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The Organizing of Database from Surlari National Geomagnetic Observatory

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Abstract: Our paper describes the organizing of database, remarks about SNGO (Surlari National Geomagnetic Observatory) and network infrastructure. Based on the geomagnetic data acquired and stored on the database server, we perform the processing and analysis of geomagnetic parameters through different spectral, statistical and correlation methods. All these parameters are included in the geomagnetic database on server. The web interface for the database meets the different needs of handling the data collected, raw or processed. The server-side programming language used for design is php. This allow us to select different periods for which access to stored data, required for different search filters and different parameters or data from different time periods can be compared. For a more in-depth analysis of the stored data, through JavaScript programming language graphs for different parameters can be drawn. Access to the web interface can be done with or without authentication, depending on the need to ensure the security of certain data collected, stored and processed. The applications are scalable for different devices that will access it: mobile, tablets, laptops or desktops.

Key words: Geomagnetic observatory, database, data in real time, data acquisition, data processing.

1. Introduction

During the last decades, infrastructure and equipment used in monitoring geomagnetic field at European and planetary level have experienced a remarkable development. New registering techniques have allowed a full automation of data acquisition, and sampling step and their precision increased by two classes of size. Systems of transmitting these data in real time to world collecting centers have resulted in the possibility of approaching globalization studies, suitable for following some phenomena at planetary scale. In our paper we show the organizing of database from SNGO (Surlari National Geomagnetic Observatory), in conformity with recommendations of IAGA (International Association of Geomagnetism and Aeronomy), INTERMAGNET (International Real-Time Magnetic Observatory Network) and our tasks to implement algorithms for geomagnetic storms forecast, in the processing software in the project No. 16PCCDI/2018: "Institutional capacities and services for research, monitoring and forecasting of risks in extra-atmospheric space", led by the ROSA (Romanian Space Agency), where SNGO is a partner.

At the same time, a significant development in the procedures of processing primary data has been registered, based on standardized software. The new stage of this fundamental research, largely applicable in various fields, is also marked by the simultaneous observation of space-time distribution of terrestrial electromagnetic field by means of stations set on satellites circling on orbits around the Earth.

In Romania, fundamental research in this field has developed within a special unit, SNGO, with acronym SUA in INTERMAGNET (International Real-time Magnetic Observatory Network) [1], which have followed two main objectives [2]:

(1) a permanent observation of planetary magnetic field within a world net of observatories;

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(2) highlighting some local disturbances, through electromagnetic induction, related to the geological structure of our country's territory.

Data regarding geomagnetic field all over Romanian territory will be revaluated, along with rendering evident some peculiarities of very long-term variations, which require long time series, operation possible only in a few observatories with a longer and continuous activity [3-5]. SNGO's current data base—covering over 75 years of non-stop observation of the transitory part of the geomagnetic field—is an important patrimony, both for national and for planetary research. We should mention that out of the 180 observatories and fundamental stations forming current world net for monitoring terrestrial geomagnetic field, only 50 stations (SNGO included) can deliver complete time series comprising seven solar activity cycles [3-5].

2. Remarks about SNGO

Geomagnetic field study in Romanian stations has started with irregular measurements in late 19th century. In 1943, the foundation of SNGO marked the beginning of a new era in the systematic study of geomagnetic field by a continuous registration of its variations and by carrying out standard absolute measurements in a fundamental station. Observatory location was thoroughly established, so that it meets the geomorphological and technological criteria. SNGO is located in Căldăruşani-Surlari astro-geodetic polygon, in an area without magnetic field anomalies or significant local heterogeneity of electrical conductivity in the basement and a sufficient distance from major industrial sources of disturbance. The observatory covers an area of 3.56 hectares and comprises seven surface and underground buildings. Inside are installed specialized equipments to monitor multiparametric fields of earth. These buildings were made during 1943-1969. The underground laboratory and the main buildings were renovated and modernized in 2006-2008 [3, 4].

