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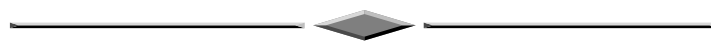
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GEODESY AND MINE SURVEYING



BODY GRAVITATIONAL POTENTIAL CALCULATION BY ITERATION METHOD

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People regularly have a need in their practical work to calculate the gravity potential and its derivatives for bodies of different shape. Examples may include the study of the Earth's form and size, exploration of mineral resources, spacecraft trajectory calculation and other tasks. Difficulties in this task solution depend on the geometrical complexity of the measured object, mass density distribution function and the required calculation accuracy. To get over these difficulties the measured body is approximated to a geometrically simple body (or a set of bodies) possessing constant matter density. Thus, the obtained results are approximate and therefore, it is difficult to estimate the accuracy of these results.

The paper discusses an iterative gravity potential calculation algorithm for bodies with regularly parametrized surface and preset density distribution function. This method is based on formation of numerical sequences for estimates "from the top" and "from the bottom", and allows assessment of the error limit for the body gravity potential calculation and completion of the calculation process once the required accuracy is achieved. The article provides findings of experimental gravity potential calculations as per algorithm discussed here for different objects (line, surface, 3D body). Obtained results show that this algorithm enables body gravity potential calculation with a tolerable accuracy achieved for a comparatively small number of iterations.

Key words: gravity potential, limit of error, numerical sequence, material curve gravity potential, material surface gravity potential, body gravity potential, gravity potential calculation grid.

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DETERMINATION OF PLUMB-LINE DEFLECTION COMPONENTS IN THE TERRITORY OF WESTERN SIBERIA BY NUMERICAL DIFFERENTIATION

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The report presents an analysis of results of the plumb-line deflection components in Western Siberia territory obtained by modern global geopotential models data, terrestrial data, GNSS-leveling and geometric leveling with the results of astronomo-geodetic measurements. The part of Novosibirsk Region was used as a test area for comparison of determination results of the plumb-line deflection components calculated by the method of numerical differentiation.

According to comparison results of the astronomo-geodetic plumb-line deflection to results of the plumb-line deflection obtained by numerical differentiation method of geoid undulation in the test area, geoid surface that is constructed on harmonic coefficients of global geopotential model EIGEN-6C4 makes it possible to determine the plumb-line deflection with the root mean square $\pm 0,34''$.

The obtained results make it possible to determine plumb-line deflection for solving scientific and practical problems of geodesy and autonomous navigation by numerical differentiation of geoid undulation obtained from the coefficients of global geopotential model.

Key words: plumb-line deflection, geoid undulation, astronomo-geodetic method, GNSS-leveling, numerical differentiation, Fourier series in the system of spherical functions, harmonic coefficients of geopotential.

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THE USE OF A SYNTHESIZED ALGORITHM VARIANT OF THE PARAMETRIC VERSION OF LSM-OPTIMIZATION OF THE RESULTS OF GNSS MEASUREMENTS FOR THEIR COMPARATIVE ANALYSIS

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The paper considers synthesized variants of the correlate and parametric versions of the least squares method (LSM)-optimization (adjustment) of geospatial data. Using synthesized variants of the correlate and parametric versions of the least squares method (LSM)-optimization was carried out equalization of GNSS measurement results by using software packages Trimble and CREDO, considering their correlation. As a test object was used a fragment of the satellite network of permanent base stations of the Novosibirsk Region consisting of 6 points: Novosibirsk (NSKW), Bolotnoe (BOLO), Iskitim (ISKT), Koluva (KOLV), Kochenevo (KOCH), Suzun (SUZU). The correlated pair-data obtained as a result of such processing have been analyzed to test the zero hypotheses regarding insignificance of both individual differences and of their mean correlated value. In conclusion the paper proposes further ways of study to establish additional criteria for such analysis.

Key words: synthesized variant LSM-optimization, GNSS-measurements computer processing, correlate version, parametric version, analysis of correlated geospatial data and unequal accuracy geospatial data, satellite network.

