New technologies of 2-D & 3-D modeling for analysis and management of natural resources

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SSC VNIIGEOSYSTEM

The state scientific center of Russian Federation VNIIGEOSYSTEM specializes on scientific, methodical and technological support of the effective solution of problems of environmental management.
More than 50 years we are engaged in the solution of applied tasks in the field of geological studying of a subsoil, mining, environmental protection; development of software products for implementation of similar projects; carrying out educational actions in these subject domains.

Laboratory of Geoinformatics

It is created in 1989 for the purpose of development of the geoinformation technologies focused at the solution of research and management problems of geological studying of a subsoil and environmental protection.
Today the laboratory has rich scientific and practical potential. The staff of laboratory makes 82 employees, 22 from which have an academic degree. Average age of employees is 35 years.

Laboratory of Geoinformatics

For ensuring technological support of research and administrative activity in the sphere of environmental management we developed a specialized modular program complex. Its components provide realization of three main stages of any monitoring project:

IAS CONSTRUCTOR

effective management of data and constructing of information and analytical systems of various complexity

GIS INTEGRO

complex analytical processing of spatial information and solution of expected and diagnostic tasks

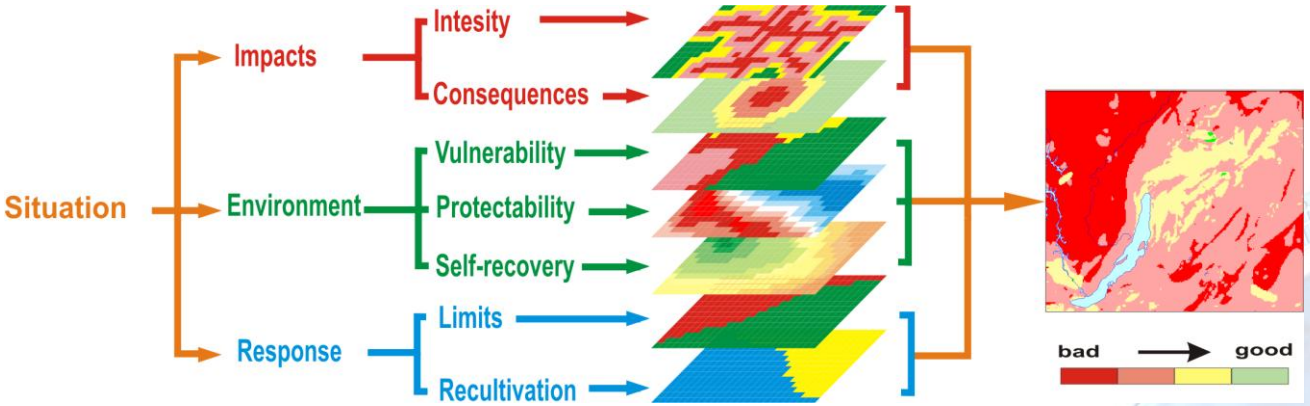
MGS SERVER

operative integration and visualization of data and results of researches as web-GIS applications

The special attention in developing a program complex is focused to creation of convenient and effective tools for creation and visualization 2D and 3D models providing the solution of tasks of the analysis and management of natural resources

Techniques of situation modeling:

Situation modeling – spatial assessment of ingenious and endogenous factors identifying of current (or prognosis) state of the ecosystems:



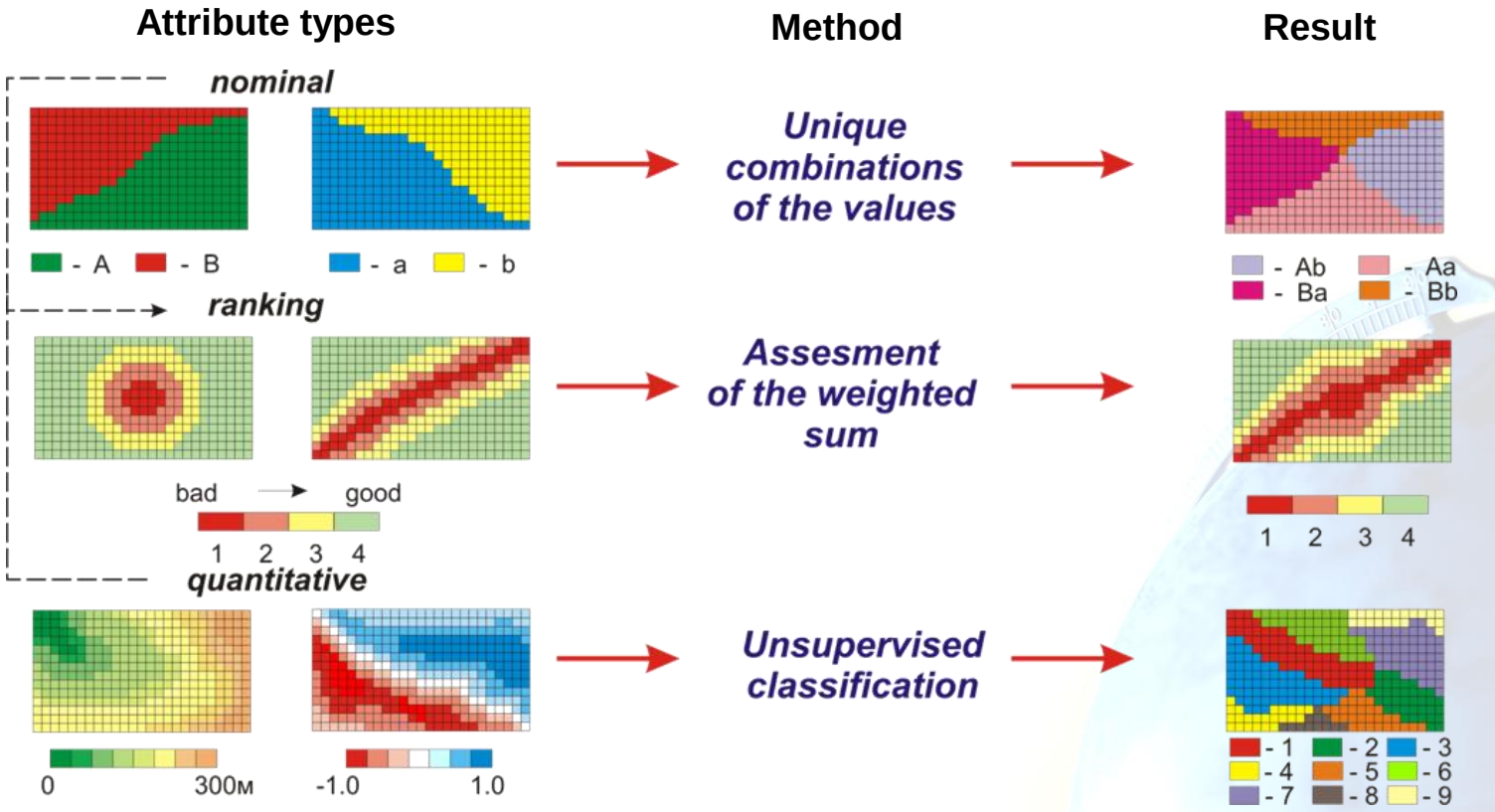
Model factors = formal characteristics of the analyzed processes: quantitative values, ranking estimates or semantic descriptions

Target function = an integrated assessment of a vector of values of the model factors for each elementary site (cell) of the territory

Techniques of situation modeling

Functional dependences for the target function calculation

1. Calculation of "coincidence" models for assessment of static situation:



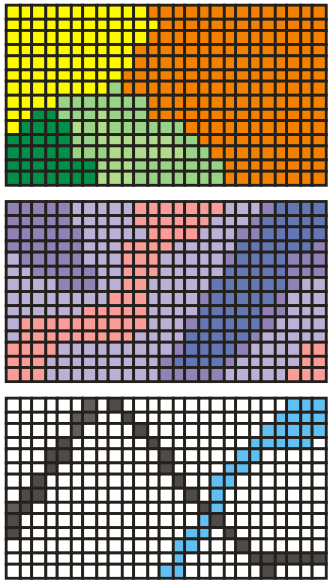
Techniques of situation modeling

Functional dependences for the target function calculation

2. Calculation of “dispersion” models for estimation of dynamic situation:

Static factors:

The properties of the environment defining nature of distribution of process

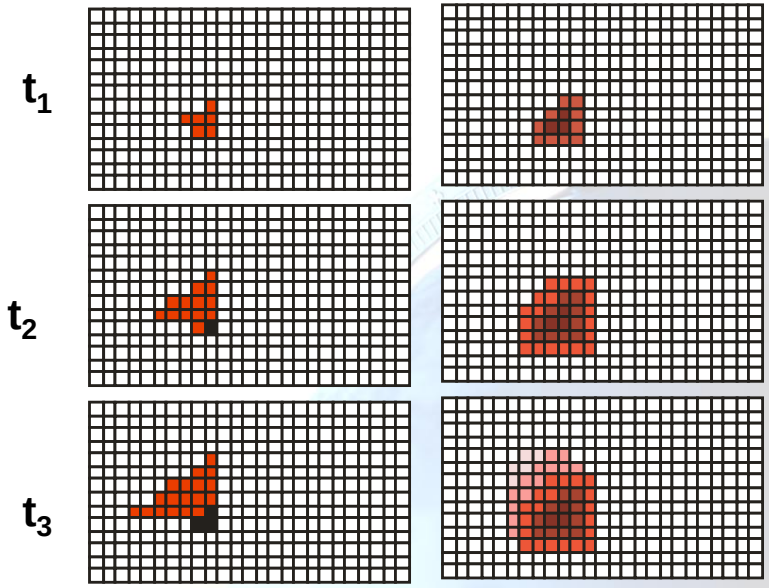


Dynamic parameters:

- *Start point*
- *Main direction*
- *Start volume*

Result:

