Database of Borok Geophysical Observatory as information resource for global electrical circuit researches

Sergey Anisimov, Konstantin Aphinogenov, Aleksey Guriev, Eldar Dmitriev*, Alexander Prokhorchuk

Borok Geophysical Observatory IPE RAS, Borok, Yaroslavl, RF

ABSTRACT: Databases of continuous natural observations are the most important experimental basis of geophysical researches. To study the processes in the global electric circuit one needs to use complex databases of the continuous observations of air-electric, air-physical, meteorological and geophysical fields, forming an Earth's electromagnetic environment. One of such complex databases is the database of middle-latitude Borok Geophysical Observatory of Schmidt Institute of Physics of the Earth of Russian Academy of Sciences. Borok Geophysical Observatory is the unique middle-latitude geophysical observatory in the European part of Russia making continuous geophysical and meteorological measurements under conditions of "geoelectromagnetic preservation area". Founded like a geomagnetic station the observatory actually carries out continuous geomagnetic observations as well as continuous measurements of air electric field, atmosphere electric current, telluric currents, variations of atmospheric pressure. Now the observatory measurement complex includes a sodar (acoustic radar) to observe wind velocity altitude profiles, an ultrasound meteorological complex to provide high sensitive meteorological measurements, a radon station and a radon monitor to measure volume activity of radon (main ionization source in the surface atmosphere). The observation data from data logging systems via local access network come to the observatory database server provided data processing and accessing. The observatory database is transformed to the web-resource on atmospheric electricity and geomagnetism. Low level of industrial pollutions in Borok, as well as complex presentation of air electrical, geophysical and meteorological data, turns the web-resource into the good experimental background to investigate the natural atmosphere electric processes.

INTRODUCTION

Databases of continuous natural observations are the most important experimental basis of geophysical researches. Nature of the processes in the global electric circuit makes necessary to use complex databases of the continuous observations at its studying. The databases have to contain results of measurements of air-electric, air-physical, meteorological and geophysical fields, forming an Earth's electromagnetic environment. One of such complex databases is the database of middle-latitude Borok Geophysical Observatory of Schmidt Institute of Physics of the Earth of Russian Academy of Sciences.

Borok Geophysical Observatory [58° 04' N; 38° 14' E] is located on the coast of the Rybinsk artificial sea [58°04´N, 38°14´E] under low level of man-made electromagnetic and natural seismic noise, far from sources of any industrial pollution. Founded like a geomagnetic station Borok Geophysical Observatory

* Contact information: Eldar Dmitriev, Borok Geophysical Observatory IPE RAS, Borok, Yaroslavl, RF, Email: eldar@borok.yar.ru

actually carries out continuous geomagnetic observations, including ultralow frequency (ULF) pulsations, variations (in the SAMNET network) and main components (in the INTERMAGNET network) of geomagnetic field [Chulliat and Anisimov, 2008]. Now Borok Geophysical Observatory monitors not only geomagnetic field but also a set of air electrical, meteorological and geophysical parameters. The data logging local access network and the database provide access to the near real time measurement data.

THE MEASUREMENT COMPLEX OF BOROK GEOPHYSICAL OBSERVATORY

The observatory is located far away from sources of electromagnetic and aerosol pollutions. The measurements are made under low level of electromagnetic and seismic noise. Now the observatory measuring equipment provides geomagnetic measurements as well as air-physical measurements. The measurement complex of Borok Geophysical Observatory [Anisimov et al., 2008] comprises many facilities including digital measurement equipment and analogue sensors (Fig. 1).

