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INFORMATION SUPPLY OF GEO-INFORMATION SYSTEMS FOR THE FORECASTING PROBLEM OF THE AVALANCHE DANGER

Alexander Kuzemin, Olesya Dyachenko, Darya Fastova

Abstract: This article is dedicated to the vital problem of the creation of GIS-systems for the monitoring, prognostication and control of technogenic natural catastrophes. The decrease of risks, the protection of economic objects, averting the human victims, caused by the dynamism of avalanche centers, depends on the effectiveness of the prognostication procedures of avalanche danger used. In the article the structure of a prognostication subsystem information input is developed and the technology for the complex forecast of avalanche-prone situations is proposed.

Keywords: GIS, prognostication, risk, situation, the avalanche danger

Introduction

A study of the natural calamities mechanisms, the development of their connections with the climatic and ecological changes led to the development of the new specialized systems technology for control, which was called geo-information systems (GIS). The basic tasks of GIS-systems are the development of the prognostication methodology for technogenic catastrophes, the estimation of risks and creation of decision making support systems. GIS-systems are intended for working and analysis of the enormous massifs of data for the definition of the characteristics of the zones of high risk, improvement in the planning, which precedes calamities and estimation of damage [1, 2]. The methods and techniques of GIS-systems make possible to evaluate strategies of reduction in the probability of the catastrophes occurrence, including the calculation of social and economic nature. This includes monitoring physical, biological and chemical parameters on the spot of calamity, control of measurement data and development of short- and extended forecast models. The developed GIS-systems make possible to continuously accumulate meteorological information, to perform different

calculations, to reveal regularities, to achieve a three-dimensional tying of results. The purpose of this article consists in effectiveness increase in solution taken by GIS-system due to the development of the complex forecast technology of avalanche danger. According to the stated goal, it is necessary to solve the following subtasks:

1. to determine structure, tasks and purposes of the developed GIS-system;
2. to develop structure and method of prognostication subsystem operations;
3. to determine information supply of prognostication subsystem;
4. to build the technology of the avalanche danger complex forecast.

Structure and the task of GIS-system

GIS-system is the totality of the following elements (Fig. 1):

1. *monitoring subsystem*, intended for guaranteeing of dynamic monitoring and mapping the indices of dangerous situations on that investigated of territories in the visual (tabular, graphic, cartographic and animated) form.
2. *integration subsystem* of the different data sources for the solution of the problems of control of natural catastrophic situations.
3. *analytical subsystem*, which ensures the complex analytical processing of information for the solution of complex analytical problems.
4. *prognostication subsystem*, which ensures the multivariant scenic and purposeful prognostication of situations on the base of the complex of the interconnected models of the separate parameters.
5. *system of decision making support*, based on the development of models and methods for making of adequate decisions of operational and strategic nature.
6. *subsystem of results representation*, which ensures data presentation in the most visual tabular, graphic and cartographic form, which reflects qualitative characteristics and basic tendencies of the indices of situation.