Process evolution or process intensity from t1 to t3



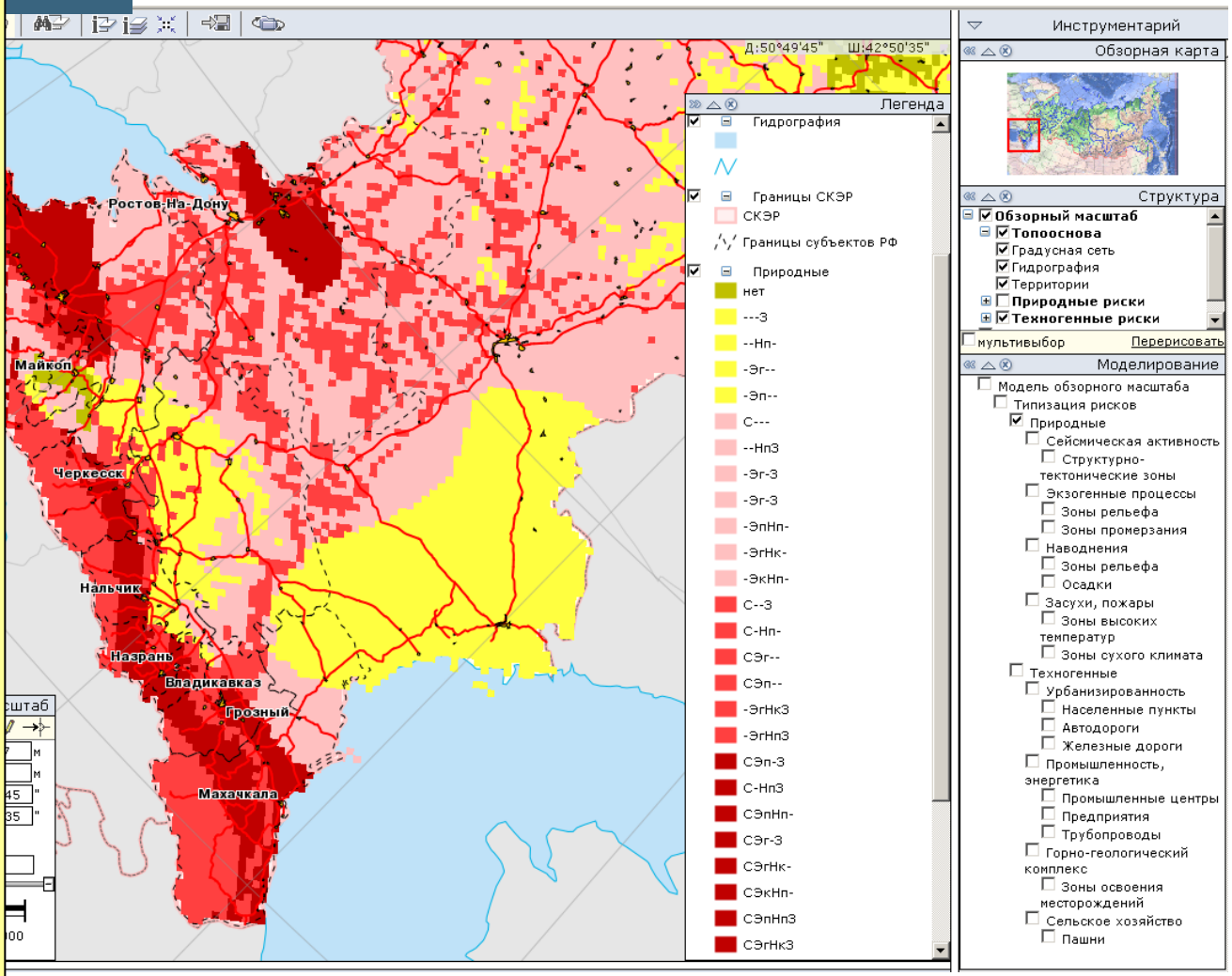
2-D SITUATION MODELING

Analysis of natural and technogenic hazards
Russian Federation, Scale 1:5000000

Model factos:
Natural hazards
- Seismicity
- Exogenous processes
- Floods
- Droughts
- Forest fires

Technogenical hazards
- Social
- Transport
- Industrial
- Mining
- Agricultural

Results:
The model allows to get a set of the most probable natural and technological hazards in the specified point



The project was funded by Governmental Programm "Scientific and pedagogical reinforcement of innovative Russia" 2009-2013

2-D SITUATION MODELING

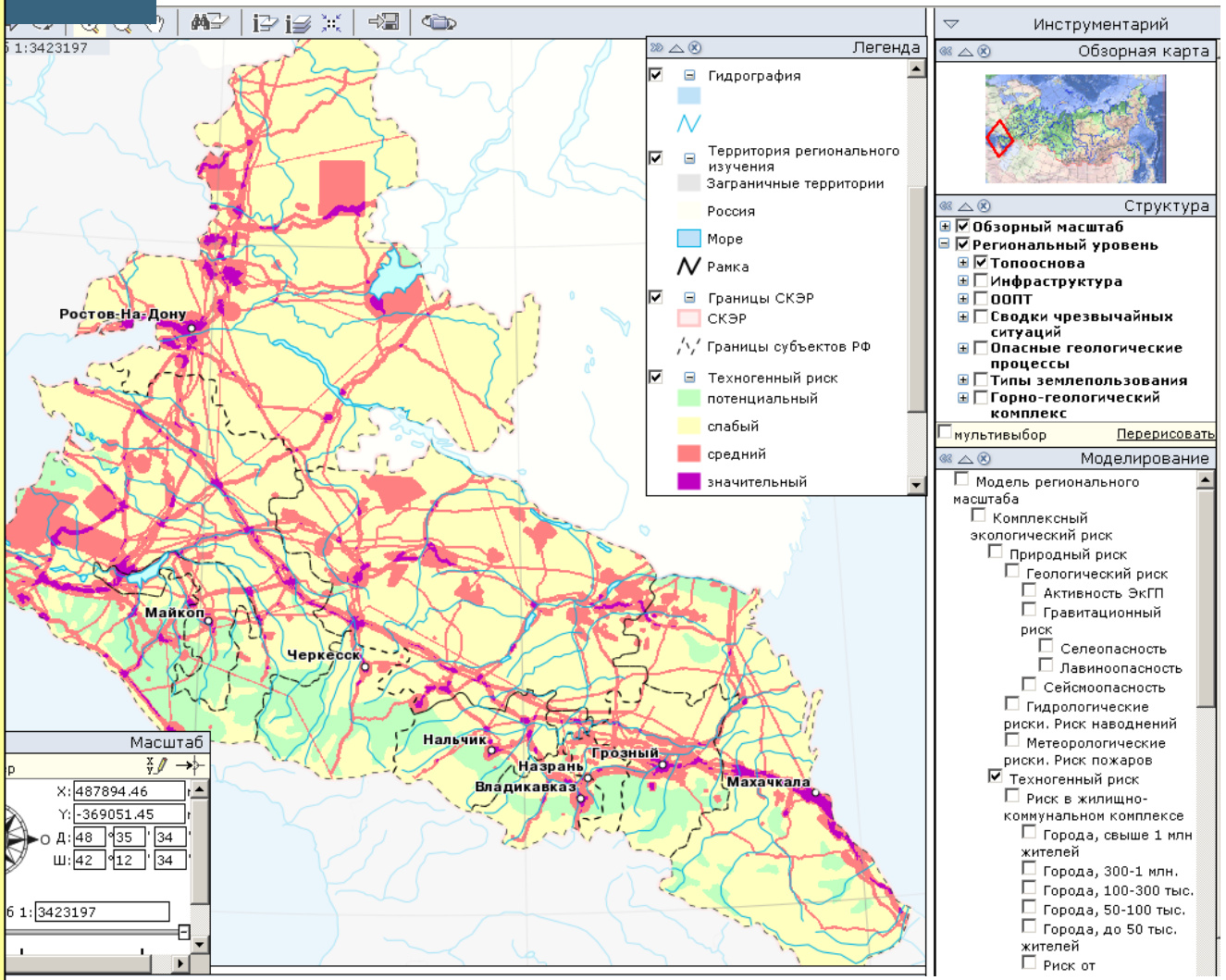
Estimation of complex ecological risk
Northern Caucasus Region, Scale 1:1000000

Model factors:
Natural risk
- Geological
- Hydrological
- Meteorological

Technogenical risk
- Population density
- Road density
- Danger industrial objects
- Zones of intensive mining explorations

Results:
The model allows to localize zones of the increased danger where manifestation of risk factors most probably, and intensity is highest

The project was funded by Governmental Programm "Scientific and pedagogical reinforcement of innovative Russia" 2009-2013



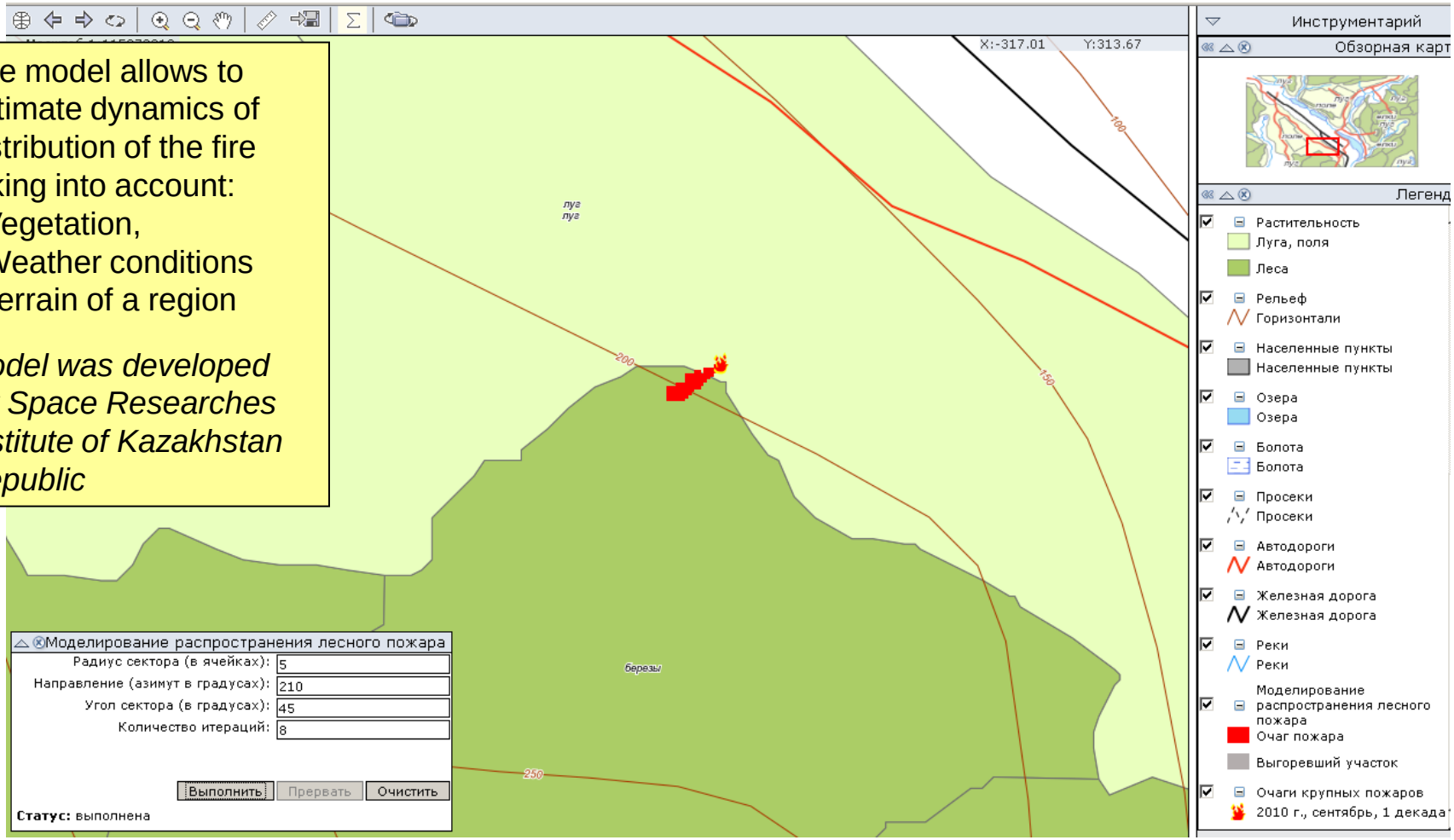
2-D SITUATION MODELING

Modeling of a forest fire distribution

The model allows to estimate dynamics of distribution of the fire taking into account:

