NEW TYPES OF GROUND-BASED AND AIRBORNE MEASURING TOOLS FOR ATMOSPHERIC ELECTRICITY

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ABSTRACT

In order to provide the information about the electrical state of atmosphere the specialized tools to measure strength of electrostatic field and air electrical conductivity are developed. In different modifications these tools are designed to install on stations of observation network and to equip the aircraft-laboratory applied for environmental research.

Designed tools have the following features: wide measuring range, low noise, digital data interface, resistance to precipitations and extreme temperatures. For calibration purpose and verification the standardized reference instruments are used.

On the basis of the developed tools the long-term monitoring of the bounding-level electrical state of atmosphere and regular similar investigating in troposphere (including clouds electricity) could be performed.

The purpose of atmospheric electricity measurements

The atmospheric electricity state could be described by follows basic quantities: the strength of electrical field, air electrical conductivity, ions spectrum, electrical current density and volume electrical charge density. Additional parameters are charge of precipitations and ionisation rate. Also, in the case of vertical sounding, one can achieve the profiles of these quantities plus ionosphere potential and electrical parameters of clouds.

These parameters characterize the global electricity circuit (GEC) that also include global thunderstorm activity and electrical processes in near space. There are relations between GEC and other atmosphere parameters – aerosol pollution, radioactivity contamination and so on. A contrary hypothesis about the influence of atmospheric electricity on climate through via the ion-assisted formation of ultrafine aerosol was made by R.G. Harrison (2004).

To verify this hypothesis the regular measurements of atmospheric electricity quantities in the surface layer and the troposphere are required. In Russia the atmospheric electricity observations on small ground-based network that now consists of five stations has been performed from 1950s. Similar airborne investigates has been regularly implemented in 1960-1980s. In the most cases only the strength of electrical field ***E*** and air electrical conductivity ***L*** were measured because of relatively low complexity of applied measuring tools.

In the last years Rosgydromet carried out two programs that involve the technical upgrading of ground-based observations and equipment the aircraft-laboratory applied for environmental research including electrical parameters of troposphere and clouds. The implementation of these programs required the new types of automated measuring tools development and our achievements in this field are the subjects of presenting paper.

Ground based measuring tools

The modernized tools for measuring the ***E*** and ***L*** parameters in the surface layer are shown in figures 1 and 2. These tools include outdoor sensors and indoor units that provide the voltage conversion, data displaying and digital interface for data acquisition (interface unit). The sensor of ***E*** is an electrostatic fluxmeter, the sensor of ***L*** based on Gerdien measurement principle.

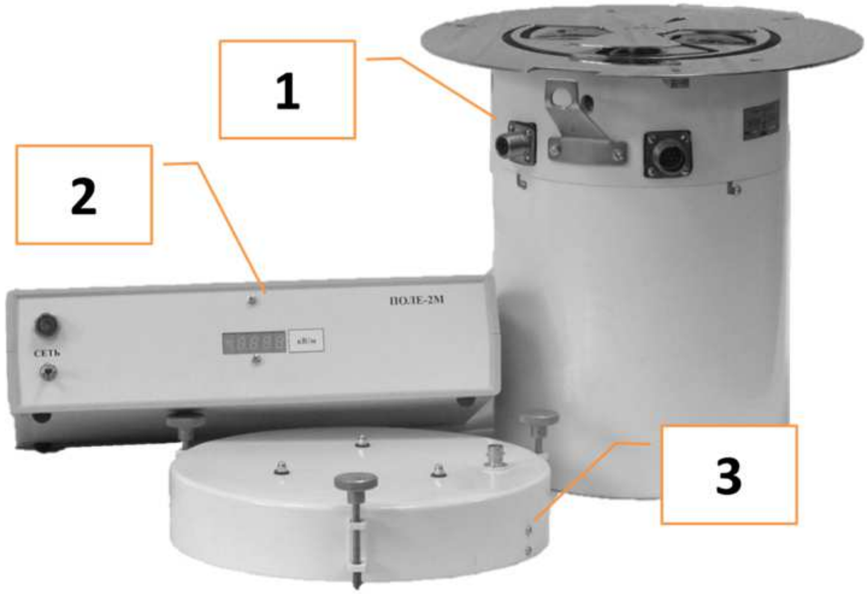

Figure 1. Atmosphere electrical field strength measuring tool.

1 – sensor (electrostatic fluxmeter); 2 – interface unit;

3 – scale testing unit (cap with mounted isolated plate).

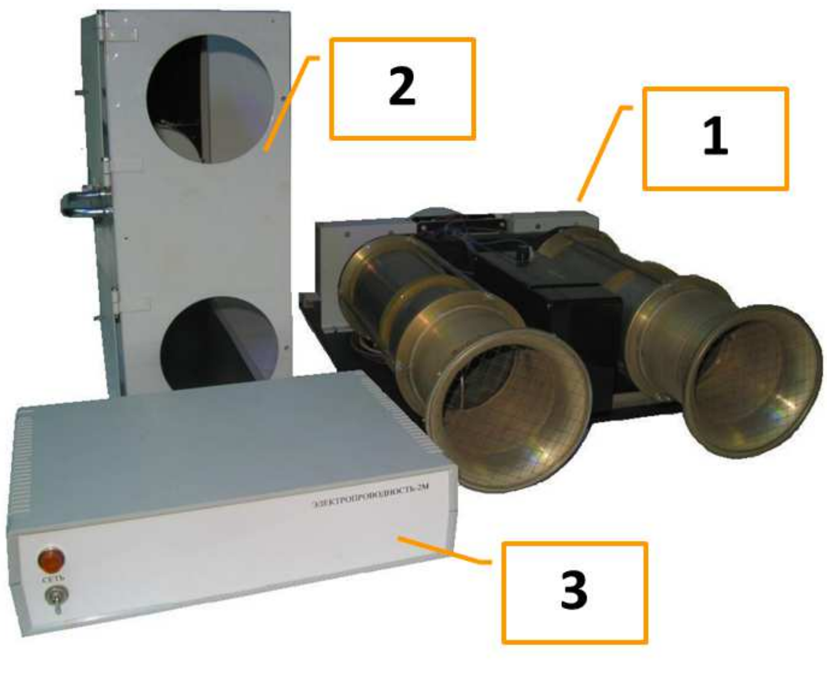

Figure 2. Air electrical conductivity measuring tool (Gerdien tube).

