2016 24th International Lightning Detection Conference & 6th International Lightning Meteorology Conference
18 - 21 April | San Diego, California, USA

# Experimental Studies of the Behavior of the Electric Field during the Thunderstorms in the Mountain Conditions near Elbrus

Kudrinskaya Tatiana
Southern Federal University,
Taganrog, Russian Federation,
egf2@tgn.sfedu.ru

Kupovykh Gennady
Southern Federal University,
Taganrog, Russian Federation,
kupovykh@sfedu.ru

Redin Alexander
Southern Federal University,
Taganrog, Russian Federation,
alexandr.redin@gmail.com

***Abstract* — The temporal variations of the atmospheric electric field potential gradient and the concentration of light ions before a thunderstorm are studied. The features of the behavior of the atmospheric electric field under various weather events (snow, storm, rain) are obtained.**

***Keywords—* atmosphere, alpine station, electric field, daily variation, concentration of small ions, measurements, thunderstorm.**

## I. Introduction

Long terrestrial atmospheric electrical monitoring is an important basis for both experimental and theoretical study of electrodynamic processes in the surface layer. The current network of ground stations for the atmospheric electricity monitoring, operating in Russia, solves the problem of collecting operating data on the electrical state of the atmosphere in order to provide information that allows to monitor the changes in this status [Adzhiev, 2011; Petrova 2011; Erokhin, 1990].

Electrical characteristics of the surface layer may be an indicator of anthropogenic impact on the atmosphere in general. The variability of the electrical field near the earth's surface is associated with the imposition of local perturbations to the global variation of the electric field. The generally accepted proof of the existence of the global atmospheric electric field generator is considered to be so-called unitary variation, which is a synchronous change the values of the electric field at all points of the globe. It should be noted that often the unitary variation detection is a difficult task in the continental areas. This is due to the action of the electrode effect near the surface, the presence of local generators of atmospheric currents, spatial-temporal heterogenity of the electrical conductivity and the volume charge, etc.

The reasons for the variations of the global component of the electric field are: changing the ionosphere potential wave geophysical processes, the change in conductivity due to the action of cosmic rays, the global thunderstorm activity. Thunderstorm activity is a powerful factor in the value of the electric field potential gradient and the ionization state of the atmosphere [Adzhiev, 2004]. The region of the North Caucasus in summer season is characterized by intense thunderstorm activity. The local thunderstorms are observed at high temperature and high moisture content of the air, mainly in the afternoon hours in the summer months.

To solve the problems of allocation the electric field global variations on the background of local factors the alpine points appear to be interesting, as they allow to eliminate the anthropogenic component in the formation of the atmosphere of electrodynamics and are characterized by a low level of radioactivity of the surface layer as well [Kupovykh, 2003; Vayushina, 1995].

## II. Methods

Currently the continuous recording of the electric field of the atmosphere is organized at three stations in the Elbrus region:

- alpine station Peak Cheget (43º16'N, 42º30 'E; 3040 m), located on the northern slope of Mount Cheget;
- research station of High-Mountain Geophysical Institute, named «Kyzburun» , (43º40'N, 43º27'E; 700 m above sea level) is located 40 km west of Nalchik;
- High-Mountain Geophysical Institute (43º29'N, 43º37'E; 500 m above sea level), Nalchik.

The measurement procedure and the composition of the apparatus have been selected basing on their work for a long time without maintenance. Software of measurement system enables measurements, transmission and visualization of values of the electric field and the parameters of lightning discharges. To register the electric field strength at all observation points the electric field meter EFM 550 (company Vaisala) was used. The measuring range of the stations Peak Cheget and Kyzburun is equipped with modem device that allows the transmission of data over a three-hour period to a remote server situated in High-Mountain Geophysical Institute.

As each generated source txt-file contains every second data for a three-hour period, a special program was designed for processing and further analysis of the report's authors (Certificate of state registration №2014661070, registered in the Register of the computer programs of the Federal Service for Intellectual Property, Patents and Trademarks 10/22/2014, Russia).