The design of the special geomagnetic recording laboratories was made after some good verification. Inside laboratories were built with 18 specially designed pillars embedded deep in the ground, which are mounted with high-resolution sensors.

Lately, SNGO has been concerned about:

(1) permanent knowledge of the structure and evolution of transitional geomagnetic field during several solar cycles [6];

(2) providing highly accurate absolute values of the magnetic field direction and intensity;

(3) characterization of the planetary and local "magnetic state" by the regular computing of geomagnetic activity indices;

(4) regular comparison of the base levels of geomagnetic records (national magnetic standards) to other planetary observatories;

(5) study of various temporal geomagnetic variations with periods in a very wide range in time from seconds to hundreds of years;

(6) determining the spatial distribution of the geomagnetic field, mainly at national level and integrating these images into continental or planetary maps. These distributions are obtained by repeated measurements in a network of points evenly distributed across the country. Determined values are used to obtain the secular variation of the normal geomagnetic field and binding of magnetic maps made in different times;

(7) contribution to establish periodic coefficients of the IGRF (International Geomagnetic Reference Field) in the IAGA with shaping local peculiarities reported in our country.

Since 1998, fundamental geomagnetic station of Romania, ONGS, was admitted as an planetary observatory in INTERMAGNET program fulfilling main obligations imposed in this capacity, mainly oriented towards the major aspects of planetary field, axis and the changes of Gaussian dipole moment, the IGRF, the level of solar activity and disturbances related to the relationship Sun-Earth, the solar wind interference and interplanetary magnetic field, or structure of convection currents in the outer core—Earth's asthenosphere [7, 8].

Permanent recordings made on SNGO or in stations temporarily installed in Romania are useful to eliminate variations with external causes, leading to application of corrections to the magnetometry survey in order to increase their accuracy because when weak geomagnetic effects are measured, these cuts are absolutely necessary for accurate localization of abnormalities of economic interest.

3. Network Infrastructure and Database of SNGO

Acquisition server (Fig. 1) for geomagnetic field remarks:

- It is implemented by the Potsdam Geophysical Research Center;
- It runs in Linux Debian;
- The data processing system is implemented in Fortran and Borland Pascal.

Acquisition sensors are:

- Two triaxial Flux Gate variometers (D, H and Z);
- Flux Gate Declinometer/Inclinometer consists of a monoaxial Flux Gate magnetometer mounted on a Zeiss Theo 010b non-magnetic theodolite with a resolution of 1 s of arc. (which measures declination and inclination absolutely);
- Overhauser proton precision magnetometer model GSM90 with temporary resolution of 5 s and accuracy of 0.01 nT (absolute total geomagnetic field F);

