Influence of the convective generator on a daily course of an electrical field intensity

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ABSTRACT: The daily course of a potential gradient of an electrical field intensity in near ground atmosphere in conditions of good weather is investigated. It is shown, that maximum of a daily course of an electrical field on middle latitude observatory Paratunka is connected with morning convection in near ground air a difference of temperatures of air at a surface of ground and at height of 25 m was chosen as the measure of a convective flow. The high correlation of the diagram of temperatures difference at these heights and daily course of intensity of an electrical field is shown.

1.INTRODUCTION

Over the oceans, in Polar Regions, synchronous plain daily variation is observed in fair weather conditions according to the universal time and independent on local time. This daily variation is called unitary variation. But in continental regions the daily variation depends on local time and conditions. In many cases there are two maximums from 7 to 10 and from 19 to 22 of LT. Also in many cases morning maximums disappear in winter month.

Braun in 1936 supposed [Brown, 1936] that the observed maximums are associated with space charge shift due to convection. These maximums are decreased during long-continued wind which prevents space charge convection and during overcast for it prevents ground surface warming which leads to convection decrease. Later many authors related the maximums of local field to convection. Nevertheless some attempts were made to attribute this effect to other processes, for example, to the Sun ultra-violet radiation. That is why the direct arguments for convective mechanism of gradient maximums of electric field intensity are still urgent today.

2. MEASUREMENT TECHNIQUES

The observations were carried out in Kamchatka at “Paratunka” observatory, IKIR FEB RAS, ((λ=158,25°E; φ=52,9°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]. «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 the sampling frequency of 1 s.

Weather parameter control was carried out by digital weather stations WS-2000 and WS-2300. The data are sent to the station via a radio channel at the frequency of 433 MHz. Air temperature sensor is installed at the height of 3 m on the shady side of the administration building. Another one is installed on a tower at the height of 25 m. Weather data sampling rate is 10 minutes.

Registered weather data:

- wind strength;

- wind direction;
- atmospheric pressure;
- air temperature at the height of 3 m;
- air temperature at the height of 25 m;
- air humidity;
- precipitation (in summer).

Air electroconductivity was measured by "Elektroprovodnost-2" which was also developed in the Branch of Geophysical Observatory.