The program generates a set of text files with the .txt extension database .xls. Each resulting file contains the following information: date and time of measurement, the measured values of the electric field potential gradient (in V/m), and the data averaged over 1 minute, 5 minutes, 10 minutes, 15 minutes, 1 hour.

Measuring the concentration of light ions was carried out with the help of the ions counter ("Sapphire-3M"). At the same time automatic registration of minute air temperature, absolute and relative humidity, wind speed and direction, pressure was performed by means of the automatic weather station (AWS-2000).

## III. Observation results and discussion

Due to the necessity of sorting the electric field potential gradient data for global and local component a set of criteria was allocated us for determining the unperturbed in an electrical respect the terms of the atmosphere. These criteria are referred to terms of «fair weather» and comprise a number of requirements, including: the lack of rain, fog, blizzards, thunderstorms; the absence of strong mist, haze and drifting snow; wind speed of 3 m/s; and no lower than 3 points cloud top.

Figure 1 shows the average daily variation of the electric field potential gradient, obtained from the mountain station Peak Cheget, Peak Terskol and Kyzburun for the period from July 13 to August 15, 2012.

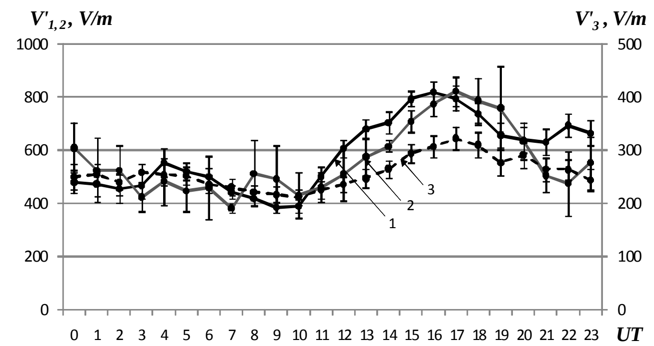


Fig. 1. The daily average values of the atmospheric electric field potential gradient in the period from 13.07.12 to 15.08.12 (Peak Cheget (1), Peak Terskol (2) and Kyzburun (3))

It may be noted that in terms of fair weather» received average daily variation of atmospheric electric field are in good agreement with the Carnegie curve, reflecting the diurnal variation.

Similarly when measuring the electric field were made in terms of «fair weather» in the polar regions the unitary variation was obtained (data received from the source: http://geophys.aari.ru). Figure 2 shows the diurnal variations of ten minutes values of the potential gradient values obtained on a polar station Vostok (78º45'S, 106º87 'E; 3500 m above sea level) and alpine station Peak Cheget (data received 15.01.2013).

These data in the figure 2 show a good degree of consistency change in the electric field potential gradient values. Both stations satisfy the conditions of observation stations for background atmospheric electricity monitoring tasks: the concentration of small particulate matter and low levels of radioactivity mainland.

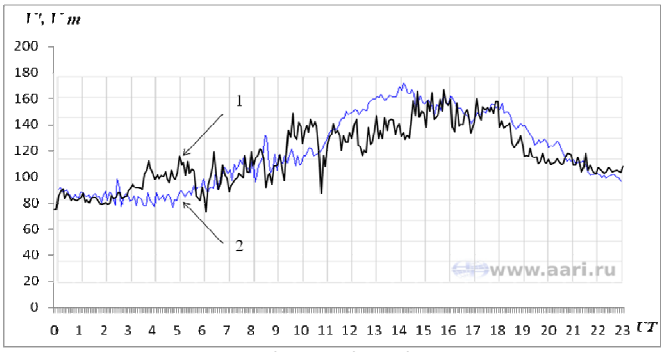


Fig. 2. The diurnal variation of electric field of the atmosphere received at alpine (1) and polar station (2); 15.01.13

Outside the terms «fair weather» such weather events such as storm, intense rainfall caused significant changes in the electric field. When snow and blizzards the high values of the electric field potential gradient (more than 5000 V/m) are observed, and the rain decreases values and changing the sign of the electric field.

