Representation of geological-geophysical data in a unified integrated GIS environment

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[1] The organization of data related to geoscience, comprising data collection, filing, processing, dissemination and application at solving scientific and practical tasks over the past years seemed rather complicated. This is caused by the contradiction between, on one hand, incessantly growing data flow and intensive development of data processing and interpretation means and, on the other hand, progressively growing difficulties of ensuring data compatibility, exchange of data and use of data processing results by a wide range of researchers and other users. The solution of problems mentioned above can be significantly facilitated by creation and application of geographical information systems (GIS) technology, as a cumulative set of means of data filing, joint processing and analysis, with geographical or spatial reference. This technology comprises traditional methods of using databases with advantages of full-fledged visualization and geographical (spatial) analysis. These capabilities can distinguish GIS from other information systems and provide unique opportunities to its application for solving a wide spectrum of problems, related to analyzing and forecasting phenomena and events of the surrounding world, by contemplating and emphasizing main factors and causes, and also their possible consequences, by planning strategic solutions and current results of undertaken activities. The recent study the GIS technology was applied for construction and program realization of integrated geoinformation environment, including digital maps comprising various thematic data levels on geoscience. *INDEX TERMS:* 0520 Computational Geophysics: Data analysis: algorithms and implementation; 0530 Computational Geophysics: Data presentation and visualization; 0555 Computational Geophysics: Neural networks, fuzzy logic, machine learning; 0594 Computational Geophysics: Instruments and techniques; *KEYWORDS:* Geographic information system, geoinformatics, artificial intelligence.

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Introduction

[2] World data centers in geosciences, in particular, the system of World Data Centers (WDCs) during the last 50 years have accumulated vast volumes of data, measured in terabyte. The Russian WDCs embrace the unique and impressive collection of the Russian and foreign data on topography and cartography, seismology, modern motions of the Earth's crust, geoecology, heat flow, bathymetry, altimetry, satellite geodesy, gravimetry, static and alternating magnetic field of the Earth, paleomagnetics, natural minerals, vertical ionospheric sounding, interplanetary data, space rays and solar activity. This data was obtained as a result of both the research carried out by the Russian observatories and stations, by expeditions and various experiments, implemented by the Russian institutes of scientific research (dozens of millions of files), and of the international data exchange. Enormous massifs of analogue data are stored by the Russian observatories and in the Geophysical Center of the Russian Academy of Sciences (GC RAS), comprising the two WDCs – in solid Earth physics and solar-terrestrial physics.

[3] Many WDCs are actively involved (for example, the WDCs on geomagnetism in India and Japan) in the process of unification of analogue and digital data into comprehensive information resources and their incorporation into the distributed system of WDC resources. These data are being used by scientists of the entire world.

[4] Providing the network access to the maximum data volumes, accumulated by WDC, thematic and problem-oriented databases and development of users interface is vitally im-

