REAL TIME DATA ACQUISITION AND REMOTE CONTROL SYSTEM FOR STATIONARY GEOMAGNETIC OBSERVATIONS

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Here we describe an integrated software and hardware solution for stationary geomagnetic observations. The solution provides a feature-rich way to perform geomagnetic data acquisition for wide range of use cases, including poor data transfer conditions and power limited environments. Data transfer is implemented with wide spread Seedlink [1] protocol, which features small data overhead and automatic recovery of missed fragments. Geophysical application of data acquisition stations often implies installation at sites that are hard-to-reach or are only accessible on non-regular basis. Therefore, our solution includes full-fledged remote control and diagnostics of station equipment via web APIs in addition to standard remote management tools like secure shell. The modular nature of this software also provides flexibility for connecting various hardware. By this moment, we have implemented full support for POS-1 [2] magnetometer; more support for other models is expected. The software is platform independent and has small CPU and memory footprints hence it runs on both low power x86 systems and ARM-based System-on-Chips, which provide great opportunities for further reduction of power requirements.

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THE ANALYSIS OF MONITORING DATA OF THE PARAMETER SCATTERING POWER THE EARTH'S SURFACE IN THE SHORT-WAVE RANGE OF RADIO WAVES

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Environmental monitoring of the earth's surface by remote sensing in the short-wave band can provide quick identification of some ecological characteristics of natural systems. This band range allows one to diagnose subsurface aspects of the earth, as the scattering parameter is affected by irregularities in the dielectric permittivity of subsurface structures. This method based on the organization of the monitoring probe may detect changes in these environments, for example, to assess seismic hazard, hazardous natural phenomena such as earthquakes, storms, volcanic eruptions, as well as some man-made hazards and etc.

The problem of measuring and accounting for the scattering power of the earth's surface in the short-range of radio waves is important for a number of purposes, such as diagnosing properties of the medium, which is of interest for geological, environmental studies of coastal and marine ecosystems.

In this paper, we propose a new method for estimating the parameters of incoherent signal/noise ratio. The paper presents the results of comparison of the measurement method from the point of view of their admissible relative analytical errors. The new method is suggested.

Analysis of analytical error of estimation of this parameter allowed to recommend new method instead of standard method. A comparative analysis and shows that the analytical (relative) accuracy of the determination of this parameter new method on the order exceeds the widely-used standard method.

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THE STUDYING OF TIME SERIES BY METHODS OF DISCRETE MATHEMATICAL ANALYSIS

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This report finalizes the search of anomalies in the one-dimensional time series in terms of DMA (discrete mathematical analysis): the initial conception of an interpreter's logic obtains its supplementary development here. First, the expert's formal opinions are expressed more completely with the help of complex measures of activity (the conception of rectification is changed to the measures of activity which prevail): second, for joining the anomalies, a recently created DPS (discrete perfect sets) algorithm is implemented.
The work is partially supported by The federal target program of Ministry of Education and Science, grant RFMEFI60714X0058.

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DEVELOPMENT AND UTILIZATION OF NEW GEOINFORMATIC ROCK ARRAY STRUCTURE AND PROPERTIES PREDICTION TECHNOLOGIES

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In order to predict the depth structure and properties of a rock array, a Markov tomography method has been developed that uses the results of remotely-measured areal topography changes of the Earth is surface and geologo-geophysical fields. The method, the mathematical foundation of which is the Markov finite chain theory, is based on the probabilistic inheritance of the Markov properties of depth deposits assumption by the overlaying beddings. The prognostic structure and properties of the subsurface deposits model has been calculated in the solution of the inverse problem, using computer analysis of the geologo-geophysical fields measured on the rock array surface.

The method has been proved as a program methodological complex that provides for rapid processing, interpretation, and 3D modeling of the structure and properties of arbitrary-genesis objects being studied.

The developed method has been successfully tested when conducting surface engineering and geological research on the areas of subterranean transportation and coal-methane facilities under construction that are subject to be built in rough terrain conditions, where the efficiency of surface geophysical methods application has proved to be insufficient. In this report, the efficiency of the method being proposed has been demonstrated using the Krasnaya Polyana area survey example.

Today, the issue of aggregating the developed method with the geodynamic zoning technology using satellite photographs lineament analysis data is being developed in order to increase the efficiency of remote prediction of subsurface deposits structure and properties.

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DEVELOPMENT OF AN INTEGRATED SYSTEM OF ENGINEERING-GEOLOGICAL AND HYDROGEOLOGICAL MONITORING OF SAFETY OF OPERATION OF MINING AND TECHNICAL FACILITIES

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The developed systems of complex engineering-geological and hydrogeological monitoring able to control the quality of the industrial facilities operation, as well as to identify the most environmentally dangerous objects and promptly take the necessary management decisions for trouble-free operation of mining natural-technical system (NTS). A set of criteria used to determine the gravity of the state of man-made or natural and man-made object, developed on the basis of the existing legal framework of the Russian Federation, as well as domestic and foreign experience in assessing the state of industrial, municipal and other economic facilities. For each test specifications set thresholds in several levels on qualitative and quantitative indicators, to achieve that signal, a warning about changing conditions and parameters functioning of the natural and man-made object. This allows change mode and carry out work timely, if necessary, carry out an alert about possible emergencies and minimize the economic loss industry and the environmental damage caused to the environment. Typification mining natural and man-made systems and objects within them allows you to develop for each selected type of NTS activities associated integrated monitoring and organize the information to better analysis.

LANDSLIDE AREAS ENGINEERING-GEOLOGICAL ASSISTANCE DEVELOPMENT

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The introduction of devised method for a complex monitoring of sloping structures organization in mining enterprises, linear structures (highways and railways) and on large building sites includes such innovative steps as:

1. Building a model of a slope based on the assessment of spatial and temporal variability of characteristics of the rock mass.
2. Then the optimal mode of gaining information is selected on the basis of the constructed model and with due regard for the geometry of network in order to minimize financial, labor and time costs and to preserve the integrity of the received information.
3. Conducting complex geotechnical and hydrogeological tests to collect stationary information (the selection of elements and determination of rocks properties these elements are made of identification of the filtration properties of rocks, etc.)
4. Introduction of technical means of remote monitoring for determining changes in hydrogeological and biomechanical characteristics.
5. Conducting systematic additional engineering and geological and hydrogeological studies for determination of temporal variability of the rocks characteristics.

The experience of creating monitoring systems of sloping structures was used in a number of projects including: «The control of the sloping structures of the Mining Corporation "Stoilensky"», «Building models of the landslide slopes in the area where the road was aligned for the control of the "Adler-mountain resort Alpika-Service".

LOGICAL-INFORMATION MODELS OF GOLD ORE DEPOSITS AS THE TOOL FOR THEIR PREDICTION AND PROSPECTING

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In recent years the rapid gold price increasing has been on the world market. It was the main reason for significantly increased demand for the precious metal, especially in the remote north- eastern regions of the Russian Arctic (Chukotka), where new mines were put into operation.

Potential prospecting criteria of gold mineralization were defined, which are divided into geological, mineralogical, geochemical and geophysical (95 parameters). They were used for the analysis of well-studied (etalon) different scaled deposits based on the comparison of qualitative and quantitative their characteristic values.

The procedure of logic-information analysis (Chizhova, 2010) on etalon deposits from database has designed for the selection of their informative features, which together can quantify the similarity measure between poor studied prospect areas and etalon deposits of studied type. In the case of positive result of the comparison it is possible to evaluate the size by analogy with designed models of small-, middle- and large-scale deposits.

The results of the analysis of the existing database of gold-quartz and gold-rare-metal deposits of the North-East of Russia were used to construct decision rules on evaluating prospective target areas and occurrences in similar geological conditions.

The logical-information models system is based on a broad set of interrelated criteria and features and representative database (47 deposits). So they may be used for study and evaluation of this type deposits in similar ore-bearing provinces including the Russian Arctic zone.

RECOGNITION OF MODERATE EARTHQUAKE-PRONE AREAS IN CRIMEA AND WESTERN PART OF THE NORTH CAUCASUS

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This paper continues the authors' research series on recognition of strongest, strong, and moderate earthquake-prone areas using intellectual pattern recognition system FCAZ (Formalized Clustering And Zoning). Moderate earthquake-prone areas in this joint region of Crimea and western part of the North Caucasus have been studied, for the first time, within the presented research. Selection of the region was justified in geological and tectonic terms.

Obtained relevant result of the FCAZ-recognition in Crimea and North-Western Caucasus is compared with the results of recognition using randomly generated earthquake catalogs. It was demonstrated that the quality of the actual FCAZ-recognition is significantly higher than mathematical expectation of FCAZ-recognition based on random catalogs. In this way, important validation reliability of the FCAZ-recognition of moderate earthquake-prone areas in Crimea and North-Western Caucasus was obtained.

The reliability of the result is also endorsed by geometry of locations of instrumental and historical moderate earthquake epicenters.

The result is useful in earthquake-resistant construction theory and practice in particular as far as construction of the bridge over the Kerch Strait is concerned.

This research is supported by the Russian Science Foundation (project № 15-17-30020).

RECOGNITION OF EARTHQUAKE-PRONE AREAS IN KAMCHATKA BASED ON THE CLUSTERIZATIONAL RESEARCH OF EARTHQUAKE EPICENTER

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The present work is a continuation of authors' research for recent years on recognition of earthquake-prone areas in different highly seismic regions of the world. This research is based solely on the clustering analysis of weak earthquake epicenters in the considered region. Recognition of this kind for the territory of Kamchatka was carried out for the first time. The algorithmic system FCAZ (Fuzzy Clustering And Zoning), previously developed by authors, was used as an algorithmic framework for recognition of earthquake-prone areas. This system has worked well for recognition in California, in the Caucasus and Crimea.

Recognition of potential highly seismic 2D (recognized objects - the earthquake epicenters) and 3D (recognized objects - earthquake hypocenters) areas was conducted for the territory of Kamchatka. The reliability of the recognition results is confirmed by the consistency of the recognized FCAZ-zones with epicenters of instrumental and historical earthquakes, the results of control experiments "complete seismic history" and "individual seismic history", and comparison with the results of recognition using randomly generated earthquake catalogs. The recognized 2D and 3D FCAZ-zones were compared with each other. They were compared with the recognition results of the classical method EPA (Earthquake-Prone Areas recognition).

The work was conducted within the framework of the Russian Foundation for Basic Research (Project № 16-35-00603 mol_a).

SEISMIC ACTIVITY MONITORING OF CALIFORNIA BASED ON THE METHODS OF DISCRETE MATHEMATICAL ANALYSIS

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The present work is the beginning of the author's research to create the phenomenological methodology for seismic activity monitoring based on the algorithms of Discrete Mathematical Analysis (DMA). DMA was developed in the Geophysical center of RAS in the middle of the last decade and it is a new approach for research of multidimensional arrays and time series.

Effective monitoring of the seismic process, which is dynamically irregular in time and space, was provided for the territory of California using DMA, based on fuzzy mathematics. This allowed recognition of its background, normal and anomalous components. The "Virtual" geographical grid nodes for monitoring of seismic activity were determined by the authors. In practice, the amount of such nodes exceeded the actual amount of nodes of seismological observations in California. DMA algorithms have made it possible to build the activity measures of the seismic process in the nodes of geographic grid within the considered region. These measures helped to choose from all the nodes the most "peculiar" ones and trace their grouping and dynamics in space and time.

In the course of this work for the territory of California the most complete and calibrated earthquake catalogs have been prepared. Seismic activity monitoring based on DMA algorithms was performed for the region. The basis of formalized criteria for the level of seismic activity and seismic hazard was developed.

This work was performed as a part of the grant of the President of Russian Federation for a state support of young Russian scientists - PhD (project number MK-4555.2016.5).

ESTIMATING THE ARCTIC FUTURES FROM THE ANGLE OF POPULATION DYNAMICS AND EDUCATIONAL PROGRESS

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The role of human capital is crucial in tackling unprecedented changes accelerating in the Arctic and potentially high number of various impacts from the outside on Arctic systems, including human dynamics and ecosystems. This importance is also emphasized in the recent Arctic Human Development Report (Larsen and Fondahl 2014) since the Arctic covers more than 10% of the planet's land area but is one of the most desolate, least populated and extremely fragile (to impacts) areas in the world, − 4 mln residents.

