Atmospheric Electric Field Measurements on the High-Mountain Stations near Elbrus

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ABSTRACT: A long series data of simultaneous monitoring of the atmospheric electric field received near Earth surface on the high-mountains stations near Elbrus has been analyzed. The analysis of surface potential gradient (*V'*) diurnal variation measured at several points during different seasons is presented. The electrode effect influence on the electric field value was investigated on the base of double-level measurements.

INTRODUCTION

The surface potential gradient (*V'*) variations are influenced by global factors and local generators effect in the surface layer, which form the space charge distribution. Turbulent mixing and air ionization rate are the primary factors determined the dynamic of atmospheric surface layer under fair weather conditions. Peculiarities of mid-latitude range PG variations were studied adequately according to the continuous measurements data by geophysical observatory “Borok” [5]. Vertical distributions of surface *V'* were considered on the example of other researches in the continental steppe observation stations [4]. The value of surface layer electric field reflects the condition of continental radioactivity (radon concentration in the atmosphere), content of aerosol, meteorological phenomena. That is why it is important to identify the observation points for solving the problem of global effects extraction on the background of local variability. The alpine stations for measurements of the atmospheric *V'* variations are interesting concerning this problem since they allow to eliminate the anthropogenic component in the electric field generation and are characterized by low level of the surface layer radioactivity.

The pioneer episodic explorations of atmospheric electrical characteristics near Elbrus were undertaken in 1930s and 1950s at Peak Terskol, “Priut-11” and Azau valley. Electric field was monitored at Elbrus stations (Nizhnij Arkhyz, Shadzhatmaz and Peak Cheget) in 1986-1988 [6, 7, 8]. Complex measurements of atmospheric electrical characteristics including *V'*, air polar conductivities, current density, ion production rate and aerosol concentration in the air were fulfilled in 1989-1992 at the Peak Cheget [3]. Analogue atmospheric electric observations were made at Kyzburun station and the Peak Terskol in 2003-2004. Regular measurements of atmospheric electric field at Kyzburun, Peak Cheget and

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Peak Terskol stations have been renewed since 2010.

METHODS

Simultaneous measurements of *V'* were established at the alpine Elbrus stations: Peak Cheget (3040 m above sea level, 43°16' N, 42°30' E), situated on the north slope of Cheget mountain and alpine station Kyzburun (700 m above sea level, 43°40' N, 43°27' E), situated at the beginning of Backsan canyon. The distance between Peak Cheget and Peak Terskol stations is about 3 km along a straight line and 70 km to Kyzburun station.

EFM 550 device by Vaisala was used for PG registration at every measurement points. It selects the values ten times per second. Measurement range is wide enough: from -10000 V/m to 10000 V/m, instrument accuracy is 10%. Sensors were installed on the building roofs at 3.5-4.5 m altitude. The position of sensor above the surface was 1 m. Meteorological parameters were observed simultaneously. The automatic 10-minutes meteorological data registration with Vaisala device was provided at Kyzburun station. Traditional methods were used for three-hours measurements at the Peak Cheget station. The comparative experiment of synchronous measurements of PG at Kyzburun and Peak Cheget was made at two levels: on the ground and on the building roof.

OBSERVATION RESULTS AND DISCUSSION

The data variations of potential gradient (*V'*) under fair weather conditions received during simultaneous data registration in July-August 2012 at two points of Kyzburun and Peak Cheget demonstrate high degree of consistency. The coefficients of pair correlation calculated for different time intervals are given in table 1.

Table 1. Correlation coefficients of *V'* at Peak Cheget and Kyzburun

5 min	10 min	15 min	hour	day
0,22	0,24	0,25	0,43	0,84

The average *V'* values received at Peak Cheget and Kyzburun were 600 V/m and 250 V/m accordingly. Statistical characteristics of *V'* variations in matched points are presented in table 2.

Table 2. Statistical indicators of V' (*V/m*) experimental distributions at the Peak Cheget and Kyzburun

Measurement point	Peak Cheget				Kyzburun			
	winter	spring	summer	autumn	winter	spring	summer	autumn
Average	569	552	659	628	405	272	240	84
Standard error	13	13	12	9	10	5	4	2
Standard deviation	141	181	216	176	156	86	72	42
Min	329	188	206	183	139	30	62	25
Max	973	1152	1410	1166	826	660	461	233

Seasonal variations of the electric field mention that higher values in warm season and lower in cold season are typical for the high-mountain point Peak Cheget. The range of measured values for summer season is wider. The *V'* variation for Kyzburun has a tendency typical for continental stations with maximum during winter and somewhat smaller scale variations.

