The solid information system for radiosounding data of upper atmosphere

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ABSTRACT

We present a solid information system for storing, accessing and collecting of Earth upper atmosphere sounding data produced by radiophysical instrument complex of Institute of Solar-Terrestrial Physics SB RAS. At present complex consists of Irkutsk incoherent scatter radar unique in Russia, four frequency modulated current waves ionosounders (FMCW) operating in vertical, oblique-incidence and backscattering sounding modes and two digital ionosounders DPS-4. We suggest a technique for unification of heterogeneous data into united format and secondary processing with unified technology based on international techniques of geophysical parameters determining. We discuss a structure of united information system with Web access which allows us to integrate our radiophysical data into worldwide network of geophysical data.

Keywords: ionosounders, information system, database, client-server technique

1. INTRODUCTION

In ionosphere researches the volume of information obtained in experiment can reach tens of gigabytes. This can be time series of radiosounding characteristics, ionograms and so on. Institute of Solar-Terrestrial Physics accumulate a set of experimental data obtained on various radiophysical instruments:

- impulse ionosounder of vertical sounding – ionograms on photo;
- vertical sounding station "Vertical" – ionograms in digital form;
- incoherent scattering radar (ISR) – electron concentration profiles, electron and ion temperatures in digital form and primary data which is the results of backscattering signals statistical processing[1];
- two digisounder DPS-4 in Norilsk (69.2°N, 88°E) and Irkutsk (52° N, 104° E) – ionograms in digital form[2];
- space distributed ionosounder with continuous linear-frequency modulated signal (FMCW), which fall in Russian FMCW network[3].

The transmitting points are Magadan (60°N, 150.7°E), Khabarovsk (48.5°N, 135.1°E), Norilsk and Irkutsk, receiving point is in Irkutsk. Vertical, oblique-incidence and backscattering modes (VS, OIS, and BS) are realized – ionograms in digital form[4]. For complex investigations on the base of various instruments data and models we need to unite heterogeneous data into unified information system and transform earlier obtained analog and digital experimental data into new form which allows us to use modern hardware and software techniques.

In this paper we present a database (DB) of Earth upper atmosphere radiosounding based on data of our Institute radiophysical instrument complex. We consider a unification technique of heterogeneous data into united format and secondary processing by unified techniques on the base of international techniques of geophysical parameters determining. We describe a structure of united information system with Web access which allows us to integrate our radiophysical data into worldwide network of geophysical data.

2. THE EXPERIMENTAL DATA FROM ISTP SB RAS RADIOPHYSICAL INSTRUMENTS COMPLEX

ISR DATA. Nowadays traditional and generally accepted processing techniques for scattered signal are determination of average spectral power of scattered signal for various ranges and calculation of average power profile of scattered

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signal as a function of range. These parameters of scattered signal allows us in the framework of generally accepted models to obtain electron and ion temperatures, electron concentration profile below and above F2 layer and plasma drift velocity along line of sight for various radiolocation ranges (heights). In order to include obtained ionosphere parameters into database we developed a program – processor/converter which allows not only to form averaged data in format needed for ionosphere parameters obtaining, but to exclude on this stage various effects due to radar location particularity and construction. This allows us to obtain ionosphere parameters from lower heights (~ 150 – 170 km for electron temperatures and ~ 120-130 km for electron concentration profile).

VS DATA. For VS experimental data unification obtained on various radiophysical instruments we have chosen a strategy of all data formats converting into unified international representation format SAO (Standard Archiving Output Format), which is used for experimental data registration of digital ionosounders DPS-4 worldwide network counting more than 70 stations[5]. The standard ionosounder software allows us in automatic regime with interactive correction to carry out ionograms secondary processing in order to obtain main ionosphere parameters. In this case the data processing is conducted in unified ideology framework that relieves ionograms processing and information analysis. The set of obtained ionosphere parameters is determined according URSI recommendations URSI[6].