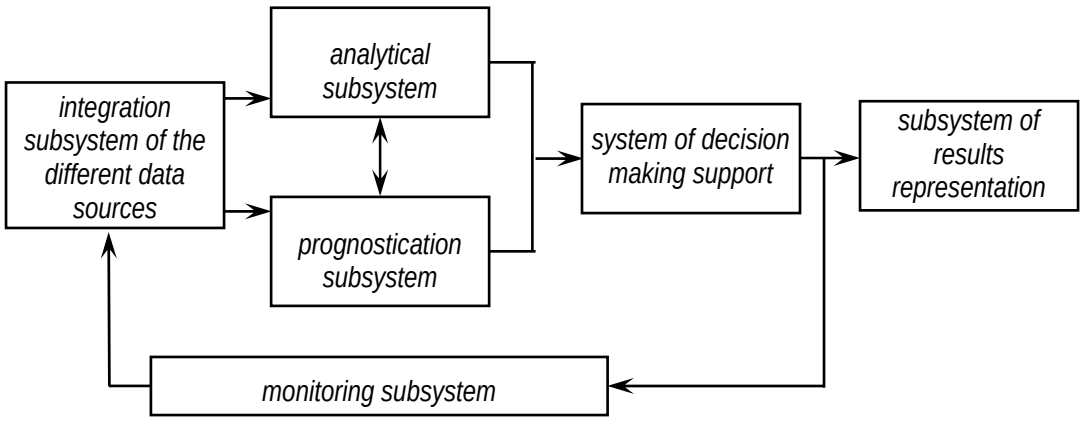

Fig. 1. GIS-system structure.

The distinctive special feature of geo-information systems is the feedback, whose function fulfills the subsystem of monitoring. In general form the role of GIS-technologies in avalanche studies is reduced to the synthesis of knowledge about the relief, the climate and the preceding events, for the purpose of possibility determination of gathering snow avalanches. For this in the GIS environment are imported already existing maps or new projects are created. The analysis of the works, dedicated to use GIS in avalanche studies, showed that the GIS-technologies at present adapt for the solution of the following problems:

- development of the zones of the origin of avalanches;
- simulation of processes and phenomena, which determine the conditions for gathering snow avalanches;
- definition of lethal areas;
- creation of the cadastral surveys of avalanche centers, data bases about the avalanches;
- forecast of avalanche danger.

Subsystem of prognostication

The technology of the prognostication of avalanche danger is the information complex, which consists of three basic blocks (Fig. 2):

1. database - is intended for collection, storage and initial processing of the data of hydrographic and weather services, snow-avalanche stations and electronic charts of surface of locality, which contain information about snow accumulations, to the underlying surface and so forth
2. Mathematical and algorithmic guarantee - is the collection of mathematical methods and approaches, on base of which is produced the simulation and the prognostication of avalanche-prone danger. The prognostication of avalanche-prone situation is characterized by four basic parameters: by place, by type, by time and with its degree of power. Each of the characteristics has available their mathematical, algorithmic and program apparatuses.
3. block of results assignment for different levels of users - the obtained forecasts are analyzed by experts and leaders of Emergency And Disaster Relief Ministry, after which they are transferred for modification to the system of decision making support for the purpose of use with the correction of anti-avalanche measures and to the elimination of the consequences of gathering avalanche.

