Connection of Lightning Activity with Air Electrical Conductivity in Dusheti

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Abstract **— Some results of investigations of the connection of the parameters of thunderstorm activity with the air electrical conductivity are represented. The connections of the thunderstorm processes with the air electrical conductivity have nonlinear nature. As the aerosol pollution of the atmosphere the air electrical conductivity depending on its level can lead both to the increase and to the decrease of the intensity of thunderstorm processes. Apparently this connection has regional nature, and depending on concrete conditions of air pollution can be shown in a various kind.**

Keywords- air electrical conductivityt; total number of lightning discharges; duration of lightning discharges; intensity of lightning discharges

I. INTRODUCTION

Several studies have reported that atmospheric aerosol pollution (radioactive and non radioactive) are associated to an changeability of the storm activity [1-6].

In early studies it was obtained, that the connections of the thunderstorm processes with the aerosol pollution of the atmosphere have fairly complicated, often nonlinear, nature. The pollution of the atmosphere depending on its nature and level can lead both to the increase and to the decrease of the intensity of thunderstorm processes. Air electrical conductivity represents not only important atmospheric electricity parameter, but also a sensitive indicator of atmospheric aerosol pollution. Therefore, on the one hand, the air electrical conductivity has a direct effect on the intensity of thunderstorm processes, on the other hand - indirect, through the influence of the aerosol pollution of atmosphere, indicator of which it is. This work is continuation of the previous researches [4-6].

II. DATA DESCRIPTION

The evaluations of the influence of the mean summary air electrical conductivity in a 24 hour period (E) on such characteristics of lightning activity as the total number of lightning discharges in a twenty-four hours period (N), the total duration of lightning discharges in a 24 hour period (T) and the mean intensity of lightning discharges in one hour (F) are carried out.

All four above-indicated parameters were measured in Dusheti (in latitude 42.08 degrees, in longitude 44.7 degrees, 900 m altitude a.s.l., located in 40 km to the north of capital of Georgia - Tbilisi). Total number of lightning discharges was recorded by PRG-15. The measurements of air electrical conductivity were conducted by the Gerdien type instrument. A measurement unit is given in 10^{-15}/ohm·m, omitted further to be more convenient.

An observation period makes 14 years, from 1969 to 1982 (April – October months). Data of daily observations are used. The values of N were measured each hour, the values of E were measured four times in a 24 hour period. Data with the number of the lightning discharges not less than 15 in a 24 hour period were analyzed (606 days with the thunderstorms).

The analysis of data was conducted with use of methods of mathematical statistics. The estimation of difference between the investigated parameters (calculated and empirical distribution functions, average) was evaluated according to Kolmogorov - Smirnov and Student's criterions. The following designations are used below: α - the level of significance, R – coefficient of linear correlation, R^2 - coefficient of determination.

III. RESULTS

The results in table 1 and fig. 1-6 are presented.

TABLE 1. THE STATISTICAL CHARACTERISTICS OF E, N, T AND F (606 DAYS WITH THE THUNDERSTORMS)

Parameter	**E**	**N**	**T**	**F**
Max	69	671	21	89.8
Min	23	15	1	1.5
Range	46	656	20	88.3
Average	41.5	90.6	7.8	10.9
St Dev	7.5	111.5	3.3	11.0
	Correlation matrix			
E	1	0.10	0.13	0.06
N	0.10	1	0.51	0.87
T	0.13	0.51	1	0.16
F	0.06	0.87	0.16	1

As follows from this table values of E varied from 23 to 69, N – from 15 to 671, T – from 1 to 21, F – from 1.5 to 89.8. The linear correlation E with N, T and F is low (R varied from 0.06 to 0.13).

Therefore for further analysis all investigated data were averaged on 7 ranges of E: 23-32, 33-35, 36-39, 40-43, 44-47, 48-53, 54-69.

As showed calculations, the connection values of N, T and F with value of E have a nonlinear nature (fig. 1-3).

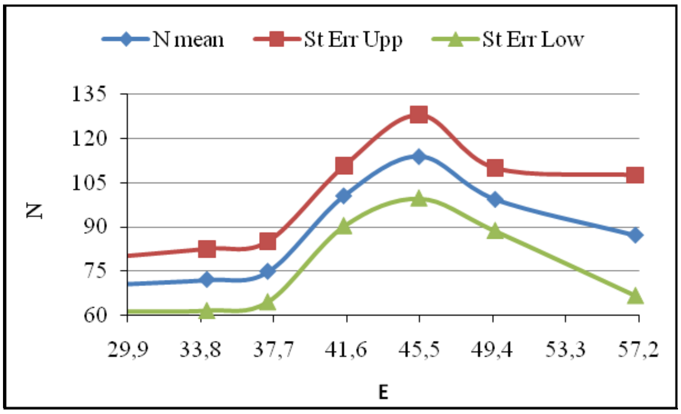

Figure 1. Connection between of mean values of N and E.