- Vegetation,
- Weather conditions
- Terrain of a region

Model was developed for Space Researches Institute of Kazakhstan Republic



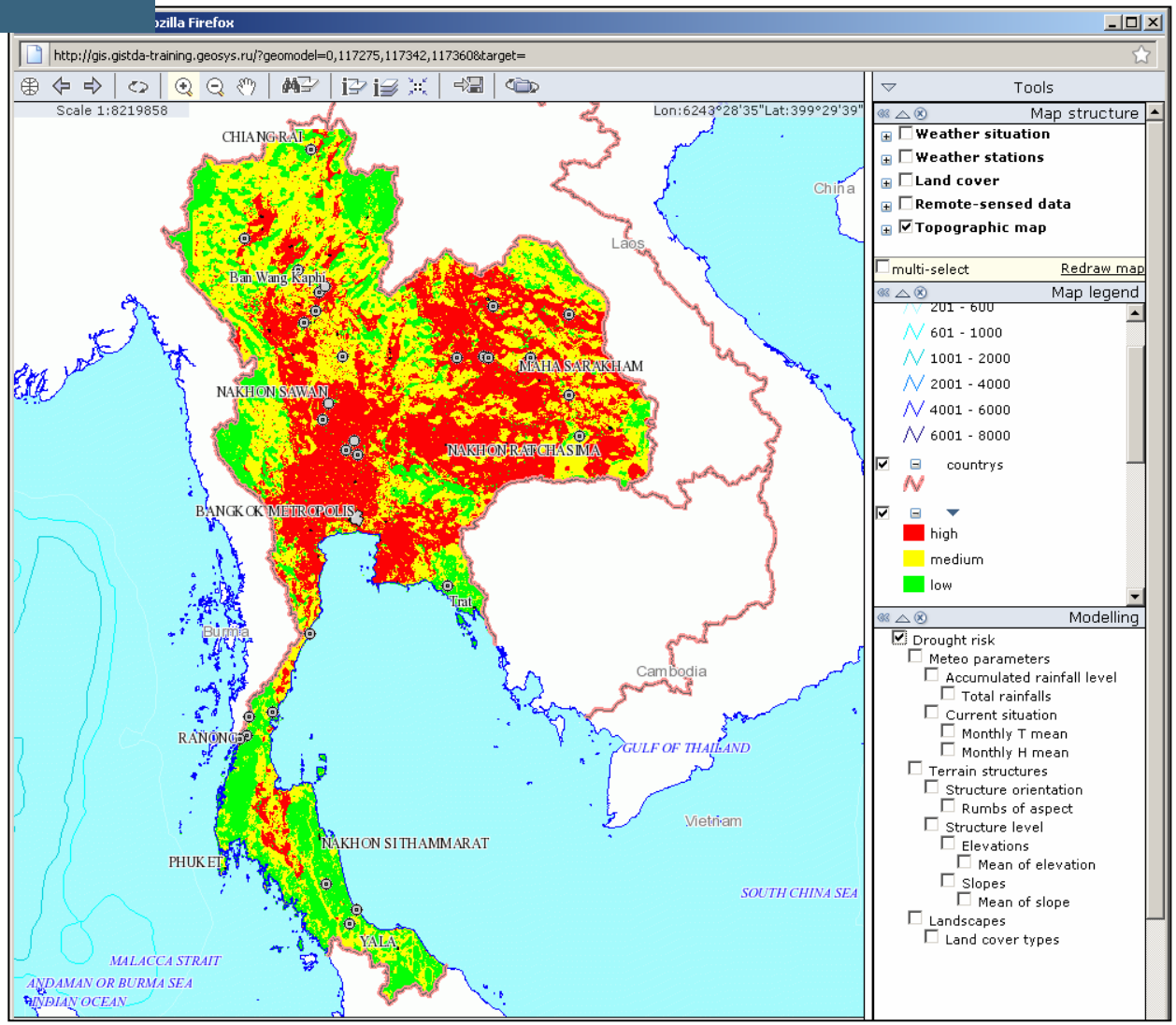
2-D SITUATION MODELING

Modeling of drought/flood risk
Scale level: Thailand, 1:1000000

Model factos:
Meteorological parameters:
• Total volume of rainfalls for last monsoon season
• Current humidity
• Current temperatures
Landscape factors:
• Vegetation
• Terrain

Results:
The model allows to localize zones of the low, medium and high risks of drought for the chosen month of year

Model was developed for Geo-Informatics and Space Technology Development Agency of Kingdom of Thailand



Support of decision-making process

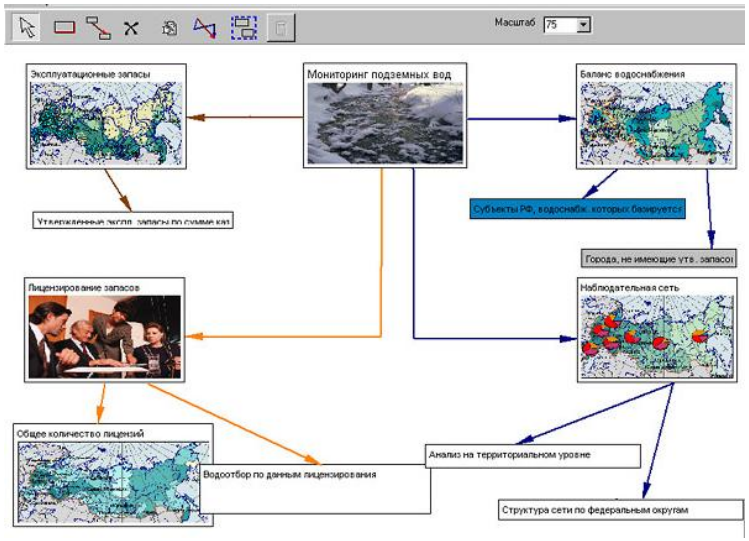
IAS Constructor

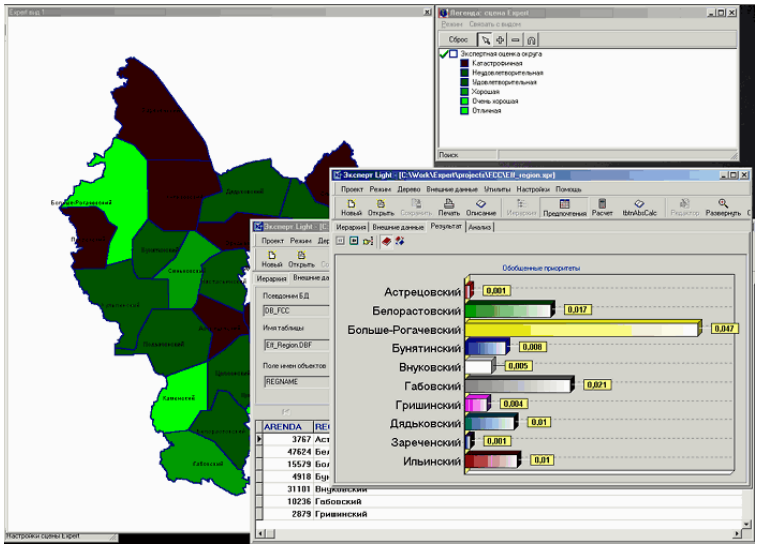
IAS CONSTRUCTOR

Support of decision-making process is based on the development of applied computer system providing tools for data storage, analysis and presentation.

Our technological platform allows:

- **to develop a data base structure**
- **to design a desktop or web application for data management without a need of writing of program code**
- **to provide advanced data aggregation, processing, and analysis tools (incl. OLAP, Data Mining, Decision Support Systems)**
- **to visualize thematic objects using built-in spatial data support or the third-party geo-information systems**