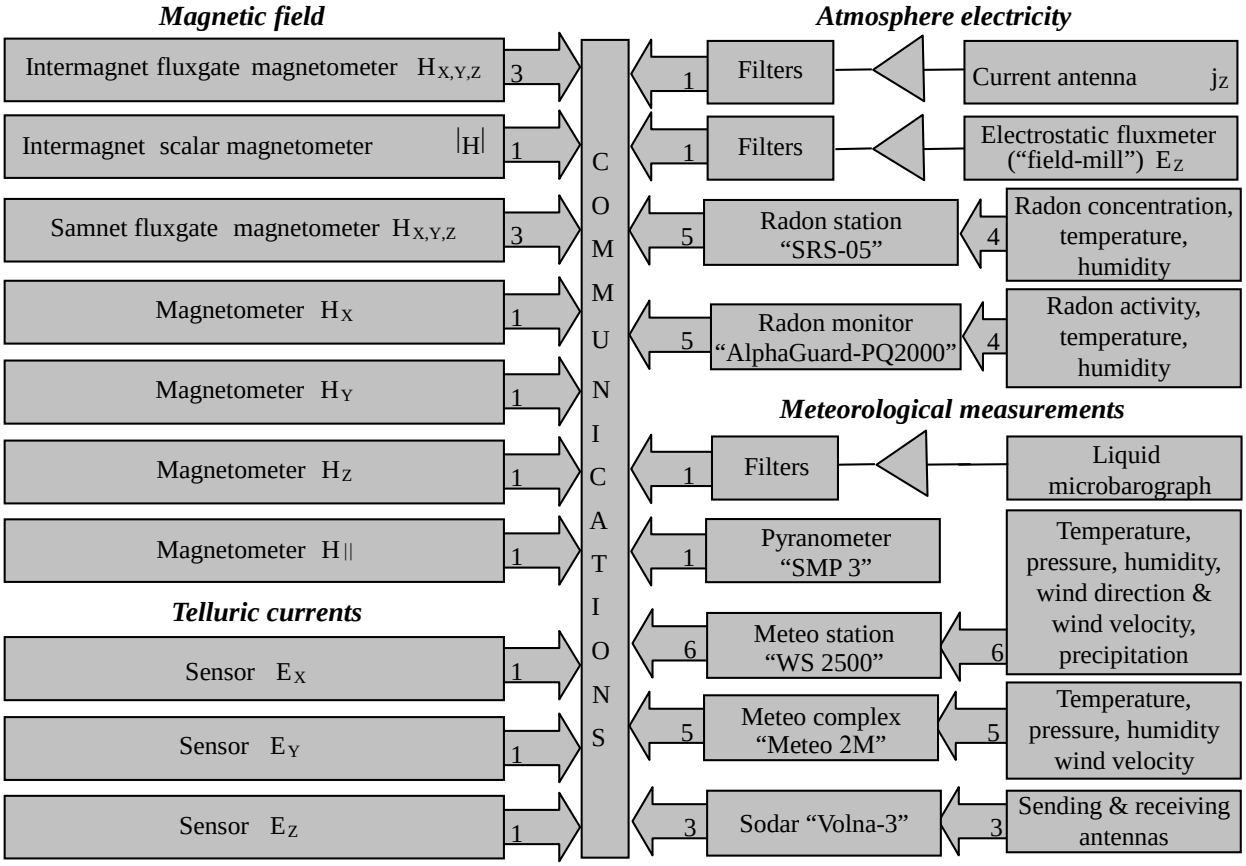

Figure 1. The measurement complex of Borok Geophysical Observatory.

The analogue sensors for air electrical and meteorological measurements are

- the "current collector" type antenna (the sensitivity is about 10^{-13}A/m^2, the dynamic range is $10^{-13} – 10^{-9}$A/m^2) to measure vertical air electric current density;
- the "field mill" type electrostatic fluxmeter (the dynamic range for DC electric field is ~80dB, the noise is 0.1 V/Hz$^{1/2}$) to measure vertical air electric field intensity;

- the liquid microbarograph (the sensitivity is ~150mV/Pa) to measure infrasound pressure variations;
- the pyranometer “CMP-3” (the light spectrum waveband is 310 – 2800 nm, the sensitivity is 5 – 20 μV/W/m²) to measure solar radiation flux density.

All signals from the analog sensors are collected and digitized by the main data logging system. The digital equipment for air electrical and meteorological measurements are

- the radon monitor “AlphaGuard PQ2000” (the measurement range is $2 – 2 \cdot 10^6$ Bq/m^3) to measure radon gas (^{222}Rn) volumetric activities in air;
- the radon station “SRS-05” type (the measurement range is $20 – 5 \cdot 10^4$ Bq/m^3, the sample period is 30 min) to measure radon (^{222}Rn) and thoron (^{220}Rn) volumetric activities in near ground air;
- the meteorological station “WS-2500” to measure temperature, pressure, humidity, precipitation, horizontal wind velocity and wind direction;
- the ultrasound meteorological complex “Meteo-2M” to measure air temperature, pressure, humidity, three components of wind velocity with sample rate of ~10 Hz;
- the sodar (acoustic radar) “Volna-3” to observe wind velocity altitude profiles up to 300 – 800 m with sample period of ~16 s.

