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# DATABASE OF SOLAR GEOEFFECTIVE PHENOMENA AND THEIR RESPONSES IN EARTH'S SPACE ENVIRONMENT SYSTEM

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**Abstract.** To facilitate the investigation of the relation between the solar events and their terrestrial consequences, a database of solar sources responsible for disturbances in Earth's space environment has been developed. A system for management of this database is described.

**Key words:** Sun: activity, flares – solar-terrestrial relations

The datasets used in the solar-terrestrial physics contain many types of data presented in different formats. The analysis of Data-Base Management Systems (DBMS) has shown that the most suitable management system for such data is the PARADOX DBMS (Petrov et al. 1991). PARADOX was selected due to its effectiveness to store and to work with data of various types and dimensions. Certainly, the best solution would be to use a universal DBMS, like ORACLE, which now can be used with many platforms, including the UNIX mainframes; this would ensure a complete independence of the database from hardware. However, due to complexity and high price of such a system, this solution for us is not realistic. Fortunately, PARADOX can support SQL requests, so the data can be accessible from many other systems.

The base itself represents a separate directory, in which the catalogues of geoeffective events are stored as a separate database for

each possible source. Now the following sources are included in the base:

(1) indexes of solar activity – "solind.db",

(2) large and geoeffective solar flares – "flare.db",

(3) flares – sources of solar proton events – "spf.db",

(4) disappearing filaments – "dsf.db",

(5) coronal holes – "corhol.db",

(6) solar proton events – "spe.db".

To facilitate the search for connections between solar sources and their geophysical consequences, some indexes and physical parameters describing geophysical conditions on the Earth are included in the database:

(7) indexes of magnetic activity Ap, Kp, C9 – "kpap.db",

(8) ring current index Dst – "dst.db",

(9) catalogue of magnetic storms – "magstorm.db",

(10) catalogue of the sudden commencement – "ssc.db".

Some parts of these catalogues are unique sets created in IZMIRAN, especially for the given project, some parts represent the samples of popular datasets. All the data are transformed into a uniform format, and typical tools for work with them are available.

The data, stored in each file have various physical sense and various structure, but all these data have one common feature – they have certain time temporary binding (date and time) of the event or measurements. PARADOX allows to combine date and time of the event in one parameter – time label (TimeStamp), which is chosen as the first field of each table. The time label represents time and date joined by a comma, for example: 20:57:00, 31/01/97. The majority of data files (tables) contain large numbers of parameters with brief and not always understandable field names. For viewing and best understanding the data, for each data file a form for data representation is created. The representation of data for the file "flare.db" in a format, is described by the form shown on Fig. 1.

Standard tools of PARADOX (not requiring a special programming) allow to carry out easily any data selection, calculate new parameters based on those available in the table and to create a convenient form for the data output. As an example, the query for extracting from the table "flare.db" large solar flares located far from the equator (latitude $<-30$ or $>+30$), calculating the duration of the

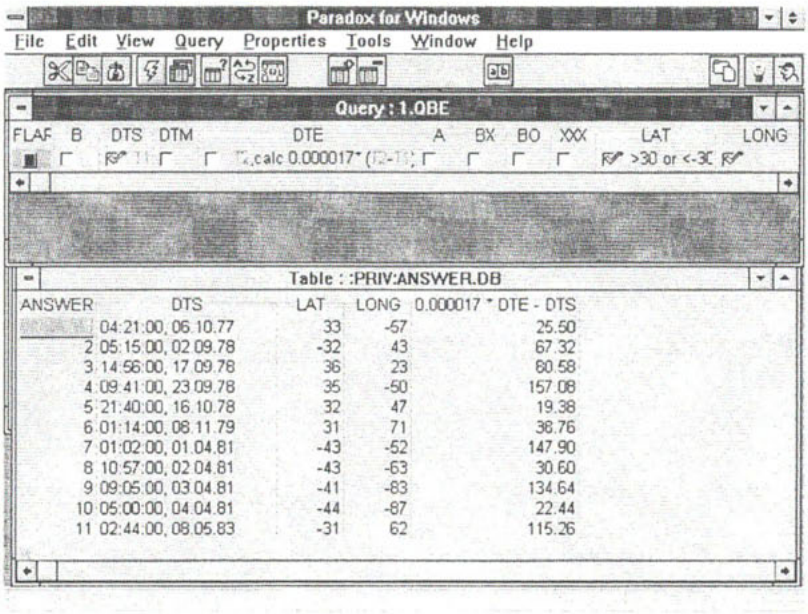


**Fig. 1.** Screen output of the table flare.db in PARADOX formatted presentation.

flare and selecting the start moment, its latitude and longitude, is shown on Fig. 2.

