

# **ATMOSPHERIC ELECTRICITY MEASUREMENTS ON A GROUND METEOROLOGICAL NETWORK OF ROSHYDROMET**

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## **ABSTRACT**

Atmospheric electric parameters such as electric field strength and air polar electric conductivity have been continuously monitored on the network of Roshydromet stations since 1950s. Evaluation of the data suggests that the changes of atmospheric electric parameters are caused both industrial emissions of aerosol gases and by emissions of radioactive substances during nuclear tests and the Chernobyl accident.

Now the network works by the uniform technique; the centralized gathering, data processing and their storage in the databank "Atmospheric electricity, ver.1.0" is provided. The device for checking used atmospheric electric sensors is developed and authorized by the Rosstandart, and also methods of carrying out of their control in situ are developed.

In connection with predicted climate changes, a change of atmospheric electric parameters near the earth's surface is probable, therefore the further support of these observations are important. Thus, our intentions consist in the following: development of the atmospheric electricity monitoring network, improvement of measuring instruments for satisfaction of the most actual requirements, maintenance of joint processing and the data analysis in a real mode of time, restoration of the international atmospheric electricity data exchange.

## Introduction

In this report the problem of regular changes within ground layer such values of atmospheric electricity as vertical component of potential gradient  $V'$  of atmosphere electric field and specific positive  $L+$  and negative  $L-$  electric air conductivity observing at the ground-based stations of meteorological Roshydromet network is discussed.

Let us remind that  $V'$  is vector variable and at the fair weather in coordinate system orientated direct up from the earth surface  $V'$  has positive polarity. Describing these measurements in most cases will be used value of summarized specific electrical air conductivity  $L$ .

## Historical overview

The first measurements  $V'$  seems to be taken in Russia as long ago as at the close of the twentieth century at Konstantinovskaya observatory near St.-Petersburg in Pavlovsk city. In 1916 there was founded by Prof. V.N. Obolensky the first-rate atmospheric electrical station equipped also with measuring devices for  $V'$ ,  $L+$  and  $L-$  Just since that time the regular measurements of  $V'$ ,  $L+$  and  $L-$  in Russia have been started. At that time the main purpose of measurement was exploration of atmospheric electrical field nature. It was considered, that new obtained information about changeability of this field as well as relation of field characteristics to other environment characteristics creates a base to solve this complicated problem and enriches meteorology with use of data about surface layer atmospheric electricity.

Later on, under the direction of Prof. P.N. Tverskoy these measurements have been taken at many points in USSR. Analyzing measurements results it was obtained dependence of surface atmospheric electricity value on air mass formation, radioactivity, dust and aerosol content. Also some links with meteorological phenomena were discover. After World War II atmospheric electricity observation was resumed already at the new place in the village Voeikovo at the scientific experimental base of Main Geophysical Observatory (MGO). These observations continue until now.

During The International Geophysical Year (IGY) in 1958 the world-wide network of ground-based observations of atmospheric electricity was created. In USSR these measurements were carried out at nine stations (see Table). The purpose of these measurements has rather changed in comparison with the first ideas of Prof. V.N.Obolensky and Prof. P.N.Tverskoy because from analysis of observation results gathered during past years it got clear, that measurements data of  $L+$  and  $L-$  from a few ground stations were not enough to investigate the nature of atmospheric electrical field. It was assumed, that this problem could be solved by means of simultaneous measurements  $V'$  at many stations, situated all over the earth, as well as measurements of  $V'$  in free atmosphere. They also intended to clear up, how comparable are the measurements results of

L+ and L- at different stations and whether they reflect the air pollution. The collection and publishing of network data were carried out by MGO, where was especially founded The World Center of Atmospheric Electricity Data.

**Table**

**List of USSR stations where surface atmospheric electrical measurements were carried out**

Station	Coordinates	Parameters	Period of measurements
Voeikovo (Leningrad-SPb)*	60.8N 30.6E	V', L+, L-	from 1947 until now
Verkhnee Dubrovo (Yekaterinburg)	56.7N 60.8E	V', L+, L-	from 1957 until now
Irkutsk	52.3N 104.4E	V', L+, L-	from 1958 until now
Yzshno-Sakhalinsk	46.9N 142.7E	V', L+, L-	from 1958 until now
Odessa	46.5N 30.6E	V', L+, L-	from 1957 to 1994
Dusheti (Tbilisi)	42.1N 44.6E	V', L+, L-	from 1957 to 1990
Murmansk	69.0N 33.0E	V'	from 1957 to 1970
Tashkent*	41.3N 69.3E	V'	from 1960 to 1995
Borispol' (Kiev)*	50.5N 30.5E	V'	from 1957 to 1968