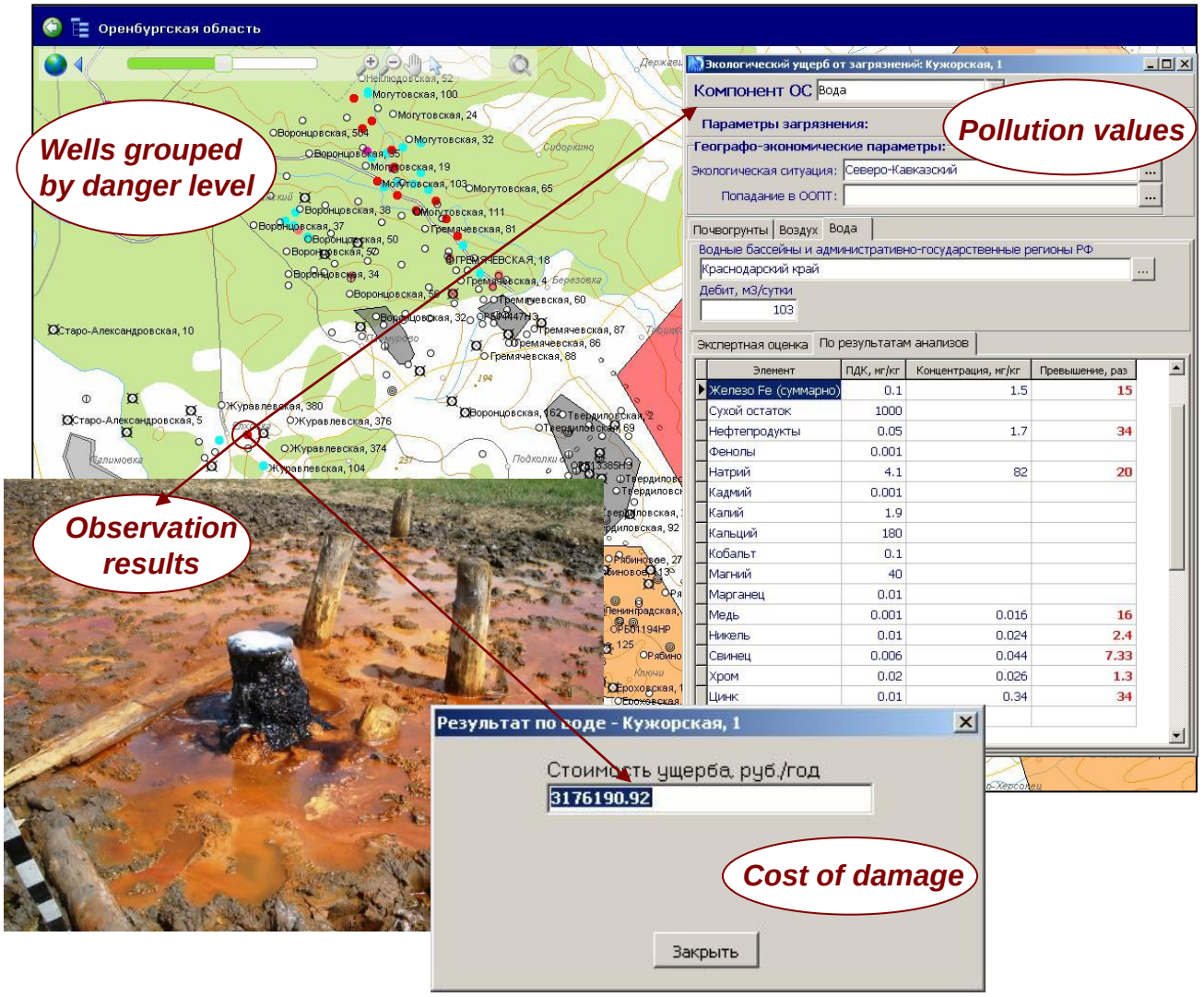


Support of decision-making process

IAS Constructor

Database of the system includes more than 90000 Russian wells and monitoring data: technical parameters and results of pollution observations (water, soil, air).

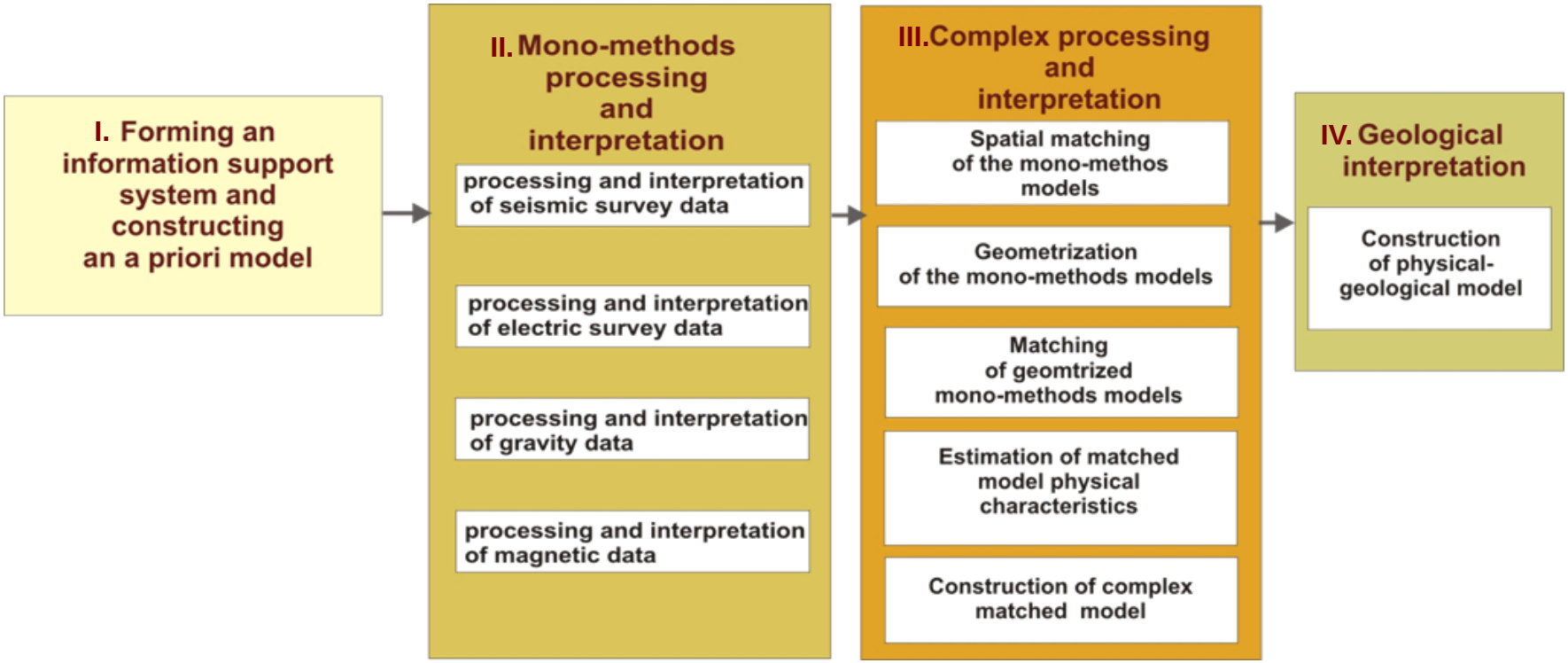
Analytical tools of the system allows:
- **to range the wells on danger level**
- **to calculate the cost of ecological damage in rubles per year**
- **to compare the cost of ecological damage to the cost of liquidation of this well.**



GIS FOR 2D & 3D GEOLODICAL AND GEOPHYSICAL MODELING

Original technology of the 2D and 3D geological and geophysical modeling is based on the integration of geo-data from all sensor levels on the Earth: space – airborne – surface – borehole studies.

Basic technology stages of complex model construction



Technology of complex model construction

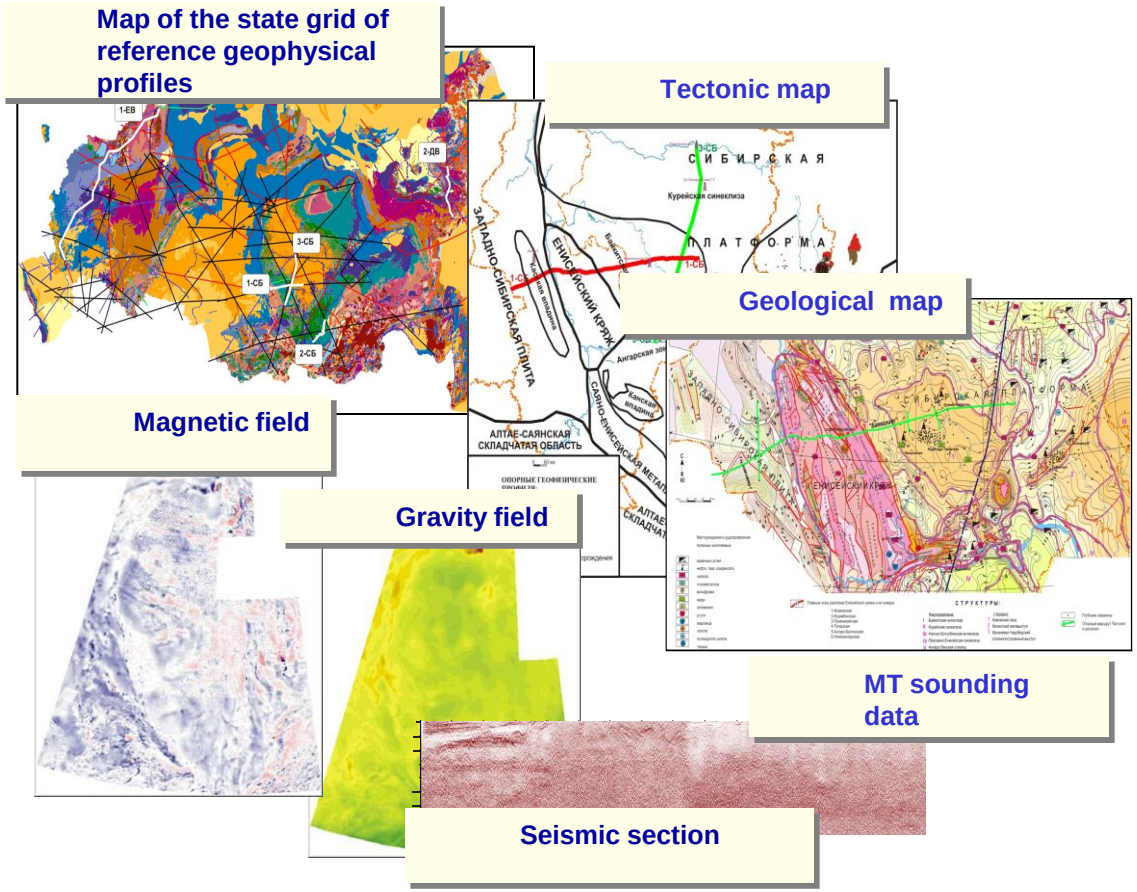
I. Forming the informational support and constructing an a priori model

Geological-geophysical database contains:

- •geophysical fields,
- •geological, topography and tectonic maps,
- •geological cuts,
- •well data,
- •petrophysical data.

