

PROBABILISTIC AND MULTIVARIATE ASPECTS OF CONSTRUCTION OF THE MODELS AND PROCEDURES FOR PREDICTION OF THE AVALANCHE-DANGEROUS SITUATIONS INITIATION

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Abstract: The interpretation model for analysis of the avalanche-dangerous situations initiation based on the definition of probabilities of correspondence of studied parameters to the probabilistic distributions of avalanche-dangerous and non-avalanche-dangerous situations is offered. The possibility to apply such a model to the real data is considered. The main approaches to the use of multiple representations for the avalanche-dangerous situations initiation analysis are generalized.

Key words: avalanches, probability, set, situation, model.

Introduction

Avalanche-dangerous regions occupy 6% of the land area. But despite this the problem of such phenomena investigations is rather important and urgent as analogous phenomena can become the cause of people's death and considerable destructions [1, 2]. Among the most essential and important problems in the given aspect one should note substantiation of the utility to use the corresponding mathematical apparatus intended both for investigation of the avalanche-dangerous situations development dynamics and for development of methods for estimation of the potential avalanche cells, prediction of avalanches volumes and descent frequency. This concerns the fact that every avalanche can be regarded as a unique phenomenon of nature with its specific peculiarities. At the same time despite its uniqueness it is possible to single out the climatic conditions variations characteristic ranges which are prerequisites to prediction of the feasible avalanche descent. Eventually, the totality of these two factors defines the presence those approaches to prediction and warning of avalanches descent, at present these approaches are used in geoinformation systems (GIS) which make it possible to accumulate continuously meteorological information, carry out various calculations, reveal regularities and realize spatial tie of the obtained results [3, 4].

Available methods of the avalanche-dangerous situations initiation prediction

There is no doubt that the foundation of avalanche-dangerous situations initiation prediction consists in the procedure of the preliminary analysis of such events. As a rule the solution of the formulated problem is based on the statistical analysis methods. In particular, the approaches of such analysis make it possible to substantiate the most significant system of the facts which is expedient to use in the avalanche-dangerous situations prediction procedures. Such approaches found their development in the predictions of snow avalanches descent based on application of the images similarity method (or the nearest neighbors method) [5] or through the application of the regression equations [6]. The data of nomograms which in a general case extend the interconnection of such indices as temperature, value of snow cover and precipitations are also used for estimation of the avalanches descent probability. But in spite of this the remaining non-predictive nature of the avalanche-dangerous situation doesn't always allow to prevent negative consequences of emergencies caused by their descent. This is associated with that the available procedures of the avalanche-dangerous situation

initiation prediction are not sufficiently precise. At the same time the severity of the problem and variety of ways to solve it motivate the necessity to search alternative methods which can give more argued answers.

Thus, as the main aim of the given investigation one can single out consideration of the approaches, alternative to the available methods, to the avalanche-dangerous situations initiation prediction. First of all, in this case the consideration of the conceptual foundations of the models and procedures of such a prediction is significant in our opinion.

The probabilistic aspects of the avalanche climate initiation medium analysis

Analysis of different characteristics of the avalanche climate initiation medium makes generally the foundation of the avalanches descent prediction. Among such characteristics the most abundant ones are: the air temperature, humidity, atmospheric precipitations volume, wind velocity, angle of the slope of surface (descent angle) where the avalanche descent is possible. In general, the variation dynamics of both individual of the above characteristics the avalanche climate initiation and their totality can, with some probability, characterize initiation either avalanche-dangerous or avalanche-non-dangerous event. As this takes place, a feasible range of the studied avalanche climate initiation characteristics variations describes a definite region of avalanche-dangerous and avalanche-non-dangerous situation. In the conceptual plan the essence of the probabilistic aspect of the avalanche climate initiation analysis can be reduced to the definition of the probability to assign some point as the considered medium current characteristics either to the region of the avalanche initiation or to the initiation of avalanche non-dangerous situation. Otherwise the given approach can be treated as a correspondence of the current characteristics of the avalanche climate initiation medium; parameters of these characteristics define some region using probabilistic distribution of avalanche dangerous or avalanche non-dangerous situations preceding this. Consequently, it is possible to speak about so-called probable conformity of the researched characteristics of the avalanche-dangerous climate environment to probabilistic distribution of the avalanche-dangerous or avalanche non-dangerous situations.