The findings of Striessnig and Lutz (2013) suggest that education, especially of women, is the more relevant determinant of socio-economic development compared to income when it comes to enhancing adaptive local capacity to e.g. natural disasters and hence climate change. However, none of the current projections delivered by the national statistical bureaus ever implemented educational attainment, a core of human capital, as an equally important dimension to age and sex in analysis of population dynamics.

Human capital based projections is a deliverable element of the IIASA Arctic Futures Initiative, the goal of which is a holistic integrated assessment, including a decision-support process and science diplomacy that contribute to informed decision-making about sustainable development in the Arctic (AFI website). In detail, this project's input will be the analysis of societal well-being and demographics specific to the Arctic (25+ regions) to further framing of the geospatial scenarios of the Arctic development with the consistent focus on the transformative role of populations and educational progress. The study is based on the theoretical, methodological, and empirical framework developed within IIASA World Population Program (Lutz et al. 2014). The produced evidence may guide models and decisions with regard to responses on changes happening in the Arctic.

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FRACTAL CHARACTERISTICS OF SEISMIC PROCESS IN ROCK MASS AT MINING. MATHEMATICAL MODELLING AND ANALYSIS

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Modern net of seismic stations (stationary and temporal) covering the Kuzbass coal basin and Altay region register seismic events related as the industrial seismicity every day. The correlation between the activation of seismic process and mining is studied in papers [1,2]. The investigations showed that the industrial seismicity might result in the release of accumulated energy of stressed regions of geomedia on one hand, and might be the trigger for disastrous seismic events on the other hand. The understanding of basic laws of seismic process, its migration and trigger effects is an actual goal for the Earth sciences. For this purpose, the investigation of critical states formation in loaded geomedia is necessary. From this point of view, the rock mass with excavation is an ideal object for studying and attempt to find out the precursors of critical states.

The development of modern numerical methods in geomechanics gives an opportunity to create the model of rock mass including the most important structural elements – roof, floor, overlying strata and to descript mathematically the evolution of stressed-strain state at mining. For this purpose, the system of equations of solid mechanics is applied. The system of equations has a mixed type and demonstrate the characteristic features of seismic process observed instrumentally and studied theoretically within the theory of self-organized criticality with simplified models [3].

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CORRELATION BASED MODELING OF THE IONSPHERIC MAGNETIC FIELD

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We present a closed loop study where we try to recover Ionospheric field models from synthetic data generated at observatory position. The method is based on a recently developed approach using correlations between the ionospheric magnetic field at different points in the space.
We construct correlation structures of the ionospheric field using long time simulations of the CM4 field model. The correlation patterns are expressed in solar magnetic coordinates in order to take into account the dominant role played by the sun. Closed loop simulation shall also be applied to test the separation of internal and external field components. Moreover we show how to quantify the uncertainties of the field components using Bayesian statistics.

KNOWLEDGE BASE ABOUT PAST EARTHQUAKES CONSEQUENCES

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The paper describes the structure and content of the knowledge base on physical and socio-economical consequences of damaging earthquakes, which may be used for calibration of near real-time loss assessment systems based on simulation models for shaking intensity, damage to buildings and casualties estimates. Such calibration allows to compensate some factors which influence on reliability of expected damage and loss assessment in "emergency" mode. The knowledge base contains the description of past earthquakes' consequences for the area under study, which includes rating of seismological surveys, peculiarities of shaking intensity attenuation, distribution of built environment and population. Computer simulation of the recorded in knowledge base events allow to determine the sets of regional calibration coefficients in order to provide minimum error of damaging earthquakes loss estimations in "emergency" mode.

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CAN GLOBAL GEOPHYSICAL DATA BE USEFUL IN HYDROLOGY OF RIVER BASINS? EXAMPLE OF THE GRACE SATELLITE GRAVIMETRY

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Our study investigates applicability of the Gravity Recovery and Climate Experiment (GRACE) satellite gravimetry data for estimating terrestrial water storage (TWS) in a river basin scale. Terrestrial water storage (TWS) is the integrated sum of all basin storages (surface water bodies, soil and ground aquifer, snowpack and glaciers) and the ability to estimate TWS dynamics is useful for understanding the basin's water cycle, its interconnection with the local climate, physics of predictability of extreme hydrological events. Despite the importance of the TWS estimates, reliable ground-based monitoring data of all TWS components are scarce or absent at all. Since observations are not sufficient to monitor TWS, hydrological models are considered as a comprehensive tool to simulate TWS components at a basin scale. However accuracy of the model-derived TWS is influenced by the uncertainty of the model structure and parameters, reliability of input data, etc. To improve the TWS-estimates, it is reasonable to combine the simulated TWS with independent observations provided by the GRACE gravity data.

Ninety-seven monthly TWS retrieval from GRACE data (from April 2002 to December 2009) was examined and compared with TWS-estimates obtained by the ECOMAG hydrological model simulations. The case study was carried out for the Northern Dvina River basin. Quantitative analyze between the hydrological model and GRACE-based TWS showed that latter is in good consistency with the simulation results on both seasonal and inter-annual time scales. Overall, the results highlight the benefit of assimilating GRACE data for hydrological applications, particularly in data-sparse regions, while also providing insight on future refinements of the methodology of GRACE-data application in watershed hydrology.

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SPECTRAL-TIME ANALYSIS OF «SERPENTINE EMISSION» GEOMAGNETIC PULSATIONS

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The «serpentine emission» pulsation state of geomagnetic field is studied. This state is characterized by significantly large frequency and amplitude modulations and the occurrence of several spectral components. A spectral-time analysis and estimation problem for the nonstationary frequency and amplitude parameters as time functions for the components of these pulsations. An estimation technique for the nonstationary parameters on the basis of implementing of local polyharmonic model is proposed. An algorithm for the estimation of the polyharmonic models' parameters on the basis of search procedure is developed. The spectral-time analysis for the «serpentine emission» frequency and amplitude parameters as calculated sequences of piecewise-constant local estimations. Providing of the decrease of the estimation uncertainties of the frequency functions is realized using the filtering with a sliding average. The examples for the «serpentine emission» spectral-time analysis are displayed.

DEVELOPMENT OF GIS-PROJECT "GEODYNAMIC MODEL OF THE SIKHOTE-ALIN OROGENIC BELT AND ADJACENT AREAS AS A BASIS FOR STUDYING, MONITORING AND FORECASTING NATURAL DISASTERS IN THE SOUTH OF THE RUSSIAN FAR EAST"

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Generation of the GIS project with various thematic layers comprising both newly acquired and already known data will allow optimal data collection, analysis and evaluation of potential disaster impacts of endogenous processes over space and time in the south of the Russian Far East. Specialized SRTM data processing is spend in order to separate linear structures, to carry out the analysis of texture characteristics of relief, as the characteristics of the tectonic features of the study area. New characteristics, such as lineaments, their density, graphics earthquake recurrence, fractal dimension lengths lineaments, faults, the fractal dimension of the entire field of earthquake epicenters, and many other characteristics are calculated. Maximum unloading zone earthquakes are determined.
The work is supported by the RSF grant 16-17-00015.

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EVALUATION OF TSUNAMI INTENSITY BASED ON RUN-UP DATA IN TSUNAMI CATALOGS

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Tsunami intensity *I* on the Soloviev-Imamura scale [1] is one of the most important parameters for characterizing the overall size of a tsunami generated by submarine earthquakes. The scale is based on the average run-up heights measured at the nearest coast. Being the intensity-type scale, it is actually used as total measure of overall size of a tsunami, i.e. as magnitude-type scale. In this capacity, tsunami intensity *I* is included in both global tsunami databases maintained by the NGDC/NOAA [2] and NTL/ICMMG SD RAS [3]. Initial evaluation of the intensity of a large number of destructive historical tsunamis in the Pacific was made by S. L.Soloviev during compiling his two comprehensive tsunami catalogs [4, 5]. The main purpose of this study is to re-evaluate the tsunami intensity of the tsunamis occurred in the Far-East region of Russia from 1737 to 2015 based on the most complete data set containing as measured as modeled data on run-up heights. Re-evaluation is based on application of a special procedure for intensity calculation built-in the PDM/TSU (Parametric Data Manager for Tsunami Database) graphic shell used for compilation and maintenance of Historical Tsunami Database for the Far-East Region of Russia. Calculated intensities of historical events allow to study their dependence on the earthquake magnitudes and other source parameters (depth, mechanism) that is important both for improvement of operational tsunami warning and the long-term tsunami hazard assessment. The work is supported by the RFBR Grant 16-05-00450.

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NEW HARDWARE AND SOFTWARE COMPLEX FOR MONITORING AND ANALYSIS OF THE EARTH'S MAGNETIC ENVIRONMENT

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Continuous and stable operation of modern complex technological systems is noticeably affected by electromagnetic processes originated from the interaction between the solar wind and the Earth' magnetosphere which form the phenomena of "space weather". Russian geomagnetic observatories and the low orbiting satellites of the SWARM mission carrying the high-precision magnetometers provide complex monitoring of geomagnetic environment and detection of anomalous events of various nature. Analysis of observatory and satellite data allows modeling the structure of the internal and external parts of the Earth's magnetic field. This report presents a new modern hardware and software complex developed for the efficient retrieval, storage, processing, and analysis of geomagnetic data with automatization of the majority of data management processes. The developed complex includes software modules for automated filtering of observatory data from technological noise and data verification with compliance with the INTERMAGNET standards, which enables production of quasi-definitive data. The complex also provides a sophisticated classification of the extreme geomagnetic phenomena and detecting extreme geomagnetic conditions, which may be hazardous for technological infrastructure and economic activity within the regions of Russia. The developed complex provides the online access to geomagnetic data (both, the initial and processed ones), information on extreme events and modeling results along with visualization on a video board and spherical screen.

This work was supported by the Federal target program of the Ministry of Education and Science of Russia, contract No. 14.607.21.0058, unique project identifier RFMEFI60714X0058, and is a part of the research aimed at creation of an experimental sample of hardware and software complex for monitoring and detection of extreme geomagnetic events using ground and satellite data.

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STATISTICAL MODELING OF THE TEMPORAL PATTERN OF SEISMICITY IN THE ZAGROS REGION, IRAN

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Earthquake is one of the major natural disasters which with the current knowledge of the human kind, this hazard is not predictable yet, but can be partly subjected to risk assessment and recognition of its pattern by using statistical methods. In this research, the seismic data of the Zagros region (Iran) during the time period of 2006 to 2014 were analyzed for the study of the temporal pattern of seismicity in this region by time series analysis method and also its accordance with the Poisson distribution model. In this study, by using the goodness of fit test based on the chi-square statistic, the suitability of the Poisson distribution with λ parameter (the average rate of the earthquake occurrence) fitness to seismic data of the region with $M_L \geq 4$ was assessed. According to the results obtained, it can be said that temporal distribution of these data do not completely follow the Poisson distribution model, but with increasing the earthquake magnitude, the data probability distribution approaches to the Poisson distribution. Additionally, in this study, we used the time series analysis method to find the productive pattern of seismicity data and based on magnitude, depth and energy released, as variables, time series plots as well as autocorrelation and partial autocorrelation charts for these data were prepared. The results indicates that the data nearly show time series ARMA (1,1) model for magnitude and energy released attributes, and ARMA (0,1) model for focal depth variable. According to obtained results of this research, it is concluded that the earthquake occurrence in the Zagros region do not completely show a random pattern. It is expected that more precise results be obtained with reducing the seismic data errors and using the data with longer time periods in the future works.

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SAR MONITORING OF LANDSLIDES IN THE BIG SOCHI REGION (THE GREAT CAUCASUS)

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The Black Sea coast of the Great Caucasus is a region of high landslide risk. In recent years landslide risk assessment has become vital because of strongly increased human-induced impact dealt with construction of the Sochi-2014 Olympic Games facilities. We studied the landslide activity in the area of the Big Sochi using the StaMPS PS-InSAR and SBAS methods. We incorporated all available radar images from the satellites with different wavelengths: 17 ALOS images, 13 Envisat images, 17 TerraSAR-X images. For all of these three sets of images we identified persistent scatterers (PS) with a density of more than 350 PS/km even for rural areas. Many areas of relatively high surface displacement rates located using the SAR data appeared to match with the landslide inventory maps. .

