IT Tools for Managing Ecological Hazards

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Abstract. The development of modern IT tools is a key vector of development in the management of natural hazards and geosciences. Thanks to the creation and implementation of geographic information systems (GIS) and technologies, monitoring of the area is greatly facilitated and the accounting of natural resources becomes streamlined. Geoinformation systems allow to take into account the social and environmental situation, accurately determining the qualitative and quantitative characteristics, structure, and location of objects. This allows the authorities at different levels to develop social infrastructure most effectively and correctly locate objects of it. In addition, geographic information systems are very effective for determining the location of an object. The requested information is provided in the form of detailed maps with additional details in texts, graphs, and diagrams. GIS tools are not a single program, but a package of programs, they have different interfaces and capabilities of working with data. Usually, the one that is best suited for the task is selected from this software package. An example of the choice of effective tools and related research in work with BigGeoData are presented in the article about aero monitoring use case.

1. Introduction
The main goals of modern geomonitoring are aimed at providing timely and reliable information that allows to:
- assess the indicators of the state of the ecosystem and the human habitat;
- identify the reasons for changes in these indicators and assess the consequences of such changes;
- identify corrective measures in cases where environmental targets are not met;
- create the prerequisites for determining measures to correct the negative situations that arise before the damage is caused.

The system of monitoring of dangerous natural processes is designed for continuous monitoring of the state of objects of observation: hydrogeological (rivers, reservoirs), endogenous geological (earthquakes) and exogenous geological (ground displacement in landslide-prone areas). Each of the monitoring systems is autonomous and interacts only with its own peripheral monitoring posts located in potentially dangerous areas (territories).

On the territory of the Russian Federation, there are a number of systems for monitoring environmental pollution and the state of natural resources. The formation of a unified state environmental monitoring system (USEMS) plays an important role in the state environmental management system in Russia.
USEMS includes:
- monitoring of sources of anthropogenic impact on the environment;
- monitoring of pollution of the abiotic component of the environment;
- monitoring of the biotic component of the environment;
- social and hygienic monitoring;
- ensuring the creation and operation of environmental information systems.
- monitoring, assessment, and forecast of the state of the environment;
- information support for environmental protection and environmental safety management bodies, as well as for all levels of the automated information and control system "Ecobesafety of Russia", information support for all levels of management structures and automated information and control systems of federal executive authorities that need environmental data;
- creation and maintenance of data banks of environmental information accessible to a wide range of consumers engaged in practical activities and scientific research in the field of environmental protection and environmental safety;
- implementation of a unified scientific and technical policy in the field of environmental monitoring.

To achieve these goals and objectives, it is necessary to use integrated information and analytical models and a system of qualitative and quantitative methods and tools [1-5].

2. Analysis of monitoring tools
Using static data from various monitoring sources. You can analyze the geoecological risk and influence the outcome of the upcoming event.

With the help of aerial surveys of the earth's surface, you can determine various georisks. For example, with the help of UAVs (unmanned aerial vehicles), you can get an accurate image of various disasters. However, this method does not work in all cases, but only when such dangers do not interfere with the flight of these devices.

Space monitoring is a fairly relevant way to assess the risks to the earth. This is a system of modern analysis and control of processes occurring on earth using remote sensing. This method allows you to quickly identify accidents, catastrophes, and natural disasters of various types, control emissions of pollutants into the atmosphere, detect fire or deforestation. And also use the resulting statistics to predict upcoming events, especially in the field of geoecology. Space monitoring is a promising area, but now it is quite resource-intensive to launch and maintain such a remote sensing system (remote sensing of the Earth) [6-9].

The task of monitoring and forecasting natural risks can be solved by developing a database that tracks certain indicators that determine the probability of natural disasters, using the methods described above.

3. Database Model
The main feature of Project is an option for storing data of plane exhaust and calculating the influence of exhausts on the map.

According to the feature, the project requires storing two completely different data groups – results of the flights and technical characteristics of planes.

The exhaust depends on the model of plane, but under the effect of side factors (like wind speed, air humidity), flight data may be differ. Therefore, a recognition of the “averaged” exhaust model because of deviation from the main trend may be incorrect. According to all these moments, the decision of using a non-relational data storing model was accepted. The model has some significant advantages, like work speed, amount of occupied memory, and more suitable for working with large amounts of entities, which provides users with data about flights.

Two non-relational databases (DB) – Q_Flight and F_Flight provide users with differently filled data about flights. Q_Flight contains places of departing and arrival, fulfill of flight and a model of plane. F_Flight contains extra data from checkpoints of flight.
In this case relational DB was not suitable, because a division of every entity into many related tables would be unnecessary complication slowing the counting process down because of increase of address to other entities inside DB.