All data from digital measurement equipment are collected by the special data logging systems. The measuring equipment software provides the data visualization and storage to the hard disk.

BOROK GEOPHYSICAL OBSERVATORY DATABASE

The logging of observation data and database uploading in near real time mode are carried out via the data logging local access network (Fig. 2).

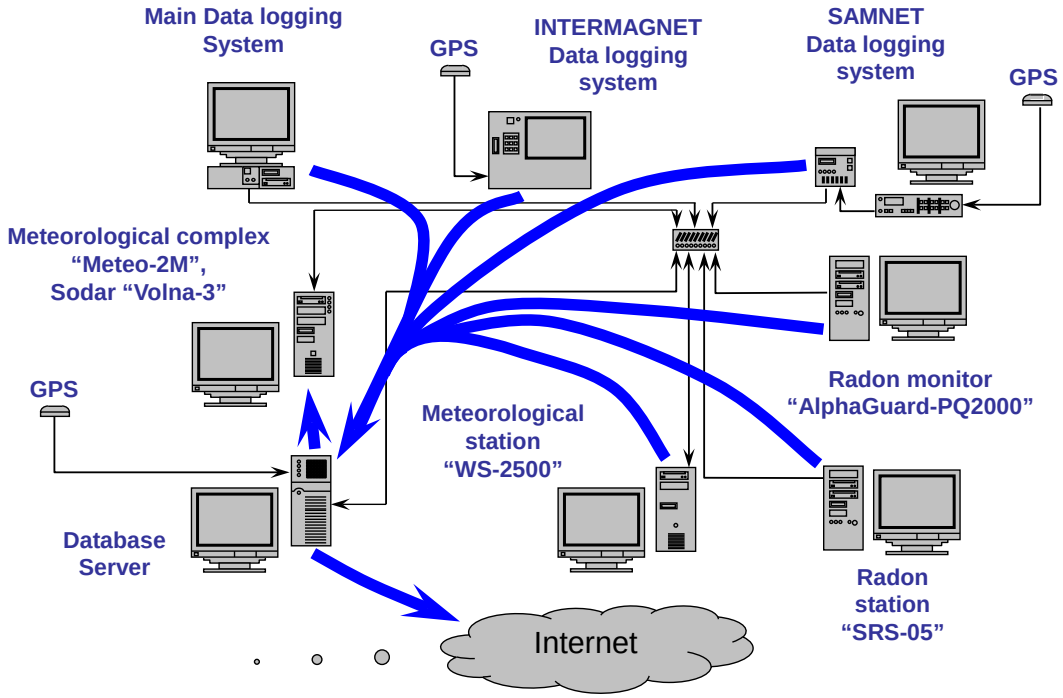

Figure 2. The data logging local access network of Borok Geophysical Observatory.

The data logging local access network includes the main data logging system, the database server and the data logging systems of digital measurement equipment. Time synchronization of all data logging systems provides by the time server installed on the database server with build-in global position system (GPS). The observation data from data logging systems via local access network come to the database server. The volume of raw data coming to the database every day is about 130 MB.

The main data logging system of measuring complex of Borok Geophysical Observatory provides logging the data from all recording analog equipment. The sampling rate of the main data logging system is 10 Hz. The storage of raw data files on the hard disk of the main data logging system prevents the data loss caused by possible failures of a local access network. The transfer of raw data files from the hard disk buffer directory to the database server via the data logging network is carried out each hour. The part of the database structure connecting to the main data logging system is presented on Figure 3.

