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The Conception of Modeling Technologies of Ecological Processes in the Southern Priaralie

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Abstract: ***The article discusses the the research in this field has come up against certain difficulties, related in particular to the information aspects. Particularly, the absence or insufficient representativeness of primary factual information.The processed data base is a corrected isomorphic mapping of the raw data in database. Isomorphism means, in this context, the sameness of architecture, elements, hierarchy and level of detail of both bases.***

Keywords: Southern Priaralie, modeling, ecological processes, ecosystem, natural transformations

1. Introduction

The growing interest in the scientific world in ecological crisis is focused on its dynamics, "points of no return", bifurcations, which is explained by the need to take timely measures for early detection, prevention, elimination and assessment of the consequences of ecological disasters. The research in this field has come up against certain difficulties, related in particular to the information aspects. Particularly, the absence or insufficient representativeness of primary factual information.An important part of ecological research, especially with the use of mathematical modeling, is the analysis of the results obtained, most often performed verbally.

There are enough scientific papers on storage and process automation of input data [1, 2, 3]. But the scientific papers with a systemic methodology of various phases of ecological research with the corresponding algorithms and programs for analytical data processing are very rare[4].The need for a system of many analysis in the study of the destabilized ecosystem of the Priaralie is driven by the coherence and nonlinear interdependence of the dynamics of the components. The experience of one of the authors of the article on the study of the ecological problems of the Southern Priaralie showed a significant dependence of the course of self-organization of an ecosystem on the priority of negative and positive feedbacks between its elements and processes. And the study of the complex interweaving of nonlinear ecosystem relationships requires the use of system modeling based on a large amount of empirical data. As a result, a macro-model was created, containing, in addition to 13 mathematical sub-models, containing, as compulsory elements, an information-statistical block for information processing and a control block that carries out system communications [5]. In the above mentioned study, the conception of system modeling of complex eco-meteorological processes is presented. In this paper we propose anabridged version of this generalized conception for the systemic study of various ecological problems of the Southern Priaralie focusing on identifying coherence and consistent patterns. The scientific originality of the study lies in the creation of a conceptual system that represents a clear logic and structure of ecological research with a technical display in the form of a unified IAS with built-in software for data processing.

2. Materials and Methods

A common methodological basis for the development of IAS is a systematic analysis and the ecosystem approach, to the foreground, establishing structural relationships between variables or elements of the system under study and common structural-functional organization of all ecosystems, regardless of the community composition, environment and their habitation.The statistical methods with a preliminary identification of the distribution laws are applied for the quantitative estimation of the synergy between the componentsof ecosystem of the Southern Priaralie. Missing data recovery, data smoothing, noise removal are performed with the interpolation methods and regression analysis [6, 7]. The technologies such as Jupyter Notebook and Minitab integrated with database were used for statistical analysis [8].

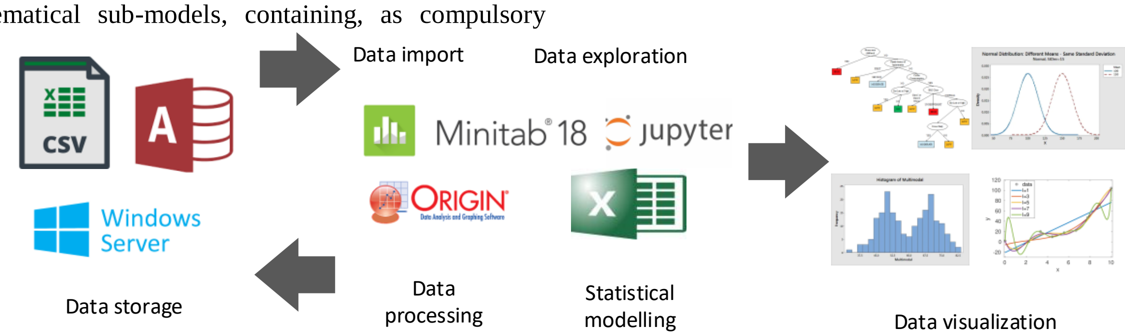

Figure 1: Software tools

The databases are built using MS SQL Server, Arc SDE. The retrospective data is collected on the base-shell of MS Access, MS Excel and MS SQL Server.

To visualize the results, the Origin 8, Jupyter Notebook and Minitab software which have the ability to display raster maps in various formats and support the import of graphics, spherical projections, digital elevation models, etc. (Fig. 1) were used.

Main part

The ecological modeling process, in contrast to the modeling of objects of a different nature, has a number of features, the most important of which are the following. An integral feature of the ecological process is poly-scale, which is expressed in the fact that state variables have different spatial and time scales, often differing by several orders of magnitude.A distinctive feature of ecological research is a large volume of input parameters, their close relationship, and sometimes insufficient representativeness. A characteristic feature of the studied ecological objects is a weak structuring, i.e. the presence of a priori not formulated quantitatively (sometimes qualitatively) links between individual processes. The ecological research is based on the principles of consistency, hierarchy, integration; formalization.The principle of consistency assumes an approach to the object of research as a system. Adequacy of the display (modeling) of the system means that system image must be a system.

The principle of hierarchy is due to the fact that the modeling of ecological processes is associated with the processing and use of large amounts of data, moreover, at lower levels, more detailed and specific information is used, covering only certain aspects of the functioning system, and at higher levels, generalized information is received that characterizes the conditions of the functioning of the entire system. Hierarchy normalizes the system and gives it robustness [9].

