Development of the information system for vegetation cover condition tracking with the help of data provided by VEGA-Science service

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Abstract. The article describes the development of an information system that is supposed to be used to aggregate information obtained from the VEGA-Science, with use it to track the state of agricultural fields. The developed information system uses information technologies to design client-server applications using databases for the .NET platform using programming languages, such as C#, Python.

1 Introduction

In the last decade, a rapid growth of information systems for various purposes using data from satellite systems of remote sensing of the Earth (ERS) has been trending upward. Based on ERS data, statistics for the state of natural resources and the development of territories are updated [1], volcanic activity is monitored [2-3] and a host of other things. The expansion of the use of ERS data is primarily connected to the large-scale development of ERS satellite systems and the improvement of the quality of the information received from them [4]. At the same time the constant volume growth of the incoming data requires the formation of up-to-date software and information systems for processing and analyzing of available data for various fields of activity.

2 Materials and methods

The data sources are diverse information systems providing access to satellite data. On of the leader of such systems is Earth Engine system founded by Google [5]. Earth Engine is a cloud platform that guarantees access to a variety of satellite images and geospatial data collection with a volume of several petabytes. The authors of the system claim [6] that system users can analyze processes on a planetary scale. In Russia, the VEGA-Science system [7], created in 2012 by employees of the Space Research Institute of the Russian Academy of Sciences (SRI RAS), is a serious competitor to the Earth Engine system. The

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VEGA-Science system enables online access to the ultra-large-scale SRI-Monitoring archives of the Research Equipment Sharing Center [8].

The formation and development of the VEGA-Science service brought about a large number of scientific and practical studies carried out on the basis of information received from it [9-13]. The researchers gave special attention to solving problems related to data analysis for agricultural facilities. It was caused, to a large extent, by the Russia's policy aimed at developing agricultural activities and ensuring the country's food sovereignty. In 2010, the Russian government set up The Concept for the Development of State Land Monitoring [14]. Nowadays, work on the development of an information support system in the field of agriculture with consideration to the transition to domestic equipment for Earth remote sensing is continuing [15-20].

The information accumulated in VEGA-Science databases is used for further analysis and forecasting. The authors have developed a software and information concept that can be considered as an add-on to the VEGA-Science service, which, according to available time series of indicators, such as temperature, soil moisture, etc., (Figure 1) allows to forecast the yield of a specific crop in the region.

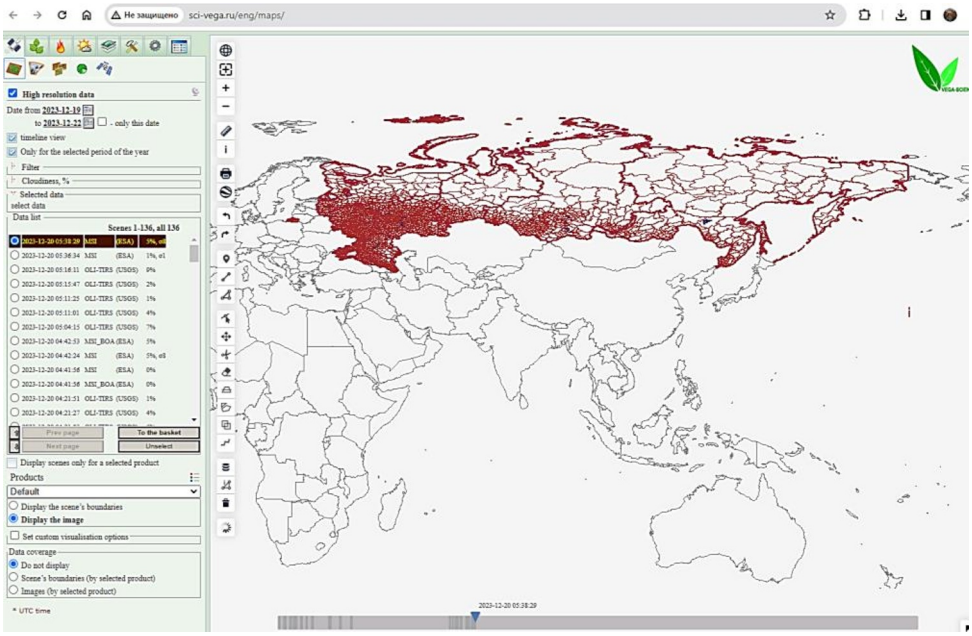

Fig. 1. VEGA-Science Web resource.