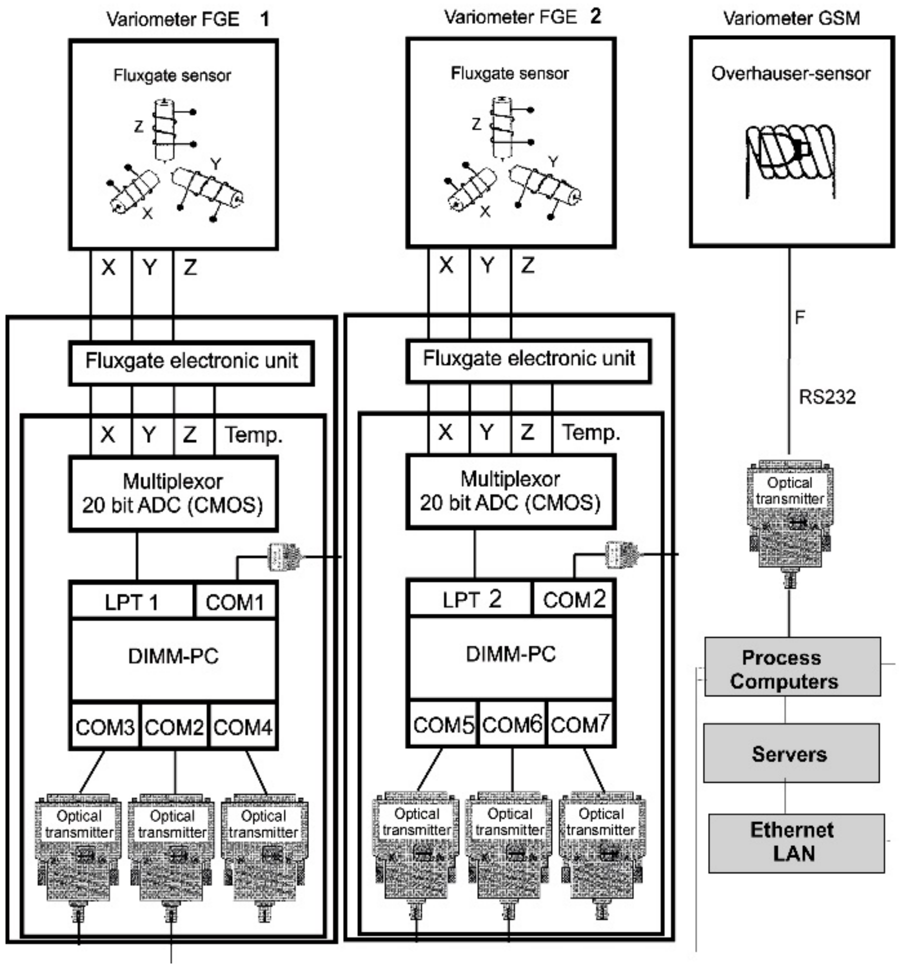

Fig. 1 Sketch of the acquisition system and data server.

Observatory archive has the following characteristics:

- Contains all data measured by the Variometer acquisition system;
- Data are extracted from the server daily;
- The data are stored in folders with the structure year\sensor used\month\day, for example: "\OBSERVATORY ARCHIVE\MAGDALOG 2020\MAG_1\4 APR\8";
- Because there are 2 sensors, there are 2 sets of measured data, which provide system redundancy;
- The data extracted from the server for the current month are provisional, for their calculation being taken into account at provisional base level, more precisely the value of the last day of the previous month. For each month there are 4 files with the *.txt extension in which values measured at different time resolutions are found;
- One minute (1 min) (data sent daily to www.intermagnet.com) for parameters X, Y, Z, H, F calculated, D, I, offset • at 5 s (F measured absolute);
- At 0.5 s (2 Hz) for parameters D, H, Z;

The archive also contains the table with K indices – 3-hour indices of magnetic activity, for all days of the current year calculated by the FMI (Finnish Meteorological Institute) method.

The data, within the repository MinIO, have the following structure:/IGR/name of data/year/month/.

Thus, within the repository MinIO there is the following file structure: IGR\year\month\Absolute data_5_sec\Data_2Hz_corected_with provisory base line\Average data at 1 minute corrected with provisory base line \ Data offset\F absolute\F calculated.

To transfer data from the Observatory Archive to the Repository MinIO, the following were performed:

The data from archive were copied to a local PC (Personal Computer) (running in Windows 10) that has VPN (Virtual Private Network) access to the SNGO network;

The data were organized on local PC respecting the structure of Repository MinIO;

A "mirroring" was created between the files on the local PC and Repository MinIO following the steps presented at http://wiki.apps.devcloud.ici.ro/minio;

After completing the transfer, the integrity of the data was verified, accessing the address http://minio.apps.devcloud.ici.ro/minio/login;

The goal of network infrastructure creation is to facilitate access to data recorded in a single format, automate pre-processing, and obtain a unique time basis (via GPS (Global Positioning System)) for all data.