Information about characteristics of planes is required for exhaust calculation. Now characteristics of planes are divided into two categories to simplify calculating and adapt them to The International Formula. The first group consists of the main values of planes, such as Name, amount, and the model of engines. The second group consists of the sizes of each plane. These groups can be shown as structured and linked entities, and for this reason the relational data storing model can be suited for storing data. The other advantage of the model is a modernization potential. For example, a table containing information about engines can be added into the DB.

4. Data normalization

It is stated to use DB of planes as an example of normalization process (Figure 1). The main trends of this will be similar to DB of airfirms.

![Figure 1. The starting diagram.](image)

Converting an ER diagram into a database scheme is performed by matching each entity and each link that has attributes to a database table. A 1:n (one-to-many) relationship between tables is implemented through a foreign key. The foreign key must match the primary or unique key of the primary (parent) relationship.

The main attributes for each table – Figure 2.

![Figure 2. Normalization process.](image)

1) The relation is in 1Normal Form (NF), if all its attributes are simple, all domains used must contain only scalar values.

Table “Airplane model”: The engine attribute has several meanings - the number of engines and their model. Obviously, the number of engines directly affects the fuel consumption, so this attribute is divided into two mandatory ones: the engine model (varchar) and the number of engines (numeric).

Table “Sizes”: The Mass attribute has many key values that affect aircraft and emissions, such as cargo capacity and passenger capacity. It was decided to divide this attribute into three mandatory ones: mass (empty aircraft, numeric), carrying capacity (numeric), passenger capacity (numeric)
2) A relationship is in 2NF if it is in 1NF and each non-key attribute is irreducibly dependent on a Primary Key (PC).

In our case, all non-key parameters unambiguously depend on the Primary key, therefore, the Second form is observed

3) Eliminate end-to-end dependencies (Third NF)

In our database, there are no transitive dependencies, in which one attribute is indirectly dependent on another, therefore, the third NF is observed. In addition, it corresponds to a special case of the Boyce-Codd Normal Form, since there is only one potential primary key (PK) in a relationship - an artificial identifier ID. It is given because it is impossible to distinguish the name of the aircraft in the PK due to possible repetitions of the names. Also, none of the indicators of the size of the aircraft prevails over the rest, which means that there cannot be a PK.

4) Clarification of ambiguities (Fourth NF)

All non-trivial multivalued dependencies are functional dependencies on its potential keys, and it is impossible for any entity to depend on anything other than the primary key within its table. Therefore, 4NF is met.

5) A relationship is in Fifth Normal Form (5NF) if it is in 4NF and there are no complex dependent connections between attributes.

In the described case, each element dependent on each other are in different entities, therefore, the fifth normal form is observed.

5. Interface development

The data on carbon dioxide emissions stored in the model described above can be conveniently visualized in the form of a map with the designation of zones of different degrees of pollution obtained as a result of aircraft flights. This principle of database collaboration and visualization can be effectively implemented through web programming, which provides modern multifunctional tools in the form of an actively developing bundle: html, css, javascript -- which is supported by the most popular Internet browsers. In particular, to develop an interactive map, we used such a feature of the javascript language as the ability to work with JSON structures that participate in the process of transmitting data from the model using an AJAX request used to speed up the user interface. For example, information about 9004 flights is displayed on the interactive map in about 13 seconds, which can be considered a quick response to the request, given that 7 seconds are spent on drawing data and that indexing to the flight database has not yet been added, which, of course, is planned to be done in the future [16-25].

In addition to the advantages of visualization of geodata using web programming described above, we can also say that the browser solution is available to a larger number of users, which can potentially help popularize and commercialize the project. This is especially of current interest because of recent negotiations between economists and environmentalists on the introduction of a carbon tax not only in European countries but also in Russia. Thus, a web resource that effectively demonstrates data on aircraft carbon emissions can potentially be purchased, for example, as a consulting service by an airline or a government agency.

6. Conclusion

The modern transformation of the geospatial industry for the purposes of the digital economy – expansion of the range of fundamental and applied research, development of technologies for solving problems of planning and making operational decisions, integration, management, analysis, dissemination, and use of geographical, temporal and spatial information and knowledge.

A modern specialist must be prepared for the continuous perception and development of new areas of activity, complex knowledge, and practical skills in a wide scientific and technological spectrum [26-43].

The considered tool solutions for use in the field of geomonitoring of carbon dioxide emissions by aircraft at this stage of development already shows its practical effectiveness according to conceptual
testing, which is determined by the work of a given version of the database and key indicators, the speed of response from it and user reports, as well as analytics in working with the interface. However, these indicators still need to be improved, which is the goal of further development stages.

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