3 Results and Discussion

3.1 Task definition

According to the results of the analysis conducted by the authors of the work, it was established that most of the scientific research in the field of agriculture, mining, water and environmental problems is based on the descriptive method or on the methods of field studies. Nevertheless, currently there exists a certain set of tasks for which these approaches are not applicable. These are, for example, the tasks of forecasting, condition assessment, remote monitoring, and recognition of satellite images. It is necessary to apply

mathematical tools using both conventional statistical methods and neural network approaches for solving such problems.

Methods for assessing the condition of various types of vegetation, including agricultural vegetation as well, are used in the work of specialists from the Space Research Institute of the Russian Academy of Sciences [21]. An approach based on the analysis of the deviation from the "norm" of the temporary observed course of vegetation indices (VI) for specific objects and regions is proposed as a solution. Data on remote (satellite) monitoring is used in this work.

The publication [22] contains the description of the development of a new locally adaptive image classification method LAGMA (locally adaptive global algorithm of mapping) to meet the requirements of mapping the land cover over large areas using remote sensing data.

Chinese scientists in their work [23] demonstrated a way to solve the problem of studying the molecular basis of the content of soy protein and oil in seeds for marker-based selection of high-quality features.

As it appears from the review presented above, both in Russia and abroad there is a demand to apply mathematical modeling methods to solve problems arising in agriculture, mining, ecology, etc. To solve these problems, the authors have developed a software concept project that implements a range of mathematical modeling methods allowing to forecast and identify correlation dependence between the studied specifications.

The necessity of the presented development lies in the fact that, firstly, most mathematical modeling programs are designed to solve a narrow range of problems; secondly, in most of the studied works the authors use improvised methods to perform calculations, i.e. at present there is no total solution that allows domain experts to perform calculations for typical tasks relatively easy.

The information system developed by the authors consists of two parts: a module that implements a graphical interface and modules containing business logic for performing modeling tasks.

From the very beginning, the solution being developed was created as a software concept that did not depend on the type of input data — the user selected data for research and conducts numerical experiments without exterior help. The database is used as the main source of information in the current version of the software concept, it guarantees at the same time a high compression ratio of information to save hard disk space and fast operation speed when accessing large amounts of data.

High computational performance in modeling complex processes is achieved by parallelizing calculations by applying frameworks, such as CUDA or OpenMP.

3.2 Information system architecture

To implement the functionality of the software package the C# and Python programming languages are used [24-25]. The modular principle was used in the development, one of its advantages is the ability to save computer resources by connecting only those modules that are currently in use. The interaction diagram is presented in Figure 2.

Since the purpose of the software concept is the processing and analysis of data provided by the VEGA–Science system, the first stage of the development was the creation of a module for uploading data from the VEGA-Science server. There has been created a database for data storing, the architecture of which is presented in Figure 3. In this case, the relational DBMS SQLite is used to accomplish the tasks set.

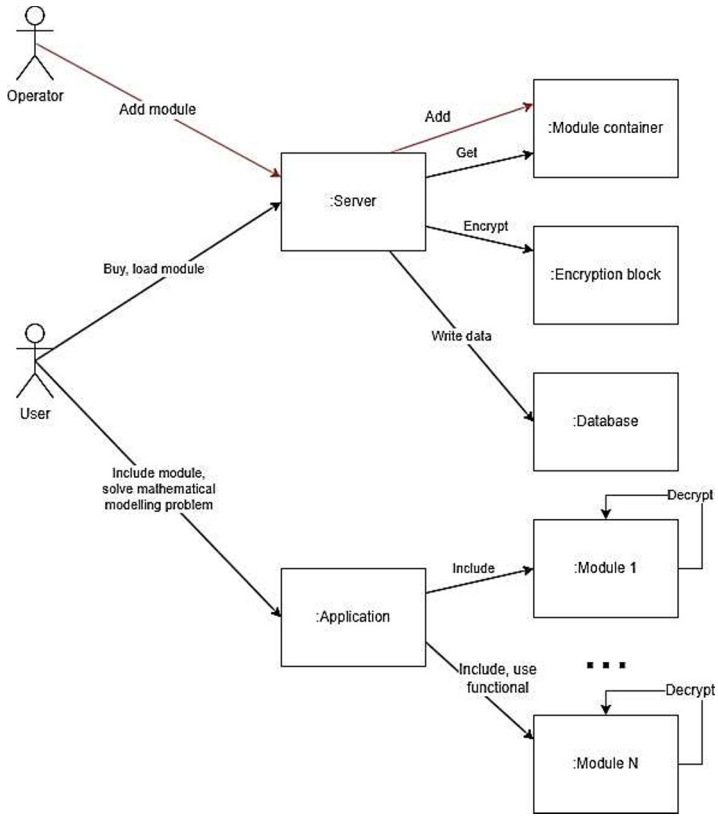

Fig. 2. Object interaction diagram.