\* - places of regular aircraft measurements in the 1960s

After IGY the measurements were continued during The Year of the Quiet Sun. And then the measurements at many stations were stopped. At the suggestion of scientists from Main Geophysical Observatory (MGO) supporting by International Commission of atmospheric electricity the administration of USSR Hydro Meteorological Service permitted to continue measurements of V', L+ and L- at the stations, mentioned above in the Table.

In seventies of the twentieth century the tasks for observation network were finally formed: it should collect operating data of atmospheric electrical condition in surface layer to provide information, which allows controlling of changing of this condition, including man's impact. This aim to a certain extent was achieved and the tasks were fulfilled.

## Instrumentation and technique of measurements

In the network were used different devices for measuring V' – from radioactive collector up to rotary electrostatic fluxmeter “Pole-2”, and different devices for measuring L+, L- – from Allik’s system unit up to device “Electroprovodnost’-2” with built-in measuring control block.

All over the time of measuring was made efforts to approach general technique to the method and technique of gathering and operating of these measurements to the method accepted by basic ground-based meteorological network of Roshydromet.

Developed measuring devices “Pole-2” and “Electroprovodnost’-2” as well as calibrator for measuring device of electrostatic field strength have satisfied these requirements in many respects. Last years this calibrator was improved and entered in the list of measuring devices of Rosstandart by name The Calibrator of Electrostatic Field Strength. In the eighties the original

measuring control technique for measuring devices of electrical air conductivity was developed. Respective control device was built in measuring device "Electroprovodnost'-2".

Network handling bases on the documents regulating general technique of data gathering and processing. Since network establishment act three such basic documents:

- Instruction for ground-based observation of atmospheric electricity elements (Leningrad, 1960);
- RD 52.04.168 – 88. Methodic directions. Observation of atmospheric electricity at the ground-based meteorological network stations. (Leningrad, MGO, 1989);
- RD 52.04.168 – 2001. Methodic directions. Atmospheric electricity observation. (St.-Petersburg, Hydrometeopublishing, 2002);

In spite of different functional layout measuring devices "Pole-2" and "Electroprovodnost'-2" have identical construction principle. Outside is placed the sensor with signal power amplifier, which allows signal transmitting with cable into the room. Inside the room is placed the central block, which allows managing of measure and control processes. It transmits signal in analog type for recording on standard detector or PC for storage and processing operation.

Treatment system of these measurements provided for obtaining of hour average values  $V'$ ,  $L+$  and  $L-$  with separating of values measured in good weather conditions, when  $0 < V' \leq 500$  V/m, there is no low cloudiness and its general number is within 3 points, no meteorological phenomena when hydrometeors appear. Also the system of data archiving for atmospheric electricity in special file format accepted by Roshydromet for all types of meteorological and physical information was developed.

For operating with data bases was developed software "Atmospheric Electricity Databank" which allows carrying out statistical treatment and compare data of different periods, different regions depending on different meteorological parameters.