The primary data for ionosounder DPS-4 are ionograms. The ionogram is two-dimensional array that gives dependence of signal amplitude on sounding frequency and time recalculated into acting height of signal reflection. Under ionogram secondary processing we select traces in the form of one-dimensional arrays that determine dependence of acting height on sounding frequency. The reflection traces from F2-, F1- and E ionosphere layers are selected separately. The ionograms processing is conducted with a help of interactive program complex SAO Explorer. By selected traces we automatically determine standard set of ionosphere parameters and calculate electron concentration profile. These geophysical characteristics are written into VS database.

Additionally for correction of international ionosphere model IRI-2001[7] we calculate model input parameters that determine the form of electron concentration profile. The data is stored in generally accepted standard digital format of digital ionosounder SAO.

VS DATA ARRAY IN ANALOG FORM. The transformation of ionograms from photo that were obtained from impulse ionosounder (II) into digital form is conducted on the base of image recognition. The source file is graphic file obtained by scanning of ionogram from photo with a help of specialized slide scanner. The ionogram region is rectangular table with frequency and range axis which have contrast straight lines that mark fixed frequencies and ranges. Every pixel of this table that is not mark line contains information about reflected signal amplitude. We implement correlation analysis technique based on comparison of processing file fragments with fragments of good test file. The selection of such technique is due to the fact that data for various observation periods greatly differs by image contrast quality and so we need a reliable standard for correct recognition of image necessary characteristics. The statistical parameters for correlation analysis are selected on the base of data checking for several various observation periods with various contrast qualities.

FMCW IONOSOUNDER DATA. On FMCW receiving complex we have the signals primary processing that includes spectral analysis of beating from receiving device, threshold processing and averaging on coincidences[4]. This allows us to take away much of the noise and greatly reduce the amount of registered information. The processed data (ionogram) is stored in file. The ionogram file consists of two mains parts. These are directly observation data with information on received signal (amplitude A of received signal; delay t, that allows to determine the propagation time in medium; sounding frequency f), and service information region (Passport) that indicates data and time of observation, receiving and transmitting points (we indicate geographical coordinates or names), antennas (type, azimuth), transmitter power level, observation duration and so on. Thereby, in passport we store all accompanying information that characterizes observation séance (up to possibility of operator name writing that may be useful for processing and interpretation of ionogram).

3. INFORMATION SYSTEM DESCRIPTION

For unification problem solving we developed an information system based on client-server technique which allows us to process, store and access heterogeneous data. The server part of information system (Fig. 1) consists of:

1. intermediate file server that enables the possibility of processing data loading;
2. the set of programs for transforming of obtained data into XML-structure;
3. the set of programs for adding XML-structures to the database;
4. database SQL-server for storing data , search query processing and data filtration;
5. file server for primary data storing;
6. WEB-server with corresponding access selection data programs for data client support.