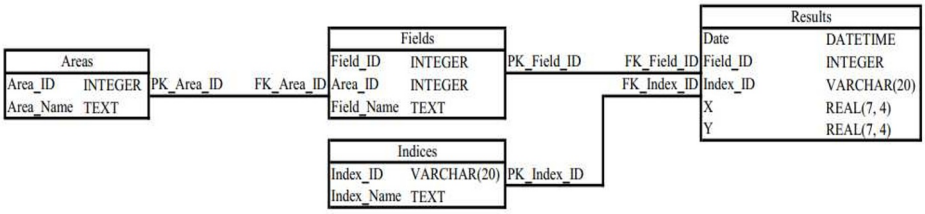

Fig. 3. Database architecture.

The database consists of four tables: Areas, Fields, Indexes, and Results. The Areas table consists of an integer field Area_ID, which is the primary key, and a field of string type Area_Name. The Areas table contains entries about regions to exclude the possibility of searching for dependencies for indicators obtained from fields of different regions. The Fields table shows records about the studied fields in a specific region. The association between these tables is implemented by the "Area_ID" field.

The VEGA-Science system contains information on more than 50 indicators ensuing from ERS data processing. The Indices table shows data on the indicators available for research, obtained from VEGA-Science. An example of the available indicators is introduced in Figure 4.

	Index ID	Index Name
1	ndvi_7dc_modis_int	7-days NDVI
2	ndvi_4dc_modis_int	4-days NDVI
3	ndvi_1dc_modis_int	1-day NDVI
4	ndvi_hrsat	NDVI on high resolution data
5	ndvi_by_ch	NDVI by channels
6	pvi_7dc_modis_int	7-days PVI
7	pvi_4dc_modis_int	4-days PVI
8	pvi_1dc_modis_int	1-day PVI
9	nir	Spectral brightness coefficient (NIR)
10	red	Spectral brightness coefficient (RED)

Fig. 4. The first 10 entries in the Indexes table.

Users of the system can specify which particular data they will use in the analysis (Figure 5). The Results table stores date and time-ordered values for each indicator.