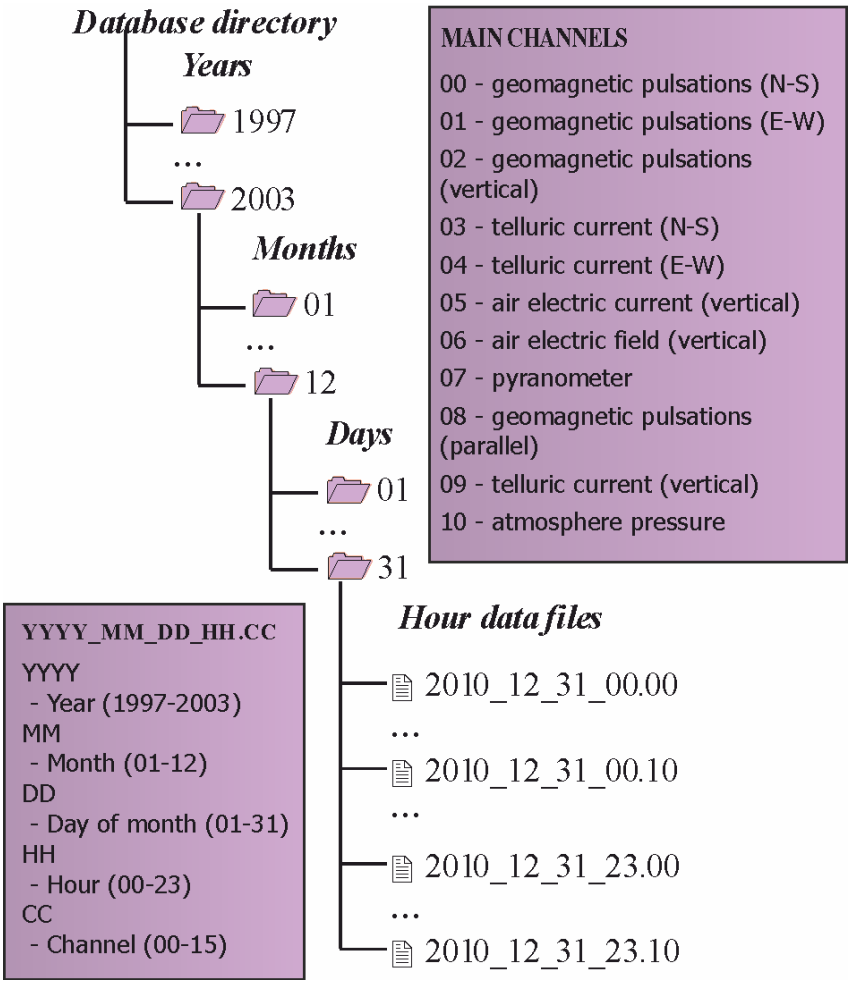

Figure 3. The structure of the Borok Geophysical Observatory database directories.

The data files contain the data from one channel, received during one hour. Names of hour data files have the format YYYY_MM_DD_HH.CC, where YYYY is a year (since 1997), MM is a month number (01–12), DD is a day of month (01–31), HH is an hour (00–23), CC is the channel number, which is the

unique identifier for each registered parameter.

The raw data of all other data logging systems are collected by the original software. The database server software makes processing, storage and archiving of the raw data in the separated directories. Processing the raw data coming from the data logging computers includes their formatting, averaging and transformation to the physical scale. Two main objectives of the processing are to transform the raw data to the digital format, convenient for data storage and access, and to obtain the data images, convenient for data viewing and analysis by users. So, there are two groups of programs. Formatting programs translate the data received from different sources into the uniform storage format and store them in the database directories. Visualizing programs produce data plots and store them as graphic files. The methods and programs of raw data processing and software of the database server were presented in [Anisimov and Dmitriev, 2009].

THE WEB-RESOURCE ON ATMOSPHERIC ELECTRICITY AND GEOMAGNETISM

The database is the background of the network information resource directed on global electric circuit, air electricity and geomagnetism. The website of the information resource (http://geodata.borok.ru) is designed for basic researches of air electric processes in the global electric circuit (Fig. 4).