1 – sensor (two aspiration tubes); 2 – case; 3 – interface unit.

The installation of outdoor sensors in the place of long-term observations is shown in the figure 3. A fluxmeter is mounted in the centre of metallic grid that flattens out a local electrical field but also produces some measuring error, removed at the data processing stage. An air electrical conductivity sensor usually is mounted on a building wall at the height above 2 meters.

Interface units of both measuring tools are plugged to PC that is running proprietary data acquisition software. Data collection from the observation network is carried out via the Internet.

Figure 3. The ground-based sensors installation example.

Airborne measuring tools

For the purpose of aircraft-laboratory equipment the similar ***E*** and ***L*** measuring tools were developed. The main feature of aircraft tools is the extended measuring range. The sensors design provides their mounting on aircraft fuselage. Also in contrast to ground-based gerdien sensor the aircraft one hasn't fun and the intake of air is performed only during the flight.

There are six sensors of ***E*** installed on aircraft – four of them in the nose section of the aircraft are pairwise symmetric (left-right pair and top-bottom pair), and two in tail section. In the figure 4 the right fluxmeter and gerdien sensor installation are shown and in figure 5 the places of three fluxmeters are marked. This design provides the measuring of all three components of ***E***-vector. Also special flight program to obtain electrical field deformation coefficients for each sensor at the place of its installation are developed (Mikhailovsky, 2000).

Figure 4. The aircraft sensors installation.

Figure 5. Locations of three fluxmeters are marked by rings.

The data acquisition software is integrated in aircraft local network that provide post-flight complex data processing. As an example of measuring results in the figure 6 the flight altitude dependence of air electrical conductivity (both positive and negative) is presented. These data and slight excess of negative values agree with results of others studies (see Chalmers, 1967).

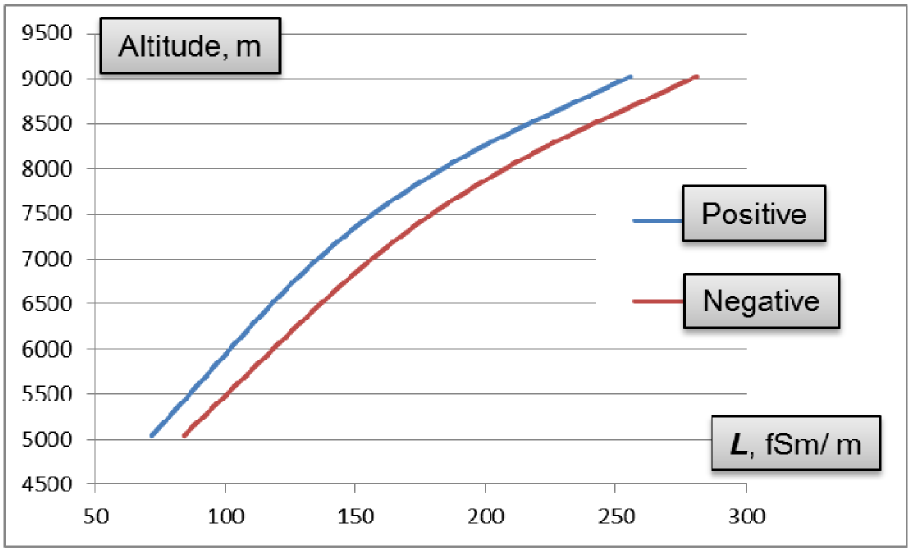

Figure 6. The altitude dependence of air electrical conductivity (flight at 2013-11-12)

Calibration equipment

In order to provide the metrological basis of atmospheric electricity measurements the development of calibration tools and methods also has been designed. All measuring tools are equipped built-in testing circuits that allow performing the check of sensor scale. For purpose of primary calibration of measuring tools the certified calibrators are used.

In the figure 7 the electrical field strength calibrator is shown. Its design is similar to the parallel-plate capacitor with guarding rings for eliminating the edge effect. This calibrator allows generate the ***E*** values in range of ±5000 kV/m. Further fluxmeter scale testing in the field is performed using the special cup (see figure 1).

Figure 7. Electrical field strength calibrator (on background)

and state certificate of correspondence (foreground).

Unlike the electrical field strength calibrator the standard of air electrical conductivity is quite complex tool. We use the State Primary Standard of the units of volume charge density of ionized air and number density of air ions (GET 177-2010) that was developed by VNIIFTRI – the leading standardization institute in Russian Federation (http://www.vniiftri.ru/index.php/en/etalons). The core of this standard is the set of radioactivity probes each of that produce the air ionization rate of some value. The calibration of ***L*** measuring tool is based on its readings comparison with standard gerdien sensor.

Conclusion

Presented measuring tools can be used in wide range of atmospheric electricity monitoring programs. In connection with predicted climate changes, a change of atmospheric electric parameters near the earth's surface and in troposphere is probable. Therefore the regular monitoring of GEC parameters is actual task.

References

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