	1.75	2.76	0.0084
21.04.12	1221	474	207	267	747	105	642	2	1.58	1.29	0.0016
30.04.12	4096	1053	282	771	3043	723	2320	16	2.89	2.73	0.0039
04.05.12	900	294	124	170	606	129	477	1	2.06	1.37	0.0011
11.05.12	5337	1936	415	1521	3401	1233	2168	7	1.76	3.67	0.0013
20.05.12	19293	4893	1812	3081	14400	3194	11206	25	2.94	1.70	0.0013
22.05.12	3622	1339	314	1025	2283	684	1599	24	1.71	3.26	0.0066
23.05.12	24214	5080	2144	2936	19134	4362	14772	551	3.77	1.37	0.0228
24.05.12	5648	1419	542	877	4229	1453	2776	62	2.98	1.62	0.0110
25.05.12	1877	1207	666	541	670	330	340	8	0.56	0.81	0.0043
29.05.12	3073	1086	292	794	1987	579	1408	3	1.83	2.72	0.0010
07.06.12	6248	2333	660	1673	3915	1731	2184	6	1.68	2.53	0.0010
08.06.12	1605	440	243	197	1165	178	987	3	2.65	0.81	0.0019

18.06.12	12432	6172	1267	4905	6260	2754	3506	23	1.01	3.87	0.0019
21.06.12	30026	11167	2942	8225	18859	8615	10244	236	1.69	2.80	0.0079
28.06.12	27788	7634	2373	5261	20154	12777	7377	397	2.64	2.22	0.0143
04.07.12	7407	3290	883	2407	4117	1405	2712	11	1.25	2.73	0.0015
05.07.12	27581	13197	1867	11330	14384	6402	7982	87	1.09	6.07	0.0032
06.07.12	5425	3044	795	2249	2381	703	1678	7	0.78	2.83	0.0013
07.07.12	4580	1805	640	1165	2775	706	2069	11	1.54	1.82	0.0024
14.07.12	2031	651	200	451	1380	322	1058	12	2.12	2.26	0.0059
27.07.12	44889	14625	3327	11298	30264	14660	15604	623	2.07	3.40	0.0139
05.08.12	8090	3086	1161	1925	5004	2567	2437	16	1.62	1.66	0.0020
16.08.12	524	190	71	119	334	179	155	0	1.76	1.68	0.0000
19.08.12	351	172	69	103	179	79	100	0	1.04	1.49	0.0000
20.08.12	5256	2438	1149	1289	2818	1673	1145	10	1.16	1.12	0.0019
21.08.12	12447	3710	1661	2049	8737	4486	4251	71	2.35	1.23	0.0057
23.08.12	13700	5290	1469	3821	8410	5445	2965	60	1.59	2.60	0.0044
29.08.12	14698	5379	1366	4013	9319	5384	3935	28	1.73	2.94	0.0019
AVG's	**13406**	**4954**	**1222**	**3732**	**8452**	**3553**	**4900**	**103**	**2**	**3**	

Several important results are:

1. The **Noise to Signal ratio** given in the right-most column shows a maximum of 0.0228 or about 2.3% which is a fair value. A noise is defined as any electrical discharge that cannot be positively identified as a lightning flash. Noises include electrical noise from household appliances, signals transmitted by wireless electronic devices, and lightning strokes that have an insufficiently well-defined waveform.

2. The average of the **fraction IC/CG** ((intra-cloud) to (cloud to ground) flashes) is **2 +/- 0.83** where 0.83 is the standard deviation. We may compare these results to those given in the Höller et. al paper [4] for a storm cell. In this paper the fraction IC/CG at the maximum of storm activity is 175/75 = 2.3, close to the average given above fort he long-term meteoLCD data (fig. 3)

3. The percentages of the three categories IC, CG and noise are ~63%, ~37% and 0.8% (fig. 4)

4. Negative CG flashes outnumber by a factor of ~2.6 positve cloud to ground flashes The average and standard deviation of the fraction **CG-/CG+** is **2.72 +/- 1.62** This relatively high positive CG count might be surprising, as figure 2 shows that the CG+ flashes represent only ~18% of the total CG's during a very strong thunderstorm (see [5]). One should remember that the fraction of 2.72 represents an average of all type of storms observed, small and intense.

5. Negative inter/intra cloud flashes also are more frequent then positive ones. The average and standard deviation of the fraction **IC-/IC+** is **2.12 +/- 1.21**

In total negative flashes represent approx. 64% and positive 36% of the IC + CG total