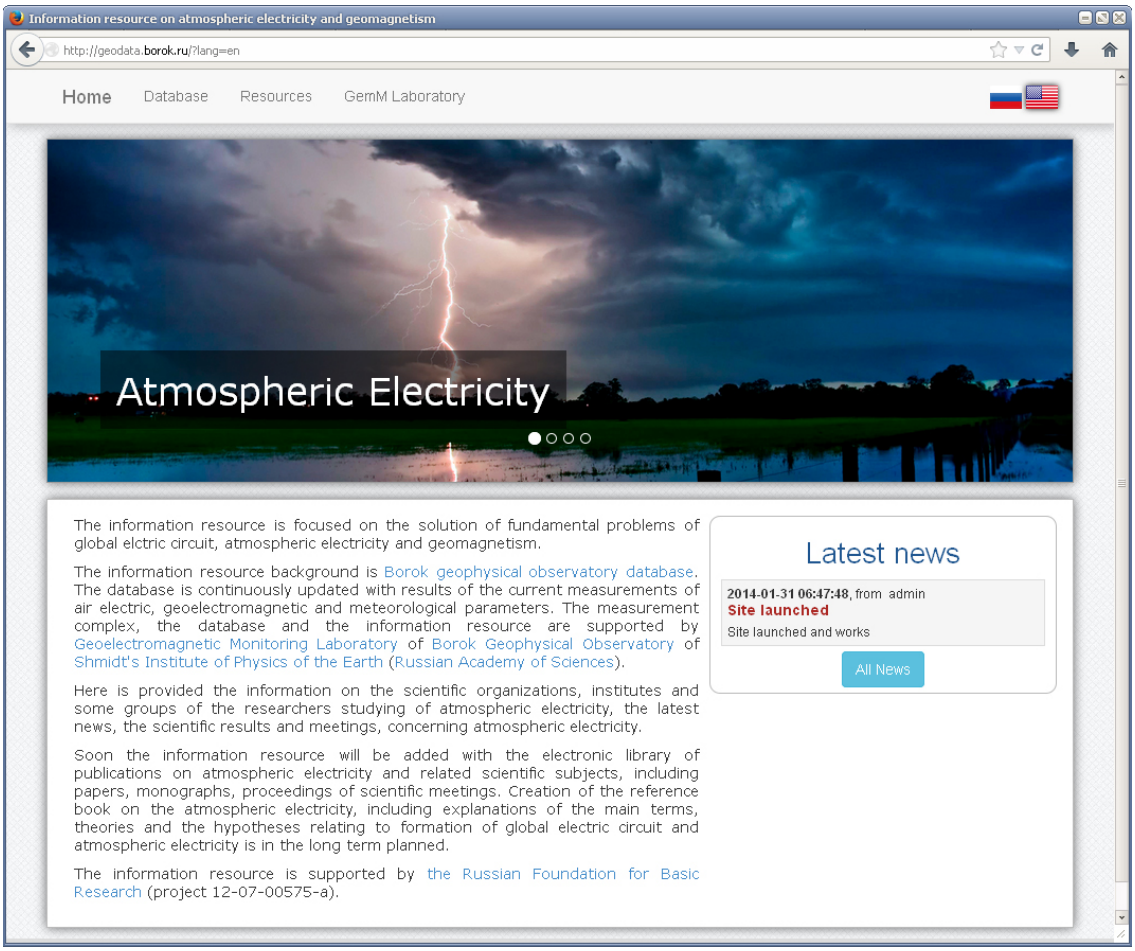

Figure 4. The first page of the information resource web-site.

The information resource web-site is bilingual (English and Russian). There are two main sections in the web-site. The database section presents Borok Geophysical Observatory database, continuously updated with results of the current measurements of air electric, geoelectromagnetic and meteorological parameters. From the database home page (Fig. 5) the web-site visitor can go to the geophysical data pages, presented the results of measurements of geomagnetic variations, ULF geomagnetic pulsations, atmosphere electric field, meteorological parameters, solar irradiance. All web-site pages in the left side have the menu with links to current level sub-items and to the upper level web-site page.