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REVIEW OF GNSS-REFLECTOMETRY METHODS FOR MARINE TOPOGRAPHIC SURFACE HEIGHT SCATTEROMETRY DETERMINATION IN RUSSIA AND ABROAD

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The paper considers methods of height determination on marine topographic surface (STS) by means of GNSS receivers that receive direct and reflected electromagnetic signals from the STS using the GNSS reflectometry (GNSS-R). It gives a brief analysis of GNSS-R methods, configuration of receivers and antennae, used in Russia and abroad, and describes the experience of GNSS-R method application in Russia and abroad.

The results of abroad experiments demonstrated that the use of the interferometric version of the GNSS-R method based on the «signal-to-noise ratio» allows to determine STS height with an error of up to 1,53 cm, however for this accurate detection of the electromagnetic signal displacement is required. Application of GNSS-R «phase delay» method allows determining the STS height with error of 1-2 cm.

The main observable parameter in the interferometric GNSS-R method using signal-to-noise ratio is the mutual coherence, or cross-correlation of two separate GNSS signals created coherently by a single GNSS transmitter and collected by a single instrument i.e. a GNSS-R receiver. A GNSS-R receiver based on the measurement of the coherence of the reflected and direct beams is named interferometric or codeless. If a model of the code of the transmitted signal is known, then the direct signal could be substituted by its known functional representation.

The methods of GNSS-R in Russia for determination of height STS are not sufficiently investigated. The available amount of experimental data on the works carried out in Russia does not allow us to make specific conclusions about the applicability of the GNSS-P method to determine the heights of the marine topographic surface with reliable accuracy.

Key words: GNSS-reflectometry, mareograph, marine topographic surface, signal-to-noise ratio method, phase delay method.

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USE OF A TOPOCENTRIC RECTANGULAR COORDINATE SYSTEM IN SOLVING ENGINEERING AND GEODESIC PROBLEMS

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The paper considers the technique of creating a geodetic base in the construction of various objects using satellite and traditional tacheometrical survey for calculating plane coordinates of geodesic network. This approach meets modern trends of geodetic base creation in construction. The implementation of satellite positioning technology offers new opportunities for production stakeout. Using local horizontal projections of the most appropriate portion of the earth's surface appears to be very promising. Furthermore, the presence of the translation algorithm coordinates from one system to another (conventional) ensures the accuracy of design work and greatly simplifies them. The paper shows an example of the geocentric coordinate translation to topocentric system (plane projection of geocentric coordinates with topocentric coordinate) in which tacheometry results are equalized. The paper gives qualitative analysis of the advantages of this technique in comparison with the Gauss-Kruger zonal coordinate system. It demonstrates the possibility of transferring the coordinates from one system to another for the preservation of traditional forms of presentation and measurement control. Attention is paid to a separate calculation of normal height.

Key words: geodetic coordinate systems, geodetic networks, global navigation satellite systems, topocentric coordinate system, tacheometric survey, equalization of measurement results, covariance matrix.

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GEODETTIC SUPPORT OF HYDRO MACHINE RECONSTRUCTION

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The authors investigate the methodology of classic technology application for determination of hydrogenerator geometric parameters in their reconstruction together with the technology, based on automated geodetic devices. The specific character of the geodetic support methodology under investigation is that the stator of the generator is not reconstructed. In this case the installation of the turbine is a more complicated task, because the runner chamber and new equipment of the turbine must be installed in line with the stator installed previously. The authors offer the measurement methods that give the error of stator centre determination not more than one millimetre. The authors consider the method of replacing the stator centre (axis) onto the bottom level of turbine blades in the runner chamber. It is recommended to take into account the electromagnetic influence from electric generators working nearby when choosing optical electronic geodetic devices for measurement. It is noticed that taking into account instrumental errors of total stations in choosing measurement method can increase the accuracy of stator centre determination in replacement of runner chamber centre onto the level of the stator.