A priori geological territory structure model is formed on the base of:

- • analysis of the available geological-geophysical information
- • modern Earth evolution concepts



Technology of complex model construction

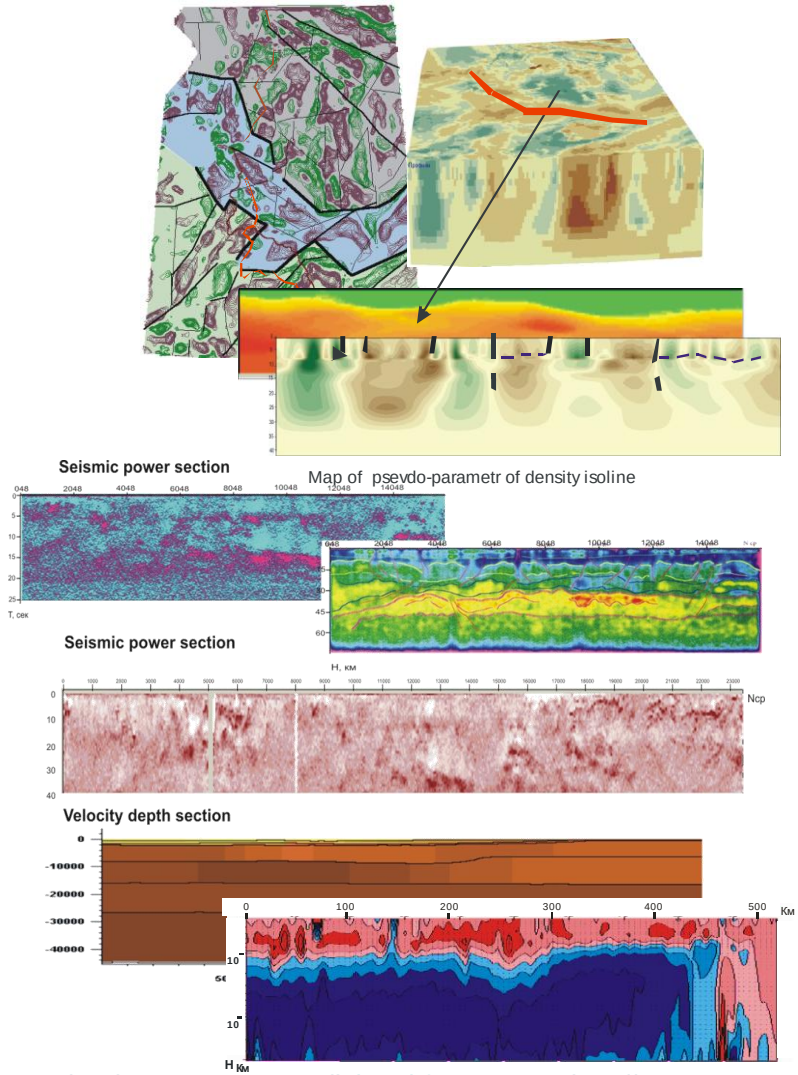
II. Mono-method processing and interpretation

Processing and interpretation of the gravity and magnetic survey data

- Preprocessing (interfering filtration and isolation of the useful component)
- Area processing (fields zoning, tectonic breaches isolation)
- Forming 3-D models of the effective sources distribution
- Forming models of the effective parameters distribution by the chosen linear cut
- Effective density model reduction to density model

Processing and interpretation of seismic and electric survey data

are carried out using specialized software applications



Result of this stage : ***various modifications of the seismic, gravitational, electrical and magnetic models along the seismic regional profile***

Technology of complex model construction

III.1 Complex processing and interpretation

Spatial matching of the mono-methods models

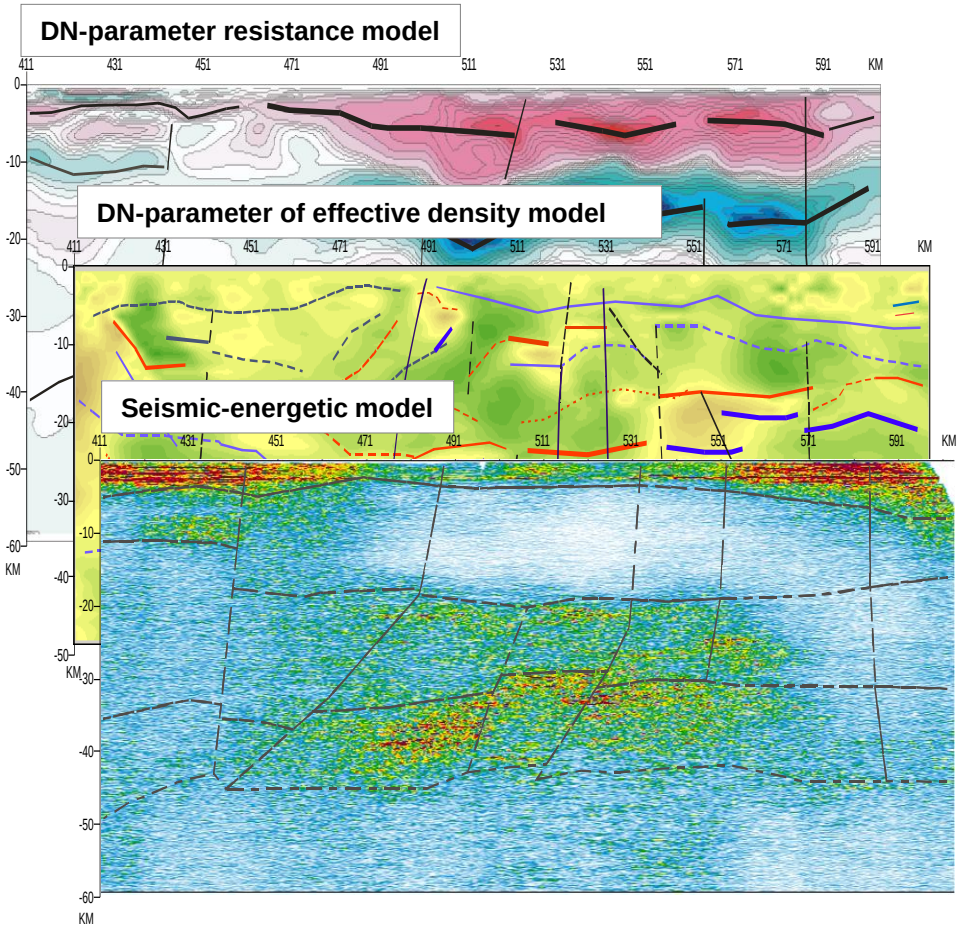
- projecting methods models on common profile
- scaling models by the Z-axis

Geometrization of the mono-methods models

- calculating differentially-normalized parameter (DN-parameter)
- tracing of DN-parameters extremes

***Stage result*：**

contrast borders of blocks and contact planes, identified on seismic, gravitational, magnetic and electrical models



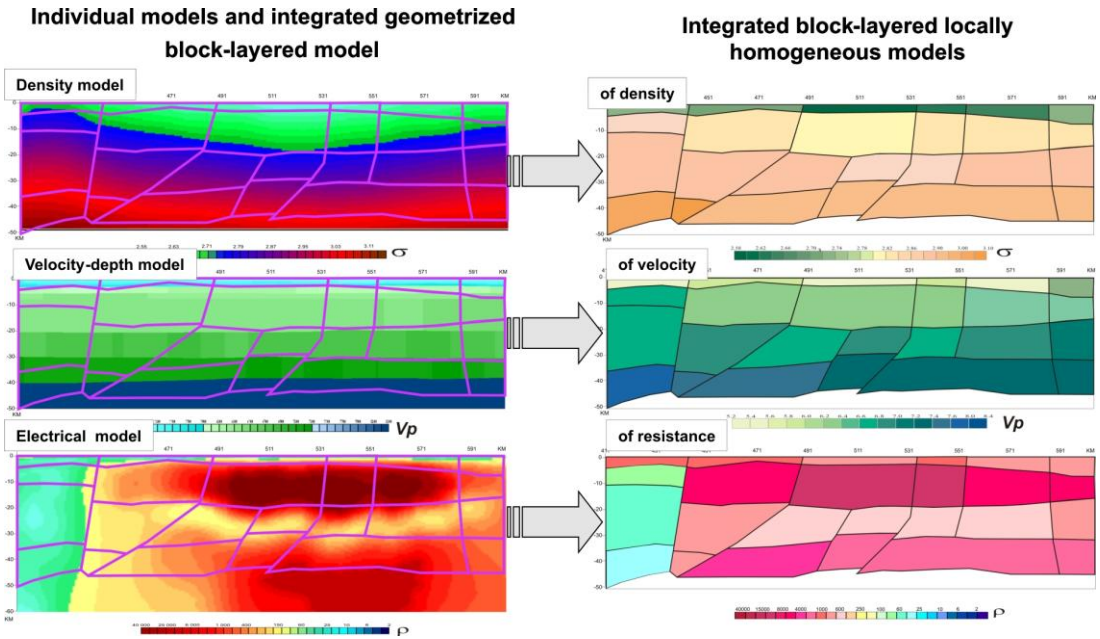
Technology of complex model construction

III.2 Complex processing and interpretation

Matching of geometrized mono-methods models

- **identification of the of the tipping and sub-vertical contact zones is carried out by the characteristics complex in the section,**
- **the borders of the object properties changes are formed on the basis of the solution of the 2D and 3D classification tasks.**

Stage result: *unified geometric structure for all geophysical models*



Estimation of matched models physical characteristics

- **average physical parameters are identified in each block of the geometric model.**

***Stage result*:** *velocity, density, resistance and magnetic susceptibility in each block of the geometric model.*

Construction of complex matched model

- **elaboration of the physical and geometric parameters is carried out by solving the direct problems of gravity, magnetic surveys, etc.**