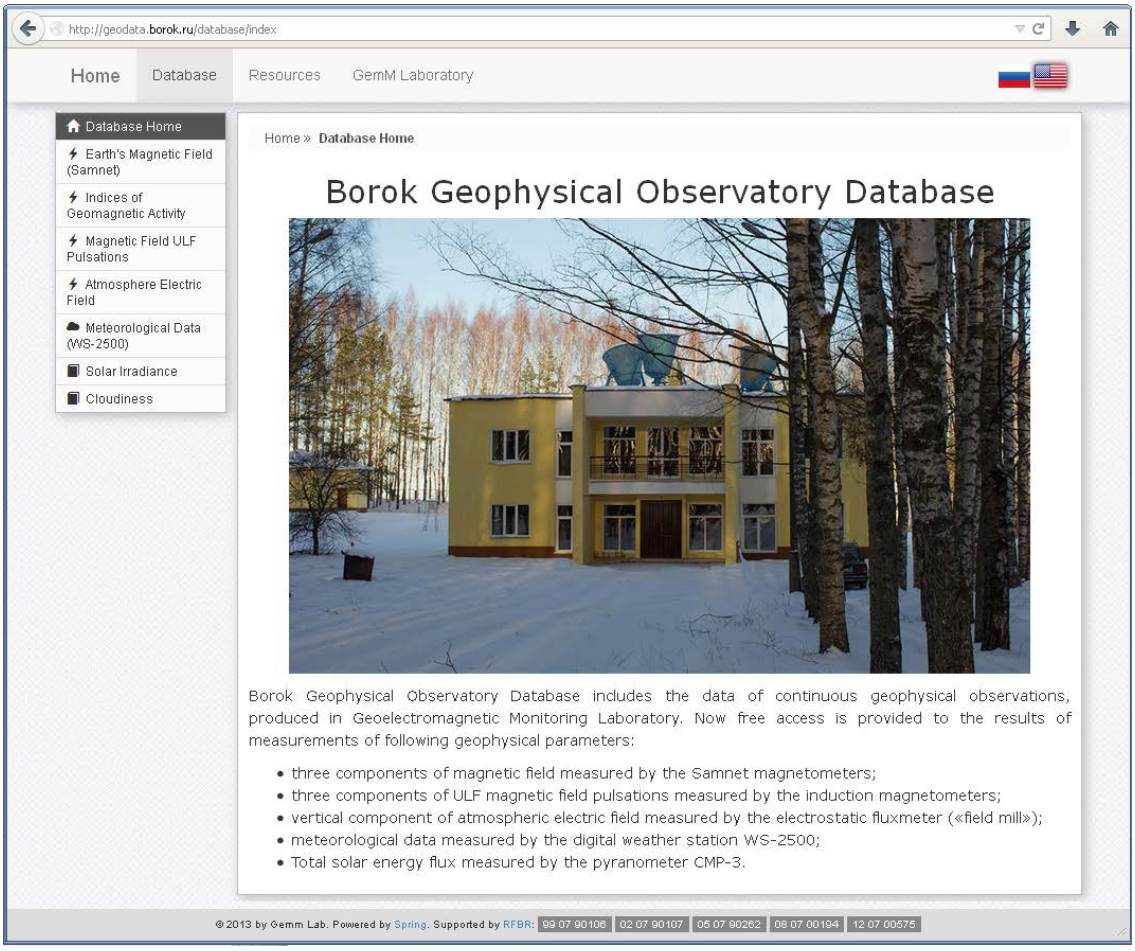

Figure 5. The first page of the database section of the information resource web-site.

The left menu items reference to the current data viewing (Fig. 6), the archived data viewing (Fig. 7) and the data request forms. All the data are presented for preview as amplitude-time plots, accepting the ULF magnetic field pulsations, presented as the frequency-time plots. To provide data safety and to prevent hacker attacks the raw data files are locked. The data, requested by database users, are formed by the web-site software. The user requests the data by filling the data request form, special for each data type; however the algorithm to processing of the data request form is identical to all data types. The user has to fulfil the form fields Starting Date (pointing year, month, day and hour), Duration (in hours), First Name (pointing user's name), Surname (pointing user's family name), E-mail (the e-mail address) and Organisation (user's affiliation). After processing of the data request the user receives via e-mail the

confirmation on request processing. The data are sent to the user by e-mail, simultaneously the database administrator is notified on the received data request and the request information is stored in the database server.