We present time series for the most active landslide areas of the Big Sochi. The calculated average surface line-of-sight (LOS) displacement rates vary from 15-20 mm/year up to 60 mm/year. For some places with extreme values of LOS displacement rates the values of displacement rates in the down the slope direction were also estimated. Results obtained with the StaMPS software were compared to those obtained by DePSI and GiANT (SBAS, NSBAS) methods.

Analysis of the time series made it possible to determine periods of activity and relative stability of the landslides and compare them to the ground observations. Detailed analysis of the time series was performed for the Baranovka landslide where very strong movements during 23-24 January 2012 damaged 35 houses.

Obtained results illustrates high efficiency of SAR Interferometry in monitoring of landslide activity in the areas of the Great Caucasus where landslides are numerous.

The work is partially supported by the RFBR grant 16-05-00937-a.

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DEFORMATION PRECURSORS OF LARGE EARTHQUAKES DERIVED FROM LONG TERM GNSS OBSERVATION DATA

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Today permanent GNSS stations being installed widely all over the world. It is possible now to study the Earth's surface deformation on a scale never possible before. Some of permanent GNSS networks are covering the seismo-generating zones. One of the more investigated seismic areas is San Andreas Fault zone of California, USA. Two of GNSS networks of this zone are well placed to study Earth's surface deformation just near the epicenters of the strong Parkfield (September 28, 2004, Mw=6.0) and El Mayor Cucapah (April 4, 2010, Mw=7.2) earthquakes. The epicenters of the earthquakes are conveniently located several kilometers far from the permanent GNSS networks.
The results of GNSS observations in areas of the earthquakes are analyzed. The characteristics of land surface deformation before, during and after earthquakes have been obtained. The results prove the presence of anomalous deformations near their epicenters. These extremes can be considered as earthquake precursors.

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DATA PUBLISHING UNDER THE "EARTH SCIENCE DATABASE" PROJECT

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The registration of objects of scientific content (articles, research papers, books, etc.) with the assignment of the digital object identifier (DOI) has become customary. Currently the DOI system is extended to a wide variety of observational data considered now as adequate results of research and should be cited as other scientific sources of information. Assigning DOI to data provides a framework for persistent identification, managing metadata, linking customers with content suppliers.

In 2014 Geophysical Center RAS initiated a new project - "Earth Science Database" (ESDB). The goals of the project are (i) accumulation of observational data collected by Russian WDCs since 195, and new data obtained under the current international projects, e.g. INTERMAGNET; (ii) providing persistence linking to registered data; and (iii) preservation of data using, in particular, connections between ESDB central and local repositories using "multiple resolution" technology supported by Crossref.

On the first stage of the Project DOIs are assigned to geomagnetic data. The first digital object identifiers were assigned to geomagnetic variations database and 1-minute values database of Klimovskaya observatory of the Russian-Ukrainian INTERMAGNET segment. Landing pages, containing brief descriptions of the data and links to data access, are placed on the Project website. Next step is assignment of DOI to database of 1-minute variation measurements of the Earth magnetic field from Russian observatories. We believe that it is a small but valuable contribution to development of the international data system and the availability of information on the Earth Sciences in general.

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GIS APPLICATIONS FOR GLACIOLOGICAL STUDIES

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In the paper we present the system of glaciological data management has been developed in the Institute of Geography of Russian Academy of Sciences (IGRAS).
Substantial and rapid environmental changes require developing methods which could be able to manage huge information flows, to optimize processes of the data acquisition, storage, analysis, and exchange. Such facilities can be provided by the newly developed GIS technologies. Digital data bases are used as the key component of the GIS methods. Digital Atlas «Snow and Ice on the Earth», glacier inventories and digital glaciological library are the basic structures making possible objective presentation of the glaciological knowledge and data. The system provides the data integration, access to the data base, and makes possible using the GIS techniques for analysis. Data integration technologies are designed to form the united information space of subject areas of the spatial data. The objects of integration in our study are the information resources of glaciology, accumulated in a distributed system of data on the IGRAS web servers and geoportals in forms of data and metadata bases, structured data files, object data files, and electronic atlases. The result of integration of the glaciological data technology application is the series of software and technology solutions. The main result of this work is creation of geoportals «Electronic Earth» (www.webgeo.ru) (2009), «The Nature and Resources of the Russian North» (www.north.webgeo.ru), «IPY-IGRAS» (www.mpg. igras.ru), all based on the spatial glaciological data. Another result is the digital and web-atlas «Snow and Ice of the Earth», presenting the example of open source of the spatial data on glaciology in the multiprogram environment. Regional data bases created for regions of the Caucasus, Altai, Arctic and the Antarctic Continent make it possible to develop various GIS models and to analyze interrelations, status and dynamics of glaciological parameters. The system of links provides easy access to distributed resources.
In our work we used the results of the studies supported through Russian Foundation for Fundamental Research (№ 96-07-89146-в, 98-05-64303-а, 01-07-90217-в, 01-05-65474-а, 13-05-12047 офи_м, 13-05-41195РГО_а), Fundamental Research Programs of Presidium of Russian Academy of Sciences “Electronic Earth”, “Assessment and ways to reduce the negative effects of extreme natural events and disasters” and Department of Earth Sciences of Russian Academy of Sciences “Physical and chemical processes in the atmosphere and cryosphere, defining climate and the environment change”

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UNIFIED NON-ALGEBRAIC FIELD/GEOMETRICAL APPROXIMATIONS FOR COMPUTATIONS

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At a numerical modelling in applied sciences *a priori* we usually do not know about the 'optimal' type (e.g., algebraic, trigonometric, exponential, and so on) of approximating for the geometrical and field functions. However, the physical phenomenon through its presenting multi-field functions resonates to the particular type of varying of these functions (i.e., if given type of varying of field functions does not mirror a particular physical situation, response can and to not be or it will be extremely slowed in form of locking, or may be the pollution effect, etc.). Therefore, we should first of all ensure any type of continuous varying of approximating representations. The unified non-algebraic lagrangian interpolation/approximation methodology for unifying of the CAD system and the computational method for computations is suggested. The main task of this approach is to extend the CAD system and the finite element method (FEM) to introduce the best uniform continuous approximations via the new formed complete families of the 1D, 2D and 3D multiscale spectral non-algebraic shape functions and via parametric mapping the master element (a square and a cube in computational spaces) into curvilinear FE. The extension is performed in seven aspects: (i) the formation of a library of multiscale spectral non-algebraic shape functions for an arbitrary number of boundary-only [1-2] and boundary and internal nodes, and also having any necessary type of varying (oscillating, rapidly damping, or slow) and depending on some parameter, (ii) the construction of the efficient and reliable non-algebraic transitional (with different numbers of nodes on different sides) compatible FE, (iii) an approximating consistency of field functions through their interpolations (no locking and zero energy modes), (iv) the developing of an adaptive multilevel macro-element approach with the boundary element possibilities within the framework of the truly FEM, (v) an implementation of the multiscale meshless FEM, (vi) an organization of the controllable functionally-parametric mesh generation, and (vii) the development of the unified CAD/analysis software. By contrast to algebraic shape functions the best uniform field and geometrical approximations by 1D, 2D and 3D continuous interpolating functions are ensured (no Gibbs' phenomenon on boundary, without an 'unexpected' splash between nodes). The numerical examples show the robustness and the accuracy for the solution of geophysical problems. The work is partially supported by the RFBR grant 15-01-05887-a.

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ENSURING ENVIRONMENTAL SAFETY BY MEANS OF GIS

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The paper summarizes twenty-five years of experience in the implementation of methods and technologies of geographic information systems (GIS) at the Institute of Geography RAS (Moscow, Russia) for geographical research, i.e. monitoring natural and anthropogenic factors affecting the variability and environmental sustainability, decision-making in the sphere of environmental security.

The paper is illustrated by examples of GIS use, e.g. «Atlas of natural and technogenic hazards and risks of emergencies in the Russian Federation», maps of extreme ecological and geomorphological situations in Russia, electronic atlases «Environmental risks in suburban and rural areas», spatial database on sources of pollution, maps of the effects of the catastrophic flash flood in Krymsk (July 6–7, 2012), data on monitoring natural-anthropogenic situation and mapping of objects of the Sochi 2014 Olympics Games.

The success of the latter projects is associated with the new technological possibilities of geographical research, network environment for storing and processing spatial data, new data sources (satellite images of ultrahigh resolution, detailed digital elevation models, lidar data, images from unmanned aerial vehicles), effective use of GIS tools, and further development of cartographic visualization methods.

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MONITORING AND MODELING OF ESSENTIAL ATMOSPHERIC PARAMETERS IN THE SUBARCTIC REGION

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The intensive experimental and theoretical studies of essential atmospheric parameters in the Subarctic region have been performed at St.Petersburg State University (SPbU) in cooperation with Russian State Hydrometeorological University since 2014 and have been supported by Russian Science Foundation grant No 14-17-00096. The experimental part of the work included ground-based remote and in-situ measurements of atmospheric temperature and gas composition by a cluster of instruments maintained by Resource Center “Geomodel” at SPbU (Fourier and grating spectrometers working in ultraviolet, visible and infrared regions, microwave radiometer, ceilometer, gas analyzers). The list of controlled atmospheric constituents has included O_3, NO_2, H_2O, CH_4, N_2O, HNO_3, $ClONO_2$, CO, HCl, HF, CO_2 and other gases. The obtained results in combination with earlier data have been used for the analysis of temporal variations of atmospheric composition on different time scales. The model studies have been conducted in several directions. The sensitivity of atmospheric trace gases in Arctic and Subarctic to the tropospheric and stratospheric temperature changes has been simulated for the period 2009-2015 using different scenarios. The global chemistry and climate model has been used to investigate the influence of the ocean temperature and ice cover on the ozone content. Model studies of the mechanisms of the increase of methane concentration due to melting of the arctic gaseous hydrates have been also carried out. The results of experimental observations of O_3 and NO_2 at SPbU have been compared with model predictions with the aim to analyze the degree of influence of processes in Arctic on the subarctic regions such as the North-West part of Russia.

MAGNETIC STATION «RED LAKE» (IAGA code: SPG). CONTINUATION OF A NUMBER OF PERMANENT MAGNETIC OBSERVATIONS IN THE VICINITY OF ST. PETERSBURG (RUSSIA) SINCE 1726

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A number of continuous observations over change of parameters of the Magnetic Field of Earth (MFE) in vicinity of St. Petersburg is made since 1726: St. Petersburg (1726-1878), Pavlovsk (1878-1941), and in SPBF IZMIRAN: in the Magnetic – Ionospheric Observatory (MIO) Voeikovo (1946 till present) and at the magnetic station (MS) "Red lake" (1968-2000). In 2012, on the MS "Red Lake" joint efforts of SPbF IZMIRAN, GC RAS and IZMIRAN have installed the standard magnetometric INTERMAGNET equipment. Observations were resumed with the highest data quality.

Magnetic variations data recording with sampling frequency 1 Hz is provided also as it's transmission into remote databases in SPbF IZMIRAN, GC RAS and IZMIRAN. Preliminary data processing by original algorithms is carried out by GC RAS, quasi-definitive data regularly transferred into Geomagnetic Information Node of INTERMAGNET in Paris.

Since 2015 regular observations of absolute values and variations of MPE are made till present, also the staff of SPBF IZMIRAN support technical maintenance of smooth operation of a complex. According to the preliminary analysis of the data for this period satisfactory compliance of INTERMAGNET standard is established.

Employees of SPBF IZMIRAN have developed the project of the auxiliary device for collecting and data recording of absolute observations taking into account MPE variations in the semi-automatic mode with a possibility of introduction and distribution in the territory of the Russian-Ukrainian segment of the INTERMAGNET network. In addition to standard observations of INTERMAGNET on MS "Red Lake" in 2016-2017 is planned the installation of the highly sensitive quantum vector magnetometer possessing high stability (~ 0.2 nT) and sensitivity (~ 1 pT), with a frequency of data collection of 10 Hz; and also the geophysical GI-MTS-1 complex with sensitivity (~ 1 pT) and with a frequency of data collection of 50 Hz.

In May 2016 the MS "Red Lake" is recommended for inclusion in international magnetometric network INTERMAGNET as a serial observatory with the IAGA code: SPG.

Preliminary data are available for viewing and downloading at:

http://geomag.gcras.ru/dataprod-plot.html.

