

# Influence of single lightning on the intensity of an air electrical field and acoustic emission of near surface rocks

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**ABSTRACT:** The effect of influence single lightning on the intensity of an electrical field in near ground atmosphere is investigated. The effect was showed in sharp fall of a gradient of intensity potential from 80 V/m up to a minus 21 V/m. Then the field has returned on its level under the formula of restoration of the condenser charge with characteristic time 17sec. Simultaneously the response of acoustic emission of near surface rocks in a range of frequencies 6.5 - 11 kHz is found out.

## 1. INTRODUCTION

In spite of long-term investigation of thunderstorm processes the scientific interest to these phenomena has not died down. The accepted at present idea, that the Earth electrostatic charge is formed by global thunderstorm activity, requires a more detailed consideration of transform processes of discharge and charge in a cloud. In the paper we investigate the process of response of a single strike in electric field intensity of the near ground layer and in acoustic emission.

The peculiarity of atmosphere electric field state in Kamchatka is a small number of thunderstorms. According to the official data only 22 thunderstorms were registered from 1937 to 1982 (45 years) [Kondratuk, 1983]. On October 2, 2008 a unique for this region event took place. At 17:46 LT (4:46 UT) a single strike occurred; it was not accompanied with precipitation. The sensors of electric field and acoustic emission, installed at "Paratunka" observatory, registered this strike. Precipitation is known to be the most disturbing factor of near ground air electric state. In the paper [Mikhailov et al., 2005] it was shown that during precipitation the noise level increases by two orders in comparison to the measurements in "fair weather" conditions. In this case the dynamics of atmosphere electric state could be observed in undisturbed by precipitation conditions. Moreover, the cloudiness on that day was not continuous, but there were separate big cumulus clouds in the sky.

## 2. MEASUREMENT TECHNIQUES

The observations were carried out in Kamchatka at "Paratunka" observatory, IKIR FEB RAS, ( $\lambda=158,25^{\circ}\text{E}$ ;  $\varphi=52,9^{\circ}\text{N}$ ). "Pole-2" sensor was used to measure the electric field intensity; it was constructed in a Branch of Voeikov Main Geophysical Observatory, by Research Center of Remote Atmosphere Sounding [Imyanitov, 1957]. The sensor is registered in GOSSTANDART (certificate RU.E.34.001.A № 7136 on 10.03.2004) and recorded in Gosreestr on 13.09.2005 № 2941-2005. «Pole-2» is installed in a field which is 200 m from the administration building at the height of 3 m; the area around it is cleaned from trees within the radius of 12 m. Registration was carried out by 14-bit ADC with sampling frequency of 1 s.

Registration of acoustic emission was carried out by a hydroacoustic receiver (hydrophone) installed in an artificial pool of 1x1x1 m size at the distance of 54 m from the electric field sensor. After multiplication the signal from the hydrophone is filtered at the following frequency ranges: 0.1-10, 30-60, 70-200, 200-600, 600-2000, 2000-6500, 6500-11000 Hz. Than the frequency divided signals are sent to amplitude detectors, stored for

4 s, digitized and recorded on a PC. The analyzed value is the total 4 s acoustic pressure  $P_s$  at every frequency channel.

Meteorological parameter control is realized by a digital meteorostation WS-2000. H, D, Z components of the magnetic field were measured by a flux-gate magnetometer FRG with the accuracy of 0.01 nT and frequency sampling of 1s.

The strike caused a sharp fall of electric field intensity potential gradient from 80 V/m to the value -21 V/m; than the value gradually recovered up to 70 V/m (Fig. 1). We did not register any change of the magnetic field in all the three components by flux-gate and proton magnetometers during the strike. Air electro-conductivity state, which was measured with 1 s interval, did not change.

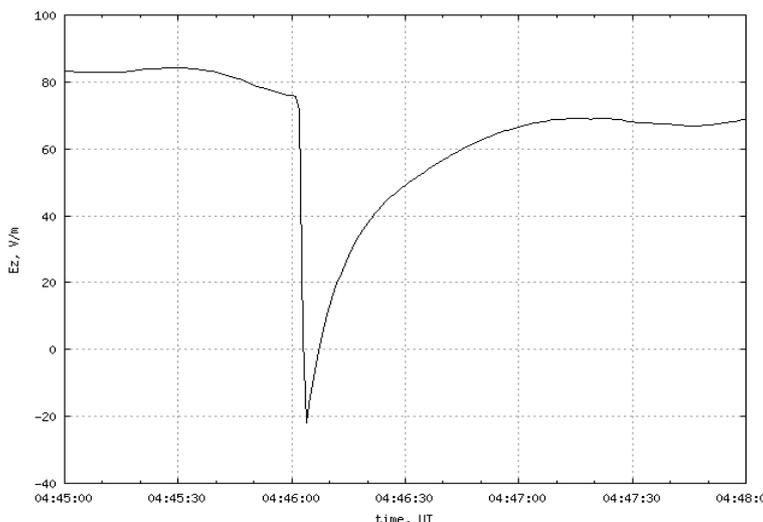


Fig. 1. Graph of potential gradient of electric field intensity in the near ground air during the strike on October 2, 2008