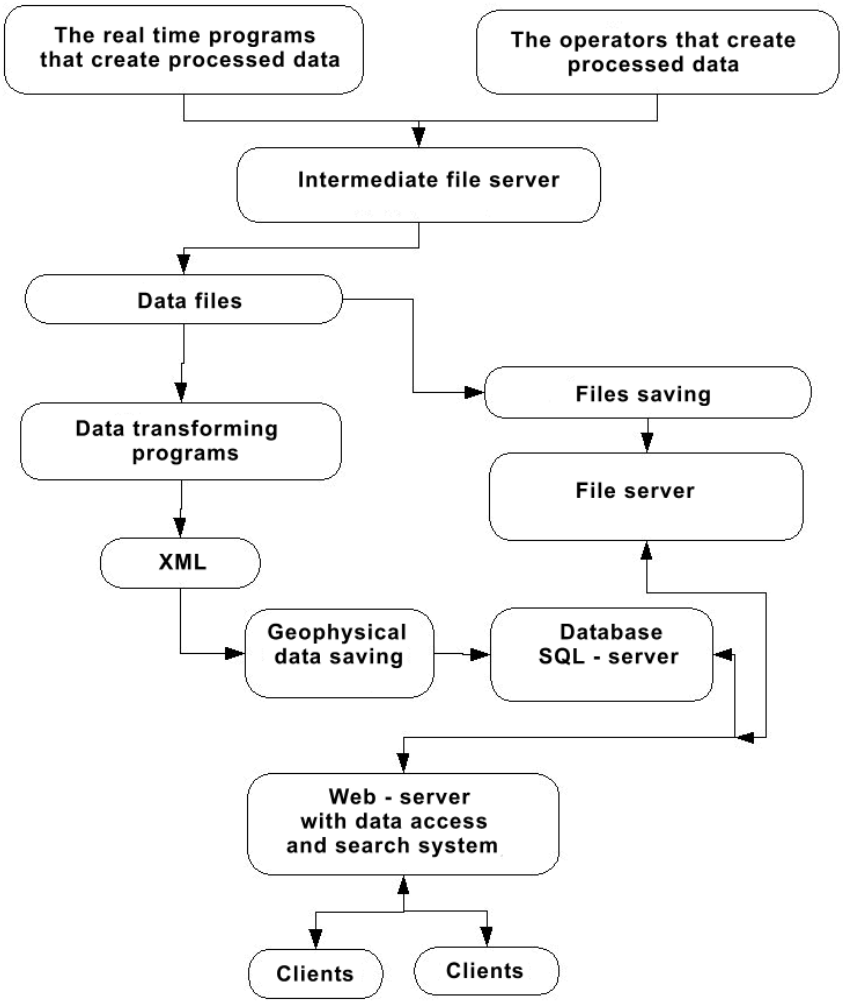

Fig. 1. Information system principal scheme.

The data adding to the database occurs automatically with a help of programs specially written for every accepted format of processing data which operated in background mode. After data obtaining the system transforms it into general XML-format and renews database. That approach allows us to realize simultaneously database renewal both for real time regime (for example, under automatic processing of Norilsk and Irkutsk digisounders) and for regime when operator renews database due to data processing obtained earlier on various devices.

The client part uses WEB-interface for database query forming and results output. The system allows us to select the data form database for selected type of radiophysical instruments and to range them by parameters and restrictions (Fig. 2). The query results are given in table form that suitable for using in any program for graphic construction and

mathematical analysis. If required (and if access possible for corresponding program module) the files can be represented to user automatically in graphic form.