In particular, procedure of such analysis can be considered proceeding from the pairwise analysis of various characteristics of the avalanche climate initiation. The advisability of such a transition is related to the fact that at

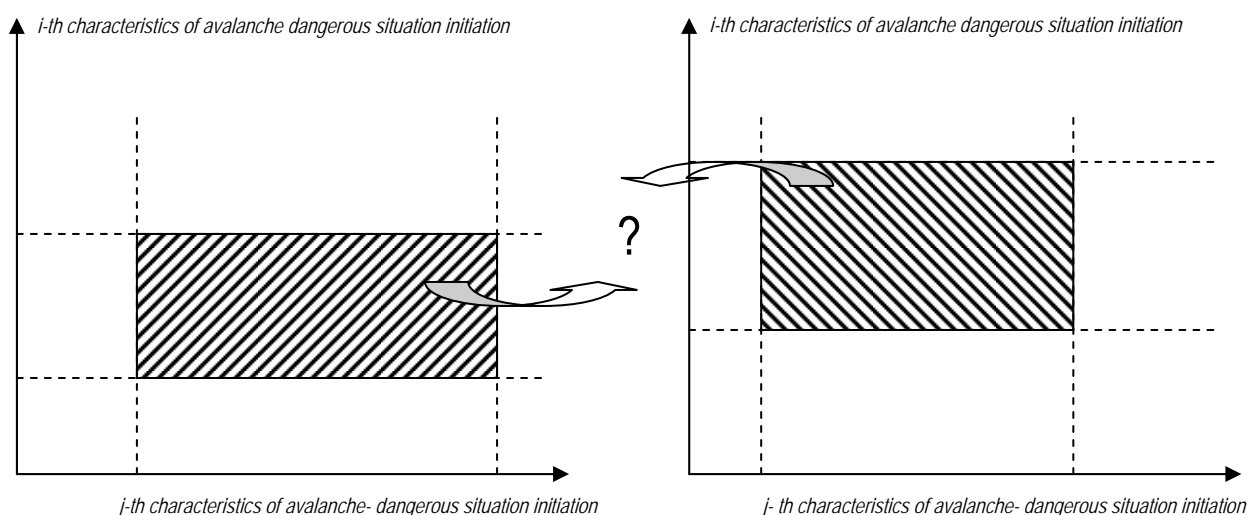


Fig.1 On the explanation of the probabilistic aspect of the avalanche climate initiation medium analysis

the stage of the preliminary analysis it is possible to omit less significant factors of impact on the avalanche-dangerous situation initiation. Thus, the base element of the analysis procedure being considered is estimation of the probability of the avalanche climate initiation current parameters to fall within the regions typical and atypical for the avalanche climate initiation. The given regions can be presented in the plane in the form of the rectangle; its metric values correspond to definite parameters of variation of the avalanche- dangerous and avalanche-non-dangerous situations initiation medium characteristics (Fig.1).

To explain the offered aspect and substantiate its significance let us analyze the probabilistic aspects of some characteristics of the avalanche climate initiation medium using the real data of the avalanches descent in ITAGAR Chychkan region Kyrgyzstan Republic within 2001–2006, obtained in the frameworks of carrying out joint scientific and research work. The essence of such analysis is reduced to the estimation of the feasible assignment of the avalanche-non-dangerous situations to the avalanche-dangerous ones and vice versa in terms of different characteristics of their initiation.

First and foremost, it should be noted that the considered characteristics of the avalanche climate initiation medium follow the normal distribution law. This makes it possible to use this law for estimation of the corresponding probabilities. The corresponding probabilities with regard to the avalanche-dangerous and avalanche-non-dangerous situations are presented in Table 1.

Table 1.

Probabilities of correspondence of the current parameters of avalanche climate initiation medium to the avalanche-dangerous and avalanche-non-dangerous situations	
Characteristics of the avalanche climate initiation medium analysis	Feasibility of correspondence
under condition of considering the avalanche dangerous situation and avalanche dangerous current parameters	
air temperature – wind velocity	0,854
air temperature – wind velocity	0,823
wind velocity – precipitations quantity	0,707
precipitations quantity – descent angle	0,809
under condition of considering the avalanche-dangerous situation and avalanche- non-dangerous current parameters	
air temperature – wind velocity	0,488
humidity – precipitations quantity	0,582
wind velocity – precipitations quantity	0,317
precipitations quantity – descent angle	0,341
under condition of considering the avalanche-non-dangerous situation and avalanche- non-dangerous current parameters	
air temperature – wind velocity	0,798
humidity – wind velocity	0,878
wind velocity – precipitations quantity	0,866
precipitations quantity – descent angle	0,939
under condition of considering the avalanche-non-dangerous situation and avalanche- dangerous current parameters	

air temperature – wind velocity	0,555
humidity – wind velocity	0,482
wind velocity – precipitations quantity	0,403
precipitations quantity – descent angle	0,591

As can be seen from the data in Table 1 the assumptions made above are reasonably justified i.e. the probability of correspondence of the like situations and parameters is essentially significant. This allows making generalization even for estimation of probable initiation of the avalanche-dangerous as a whole. To do this one should consider

- either generalization of the obtained probabilities reasoning from the significance of different groups of characteristics of the avalanche climate initiation characteristics analysis in the assumption that the probabilities of correspondence can be considered as conditional probabilities of the concrete situations analysis;
- or a separate group of characteristics of the avalanche climate initiation medium analysis based on the greatest/least values of the correspondence probabilities.