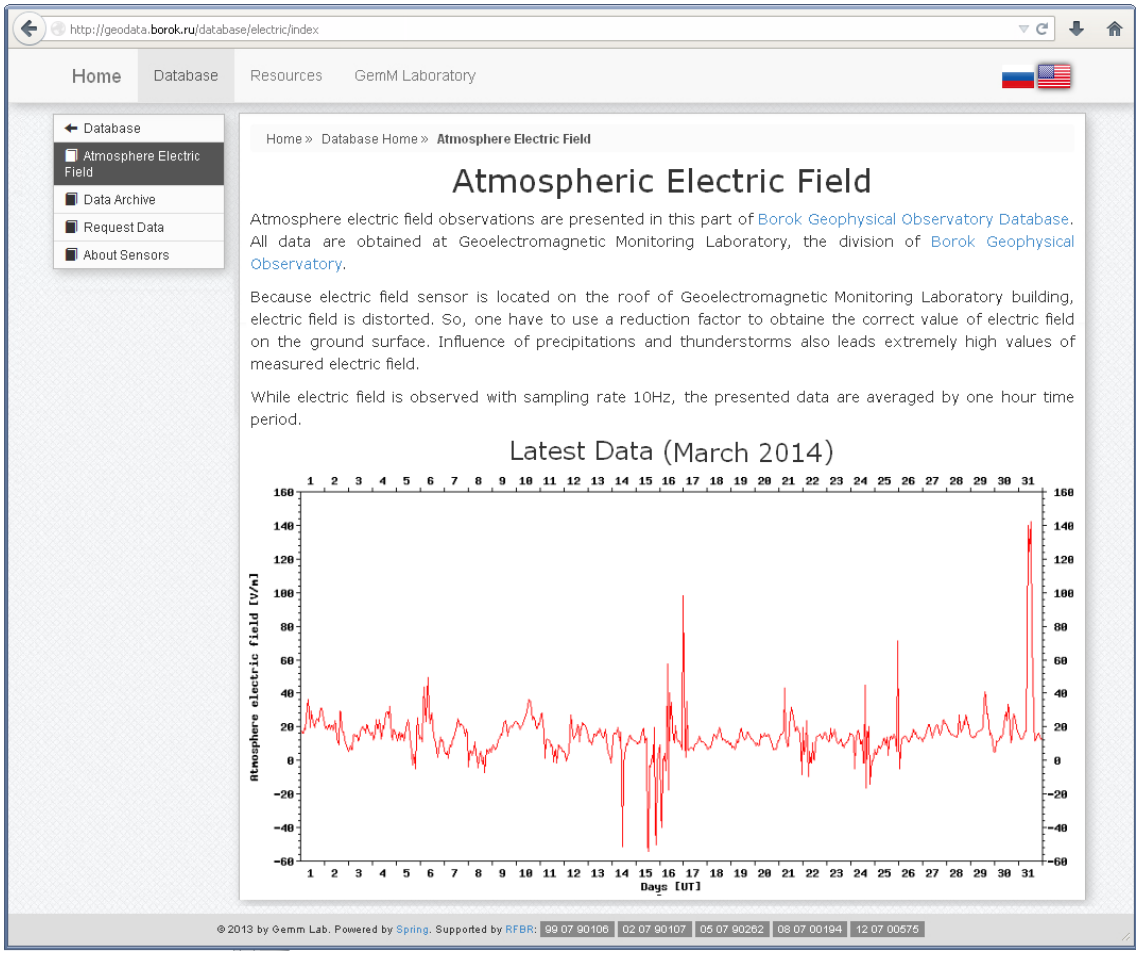

Figure 6. The page of the information resource web-site with the latest atmospheric electric field data.

Now free access is provided to the results of measurements of three components of magnetic field measured by the Samnet magnetometers; three components of ULF magnetic field pulsations measured by the induction magnetometers; vertical component of atmospheric electric field measured by the electrostatic fluxmeter ("field mill"); meteorological data measured by the digital weather station "WS-2500"; total solar energy flux measured by the pyranometer "CMP-3".

Some results of data analysis are also presented in the database section as indices of geomagnetic activity and cloudiness. The K-index, characterized the irregular geomagnetic field perturbations, is calculated by a standard algorithm, first introduced by J. Bartels in 1938. K-index is quasi-logarithmic local index of the 3-hourly range in magnetic activity relative to an assumed quiet-day curve for a single geomagnetic observatory site. The K-indices, related to Borok Geophysical Observatory, are calculated from the most disturbed horizontal component of geomagnetic field. The raw data are coming from the fluxgate magnetometer of Samnet network. The quiet-day curve of magnetic field is calculated as median averages from quiet days for each month. The deviations are converted using a semi logarithmic table into

K-indices, consisted of a single-digit 0 thru 9 for each 3-hours interval of the universal time day (UT). The cloudiness index is estimated using the total solar irradiation measurements by the pyranometer “CMP-3”. The estimations of the minimum and maximum overcast in points (0 — no clouds, 10 — the sky is completely cloudy) are calculated by the original algorithm to compare the measured solar irradiance with the value, evaluated from the astronomic data.