### 3. MAIN RESULTS AND DISCUSSION

During a thunderstorm with every strike a charge of 20-30 coulombs is emitted [4]. Charge recovery occurs according to the same law as condenser charge recovery. During such discharges one may observe a sudden field decay and than an exponential return to the initial value with specific temporal constant of the order of 5s slightly changing from time to time [Feynman et al., 1964]. When studying ground-cloud discharges the charge recovery pattern is usually calculated by the following formula:

$$Ez(t) = Ez1 \cdot \exp\left(-\frac{t}{\tau}\right) + Ez2 \cdot \left(1 - \exp\left(-\frac{t}{\tau}\right)\right)$$

where  $Ez(t)$  – potential gradient of electric field intensity,  $Ez1$  – its value just after a strike,  $Ez2$  – value of the recovered discharge. Numerical values in this formula were determined by the method of least squares with a mean square error [Chalmers, 1974]:

$$Ez(t) = -19.5 \cdot \exp\left(-\frac{t}{17.1}\right) + 69.1 \cdot \left(1 - \exp\left(-\frac{t}{17.1}\right)\right)$$

Thus the charge in a cloud recovered with the typical time of  $\tau = 17$  s.  $Ez1$  corresponds to surface charge density on the ground. If we imagine the cloud-ground system as a condenser than in such a presentation  $\tau$  has a

physical meaning as  $\tau = RC$ , where  $R$  — resistance, and  $C$  – capacitor capacity. Relaxation time  $\tau$  is also determined by ion mobility. Usually its mean value is about 7 s in the regions with high thunderstorm activity [Chalmers, 1974].

Graphs of the measured values and of approximating curve (relaxation curve) are shown in Fig.3. A similar dependence with the same temporal scales was obtained in the model of quasi-stationary electric structure of a thunderstorm cloud based on exact solution of static equation in plane-stratified atmosphere with exponential way of conductivity [Davydenko et al., 2007].