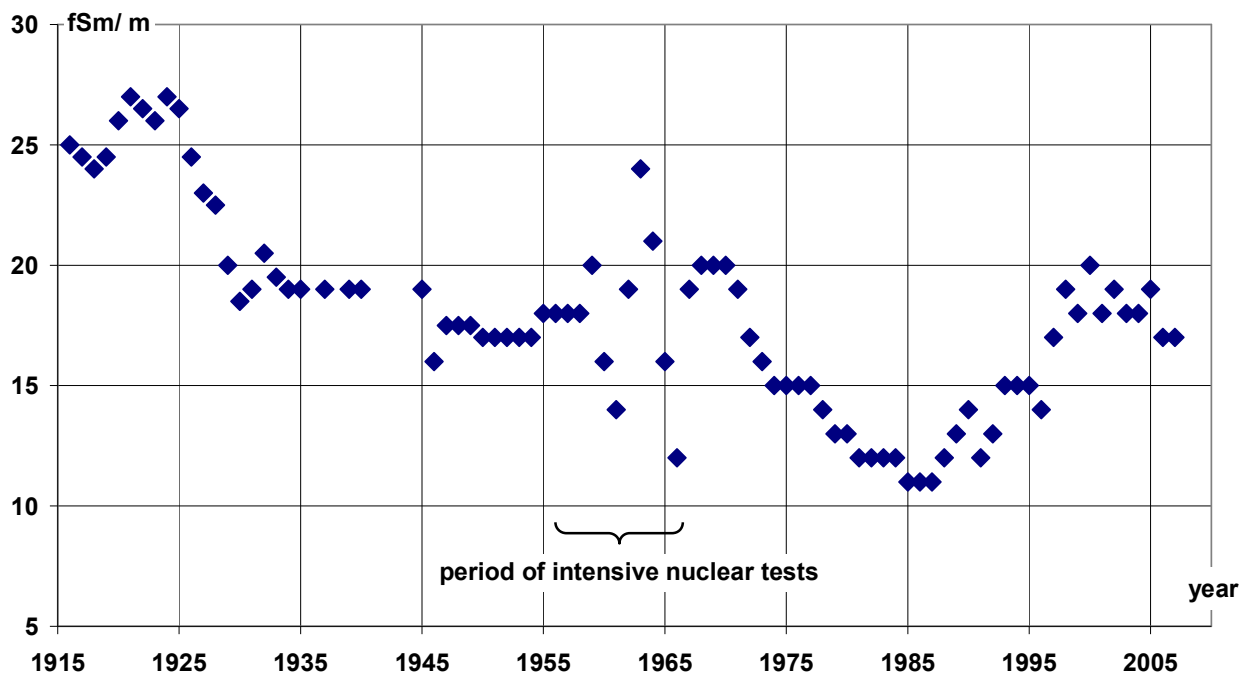
The obtained in atmospheric electrical network data are published in annual reviews "The background environment condition review in Commonwealth of Independent States countries" and "Environment pollution review in Russian Federation".

## **Some results of long-term AE network measurements**

The research results of long-term measurements  $V'$ ,  $L+$  and  $L-$  as well as relation between these electrical characteristics and characteristics of background atmosphere pollution were published [Khlebnikova a.o., 1996, Klimin, Shvarts, 1996]. It was discovered the long-term decrease tendency for  $L$  at the points of measuring  $L+$  and  $L-$  being observed during many years of twentieth century and these data were presented. Also significant role of the smallest aerosol