Key words: reconstruction of hydro machine, geometrical centre of stator, stator ellipticity, total station, vertical projection device.

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INVESTIGATION OF METHODS FOR DETERMINING GEOMETRIC PARAMETERS OF ROTATING AGGREGATES BY LASER SCANNING DATA

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The paper performs the analysis of literary and Internet sources on this topic, considers various methods of rotating aggregates alignment with using laser scanning data, gives the theory of mathematical processing of measurements of rotating aggregates. It is noted that a cold alignment of rotating aggregates based on laser scanning data, allows obtaining very high accuracy in determining geometric parameters. The deterrent of this technology is the insufficient accuracy of creating a reference geodetic network and scans stitching. The paper gives examples of production testing methods at cement plants in Western Siberia conducted in 2015-2017 on two eight-column kilns of clinker. It is shown that, based on laser scanning of operating rotary kilns, the scanning data can be performed and the characteristics of the rotating kilns can be determined with high accuracy. The paper considers the problems that require further research and solutions.

Key words: alignment, modeling, analysis, geodetic measurement, axis straightness, terrestrial laser scanning, adjustment.

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USE OF MODERN AUTOMATED GEODETIC DEVICES FOR MONITORING HYDROTECHNICAL CONSTRUCTIONS OF HYDRO POWER STATIONS

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The article considers the experience of using automated geodetic devices in hydrotechnical construction displacement monitoring systems. The analysis of using modern GNSS receivers and high precision total stations showed that they provide the result of appropriate accuracy taking into account all factors influencing the measurement accuracy. It is recommended when choosing

geodetic devices for monitoring not only to determine their metrological characteristics, but estimate errors of displacement detection in laboratory conditions and with the measurement results of the object under control. It is suggested to use GNSS receivers together with total stations in performing displacement measurements. It is recommended when designing such continuous displacement monitoring systems to provide the possibility to perform metrological calibration of geodetic devices without dismounting the system. It is noted that in performing industrial measurements and taking into account instrumental errors and errors, which appear due to meteorologic conditions changes, automated total stations provide measurement accuracy which is higher than declared.

Key words: hydrotechnical constructions, automated informational diagnostic monitoring system, GNSS receiver, automated total station.

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GRAVITY OBSERVATIONS IN SIBERIA DURING SOLAR ECLIPSE

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Mobile absolute and spring gravimeters are used for different kinds of gravity observations. Modern methods and equipment allow to make gravity measurement at 10^{-9} level from normal value g_0 (up to 1 microgal = 10 nm/sec^2). Tidal and apparatus effects are excluded. Precise gravity observations during solar eclipses are used for gravimeters testing and for gravitation hypothesis estimation (shielding Moon effect on gravitational force of the sun). We made measurement using spring gravimeters Ascania and LaCoste&Romberg and absolute GABL gravimeters of different modifications (made by Automation and Electrometry Institute of the Siberian Department of the Russian Scientific Academy). The result of three solar eclipses 1981, 1997 and 2008 at southern Siberia are discussed and analyzed. The observation showed that gravity effect at eclipse moment was absent on microgal level. Also we reviewed the gravity force stability by results of Kluchi station (Novosibirsk, Siberia, Russia).

Key words: gravity force, gravity force variation, absolute laser gravimeter, spring gravimeter, solar eclipses in Siberia, atmospheric and ionospheric effects, gravity force stability, gravitational absorption effect.

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SOME ASPECTS OF DIGITAL TECHNOLOGY FOR GEODETIC MONITORING AND DIAGNOSTICS OF BEARING STRUCTURES OF UNIQUE ENGINEERING CONSTRUCTIONS

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An aspect of a digital technology for geodetic monitoring, such as acquisition and updating of digital data obtained with CCD and CMOS matrix is regarded in the article. A system of deformation monitoring, based on joint measurements and analysis of heterogeneous digital data obtained by e-tacheometry and digital survey, is described. Special attention is paid to the role of TIM-modelling in the development of a specific object optimal monitoring.