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DEFINITION OF FORTHCOMING STRONG EARTHQUAKE EPICENTER POSITION USING THE METHOD OF PASSIVE ULF MAGNETIC LOCATION

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Results of passive ULF (F=0.001 – 1 Hz) magnetic location method using are represented. The method we used for definition of forthcoming strong earthquake (EQ M>5) epicenter position. Three magnetic stations situated at tops of a triangle at the Earth's surface at distances 3-6 km one from the other are a magnetic gradientometer. The gradientometer allows determining along the Earth's surface gradient and phase velocity vectors of ULF magnetic disturbances (F=0.001-1 Hz) of ionosphere and lithosphere origination. As a rule, the gradient vectors are directed to a local source of the ULF variations and the phase velocity vectors are directed in the opposite direction.

We found that values of the gradient and phase velocity vectors have anomaly change 1-2 months and 2-6 days prior to strong earthquakes. New direction to forthcoming EQ epicenter appears in distributions of the gradient vector directions and opposite direction appears in distributions of the phase velocity vector directions. Two-three gradientometers disposed at distances ~100 km in seismic active area allow to observe at ~40000 km^2 area an appearance of local magnetic anomalies of the geomagnetic disturbances originating from an evolution and activation of tectonic processes before EQ. Examples of gradient and phase velocity value changes and allocating at controlled area of supposed regions of forthcoming strong earthquakes are presented. The gradient and phase velocity vectors of the ULF magnetic disturbances can be used as one of factors for a short-term prediction of the strong earthquakes.

MAGNETIC FIELD VARIATIONS INDUCED BY TSUNAMI 11.03.2011 IN COASTAL ZONE

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Very strong earthquake (EQ) with magnitude M=9 happened 11.03.2011 at 05:46:24 UT near the eastern coast of Japan. This EQ was strongest in the known Japan history. The EQ epicenter was located ~370 km from Tokyo and in ~115 km from nearest coast. The 370 km rupture aroused at ocean bottom. Vertical displacement of the bottom equaled 5 m. The EQ stimulated a tsunami that destroyed APS Fukushima.

Data of six three-component magnetic stations and one seismic station situated along of the eastern coast of Japan were used for analysis of magnetic field variations induced by tsunami movement. Two closest to the EQ epicenter magnetic stations were at ~150 km distance from the epicenter and at ~30 km from the coast.

It was found that after ~30 s (that corresponds to ~5 km/s propagation velocity of a seismic wave) from the EQ moment the seismic station recorded the EQ waves. After ~ 50 s from the EQ moment (that corresponds to ~ 3 km /s propagation velocity) the closest magnetic stations registered in three magnetic components a short splash (probably a magnetic response of the tsunami origination). Duration of the burst amounted to ~ 100 s. The main magnetic period of the oscillations was about 30 s with 2-5 nT amplitude. The tsunami wave arrived to the coast after 8-9 min later on the EQ moment. At the closest magnetic stations, the H component of the earth magnetic field decreased at ~5 nT after ~600 s from the EQ moment. The D component value increased at ~10 nT and Z component had at first ~ 1.5 nT increasing, than it decreased at ~6 nT. Magnetic field tsunami spectrum had variations with ~10 min and 2-3 min periods with ~1 nT amplitudes. A process of the earth magnetic field recovery lasted about 1-1.5 hours after the EQ moment.

AUTOMATED EARTHQUAKE DETECTION AND PHASE PICKING FOR THE RECORDS OF BOTTOM SEISMOGRAPHS NETS

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Geodynamic factors, predominantly related to seismic hazard, are among the main factors of risk for planned offshore oil and gas production facilities. Thereby there is a need in seismic hazard assessment of construction areas for offshore drilling platforms or subsea pipelines and seismological monitoring of the platforms that already in service. Bottom seismographs usage confronts the researchers with the problem of automatic processing of large volume of records. In the present work an efficient algorithm for earthquake detecting and phase picking based on seismic events duration and correlation analyses is presented. It takes into account the features of bottom records such us spikes, microseisms, ship noise and etc. For verification of developed algorithm the bottom seismographs records from Anapa region of the Black Sea were used.

The work is partially supported by the Russian Science Foundation (project no. 14-50-00095).

AN APPROACH TO DEVELOP AUTONOMOUS MODULE OF LOCAL INFRASOUND MEASUREMENT NETWORK

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In this work we describe developed in the laboratory of robotics Gorno-Altaisk State University infrasound measurement module, which allows to record infrasonic waves generated by medium- and low energy events as a man-made or natural origin. The measuring unit has an independent power supply and data transmission channel in GSM network through INTERNET modem synchronization and GPS module. The simplicity of technical solutions, small size and an autonomous power supply from renewable energy may find wide use in the design of easily tunable local measurement networks.

PROBLEM OF GEOMAGNETIC SECULAR VARIATION ACCOUNTING FOR TECTONOMAGNETIC STUDIES

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Problem of secular variation (SV) accounting of geomagnetic field for tectonomagnetic studies at Baikal region are considered. This accounting could be made by means of, for example, global IGRF-11 model or exact geomagnetic annual observations on tectonomagnetic network. The method of calculation of SV according to the observation on the Baikal network based on essential difference of source depths of SV and the tectonomagnetic anomalies is offered. Thus, use of the IGRF-11 model gives a considerable error at accounting of SV. Therefore, the preference needs to be given to the SV model calculated according to observations on the Baikal network. The account and an exception of SV have allowed mark out anomalies up to several nT [Kuleshov and Dyadkov, 2013]. However, additional researches are required for definition of the tectonomagnetic anomaly nature.

The work is partially supported by the Earth Science Branch RAS grant 7.1.

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MODERN GEOLOGICAL KNOWLEDGE AS THE BASIS FOR THE ACCOUNTABILITY OF POLITICAL LEADERS FOR THE PROVOKED MAN–MADE GLOBAL CATASTROPHE

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The evolution of bio -, noo - and the InfoSphere (of societies) is based on the cyclicity and periodicity of geological processes and is subject to the laws of synergetics claiming the interconnectedness of all planetary processes. The authors to justify conclusions considering the three types of loops: galactic (mega - and macrocycles), planetary and solar. Planetary cycles under the influence of the interaction of the system Earth – Moon on the galactic background (about 215 MA) solar (11.8 (average 12±3) years) (the history of the Earth .., 2005, etc.). The cumulative effect of galactic and planetary cycles leads to global tectono - magmatic events: first of all, earthquakes and volcanic eruptions on the long-term formations of plumes and superplumes in the body of the Earth, rifting, formation of supercontinents, the introduction of magmatic masses, etc., as well as biological "revolutions" ("skeletal", "vegetable", etc.), etc. In the biosphere metamorphosis less visible to human sight: mutations, changes in the size and composition of the rings of trees, etc., unreasonable the appearance or disappearance of species. In the social sphere, seemingly "unexpected" military conflicts, political hysteria, the UPS and downs in the development of civilizations and States, as well as discoveries, including world class in different fields of science, technology, etc.

Seismic activity is confined to the youngest planetary formations, including the highest seismic activity really have the area within the lines: the Azores - Gibraltar ridge – Turkey - Caucasus – Himalaya – Sunda trench – trench Tonga – Kermadec trench. This is due to geoelectric heterogeneities (waveguides, electrically conductive zones, areas higher acquisitions of seismic waves and intense stratification), active fluidization in subhorizontally fluid-filled bodies of the earth's crust predominantly in the upper zones. For the period 1999-2004 within the Anatolian-Iranian-Caucasian tectonic block and water area of the Caspian sea occurred on 23 glubokovodnykh earthquakes that differed in magnitude (here and further on Keramova, 2005).

The main tectonic zone of the planet is the axis States, which is dominated by naturally regenerated men. Episodes of seismic activation along the "main conflict area" of the planet at the present moment are not only powerful regular geological phenomena, but successive wars and social conflicts. Perhaps it is natural (gas), natural fluidization of the territories over the faults in the eve of disasters may lead to an excited state of weak minded people who give in to the brainwashing and mass psychosis.

Historically recorded solar flares, earthquakes, cyclic atmospheric processes, some phenomena in the life of the biosphere are in resonance with popular uprisings and wars, the birth of new and the persecution of other religions, great world importance discoveries, etc.

However, in modern warfare, in which powerful Arsenal of seismic influence on the envelope of the planet, become a geological force comparable to the effects of solar activity. Short or long, but the systematic bombing of within the Major collisional zones of the planet upset the balance of equilibrium of a system: the rock – fracture – dynamics – fluid, activating of a trigger unplanned Nature of earthquakes. Eg., military conflicts and, especially, a powerful bombing in Afghanistan, Yugoslavia, Iraq, ended catastrophic for the population zemletryasenii. The authors analyzed the natural disasters and historical events in 2000 years (History of Land in .., 2005). Statistics indicates full compliance of solar activity follow-up within ±2-3 years before and after the processes on Earth - from the excitement of the most emotional segments of society, sudden wars and earthquakes before the economic crises. Interconnection method of analysis proposed by A. L. Cizewski for two occasionally connected systems - solar activity and rhythms of the natural (terrestrial) processes, allows to optimize the prediction of many natural and social processes. The determination of the tendency of future changes in the natural environment under the influence of natural and anthropogenic factors impact possible with probability of the order of 60-65%.

The analysis of geological and cosmic knowledge and its application highlight the need to inform the public about the latest achievements of geological science in planetary and space scale and create conditions for compulsory introduction of these achievements into practice. The maximum aging of scientific development takes place within 5-10 years.

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MONITORING OF EQUIPMENT AND BUILDINGS OF HYDROELECTRIC POWER PLANTS BY USING THE DATA OF SEISMIC OBSERVATIONS

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The GS RAS in recent years developed a technique for monitoring the state of the equipment and structures of hydroelectric power stations, based on analysis of records of microseismic oscillations derived from seismic stations located at a distance from the object. The technique allows for remote monitoring of a vibrating condition of working hydroelectric power plants equipment. It allows you to keep track of changes in the values of the natural frequencies of buildings and thus to monitoring of their technical condition. It allows you to get more objective information necessary for the investigation of the causes of emergency situations on hydropower plants.

GEODYNAMIC MODEL OF THE ARCTIC EVOLUTION AND THE OUTER LIMITS OF THE RUSSIAN CONTINENTAL SHELF IN THE ARCTIC OCEAN

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The present study comprises a model of Arctic lithosphere evolution since Cretaceous to present. The model is based on the mechanism of upper mantle substance circulation beneath the Arctic lithosphere linked with Pacific lithosphere subduction. Seismic tomography data obtained for the Pacific-Eurasia-Arctic joint area indicate that Pacific lithosphere slab sinking to the mantle in subduction zone transforms into the horizontal layer upon reaching the upper mantle foot, this layer extending for two or more thousands km beneath the Eurasian continent. This pattern of seismic tomography indicates the presence of a horizontal convective cell where a flow of substance moving along the upper mantle foot from a subduction zone into the continent is compensated by return flow moving along the lithosphere foot towards the subduction zone. The return flow makes continental lithosphere extension, giving rise to processes of rifting, magmatism and spreading. The given model allows to understand main features for the Arctic evolution since early-mid Cretaceous to present. Numerous seismic profiling data obtained for shelf and deep water sedimentary basins in the Arctic Ocean as well as on land geological investigations reveal that since Aptian up to present the Arctic region has been characterized by sublatitudinal lithosphere extension. This extension is explained by the dragging effect of the return mantle flow on the Arctic lithosphere foot. The model shows the phenomenon of “Arctic plum” to be caused by the upper mantle uprising flow of convective cell. The proposed model is considered to be a scientific substantiation of the partial revised submission of the Russian Federation to the UN Commission on the limits of the continental shelf in respect of the continental shelf of the Russian Federation in the Arctic Ocean.

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THERMAL AND DYNAMIC PERTURBATIONS IN THE WINTER POLAR ATMOSPHERE ASSOCIATED A MAJOR SUDDEN STRATOSPHERIC WARMING

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The winter polar stratosphere is often unstable and may experience dramatic changes associated with the occurrence of sudden stratospheric warming (SSWs), when there is greatly increased temperatures within a few days occurring in midwinter. Such events are caused by enhanced planetary wave activity that induces a westward forcing and decelerates or even reverses the eastward polar night jet. During a major SSW a specific signatures of atmosphere-ionosphere coupling is observed in the vicinity the stratospheric polar jet. Wind reversal from eastward to westward occurred at 80-100 km altitude. The magnitude of mesospheric cooling is comparable with the stratospheric warming (~50 K) but the former decay faster than the latter. Deepening of the thermal inversion layer at the mesopause is observed during the peak of the mesospheric cooling. A shorter period AGW occurrence in the ionosphere decays just after the mesospheric temperature reaches its minimum. The effect may be explained by selective filtering and increased turbulence near the mesopause.