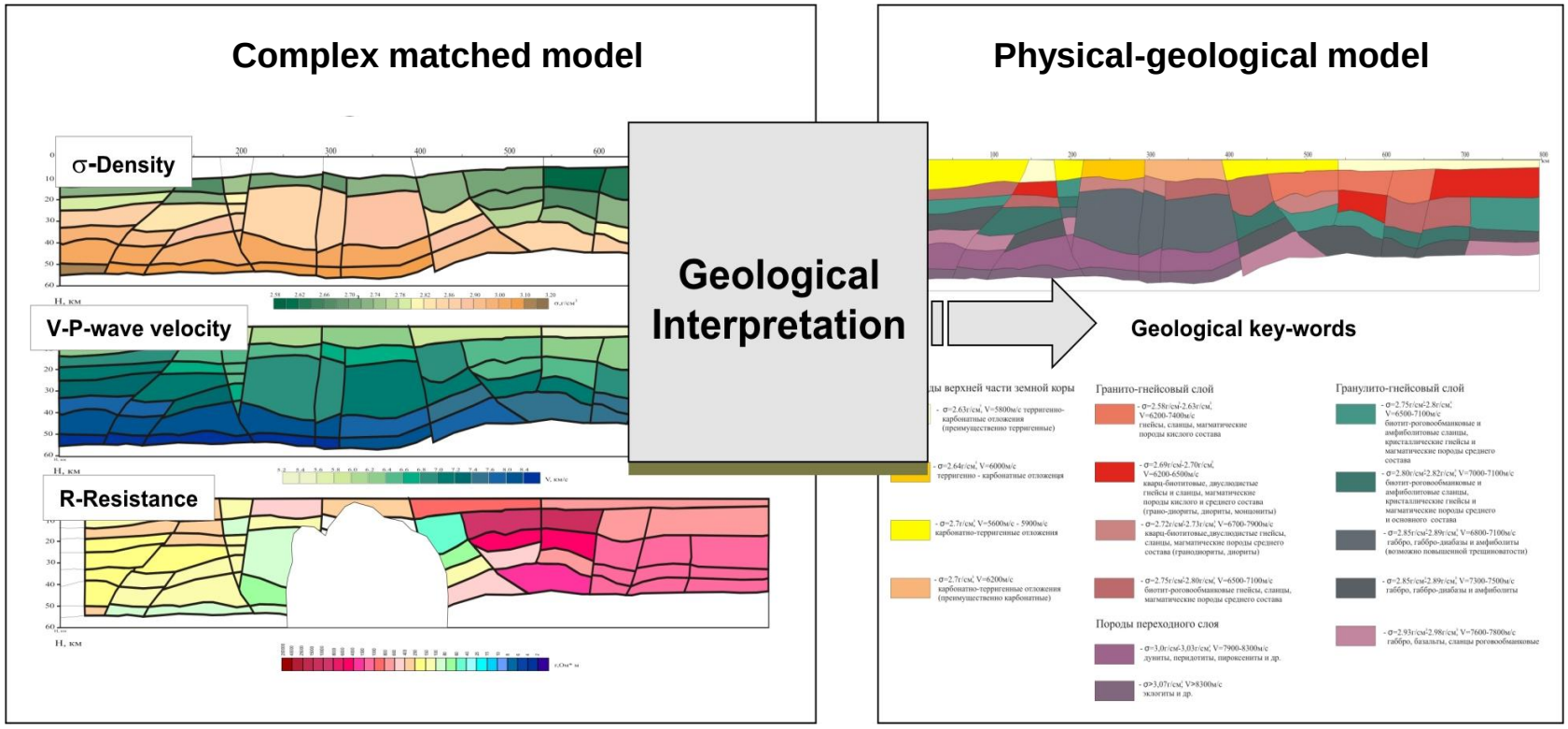
***Stage result* :** *complex block-embedded model, reconciled by all geophysical fields.*

Technology of complex model construction

IV. Geological interpretation

Constructing of physical-geological model

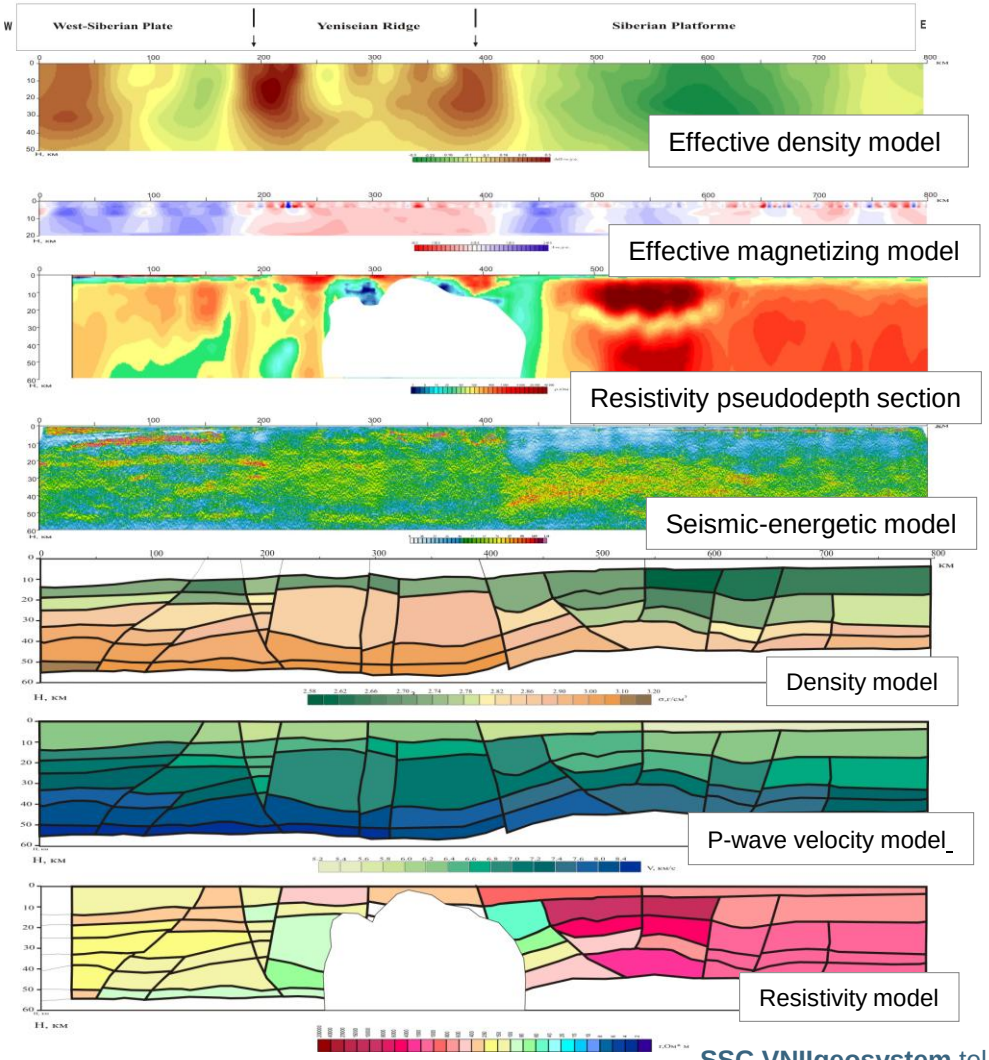
Obtained complex model is the base for the geological interpretation. Along the physical parameters values and ideas about the changes in the rocks physical properties the forecast of the Earth crust material composition is carried out.

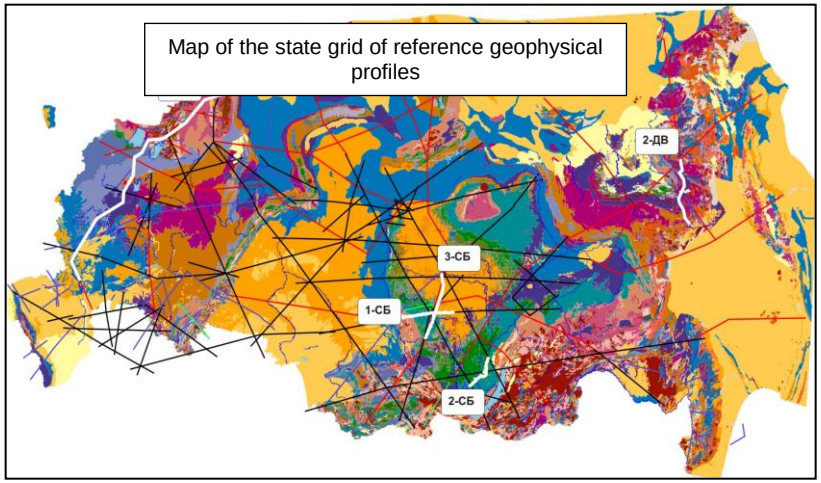


GIS FOR 2D & 3D GEOLODICAL AND GEOPHYSICAL MODELING

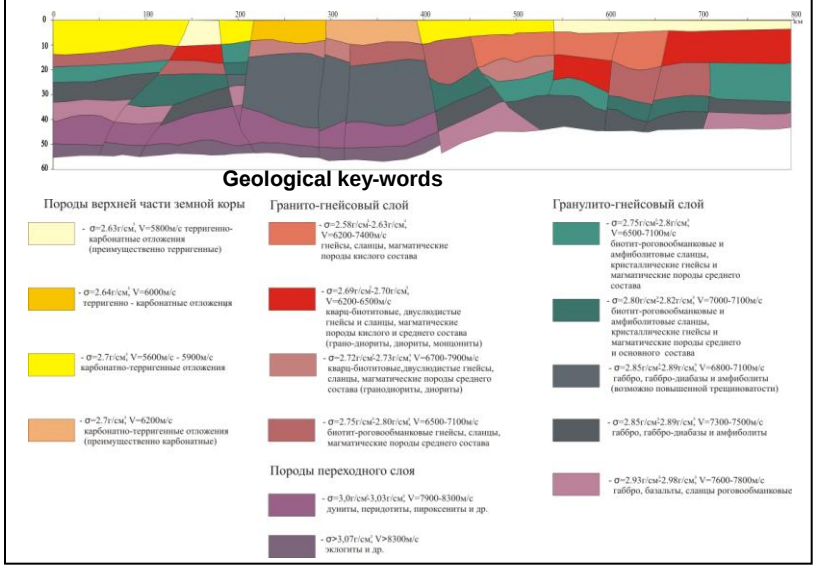
Examples of applications:
1. Physical-geological models construction on the regional profiles

Methods and complex models along the 1-SB profile:





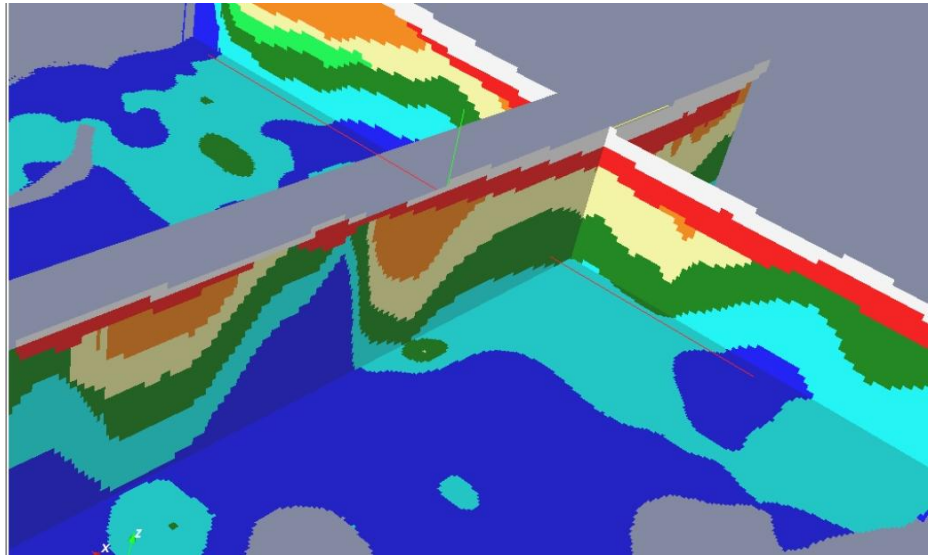
Integrated physical-geological model



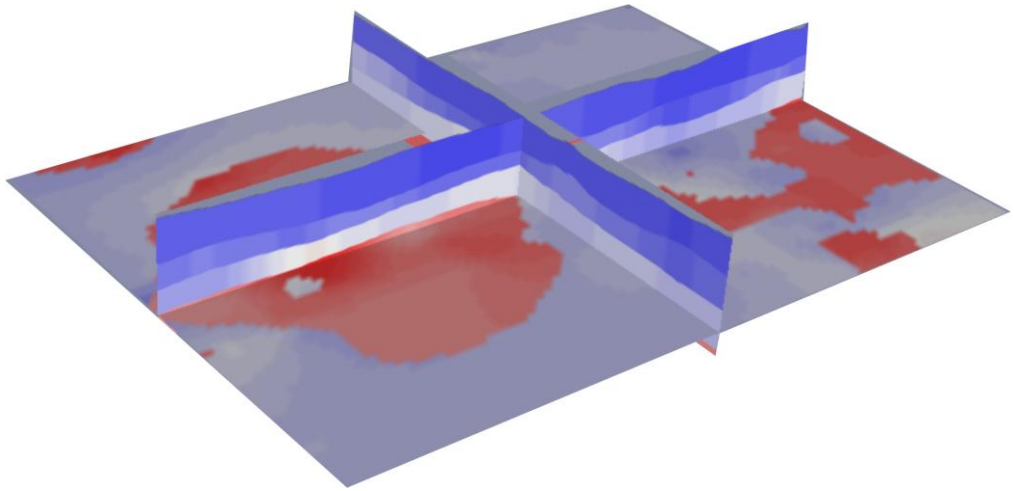
Examples of applications:

2. 3D density model of the South of East and West Siberia construction

The volume density model of the embedded sedimentary mass, matched with the seismic (CDP method, DSS) and magnetic data was obtained.



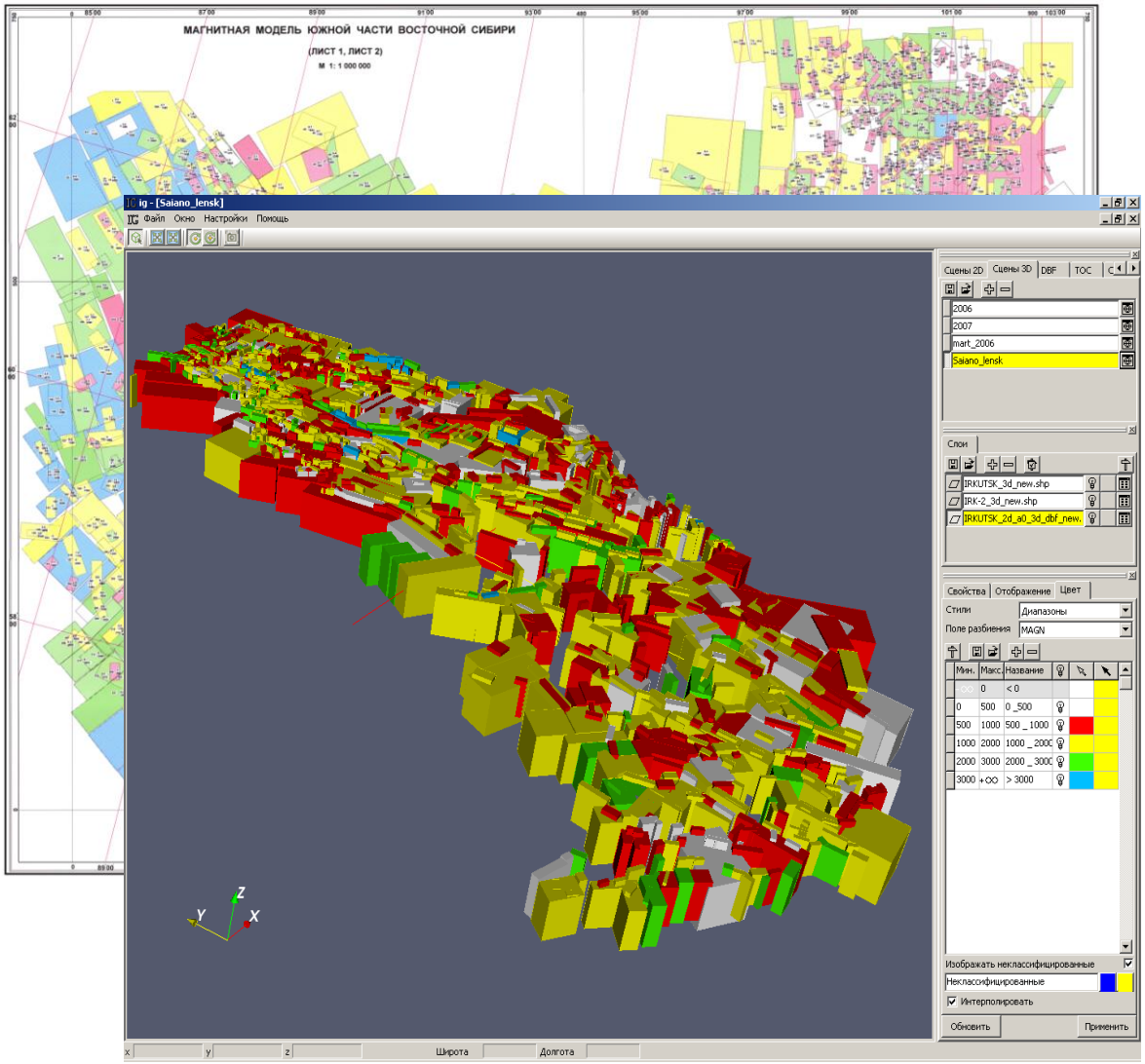
Deep-earth block-embedded density model of Earth crust of the South of East and West Siberia, matched with the seismic data along the DSS profiles, was made.



GIS FOR 2D & 3D GEOLODICAL AND GEOPHYSICAL MODELING

Examples of applications:

3. Construction of the volume magnetic model of the Siberia's South

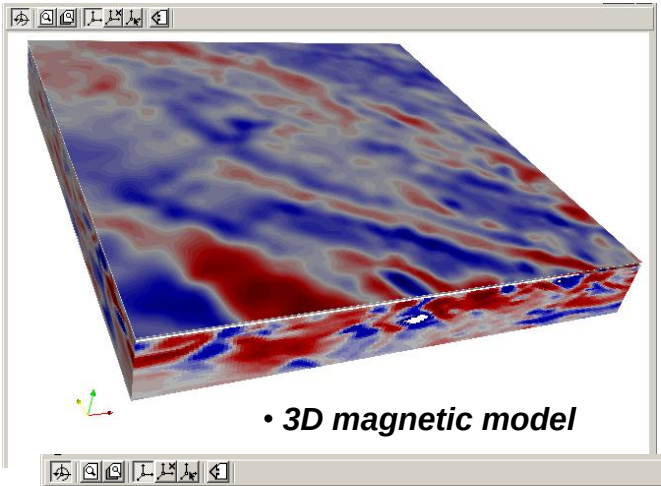


- **Magnetic inverse problem solution**
- **Statistical data processing**
- **Tying anomaly-source objects to various boundary surfaces**
- **Sorting them by the deep levels and forming the initial model**
- **Magnetic direct problem solving for the rectangular prisms**

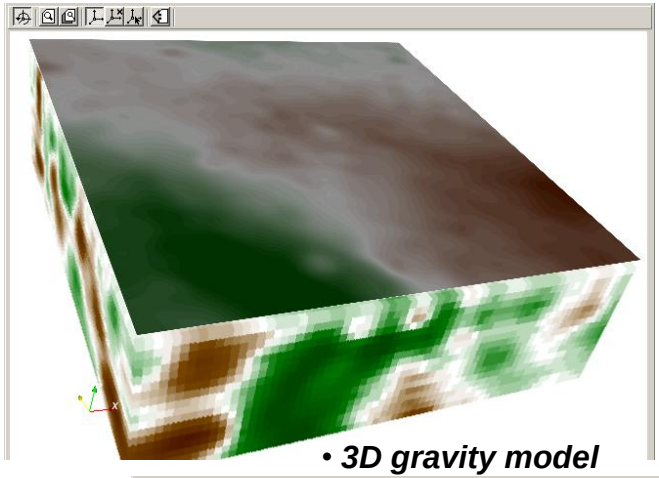
3-D magnetic model of the Siberia's South Fragment

Examples of applications:

4. Constriction of 3D geological-geophysical model of the basement (under restrictions of the weak territory exploration degree)

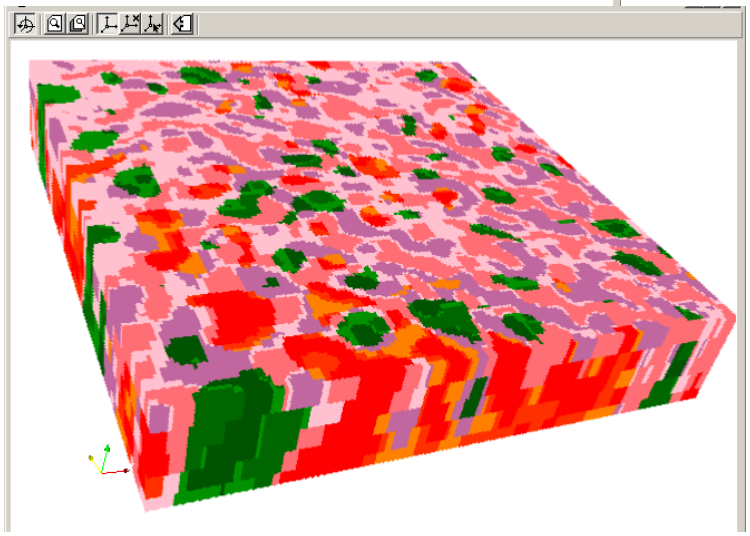


• *3D magnetic model*



• *3D gravity model*

In accordance with classification results of the volume models of the effective density and magnetization, the geological interpretation was carried out taking into account petrophysical rock properties data.