Figure 3 shows examples of minute variations in the electric field potential gradient per day during a snowfall with strong winds (Figure 3a) and rain (Figure 3b), obtained by measurements on the peak of mountain station Cheget January 20 and May 26, 2013.

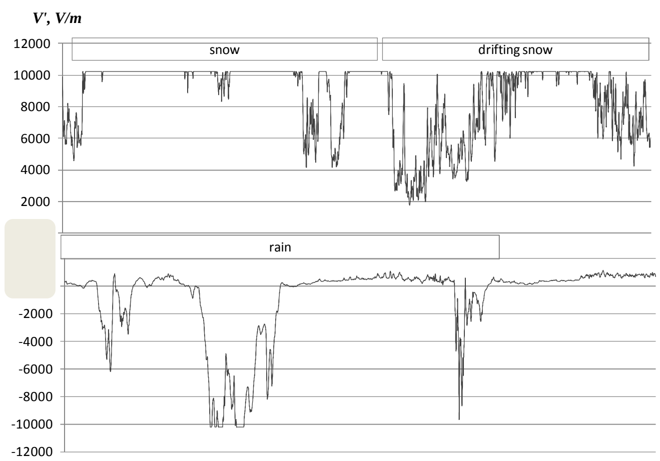


Fig. 3. The daily change in the electric field of the atmosphere in different weather phenomena, received at Peak Cheget: a) 20.01.2013, b) 26.05.2013

The observed variations in the structure of the electric field during a snowstorm are caused by strong electrification snowflakes. Values of the electric field potential gradient are «cut off» from the top (Figure 3a), because the device does not allow to register values High: -10 kV/m, and charged snowflakes can create a field strength of 20-30 kV/m. When heavy rains take place the variations of the electric field potential gradient are caused by the fact that this phenomenon is accompanied by ominous atmosphere with considerable cloudiness.

Table 1 shows the average values of the electric field potential gradient under cloudy (9-10 points) and cloudless weather for two seasons: winter (December-March) and summer (June-September) in 2013.

**Table 1. Average values V' (V/m) at Peak Cheget**

| *winter* | | *summer* | |
|---|---|---|---|
| *cloudiness* | *cloudless* | *cloudiness* | *cloudless* |
| 3450 | 800 | 730 | 670 |

In the ominous period when a strong electric field is observed, the structure of the electrode layer is mainly determined by the gradient of the electric potential of the atmosphere, which determines the behavior of the concentration of light ions, whereas the effect of weather conditions is minimal.

Based on the experimental data, we investigated the variations of the electric field potential gradient and the polar small ion concentrations witch obtained in ominous period when significant changes in the electric field took place. When there is an increase in the electric field gradient values of the potential order of magnitude (up to 2500 V/m) concentration of negative ions decreases significantly. A similar reduction in the concentration of positive ions is observed when the electric field changes sign. In cases of reversed polarity and high values of the atmospheric electric field (more than -1000 V/m), the concentrations of negative ions are reduced significantly.

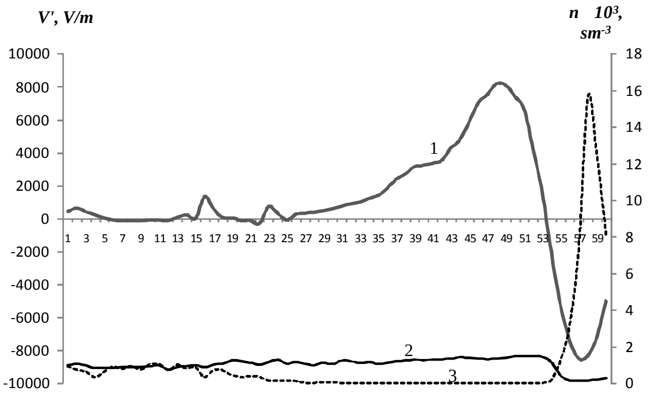


Fig. 4. Variations of the atmospheric electric field potential gradient (1) and concentration of positive (2) and negative small ions (3)

Figure 4 shows an example of minute variations in atmospheric electrical characteristics (concentration of polar ions and electric field potential gradient) in the ominous atmosphere obtained at the alpine station Peak Cheget.

