

INVESTIGATION OF RELATIONSHIP BETWEEN LIGHTNINGSTORM CHARACTERISTICS IN ST.PETERSBURG AREA

V.N.Stasenko and A.A.Ganzha
Russian Federal Service for Hydrometeorology and Environmental Monitoring
(stasenko@mcc.mecom.ru)

V.S.Verba and V.A.Gandurin
Vega Radio-engineering Concern JSC
Moscow, Russian Federation

1. Introduction

Different lightning location systems provided lightning data for NWS. In this paper we analyze lightning data set recorded in 1993 from ALFD – 141T sensor installed in the St. Petersburg region. It was assumed that this sensor detects cloud-to-ground lightning over the region with complicated topography and that lightning flash (LF) distribution can be used for regional thunderstorm variability investigation.

It is generally accepted viewpoint that lightning activity pattern tends to be informative for weather hazards developing within convective storm. However, very high LF variability in clouds of different origin (frontal and air mass clouds) pose difficulties if one will try to interpret the ALDF data in terms of cloud danger for weather dependent productions and services. From this point of view, too much has to be done to get physically and statistically proven LF-hail, LF-excessive precipitation and LF-tornado correlations. That is why we began thunderstorm study in less disturbed environment to investigate separately as much as possible orographic (air mass convection) and dynamic (frontal convection) effects on local thunderstorms.

In order to assess variability of LF characteristics, an experimental data set of 19 days (July and August 1993), when air mass thunderstorms only took place, was analyzed. Single ALDF sensor and X-band weather radar were used to monitor thunderstorms within 200 km range which encompasses partly Gulf of Finland and large lakes of the North-West of Russia dominating summer convection of the region.

2. Method

Following questions upon an assimilation of thunderstorm information in mesoscale may arise: how large variation of lightning activity might be and what is the reason of it? To investigate the degree of similarity of thunderstorms developing simultaneously in nearly identical air mass conditions, statistical characteristics of LF parameters were analyzed within 200 km range.

Low gradient pressure fields allow for stationary thunderstorms developing over the Gulf of Finland and near Ladoga and Onega and other lakes of the region. Single sensor gave us only azimuth distribution of 5800 cloud-to-ground LF associated with these clouds.

In the region, convection took place mostly near lakes in a form of clusters of 30-50 km size lasted for hours and was accompanied by non-frequent LF. Almost uniform intensity of thunderstorms (9-10 fl/min) let us to make a comparative analysis of LF statistics (\bar{x} , σ_x) among clusters which were located 50-150 km apart. The following LF parameters were analyzed: LF polarity and multiplicity (number of return strokes, RS), RS amplitude (in LLP units), RS amplitude rise time and RS pulse width (in μ s). LLP units were converted then to stroke current using factor of 0,4 (medium-range gain of ALDF was pre-selected).

3. Results

Total LF statistics indicated mainly negative LF polarity (80%). Time distribution of the total LF including LF multiplicity is shown in Fig. 1. Total number of positive LF was 20%, varying on different days from 1 to 58% (seemingly we faced the problem of "small positives").

From Fig. 1a and 1b, we observe typical diurnal LF distribution with peak flashing rate of 9-10 fl/min and multiplicity of 3-4 RS which occurred since 15.00 till 19.00 local time. It is noteworthy that LF with 8-10 RS were fixed in air mass thunderstorms of 9-10 km height at the latitude of St. Petersburg.

LF statistics grouped in Cu clusters for 19 days is shown in the Table. The data stored in the Table revealed significant scatter of LF characteristics among the clusters up to 3-7 times as a whole. Meanwhile, large differences (up to 3-4 times) in average values of A and τ in thunderstorms developed simultaneously on July 23 and 30, 1993 notify substantial distinctions in electric properties of these clouds.

Such a scatter of RS em characteristics averaged by different clouds and days gives evidence of differences in cloud microphysics and dynamics which were not captured by the radar. Large variability of processes lead to LF even in seemingly uniform air mass convection shows us the complexity of cloud charge structure (amount and location of main charged volumes) we need addressing to in the future.

Distribution of RS peak currents (LLP units) revealed gradual decrease till the end of convection what is also typical for air mass thunderstorms.

4. Conclusion

This preliminary study of air mass thunderstorms in the St. Petersburg area supports the opinion that diversity of underlying surface gives an effect on characteristics of lightning in convective clouds developing over.

Mechanisms responsible for such an effect are beyond the scope of this article, however, difference of 3-4 times inherent in the LF averages exists and can be attributed to varying physical properties of the clouds what is contrary to existing opinion on certain similarity of air mass convection over the region.

To make further step in lightning – severe weather phenomena correlation, comprehensive analysis of multiparameter radar, microwave radiometers data and homogeneity of the atmosphere in mesoscale is needed focused on measurements of cloud and atmospheric variables with a good enough space and time resolution.