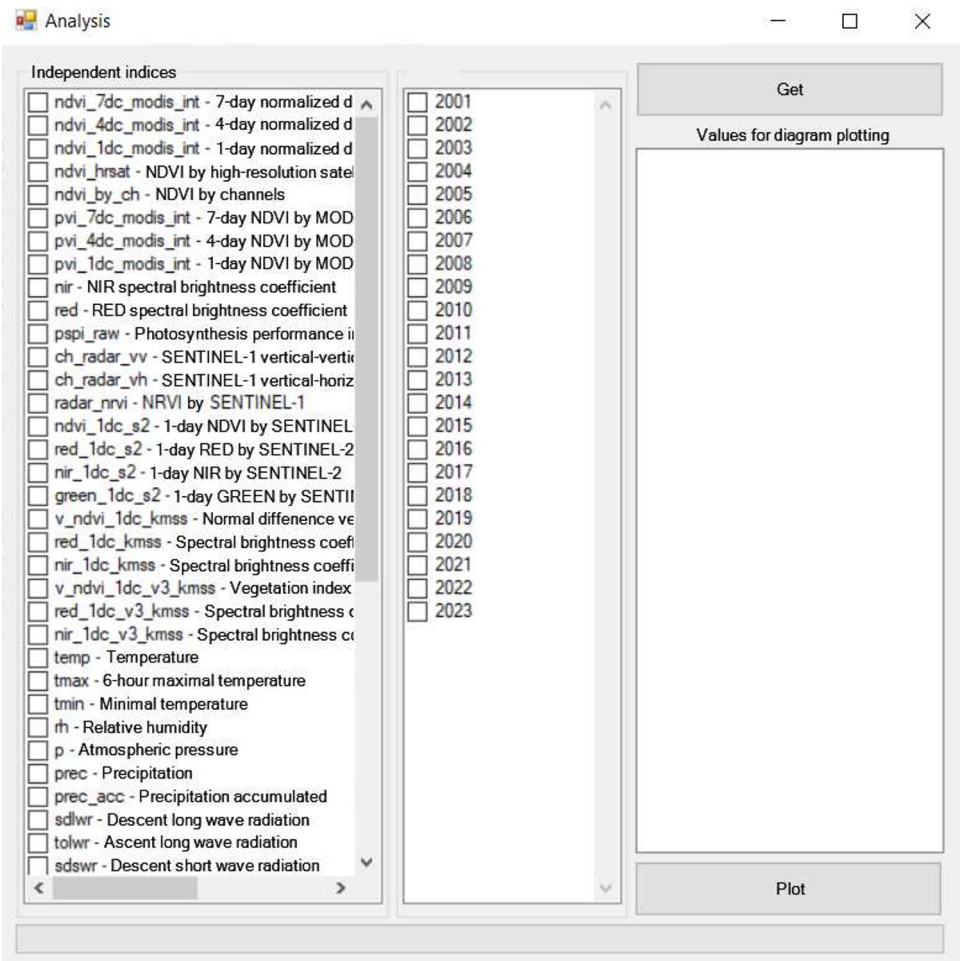

Fig. 5. Data loading module.

Since the VEGA-Science data is transmitted to the client in JSON format, the authors implemented the function of converting data into a database format (Figure 6). Information is stored as a "key-value" pair in JSON format. In this case, the key is the line $xy[i]$, and the value is a pair of numbers ($x[i]$, $y[i]$), where $x[i]$ is the command box used further for element comparison, and $y[i]$ is the indicator value. To get (deserialize) data, a set of operands of the Get() method of the FromServer class is used. The transition from the values of the command box $x[i]$ to the date and time values is carried out by comparing them with the values obtained by the labels key.

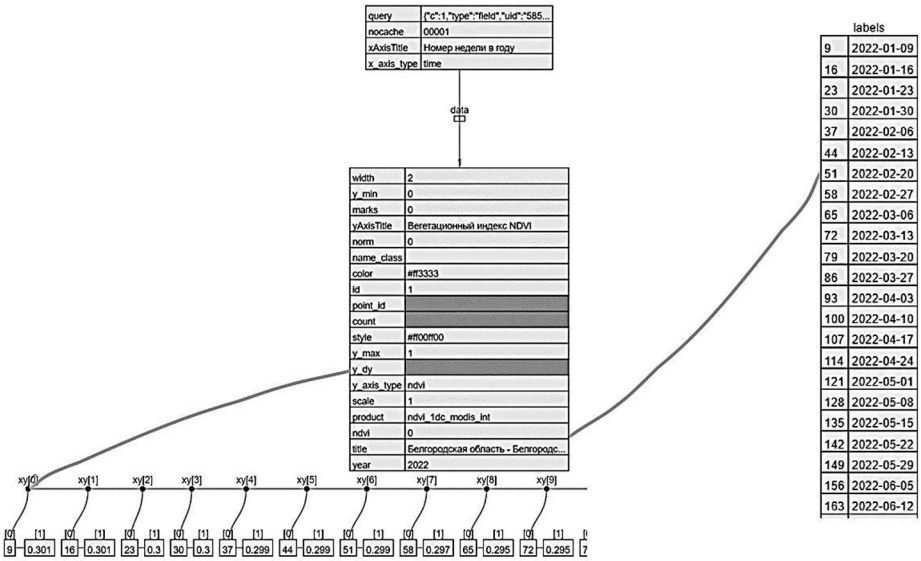

Fig. 6. The structure of the JSON file transmitted to the client (keys "xy" and "labels").

As noted earlier, the system under design has a variety of advantages over similar programs. One of these advantages is modularization. The user can enable only those functions that are currently in use within a single session. This approach reduces the load on the computer computation power, thus, the total performance of the information system will increase ultimately.

4 Conclusion

In the article, the authors have presented an argument for the need of development of an information system that can be used for solving mathematical modeling problems in relation to the domain of agriculture, mining, water and environmental problems.

The description of the architecture of the software concept, the purpose, and the structure of individual elements, such as a database, has been presented. There have been given reasons for the technology choice.

A special feature of the information system being developed is the modular architecture. It means that within a single session the user can enable only those functions that are in need at the moment. Thus, this system can be easily modified by adding new mathematical methods required for operation. In addition, it ensures optimal performance and consumption of computing power.

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