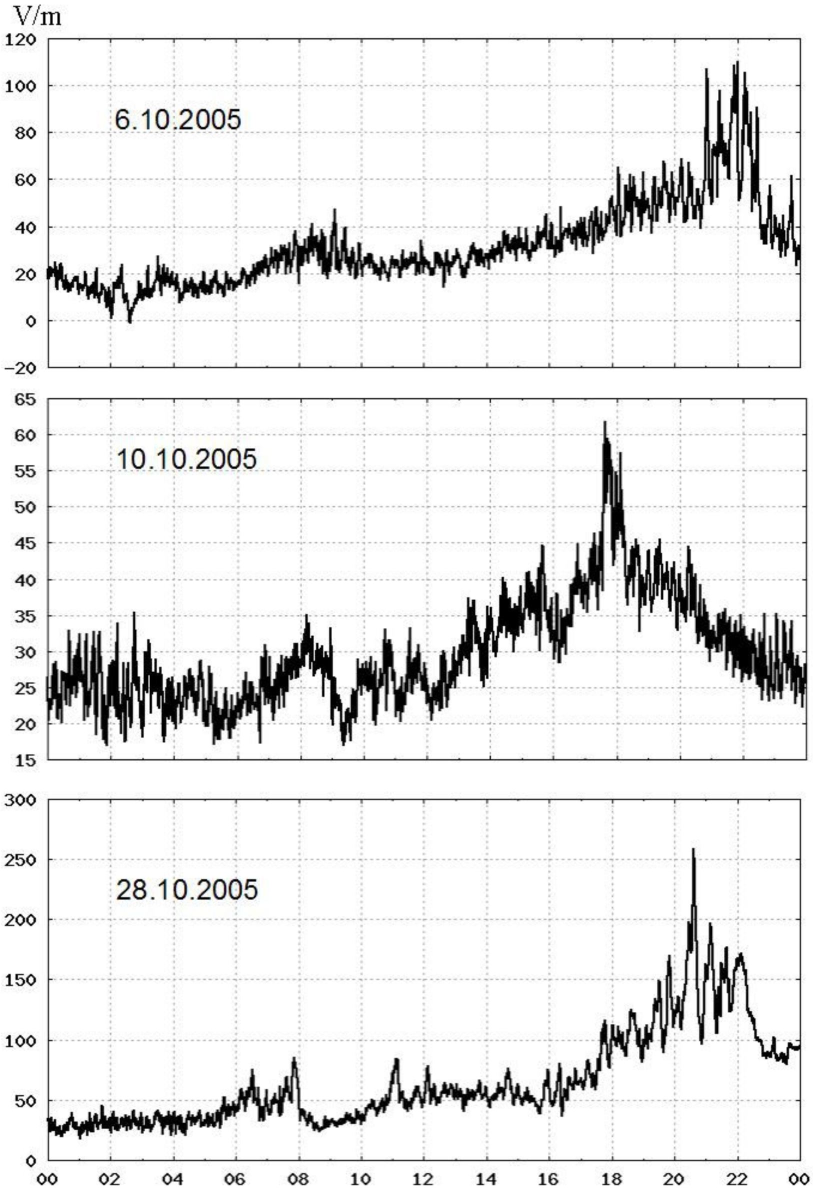

Fig. 1 Daily variation of potential gradient of the electric field intensity on October 6, 10 and 28 2005, UT. LT is UT +13 hours

3. MAIN RESULTS AND DISCUSSION

At "Paratunka" observatory the daily variation of potential gradient of the electric field intensity (Ez) illustrated in Fig.1 is observed in fair weather conditions. Local time at the observatory differs from the universal time by 13 hours in summer and by 12 hour in winter. Daily variation maximum is observed in morning hours LT. Sometimes evening local maximum appears; it is much less in amplitude than the morning one. During active snow melting, from April to the end of May, a clear picture of daily variation is not observed. To study the nature of the morning maximum the daily variation of temperature and potential gradients of the electric field intensity in fair weather conditions were investigated for the period 2005 — 2009. Temperature difference at the height of 25 m and 3 m was considered as temperature gradient. An example of graph comparison of field daily variation with temperature vertical gradient is shown in Fig.2. Good correlation was obtained.

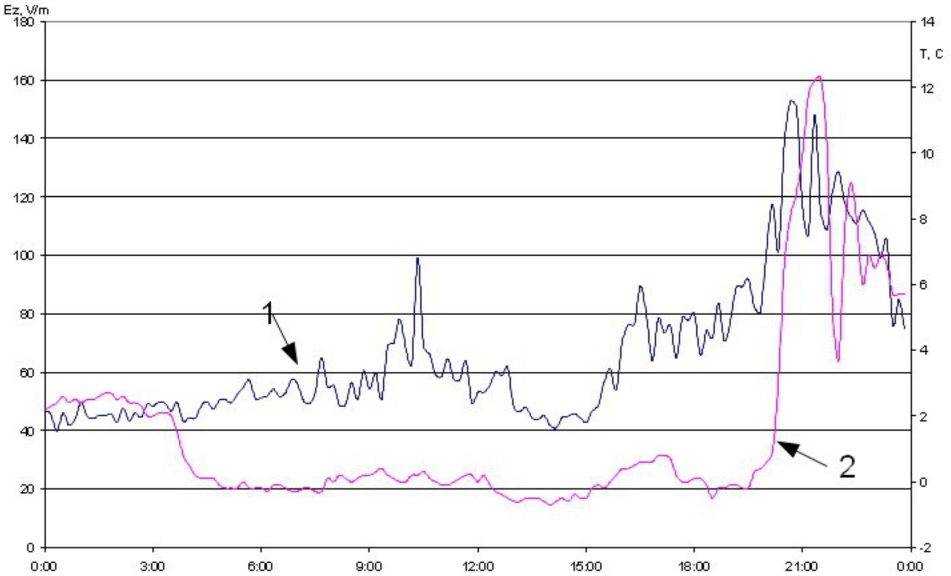

Fig.2 Potential gradient of the electric field intensity, the left scale (1), and air temperature difference at the height of 25 m and 3 m (2), right scale, on November 6, 2007