As a result of the fulfillment of this query, a table "answer.db" presented on the bottom part of Fig. 2 is created. For selecting the data from several files simultaneously, it is necessary to use the opportunities of the programming language ObjectPAL, which is a very powerful tool for the end user. For typical problems of scientific researches it is enough to master only one of the ObjectPAL objects – the so-called script. Script is a separate file in which ObjectPal instructions are written down and is similar to a usual program of a high level language (Pascal, C). Therefore the person familiar with programming in any of these languages can learn to write script in a few hours. To facilitate writing one's own programs a few template scripts (programs) for typical problems arising during the work with such data are available. These programs are supplied with detailed comments and can be used as a pattern for the creation of the

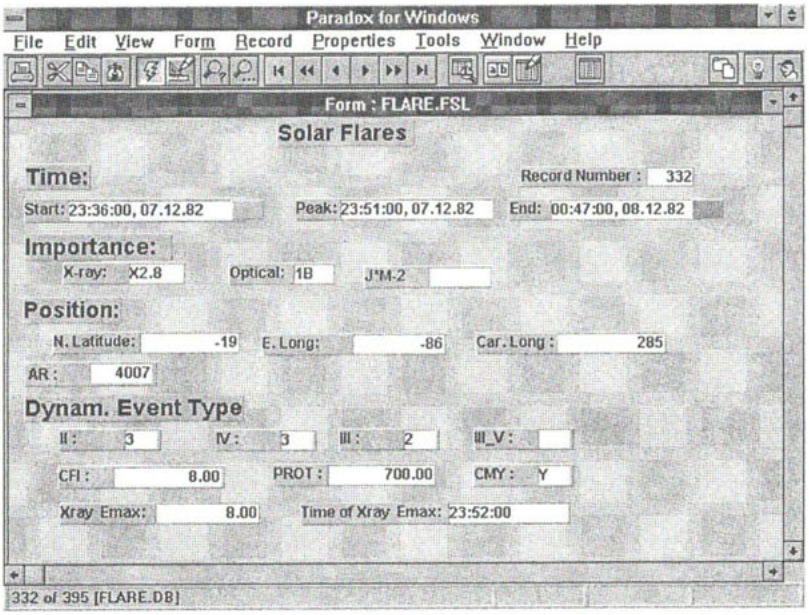


**Fig. 2.** Query for data selection (upper panel) and result of running this query (lower panel).

new scripts. The program: (a) creates a new table (flaressc.db) for the flares satisfying the given condition, (b) chooses from the table (flare.db) the start moment of the flare and its coordinates, and (3) selects from the table (ssc.db) the moment of SSC and calculates the delay of SSC from the start moment of the flare.

The database is a part of the computer version of the technique of the geoeffective solar event forecast (Ishkov 1998). It is an expert system, for which the current input data come directly from the Sun Service NOAA by INTERNET (or by any other accessible communication means). The system allows manual input of the initial data received from direct observations of the Sun or from the current database. Block diagram of the system consists of: BC – the block of communication and reception of primary data; BSSD – the block of solar situation display and issuing of the "background" forecast; BF(FL) – the block of realization of the forecast of large solar flares; DB – the database of disturbances in the Earth's space environment

and their sources on the Sun; BF(GS) – the block of geomagnetic disturbances forecast; BF(SPE) – the block of the solar proton forecast; BF(SID) – the block of the sudden ionospheric disturbances forecast.

The method of solar flare prediction for large and proton solar flares has been tested on Russian scientific satellites such as GRANAT, GAMMA, and KORONAS-I. The method of geomagnetic storm prediction has been tested on medical-biological experiments in 1996–2000. The forecast (in Russian version) is presented on the site:
http://www.izmiran.ru/space/solar/forecast.html

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