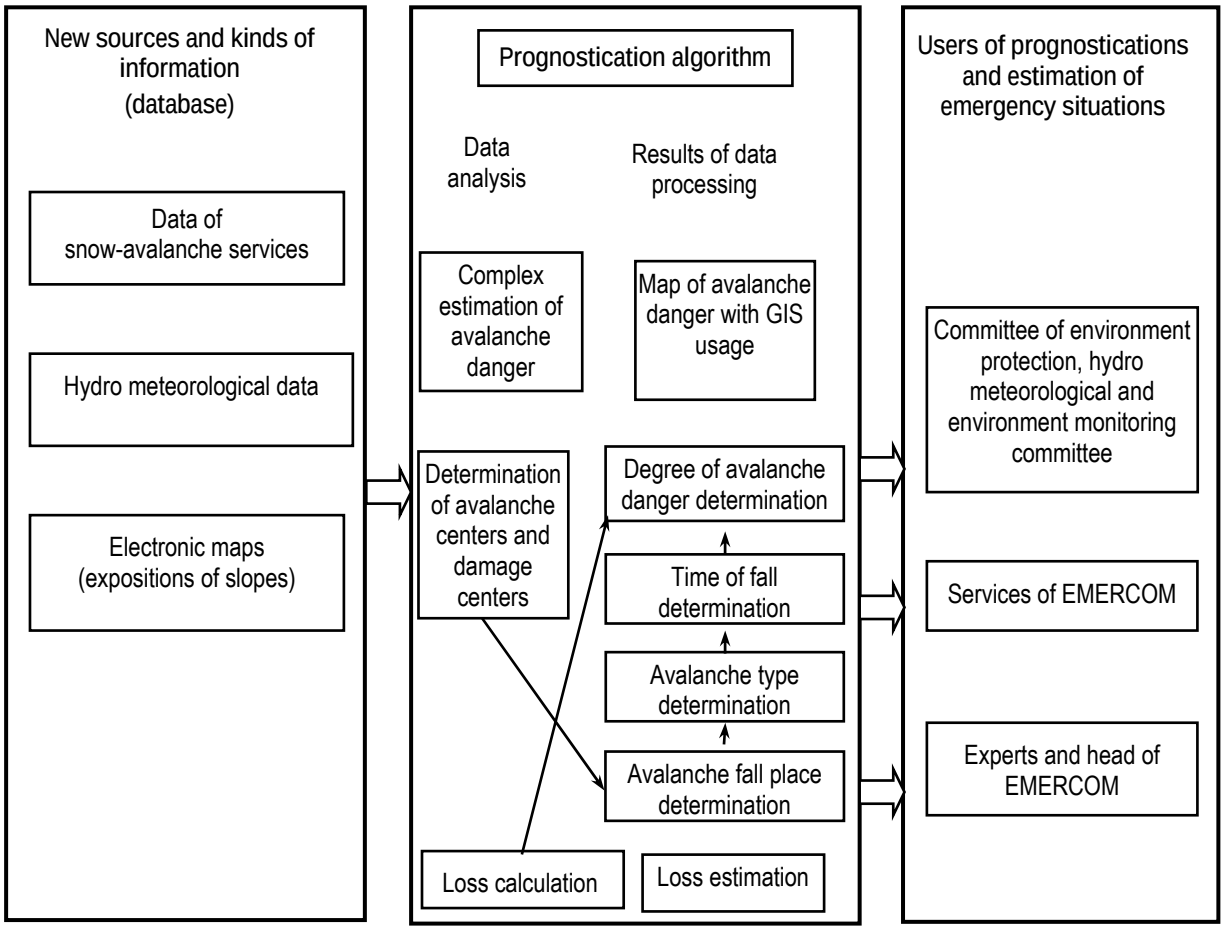

Fig. 2. Technology of avalanche danger prognostication.

For the realization of the complex forecast of avalanche-prone situations it is necessary to determine the place of gathering avalanche, to produce its classification on the genesis, to determine time and degree of the power of avalanche. The place of gathering avalanches is determined with the aid of the electronic charts of area relief, on which is determined the slope of slopes, they calculate the thickness of snow cover and the distance of ejection.

The genetic type of avalanche depends on the geographical and climatic special features of mountain locality. 5 basic genetic types of avalanches can be specified:

1. avalanche of the freshly fallen snow.
2. wet avalanches.
3. avalanche of snowstorm snow.
4. avalanche of temperature reduction.
5. avalanche of sublimation diaphthoresis.

This classification of avalanches is conditional, since it is very difficult to find the relation of the processes of the appearance of avalanches with the natural conditions of avalanche-prone regions. Depending on the genesis of avalanches the procedures of remaining characteristics prognostication of avalanche danger are selected. In the world practice a large quantity of power estimation scales of avalanches is used - these are the European scale, the American scale, the French scale of avalanches power evaluation [4]. In the developed subsystem of the prognostication of avalanche danger adapts the French scale of the evaluation of the power of avalanche danger, developed By F. Rapin [5] (table 1). The hazard level is evaluated by five progressively growing steps, which are described through such physical parameters as the damaged territory, the thickness of avalanche board, the volume of derailed snow, dynamic pressure, probability of caving avalanches and their effect on the vital activity in the mountains.

Table 1.