Key words: digital technology, industry 4.0, inclinometer, total station, CCD matrix, TIM technology, modelling, analysis, prediction, deformation, accuracy.

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TAKING ACCOUNT OF RADIOSIGNAL TRAJECTORY CURVATURE IN TROPOSPHERIC LONG-DISTANCE RADIO MEASUREMENTS OF SATELLITES

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The article considers phase path curvature influence of electromagnetic wave in the Earth's troposphere on the measured distance and the theory of taking account of this influence on the results of long-distance radio trajectory measurements of satellite. The article presents the necessary formulas for calculation of difference of electromagnetic wave phase path length from direct range line to the satelite. The article introduces mathematical models of non-query phase and impulse long-distance radio trajectory measurements of satellites, which are more appropriate to the real geometrical and physical conditions of measurement process and which take this difference into account on the correction level. Practical application of the suggested theoretical and methodological statements make it possible to increase the determination accuracy of state parameters of nonlinear dynamic system, consisting of several satellites and ground points. The parameters include spacecrafts' motion parameters, spatial coordinates of ground points, elements of relative orientation of different geodetic networks, Earth's rotation parameters and also some number of other geodetic and geodynamic parameters.

Key words: space aircraft, tropospheric refraction, radiotechnical measurements, radiosignal trajectory curvature, mathematical models of measurements.

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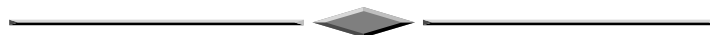
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LAND MANAGEMENT, CADASTRE AND LAND MONITORING



AUTOMATION OF REAL ESTATE DATA ACQUISITION: VERIFICATION CONTROL AND INFORMATION SUPPORT OF CADASTRAL VALUATION

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The article deals with the issue of automation of real estate information acquisition for the purpose of verification of Unified State Real Estate Register data and information support of cadastral valuation. The expediency of using geoportal technologies in the implementation of inventory, land cadastral and evaluation works is explained. The analysis of the functional capabilities of modern geoinformation systems for the creation of cartographic support of a geoportal is carried out, the workflow of the technological process for the preparation of cartographic data is given. The technological scheme of preparation of a multiscale electronic map for the geoportal, and main characteristics of different-scale cartographic images are presented. The description of the developed software for automation of activity of experts-appraisers of real estate as well as for cadastral engineers is given. Recommendations for the use of the software in carrying out spatial planning, municipal management, creation and updating of information bases of municipal spatial data funds are given.

Key words: inventory, land cadastral work, data acquisition automation, information support, geoportal, real estate.

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METHOD FOR DESIGNING BORDERS OF MUNICIPALITIES IN INHOMOGENEOUS GEOSPACE

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At the Unified State Real Estate Register there is information about 51 % of the boundaries of municipalities. This leads to a decrease the efficiency of management of the land property complex of the municipality and the impossibility of qualitative preparation of the documents of land-use planning and urban zoning. This fact is caused by the lack of legislative, methodological and technological support for this type of work.

Based on the study of the basic requirements and principles for determining the boundaries of municipalities, a special computer technology was developed. The technology allows automating this process and eliminating system errors.

The findings can be used by surveyors to describe the boundaries of municipalities with the aim of increasing the efficiency of this type of work.

Key words: municipality, designing, land area, boundary, determination, change, specification, order, approach.

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RESEARCH OF THE VARIANTS OF REAL PROPERTY 3D MODELS FOR PURPOSES OF CADASTRE

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In connection with the progress in the Russian economy, the demand for effective land management is growing now, especially in multilevel housing development. It is necessary to ensure the operation of a three-dimensional cadastral system that takes into consideration 3D models of real property items located at different levels.

The purpose of the study is to provide a pattern of three-dimensional models of real property items (buildings, structures and objects of unfinished construction) that meet the requirements of the Cadastre of the Russian Federation.

Classification of options for building 3D models was developed as a result of the generalization and systematization of information of three-dimensional modeling of real estate in foreign countries. Based on this classification, a three-dimensional version of the model is offered, which is most suitable for Russia and meets the requirements of the Unified State Real Estate Register.

