Geodesic tasks of global monitoring

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Abstract. The rapidly developing anthropogenic impact on the environment generates a need for a monitoring system based on aerospace methods of Earth observation. The foundation of monitoring feasibility study is cartographic materials based on aerospace information as well as traditional geodetic methods. One of the main elements of any sectoral and global monitoring system is the definition of the list of objects, with allocation of qualitative and quantitative characteristics. In the context of global monitoring, this process is performed more appropriately on the basis of remote sensing materials. In this case structural analysis of aerospace monitoring information support becomes very important. Detailed elaboration of monitoring object interpretation features allows increasing information content of cartographic materials. When interpreting boundaries of monitoring objects, the most important are plan outlines and internal structure of the researched object. Effective investigation of environmental monitoring problems on a global scale is based on integrated use of aerospace, topographic and geodetic methodology. The author’s concept of classification of cartographic support for global monitoring expands the research tools for the assessment of global processes of change in the Earth’s surface. The use of predictive cartographic materials in the step-by-step monitoring of global exogenous processes is the most effective tool for fixing changes in landforms.

1 Introduction

The state of the environment is constantly changing. In order to control its condition and to make informed decisions in a timely manner, an environmental monitoring system has been established. Environmental monitoring—a system of systematic observation of the state of the environment—is a highly relevant field of scientific and production activity, which is based on the achievements of many technical, natural and even humanities disciplines. Numerous researches on dynamics, anthropogenic changes, forecasting of development and environmental protection are directed directly on the solution of monitoring questions. The increasing continuous anthropogenic impact on the environment disturbs the stability of natural complexes, therefore, the development of structural elements of operational control of the state of ecosystems, which is performed by means of remote sensing, is becoming increasingly important.
2 Methods

Methods of global monitoring system make it possible to carry out observations not only of the physical geometry of the Earth's surface, but also to study the kinematics of the Earth, its geosphere, as well as to monitor deformations of the Earth's crust [2].

At present, the tasks of hydrometeorological environmental monitoring are sufficiently developed and solved in theoretical, methodological and organizational terms. In biological, geological and socio-economic sciences these directions are less developed, although they are in a promising growth stage. Research on monitoring programmes, claiming regional and global scale, long-term development and great practical importance, needs good development of problematic and methodological issues.

An effective tool of the monitoring system is geoinformation technology, which allows collecting, processing and analysing large volumes of spatial and temporal data, while modelling global processes of changes in the Earth's surface [3].

The purpose of monitoring should be formulated as precisely as possible, as it determines the content and sequence of studies on the development of the monitoring framework, as well as directly the organizational and technological process of monitoring. In general, the purpose of monitoring can be sectoral, regional and subject-specific. However, this division is relative and to a certain extent arbitrary. Indeed, sectoral objectives are always to a certain extent territorially limited and affect the list of objects monitored. The study areas determine the set of sites, while the latter determine the areas. Despite this relativity, it is always important to present the primary purpose of monitoring.

Examples of sectoral monitoring uses include transport (roads, pipelines), agriculture (croplands, pastures) and industry (mining, oil and gas). The studies on environmental monitoring of the administrative district, the territory of the reserve, the river basin are of regional importance. Subjects (objects) of monitoring may be natural-territorial complexes, components (relief, hydrography) of natural environment and their elements (valleys, rivers).

As important features of any type of monitoring it should be noted its duration or time intervals of work, as well as the accuracy of observations. As a function of the purpose, these characteristics influence the methods of work, their technology and organisation.

Focusing on the methods of environmental monitoring studies, let us draw attention to the debatability of the issue of staging studies under the "aerospace monitoring" program. Undoubtedly, aerospace methods have recently been generally recognized as one of the most effective in studying the dynamics of the natural environment, its condition and anthropogenic disturbance [10]. On the other hand, traditional methods, in particular, field routing, geodetic, stationary methods still remain fundamental. However, the separation of "geodetic" or "hydrochemical" monitoring of certain phenomena has not yet been required, and it looks illogical.

The first place in classifying the types of monitoring should be their purpose. Virtually all types of monitoring require a combination of methods to support them. The formulation of objectives and the development of research frameworks "for the method" rather than "for the purpose" is dangerous in that it may not lead to a final solution and may substitute methodological developments for the final conclusions.