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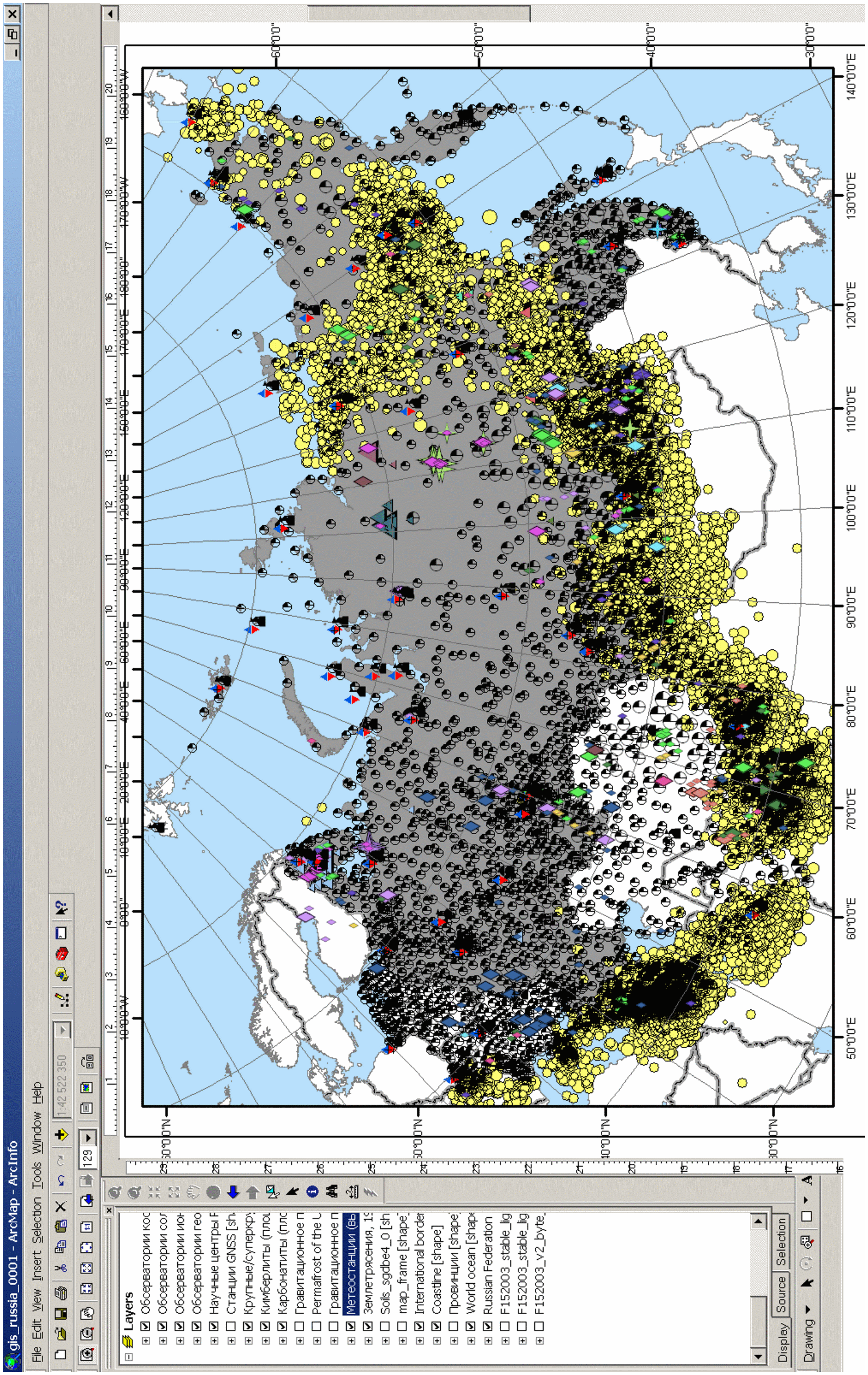
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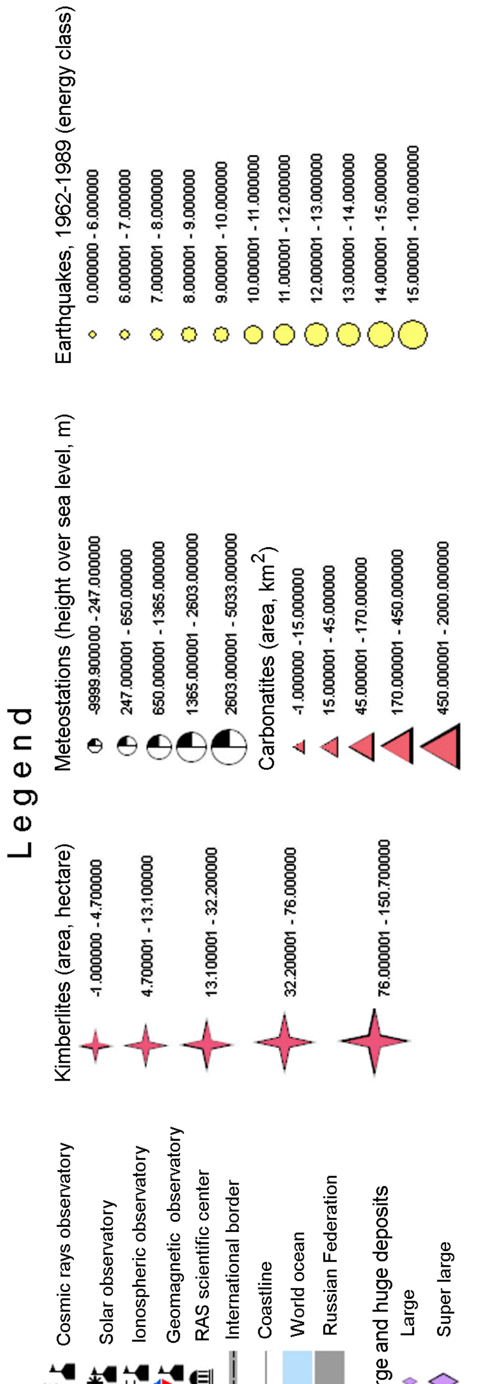