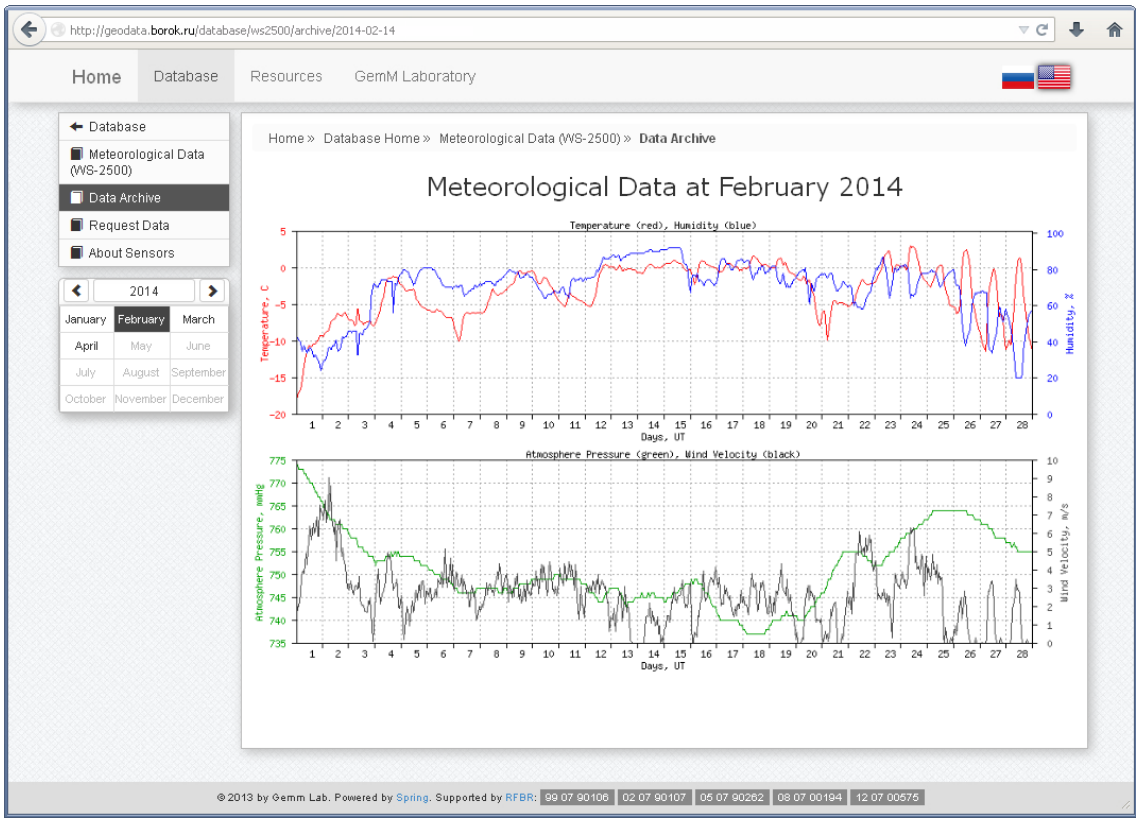

Figure 7. The page of the information resource web-site with archived meteorological data.

The resources section of the information resource web-site is now under construction. It would be provided the information on the scientific organizations, institutes and some groups of the researchers studying of atmospheric electricity, the latest news, the scientific results and meetings, concerning atmospheric electricity. The information resource will be also added with the electronic library of publications on atmospheric electricity and related scientific subjects, including papers, monographs, proceedings of scientific meetings. Creation of the reference book on the atmospheric electricity, including explanations of the main terms, theories and the hypotheses relating to formation of global electric circuit and atmospheric electricity is in the long term planned.

CONCLUSIONS

The air electrical and meteorological measurements as a part of geophysical monitoring create the experimental background to investigate low atmosphere electricity. Borok Geophysical Observatory is equipped with the unique experimental complex for air electrical, meteorological, geomagnetic and radiophysics measurements with high resolutions and sampling rates. Borok Geophysical Observatory

database is focused on the atmosphere electricity researches [Anisimov et al., 2003; Anisimov and Dmitriev, 2007; Anisimov and Dmitriev, 2011]. Low level of industrial pollutions in Borok, as well as complex presentation of air electrical, geophysical and meteorological data allows Borok Geophysical Observatory database to be very useful to investigate the natural atmosphere electrical processes. The creation of the information resource directed on global electric circuit, air electricity and geomagnetism on the basis of Borok Geophysical Observatory database provides access to the experimental data and scientific results concerning in the global electric circuit researches.

ACKNOWLEDGMENTS

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