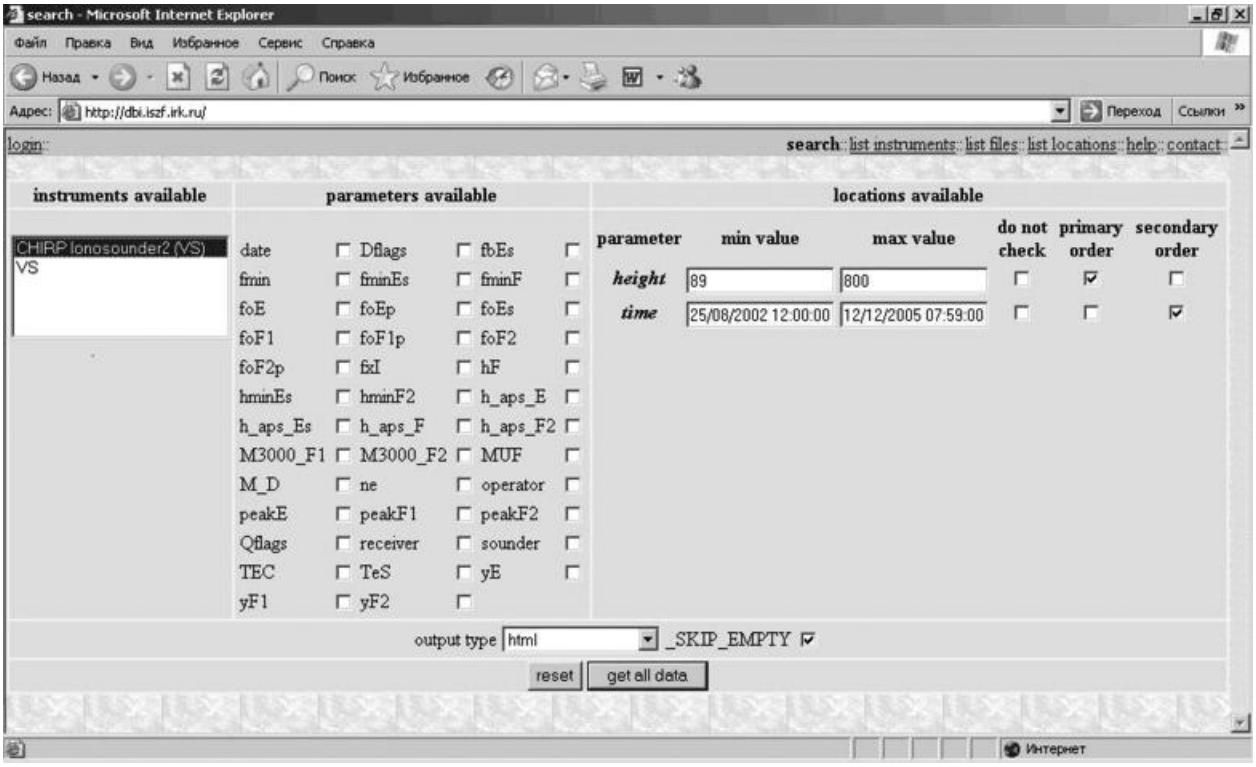

Fig. 2. Principal type of Web data browser.

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4. DATA STORING STRUCTURE

The problem of storing and access for heterogeneous data requires specially developed structure of data storing and representation. As a general format for input data description we select the mark language XML (http://xml.org) which has necessary complexity for heterogeneous data support.

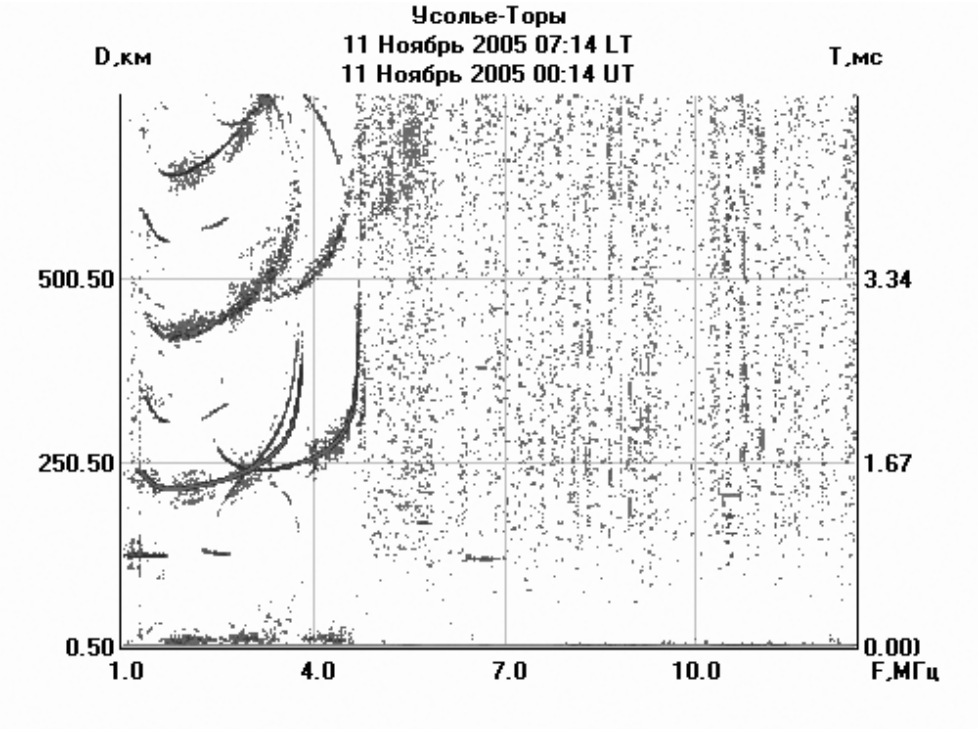

Fig. 3. The general type of graphic interface of VS ionogram output obtained automatically from unprocessed data.