The findings can be applied by cadastral engineers who build 3D models of real property items in accordance with the requirements of the current legislation. Also, they can be the basis of statutory instrument and methodological recommendations for creating a 3D-cadastre in the Russian Federation.

Key words: 3D model, 3D cadastre, real property, formalization, spatial model, boundary surface, peak, edge.

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ACCURACY EVALUATION OF 3D MODELS BY USING UNMANNED AERIAL SYSTEM

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Modern needs for cadastral work on urban territories provided active introduction of unmanned aerial systems, including for the creation of 3D models of real estate objects. The created 3D models should provide appropriate spatial accuracy for reference points' determination of object boundaries, which nowadays is regulated only with respect to the planned component.

The objective of the study is to develop a methodology for assessing the accuracy of 3D models of real estate objects based on aerial photography at various altitudes, using the example of a reference polygon.

The study is an experiment. And the 3D model of the reference polygon was created on the basis of this experiment, which meets modern requirements of Unified State Real Estate Register. The model accuracy does not essentially depend on aerial photo altitude and resolution. To determine the mean square error in the 3D model of the object, a method was developed based on the theoretical justification for the possible use of the plan-altitude control points as reference points, and further comparison of the coordinates and heights of the data points obtained from the 3D model with the reference values.

The developed methodology can form the basis for normative legal acts on the accuracy evaluation of real estate objects' 3D models in the cadastre, as well as be used by cadastral engineers for performing various types of cadastral work.

Key words: 3D model, unmanned aerial system, accuracy spatial, point cloud, real estate object, accuracy evaluation, mean square error.

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DEVELOPMENT OF TECHNOLOGICAL SCHEME FOR PREPARING DELIMITATION PLAN OF EARLIER REGISTERED LAND PARCELS

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Modern condition of cadastral information in Unified State Register of Real Estate (USRRE) is characterized by big number of earlier registered land parcels, which were registered in State Cadastral Register (SCR) without precise determination of reference point coordinates and square of land parcel which was claimed in a declarative way. This situation negatively influences land-property relation regulations in territorial entities of the Russian Federation, leading to a lot of problems with boundaries determination, taxable base correction, registration of newly-made land parcels in SCR.

The solution of this problem is mass cadastral works in verification of boundaries of earlier registered land parcels, which result in delimitation plan. Lack of planning in the work of a cadastral engineer leads to substantial increase of labour consuming and, thus, time elongation of cadastral works.

Besides, lack or non-sufficient list of regulatory requirements to the accuracy of geodetic works, performed in verification of boundaries of earlier registered land parcels, causes new errors in register. At the same time the old errors in cadastral information in (USRRE) are not corrected.

Thus the objective of this paper is the development of technological scheme for verification of boundaries of earlier registered land parcels, the determination of key aspects determining the order of technological operations and the determination of regulatory requirements to the accuracy of geodetic control for reference points coordinate determination. The realization of these regulatory requirements will allow to fill USRRE with reliable cadastral information, excluding any register errors, and to create single geospace for solving numerous tasks in urban development and territorial entities management.

Key words: Unified State Register of Real Estate, earlier registered land parcel, immovable property, capital construction object, delimitation plan, reference points coordinates, technological scheme, cadastral works, technological operation, register errors, reference cadastral network, reference fine grid, mean square error, GNSS – technologies, cadastral engineer.

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ON THE QUESTION OF MAINTENANCE OF THE UNIFIED STATE REGISTER OF REAL ESTATE IN RUSSIA

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Management of Federal registration service carries out the state cadastral registration and state registration of rights to immovable property according to the application request of individuals and legal entities, and transmits information about the rights holders to the tax authorities. Thus, if there is no application request, Rosreestr management doesn't perform any actions for real estate formation. Maintenance of the Unified State Register of Real Estate on the applications of individuals and legal entities does not allow to complete cadastral database with whole information on real estate and their owners. However, this is not the only reason for the containment of real estate formation processes. This can also include a plurality of characteristics made in the Unified State Register of Immovable Property (USRIP), veiled process of registration of objects, a significant number of reasons for the suspension of cadastral registration. In addition to the above, the main document confirming the rights of individuals and legal entities to the objects is canceled. It is replaced by extracts from the USRIP, which have a short expiry date term, and it causes a lot of complaints from the owners of real estate. This article recommends the main changes to the legislation regulating real estate register maintenance, and also the negative aspects of innovations which takes place.