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EXTREMES IN THE SUBSTORM AURORAL ELECTROJET DURING THE TO EXCEPTIONALLY HIGH SOLAR WIND STREAMS

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The exceptionally high solar wind stream activity in 2003 caused a record intensity in the auroral electrojet currents, leading to a major reduction of the horizontal field at auroral latitudes and to a notable strengthening of the vertical geomagnetic field in the polar cap. This strengthening is clearly visible in the observatory annual values as a significant deflection in the corresponding secular variation. A similar but weaker deflection also occurs during the strongest high speed stream years of the earlier solar cycles, e.g., in 1983 and 1994. We also found that, in addition to the disturbed times, the westward electrojet was often enhanced even during the most quiet times
of the strongest high speed stream years. The quiet time level was more disturbed in 2003 than in other high speed stream years, when an exceptionally clear signal was seen in the polar cap vertical magnetic field intensity even in the annual mean curve in this year.

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COASTAL MONITORING USING UNMANNED GROUND VEHICLES

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Currently, for monitoring of coastal zones there are several mobile systems, equipped with scanning equipment, video inspection systems and positioning [1,2]. Within the project an experimental prototype of unmanned ground vehicles (UGV) for coastal monitoring and forecasting marine natural disasters has been constructed. The composition of its measuring equipment includes the following components: lidars LMS511-10100, GNSS antennas (AT330), weather station Vaisala WXT520, camera AXIS Q6042-E, radar MRS-1000. For operating in various climatic and landscape conditions there has been chosen the special modular structure with the possibility of re-equipping by different types of movers (wheeled, tracked, rotary-screw). Preliminary testing of operation of the UGV experimental prototype allows speaking about the effectiveness of the developed technology.

The presented results were obtained in Nizhny Novgorod State Technical University n.a. R. Alekseev with financial support of applied scientific research of the Ministry of Education and Science of the Russian Federation (agreement № 14.574.21.0089 (unique identifier of agreement - RFMEFI57414X0089)).

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3D DENSITY MODEL OF TIMAN PECHORA REGION

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Geological and geophysical 3D model creation for Earth crust and upper mantle structure is fundamental direction in Earth science. These models allow us to make conclusions about formation conditions and tectonic evolution of geological structures. Geophysical and (mostly) seismic studies showed that geological environment on deep horizons have a complex hierarchical structure with layers and blocks and is not homogeneous either along or across the upper lithosphere seismic floor. Such regularity is found on almost all deep seismic soundings (DSS) profiles, which total length on Ural region area under study is more than 10000 km.
Reasoned regional geology problem solving is almost impossible without including impact of upper lithosphere deep structure features. We demonstrated that quite informative data could be got from regional profiles and DSS traverses, which were made in significant amount on all Russia territory. We used such data to create 3D geological-geophysical model for Timan-Pechora region upper lithosphere. Our research was supported by Russian Science Foundation (grant 14-27-00059).

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STRESS-STRAIN STATE (SSS) OF THE EPICENTRAL AREA OF THE 1992 M = 6,8 ERZINCAN EARTHQUAKE (TURKEY)

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The epicenter of the 13.03.1992 M = 6.8 strong tectonic earthquake is localized in the region of North Anatolian Fault (Turkey) at the junction of tectonic faults of lower rank. The earthquake focus is located at a depth of 10 km, with a compression axis oriented along the meridian. The authors used a fault tectonic scheme of mathematical modeling of stress-strain state of epicentral area before and after the earthquake. For this purpose, i.e. for the calculation of stress-strain state of blocky heterogeneous arrays in the field of tectonic stresses, we used the software developed by the Laboratory of Geodynamics of GC RAS.

It is shown that the focal area of the 13.03.1992 M = 6.8 earthquake and the subsequent direction of propagation of tectonic fault is determined by the stress intensity and abnormally high shear stresses in the precursory phase prior the earthquake. After the formation of the fault the stress-strain state of the epicentral zone varies considerably. The area of static stress drops corresponds to the area of localization of aftershocks at the maximum values of stress drops of about 20 MPa. The modeling of stress-strain state of potentially dangerous areas of mutual influence of active tectonic faults opens up new possibilities for predicting the locations of strong tectonic earthquakes and efficient geophysical research.

JUSTIFICATION OF THE CHOICE OF LOCATIONS FOR THE COAL ROCK DUMPS ON THE BASIS OF DATA GEODYNAMIC ZONING

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Spontaneous combustion of coal waste dumps is a topical environmental problem in mining areas. The stockpiled rock mass is a source of emissions into the environment of gases, dust, toxic chemicals and radioactive substances. Choice of locations for coal rock dumps is designed to prevent their spontaneous combustion, has potential applications in the mining industry.

The planned area of placement coal waste dumps is researched by the method of geodynamic zoning with finding borders of geodynamic active blocks. The width of impact of these borders is evaluated and they are identified on the ground.

Application of the proposed method should prevent the spontaneous combustion of the stored rock. Proposed method for the selection and the method of preparation of the site will reduce the negative impact of burning coal rock dumps on the environment and the population of mining areas, as well as to reduce material costs for coal waste dumps extinguishing and restoration of earth surface.

ABSOLUTE VECTOR OVERHAUSER MAGNETOMETERS POS-3 & 4 FOR GEOMAGNETIC MONITORING

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Due to the high absolute precision (up to 0.2 nT) and stability (<0.05 nT per year) scalar overhauser magnetometer POS-1 found wide application in the magnetic observatories and hazard monitoring systems. Presented new modification for measuring the vertical component (POS-3) or the vector (POS-4) magnetometers based on the switching bias fields methods [1]. We discuss the long-term experience in the testing of magnetic observatories ARTY and PARATUNKA. Sensitivity control method by the dispersion of the precession signal periods proved to be a useful [2].

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EARTHQUAKE HAZARD AND RISK ASSESSMENT BASED ON UNIFIED SCALING LAW FOR EARTHQUAKES THE GREATER CAUCASUS AND CRIMEA

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We continue applying the general concept of seismic risk analysis in a number of seismic regions worldwide by constructing regional seismic hazard maps based on morphostructural analysis, pattern recognition, and the Unified Scaling Law for Earthquakes (USLE). The USLE generalizes the Gutenberg-Richter relationship making use of naturally fractal, multiscale distribution of earthquake sources of different size in a seismic region: $\log N(M,L)=A-B\cdot(M-6)+C\cdot\log L$, where N(M,L) is the expected annual number of earthquakes of a certain magnitude M within an seismically prone area of linear dimension L. The parameters A, B, and C of USLE are used to estimate, first, the expected maximum magnitude in a time interval at seismically prone nodes of the morphostructural scheme of the region under study, and then to map the corresponding expected ground shaking parameters including macro- seismic intensity. After a rigorous testing against the available seismic evidences in the past (e.g., the historically reported macro-seismic intensity), such a seismic hazard map is used to generate maps of specific earthquake risks for population, cities, and infrastructures (e.g., those based on census of population). The methodology of seismic hazard and risks assessment is illustrated by application to the territory of Greater Caucasus and Crimea. In particular we consider also the dynamical estimation of the regional daily seismic hazard in two years after the 11 October 2008 Kurchaloy, Chechnya earthquake.
The work is supported by the Russian Science Foundation, project #16-17-00093.

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GIS MODELING AND MACHINE LEARNING TECHNIQUES FOR HAZARD EVENT PREDICTION USING ENGINEERING SURVEY DATA

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During the last ten years, machine learning approach for data analysis has been a topic of growing interest for the scientific community. Not surprisingly so, since the last decade it has brought about a true revolution in the world of technology with new and extremely advanced approaches to computer modeling. As far as engineering depends on data processing it is very important to provide it with modern and reliable analytical systems.

Nowadays, implementation of geo-information systems within the field of Earth Sciences and affiliated parts of industry is highly relevant. Particularly for engineering surveys it gives a tremendous potential for data analysis. In addition, rapidly growing open source community of data science provides us a chance to implement new and flexible software for data mining.

The present study makes an attempt to combine basic principles from GIS modeling and machine learning techniques in order to develop sustainable prediction systems for hazardous events. The models are based on the results of engineering surveys and remote scanning within the Taman peninsular. Particularly, they describe distribution of the most hazardous processes for the buildings construction: collapsibility and landslides. The final model is aimed to determine suitable sites for civil development based on geological safety and resource economy perspective. We explore nonlinear connections between different variables using the most up-to-date methods of computational mathematics in order to realize full potential of our data.

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VISUALIZATION OF THE EARTH'S MAGNETIC FIELD PARAMETERS BASED ON OPERATIONAL GROUND AND SATELLITE GEOMAGNETIC DATA ON A DIGITAL DEMONSTRATION COMPLEX WITH A SPHERICAL SCREEN

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This research is aimed on provision of compatibility and interoperability between the hardware and software system for management and intellectual analysis of observatory and satellite geomagnetic data and the digital projection systems with a spherical screen. The web-service for interpolation of geomagnetic field hourly variations, developed at GC RAS, generates digital maps in the form of raster images, which are visualized on the spherical screen.

Raster image specifications (PPI, resolution and color depth) were defined for optimal visualization of thematic objects of the minimal size, which can be clearly identified on the spherical screen by a user from the specified distance. Visualization process consists of rendering of prepared images composed of rendering into a cubical structure, which involves "baking" all data in a single layer in a suitable for its following projection shape, and the synthesis of the final image, which is necessary to carry out the reverse process - to project the image from the cubical structure on a flat projection screen and further through the lens on the spherical screen.

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DEVELOPMENT OF GEOSPATIAL DATABASE ON HYDROCARBON EXTRACTION METHODS IN THE 20TH CENTURY FOR LARGE AND SUPER LARGE OIL AND GAS DEPOSITS IN RUSSIA AND OTHER COUNTRIES

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This project is being developed in the framework of the program № 1.4 of Russian Academy of Sciences *"Study of historical process of science and technology development in Russia: a place in the world scientific community, social and structural transformation"*. The project targets geospatial database on hydrocarbon extraction methods in the 20th century for large and super large oil and gas deposits in Russia and other countries. The work was executed by sequential steps. At first domestic and international relevant sources of information were collected, merged and analyzed. The list of the attribute data base tables and their values have been elaborated from this analysis.

The project's main objective is a comparative analytical study of the hydrocarbon extraction methods to assess the role of RF on the global scale. To increase effectiveness of the results a multifunctional web-service is being developed basing on ESRI Geoportal Server platform. The later is characterized by the following features. They are: multi-level access to data; search by parameter presets; viewing and filtering of selected data layers using online mapping applications; sorting of metadata, including bibliographic information for each field. Such a complex approach and multidisciplinary database will play important role for solving various tasks in the area of oil and gas exploration and extraction. This poster will present results of this systems analysis study concerning positions of different oil and gas countries in the list of the leaders.

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THRESHOLD SENSITIVITY OF QUARTZ TORSION MAGNETOMETERS ON A BASE OF VICALLOY AND SAMARIUM-COBALT

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Due to the need of providing a geomagnetic observatories network of Russia with the magnetometers of a domestic manufacturing, which meet the requirements of the international Intermagnet network, and the planned transition of Intermagnet to one-second registration, extremely achievable parameters of magnetometers on the base of quartz torsion variometers are investigated. Influence of instability and noise of the opto-electronic converter on a threshold of sensitivity of a magnetometer with the negative feedback (NF) is considered and extreme values of a sensitivity threshold of the magnetometer are estimated for different magnetic materials used, depths of NF and the demanded frequency range of measurements. Criteria for optimization of the sizes and a form of the magnets which are made of various magnetic materials are determined by a condition of a maximum relation of the magnetic moment to the moment of inertia. Theoretical and experimental estimates of noise level of magnetometers on a base of vicalloy and samarium-cobalt are given. It is shown that for threshold sensitivity of the magnetometer about 1 pT, the frequency range of the magnetometer with a sensor on a base of vicalloy is limited by a frequency about 1.6 Hz, samarium-cobalt – 6.4 Hz. The received values of a frequency and threshold sensitivity for the specified magnetic materials completely meet the requirements of Intermaget for one-second data and are probably the extreme values for quartz variometers with the opto-electronic converter of angular movements.