The principle of integration is aimed at studying the integrative properties and consistent patterns that appear as a result of combining the functions of interaction of ecosystem elements in time and space [10]. A structural aspect of the integration principle is a construction of integrated computational process or an integrated model. For the research aspect, the principle of integration is expressed in the theoretical generalization of the obtained results, in the identification of the consistent patterns implicitly embedded in them.The formalization principle is aimed at the analytical expression of the quantitative and complex characteristics of dynamic system (DS) elements, the dynamics of binary interactions and system dynamics in general, and makes the aspects and development trends of the process as clear as possible. Importantly, a significant compression of information takes place. In contrast to the classical separation of the system modeling process into a number of phase or stages, "successively replacing each other through time or ran in parallel" [11]. In this conception, there is no strict time distribution of individual tasks of the research process. Unlike the above-mentioned application of modeling, it alsobroadly uses of processing technologies.

We proceed from the general provisions of the conception to the technological organization process of the ecological modeling - an information analysis system (Fig. 2) which consists of 3 blocks.Block A is designed to work with input data and consists of two databases and a link bar - a data correction program module, the key functions of which are the restoration lines by interpolation methods with an indication of their accuracy, spatio-temporal coordination and reduction to a unified system of measurements.

The raw data in database is filled with documentary, factual, cartographic, visual, etc. data with the references to the sources, a list of which is compiled and stored in a separate table.

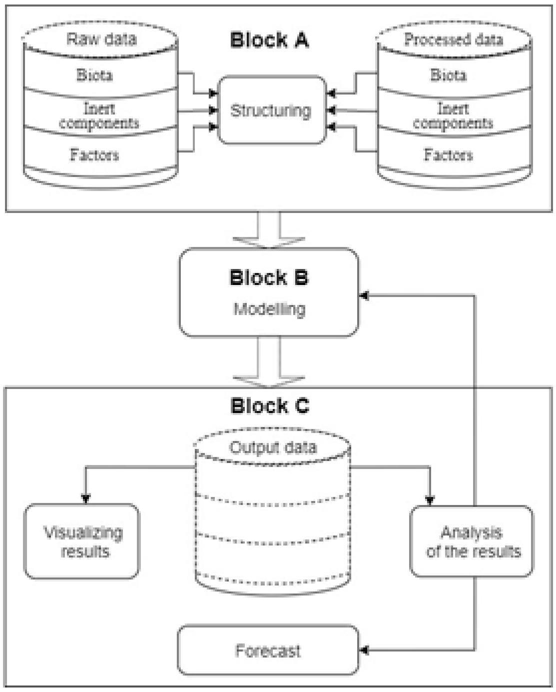

Figure 2: Information analysis system

The processed data base isa corrected isomorphic mapping of the raw data in database. Isomorphism means, in this context, the sameness of architecture, elements, hierarchy and level of detail of both bases. The databases of block A are presented in three information-logical levels: "Biota", "Inert elements", "Factors". The detailed architecture is determined depending on the specific tasks being solved.

Block B - a block model - is presented as a "black box", since the models, depending on the research goal, may be different. The content of this block depends on the complexity of the model.For example, for balance models or models consisting of linear equations, the variable values are imported directly from block A. In this case, the content of block B is only the model implementation program. If the mathematical setting of the problem to solve is represented by a system of nonlinear equations (a system of models), block B should contain, in addition to the model implementation program, an information-statistical module (ISM) for storing, coordinating and adapting intermediate data for information exchange within the system of models [5].

Block C is used for the analysis and interpretation of the output data. Statistical, formatted, or any other data transformation is required not only for the input data, but also for the output data. The predicted data obtained during the model implementation are usually presented in the form of matrices and do not explicitly contain information on the consistent patternof dynamic processes and their interrelationships. Therefore, the further processing of the output data is required for visualization and to improve the learning of the modeling results in the form of tables, graphs and analytical expressions of consistent patterns and relationships. In this regard, in block C, a database is createdfor the output data, time-sliced, of ecological objects, location, etc. according to the objectives of the study. The key function of this database is spatial registration, which consists of geographic, screen and virtual coordinates of ecological objects.

The analysis of the obtained results starts with the validation of the model, i.e. comparing the output data with the corresponding data of the database of raw datain block A. For this purpose, block C provides an algorithm for residuals estimation, checking the coincidence point (maxima, minima, bifurcations, breaks, bend). In case of significant discrepancies, it is necessary to correct the model (return to block B).

The most informative in the analysis is the graphical interpretation of the data, with which, in our opinion, it is advisable to start the process of inferences and conclusions about the features and patterns of ecosystem behavior.

The final phase of block a C is the prediction of the state of both the studied object and the process. A strong relationship, synergy of output data model excludes the possible construction of forecast background. To determine the forecast scenario, only the trends predicted at the formalization phase anddevelopment trend of the research object can be used by carefully checking the validity of the extrapolation.

3. Conclusion

A large amount of unstructured data is a common problem for ecologicalresearches in the Southern Priaralie. The dynamism and specificity of the Aral Sea crisis requires systematic expeditions and well-established monitoring, the absence of which we have to acknowledge.The coherence, interrelatedness of ecological processes in the ecosystem of the Southern Priaralie, which have a common control parameter - a sharp reduction in river runoff - requires the use of system analysis, an important component of which is modeling.The developed information analysis system can serve as a significant support in organizing and systematizing the modeling process.The outlined conception of ecological research technology is a new step in increasing the efficiency of scientific technologies for ecological researches in regions with intensive natural transformations.

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