Key words: Extracts from the USRIP, Unified State Register of Immovable Property, immovable property, immovable property owner, Federal laws.

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STUDIES OF POSSIBILITIES ON USING UAS FOR REAL ESTATE MODELING

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Modern condition of Unified State Register of Real Estate is characterized by higher requirements to accuracy, reliability and operational efficiency of inserting data about real estate objects. Carrying – out of these requirements is possible with the use of photogrammetric models of immovable object (buildings, constructions, work-in-progress objects), which were obtained with the use of technical program means.

The objective of research is the estimation of unmanned aerial systems (UAS) use for modeling immovable objects.

The research is experimental. The result of the experiment is 9-storeyed residential building photogrammetric model, created on the basis of aerial survey (AS) with the use of helicopter-type UAS DJI Phantom 4.

There was performed the accuracy evaluation of the photogrammetric model based on plan and perspective AS, obtained with the use of UAS. The accuracy of the created model meets the requirements of Unified State Register of Real Estate in the part of reference points coordinates determination, construction elements of buildings, constructions and work-in-progress objects.

To increase the accuracy and informative value of photogrammetric models of objects it is necessary to perform perspective AS in addition to planned one. The result of mutual photogrammetric processing of both planned and perspective AS provides uniformity and details of dense points massive, used further for modeling immovable objects.

Key words: unmanned aerial system (UAS), photogrammetric processing, photogrammetric real estate 3D-model, planned aerial photography, oblique aerial photography, dense point cloud, accuracy evaluation.

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ECOLOGY AND ENVIRONMENTAL MANAGEMENT



ROLE OF REGIONAL AND LOCAL PHYSICAL-GEOGRAPHICAL DIFFERENTIATION FACTORS IN ECONOMY USE EVALUATION OF INNER ASIA TERRITORIES

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Extreme "vulnerability" of Inner Asia steppe ecosystems in condition of severe climate and anthropogenic burden underlines the importance of questions of studying operational evaluation of economic use, planning and rational territory management.

For operational independent evaluation of Inner Asia territory economic use, the basis for subsequent ecological monitoring and management rationalization was suggested the methodology with using remote sensing data. The result of conducted research stated the squares of actually used arable lands, deposits and also the parcels with damaged vegetation cover on deposit areas; was conducted the zoning within the basin parcel under research.

The obtained data show that underestimation of azonal and local factors of environmental differentiation leads to substantial and longstanding negative consequences both for environment and economic activity of local people.

Key words: basin, economic use, relief model, zoning, steppe ecosystems, territory assessment, remote sensing data.

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METHODOLOGY OF SCIENTIFIC AND EDUCATIONAL ACTIVITY



OPTIMIZATION ACTIVITIES OF THE SCIENTIFIC AND TEACHING STAFF WITH THE INTRODUCTION OF PROFESSIONAL STANDARDS IN THE UNIVERSITIES OF THE RUSSIAN FEDERATION

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The authors analyze the changes in the work of teachers, arising from the entry into force of the professional standard "Teacher of vocational training, vocational education and additional vocational education" in the Russian Federation. The modern innovative university represents a mobile system of continuous education, aimed at training world-class personnel capable of quick adaptation to the conditions of the external environment. It is proposed to organize a gradual system of personnel certification in order to improve the work effectiveness of employees and strengthen the respectable image of the University.

Key words: academic and teaching staff, professional standard, qualification requirements, generalized labor function, labor actions, special conditions of admission, certification, optimization.

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