Figure 1. Example of visualization of the geoinformation analytical system "Earth Science Data for the Territory of Russia".

portant. The International Council for Science (ICSU) defines scientific data and information as a priority domain of development in the years to come, essential for all the spheres of life and activity of the world community and urges to undertake measures to replace the old analogue data with electronic data, for its active use in up-to-date and future scientific research. The ICSU WDC Panel calls upon all the centers to provide the Internet access to all data compiled by the WDC system and the opportunity to the scientific community to use it, ensuring convenient means for search, viewing and selection of data. The attitude to data on the international scale emphasizes the urgency and expediency for the Russian Federation of establishment of a system of integrated Russian language access to global data resources. This is extremely important nowadays, taking into account the insufficient development of the Russian geoscience systems of observation.

Discussion

[5] The present research is aimed at the integration of data on geography, geology, geophysics, geoecology and other Earth sciences in the comprehensive problem-oriented geoinformation system (GIS) [*Belov et al.,* 2007; *Beriozko and Eliutin,* 1995] including the intellectual system of geoinformation analysis (see Figure 1).

[6] The developed theory and methods of artificial intelligence must become not only an integral, but the main core (nucleus) of a modern geoinformation system. At the present time geoinformation systems provide only limited opportunities for general analysis of geodata handled. At the same time, among the scientific community, dealing with the Earth sciences data, the requirement of more profound and comprehensive data analyzing and processing is constantly growing. The methods of fuzzy mathematics, developed by the GC RAS correlate with a fuzzy character of geophysical data [*Agayan and Soloviev,* 2004; *Gvishiani et al.,* 2002, 2003a, 2005b; *Mikhailov et al.,* 2003; *Soloviev et al.,* 2005; *Zlotnicki et al.,* 2005]. It not only brings the analysis of initial geodata to the higher scientific and practical level, but provides scientifically based recommendations on interpreting the results obtained. As it was pointed out by a number of leading scientists of the world, due to the fact that the data and knowledge of the Earth are incomplete and fuzzy by their nature, their most adequate presentation and formal method of processing should also be fuzzy. The evaluation of natural environment and risk is a task of identification of a complex character of potentially dangerous situation on the basis of huge data volumes of environmental monitoring. The artificial intelligence methods, developed by the GC RAS, and presently applied to volcanic activity monitoring, search of magnetic and gravitational anomalies, search and interpretation of anomalies in geophysical fields, detecting of signals on various types of times series records, to solving geodynamic problems etc., turned out to be a success.

[7] The following three tasks are supposed to be solved:

[8] 1. The GIS technology application for elaboration and programme realization of the integrated geoinformation environment, assigned for unification, processing and visualization of databases and knowledge on geography, geology,

geophysics and geoecology of Russia and their availability in the Internet;

[9] 2. Elaboration in the GIS environment of a digital map of the Russian Federation, incorporating various thematic layers of data of geographical, geological, geophysical geoecological, technogenic and economic character;

[10] 3. Adaptation of the existing artificial intelligence algorithms of geodata processing for their direct incorporation into the GIS environment.

[11] The first task main objective is development and expansion of means of integration in the comprehensive geoinformation environment of different cartographic, geological-geophysical data and events, natural processes and phenomena with data on the technosphere.

[12] The second task presumes creating in the GIS environment a digital map of the Russian Federation, incorporating thematic layers of the following data: topography, geodesy and gravimetry, spatial geodesy, remote sensing of the Earth, hydrography, geology, natural minerals, geoecology, seismology, oceanography (for the seas, surrounding Russia), volcanoes, tectonics, plates motion direction and velocities according to GPS data, etc. Each thematic layer will be supplied with the corresponding metadata information structured and organized in accordance with the special template elaborated. The family of programmes ArcGIS 9, developed by the Environmental Systems Research Institute (ESRI, USA) will serve as a foundation of this information system.

[13] The third task is aimed at construction of an algorithmic shell in the frame of GIS, ensuring the intellectual capacity of GIS-infrastructure. The shell will comprise a set of customizable algorithms for geodata processing and decision making based on geostatistical and artificial intelligence methods. These methods were developed and applied successfully for a long period of time by the Geophysical Center of RAS, one of the internationally famous institutes, engaged in developing algorithms on the basis of fuzzy mathematics. The algorithms are being applied in important international projects, including the joint collaboration with France, USA and Ukraine on volcanoes monitoring, seismicity, seismic risk evaluation, prediction of eruptions, earthquakes etc. The results of this work are regularly published by prestigious international scientific editions.

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