• *Classification results of the volume models*

• *3D geological-geophysical model (depths 5 km)*

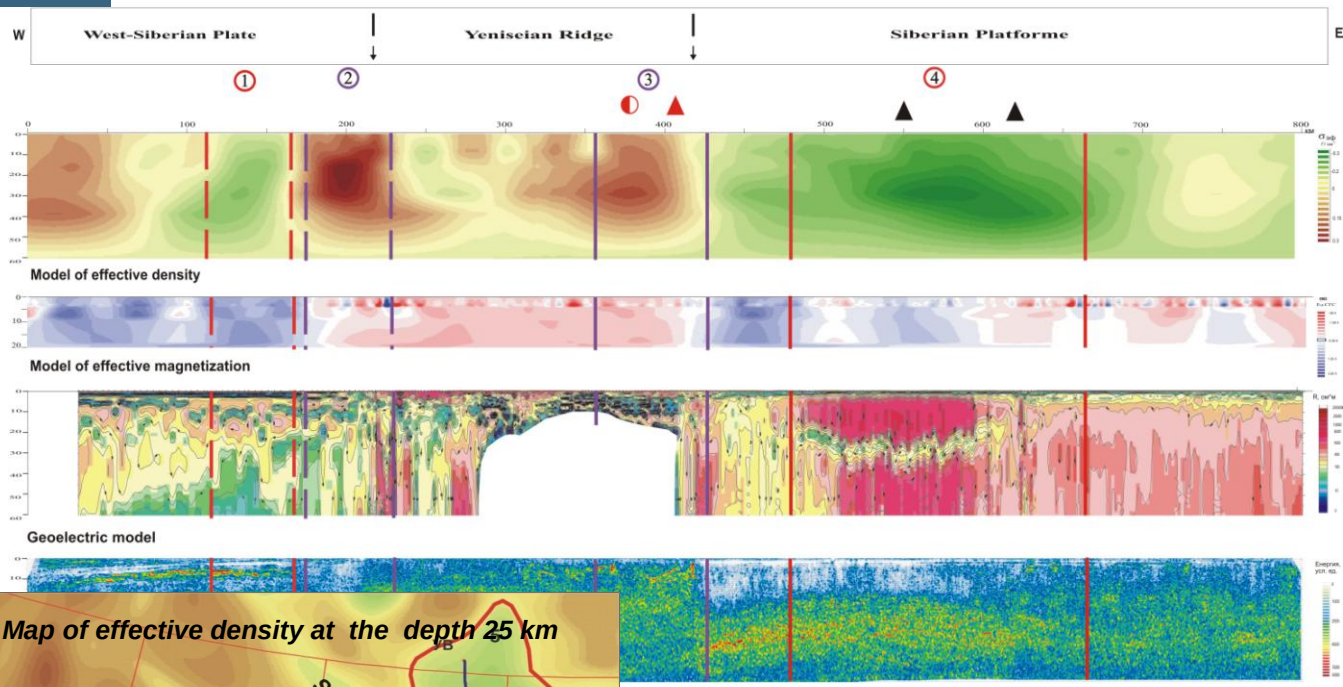
GIS FOR 2D & 3D GEOLODICAL AND GEOPHYSICAL MODELING

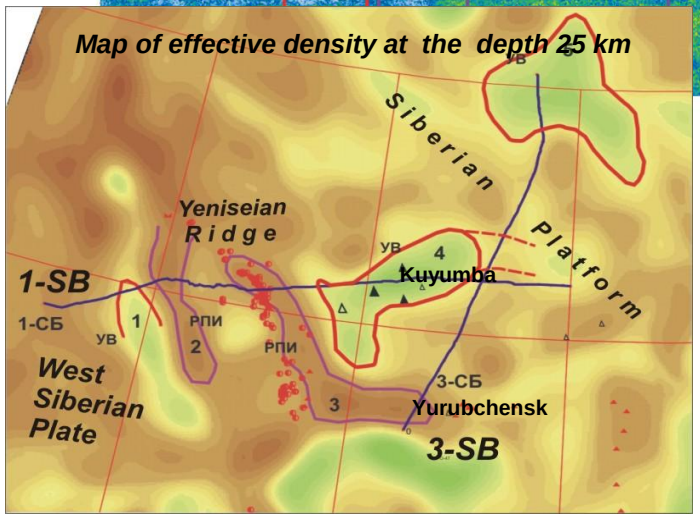
Examples of applications:
5. Forecast of the petroleum and ore perspective areas near the East Siberian profiles

The **hydrocarbon specialization targets** have such characteristic features of the structure:
- decompaction of the Earth's crust within a large range of the crust thickness,
- presence of deep-seated faulted zones penetrating to the sedimentary mantle
- occurrence of potential HC traps in the sedimentary mantle.

The **ore specialization targets** identification based on analysis of the gravity and magnetic fields features.

Geophysical models along profile 1-SB





Map of the mineragenical perspective areas near the key geophysical profiles of East Siberia (1-SB and 3-SB).

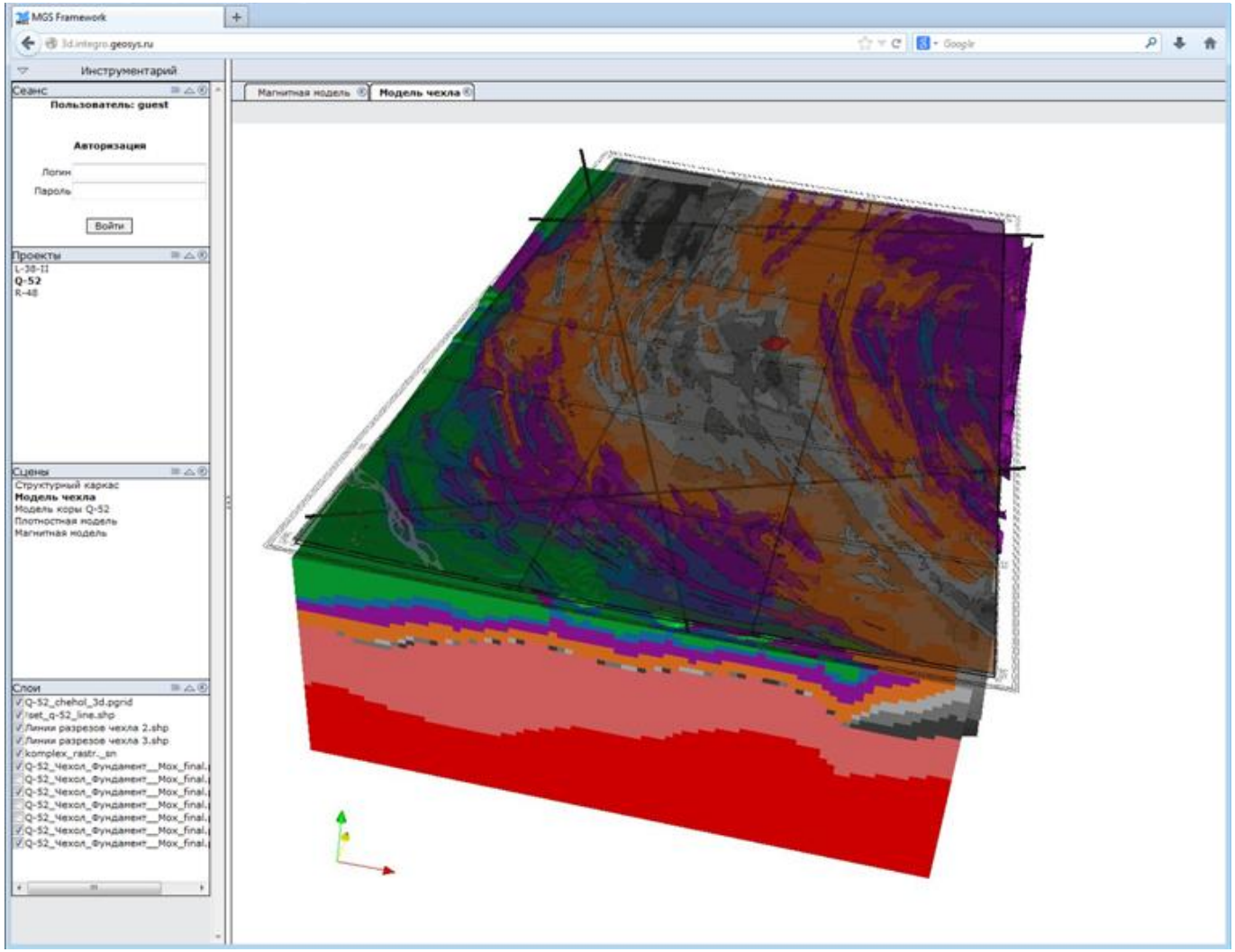
Legend

Predicted minerogenetic areas identified from the results of integrated interpretation of geophysical data acquired along regional lines:
a) Ore specialization
b) Hydrocarbons
c) HC traps

Ore mineral deposits	Hydrocarbon resources
gold	oil
iron ore	gas

WEB-PUBLICATION OF 3D GEOLODICAL MODELING

Examples of applications:
6. 3D geological models for regions of Eastern Siberia (R-48, Q-52) and Northern-Caucasus oil-and-gas bearing region (L-38-II)



The geological models created as INTEGRO desktop applications can be published as web-GIS with use of MGS-framework

Libraries of MSG-framework provides effective 3D visualization of models of any complexity in the remote access mode

Today you can get access to 3D models of a geological structure of various regions of Russia

Program complex for realization of the presented technologies

The program complex developed for realization of the presented technologies successfully combines wide orientation, effective functionality and availability to any type of customers.

Its use doesn't demand special studies, the intuitive interface of a complex is oriented on experts: geologists, ecologists, municipal employees, experts in the field of management and so forth.

The product isn't exacting to hardware, is simple in installation and operation. For the solution of specialized tasks use of modules separately from each other with the subsequent possibility of acquisition and integration of missing parts of a program complex is allowed.

Training, support and updating of components of a complex under specific objectives and specific conditions of operation is if necessary carried out.

GIS Integro

IAS Constructor

MGS

In conclusion

- All components of the program complex have the patent certificate in Russian and English languages.
- All of the presented technologies can be purchased.
- Provided the software version in English.
- For all requests relating to the buying and training, please contact *sale@geosys.ru*

THANK FOR YOUR ATTENTION!

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