CHARACTERING THE GEOMAGNETIC FIELD VARIABILITY FOR THE STUDY OF GEOMAGNETIC STORM IMPACT ON ELECTRIC POWER LINES

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PGI deployed and operates since 2010 a system for recording of geomagnetically induced currents (GIC) in the power line system. This system consists from 5 stations elongated in latitudinal direction at Kola peninsula and in Karelia. The GIC intensity is determined by variations of geomagnetic field. Predominantly geomagnetic field disturbances are oriented in the N-S direction, and produced by the E-W ionospheric currents. Thus, such disturbances seemingly will not induce any significant GIC in a latitudinally-oriented system. However, during magnetic storms GIC in power systems were quite significant. We apply to the geomagnetic data from magnetometer array various techniques to characterize the geomagnetic field variability: vector mapping of time series and a measure of time variations of vector angle cosines. This technique has shown that ionospheric currents fluctuate not just in E-W direction, but chaotically in both E-W and N-S directions. In this paper we examine the relative contribution of various geomagnetic disturbances (SC, storm onset, Pc5 pulsations) into enhancements of GIC using data from PGI GIC-recording system and IMAGE array of magnetometers.

The work is partially supported by the RSF grant № 16-17-00121.

REMOTE SENSING DATA IN SMALL-SCALE PERMAFROST-HYDROGEOLOGICAL MAPPING PECHORA ARTESIAN BASIN

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For the first time materials for Aerospace Survey were used on a large scale in studies on hydrogeological mapping and geocryological zoning of the Pechora artesian basin. The European North-East of Russia zoning of permafrost conditions is closely linked to the natural zoning. There is an increase in severity of natural and permafrost conditions from the south-west to north-east, namely from the northern boreal forest to the tundra. Tundra match continuous permafrost distribution, the taiga is associated with the thawed soils, northern forest-tundra distributes in the zone of divided permafrost, south is referred to an island distribution type. More fractional division hardly has the real natural basis. According to Landsat images the dark coniferous forests, which nestle the most far in the high latitudes are confidently deciphered. Pine dry habitats are also authentically determined. Such plantations are characteristic of the right bank of Pechora River to the latitude of the mouth of the Shuchiya River and distributed on limnokames composed of sandy sediments. To the north in similar conditions grows larch (Naryan-Mar area), and further to the north the crooked birches are found. Such areas of distribution of lacustrine-glacial sediments with sandy composition indicate softer permafrost conditions. Often sands are exposed, and they develop the processes of deflation. Within the taiga zone non-forested areas are easy to interpret. They are frequently confined tracts of frozen peat bogs. To confirm this fact it is preferable to use the more detailed satellite imagery with a spatial resolution of 2.5-5.0 m in the area (SPOT-5), which show easily interpreted polygonal structures and differentiated image of wooden layers and ground cover.

PERMAFROST DYNAMICS ALONG THE COASTLINE OF THE AREA OF DMITRY LAPTEV STRAIT

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Comparison of multitemporal remote sensing data from the 1950s, 2000s and 2010s along the coastal zone of the Lyakhovsky Islands and the southern shore of the Dmitry Laptev Strait, shows that the retreat of ice coast is the most prevalent process. It is revealed in areas composed of Ice and Alas complexes and alluvial-marine terraces. The coastal erosion rate in the region verged 3.2 m per year during the 50-year period (1951-2000) and 6.4 m per year during the past 13 years. Thermo-abrasion of ice complex cliff (15-20 m high) is accompanied by thermo-denudation. Here, the rate of erosion has also increased by more than 1.5 in recent years.

Under the influence of thermo-abrasion and thermo-denudation subaerial ice-rich sediments pass into the submarine sequences, which gives rise to their degradation. Bottom degradation occurs under the action of the geothermal flow. Temperature transformation in the permafrost precedes the start of this process. Gradual destruction lasts about 1500-2000 years for permafrost layers 500-700 m thick. It manifests in the reduction of sediment thickness at the bottom and changes in its state. Ice-bonded permafrost is gradually transformed into ice-bearing permafrost, resulting in changes of unfrozen water content and physical and mechanical ground properties. Degradation of the top layer permafrost depends on the sea depth interval, structure and ice content of the sediments, coastal erosion rate, hydrodynamic activity and duration of its position underwater. Summer warming of bottom waters up to 10-12 ° C causes thawing of bottom sediments, seasonally at depth interval 0-2 m and perennially at interval 2 to 6.7 m. Thawed sediments are gradually thickening seawards and, eventually, reaching many tens of meters.

VARIABILITY OF RESERVOIR INDUCED SEISMIC RESPONSE IN KOYNA-WARNA: FROM FIELD OBSERVATIONS TO LABORATORY SIMULATION

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Comparative analysis was conducted for the dynamics of reservoir induced seismicity (RIS) in the seismic area of Koyna-Warna (Western India) and for annual variations of the water level in reservoirs during the period of 1968-2012. The cyclic variations of water levels cause a cyclic response of seismicity in the seismic area between the Koyna and Warna reservoirs.
The spring peak of RIS corresponds to the beginning of annual reservoir unloading after six months of approximately constant high levels. This maximum is present at not all times and increases after Warna reservoir filling. It can be assumed that the maximum is of kinetic origin, linked with fluid pressure diffusion, long-term rock strength and stress-corrosion. The autumn peak corresponds to the final stage of reservoir loading and rising of maximum water level. It can be assumed that it is of dynamic origin, induced by direct impact of additional water pressure and the rate of its variations. An additional winter peak appears during loading of the Warna reservoir and coincides with the interval of maximal water level. Temporal changes of amplitudes of annual peaks of seismicity found to be not correlated with the water level variations.
It is assumed that triggered seismicity in this region is caused by a combination of dynamic and kinetic factors, i.e. accumulation of stresses and water diffusion into the massive.
Modern laboratory equipment and technique allow to model natural triggered seismicity by the initiation of acoustic activity in the loaded sample. The penetration of water from the surface of the sample into the inner part initiates acoustic emission swarms, which migrate to the area of increased stress and results in forming a macrocrack. The revealed features of temporal variations of parameters of the acoustic regime at the stages of excitation and decay of acoustic activity are qualitatively similar to those in the seismic regime. Changes of stress field after stick-slips result in the destruction of the acoustic response to the periodical axial loading modulation.
The study was carried out under a project supported by the RSF, grant 16-47-02003.

NANOSEISMOLOGY AS A TOOL FOR THE STUDY OF NATURAL AND TECHNOGENIC HAZARDS

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The GS RAS developed domestic equipment and a number of techniques that allow to study the oscillation amplitude in nanometers. This made it possible to create a new trend of seismic monitoring (nanoseismology), based on the registration and processing of not only the seismic events, but also of seismic noise. Nanoseismology allows the study of Earth using powerful vibrators, monitor seismic stability of buildings and operation of large industrial equipment. New technologies have allowed to understand the causes of the accident at the Sayano-Shushenskaya HPP and propose measures to control vibration of hydraulic units and dams, examine the physical condition of hydroelectric power stations, bridges, apartment buildings and industrial objects. Work has begun on the establishment of monitoring systems in the Kuzbass region of technogenic seismicity.

"SUPERSONIC" MAGNETIC POLES

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The temporal changes in the magnetic field of our planet are usually analyzed through the behavior of its angular and force components. But the same changes may be analyzed using the more integrated and comparable characteristics of the magnetic field linked to the orientation (position of the magnetic pole) and magnetic momentum (local magnetic constant) of the central dipole. The data of magnetic observatories, translated into coordinates of corresponding virtual magnetic poles, shows surprising mobility of the magnetic poles, which at time develop ultra-sonic speed. The trajectory of the magnetic poles both in calm time and during magnetic calamities is not a chaotic movement but a series of “loops” of varying shapes and sizes. The differences in identified locations of the virtual magnetic poles, produced by each magnetic observatory, depend in addition to the level of disturbance of the magnetic field, on the proximity of each observatory to the true magnetic pole. These differences can be between 5–10 km and 200–300 km of the arc of the great circle a day.

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ON PERSPECTIVES OF INTERMAGNET OBSERVATORIES USAGE FOR RESEARCH IN SPIN GRAVITATIONAL INTERACTIONS AND COSMOLOGY

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The recent LIGO successful proof on existence of the gravitational waves was a major motive of this proposal. In addition the high precision atomic magnetometers can be used for other fundamental research including spin-gravity coupling, tests of Lorentz and CPT violations, detection of dark matter. It is easy to see that many requirements are completely satisfied by the existing network of INTERMAGNET observatories including K or Ce and Overhauser magnetometers [1,2] with large volume sensor and special algorithms for the precession signal accumulation. There is already the similar network GNOME [3].

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DEVELOPMENT OF THE USER INTERFACE FOR GEOMAGNETIC DATABASE

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The WDC for STP, Moscow has an extensive collection of geomagnetic data obtained from about 260 worldwide observatories. Archive includes film copies and digital images of magnetograms, 1-minute, mean hour and annual mean values of geomagnetic field components, geomagnetic indices, catalogues of magnetic storms. Most of data refers to the time interval since 1957 till present. In recent years the Center makes considerable efforts for transfer historical data to an electronic form and digitization of them. Data in electronic form are disseminated to the community through the website in standard format adopted in the ICSU WDCs System. Considerable part of the data, especially the historical data in analogue form, are available only by request.

We describe a new user interface developed for access to the relational geomagnetic database, which on the first stage will include 1-minute, mean hour and annual mean values of geomagnetic field components and K index values obtained at the observatories of Russia and CIS countries. User can request data using list of codes or geographic coordinates for selection of observatories or the world vector map. The world vector map was created using jVectorMap which works in all modern browsers. Information about the observatories such as location, year of opening or closing, etc. will be showed to user after his selection. Then user indicates in the request form geomagnetic field components, time interval and one of the data formats. The program gives a sample result in one of the widely used formats such as WDC, CSV or IAGA2002. The sample result can be loaded on the user's computer. Software is created on PhP and JavaScript. The developed interface will provide more convenient and easy access to geomagnetic data.

ON THE DEVELOPMENT OF A NEW SEISMOLOGICAL PARADIGM

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Rocks in the region of earthquake preparation are considered having the form of partially amorphized fluid- and gas-saturated composite. An elastic body in the form of high-pressure gas with the predominating amount of hydrogen is located in the cavities of composite matrix. Collapsing of gas cavities results in the matrix deformation controlled by the elastic properties of high-pressure gas. This deformation determines pseudoelastic rebound of the medium. We show that energy release of this process corresponds to the estimates of energy accumulated in the earthquake preparation zone. We propose the formation mechanism of gas cavities having the pressure exceeding lithostatic.

We show the obtained empirical equation for estimation of hydrogen content in the lithosphere and the mantle. Numerical simulation results of electric currents induction in the lithosphere and upper mantle after geomagnetic storm causing fluid electrolysis are presented.

We show that system of dynamically and kinetically complexed geophysical phenomena such as the empirical scheme of short-term earthquake prediction can be considered as the earthquake precursor on the basis of principle of pseudoelastic rebound of the medium.

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APPLICATION OF GENERALIZED REGRESSION ANALYSIS TECHNOLOGY FOR GEOMAGNETIC DATA FILTERING

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Geomagnetic data can have a number of particularities: significant nonstationarities, possible low-amplitude signal recordings and noises, derivative discontinuities, irregular sampling, which can make it impossible to apply the applications of common filtering techniques effectively. The generalized regression technology is proposed.

Its basic setting includes the building of systems of local approximation models represented by nonlinear functions with a small number of parameters; commonly, the parameters are bounded by constraint sets. Local functionals are defined, and the filtering procedure amounts to the solving of a sequence of unrelated constraint minimization problems.

The generalization of the basic setting is realized with provision for the approximation model relations in the junction points of local intervals. A functional is defined, and the constraint minimization problem is solved for the achievement of the filtering result as a spline model.

The further approach is based on the recordings obtained from a system of magnetometers. Local models, a set of relation conditions between the models for the magnetometers, and local functionals are defined. The corresponding minimization problem is solved on the basis of constraint minimization.