Multivariate aspects of the avalanche climate initiation medium analysis

In any case the obtained above correspondence probabilities for some interval of time make it possible to pass to the examination and analysis of the multitude of the avalanche dangerous initiation. As an alternative to the boundary of the distribution polygons built using the correspondence probabilities in some temporal interval can be considered. The analysis of such sets allows formalizing the totality of the avalanche-dangerous and avalanche-non-dangerous situations and creating the procedure of the corresponding prediction.

Moreover, the fuzzy sets theory methods and approaches can be used as one of the specified problem solution directions. In particular, such an approach can be used for prediction of the avalanche descent time. A fuzzy-set description of the avalanche-dangerous and avalanche-non-dangerous situations makes it possible to perform. The essence of such description reduces to creation of the fuzzy model of estimates of the avalanche dangerous situations temporal characteristics. Thus, for example, it is possible to suppose that in the case of the avalanche non-dangerous situations the time till the tentative avalanche descent will be the greater the greater is the likelihood of assignment of the current parameters of the analysis of the avalanche climate initiation to such a situation. Respectively, in the case of minor probabilities of the avalanche climate initiation analysis current parameters assignment to such situation can points to insignificant reserve of time till the avalanche descent commencement moment. When considering the avalanche dangerous situations the corresponding characteristics are the converse ones. This makes it possible to introduce the avalanche descent commencement into a definite fuzzy set functions and their generalization will just allow predicting the avalanche descent time (Fig.2).

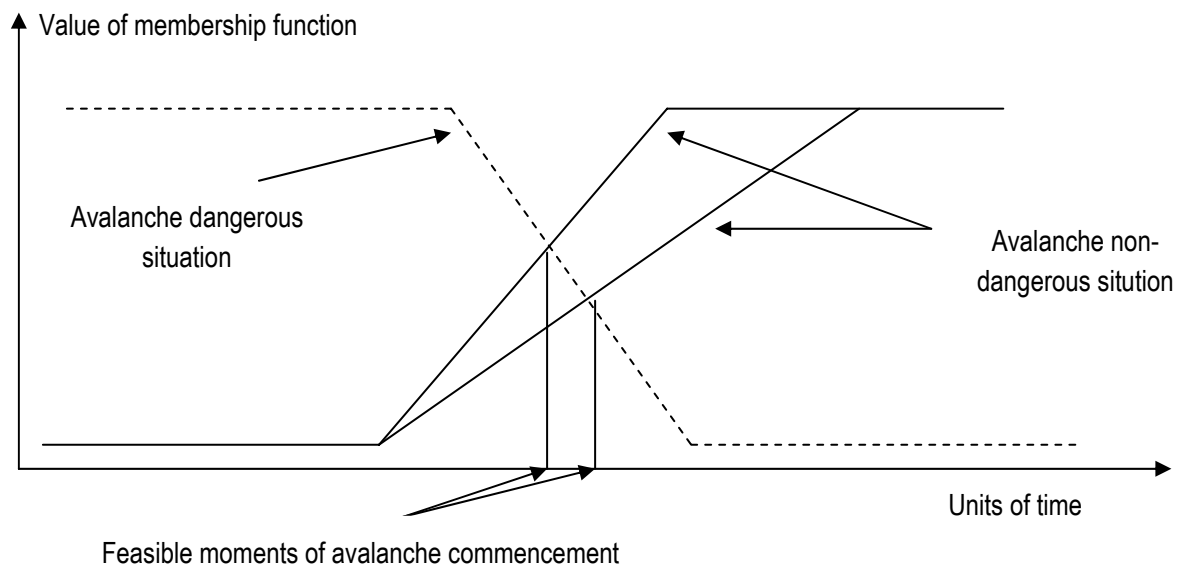


Fig.2. Fuzzy model in analysis of avalanche descent commencement

It is possible to pass on to the distribution functions when estimating the avalanches descent time based on the analysis of the corresponding probabilities to subdivide available data into the avalanche-dangerous and avalanche-non-dangerous ones.

Thus, the model construction generalized scheme and construction of the procedure for prediction of the avalanche-dangerous situations initiation is reduced to:

- sequential obtaining of the probabilistic characteristics of the avalanche climate initiation medium;
- construction of the corresponding sets of subdivision into avalanche-dangerous and avalanche-non-dangerous situations;
- analysis of the avalanche descent initiation time using fuzzy models of its interpretation.

Conclusion

This work presents the general concept of building models and procedures for prediction of the avalanche-dangerous situations based on the probabilistic and multiple approaches to its interpretation. Such an approach allows, first and foremost, to take into account the range of variations of the factors acting on the avalanche-dangerous situations initiation, to build adequate procedures for their prediction. Moreover, the essential characteristics of the problem under consideration which is confirmed, in particular, by the feasibility of the probabilistic model of the general approach based on the real data.

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