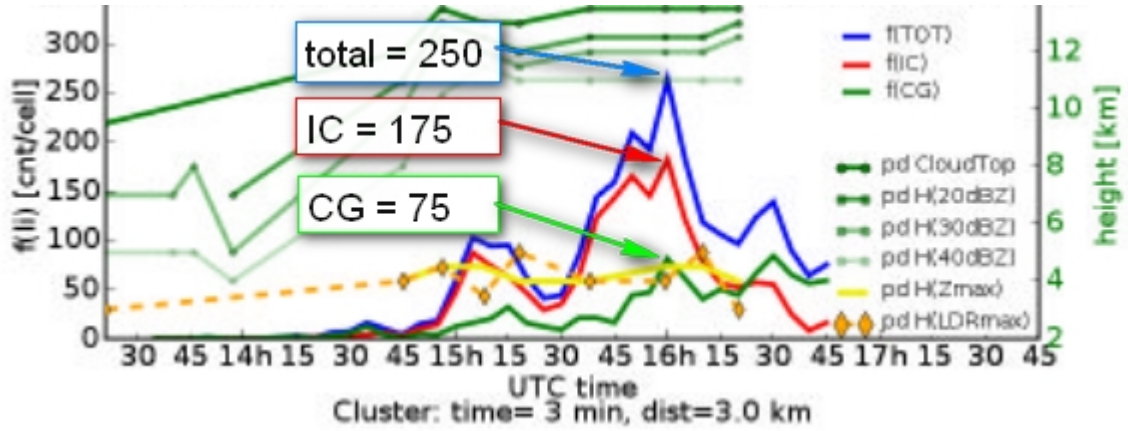

Fig. 3.: Maxima of flash types in a storm cell during a severe thunderstorm. Adapted from [4]

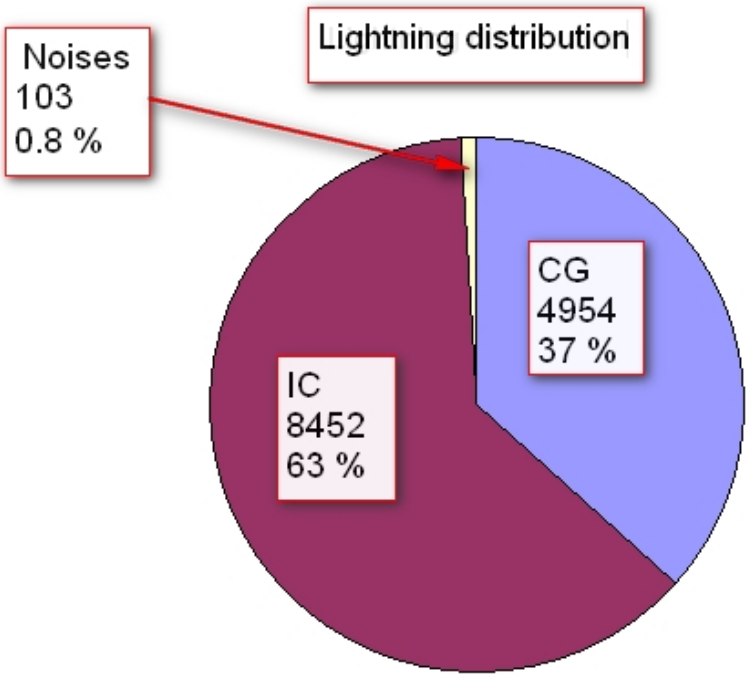

Fig. 4.: Pie chart of the noise and flash type frequencies (in percent)

4. Storm days and relation with air temperature

The following table shows the number of days where the flash total is greater than 10000; this arbitrarly choosen number will be used to classify a day as a thiunderstorm day. Only the months May to August will be retained; as the noise counts are small, they will not be subtracted from the totals., .

Year (May to August)	**days with flash count > 10000**	**total of flashes**	**Mean air temperature °C**
2010	9	267314	16.81
2011	10	321235	17.03
2012	10	289042	17.09

No clear trend is visible from these 3 years. Even if the totals differ by about up to 20%, the number of storm days is practically the same, and no relation with mean air temperature shows up. A further analysis extending over a much longer period could possibly give some hints on a possible influence of mean air temperature on the observed frequency of thunderstorms and flash count.

5. Conclusion

The BOLTEK Storm Tracker together with the Lightning 2000 software is a rather inexpensive device for locating thunderstorms and analysing flash count and flash types. In use since 2003 at the meteorological station of the Lycée classique Diekirch (http://meteo.lcd.lu) it allows an easy analysis of the frequencies of cloud to ground and inter/intra cloud lightning and of their polarities. The results from a three year period 2010 to 2012 show that negative flashes outnumber positive ones by more than 2, and inter/intra cloud flashes are nearly 3 times more frequent than cloud to ground flashes.The number of observed positive CG flashes seems rather high in the global count, as it is usually assumed that CG+ flashes represent not more than 10% of the totals. The detection efficiency of the Boltek/Lightning 2000 equipment is unknown.[6]. Future studies should extend on longer periods and use precipitation volume during storm days for an analysis of an eventual correlation with CG+ percentage [6]

References:

1 http://www.skyview.co.uk/acatalog/STORMTRACKER.html

2 http://www.euclid.org/blids.html

3 http://www.aninoquisi.com

4 Höller H. et al.: Lightning measurements and its Application for Severe Storm Detection and Nowcastiing. Deutsches Zentrum f. Luft- und Raumfahrt e.V. (link)

5 Mathias, L.: Analysis of thunderstorm and lightning activity in the Greater Region (Part 2) (link)

6 Poelman, D.. On the Science of Lightning. Royal Meteorological Institute of Belgium, 2010 (link)