The diurnal variations of *V'* during summer and winter seasons measured at Peak Cheget and Kyzburun were constructed on the basis of experimental data. Typical diurnal variations of atmospheric surface layer electric field are given in figure 1a, 1b in relative terms (relative to the mean value) for summer and winter seasons.

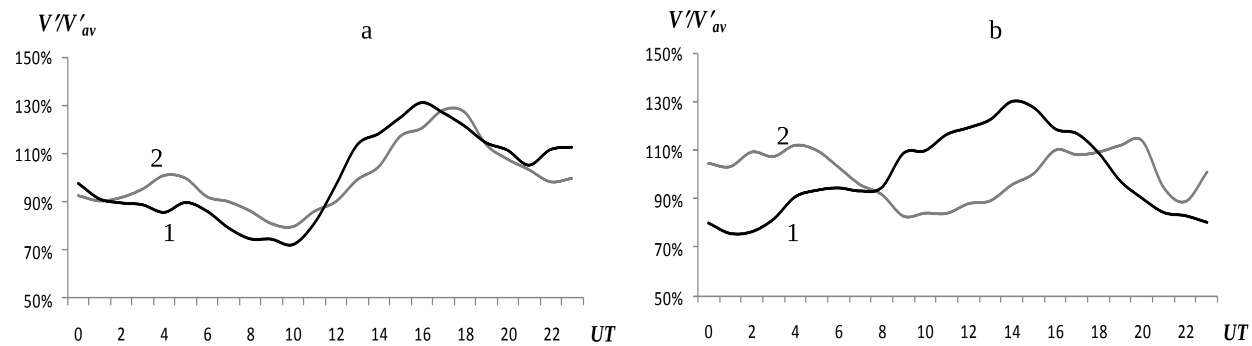

Figure 1. Typical diurnal variations of atmospheric electric field at the Peak Cheget (1) and Kyzburun (2) during summer (a) and winter (b) seasons

As follows from the fig. 1, the summer maximum of PG at Peak Cheget is observed during daytime (local time). It caused by more advanced convection and turbulent diffusion of the atmosphere (effect of convective current generator). Potential gradient values during winter undergone minor changes relative to the mean value. Besides there is wide maximum (09-18 UT), i.e. at day time according to the local time.

Additional maximum is observed for electric field diurnal variation at Kyzburun station in night hours of local time. It is typical for both summer and winter seasons. In the summer season the daily maximum (16–19 UT) has a larger amplitude than in the winter season. Larger amplitude is peculiar for night maximum (03–05 UT) in the winter season. Obtained results are in a good agreement with the results received in the earlier works. Thus the average values of potential gradient received in 1989 and 2003-2004 are slightly different because of different altitudes above the ground of sensors installation [2, 3].

It should be noted that in summer months the diurnal variation of potential gradient is characterized by a distinct evening peak (16-19 UT) and morning minimum (09-12 UT) for both stations. The mean-diurnal PG variations simultaneously obtained at Peak Cheget and Kyzburun during 15th of July to 13th of August 2012 are presented in figure 2. Received mean-diurnal variations of electric field are in a good agreement with Carnegie curve which defines the unitary variation of the ionosphere potential gradient.