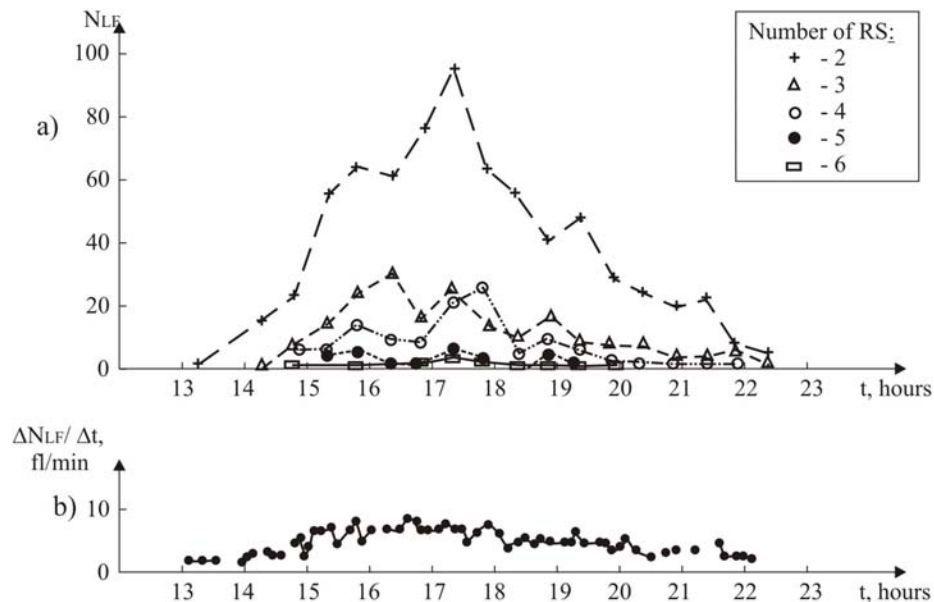


Figure 1. Lightning flash time distribution: a) LF multiplicity and b) LF rate for the whole data set

Table

Lightning flash statistics measured by ALDF – 141T sensor in St. Petersburg region

Date		23.07.93					25.07.93		26.07.93			27.07.93			
RS parameters		Cu cluster number													
		1	2	3	4	5	1	2	1	2	3	1	2	3	4
Amplitude, LLP units	\bar{A}_{max}	73,14	59,76	54,53	205,04	112,39	142,12	105,34	73,45	71,82	47,49	51,65	71,11	61,1	59,94
	σ_A	2,99	4,75	4,98	25,88	14,40	11,78	8,36	7,8	8,07	2,45	4,7	2,44	2,36	4,70
Ampl. rise time, μs	τ_A	4,24	3,91	3,84	5,86	4,97	4,6	4,66	4,61	3,79	3,83	3,9	3,62	3,86	4,5
	σ_τ	0,09	0,11	0,23	0,37	0,30	0,29	0,23	0,28	0,19	0,11	0,12	0,07	0,06	0,3
Pulse width, μs	τ_W	22,53	20,78	20,97	23,45	24,48	19,9	20,31	23,10	20,89	20,69	18,44	18,67	19,11	20,86
	σ_τ	0,36	0,48	0,98	0,86	1,1	0,61	0,59	0,94	0,98	0,63	0,47	0,33	0,29	1,06

28.07.93		30.07.93			31.07.93		01.08.93			02.08.93		04.08.93	05.08.93	08.08.93
Cu cluster number														
1	2	1	2	3	1	1	2	3	1	2	1	1	1	
48,13	37,84	29,12	98,39	96,98	49,04	52,3	55,1	71,32	46,22	62,92	41,08	212,36	79,52	
4,96	3,27	2,73	14,71	13,43	2,39	4,01	4,46	6,96	2,50	7,33	3,89	33,18	14,42	
3,98	3,45	3,62	6,65	8,4	4,43	3,98	3,95	4,05	4,17	4,86	4,57	5,00	4,33	
0,24	0,18	0,36	0,61	1,31	0,15	0,19	0,23	0,18	0,17	0,61	0,35	0,26	0,43	
19,1	19,4	18,54	23,22	23,23	18,55	20,32	23,85	20,33	17,80	20,99	22,54	23,28	19,37	
0,96	0,81	1,3	0,95	2,27	1,53	0,88	1,21	0,81	0,70	1,71	0,99	0,97	1,02	

13.08.93		14.08.93	15.08.93	16.08.93			17.08.93			18.08.93		19.08.93	
Cu cluster number													
1	2	1	1	1	2	3	1	2	3	1	2	1	2
53,68	31,44	37,79	64,98	39,33	56,64	62,8	73,36	87,13	117,91	37,6	52,08	153,36	153,19
6,03	2,65	2,67	10,58	2,03	2,41	2,7	2,7	4,01	8,4	0,48	2,59	25,21	28,46
4,42	3,48	3,51	5,04	3,31	3,23	3,68	3,87	4,04	3,98	3,14	4,24	5,10	4,42
0,59	0,31	0,19	0,53	0,13	0,06	0,09	0,07	0,07	0,12	0,02	0,13	0,42	0,24
20,64	25,59	21,59	17,34	17,85	17,22	19,52	21,04	20,61	23,66	18,90	21,75	22,59	21,66
1,94	1,45	1,32	1,18	0,62	0,33	0,49	0,28	0,35	0,55	0,19	0,57	1,13	0,81