The operating system chosen to support the services provided is the distribution of Linux OpenSUSE 11.1 for services running on x86 machines and the services hosted on the Cisco router run under Cisco IOS 12.4T.

Short description of network and infrastructure features at the SNGO:

- NAT (Network Address Translation) local network access implemented natively by the Cisco-880 router;
- VPN (Virtual Private Network) remote access server in the Observer's local network for users located in other locations implemented through Cisco IOS 12.4T;
- DHCP (Dynamic Host Configuration Protocol) automatic configuration of network settings implemented with ISC dhcpd 3.1.1;
- DNS (Domain Name System) address resolution by name and vice versa implemented with ISCBIND 9;
- Integrated LDAP (Lightweight Directory Access Protocol) authentication of users in the local network implemented with open ldap 2 2.4.12; LDAP user authentication is the process of validating a username and password combination with a directory server;
- *NTP* (Network Time Protocol) clock synchronization service for all computers connected to the local network implemented with ntpd 4.2.4;
- Database server for storing data from all Surlari Geomagnetic Observatory acquisition systems implemented with MySql 5.0.67;

• Web server hosts the observatory's web site deployed with Apache 2 2.2.10;

File storage and file transfer services to the Web server for Intranet users are make automatically and periodically (e.g., averaged values at 5 s or 60 s).

• FTP (File Transfer Protocol) server file transfer services for intuitive users using Intranet vsftpd 2.0.7;

• File server for general use file storage with Samba 3.2.4.

For implementation, these services have been grouped into 4 categories, taking into account their specificity, the need for hardware resources to run, and critical dependency between them. For implementation, the solution was chosen as each group to run on a separate server.

Cisco-880 router runs NAT and VPN server services (already implemented and active):

netserv *—server for common network services: DHCP, DNS, LDAP;

dbserv *—database server;

filer *—file server;

webserv *—Web server and FTP.

To reduce costs and reduce the number of computers installed, all are virtual machines running under VMware Server 2 on a single physical server for a high reliability (RAID 1 for dual hard drives, dual NIC (Network Interface Card) mounted in fail-over architecture, UPS (Unit Power System) with monitoring software).

Modernization of the network infrastructure has been carried out so that it can provide all the services necessary for the exploitation (Figs. 2 and 3).