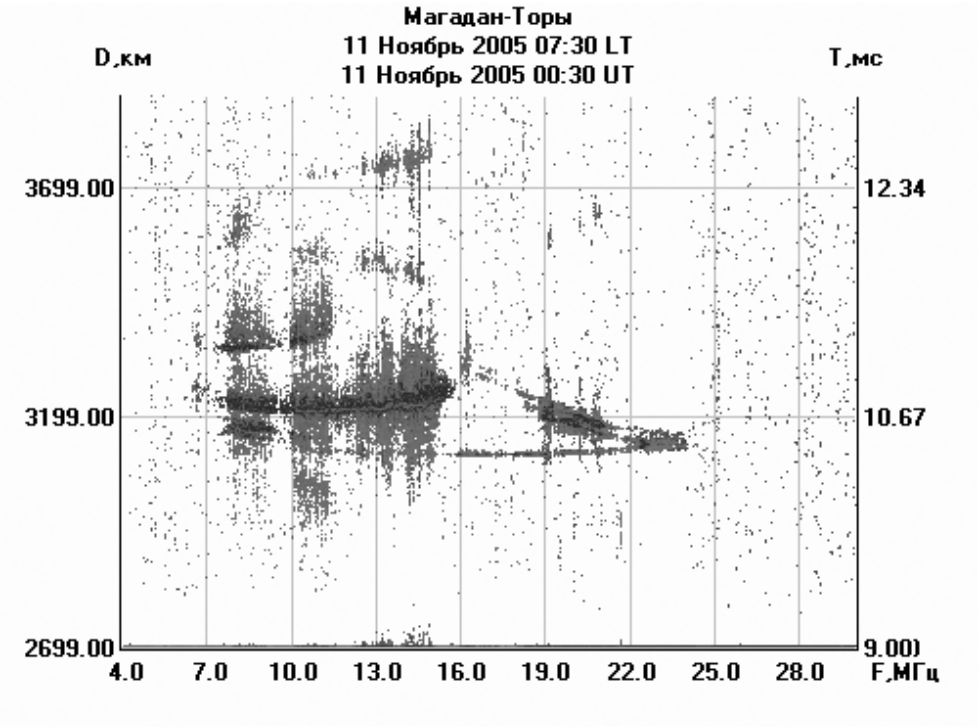

Fig. 4. The general type of graphic interface for OIS ionogram output obtained automatically from unprocessed data.

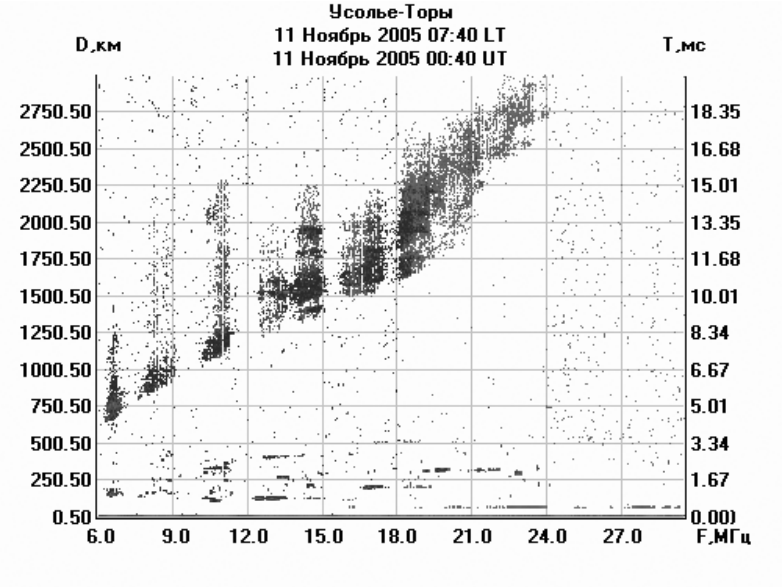

Fig. 5. The general type of graphic interface for BS ionogram output obtained automatically from unprocessed data.