Similar relative behavior of temperature gradient and of electric field intensity gradient was also observed on other days with fair weather conditions. Field morning maximum at 20-22 UT was always associated with temperature difference maximum. Secondary evening field maximum was weakly related to temperature. Its appearance was more determined by daily variation of electroconductivity.

Electric field daily variation may be presented as composed of three components: $\Delta E = \Delta E_{unit} + \Delta E_{\lambda} + \Delta E_{\rho}$ [Tverskoi, 1949], where:

$$\Delta E_{unit} = \Delta\varphi/R * 1/\lambda \qquad (1)$$

unitary variation, $\Delta\varphi$ – Earth-ionosphere potential difference, R – resistance in the Earth-ionosphere air column, λ – air electroconductivity;

$$\Delta E_{\lambda} = -E/\lambda * \Delta\lambda \qquad (2)$$

variation associated with air conductivity, E – field intensity, λ – air electroconductivity

$$\Delta E_{\rho} = 1/\lambda * \Delta (k*dq/dh) \qquad (3)$$

variation associated with air convection, k – numerical coefficient, dq/dh – heitht space charge separation.

The major contribution to the gradient maximum of electric field intensity at “Paratunka” observatory is made by morning air convection, formula (3), occasionally by electroconductivity variation, formula (2), and unitary variation while sunrise coincides with its maximum, formula (3). The convective mechanism of the morning maximum may be explained by the following. After the sunrise positive ions and space charges gathered by the ground surface begin to rise. When the temperature gradient is high, up to 120C (Fig.2), strong fluctuations of field values and temperature gradient are observed in the maximum. Formation of convective cells is supposed to be the most probable explanation of such fluctuations. At cell borders air movement is in the form of up-flowing and down-flowing currents which transmit the charge.

The evening maximum is determined by electroconductivity variation, formula (2).

The Sun ultra-violet rays, being the main ionizer of the atmosphere at high altitudes, do not have any significant impact in the lower layers of the atmosphere as long as all the rays with short waves, having enough energy to ionize the gases in the atmosphere, are absorbed at high latitudes. Only the rays which can produce merely photoeffect reach the troposphere boundary. In the result of small photoeffect of the rocks on the Earth surface, of water, and of atmospheric suspended particles the ionization is so small that it may be neglected [3].

The importance of measurement of temperature vertical gradient for continuous observations of electric field has not been mentioned up to the present [Guiding Document, 2002]. Even in the recent experiments where convective pattern of the morning maximum was suggested the measurements of temperature vertical gradient were not carried out [Marshall et.al., 1999]. As long as the relation of these values becomes clear in fair weather conditions it is recommended to install air temperature sensor at different heights closely to the measurement complex. In this case we receive the opportunity to normalize the field values to temperature variations. Such measurements are necessary to be included into methodical recommendations.

4. CONCLUSIONS

In the result of processing of the observations over the temperature vertical gradient and electric field intensity gradient in the near surface air at “Paratunka” observatory in 2005-2009 it was obtained that in the daily variation of these values the morning maximum is well observed in fair weather conditions. This maximum in electric field intensity gradient is determined by the convective processes in the near surface air. It is confirmed by temperature vertical gradient daily variation. Occasional evening maximum of the field is determined by air electroconductivity daily variation. A supposition was made that large variations of electric field intensity gradient near the maximum are determined by convective cell formation. It is recommended to complete the major measurements with temperature difference measurements at different heights for continuous observations and expedition work to observe electric field.

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