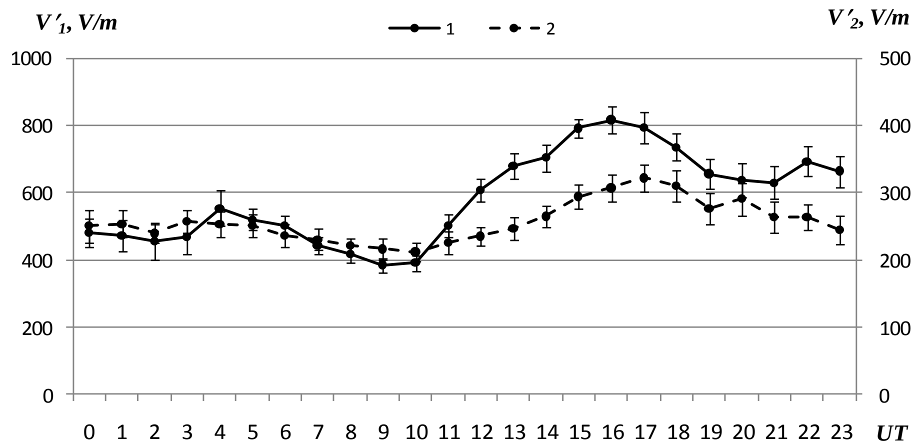

Figure 2. The average daily change in the electric field of the atmosphere received at Peak Cheget (1) and Kyzburun (2); 13.07.12 – 15.08.12

Meteorological conditions of mentioned stations are slightly different by temperature regime and wind speed. The Peak Cheget station is characterized by lower average values of temperature though the difference between night and day values is the same as received at Kyzburun station. The mean values of wind speed at Peak Cheget are somewhat higher in day and evening hours. Mean values of meteorological characteristics (day and night) are given in table 3 for indicated stations.

Table 3. Average day and night values of meteorological characteristics at Peak Cheget and Kyzburun (13.07.2012–15.08.2012)

	atmospheric temperature, °C		wind speed, m/s		relative humidity, %	
	day	night	day	night	day	night
Peak Cheget	12,4	8,5	3,8	2,6	59	76
Kyzburun	24,4	20,3	2,6	2,1	65	76

The experiment to study the influence of electrode effect on the electric field measurements at different heights above the ground was undertaken in August 2012. Simultaneous measurements of potential gradient were made on two levels of surface and building roof at two mentioned points of Peak Cheget and Kyzburun. The coefficient of the electrode effect (*V’* ratio on the roof and on the earth's surface) and the spread of this characteristic relative to average value were calculated on the basis of simultaneous measurements with the following formula:

$$K = \frac{1}{n}\sum_{i=1}^{n}\frac{E_{2i}}{E_{1i}}; \frac{\Delta K}{K} \qquad (1)$$

where E_{1i} and E_{2i} are the mean-hour values of potential gradient on the Earth surface and on the building roof accordingly, *n* is the number of hour series.

Received values of coefficient *K* and its spread for different intervals of the electric field value near the surface are given in Table 4.

Table 4. Values of electrode effect coefficient *K* at Peak Cheget and Kyzburun stations

Peak Cheget (*n=100*)			Kyzburun (*n=50*)		
V′, V/m	K	ΔK/K	V′, V/m	K	ΔK/K
< 100	4,7	31%	< 60	1,8	16%
100 –180	4,0	16%	60 –100	1,6	5%
> 180	3,1	20%	> 100	1,3	25%

Coefficient *K* received by the measurements data of Peak Cheget has higher values and wider spread of the value which is caused by orography of location. The coefficient *K* dependence on the value of measured electric field on the ground level demonstrates its decrease with field increase caused by electrode effect action.

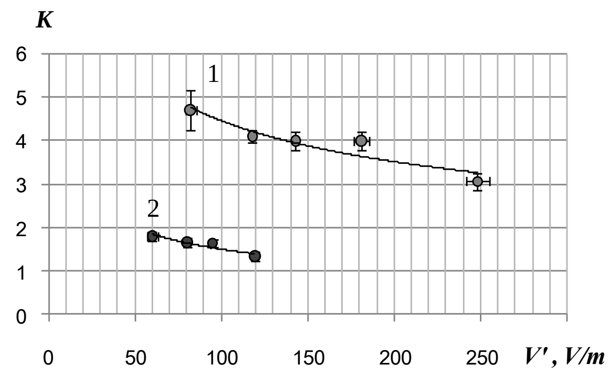

Figure 3. Dependence of the electrode effect coefficient *K* on the V' values on the ground level at Peak Cheget (1) and Kyzburun (2)

Increase of electric field in the atmospheric surface layer leads to increase of the electrode layer thickness and as consequence to reduction of electrode effect coefficient at two heights.

CONCLUSIONS

According to the uninterrupted simultaneous measurement of the surface potential gradient (V') it was received that diurnal variations of electric field received during summer season at high-mountains stations have global component consentient with unitary variation influenced by local (convective) current generator. The dependence of electrode effect on the electric field values should be taking into account for analysis of atmospheric surface layer electric field values.

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