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REMOTE SENSING FOR DISASTER RESPONSE AT SUB-PIXEL LEVEL

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Remotely sensed imagery data from satellites have become important tools to response damage due to natural disasters. Due to the ability of remote sensing technology to acquire spectral measurements of landslide areas at various spatial and temporal scales, the extraction of landslide areas become fast and reliable. The fuzzy based classifier (Noise Cluster (NC) with entropy) was applied to identify Kashmir earthquake (2005), induced landslide areas as soft computing approaches via supervised classification. It has been found that, the classifier generated good results for landslide areas identification.

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FLUID-MAGMATIC SYSTEMS AND VOLCANIC CENTERS IN NORTHERN CAUCASUS: RESULTS OF GEOPHYSICAL AND GEOLOGICAL STUDIES

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The central segment of Alpine mobile folded system and the Greater Caucasus are considered with respect to fluid-magmatic activity within modern and Holocene volcanic centers. Results of complimentary geological and geophysical studies carried out in the Elbrus volcanic area and the Pyatogorsk volcanic center are presented. On the basis of experimental data acquired by means of the recently established geophysical observatory in Northern Caucasus there were obtained results for fundamental studies of regional geophysical processes, including catastrophic events. The deep magmatic source and the peripheral magmatic chamber of the Elbrus volcano were outlined via comparative analysis of geological and experimental geophysical data. It has been determined that the peripheral magmatic chamber and the deep magmatic source of the volcano are located at depths of 0–7 and 20–30 km below sea level, respectively, and the geothermal gradient beneath the volcano is 100°C/km. Analysis of processes of modern heat outflux produced by carbonaceous springs in the vicinity of the Elbrus volcano and degradation of glaciers has been carried out with respect to updated information about spatial configuration of a deep fluid-magmatic structures. Relations between hydro-chemical properties of carbonaceous mineral waters and structural, petrologic and geochemical features of fluid-magmatic system of the Pyatigorsk volcanic center were determined and discussed along with results of recent geophysical studies.

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KLIMOVSKAYA: A NEW GEOMAGNETIC OBSERVATORY

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In 2011 Geophysical Center RAS began to deploy the Klimovskaya geomagnetic observatory in the south of Arkhangelsk region on the territory of the Institute of Physiology of Natural Adaptations, Ural Branch, Russian Academy of Sciences (IPNA UB RAS). The construction works followed the complex of preparatory measures taken in order to confirm that the observatory can be constructed on this territory and to select the optimal configuration of observatory structures. The presentation gives a detailed description of the observatory equipping stages, the technological and design solutions, and the results of the registered data quality control. They argue that Klimovskaya observatory can be included in INTERMAGNET network. The observatory can be used to monitor and estimate geomagnetic activity, because it is located at high latitudes and provides data in a timely manner to the scientific community via the web-site of the Russian-Ukrainian Geomagnetic Data Center (http://geomag.gcras.ru). The role of ground observatories such as Klimovskaya remains critical for long-term observations of secular variation and for complex monitoring of the geomagnetic field in combination with low-orbiting satellite data.
This research was conducted in the framework of the Federal Target Program of the Ministry of Education and Science of the Russian Federation, agreement No. 14.607.21.0058 and ID No. RFMEFI60714X0058. It contributes to the development of methodological recommendations for support and improvement of the Russian network of INTERMAGNET geomagnetic observatories.

SEISMICITY DATA AND LABORATORY EXPERIMENTS ON CORE SAMPLES FROM SEISMICALLY ACTIVE KOYNA REGION, INDIA

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Extensive seismicity data has been generated in the seismically active Koyna-Warna region of Maharashtra, India for the last five decades. Earthquakes continue to occur in the region since early 1960s when the initial construction and impoundment of the Koyna dam began. Prior to this, the region was devoid of any significant seismicity. The largest known M6.3 earthquake in 1967 in the region is the best known example of Reservoir Triggered Seismicity (RTS). Several studies were done to explain triggered earthquakes based on seismicity and reservoir water levels, nucleation process, pore pressure changes, seismic and hydrological precursors. In an earlier Indo-Russian collaborative work, joint experiments on cyclic loading of rock samples for modelling of transient seismic process were carried out at the Geophysical Observatory "Borok" of IPE, Russian Academy of Sciences. Data bases of acoustic emission, loading deformation, speed of elastic waves for the subsequent analysis and interpretation were also generated. All these experiments were conducted on rock samples collected at the surface. Our preliminary results from the Koyna earthquake catalogue revealed variations in seismicity parameters prior to two strong earthquakes to have a pattern of prognostic anomalies typical of tectonic earthquakes. In tectonic earthquakes, unstable conditions in a source zone develop gradually leading to a metastable zone which shows variations in certain seismicity parameters known as prognostic anomalies.

In a new project proposed under RSF-DST initiative we intend to take these studies forward by conducting laboratory experiments on core samples obtained from deep boreholes (~1.5km) drilled around seismic source volume between Koyna and Warna reservoirs in a recent initiative of the CSIR-National Geophysical Research Institute, Hyderabad and Ministry of Earth Sciences, Govt. of India. This study provides a unique opportunity to understand physical parameters of fracture process and to compare them with earthquake catalogues to identify factors determining the pattern of induced or triggered earthquakes. Also, the aanalysis of transient processes is an important part of investigation of the nature of origin and evolution of failure processes in lithosphere. The investigation both in situ and in laboratory allows clarifying the basic properties of the medium and physical mechanisms controlling the dynamics of seismicity in the lithosphere.

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SEISMOLOGY AND SATELLITE GEODESY: MULTISYSTEM APPROACH TO THE EARTHQUAKE MONITORING

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For more than two decades the world-wide space geodetic technique has proven its capacity for investigation of slow crustal deformations. Along with seismological observations, the satellite geodesy provides a comprehensive tool to investigate the full range of contemporary crustal motions, both smooth interseismic trends and abrupt coseismic offsets. One of the most remarkable recent advances in the earthquake monitoring is the ability of the satellite geodesy to resolve the mechanisms of great earthquakes. This includes the estimates of the slip distribution, scalar moment release, shear stress localization. Geodetic observables are sensitive to the total coseismic slip, including slow components beyond the seismic instrument bandwidth, and they are not biased when recording the strong motions in the near field. We present the technique for inversion of coseismic offsets into a seismic source model and examples of such inversions for various great earthquakes. We demonstrate the ability of satellite geodesy to improve purely seismological inversions by combining these two techniques into a powerful tool for seismology.
The work was partially supported by the RFBR grant 08-05-12028-ofi.

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QUANTILE REGRESSION AS AN INSTRUMENT TO DETAILED CLIMATE TREND ASSESSMENT

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Quantile Regression (QR) is a statistical instrument to provide regression estimate for any quantile between 0 and 1 of the dependent variable. Being provided by a number of statistical packages (such as SAS, STATA, R), QR, unlike traditional regression algorithms, enables to estimate climate trends, among other, for those values of climate variable that are in the "tails of distribution" and often are related to extremes and disaster phenomena. However, the applications of the QR to earth and environment studies are not very numerous yet. The paper contains the results of QR trend estimates for the surface temperature over the territory of Russian Federation. For different quantile values and for each of the four seasons, the spatial patterns of QR trends are assessed.

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TECHNOLOGIES OF RIHMI-WDC IN OLD DATA RESCUE, MANAGEMENT AND QUALITY ASSUREMENT

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The lack of detailed observational data for the early periods of surface meteorological and upper-air observations requires very careful and urgent efforts to rescue these data, to manage the data for the needs of preparing high quality data sets in digital formats. One of the fields of using the data is providing inputs to reanalys extended back to late XIX and early XX centuries. Such are 20CR Project by NOAA and ERA reanalysis Projects by ECMWF. The paper contains detailed steps of rescue the old meteorological surface and upper air data for ERA CLIM and ERA CLIM2 Projects. After scanning old manuscripts and books, the OCR (Optical Character Recognition) algorithms are used in digitizing, the statistical tables and statistical graphs are used to detect the erroneous values and to provide feedback to primary sources. Different quality check approaches are applied to the data before use in reanalysis assimilation. In turn, the observational data are used to assess the reproducibility of climate events by 20CR and ERA-20C reanalyses.

The support from EU FP7 Projects ERA CLIM and ERA CLIM2 is highly appreciated.

UAV MONITORING OF A GEOTHERMAL FIELD IN OPERATION: KHANKALA RESERVOIR, NORTHERN CAUCASUS

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Development of a geothermal reservoir requests a complex system of wells, pipelines, and pumping equipment. A numerous set of working stations at geothermal reservoir need a strong monitoring of possible natural hazards and environmental impacts of their works. One of the type of environmental damage can be spilling salt water from geothermal station. Tracking leaks and places dripping water is necessary for the timely prevention of pollution. In this work, we discuss the results of a survey using an infrared sensor on unmanned aerial vehicle (UAV) over the Khankala geothermal station in operation (Chechen Republic) obtained at April 2016. The analysis of this data was the basis on the methods of monitoring at geothermal reservoir exploitation. The infrared survey allows us to locate the leaks including the ones of the old wells, and to trace pipelines of the district heating system (DHS). Infrared data processing confirmed by the ground visual survey facilitates classification of the heat anomalies caused by different DHS elements. An experiment conducted at the Khankala heat geothermal plant demonstrates a possibility to define a regime of the plant's operation. The method of the infrared monitoring of a geothermal field in operation can also be applied to monitoring of an oil and gas deposits, as well as to the other industrial sites, which include any operations with got fluids of different kind.

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GEODYNAMIC HYPOTHESIS OF CATASTROPHIC EARTHQUAKES IN SUBDUCTION ZONES

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Based on the analysis and synthesis of evidence on the kinematics of the upper lithosphere during and after the earthquake Tohoku-Oki as the subject for discussion Alternative hypotheses about the sources of power such catastrophic earthquakes occurring in the area of Japanese islands.

GPS-observations confirmed facts displacement of the upper part of the lithosphere caused by earthquakes in the eastern direction during earthquakes with magnitude M > 7.5, suggest that over the past 100-120 years, the Japanese archipelago has shifted in the direction of the oceanic plate at a distance 10-14 m. If we take the maximum speed of horizontal movements Pacific plate westbound 92 mm/year, for 100-120 years it should integrally displaced approximately 10 m. Thus, the horizontal displacement of the oceanic plate in a westerly direction and reverse «rollback» edge of the Eurasian plate to the east by earthquakes in the mentioned period are comparable with each other.

A hypothesis on the origin of power sources geodynamic Japan earthquake typ which, without explaining the reasons for internal model, repelled from the actual material.

1. Elastic energy accumulation occurs in the deep parts of the continental plates where the maximum stresses exist, as rocks retain their elastic properties. This depth can be evaluated bythe maximum depth of earthquakes - 700-600 km.

2. Causes of the excess energy can be different and require separate consideration. We can only say that there is an asymmetrical distribution of the ratio of the horizontal and vertical components of the stress tensor when a layer at a depth of horizontal stresses is growing at a faster rate than vertical. This leads to the creation of efforts upwards at an angle of 45-55^0 depths of the continental plate.

3. This force effect leads to the formation of zones of increased stress or denser rocks (set according to seismic tomography). When exceeding some threshold voltages failure occurs at the boundary of the medium plates in the form of reverse faults and displacement of large blocks in the upper crust in the direction of least resistance.

4. On the eastern border of the continental plate uplift occurs with dextral shear component. In this part of the plate «leans» on the western part of the ocean, making it sub-horizontal tensile stress. Such destruction occurs at intervals of about once every 40-50 years in the seismic gap.

MODERN GEODYNAMICS OF SOUTH YENISEI RIDGE, ACCORDING TO GNSS OBSERVATIONS

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It was decided in the late 90s to build the first in Russia deep nuclear waste repository within Nizhnekansky granitoid massif, in the southern part of the Yenisei Ridge. In this regard, in 2010 created a geodynamic testing ground for monitoring of crustal movements based on GPS/GLONASS global navigation satellite systems. Over the last five years 30 stations of the geodynamic polygon carried out regular observations.

We investigated the dynamics of changes in the lengths of ΔL baselines for separate epochs of observations. In 2010-2013 the absolute values of ΔL were significantly lower than for the periods 2013-2014 and 2014-2015. For the entire observation period the average value of the differences of the line lengths is 3.8 mm. This suggests that in general the area experienced strain during the period 2010-2015.