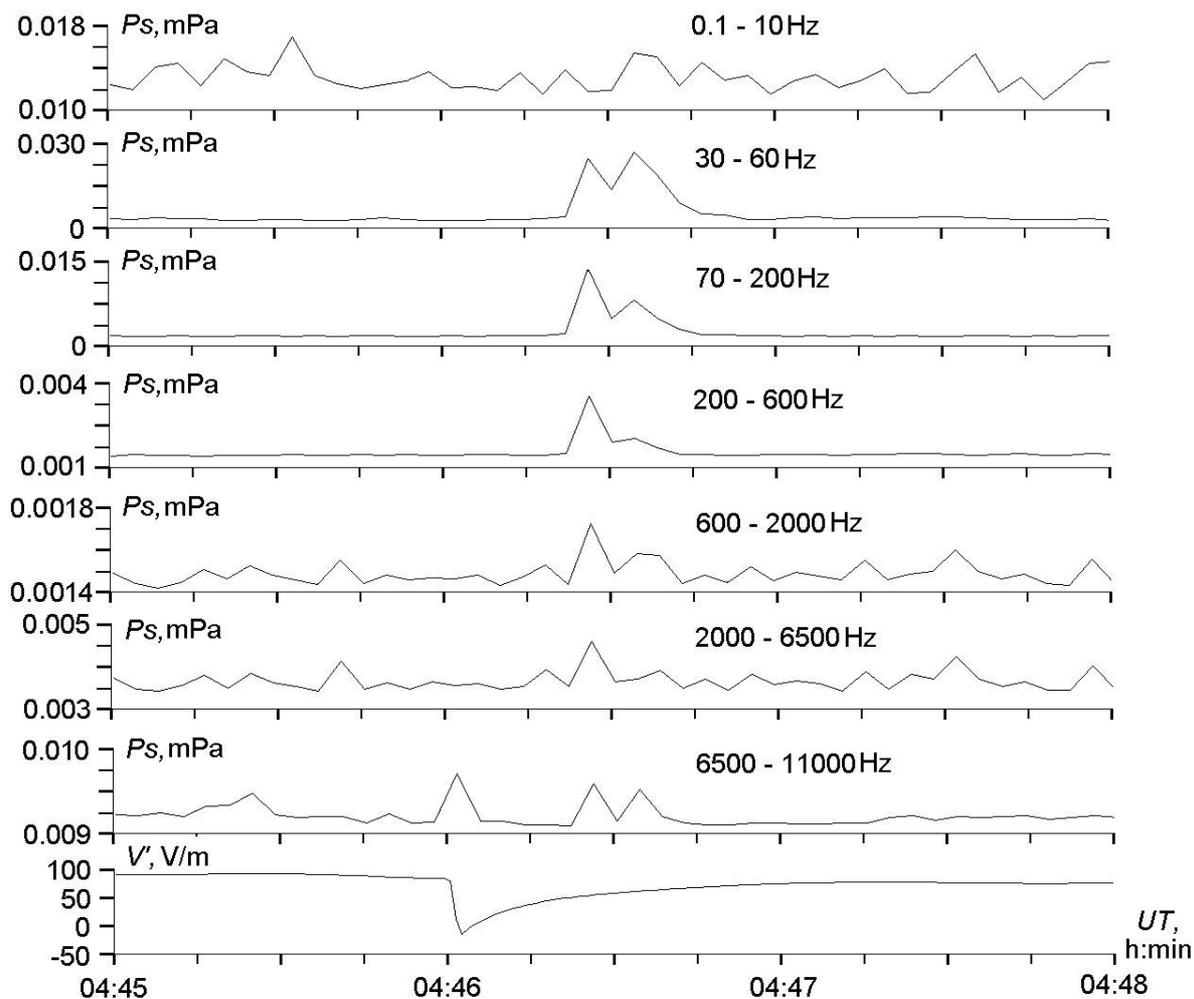


Fig.2. Graphs of acoustic emission at seven frequency ranges and of potential gradient of electric field intensity in the near ground air (in the bottom) during the strike on October 2, 2008

Thus, good correspondence of the model and the observations was received. The fact that the intensity fall, as opposed to the model, occurred not to zero value but to the value -21 V/m indicates a non-nil value of charge surface density.

Simultaneously with the electric field the acoustic emission response on the strike is observed (Fig.2). Signal directly from the strike was registered in the most high frequency range of 6.5 - 11 kHz, and the following sound wave was registered in all the channels. According to 24 s difference of arrival of these signals, considering sound velocity in the air of 330 m/s, the distance to the source was  $\sim 8$  km. Earlier, in the

experiments on loaded pieces of geomaterial it was shown that acoustic emission signals are emitted during electro-effects [Bogomolov et al., 2004]. In this case such an effect was received for the first time in natural conditions under the influence of the strike.

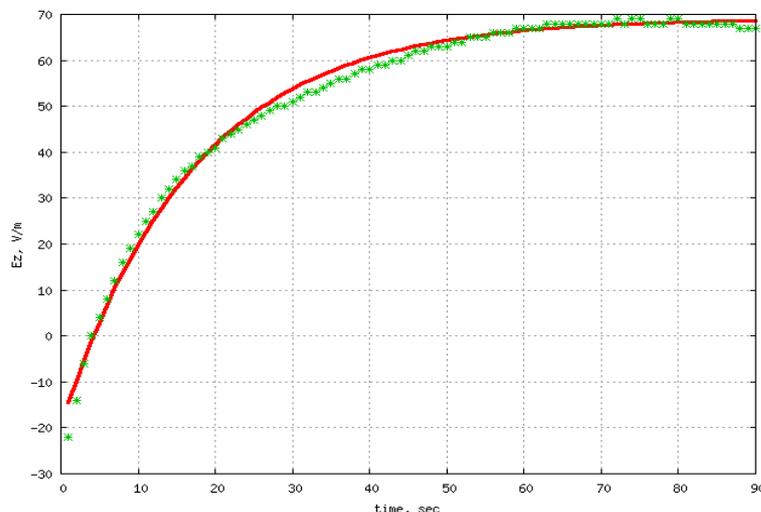


Fig. 3. Graph of field recovery after the strike (dots) and approximation by the formula (2) (line)

#### 4. CONCLUSIONS

In the result of observation of a single strike in the conditions without precipitation the following effects were detected:

1. A sudden fall of potential gradient value of electric field intensity in the air at the height of 3 m from 80 V/m to minus 21 V/m. Then the field recovered its level up to the value 70 V/m with typical time of 17 s. The process of field recovery is approximated by the formula  $E_z(t) = -19.5 \cdot \exp(-t/17.1) + 69.1 \cdot (1 - \exp(-t/17.1))$  with mean square error 0.2. Field intensity of 21 V/m is determined by surface charge density on the ground.

2. 10 s acoustic emission response was registered in the frequency range of 6.5 - 11 kHz.

#### ACKNOWLEDGEMENTS

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