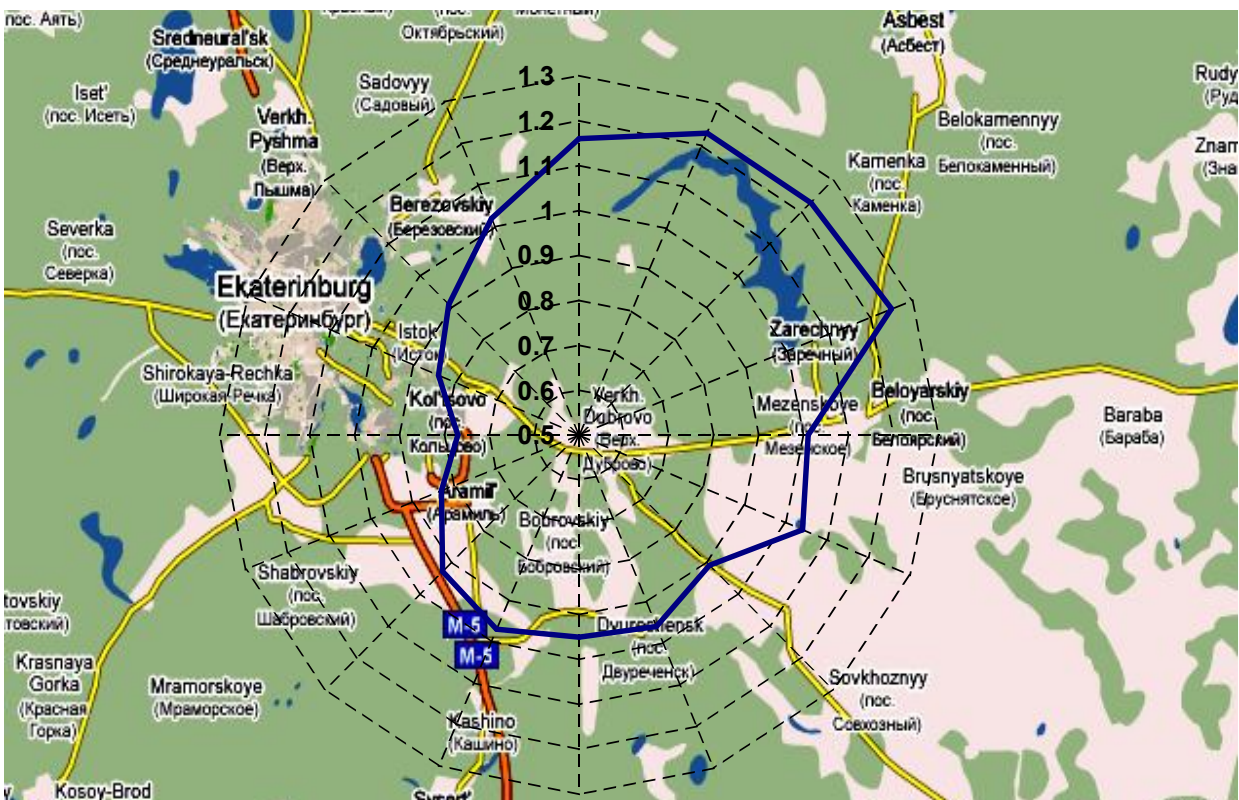
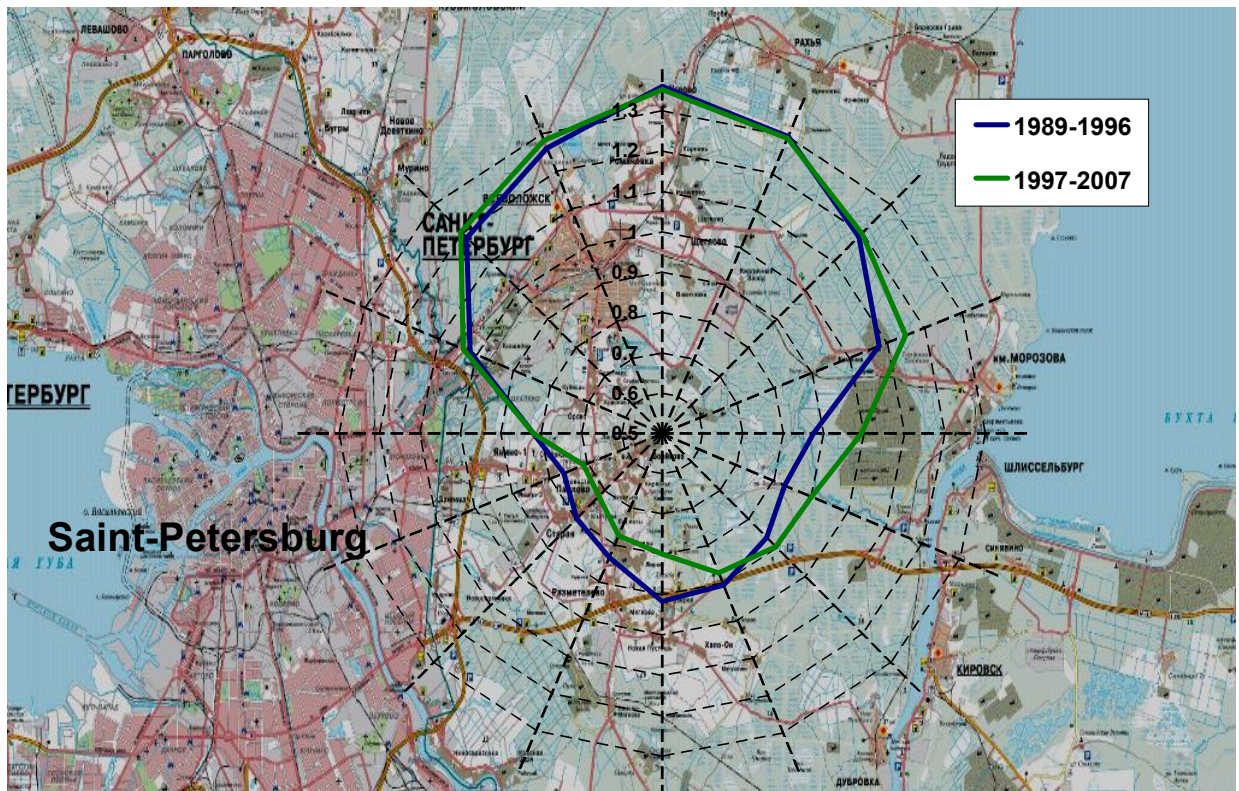
particles in electrical condition formation in atmosphere surface layer was discovered. Relation between L+ and L- characteristics and some background characteristics of atmosphere pollution was found.