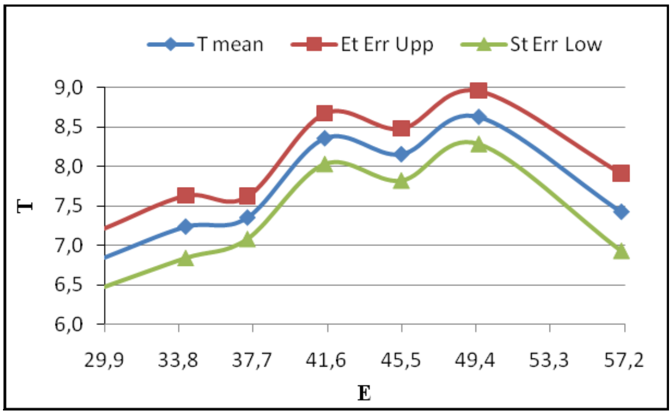

Figure 2. Connection between of mean values of T and E.

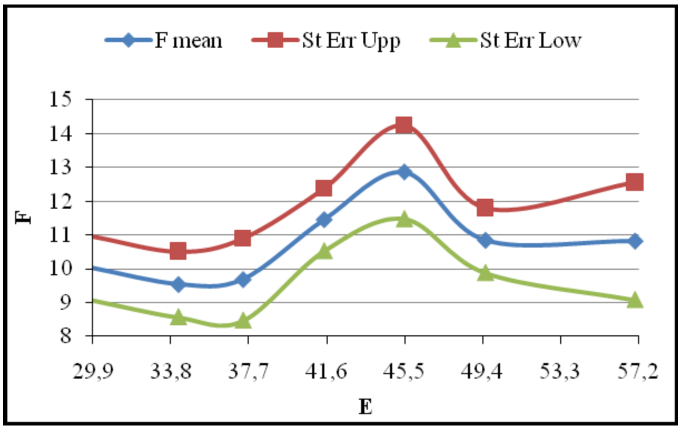

Figure 3. Connection between of mean values of F and E.

As follows from fig. 1-3 with an increase of the values E the indicated parameters at first grow, and then they decrease. Maximum values of the indicated parameters are taken with values $44 \le E \le 47$. For example the values N, T and E for the different ranges of E are given below.

$N = 113.8 \pm 14.1$ for $44 \le E \le 47$
$N = 70.8 \pm 9.3$ for $23 \le E \le 32$
$N = 87.2 \pm 20.3$ for $54 \le E \le 69$

$T = 8.2 \pm 0.3$ for $44 \le E \le 47$
$T = 6.8 \pm 0.4$ for $23 \le E \le 32$
$T = 7.4 \pm 0.5$ for $54 \le E \le 69$

$F = 12.9 \pm 1.4$ for $44 \le E \le 47$
$F = 10.0 \pm 0.95$ for $23 \le E \le 32$
$F = 10.8 \pm 1.7$ for $54 \le E \le 69$

The equations of the regression of connection N, T and F with E take the following forms (the polynomials of fifth degree):

$$N = 0.0003186 \cdot E^5 - 0.0662 \cdot E^4 + 5.414 \cdot E^3 - 217.794 \cdot E^2 + 4313.433 \cdot E - 33614.5 \quad (R^2 = 0.996,\ \alpha = 0.001,\ \text{fig. 1})$$

$$T = -0.000004568 \cdot E^5 + 0.00098186 \cdot E^4 - 0.08376 \cdot E^3 + 3.5393 \cdot E^2 - 73.8589 \cdot E + 614.492, \quad (R^2 = 0.937,\ \alpha = 0.001,\ \text{fig. 2})$$

$$F = 0.000036126 \cdot E^5 - 0.00750385 \cdot E^4 + 0.61372 \cdot E^3 - 24.7082 \cdot E^2 + 489.9 \cdot E - 3819.867, \quad (R^2 = 0.998,\ \alpha = 0.001,\ \text{fig. 3})$$

The empirical and calculated curves of the indicated equations of the regression practical merge with each other. Therefore fig. 1-3 depicts empirical curves only.

The integral empirical distribution functions of N, T and F for different values of E in the fig. 4-6 are presented.

The calculated distribution functions of N, T and F for different range of E take the following form:

$$f(N) = a \cdot N^b$$

$a = 25596.82$, $b = -1{,}59$ for $44 \le E \le 47$
$a = 175145.1$, $b = -2{,}042$ for $23 \le E \le 39$
$a = 70771.3$, $b = -1.8224$ for $48 \le E \le 69$
(R^2 not worse 0.99, $\alpha = 0.001$, fig. 4)

$$f(T) = a \cdot b^T \cdot T^c$$

$a = 9.9361$, $b = 0.54803$, $c = 2.74716$ for $44 \le E \le 47$
$a = 1.67705$, $b = 0.514065$, $c = 3.99627$ for $23 \le E \le 39$
$a = 5.3774$, $b = 0.63362$, $c = 2.55488$ for $48 \le E \le 69$
(R^2 not worse 0.97, $\alpha = 0.001$, fig. 5)

$$f(F) = a \cdot N^b$$

$a = 489.376$, $b = -1.271$ for $44 \le E \le 47$
$a = 820.442$, $b = -1.5015$ for $23 \le E \le 39$
$a = 479.48$, $b = -1.25$ for $48 \le E \le 69$
(R^2 not worse 0.98, $\alpha = 0.001$, fig. 6)

The empirical and calculated curves of the indicated distribution functions practical merge with each other. Therefore fig. 4-6 depicts empirical distribution functions only.