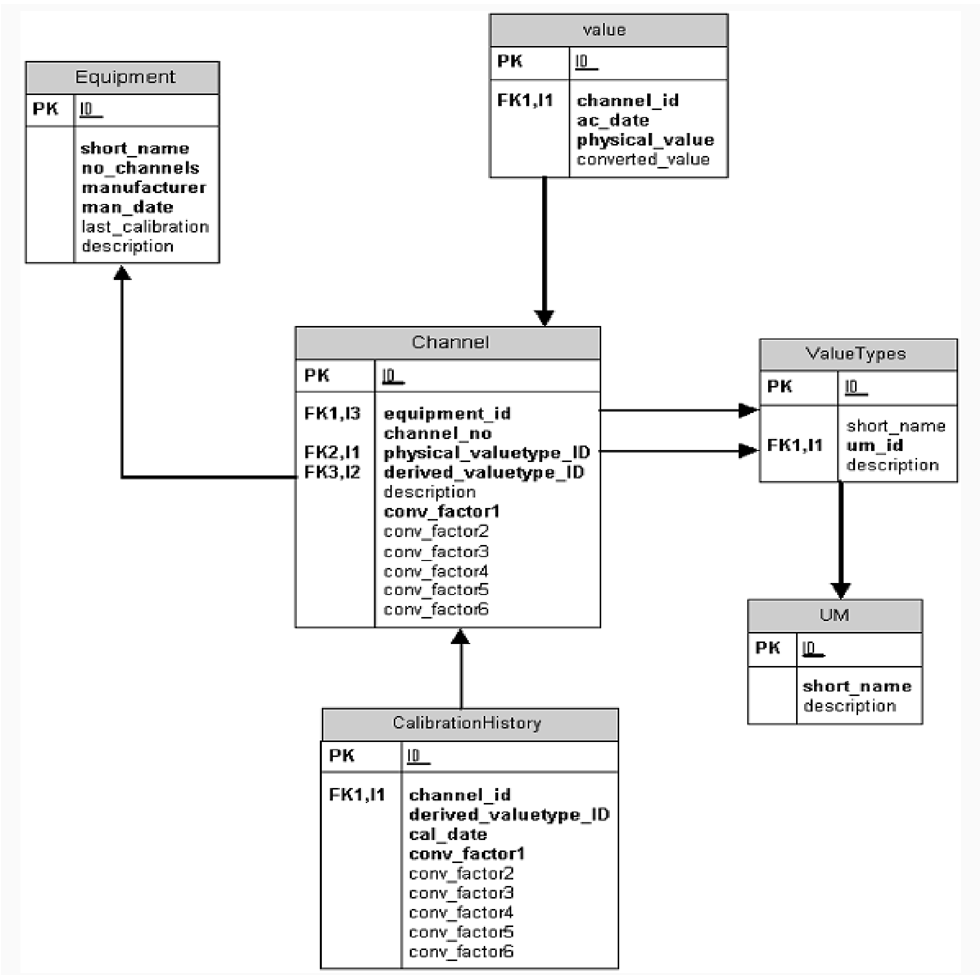

Fig. 2 Sketch of the data server and description of each unit within the data server.