For adding to database the source data must be transformed to XML-structure (Fig. 6) of developed format which supports the next particularities of processed data:

1. The possibility of data array correlation with determined parameter set – location, time, geographical longitude, latitude and so on. The system automatically adds new parameters that characterize locations and automatically supports free search by these parameters. The necessity of this possibility is connected with heterogeneous data which is needed for location description in space and time with calculated geophysical parameters. For example, for full electron content storing we need to correlate time and geographical longitude and latitude, for electron profile storing we additionally need height above earth level.
2. The possibility of arbitrary amount of geophysical parameters correlation with data array: electron concentration, drift velocity, F2 layer maximum height, full electron content and so on. The system automatically supports the adding of new parameters and theirs output due to queries. The necessity of such possibility support is caused by heterogeneous data and instruments.
3. The possibility of data array correlation with file or set of files. The system allows access to files for unprocessed data viewing. The system particularity is possibility of data connecting with file by file unique index so we do not need full file description in every XML-file. The necessity of that possibility is connected to the fact that the majority of obtained geophysical parameters are produced by experiments results which primary data are stored in some electronic format.
4. The possibility of data array correlation with function (functions) that has certain parameter set for model calculation storing support in the database.
5. The possibility of data array correlation with corresponding instrument (for example, Irkutsk IS radar, Irkutsk and Norilsk digisounders, FMCW-ionosounder and others). The data search system allows the selection of needed instrument or a set of such instruments under queries forming to database. The system particularity is possibility of data connecting with instrument by unique index so we not need full instrument description in every XML-file. If the instrument is absent in the database the system automatically adds it with a help of XML-structure description.
6. The data in database are stored in connected table form which intercoupling structure supports source XML-structure storing.
7. Thereby, the developed structure of solid information system allows us to integrate various instruments into unified database with Web access and so enables us to carry our complex investigations with a help of long data series including analog data for long period.

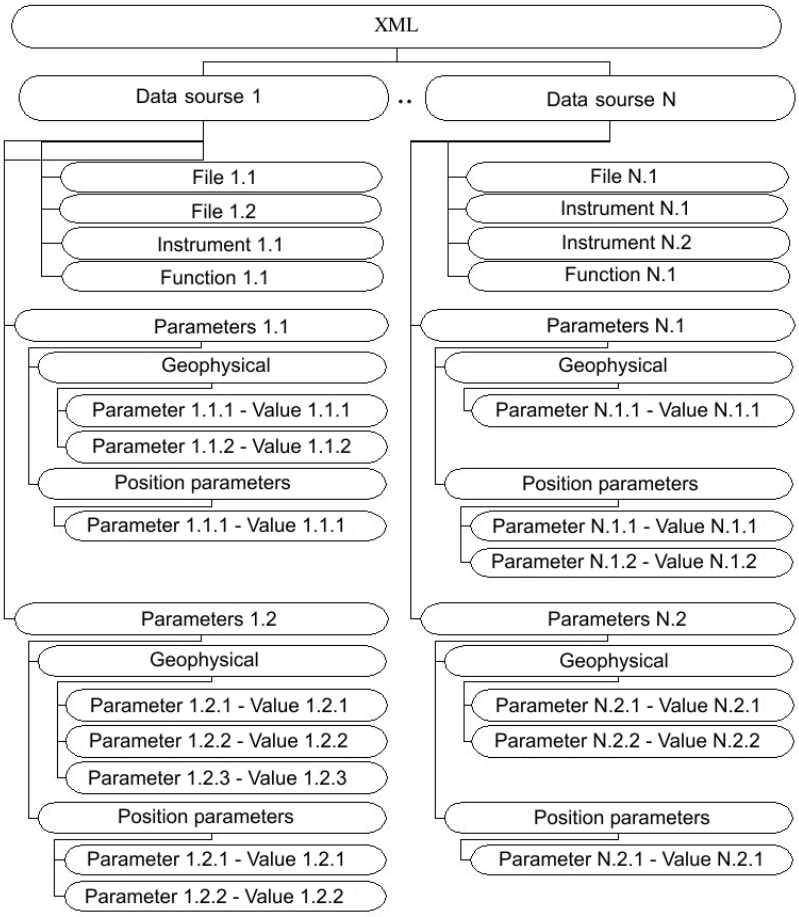

Fig. 6. The principal structure of XML-file describing entering data.

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