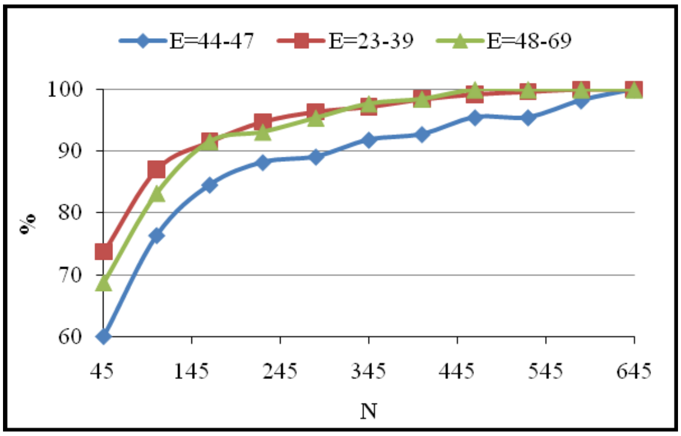

Figure 4. The empirical integral distribution functions of N for different values of E.

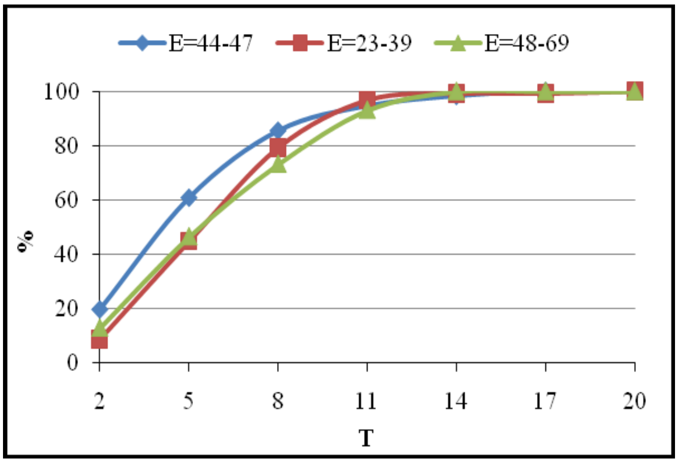

Figure 5. The empirical integral distribution functions of T for different values of E.

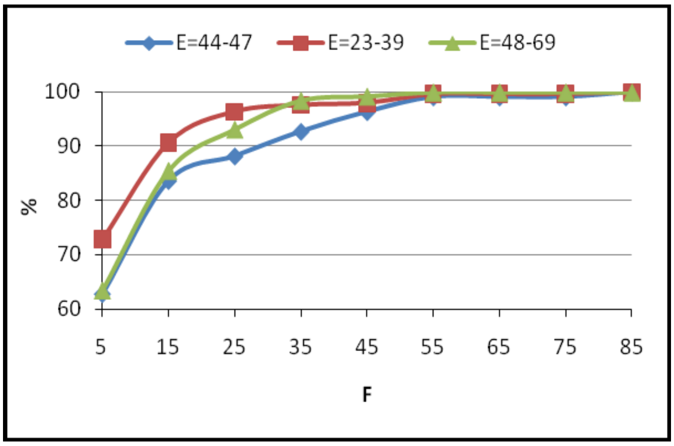

Figure 6. The empirical integral distribution functions of F for different values of E.

According to Kolmogorov – Smirnov criterion the distribution functions of N, T and F for $44 \le E \le 47$ are differ from the same distribution functions for $23 \le E \le 39$ and $48 \le E \le 69$ (α is not worse 0.25).

Thus, as in the case with the aerosol pollution of atmosphere, the connection of the investigated parameters with the air electrical conductivity has complex nature. Apparently this connection has regional character, and depending on concrete conditions of pollution of atmosphere can be shown in a various kind.

IY. CONCLUSIONS

The connections of the thunderstorm processes with the air electrical conductivity have nonlinear nature (the polynomials of fifth degree).

The air electrical conductivity depending on its level can lead both to the increase and to the decrease of the intensity of thunderstorm processes. Maximum values of the total number of lightning discharges in a twenty-four hours period, the total duration of lightning discharges in a 24 hour period and the mean intensity of lightning discharges in one hour are taken with values of the mean summary air electrical conductivity in a 24 hour period from $44 \cdot 10^{-15}$/ohm·m to $47 \cdot 10^{-15}$/ohm·m.

Apparently this connection has regional nature, and depending on concrete conditions of air pollution can be shown in a various kind.

The determination of the possible reasons of the indicated connections is the object of future investigations.

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