The reason for the sharp increase in the values of ΔL in 2014 is a well-known fundamental property of the Earth's crust (according to well-known scientists V. I. Gzovsky, M. A. Sadovsky, et al.), which is the cyclical development of geodynamic movements in time, when relatively long periods of accumulation of elastic energy, accompanied by relatively small movements, were followed by periods of intensification of movements, often of the opposite sign.

For quality control and evaluation of the accuracy of the measurement results a network adjustment was performed. For comparison the estimations of the mean square error (MSE) for the period 2012-2015 were shown. The MSE of the points' location has shown that the MSE of horizontal and vertical accuracy amounted to 3.0-3.7 and 6.0-6.5 mm, respectively. Thus, it is evident that the greatest ΔL changes during the movements' intensification were caused by geodynamic reasons, and not by noise or possible technical errors in observations or calculations. Maps of the Earth's surface dilatation zones (deformation rate) showed that the maximum deformations were recorded in the area of Muratovsky and Atamanovsky faults located at the junction of the Siberian Platform and West Siberian plate.

SYSTEMATIC APPROACH TO THE EVALUATION OF GEODYNAMIC STABILITY OF PLACEMENTS OF THE NUCLEAR FUEL CYCLE

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When choosing locations for nuclear fuel cycle facilities is an effective use of the provisions of the system analysis. This allows in conditions of information uncertainty make long-term predictions about the geodynamic stability of the geological environment. The methodology of the system approach to the choice of area isolation of higt-level radioactive waste.

The basis of the following principles:

1. The sequential decrease in the studied areas and elements of the geological environment;
2. Statement of experimental observations on the weakest link, designed to maximize the information detected on the basis of mathematical modeling;
3. Sequential execution stages (in accordance with IAEA requirements): a) selection of the area and the site; b) an assessment of their sustainability; c) prediction of changes in the predetermined time period; g) monitoring;
4. Accounting for changes in the stress-strain state of the rocks;
5. Using the optimal length of time series of instrumental observations of the state of the geological environment.
6. Accounting in geodynamics spatio-temporal scale effects.

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ACCURACY AND COMPUTATIONAL EFFICIENCY FOR RISK-MANAGEMENT OF NATURAL DISASTERS

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An essential part of stresses and risks in societies and their environments is imposed by low-probability high-impact events, such as natural disasters. These stresses and risks could be reduced by the development of a strategy, which promotes the adaptation, resilience and resistance of societies to catastrophes and contributes to a decrease of risk and vulnerability. That is why the research, devoted to decision-making for risk-management of catastrophic events, is motivated by different needs of people on international, national and local policy levels.

However, financial and social risks imposed by natural disasters can be extraordinarily difficult to measure, to model and to manage, especially due to nonlinear interdependencies between

1. types of natural disasters: e.g. earthquakes may generate tsunamis;
2. times of event occurrence: e.g. hazards, which occur before the full recovery after previous shocks, may cause higher financial damage as expected due to cascade effects, especially in case of low risk capital;
3. regions of disaster occurrence: e.g. hazards very often spread over wider areas (for example, flood events in EU).

Neglecting such interdependencies can lead to a severe underestimation of risk.

In this presentation, we describe methods, which allow to incorporate regional and hazard-type interdependencies in risk via the use of structured copulas, reducing the dimensionality of the problem and assessing the potential impact of current and future extreme events. Implementing time interdependencies via the use of multi-stage scenario generation techniques, we estimate conditional and unconditional probability distribution functions, which allow to avoid underestimation of losses and, hence, of the risk.

The decision-making, based on such distribution functions, fully acquires for uncertainty, taking into account heavy tails of the distribution and possible worst-case outcomes. Therefore, the behavior pattern, that promotes the adaptation, resilience and resistance of societies to catastrophic events and contributes to decreasing their risk and vulnerability, could be developed and used on international, national and local policy levels.

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DEVELOPMENT OF PORTABLE “NOISEMETER” TO PERFORM MAGNETIC AREA NOISE SURVEY

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In present work we describe recently developed device for noise metering. Device "noisemeter" may to use for searching sources of alternating magnetic field. The noise meter work in three frequency ranges: lower 50 Hz, higher 50 Hz and 50 Hz. Device has on-board GPS-receiver, SD card memory and able to work in noisy environments. In present work we apply developed device to perform alternating magnetic noise survey at geomagnetic station Baigazan, lake Teletskoye.

THE METHOD OF ESTIMATION AND PREDICTION OF ANTHROPOGENIC IMPACT OF MINING OBJECTS ON ENVIRONMENT

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In the result of exploration, development and exploitation of mineral deposits were formed natural-technical system (NTS), the effect of which on the environment is difficult to predict in space and time. Crash for this kind of title can lead to severe environmental and industrial disasters.

This paper presents the developed systematic framework and the mathematical formalization of complex geoecological estimation of complex objects of mining operations. Monitoring data are interpreted by the zoning of natural-technical systems a set of indicators of anthropogenic load by means of generalized functions, which are normalized by their sum in a multidimensional Euclidean space. The processing for this function is carried out using modern methods of geostatistics, optimization, system and functional analysis.

The undeniable advantage of introducing the generalized functions of human activity is its complexity and versatility, allowing a more accurate account of spatial and temporal variability properties of natural-technical systems, in contrast to classical interpolation methods.

This method has been applied to monitoring and modeling of geo-ecological state of the open-cast mine that allows to give recommendations for environmental protection.

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TO THE THEORY OF TECHNOGENETIC SEISMICITY

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Key words: impact, vibration, dry friction, displacement, models, theory, experiment, technogenetic earthquakes, oil-gas field, hypothesis.

The hypothesis of technogenetic causation of some earthquakes is known for relatively long time. By now, a number of facts and researches approving the hypothesis are collected. A theoretical explanation for the hypothesis can be given on the basis of a mechanical model utilizing the concept of the effective vibration dry friction coefficient and the theory of vibration displacement, developed previously in the Mekhanobr Institute.

The main effect described by the model is that the effective dry friction coefficients are decreasing as the result of even mild vibration and impacts exposure. The oscillations of an elastic body resting on a rigid base that are excited by an impact cause significant decrease the normal reaction, or even nullify it. As the result, the body might be displaced even by minor side loads. When the shearing force is not sufficient to initiate the displacement yet able to maintain the sliding, the position of the body becomes unstable: even minor perturbations can trigger sudden dramatic shift of the body releasing potential energy. This effect corresponds to the trigger-like nature of seismic phenomena.

The results of the research allows for hypothesizing that the effect of increased oil recovery factor of a layer observed in a number of cases of vibration influence, is due to the displacement of lithosphere plates causing the increased pressure in the oil-gas layer.

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ANALYTICAL INFORMATION SYSTEM FOR CONTROL AND SPECTRAL ANALYSIS OF GEOMAGNETIC FIELD AND SPACE WEATHER PARAMETERS

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In modern World the specialists in natural and technical sciences pay great attention to collection and analysis of data about an influence of geomagnetic variations on existence and evolution of objects and systems of various origins. Today geomagnetic field and its variations parameters are partially studied and monitored by magnetic observatories, the majority of which is concentrated in Europe. Another problem is a lack of free-access effective technologies and ergonomic tools to provide geomagnetic and space weather data integration into integrated information space. As a result there is no easy-to-use and effective tool for operative monitoring, analytical control, modeling and visualization of geomagnetic and space weather data for specialists in various spheres. To solve these problems the present work is concerned with research and development of integrated information space for monitoring and analytical control of parameters of space weather, geomagnetic field and its variations. The research results are represented as analytical information system GEOMAGNET (http://www.geomagnet.ru), which is useful for specialists in various spheres as a tool for operative monitoring, analytical control, modeling and visualization.

The reported study was supported by RFBR, research projects No. 14-07-00260-a, 15-17-20002-d_s, 15-07-02731_a, and the grant of President of Russian Federation for the young scientists support MK-5340.2015.9.

MAGNETIC STORMS ON YAMAL, EASTERN ARCTIC

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In the present study we consider the data base of magnetometer network in Yamal, Eastern Arctic which were collected in period of August 2013 to May 2016. The set of magnetometers along meridian GM-145 operate in the real time, and will display time-space dynamics of magnetic storms which form the regional space weather. Most popular service is the auroral forecast and the local magnetic variations. The magnetometer data was analyses to check out the rapidly-varying magnetospheric and ionospheric processes. We find many good samples of magnetic storms which play hazardous role in the destruction of the Earth's electro-magnetic environment. Our observations is in high demand by geophysical prospecting companies in Yamal area. One of the key issues are the magnetic field corrections during directional drilling. The real-time magnetometer data used as the base for the open source information system in the project "Polar Geophysics of Yamal" . The data base of magnetometers from Yamal will have a good prospects of usage in a wide variety of research, applications, public outreach and educational projects.

ANALITICAL SOLUTIONS FOR NON-LINEAR PARTIAL DIFFERENTIAL EQUATIONS.

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It is known that some physical quantities are functions φ and Ψ of two variables "x" and "y", where φ and Ψ are connected by Cauchy-Riemann equations:

$$\frac{\partial \varphi}{\partial x} = \frac{\partial \Psi}{\partial y}\ ;\ \frac{\partial \varphi}{\partial y} = -\frac{\partial \Psi}{\partial x} \qquad (1)$$

In two - dimensional problems of electrostatics φ - is the potential and Ψ is the charge functions. Let us note that for uncompressible fluid φ is the velocity potential and Ψ is the stream functions correspondingly. Gravitational, electric and magnetic potentials as well satisfies Laplace's equation: $\Delta\varphi = 0$. The resemblance between these directions are so closed to each other that the mathematical theory common to all is most conveniently developed in one piece.

For non-linear partial differential equation the methods of solution as follows: numerical solution, by using of definite or contour integrals, by power series, asymptotic methods. We got analitical solution for non-linear conduction of heat equation for porous media. Author don't know another example, when non-linear partial differential equation had been solved by this way. We neglect viscosity and treats the fluid as having a constant density independent of pressure and of any other complication such as variation of temperature. The main goal is to find analitical solutions for other cases.

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MODULAR AMPHIBIOUS VEHICLES FOR COASTAL RESEARCH

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Data obtained by direct movement on shallow waters of coastal zones, allowing carrying out research of wave dynamics and general ecological situation in a surf zone, are extremely important. An example of a special amphibian is mobile system MARC-1 [1]. Within the project there has been developed a concept of support-traction systems for coastal research mobile complexes. The developed physical model (layout) of chassis of the amphibious vehicle will have the ability to change their own geometric parameters. This approach provides the opportunity to choose rational chassis parameters and modes of operation of modular amphibious vehicles (MAV) for conducting research in a specific (separate) coastal zone. The structure of MAV will include the following equipment: single-board microcomputer Raspberry Pi 2, stepper motors FL110STH – 1.8° NEMA 42, camera Original Sjcam SJ4000, external battery Energizer XP8000A-Kit.

The study was carried out with the financial support of RFBR (Russian Foundation for Basic Research) in the framework of the scientific project number 16-38-00672 mol_a.

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METHODS OF DATA MINING FOR EARTH SCIENCE DATA ANALYSIS IN GIS ENVIRONMENT

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Implementation of modern GIS for spatial data management and analysis is one of the most important trends in modern computer oriented geoscience. In this report we give an outlook of a software complex designed for integration of geoscience data and algorithms of cluster analysis in a unified GIS-environment. The developed software system provides access to an extensive database for geospatial data and a set of algorithms, based on the Discrete Mathematical Analysis (DMA). The design of the system provides application of these algorithms to multiple data layers, and requires only a Web-browser and Internet connection.
This report presents the mathematical description of DMA-based algorithms for data mining and data analysis, which have already been incorporated into the system. The results of algorithms' application to geophysical data from the system's geodatabase are also discussed in this report.

This research was conducted in the framework of the Program of Fundamental Research of RAS Presidium No. 4.

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A MARKING AND FORECASTING METHODS OF DANGEROUS DYNAMIC PHENOMENA IN COAL SEAMS TO ENSURE SAFE CONDITIONS OF MINING OPERATIONS AT COAL MINES

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In the present work we apply the safe conditions of mining operations necessary to carry out continuous monitoring of the parameters characterizing dynamic phenomena in coal seam. And on the basis of the continuous monitoring automated geographic information systems to evaluate and forecast the danger of dynamic phenomena in coal seam. The importance of such assessment and forecast of the danger must be carried out in the space of coal seam bottom (local forecast) and for the whole mine field (regional forecast). The work is partially supported by the RFBR grant 16-17- 00029.

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