Concerning the researches being carried out lately under the program of "aerospace monitoring of geological environment", it should be noted that within the framework of monitoring of geological environment one can distinguish (according to the principle of subject matter) the monitoring of modern movements of earth's crust, underground waters, permafrost and exogenous processes. [7] Each of the specified kinds demands for its carrying out application not only remote, but also some other methods.
Development of a feasibility study for monitoring of a particular purpose implies, first of all, determination of the list of monitoring objects, their qualitative and quantitative characteristics (parameters), magnitude and direction of changes in these characteristics. Undoubtedly, the essence of the objects, their origin and development are of paramount importance for the development of the monitoring programme.

At the same time, to define the role of aerospace methods in general complex of works are important such features of objects which condition their representation on images. This will make it possible to systematize the features of monitoring objects interpretation and formulate the requirements to aerial and space information. From this point of view, it is expedient to analyze in detail the following features:

- occurrence in plan – point, focal, linear, area;
- distribution – single, local, widespread, continuous;
- dynamics – increase or decrease in size or number, complexity or simplification of structure, emergence or disappearance, activation or weakening;
- Nature of boundaries – sharp, fuzzy, diffuse, straightened, sinuous.

The characteristics listed above largely determine the informative value of remote sensing materials. Thus, in terms of detection probability, the first place is occupied by area objects, followed by point objects. Linear objects are often close to the resolution value, but having a width equal to the diameter of point objects, they require about three times lower resolution for their detection.

If we evaluate the relative role of plan outlines and internal structure of objects in their study, we can say that for point objects their importance is minimal, for local ones small and about equal, for linear objects the plan outlines are more important and for area objects the internal structure is more important.

Changes of objects indicating activation of processes and phenomena are in general more easily fixed on images as they are characterized by higher speeds, less uniformity, sharper boundaries. It is such changes, most often associated with anthropogenic influence, that are among those investigated in monitoring. Changes characteristic of ecosystem weakening or stabilisation stages are generally longer lasting, more uniform and more difficult to detect.

When classifying boundaries in terms of interpretability, it is easier to recognize sharp, straightened boundaries that are often marked by kinks or gradients in the terrain. Blurred and diffuse boundaries are more difficult for interpretation, as well as curved boundaries expressed by incoming angles or changes in one plane. Accordingly, changes in the position of boundaries are easier to capture and measure when the boundaries themselves are easier to interpret.

According to the dynamics of objects, boundary changes can be reduced to three main types:

- change without directional displacement;
- directional displacement without boundary type change;
- directional displacement combined with boundary type change.

The larger and more structurally complex the sites are, the more complex the changes in their boundaries are in general – up to a combination of all three types listed.

The classification of maps used in monitoring can be summarised as follows:

1. Maps available at the outset of operations. These are mainly general-purpose topographic maps and broad thematic maps.
2. Maps prepared on the basis of existing materials at the stage of developing the monitoring framework and creating a feasibility study. Such maps can be given any specialisation and orientation. Along with thematic maps at this stage it is possible to create specialized topographic maps in which the dynamic state of objects and the direction of their changes should be reflected in detail.
3 Results

In particular, geological, geomorphological and soil maps are used in monitoring of exogenous processes at the first stage, maps of relief dynamics and its resistance to anthropogenic impacts are prepared at the second stage, charts with precise record of changes in relief forms are prepared at the third stage and charts of forecast of exogenous processes and measures to prevent or eliminate their hazardous impact are prepared at the fourth stage.

Speaking about the importance of cartographic support of the monitoring phases, it should be emphasized that the wide scope of work on updating topographic maps and the growing work on creating specialized topographic maps dramatically increases the role of this information in solving monitoring tasks. On the other hand, accurate instrumental methods of studying the dynamics of natural objects are the basis of the monitoring process. Thus, the complex of aerospace, topographic and geodetic works should be considered as the foundation of any research within the broad problem of environmental monitoring.

The application of knowledge-based image analysis techniques can significantly improve mapping within landscape maintenance and environmental protection tasks using remote sensing on a local scale. With some effort, very good results can be achieved, in some cases with very high accuracy [8].

But it is also becoming apparent that these procedures also have their limitations, and assessments, for example at the species level, will continue to be the domain of field mapping and specialist work. However, objectivity and speed of estimation can be improved with knowledge-based systems, and the integration of different sources of information is another advantage [9].

References

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