Coefficients mutual correlation potential gradient of the electric field and concentration of polar ions calculated to Example 10, these measurements give sufficiently large values: $K(V', n_+)=0{,}60\div0{,}90$ and $K(V', n_-)=-0{,}50\div0{,}85$.

In the ominous atmosphere there is a significant reduction in the concentration of small ions of opposite sign, and a large space charge is formed near surface even with a slight change in the electric field potential gradient (100-200 V/m). Figure 5 shows an example of such a change in atmospheric electrical characteristics.

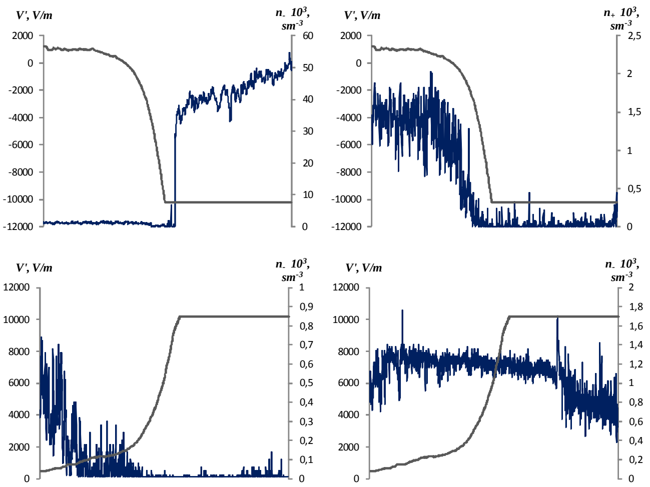


Fig. 5. Variations of the atmospheric electric field and concentration of the polar ions in the ominous atmosphere

## IV. Conclusion

Thus, the revealed changes of the concentrations of polar ions together with the behavior of the electric field can be considered as indicators of approaching thunderstorms. This is especially valuable in mountain terrain where the visual or other instrumental methods to monitor the atmosphere can be difficult.

## Acknowledgment

The authors would like to thank the colleagues of High-Mountain Geophysical Institute, North-Caucasian Paramilitary Service of Active Influence on the Meteorological and other Geophysical Processes for taking part and help in experimental researches.

## References

Adzhiev A.H., Kupovykh G.V. (2004) Atmospheric-electrical phenomena in the North Caucasus, Taganrog. [in Russian].

Adzhiev A.H., Boldyreff A.S., Dorina A.N., Kudrinskaya T.V., Kupovykh G.V., Novikova O.V., Panchishkina I.N., Pestov D.A., Petrov A.I., Petrova G.G., Redin A.A. (2011) Alpine Atmospheric Electricity Monitoring and Radon-222 Measurement near Elbrus // Proc.14th Int. Conf. Atm. Electricity. – Rio de Janeiro, Brazil.

Kupovykh G., Morozov V, Shvartz Ya. (2003) Electrode Effect under Alpine Conditions // Proc. 11th Int. Conf. on Atmosph. Electr.,Versailles.

Petrova, G.G. Petrov A.I., Panchishkina I.N., Kudrinskaya T.V. (2011) The Expedition Research of Processes of the Atmospheric Electrode Layer Formation // Proc.14th Int. Conf. Atm. Electricity. – Rio de Janeiro, Brazil.

Vayushina G.P., Kupovykh G.V., Martynov A.A., Sokolenko L.G. et al. (1995) Results of Atmospheric Electric Field Observations on the Alpine Station Peak Cheget near Elbrus. Main Geophys. Observatory Proceedings, Saint Petersburg: Gidrometeoizdat №545. [in Russian].

Erokhin V.N., Kanaev A.S., Kupovykh G.V. and others (1990). Analysis of Synchronous Electric Field Measurements near Elbrus and at Kola Peninsula, Results of international geophysical projects researches. Magnetosphere researches. Moscow. № 15. [in Russian].