Fig.1 shows secular change of annual average L values based on long-term measurements in outskirts of Petrograd – Leningrad – St.-Petersburg. One could see that in the period of intensive nuclear tests (in the 1950s and the early 1960s) the negative trend of series was disturbed. There were many reports about drastic increase of air electrical conductivity in many locations where these measurements were carried out in this period. Then in the beginning of the 1970s the trend was resume, but later it was change into positive trend after about 1985. The reason of this change can be consist in decrease of industrial activity during economic recession in our country. In last decade a certain negative tendency is observed again and it could confirm a strong relation between L and aerosol air pollution due to increase of transport intensity in resent years. However a more confident assertion can be make after a longer period of measurements only.



**Fig.1 Secular change of air electrical conductivity L near Petrograd – Leningrad – Saint-Petersburg**

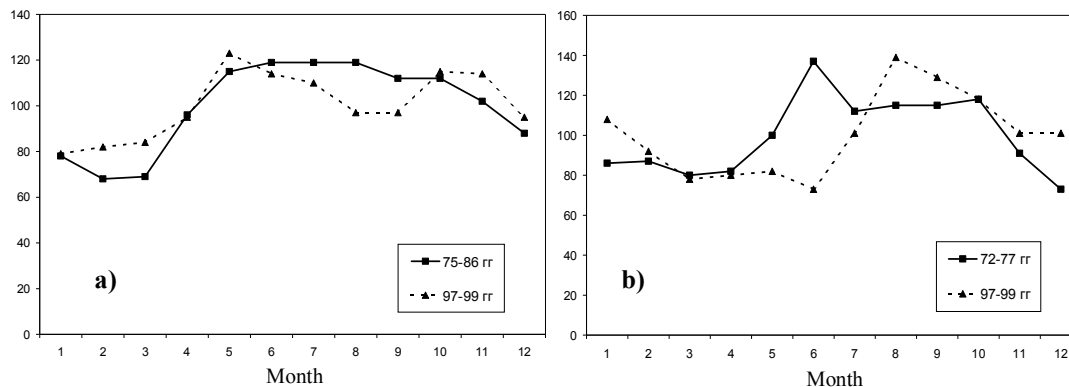
Irregular L distribution upon wind directions what in our opinion seems to be associated with income of having different pollution air masses is shown in Fig.2. This example uses measurements data obtained in Voeikovo and Verhneye Dubrovo. But the same results are obtained also at other observation points in USSR.



**Fig.2** Dependence of relative air electrical conductivity on wind direction near Saint-Petersburg (upper fig) and Yekaterinburg (lower fig).

Also the change of seasonal motion  $L$  during last ten years in comparison with prior measurements periods was discovered (see Fig.3). One could see that in 1998-1999 (as well as in the next years) the part of winter values  $L$  into annual average  $L$  has increased. But it is possible by decrease of aerosol-formative gases emission following to gathering of the smallest aerosol

particles within surface layer during winter inversion. In the last years as a powerful source of aerosol-formative gases is motor transport, which motion activity increases in summer. This effect is noticeable both in Voeikovo and in Irkutsk. Instead of classical continental annual motion L with winter minimum and summer maximum appeared specific dip in summer and autumn months.



**Fig.3 Comparison of average annual motion L in Voeikovo (a) and in Irkutsk (b) during different terms. Relative values L, given in diagrams, are average monthly values L, divided by average annual values and multiplied by 100.**

## Conclusion

In view of predicted impending climate change as well as restoration of industrial potential in Russian Federation a change of atmospheric electric parameters near the earth's surface is probable. In this connection our purposes are as follows:

- to keep network of measurements points of  $V'$ ,  $L+$  and  $L-$  in the same size;
- to improve the network measuring instruments of  $V'$ ,  $L+$  and  $L-$  in accordance with new abilities and ideas;
- to provide co-operation in handling and analysis of meteorological and atmospheric electrical data observations in real-time mode;
- to restore international data communication of atmospheric electricity in surface layer.

In authors' opinion it can be useful to include the measurements of air electrical conductivity, as a sensitive air mass qualifier, in Background Air Pollution Monitoring Network (BAPMoN) either at the stage of planning a new station place or on functioning stations to make a selection and analysis of obtained results of basic monitoring elements.

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