Scale of the avalanches power degrees

	Degree of avalanche power	Physical parameters	Probability of avalanche caving
1	Insignificant	Damaged territory:~0.2 GA Thickness of the avalanche board: 20 cm Amount of derailed snow: $\sim 100\,\mathrm{m}^3$ Dynamic pressure: ~2 KPa	Caving is possible only with the very significant increment loads on the separate very steep slopes. Spontaneously can occur only the motions of snow
2	Moderate	Damaged territory:~1 GA Thickness of the avalanche board: 40 cm Amount of derailed snow: $\sim 1000\,\mathrm{m}^3$ Dynamic pressure: ~10 KPa	Caving is possible with the significant increment loads first of all on the slopes indicated, spontaneous caving of avalanches highly improbably
3	Significant	Damaged territory:~5 GA Thickness of the avalanche board: 80 cm Amount of derailed snow: $\sim 10\,000\,\mathrm{m}^3$ Dynamic pressure: ~50 KPa	Caving is possible with the insignificant increment load on the slopes indicated. Is possible caving separate average and less probably large avalanches
4	Large	Damaged territory:~20 GA Thickness of the avalanche board: 150 cm Amount of derailed snow: $\sim 80\,000\,\mathrm{m}^3$ Dynamic pressure: ~200 KPa	Caving is possible on the majority of slopes with insignificant increment load
5	Very large	Damaged territory:~50 GA Thickness of the avalanche board: 250 cm Amount of derailed snow: $\geq 400\,000\,\mathrm{m}^3$ Dynamic pressure: ~500 KPa	A numerous spontaneous avalanche caving on any slopes are expected

A time aspect of avalanche danger forecast provides for determination of the possibility of gathering avalanches in the assigned territory into the caused time interval. Among the difficulties, connected with the calculation of the time aspect of the avalanche activity, it is possible to state [6]:

1. Provided in the scientific literature classification of forecasts on short -, middle- and long-term does not use the fixed time intervals for their separation. The analysis of works on the prognostication of avalanche danger shows that in practice the forecast can be comprised for day, 48 hours, 72 hours, for the winter season, for the long-standing interval of time.
2. Forecasts of avalanche danger are created with the use of those of specially developed for the region or the separate center procedures, which determine the algorithm of avalanche danger detection.
3. A lot of procedures provides for the forecast of avalanche-prone period - the time interval, for which it will remain the action of avalanche formation factor. Usually, this approach is used with the forecast of avalanches during the snowfalls and snow-storms. Avalanches are forecasted from the moment of achieving the critical conditions to the end of the snowfall (snow-storm), and for the period from one to two days from their end - thus far the instability of snow cover remains.

Lead time (time between forecast composition and beginning of its action) of forecast, placed in many procedures of forecast is equal to zero. In practice this indicates the statement of facts of reaching the avalanches of conditions critical for the gathering. The basic reasons for this lie in the transience of avalanche-prone situation appearance (from several hours to days), a constant change in the meteorological conditions, impossibility of the continuous and general collection of necessary information. The complex forecast of avalanche danger is the necessary information, which is the basic tasks of the system of support and decision making are:

1. guarantee of the planning, planning, controlling organizations with the information about propagation of natural dangers, creation of land cadastre, selection of optimum places for building of linear and area units (Russia, USA, Switzerland, Austria and other.);
2. ecological control of region - influence of avalanches on the dynamics of landscapes, the nature and the boundaries of plant communities;
3. selection of tourist groups safe movement ways;
4. development of anti-avalanche activities;
5. study of interrelations of dangerous natural and anthropogenic phenomena (Russia, The USA).

Conclusions

This article examines the geo-information system, intended for predicting of avalanche danger and decision making by the averting and overcoming of its consequences. Structure and tasks of the developed GIS-system are examined. The subsystem of prognostication is in detail represented, is described its information input, which consists of the data base, mathematical and algorithmic complexes, the block of the assignment of results. Is proposed the technology of the complex forecast of the avalanche danger, which includes the determination of the position of gathering, the classification of avalanches on the genesis, the determination of time and degree of the power of avalanches.

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