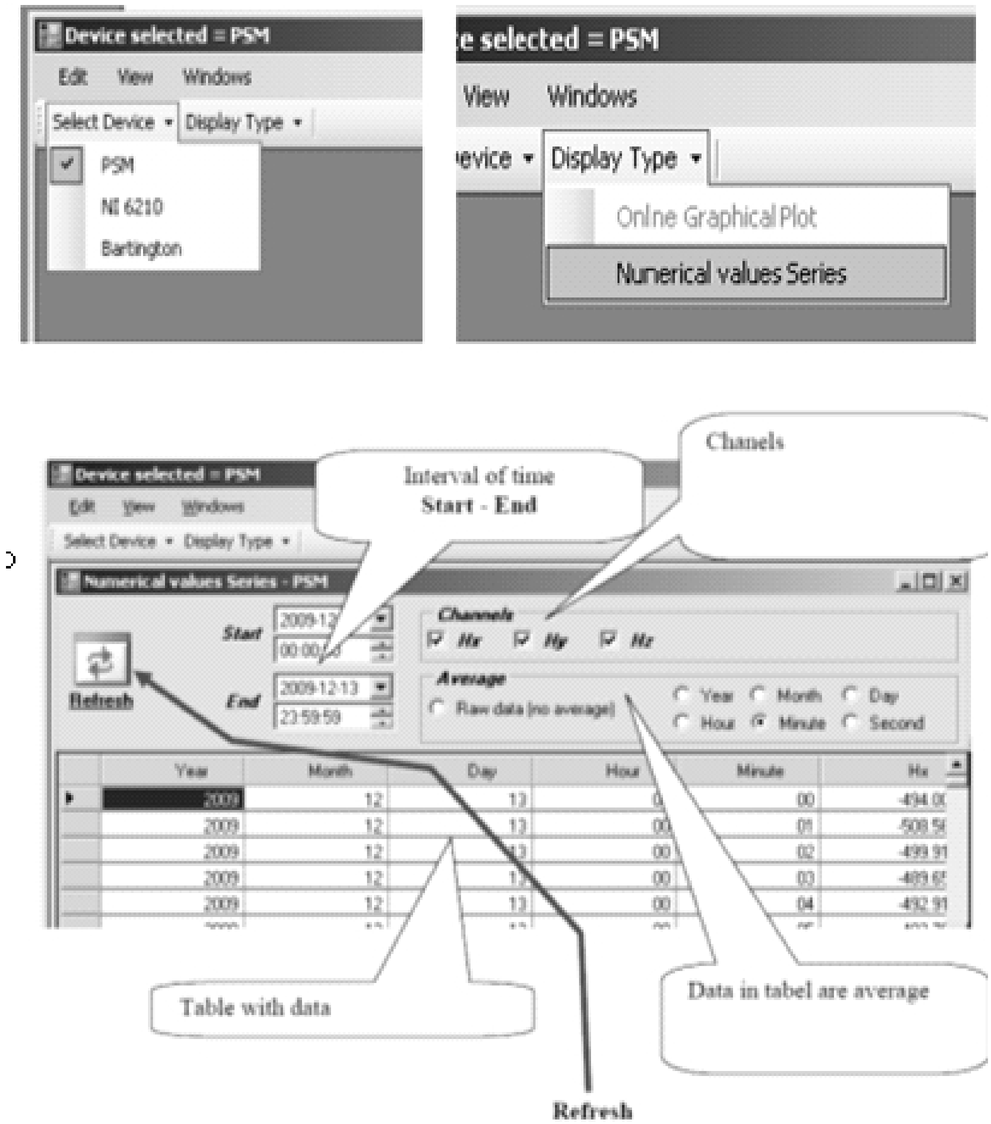

Fig. 3 Schematic overview of the database acquisition and management program.

The software package consists of the following components:

(1) SQL Server. VI on the database server is designed to transmit measured values in two ways:

(a) upon request, to applications installed on computers of different users, users can log in with a username and password to access the data stored on the database server;

(b) automatically and periodically transmit averaged values to the Web server.

Client VI, with multiple installations on different users' computers, has the role of allowing them to create on their own computers text files containing measured values retrieved from the database server (Figs. 2 and 3);

This allows the user to select the start and end moments of the time period for which the SQL Server VI, application will be requested, copy the measured values;

The user can specify, where appropriate, the path and file name in which the measured measurement values transmitted by the SQL Server VI application are saved;

(2) Web Server VI is installed on the Web server and receives the measured values, periodically transmitted by SQL Server VI and will save them in text files;

The files are daily, the file name is DD-MM-YY, and the files within a month will be stored in the same folder, the monthly folder name being MM-YY.

(3) Java Client VI, is installed on the Web server and is called by the actions of the various web page visitors and allows viewing of measured values in graphical form.

These software applications respect the SNGO internal network and public network connections, thus centralizing data acquisition and online transmission on Web Server. Standard processing of geomagnetic data according to INTERMAGNET requirements includes calculating the average at 1 min of geomagnetic components values and obtaining provisional data files, establishing the base level of records as well as adopting the baseline level and making definitive data.

4. Conclusion

This infrastructure and organizing of database from SNGO allow us to monitor and make all processing procedures of data according to recommendations of IAGA and INTERMAGNET.

Preliminary data in the form of average values at 1 min of recorded components contained in daily files that have the extension code of the observatory are corrected with the value of the base level adopted for each component for that day.

Files obtained in this way are processed with an application that converts them from daily text files into monthly binary files containing the minute averages of recorded and corrected components.

The final data set delivered to GIN (Geomagnetic Information Node) at the beginning of the year following the one for which they are calculated will contain 12 monthly binary files with geomagnetic components and magnetic activity indices for each month, a geomagnetic field component annual file, a file with the basic and calculated values for geomagnetic field records and a readme file containing data on the recording technique, the absolute measurements used in the observatory and the personnel carrying out these works. In a grant of the Romanian Ministry of Research and Innovation, CCCDI-UEFISCDI, project No. 16PCCDI/2018: "institutional capacities and services for research, monitoring and forecasting of risks in extra-atmospheric space", led by the ROSA where SNGO is a partner, we propose to implement algorithms for geomagnetic storms forecast, in the processing software.

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